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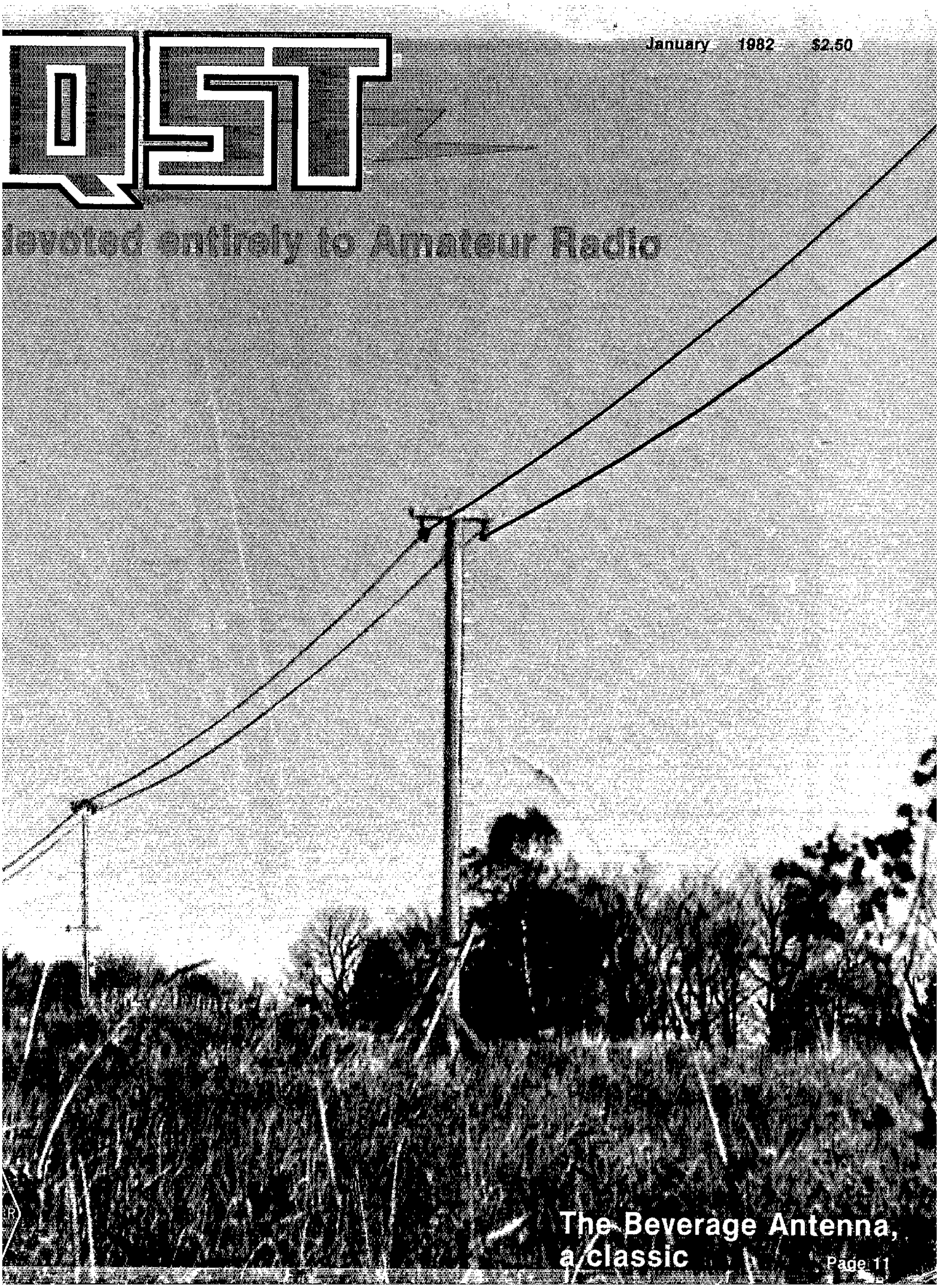
QST
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devoted entirely to Amateur Radio
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QST

January 1982 *Volume LXVI Number 1*

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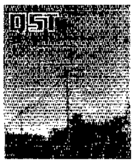
THE COVER



"Wichita Lineman's" work? No, it illustrates the classic two-wire Wave Antenna pioneered in 1922 by H. H. Beverage and R. B. Bourne. See the update and reprint beginning on page 11.

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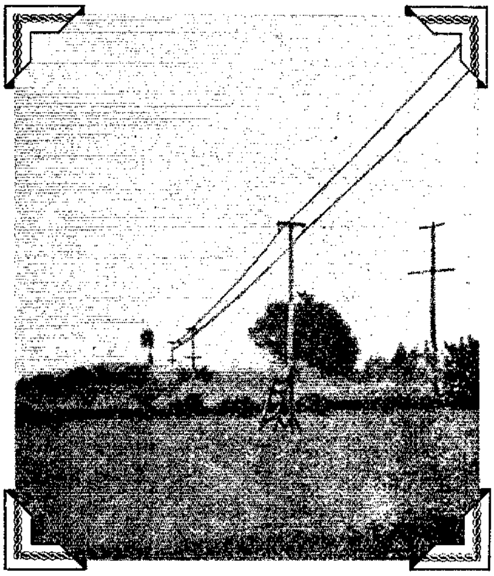
The Classic Beverage Antenna, Revisited

Established theory is timeless, but many amateurs do not have access to the archives that contain classical data of present-day interest. Medium-frequency DXers should appreciate this update on an historical 1922 QST article.[1]



(reproduced from November 1922 *QST*)

By H. H. Beverage,* ex-W2BML and Doug DeMaw,** W1FB

Why the Beverage or "wave" antenna? That's a question the seasoned 160-meter DXers need not ask, for many of them have used Beverage antennas to enhance the effective signal-to-noise ratio while attempting to extract weak signals from the sometimes high levels of atmospheric noise and QRM. Alternative antenna systems have been developed and used over the years, such as loops and long spans of unterminated wire on or slightly above the ground, but nothing seems to surpass the Beverage antenna for 160-meter weak-signal reception.

The practical limitation for many amateurs is the size of their property: a Beverage antenna must be a wavelength or greater in dimension, which for 160-meter work requires a minimum practical antenna length of 166.6 meters (546.8 feet) at 1.8 MHz (feet = meters × 3.281). In an ideal situation, one would deploy a number of Beverage antennas in order to facilitate weak-signal reception from a variety of favored directions, such as Europe, South America, Africa and Oceania. The magnitude of the property-size requirements for such a system might seem incomprehensible to the urban amateur, but the objective can be, and frequently is, realized by amateurs who live in rural areas. Some amateurs are part-time users of Beverage antennas. That is, they erect one or more of these antennas for short periods of time (with the kind permission of neighbors), mainly to improve reception during 160-meter contests and DX operations. One well-known top-band DXer has for many years stretched a Beverage antenna across and beyond an interstate highway (not recommended) for use during 160-meter contest weekends.

The property requirements are complicated further by the need for an effective ground system at the terminated end of the wave antenna. Although the ground screen or radials are normally buried a few inches below the surface of the earth, one cannot, without permission, bury a ground system on someone else's property. Some amateurs have reported reasonable success by driving a number of rods into the ground near the terminating resistor, then bonding the rods to one another by means of heavy conductive strap. However, the characteristics of the antenna are subject to change with the season in accordance with the conductivity of the soil, which is determined in part by the moisture content. The same is true, but to a lesser extent, when buried radials are employed for the ground screen.

Numerous attempts have been made to develop short or "baby Beverages," but the performance was always a compromise to that of a full-size Wave Antenna.[2] It is recognized, however, that some improvement in mf weak-signal reception is better than none, so the shortened version of a Beverage antenna may be worth investigation by those who have limited property.

It is ironic that arrays of small receiving loop antennas, operated in phase and simultaneously rotatable, have been proven to be highly effective in medium- and low-frequency weak-signal reception. But these arrays also require considerable property if they are to be utilized correctly. Furthermore, the cost of such a system, as opposed to a Beverage antenna, is substantially greater.

There seems to be a popular misconception about the frequencies for which the Beverage can provide the stated performance. It is not a suitable antenna for high-frequency reception. One must follow the general rule that applies to loop antennas: *employ the Beverage antenna at*

[1]References appear on page 17.

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**ARRL Senior Technical Editor

medium frequencies and lower. Although some have reported improved reception from Beverage antennas at 3.5 and even 7.0 MHz, the suggested upper frequency limit is 2.0 MHz. Occasional improved reception at hf may result from propagation conditions at a given time, but because the incoming sky waves above medium frequency arrive at moderate and high angles, and with changing polarity because of being reflected from the ionosphere, the Beverage is not suited to effective use in that part of the spectrum. The wave antenna is responsive mostly to incoming waves of low angle — those that tend to follow the contour of the earth and maintain a constant polarization. This reasoning is applicable to loop antennas as well. The apparent effectiveness of Beverage antennas above 2.0 MHz probably results from a reduction in local QRN and QRM off the sides and back of the antenna. A loop antenna would provide a similar improvement in reception, especially if a sense antenna were included to ensure a cardiod response.

The successful deployment of a Beverage antenna is dependent in part on understanding the concept and development of the system. The following text has been taken from the original disclosure in the amateur literature, which appeared under the H. H. Beverage byline in November 1922 *QST*. With the recent return of the 1.8- to 2.0-MHz band to U.S. amateurs, and with the easing of the earlier power restrictions in that band, it seems timely to present the original paper again.

Theory and Development

The Wave Antenna, which later became known as the Beverage Antenna, is a unidirectional antenna. It was developed by author H. H. Beverage, Chester Rice and E. W. Kellogg of the General Electric Co., and is covered by patents and applications. The Wave Antenna was first brought to the attention of the amateurs by Paul F. Godley, who described it in his report on the reception of American amateurs at Ardrossan, Scotland.

Theory

If a wire is suspended in space, it has a certain capacitance and inductance per unit length, which bear a definite relation to each other. This relation may be expressed as $1/\sqrt{LC} = V$, where V is a constant. This constant is the velocity of light. For example, if L and C are expressed as the capacitance and inductance per meter, then V = 3 × 10 meters, which is the velocity of light in meters per second. If a larger wire is used, or if two or more wires are used instead of one, in the ideal case the inductance decreases in the same ratio as the capacitance increases, so that L × C is always a constant. This means that, for the ideal wire, the currents induced in that wire will always travel along it at the velocity of light, independent of the size or number of wires.

A Beverage Antenna needs to be supported at several points and must run horizontally within a few feet of the earth. The effect of the supporting insulators and the proximity of the earth is to increase the capacitance in a greater ratio than the inductance decreases, so the velocity of the currents on a practical wire is always somewhat less than the velocity of light. On short wavelengths, however, the velocity approaches very close to the velocity of light, generally between the limits of 85% and 98% of the velocity of light for 200 meters (1.5 MHz), depending upon the size and number of wires.

In Fig. 1 is shown the simplest form of Wave Antenna. It consists simply of a wire, at least one wavelength long, stretched in the direction of the transmitting station. For explanation purposes, it may be assumed that the transmitting station is east of the receiving station, and that the receiver is placed at the west end of the antenna, as shown. The traveling wave from the transmitting station moves from east toward the west at the velocity of light. As the wave moves along the antenna, it induces currents in the wire that travel in both directions. The current that travels east moves against the motion of the wave and builds down to practically zero if the antenna is one wavelength long. The currents that travel west, however, travel along the wire with practically the velocity of light, and, therefore, move along with the wave in space. The current increments all add up in phase at the west end, producing a strong signal as shown by curve A in Fig. 2. In a like manner, static or interference originating in the west will build up to a maximum at the east end of the antenna as shown by curve B in Fig. 2.

If the east end of the antenna were open or grounded through zero resistance, all of the energy represented by curve B would be reflected and would travel back over the antenna to the west end, where part of the energy would pass to earth through the receiver and part would be reflected again, depending upon the impedance of the receiver input circuit. The horizontal plane intensity diagram would be bidirectional, as shown in Fig. 3. The reception from the west is not as good as from the east because some of the energy is lost because of attenuation in the wire as the reflected wave travels back from east to west.

In order to make the antenna unidirectional, it is necessary to stop the reflections at the end farthest from the receiver end. This is accomplished simply by placing a noninductive resistance between the antenna and ground at the far end. If this resistance is made equal to the surge impedance of the wire, it absorbs all of the energy and prevents any of it from being reflected back to the receiver. The intensity characteristic becomes unidirectional, as shown in Fig. 4.

The value of the surge impedance depends upon the size, number and height of the wires above ground, but is independent of the length of the wire. For practical construction with one or two no. 12 copper wires, the surge impedance lies between 200 and 400 ohms. The

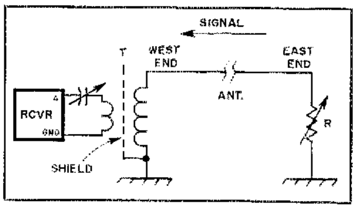


Fig. 1 — The simplest form of Wave Antenna.

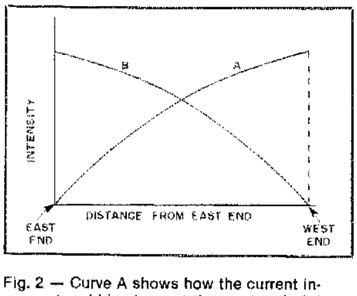


Fig. 2 — Curve A shows how the current increments add in phase at the west end of the antenna. Curve B illustrates how the static and interference add at the east end of the antenna (see text).

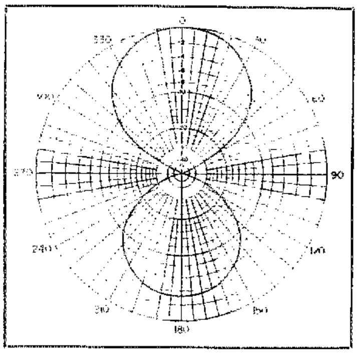


Fig. 3 — Directivity pattern of a Beverage antenna that is one wavelength long. It does not have a damping impedance included.

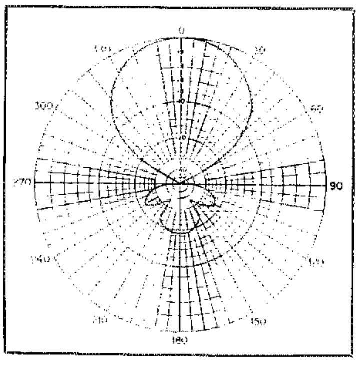


Fig. 4 — Directivity pattern for the antenna of Fig. 3. The antenna has been damped properly.

surge impedance is theoretically equal to $R = \sqrt{L/C}$, where L and C are the inductance and capacitance per unit length.

Godley used the simple form of wave antenna shown in Fig. 1. However, this is not the most practical form, as it is necessary to go to the far end to make adjustments of the damping resistance.

Feedback Antenna

If two parallel wires are used, the Wave Antenna becomes very flexible, and the receiver may be placed at either end with local control of the damping. In Fig. 5, for reception from the east, the receiver at the west end is replaced by the primary, P, of transformer T2. The primary is coupled to the secondary, S, as closely as possible, and feeds the energy over the two wires as a transmission line. A second transformer, T1, at the east end, feeds the energy from the transmission line into the receiver. The energy fed over the transmission line circulates around the line as in an ordinary telephone line and, therefore, the currents pass through both halves of the primary of T1 in the same direction, inducing voltages in the secondary, that feed into the receiver. On the other hand, currents coming over the wires as an antenna, that is, from the west, are equal and in phase on both wires, and upon passing to ground through the two halves of the primary of the output transformer, T1, they pass through the winding in opposite directions and neutralize. With this circuit, the energy reaching the receiver is the same as it would be if the receiver were placed at the west end, except for the transmission-line losses, which ordinarily are 20 to 25% with proper design. With this feedback system the operator can make adjustments of the surge resistance without leaving the station, and can listen to the signals while he or she is making the adjustments.

Fig. 6 is equivalent electrically to Fig. 5, but in this case T2 has been replaced by a simpler circuit. By grounding one wire and leaving the other wire open, the energy is reflected on each wire, but the reflected currents on the transmission line are 180 degrees out of phase on the two wires and, therefore, a difference of potential exists across the terminals of the primary of T1, exactly the same as when the reflection transformer, T2, of Fig. 5 was used. If the ground resistance at the reflecting end is zero, the reflection of energy with the connections of Fig. 6 would be 100% efficient, and the only loss would be the transmission-line losses. The open ground reflection connection is preferable to a transformer, on short wavelengths particularly.

It is possible to damp a two-wire antenna from either end. In the case of Fig. 6, the signal from the east built up to a maximum at the west end, and was then reflected up to the east end, where the receiver and damping circuit were placed. In the case shown in Fig. 7, the receiver is placed at the west end as in the case of the simple antenna of Fig. 1. Instead of placing the damping circuit at the east end, however, it is placed across the transmission line at the west end, where the receiver is. This damping circuit is practically just as effective as it would be if actually placed at the far end. This circuit also has the advantage that the desired signals do not pass over the transmission line, and the transmission-line losses are avoided.

In order for the damping circuit to be effective, it is necessary that the two wires of the

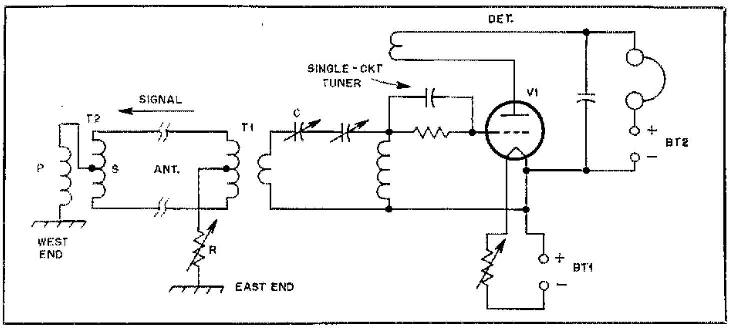


Fig. 5 — The receiver at the west end of the antenna is replaced here by primary P of T2. (See text.)

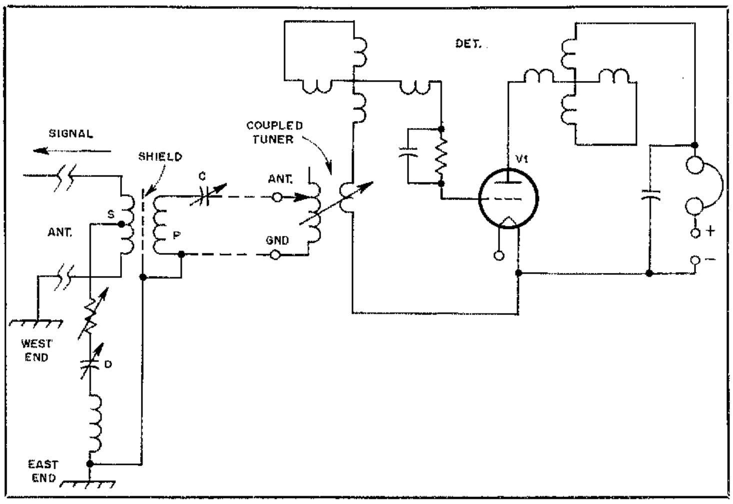


Fig. 6 — This circuit is equivalent to that of Fig. 5, except that T2 has been replaced by a simpler circuit. The damping circuit is labeled "D."

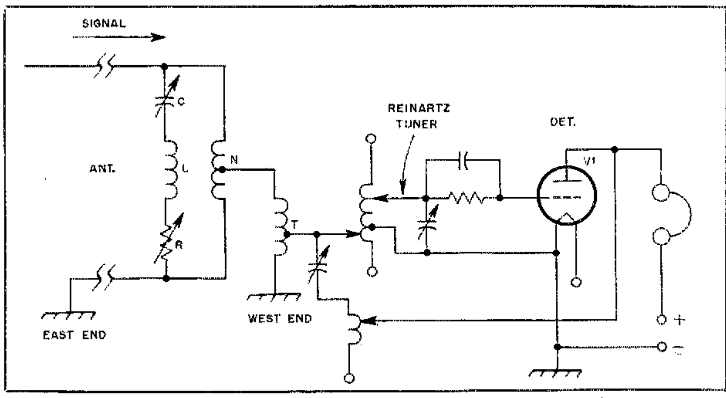


Fig. 7 — This example shows the damping circuit, D, across the two-wire Beverage antenna. The value of the damping resistance will vary with the wavelength.

antenna be joined through an inductance that is of high impedance compared with the impedance of the damping circuit. The best way to accomplish this result is to use a coil with a midpoint tap, as shown at N in Fig. 7. With respect to the transmission line, the two halves of this coil are adding, so the inductance across the line is high. With respect to the receiver, however, the two halves of the coil are opposing, so that the impedance in series with the output transformer amounts only to the leakage reactance of the coil, N, which can be made very small. A satisfactory inductor for N, for 200 meters, was a 24-turn coil, 7 inches in diameter, with a tap at 12 turns for feeding the output transformer, T. This coil was about 0.3 mH across the line, or 1900 ohms at 300 meters (1 MHz), and nearly 3000 ohms at 200 meters, which was high enough to have no appreciable influence on the damping circuit, and yet had low enough leakage reactance to allow the signals to pass to the receiver without noticeable weakening.

Damping Circuits

In Figs. 6 and 7, damping circuits D are shown that consist of resistance, inductance and capacitance in series. Because of distortion on the antenna, to back-wave effects, to interfering signals or static coming from such a direction as to be received on one of the little "ears" on the back of the antenna, as shown in Fig. 4, and so on, it often happens that there are appreciable residuals that are desirable to eliminate. This is possible by making the damping-circuit reactance either slightly capacitive or slightly inductive, instead of purely resistive. In some cases it may be desirable to reflect a small amount of energy to neutralize undesirable signals from the back end. This is readily accomplished by adjusting the resistance and capacitance of the damping circuit. The capacitance and inductance in this damping circuit are usually found to practically neutralize each other for the best adjustment; that is, they should tune approximately throughout the band of wavelengths it is desired to receive. If the wavelength being received is varied over wide limits, it is necessary to readjust the damping circuit capacitor for best results, although the adjustment is usually quite broad. The resistance does not need readjustment except in special cases.

For a range of 180 to 360 meters (1.66 to 0.83 MHz), the damping circuit consists of an inductance of about 0.08 mH, a variable capacitor of 0.0015-μF maximum capacitance and a noninductive variable resistance in steps of 1 ohm from 0 to 500 ohms. A decade box is ideal for this purpose. However, ordinary wire-wound potentiometers (inductively wound) have been used with success in damping circuits. It is necessary to select a potentiometer with sufficiently low inductance to tune well below the shortest wave it is desired to receive; then the inductance of the potentiometer is taken into account when calculating the value of inductance to be used in series with the resistance and capacitance. In this manner the inductance of the potentiometer used for the variable resistance may be tuned out, and the damping circuit may be made a pure resistance for any one particular wavelength.

When the damping circuit is placed across the transmission line as shown in Fig. 7, the value of the damping resistance may vary considerably with wavelength, becoming lower for short wavelengths, owing to the increase in attenuation at short wavelengths partially damping the antenna. In other words, the transmission line acts as a resistance in series with the damping circuit, and the transmission-line resistance becomes appreciable at short wavelengths.

Antenna Design

It is obvious from the theory of the Wave Antenna just given that it must point toward the desired signals or directly away from the desired signals. In case the antenna is pointed away from the signal, then the maximum signal occurs at the far end and must be brought up over the transmission line to the receiver, as shown in Fig. 6. In case the antenna is pointed toward the signal, it is necessary to put the damping circuit on the transmission line, as shown in Fig. 7. It is possible to use a single antenna for reception from either direction by switching arrangements to change to either the connection of Fig. 6, or that of Fig. 7, at will. It is preferable on short wavelengths to point the antenna toward the signal, using the connections of Fig. 7, but the feedback of Fig. 6 gives practically the same results except that the signals are not quite as loud as a result of the transmission-line losses.

It is necessary to run the Wave Antenna in as straight a line as possible and not nearer than 200 feet (61 m) to other parallel wires, such as telephone and power lines, as the influence of these wires is liable to distort the directive characteristic of the antenna. Other wire lines may be crossed at right angles without undesirable effects. In cases where it is not feasible to run the Wave Antenna in line with the desired signals, it is possible to get good reception with the antenna somewhat "off line" by sacrificing signal intensity. By referring to Fig. 4 it is seen that for the average antenna one wavelength long, it is possible to be 45 degrees off line before the signal drops to half intensity. Beyond 45 degrees the signal falls off very rapidly. Twenty degrees off line, the signal intensity has fallen off only 10%, so very good reception may be obtained. If the antenna is two wavelengths long, it is more directive, and it is not possible to receive well if it is more than 25 or 30 degrees off line.

The antennas are constructed of copper or other nonmagnetic material, although Cutler of W7IY reported in October 1922 *QST* that he had obtained good results on a galvanized-iron wire. The size of the wire is usually between no. 10 and no. 14 B&S, although it is possible to get fair results even with no. 18 bell wire. The usual construction is to put up two wires on a cross arm about 2 to 3 feet long. The wires are suspended by porcelain cleats, or in more permanent construction standard telephone pins and high-grade insulators are used.

The height of the wires above ground has a marked influence on the velocity of the currents along the wires when the wires are close to the ground, but if the wires are 10 feet above the ground there is little to be gained in velocity by making them higher, as shown in the curves of Fig. 8. These data were taken on an antenna at Belmar, New Jersey, by H. O. Peterson. This antenna extended over fairly conducting soil. The character of the soil underneath the antenna influences the velocity to some extent, but the data of Fig. 8 are about the average velocity. These curves show that the velocity becomes lower at longer wavelengths.

If the velocity is too slow, then the currents in the wire lag in phase behind the wave in space, and a point is soon reached when the current in the wire from the far end is so far behind in phase that it not only does not add to the increments from points close to the receiver, but may actually subtract. The maximum length that it is feasible to use is that length at which the current in the wire lags 90 degrees behind the wave in space. This length is given by

$$L = \frac{\lambda}{4\left(\frac{100}{C} - 1\right)}$$

where

λ = wavelength in meters

C = signal velocity on antenna expressed in percent velocity of light.

For example, from Fig. 8 we find that the velocity of the currents in the two wires suspended at a height of 10 feet is about 88% of the velocity of light for 200 meters, so the maximum usable length is:

$$L = \frac{200}{4\left(\frac{100}{88} - 1\right)} = \frac{200}{0.544} = 367 \text{ meters}$$

Therefore, it is not feasible to use a two-wire antenna suspended at a height of 10 feet for an antenna that is more than two wavelengths long for 200 meters. By increasing the height, the velocity will increase, and longer wires may be used. Fig. 8 shows that the velocity increases slowly with the height about 10 feet, so the wires must be much higher to be of material advantage. Making the wires too high introduces a difficulty on short waves that does not occur on long waves, and that is the "end" or vertical-antenna effect. The effective height of a 200-meter Wave Antenna is about 5% to 10% of its horizontal length, depending upon the nature of the earth beneath the antenna, and so on. If an antenna is 200 meters long, therefore, the effective height will be between 10 and 20 meters. If the antenna is on supports 10 feet high, the vertical or end effect may be equivalent to an effective height of nearly 3 meters (10 feet), distorting the directive curve. In Fig. 9 is shown the directive curve of a Wave

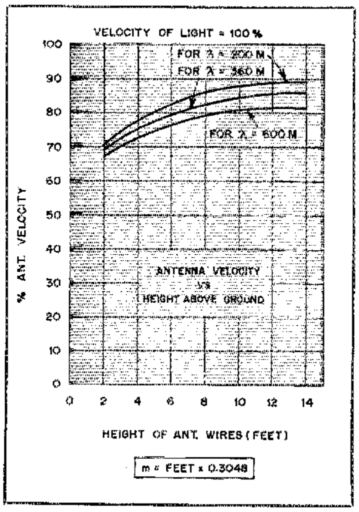


Fig. 8 — Curves that show the antenna velocity factor as a function of the height above ground.

Antenna of 15-meters effective height with a vertical or end effect of 3 meters superimposed upon it. It will be noted that the end effect may mount up to very serious proportions if the antenna is made too high. It is, however, possible to balance this end effect by means of a separate vertical antenna, as shown in Fig. 10. P1 is the standard primary, while P2 is a second primary coil of about the same number of turns, which is wound over P1 but in the opposite direction. In practice, however, the end effects seem to be very much smaller than predicted theoretically, so as a general rule if the antenna is not over 10 feet high the end effects are so small that it is not worth the trouble to balance them. From the foregoing considerations, it is evident that 10 feet is a good average height for short Wave Antennas.

Design of Transformers

With the feedback circuit of Fig. 6, only one transformer is necessary. The output transformer, T1, was wound on a 7-inch cardboard tube. The primary, P, was 20 turns of no. 24 enameled copper wire, with a tap at 10 turns or the exact center. Over the primary was placed a shield consisting of a piece of tinfoil insulated from both windings by means of paper. This shield was grounded to cut out capacitive currents between primary and secondary. It is important that the tinfoil or other metal foil be not quite a complete turn around the primary; the ends must not touch or it will act as a short-circuited turn and introduce high losses. The secondary consisted of 5 turns of no. 18 bell wire wound over the tinfoil shield. The center of the secondary winding was lined up carefully over the center of the primary winding; otherwise the transformer would not be balanced. With the circuit of Fig. 6, the transformer balance was tested by opening both wires at the west or reflection end. When T1 was properly balanced, the receiver was quiet, indicating that the two halves of the primary were perfectly symmetrical with respect to the secondary.

T1 of Fig. 6 was designed to work with a coupled receiver. The secondary of the output transformer was connected in series with the primary winding of the receiver input transformer and was tuned by the series capacitor, C. For 200 meters, it is usually better to use a separate capacitor, C, outside of the tuner capacitor as shown in Fig. 5, but for longer wavelengths this series capacitor may be omitted.

When the circuit of Fig. 7 was used, the transformer just described was used with success, but better results were obtained by cutting the primary turns down to 15 instead of 20. This transformer is shown in Fig. 1, but may be used with the connections of Fig. 7. A metal-foil shield is used between primary and secondary, and is grounded as shown. In all of these transformers the coupling between primary and secondary should be as close as possible.

Fig. 7 illustrates an auto-transformer, T. The total turns are 15, and the receiver is tapped off at 5 turns. The diameter of the turns is 7 inches, but smaller diameters have been used by increasing the number of turns to obtain the same inductance. This auto-transformer connection was once adapted to a Reinartz tuner with excellent results by Roland Bourne, W1ANA, at W2BML.[1]

Surge Resistance and Velocity Factor

The velocity factor and surge resistance were easily determined by oscillator tests. An

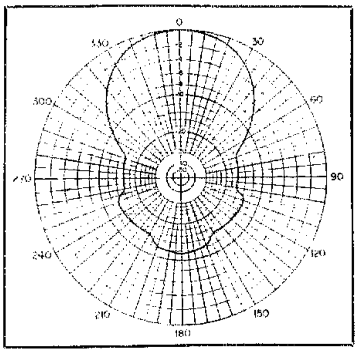


Fig. 9 — Directivity pattern of a Beverge antenna with an effective height of 15 meters, with a vertical or end effect of 3 meters superimposed upon it.

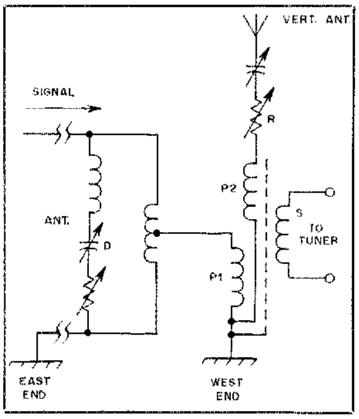


Fig. 10 — A separate vertical antenna can be used to balance out the end effects discussed in the text. The circuit arrangement is depicted here.

oscillator was coupled to the antenna, as shown in Fig. 11. A coupling coil, L, was included in the antenna circuit. It consisted of only two turns. The far end of the antenna was left open for the first test, and a resonance curve of the antenna was taken. The curve is plotted as curve A in Fig. 12. Then both wires of the antenna were grounded at the far end, and the resonance curve taken again. This is shown as curve B in Fig. 12. In order to find the velocity, it is necessary to calculate what the resonance points would be if the velocity of the currents on the wires were equal to the velocity of light.

The length of the antenna was carefully measured. In the case of this particular antenna at Belmar, New Jersey, the length was 240 meters. Assuming that the velocity of the currents on the antenna is equal to the velocity of light, the first resonance point with the far end of the antenna open will be the quarter-wave oscillation, as in an ordinary antenna. The wavelength will be $4 \times 240 = 960$ meters. The next resonance point will be the three-quarter-wave oscillation, or $4/3 \times 240 = 320$ meters. The next will be the 5/4 oscillation, or $4/5 \times 240 = 192$ meters, and so forth, for all odd

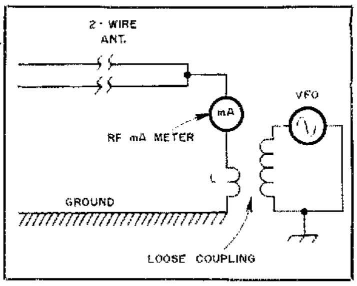


Fig. 11 — An oscillator can be coupled to the antenna, as shown here, to determine the velocity factor and surge resistance.

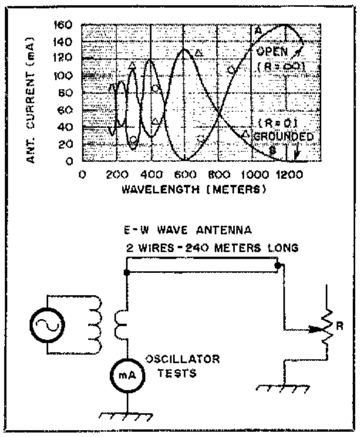


Fig. 12 — Curves obtained with oscillator tests of a 240-meter-long Beverage antenna (see text).

Table 1

Calculation of Velocity of Currents on Antenna

Length — 240 meters, 2 no. 10 wires, 3 meters high

Mode of Oscillation	*Wavelength Calculated*	*Wavelength Observed*	*Vel/Wires Vel/Light*
1/4	960	1200	80%
2/4	480	590	81%
3/4	320	390	82%
4/4	240	280	86%
5/4	192	220	87%
6/4	160	180	89%

multiples of the quarter-wave oscillation. In a like manner, with the far end of the antenna grounded, the antenna will oscillate at all even multiples of the quarter-wave oscillation. These calculated values are recorded in Table 1. In the next column, the observed values taken from Fig. 12 are recorded. By dividing the calculated value by the observed value, we get the actual velocity at that particular wavelength in terms of percent of velocity of light.

To determine the surge resistance, a noninductive resistance was placed between antenna and ground at the far end, and the resonance curve was taken again. Fig. 13 shows the results of this test on the Belmar antenna. Curve A, with 500 ohms at the far end, shows broad but unmistakable resonance points at open oscillation wavelengths. On the other hand, curve B, with 200 ohms at the far end, shows grounded resonance points. Curve C, with 300 ohms at the far end, shows no resonance points, indicating that the antenna is quite aperiodic. Therefore the surge resistance for this particular antenna is approximately 300 ohms. The downward bend of curve C below 200 meters is not caused by the antenna, but results from the oscillator output falling off when the coupling capacitor approached zero setting.

When one of the wires was grounded at the far end, the other wire was left open and the damping resistance was placed across the wires at the station end, as shown in Fig. 7, a smooth curve, similar to the curve C of Fig. 13, was obtained when the noninductive resistance was 500 ohms. In this case, however, there were slight irregularities in the curve that do not appear in curve C of Fig. 13.

Fig. 14 shows the resonance and damping curves taken on a single-wire antenna by R. B. Bourne at W2BML/W2EH. This wire was 195 meters long, and was suspended from trees at a height varying from 15 to 20 feet. It was interesting to note that Bourne's antenna had a velocity of approximately 93% of the velocity of light at 200 meters and, therefore, showed that a single wire could be used up to a length of over three wavelengths, or approximately 2000 feet. Such an antenna should show very directional properties, but lacks the flexibility and ease of adjustment of the two-wire antenna.

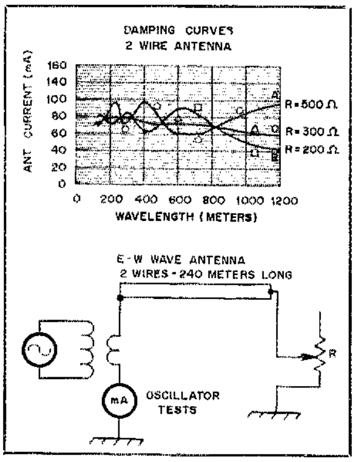


Fig. 13 — Damping curves for a two-wire Beverage antenna (see text).

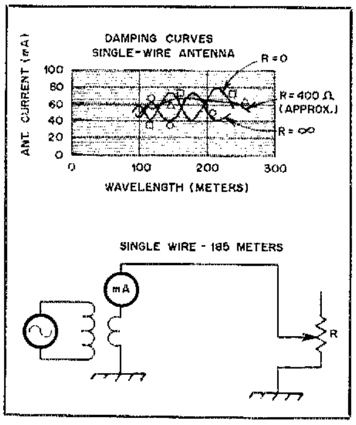


Fig. 14 — Damping curves for a single-wire Beverage antenna.

Performance

Two 200-meter Wave Antennas were erected at Belmar, one running west from the station and the other running south. These antennas were arranged with switching such that the connections of Fig. 6 or Fig. 7 could be selected at will on either antenna. That is, the west antenna could be used for reception from either the east or the west, and the south antenna could be used for reception from either the north or south. For comparative purposes a flat-topped single-wire antenna, 40 feet high, was erected. The effective height of this vertical antenna was estimated as approximately 8 meters. The signals on the Wave Antennas were about 50% stronger than on the vertical, giving an effective height for the Wave Antennas of 12 meters. This figure corresponds to about 5-1/2% of the horizontal length of the Wave Antennas.

Listening tests on these antennas showed marked directive properties, as expected. Listening south, most of the stations heard were in the third and fourth districts, but careful adjustments were necessary to eliminate second-district stations to the north. With the antenna directive toward the north, the best reception was from the first and second districts, although several eighth-district stations were heard. The east-west antenna worked better than the north-south antenna, probably because the ground resistance at both ends was less than an ohm, whereas the ground resistance at the far end of the north-south antenna was very high (nearly 300 ohms) making it difficult to operate the damping circuit effectively. The reception from the west was excellent, great numbers of Midwest, Southwest and West Coast cw stations being heard without interference from first- and second-district stations. With the antenna directed east, only local W2s, Long Island W2s and a few W1s were heard. There was considerable QRN reduction at times on the eastward reception, as the QRN was often heavy in the south or west.

On the 360-meter broadcast station wavelength, very good results were experienced in eliminating interference, particularly when using the antenna for west reception and cutting out New York and Schenectady interference. Station WOC at Davenport, Iowa, was received particularly well on the Wave Antenna at times when reception was impossible on the vertical antenna, owing to local interference.

Even on 600 meters, these Wave Antennas showed very good directivity, particularly for reception from ships at sea.

Bourne's antenna at Riverhead, Long Island, ran in a direction about 10 degrees north of west. He reported his results as follows: "Signals from the south and southwest come in with about 25% to 50% increase in signal strength over a vertical antenna 60 feet high. Signals from New England are, in general, very weak, and in some cases cannot be heard at all when using the Wave Antenna. No interference from ships or shore stations using commercial wavelengths was noticed. WSA, at Easthampton about 20 miles away, at times had a very strong harmonic on about 225 meters, which interfered seriously with 200-meter reception when the ordinary antenna was used, but because this station was southeast, no interference was experienced when using the Wave Antenna. Radiophones on 360 meters came in with about the same intensity as with the vertical antenna, but often the signal-static ratio was much improved with the Wave Antenna, and, as with 200-meter reception, interference from WSA and WBC (East Moriches, 10 miles away) was entirely done away with."

The amount of static reduction experienced with the 200-meter Wave Antenna at Belmar depended entirely upon the distribution of the static at different times. On several occasions a marked improvement was noted in the signal-static ratio when receiving from the east and north, and sometimes when receiving from the west, but it was rarely observed to make any marked improvement when receiving from the south.

The author wishes to acknowledge the valuable assistance received from Messrs. H. O. Peterson, R. B. Bourne and A. B. Moulton, in the collection of these data on the 200-meter Wave Antennas.

Practical Considerations

The foregoing text from the 1922 *QST* article discusses slight differences in overall performance with respect to the wire gauge used in a wave antenna, with the smaller-diameter wire being the less desirable choice. In a practical amateur installation it is unlikely that one could discern a performance difference without having two antennas to compare — one with heavy-gauge wire and one with, say, no. 20 wire. Many amateurs have reported good results when using the smaller wire sizes for single-wire Beverage antennas. But, if the heavier wire is available, it should be employed in the interest of optimum performance. The longevity of the system under the stresses of wind and icing will be superior when the antenna is made from no. 10 through no. 16 wire. If for some reason it is desired to have a measure of "invisibility" for the antenna, one should not overlook the possibility of using light-gauge wire.

Quality insulators are required at the support points of the wire. Some amateurs have merely secured their Beverage antennas along the span by wrapping the conductor around tree trunks and fence posts. This is not recommended if proper performance is desired. The incoming signal energy should be able to traverse the wire without propagation discontinuities and losses along the antenna length. Good insulators will help to make this possible.

The least complex of the Beverage antennas is the single-wire version, although the two-wire type offers greater flexibility of adjustment. In any event, the integrity of the termination and ground system is a matter of prime importance. Some amateurs have simply driven an 8-foot pipe into the ground at the far end of the antenna, then attached the terminating resistor to it. Depending upon the earth conductivity at a given location, this technique may represent no ground system whatsoever! A quality ground system contains a substantial number of buried radial wires, as is the case with quarter-wavelength vertical antennas. If an extensive ground arrangement isn't practical, the amateur should use as much wire as possible, even if some of the radials are quite short. Sufficient wire should be used to ensure that the ground resistance is as low as possible.

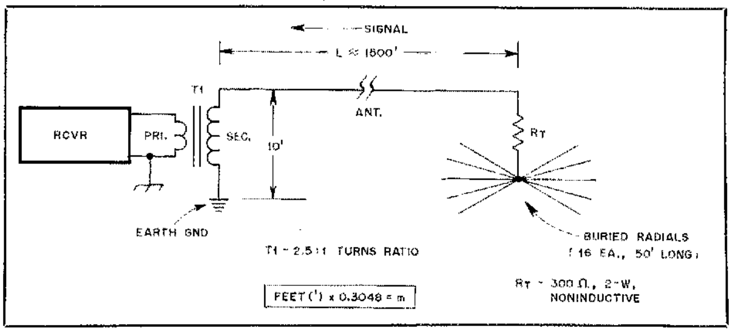


Fig. 15 — Circuit of the 160-meter Beverage antenna used at W8HHS for DX reception. The primary and secondary windings of T1 were returned to separate ground points to resolve unwanted common-mode bc-band signal coupling that affected receiver performance.

Other Considerations

Fig. 15 illustrates a Beverage antenna used by W1FB (then W8HHS) in Michigan for 160-meter reception in the early 1950s. It was roughly 1500 feet (three wavelengths) long, which posed no physical problems on the 40-acre farm site. The terminated end was toward the northeast to accommodate reception from Europe. The transmitting antenna was a 60-foot vertical with center loading and 20 buried radials that were dispersed uniformly from the base of the vertical to a length of 80 feet each. Signals that could not be heard in the noise while receiving with the vertical could be elevated above the atmospheric noise by as much as two S units when using the Beverage antenna for DX work to Europe. Owing to the majority of the noise fronts existing to the southwest, in the Gulf of Mexico region, and because of the back-rejection of the Beverage, such an improvement was possible. Heavy QRN could often be heard with the vertical, even though the weather was clear locally and for a thousand miles or more to the southwest. Noise from storms can be propagated a great distance when conditions are other wise good at 1.8 MHz.

One problem that was experienced with the antenna of Fig. 15 became manifest as severe receiver overloading from a nearby commercial a-m station on 1240 kHz. The receiver dynamic range and front-end selectivity of that period were generally anything but spectacular. Hence, cross-modulation and other overload effects were not uncommon to 160-meter operators. The difficulty was resolved by breaking up the common-mode transfer path from the antenna to the receiver. At first the return ends of the primary and secondary windings of T1 were brought a common ground point. By returning the low end of the T1 primary to the receiver ground terminal and the low end of the secondary to the earth ground, the overloading ceased. The Beverage antenna was an effective collector of bc-band energy! T1 was used to provide a broadband transformation from 300 ohms (unbalanced) to 50 ohms unbalanced at the receiver input. A small TV-set flyback transformer core was used in the transformer. A 900 μ_i ferrite toroid core would be excellent for the purpose today. QST

References

[1] H. H. Beverage, "A Wave Antenna for 200-Meter Reception," *QST*, November 1922, p. 7. The professional disclosure of the wave antenna was presented by H. Beverage, C. Rice and E. Kellogg ("The Wave Antenna, a New Type of Highly Directive Array"), in the *Transactions* of the AIEE for 1923. It contains 51 pages of technical information.

This presentation of the original *QST* work by Beverage has been edited for style, tense and terminology to bring it up to present-day *QST* technical language. The diagrams, curves and radiation patterns have been redrafted to conform to present-day symbology and style. Nothing else has been changed. The reprint of the article is presented in smaller type size to differentiate between the writing of H. H. Beverage and D. DeMaw.

[2] B. Booth, W9UCW, "Weak Signal Reception at 160 — Some Antenna Notes," June 1977 *QST*.

[3] J. Reinartz, W1QP, "Some Further Improvements in My Tuner," *QST*, October 1922, p. 12.

Strays

I would like to get in touch with . . .

☐ amateurs who are interested in the use of home-built QRP transmitters. Bill Copeland, WB6RVE, P.O. Box 191, Duarte, CA 91010-0191.

☐ amateurs who could advise me about getting a 3CV 1500A7 vapor-cooled transmitter tube for the Alpha-70V. C. L. Hine, N2AQS/AFAIRJ, 517 Charles St., New Milford, NJ 07646-1999.

Members of the Alexandria, Virginia, ARES are shown on a tour of the city's new emergency communications bus. W4HFH, the Alexandria ARC station, is located in the bus along with radios for the police, fire and city traffic departments. *(K4BAV photo)*

PAØBZ was the first Dutch amateur to receive a transmitting license, in 1929. The Hartley transmitter with series feed is shown at the left; behind it is the anode power supply. Other pieces of gear on the bench are a wave meter, receiver and receiver power supply. *(photo courtesy of University Museum, Utrecht, Netherlands)*

Designing a Microprocessor-Based RTTY Speed and Code Converter

Part 1: Make your old teleprinter much more useful! This construction project gives the RTTY enthusiast a perfect opportunity to learn fundamental microprocessor-system design techniques.

By Greg McIntire,* AA5C

Recent advances in integrated-circuit technology have provided a real opportunity for the RTTY enthusiast. Every day, more and more mechanical teleprinters, and even some video displays, are being replaced by state-of-the-art terminals. The old equipment frequently ends up in the surplus market where it can be purchased by amateurs at a low cost. These same advances in technology have also created a problem: In the past, most RTTY operation was at 60 wpm using the Baudot code.[1] Now 60- and 100-wpm Baudot is common, and 110-baud ASCII is becoming increasingly popular. A few other speeds are also encountered occasionally (67- and 75-wpm Baudot, for example). How can the amateur handle all of these different speeds and codes?

Usually a machine will operate only at one speed and with one code. Often, as in my case, the gears needed to run a machine at a different speed can cost as much as the machine itself. Even with different gears the teleprinter is still limited to operation at one speed and with one code. What is needed is a device that will convert the incoming signal to the code and speed accommodated by your machine. A home computer can be programmed to do the conversions, but this ties up an expensive resource. To provide a flexible and inexpensive solution to the problem I chose to build a microprocessor-based converter.

This converter costs approximately $50 to build and has the following features:

1) 60- to 100-wpm Baudot speed conversion.

2) 100- to 100-wpm Baudot buffering.

3) 110-baud ASCII to 100-wpm Baudot speed and code conversion.

4) Selective calling (SELCAL) with teleprinter motor control.

The delight of using a programmable converter is that different teleprinters can be accommodated by changing the software — no hardware changes are required. Four versions of the software are now available. They will accommodate 60-, 67- and 100-wpm Baudot and 110-baud ASCII machines.

The Design

Many trade-offs must be considered when solving a problem with a microprocessor. One important consideration is how much hardware versus software is to be used. In this design I have chosen a minimal-hardware approach to keep the cost as low as possible. This, however, implies that the complexity of the software is increased.

The hardware required consists of 11 commonly available ICs, three transistors and a few resistors and capacitors. It all fits on one 4- × 4-inch (mm = in. × 25.4) Radio Shack prototyping board (Radio Shack number 276-1555). The software is contained in a 2716 EPROM.[2]

In any application of a microprocessor, the system interface requirements should be well defined before the detailed design of the hardware begins. This unit interfaces with my system as shown in Fig. 1. The necessary interface connections are:

MODE — Selects the speed and code conversion to be made.

TXRX — Indicates the direction of the conversion.

DEMODULATOR — Input of the received signal from the demodulator unit (1 = space, 0 = mark).

MOTOR START — Signals the presence of a valid received signal. This is normally used to control the teleprinter motor.

SELCAL — Turns the selective calling function on and off.

CURRENT LOOP — Standard teleprinter current loop that carries information to and from the teleprinter. Some builders may wish to include opto-isolation in this line.

STANDBY — Provides a means of turning the teleprinter motor on and off manually.

BUFFER EMPTY — LED to inform the operator that the buffer has been emptied.

BUFFER OVERFLOW — LED indicator that lets the operator know that, unless the incoming information is stopped, data will be lost. This indicator should be monitored when converting from a higher speed to a lower one.

AFSK — Output to key either an afsk generator or transmitter fsk input.

MOTOR RELAY — Controls the teleprinter motor relay.

The Microprocessor and Support Hardware

With the system interface defined, the hardware can now be designed. Most of the readily available microprocessors interface with the outside world through TTL-level compatible signals. This makes it necessary to convert the various interface signals to or from TTL levels. Fig. 1 shows how these conversions are made. The microprocessor I chose to use is the Intel 8085A.[3] It is inexpensive, readily available, runs on a single 5-V supply, and has the clock generator and several other system functions built into the chip. A

'Notes appear on page 21.

*5232 Aztec Dr., Box 77512, Lewisville, TX 75056

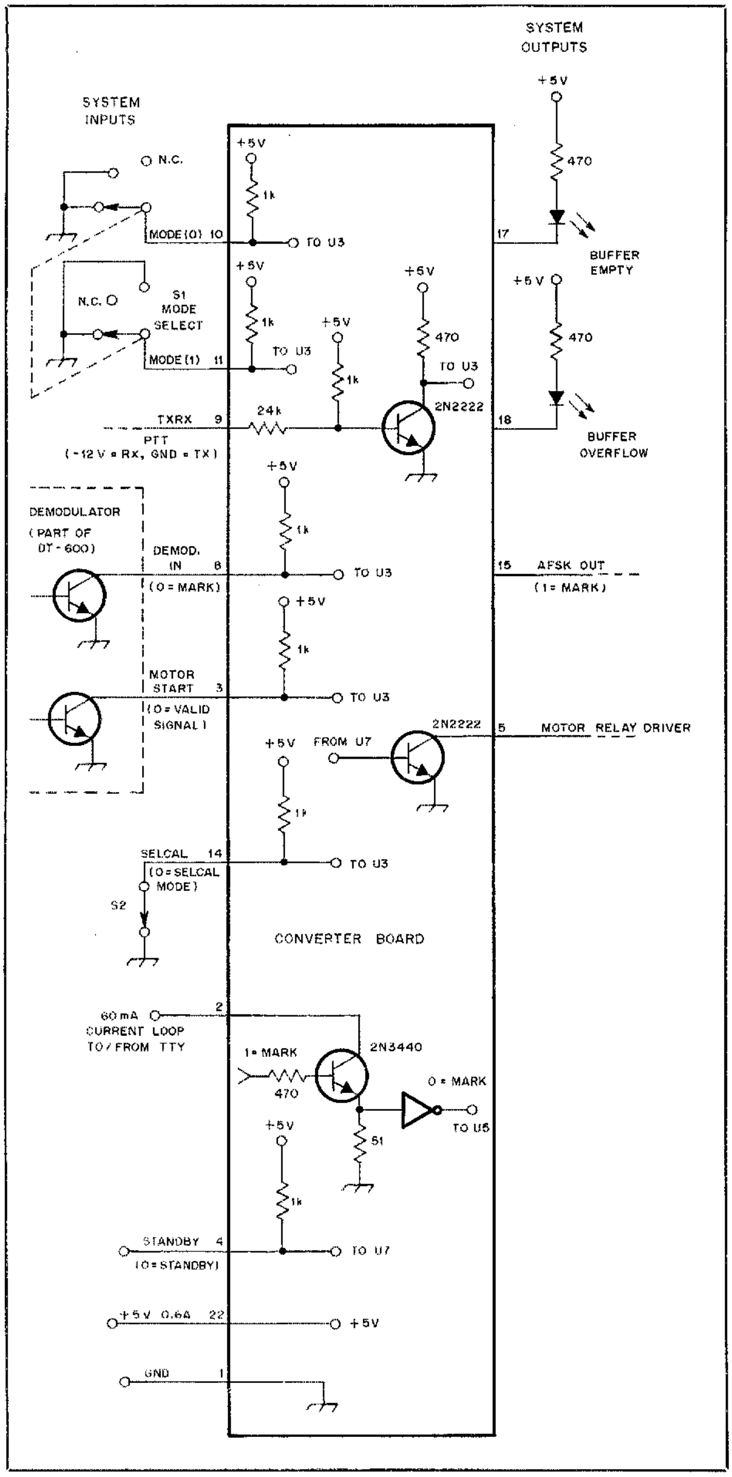


Fig. 1 — Interface diagram of the AA5C Code/Speed Converter. On the left are the inputs to the system, and the system outputs are shown on the right. The teleprinter current loop serves as both an input and an output.

more important reason for choosing the 8085A is that a large amount of software support exists for the 8085/8080 and Z80 families of microprocessors. The TRS-80, for instance, can be used to develop software for the 8085 as well as the Z80. Because I decided to use a software-intensive approach, this is a very important consideration.

The block diagram of the microprocessor and support hardware is shown in Fig. 2. The system clock is provided simply by connecting a crystal to the 8085A. All of the necessary oscillator circuitry is contained on the chip. The maximum crystal frequency of 6.00 MHz is used to obtain the greatest possible processor execution speed. Internally the 8085A operates at a clock frequency equal to one half the crystal frequency, or 3.00 MHz in this case. An external 2-kHz oscillator, driving one of the processor interrupt inputs, provides an asynchronous, real-time reference for the microprocessor. This enables the software to make use of known time intervals without having to count instruction cycles. Anyone who has programmed software timers will appreciate the relief that interrupt driven timers afford the programmer.

It is important to understand the concept of a "bus" when working with microprocessors. A bus is simply a set of wires carrying related signals between the various devices in the system. The devices, such as the processor, memory and the input/output (I/O) ports, are connected to the bus in parallel. For example, the data bus is the set of eight lines that carry the signals making up a data word (or byte). The 8085A has three buses: a 16-bit address bus, an eight-bit data bus and a control bus.

To reduce the number of pins required on the microprocessor package, the 8085A multiplexes the least-significant eight bits (or LS byte) of the address with the data bus. During the first clock period of each machine cycle, the 8085A outputs the LS byte of the address on the address/data bus pins. At the same time it outputs a control signal ($\overline{ALE}$) to the address latch (U3), enabling it to latch the address bits. The bus is then free for data transfers during subsequent clock periods of the cycle. Information travels both to and from the processor on the data bus. This means that devices connected to this bus must have selectable, high-impedance output states so that multiple driver conflicts can be avoided. The address bus is decoded by U6 and used to independently select which device is to use the data bus. Device selection is further qualified by the control signals: The $IO/\overline{M}$ is used to make the distinction between memory and I/O operations, while the $\overline{RD}$ and $\overline{WR}$ signals indicate whether the operation is a read or write. If $\overline{RD}$ is low the operation is a read (information transferred to the processor), and if $\overline{WD}$ is low the operation is a

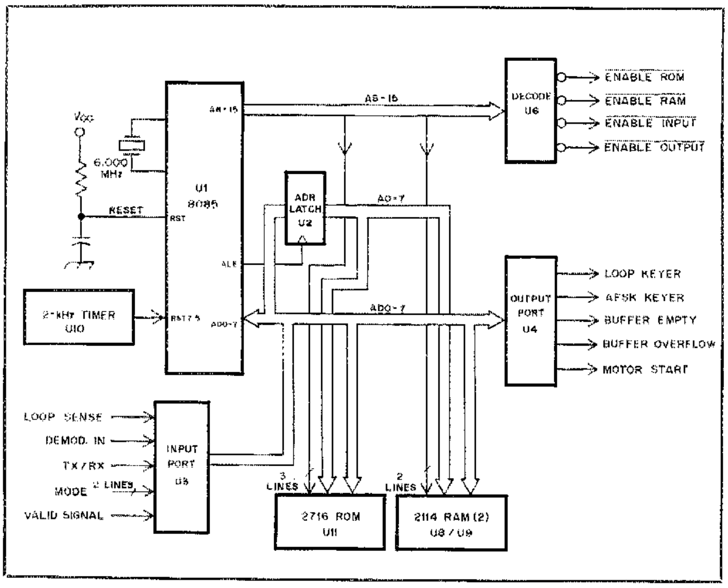


Fig. 2 — Shown here is the block diagram of the RTTY converter.

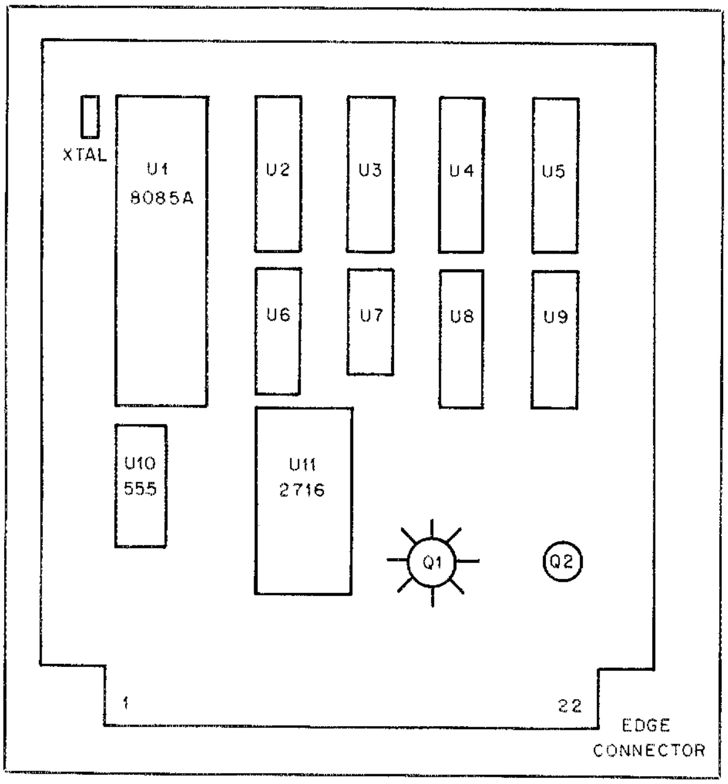


Fig. 3 — Component placement diagram for the RTTY converter.

Fig. 4 — Schematic diagram of the AA5C Code/Speed Converter. Components not listed below are numbered for text reference only.
C1 — 0.047 µF Mylar or polystyrene capacitor.
Q1 — High-voltage silicon transistor. V_{CEO} = 250 V, I_C = 1 A, P_D = 1 W, Motorola 2N3440 or equiv.
U1 — Intel 8085A microprocessor.
U2, U4 — 74LS374, octal D-type flip-flop with 3-state outputs.
U3 — 74LS244, octal buffer/line driver with 3-state outputs.
U5 — 74LS240, octal buffer/line driver with 3-state outputs.
U6 — 74LS138 or 8205, 1 of 8 decoder/demultiplexer.
U7 — 74LS00, quad dual-input NAND gate.
U8, U9 — Intel 2114 static RAM.
U10 — NE555 timer IC or equiv.
U11 — EPROM, Intel 2716 or equiv. The author will make programmed EPROMs available for $25. See details in Part 2 of the article.

write (information being output by the processor).

Construction

The schematic diagram of the converter is shown in Fig. 4, and the placement of the components on the prototyping board is shown in Fig. 3. This version of the converter was constructed using wire-wrap techniques. A printed-circuit version does not exist at this time and would probably be of moderate layout difficulty. Good construction practices should be used throughout. The current loop needs to be located near the edge of the board and not amid the logic. The current loop transistor (Q1) requires a finned heat sink if a 60-mA, high-voltage loop is used. If a different loop current is used, the value of R1 must be chosen so that 3.5 volts is developed across it when the loop is in the mark condition. It is important to bypass the 5-V supply to ground with a 0.1-µF ceramic capacitor at each IC. The supply voltage should be further decoupled by means of a 10-µF electrolytic capacitor at the point where it enters the board. The power supply requirements are 5 V at 0.6 A (only 3 W to solve the problem!). The capacitor used in the timer circuit (C1) should be a polystyrene or Mylar type to minimize frequency drift with temperature.

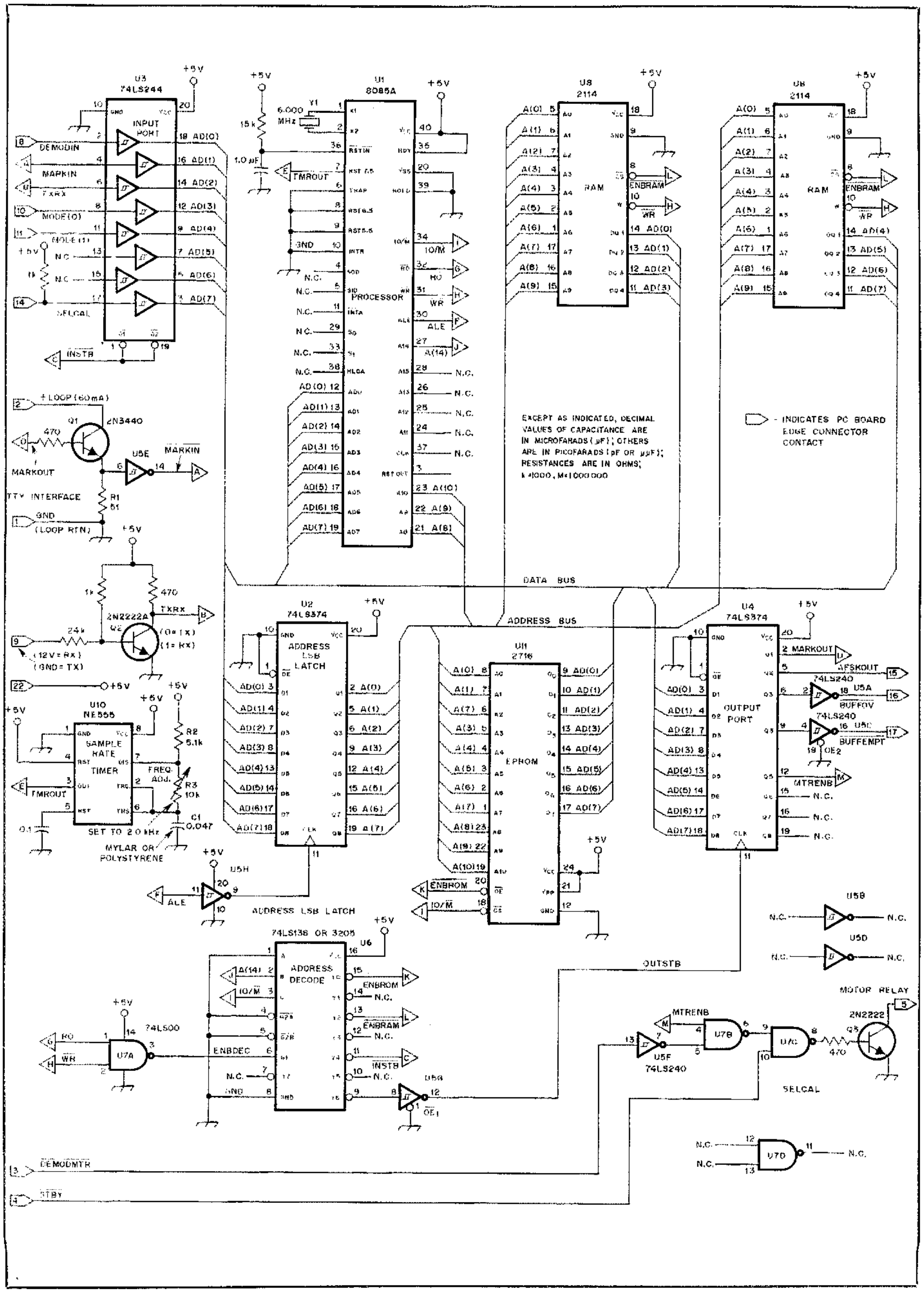
The final steps in implementing a microprocessor application are the design of the software and getting the system "up and running." Those steps involved in solving the RTTY speed and code conversion problems will be covered in Part 2 of this article. QST

Notes

[1]The five-unit teleprinter code commonly used by amateurs, and called the Baudot code, is actually the Murray code.

[2]The author will make programmed EPROMs available for $25. Details of the software and EPROM are given in Part 2 of this article. A listing of the PL/M/80 source program and the object code will be available from ARRL — details are given in Part 2.

[3]Complete details and specifications for the 8085A and other microprocessor components can be found in the *Intel Component Data Catalog*, available from Intel Corporation, Literature Department, 3065 Bowers Ave., Santa Clara, CA 95051.


U3
74LS244
INPUT PORT
U1
8085A
PROCESSOR
6.000 MHz
2114
RAM
DATA BUS
ADDRESS BUS
U2
74LS374
ADDRESS LSB LATCH
U11
2716
EPROM
U4
74LS374
OUTPUT PORT
U10
NE555
SAMPLE RATE TIMER
SET TO 2.0 kHz
MYLAR OR POLYSTYRENE
74LS138 OR 3205
ADDRESS DECODE
TTY INTERFACE
+LOOP (60mA)
GND (LOOP RTN)
2N3440
2N2222A
MOTOR RELAY
2N2222
SELCAL
OUTSTB
DEMODMTR
STBY
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF); OTHERS ARE IN PICOFARADS (pF OR μμF); RESISTANCES ARE IN OHMS; k=1000, M=1000000
- INDICATES PC BOARD EDGE CONNECTOR CONTACT

WARC Bands and 160 Meters on the 75S-1

A handful of parts and a couple of hours is all you need to modernize your station receiver. You'll say, "Look, Ma, no holes!"

By Earl Bray,* VE3EB

The Collins 75S-1 is a classic tube-type ssb/cw/a-m receiver. It covers fourteen 200-kHz band segments between 3.4 and 30 MHz. Changing the heterodyne crystal-oscillator frequency changes the band-segment frequencies. The crystals provided with the receiver give complete coverage of 80 through 15 meters, plus WWV at 15 MHz and portions of 10 meters.

I wanted coverage of the new WARC-sanctioned bands and 160 meters without giving up coverage of the other bands. Additional crystals and a switching method are all that is necessary for adding the WARC bands. Adding 160-meter coverage presents more of a challenge because it requires a slight modification to the input and oscillator circuits.

These modifications do not degrade performance or lessen the resale value. No holes are drilled; rewiring is simple and straightforward. You will need the owner's manual (schematic diagram), a few parts and some tools.

Before buying the required parts, remove the cabinets and observe the space that is available for the additional components. Also, study the schematic diagram. In other words, plan ahead, and avoid the crush when it's time to reinstall the cabinet.

Step By Step

Remove the rf gain control from the panel and replace it with a fixed-value 10-kΩ, 1/2-W resistor (R156, Fig. 1). Place it in a piece of heat-shrink tubing, and secure it in the nearby chassis grommet.

Mount a three-pole multiposition wafer

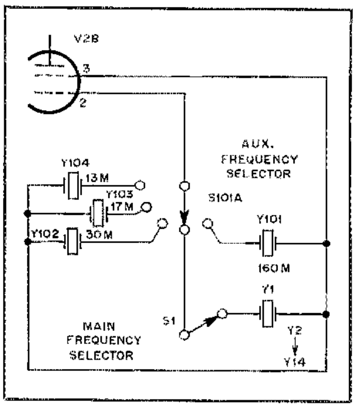


Fig. 1 — New switching arrangement for the 75S-1 (see text for details).

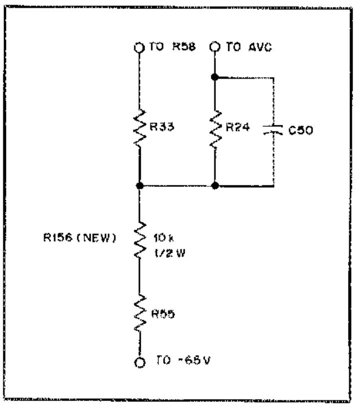


Fig. 2 — Revised rf-gain control circuit. R156 replaces the potentiometer.

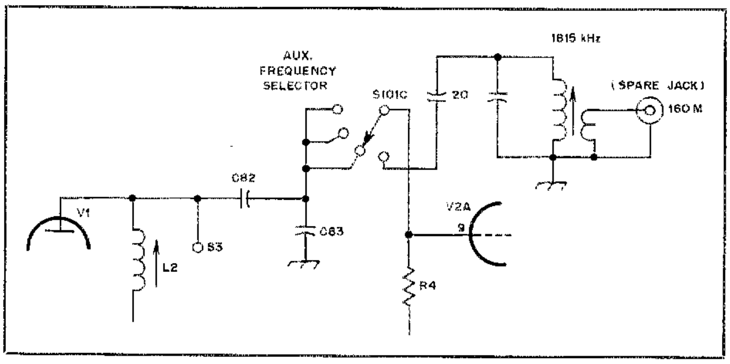


Fig. 3 — 160-meter input network.
C1 — 750-pF polystyrene capacitor.
L101 — 4 turns of no. 24 enam. wire over the center part of the L102 winding.
L102 — Slug-tuned inductor, 9 μH nominal. J. W. Miller Co., no. 42A826CBI or equiv. (19070 Reyes Ave., Box 5825, Compton, CA 90224).

[1]Notes appear on page 24.

*Lakewood Park Dr., RR 1, Huntsville, ON P0A 1K0

switch, designated S101, in the vacated panel hole. The number of switch positions, less one, determines the number of additional band segments. One position is used for "normal" operation.

Remove the coaxial cable from S1, and connect it to the common terminal of S101A (see Fig. 2). Run a bus wire from S1 common to the S101A terminal you elect to use as "normal." Install additional crystals (4955 kHz for 160 meters and others, as per the 75S-1 formula; HC18/U types are ideal) between the common bus on the crystal board and selected S101A terminals.

Remove C82 and C83 from V2 pin 9, and connect a stiff bus wire from the common junction to S101C terminals (Fig. 3). Install a 1.8-MHz tuned circuit in the area of the V2 terminal strip. Connect it through a 20-pF mica capacitor to the selected 160-meter terminal of S101C.

Route coaxial cable from 1.8-MHz antenna tap or winding to the spare phono jack on the rear apron. Connect a rigid bus wire from S101C common to V2 pin 9.

Remove the shield can from T6/S2, and connect an insulated wire from the C69/C70 terminals of S2 (these are adjacent to the chassis) to the 160-meter terminal of S101B through a 180-pF, silver-mica capacitor (Fig. 4). Dress the wire and capacitor close to the chassis. Replace the shield can after filing a 1/8-inch "U" notch in the lip of the can to let the wire exit the compartment. Attach the common terminal of S101B to ground.

It is possible to run a no. 20 enamel wire through the band switch shaft hole without the notch in the can. The 180-pF capacitor could be connected directly to pin 6 of V2, in which case all trimmers associated with S2 would have to be readjusted.

Depending on switch size, the wafers may have to be held apart with longer spacers (Fig. 5). The wafers will clear the crystal board wiring with one forward and two behind the crystal board. If you can obtain a physically smaller switch with more positions, so much the better. I chose to use position 2 as normal (or straight-through positions), 1 as the 160-meter position, and positions 3, 4 and 5 for the WARC bands. The old rf gain control markings on the front panel have 30° separation and coincide with the switch detents of my 12-position switch.

The preselector control, now simply an injection-level control, peaks the low-end 160-meter signals at about 1.5 on the log scale (main band switch set in any 80-m position). This control also performs adequately as an rf-gain control. If you desire an rf-gain control, the af-gain control can be replaced by a dual unit.

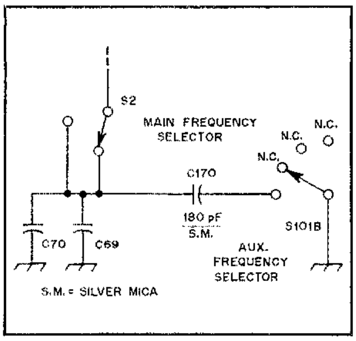


Fig. 4 — Circuit for switching in additional capacitance during 160-m operation. See text for details.

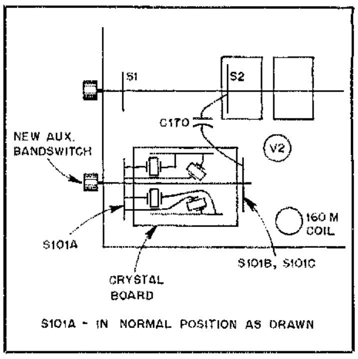


Fig. 5 — Physical arrangement of new switch and associated components.

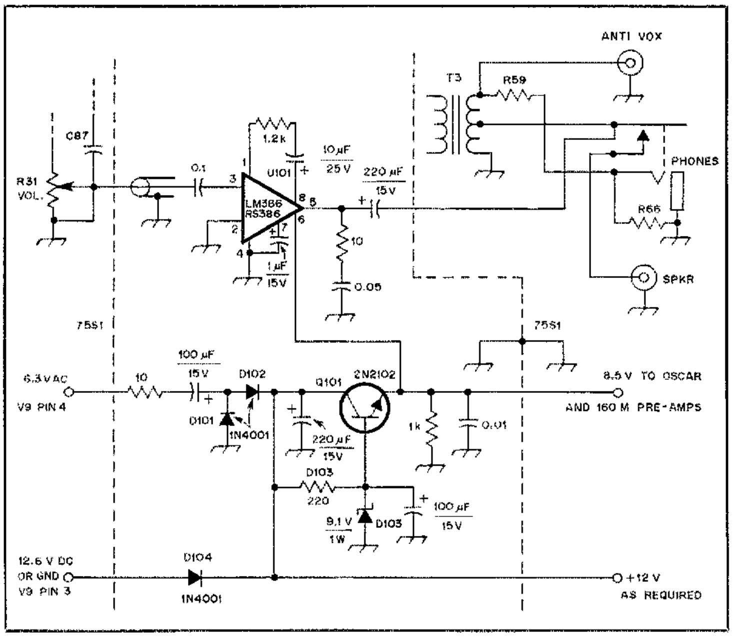


Fig. 6 — Diagram of new audio-amplifier stage and power supply. Resistors are 1/2-watt, carbon-composition types. Capacitors are disc ceramic, except those with polarity markings, which are electrolytic.

D101, D102, D104 — Silicon power diode, 1 A, 50 PIV, 1N4001 or equiv.

D103 — Zener diode, 9 V, 1 W, 1N4739 or equiv.

Q1 — Silicon power transistor, npn, 2N2102 or equiv.

U1 — Audio-amplifier IC, 1 W, LM386 or equiv.

More Modifications

My 160-m front end is a simple tuned circuit peaked at 1815 kHz. There is space for a preamplifier or a band-pass filter, which would enhance the performance. A separate 160-m receiving antenna is required. At present, I use an outdoor loop and FET preamp, but for casual operating, a simple random-wire antenna seems sufficient.

The method of mounting and securing the 160-meter tuned circuit will depend upon the type of coil you use. It may be cemented to a small scrap of circuit board, and this in turn secured to the chassis with some more cement. Or you might consider using double-sided tape. I recommend that C170, the 160-meter oscillator padder, be secured with cement as well. A length of hook-up wire, loosely coupled between the Y17 wiring and the 160-meter coil, provides an adequate calibration signal.

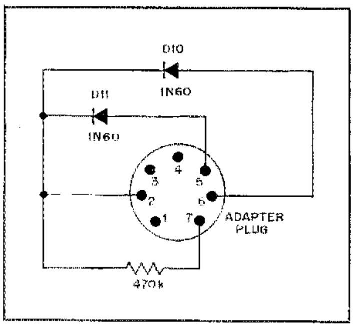


Fig. 7 — Plug-in diode detector to replace tube version. D110 and D111 are 1N60 diodes. See text for discussion.

I decided to add a solid-state audio section by replacing V7 and V8 with an IC that delivers plenty of audio with a fraction of the heat.[2] No original wiring is disturbed, and restoration to standard should be quick and easy.

I built a "bare-bones" adaptation of Rusgrove's amplifier on a circuit board. It replaces the noise blanker plate (see Fig. 6). It could be made more compact than this and could be mounted in one of several places above or below the chassis. A voltage-doubler circuit supplies operating potentials of approximately 12.5 and 8.5 volts dc. Note that an extra diode is included that would supply power in the event of 12-Vdc operation of the 75S-1.

No attempt has been made to rearrange the heater buses for 12- or 24-Vdc operation. I do not contemplate other than normal ac operation.

I made a plug-in diode-detector module for the vacated 6AT6 (V7) socket (Fig. 7), but the components could probably be plugged directly into the socket pins. A 470-kΩ resistor (pin 2 to pin 7) simulates the normal +2.5-Vdc cathode bias.

Try these modifications. I hope you'll agree the classic 75S-1 is even better now! QST

Notes

[1]Millimeters = inches × 25.4.

[2]J. Rusgrove, "A General-Purpose Audio Amplifier," *QST*, November 1976, p. 32.

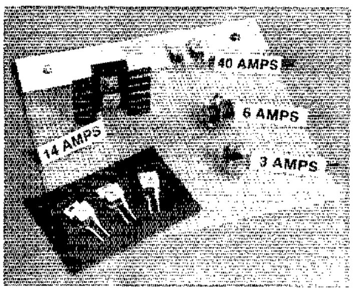
New Products

TAB-MOUNTED STANDARD AND FAST-RECOVERY RECTIFIERS

☐ Motorola has introduced a 10-device series of standard- and fast-recovery power rectifiers. The Motorola 339-02 case (a TO-220 configuration) offers the installation flexibility of chassis mount and pc-board mount with or without a heat sink. According to the manufacturer, they are less expensive than stud-mounted devices with equivalent current capacities.

The devices in this series can handle voltages from 50 to 600 V and currents from 3 A in a pc-board mounting (without heat sinking) to 40 A in a chassis-mount situation. The fast-recovery rectifiers are designed for applications such as switching power supplies, inverters and converters.

The fast-recovery types have a "soft" recovery time of 200 ns maximum, providing high efficiency at frequencies up to 250 kHz. The standard rectifiers are designed for applications requiring a high-current surge (400 A at T_j = 175° C) and peak performance at an elevated temperature — 24 A at T_c = 150° C. Delivery is from OEM stock and through authorized Motorola distributors. For further information, contact Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036. — *Paul K. Pagel, N1FB*



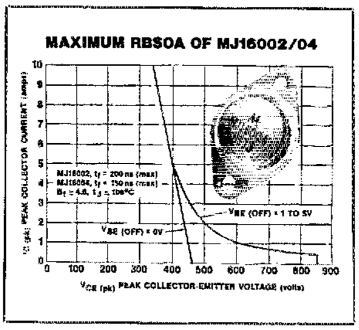
MOTOROLA SWITCHMODE III POWER TRANSISTORS

☐ A low-priced line of Motorola's Switchmode III power transistors has been introduced for applications requiring reduced current ratings. The MJ16002 and MJ16004 can handle 5 A of continuous collector current.

Npn devices, the MJ16002 and MJ16004, rated at 450 V and 125 W, are designed for high-voltage, high-speed power switching in inductive circuits where switching speeds are critical. They are well-suited for line-operated high-frequency switchmode applications. The MJ16004 is a selected high-gain version of the MJ16002 for applications where drive current is limited.

A unique feature is the speed at which these devices can switch — speeds approaching those of power MOSFETs. At a current of 3 A in an inductive circuit at 212° F (100° C), the MJ16004 typically has the following switching times: fall time, 80 ns; crossover time, 90 ns; storage time, 400 ns. These devices can switch through a 500 mA current at the rated V_{ce} of 850 V.

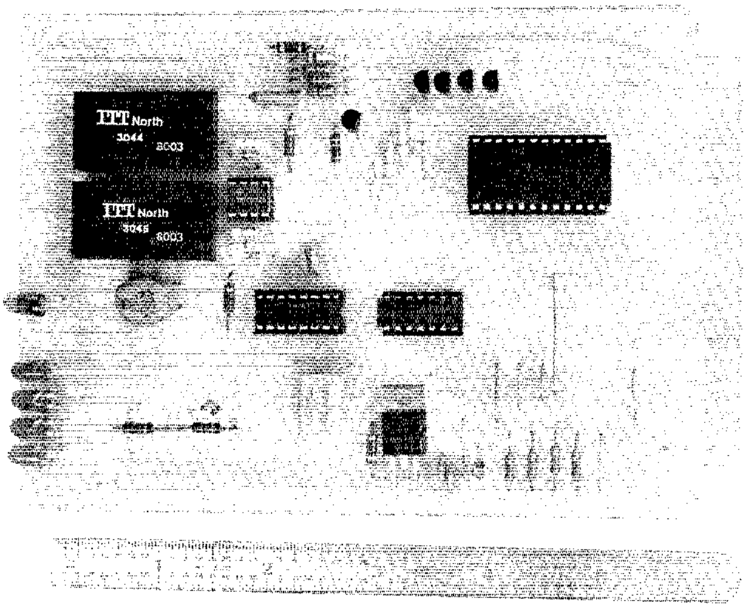
Switchmode III devices offer new performance potentials for applications such as switching regulators, inverters, solenoid and relay drivers, motor controls, and deflection circuits. Both devices are available in the standard TO-3 metal package. Prices for the devices in 100 to 999 quantities are: MJ16002, \$2.70; MJ16004, \$4.30. For further information contact Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, AZ 85036. — *Paul K. Pagel, N1FB* QST



The DTMF "Easy-Ceiver"

Tired of fighting with your Touch-Tone receiver? Do certain voice frequencies turn the autopatch on or off? Does the repeater control system need a reliable DTMF receiver to make it work properly? Yes? Then here's the answer!

By Joe Jarrett,* K5FOG



Most people who have been around the repeater ranks for a while are aware of the 567 IC PLL decoder. Decoders using seven or eight of those ICs are not only complex, but suffer from frequency-drift problems and are difficult to protect from voice "talk off." Even when polystyrene capacitors and metal-film resistors are used, the free-running oscillator in each IC drifts with temperature. This necessitates occasional trips to the repeater site to readjust the decoders.

Another problem with that method of DTMF (Dual Tone Multi-Frequency) decoding is that the exact phase of the free-running oscillator with respect to the incoming tone frequency is impossible to predict. This means that some detection times are in microseconds (when the incoming tone and free-running oscillator are almost in phase). Other detection times are tens of milliseconds in length (when the two frequencies are far out of phase). The values of the low-pass filter and output-filter capacitors can be adjusted to slow down the decoders, but often the result is a slow DTMF receiver that occasionally responds erroneously to the "right" voice.

Several manufacturers now produce IC DTMF decoders that eliminate drift and largely eliminate the talk-off problems. These ICs unfortunately require band-split filters that are tedious to design and build. While some attempts to solve the filter problem have been made by using active filters, these filters often require hand tuning, and use of polystyrene capacitors and metal-film resistors for stability. The designs that don't require precision components use extra filter stages that are even more intricate. There is, fortunately, another choice.

A Solution

Hybrid versions of the required filters are available from several manufacturers. While these are more costly than the hand-built filters, they simply plug in and work without adjustment. This means that a DTMF receiver can be built with relatively few components, will exhibit a wide dynamic range and will never require tuning. This is a description of just such a receiver. It uses the Mostek MK5102(N)-5 or MK5103(N)-5 DTMF decoder and the ITT North Microsystems model 3044 and 3045 hybrid filters.

The MK5102 and MK5103 tone decoders are identical except for their internal tone detection algorithm. Both circuits

*4501 Hudson La., Tampa, FL 33624

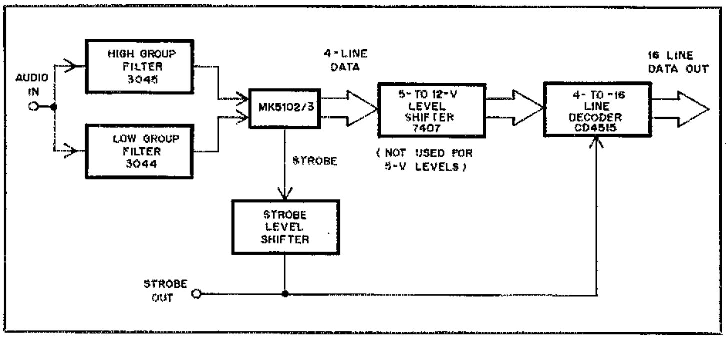


Fig. 1 — Block diagram of the MK5102/3 DTMF receiver.

Table 1

Output Level Jumper Connections

12-V CMOS Output Levels	*5-V TTL Output Levels*
W3 from E to G.	W3 from E to F.
W11 from I to H.	W11 from J to K.
Install R10-R13, incl.	Omit R10-R13, incl.
R14-R17, incl., are 1 kΩ.	Omit U5 and socket, and jumper U5 pin connections: U5 pin 1 to U5 pin 2; U5 pin 3 to U5 pin 4; U5 pin 5 to U5 pin 6; U5 pin 9 to U5 pin 8. R14-R17, incl., are 470Ω.

Input Voltage Jumper Connections

Input Voltage	*Card Edge Connector*	*Jumper*
12 V	A	W1 from A to B
12 V	B	W2 from C to B
(Note: If 5-V on-card regulator is used, the following jumpers are not required.)		
5 V	A	W1 from A to D
5 V	B	W2 from C to D

Table 2

4-Bit Binary Decoded Digit Display Map

Tone	*DS1*	*LED DS2*	*DS3*	*DS4*
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
Ø	1	0	1	0
*	1	0	1	1
#	1	1	0	0
A	1	1	0	1
B	1	1	1	0
C	1	1	1	1
D	0	0	0	0

A "1" indicates the LED is on, and a "0" that it is off. When the incoming signal ceases, the LEDs will indicate the last decoded digit.

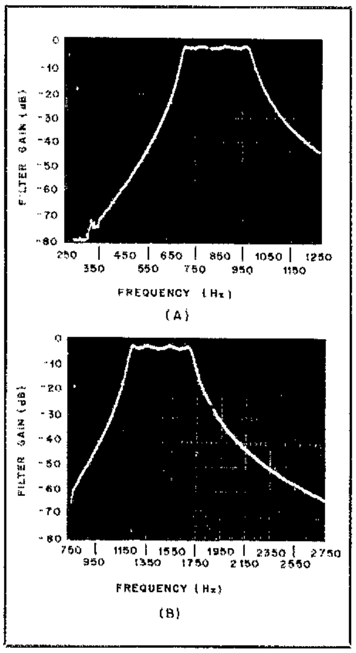


Fig. 2 — Frequency-response diagrams of the ITT North Microsystems filters. At A, the response of the low-group filter; that of the high-group filter is at B.

do half-period, whole-period, sub-group averaging and multiple sub-group averaging in the detection of a valid DTMF tone pair. The detection criteria for the MK5102 are more severe than that of the MK5103, however. The MK5102 is therefore less apt to be fooled by certain voice frequencies, yet is more susceptible to noise interference. An MK5103 is better suited for use in noisy environments, but I have found that in most applications, either unit will work satisfactorily.

The Easy-Ceiver

Fig. 1 is a block diagram of the DTMF Easy-Ceiver. Incoming audio is fed in parallel to both the high-group and low-group filters. Each filter has the correct band-pass response (see Fig. 2) for the associated tone group. The output of each filter is fed to an op-amp limiter, which "outputs" an approximate square wave to the MK5102/3. Since the output of the decoder is a 4-bit binary code, a 4-to-16 line decoder is used to provide the necessary 16 outputs. The decoder strobe output is buffered and provided for off-card use.

The board[1] used in this design may be programmed by means of jumpers (see Table 1) for either 5-V TTL or 12-V CMOS outputs. A single 12-V supply can be used because provisions have been made for the installation of an on-card 5-V regulator that will provide the operating voltage for the MK5102 decoder and the 7407 open-collector TTL buffers. The edge connector may also be strapped to bring 5 or 12 volts to the board and can thus work in bused systems with a 5- or 12-V supply. The strobe and 4-bit binary outputs from the decoder are also sent to LED drivers that indicate which digit was decoded. This decoding scheme is shown in Table 2.

A special circuit technique is used to interface the filters and op-amp limiters (which normally require a dual-voltage supply) to the decoder board 12-V supply. A pseudo ground at +6 V is developed by means of a divider consisting of R6, R7 and C8 of Fig. 3. This is connected to the noninverting input of the limiters and to the ground pin (18) of the filters. The negative supply-voltage pins of the limiters and filters are then connected to the 12-V ground of the decoder board. This allows the filter input voltage swing to be as high as 11 volts peak-to-peak, enough for almost all applications. Simple diode limiters used with U3 produce an output square wave of approximately 1.4 volts peak-to-peak. This is adequate to feed the decoder.

The 4-bit binary output code of the MK5102/3 is selected by connecting the format control pin (5) to the +5-V supply. While not compatible with the board used here, a 2-of-8 output code may be selected by letting pin 5 float. (This output code is shown in Table 3 and a representative circuit is shown in Fig. 4.)

U5 is used as a level shifter to convert the 5-V outputs of the decoder to 12-V CMOS compatible outputs. If the board is to supply 5-V output levels, the U5 may be omitted and jumpers placed between the input/output pin connections. R10 through R13 should also be removed.

U6, a 4-to-16 line decoder, provides negative logic outputs; i.e., the outputs are normally high, and the decoded digit output goes low. If positive logic outputs are desired, a CD4514B may be substi-

[1]Notes appear on page 29.

tuted directly for the CD4515B. Q5 inverts the strobe signal, drives the strobe LED (DS5) and provides the level-shifting function if necessary.

Envelope-Decay Detector

The MK5102 has a worst-case decode time of 33 ms and an interdigit time of 35 ms, while the MK5103 exhibits times of 30 and 35 ms, respectively. The actual decode and interdigit times are somewhat filter-dependent. Filter delays and ringing can cause these times to be lengthened by 10 ms or more. A Mostek application note describes an envelope-decay detector (Fig. 5) that works with the limiter. This circuit allows the receiver to perform at maximum speed. If decode speed and interdigit timing are critical factors, this circuit should be added.

The envelope-decay detector of Fig. 5 consists of two precision rectifiers, two sample-and-hold circuits and a comparator. Circuit action compares the instantaneous peak voltage (at the noninverting input of U2) with a voltage equal to one half the peak value (at the inverting input of U2) and senses when the input voltage amplitude of U1A is starting to decrease. The decrease indicates that the input tone is no longer present and that the filters are in a decreasing-amplitude ringing condition. When this is sensed, the envelope-decay detector immediately cuts off the low-group tone input. Thus, interdigit timing is decreased significantly, enabling the tone receiver system to run at maximum speed, greater than 12 digits a second.

Construction

For the sake of simplicity and cost effectiveness, the pc board was designed as a single-sided one. Because of this, there are 11 jumpers to be installed; all are required except W2, which is optional. Refer to Table 1 for the appropriate jumper connection information.

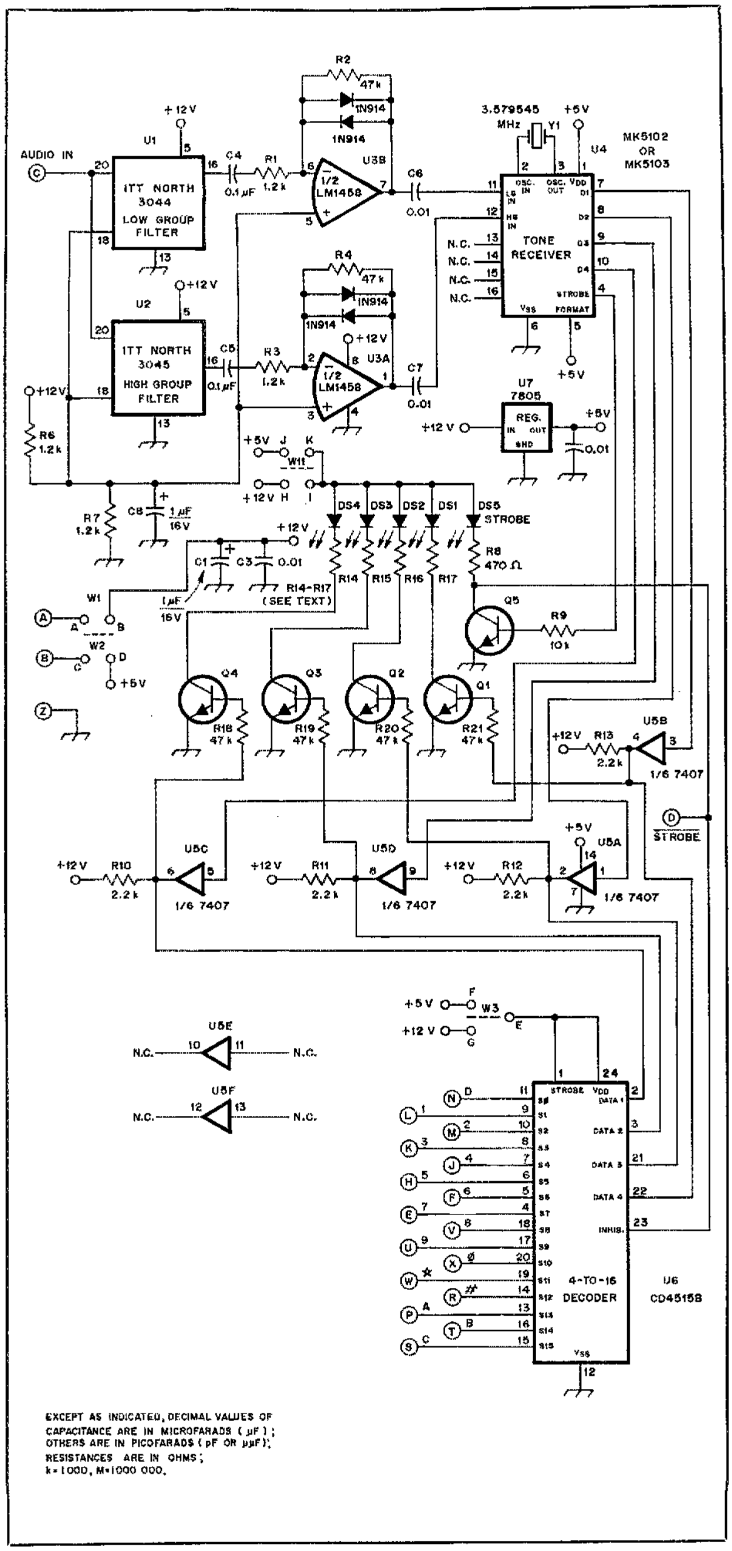


Fig. 3 — Schematic diagram of the Easy-Ceiver. The circuit board edge-connector pads are indicated by the circled letters. W = jumper. All resistors are 1/4-watt, 5 or 10% carbon composition or film types.
DS1-DS4, incl. — Red LED.
DS5 — Green LED.
R14-R17, incl. — 470 or 1000 Ω (see Table 1).
Q1-Q5, incl. — Npn general-purpose switching transistor, 2N2222A or equiv.
U1 — ITT North Microsystems Division 3044 low-group filter.
U2 — ITT North Microsystems Division 3045 high-group filter.
U3 — Dual op amp, LM1458 or equiv.
U4 — Mostek MK5102(N)-5 or MK5103(N)-5 DTMF decoder (see text).
U5 — TTL hex open-collector buffer (see text).
U6 — CMOS 4-to-16 line converter CD4514B or CD4515B (see text).
U7 — Three-terminal regulator, 5 V, 1 A, MC7805CT or equiv.
Y1 — 3.579545-MHz TV color-burst crystal in HC-6/U holder.

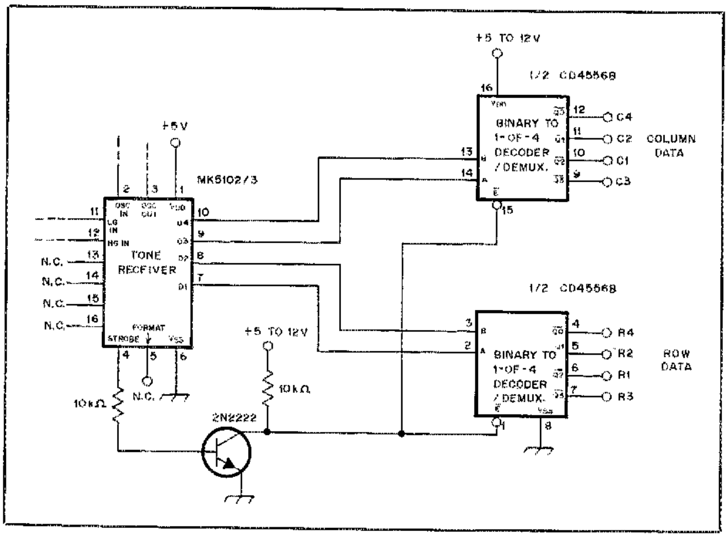


Fig. 4 — This circuit can be incorporated in the DTMF receiver should a 2-of-8 output be required.

Table 3

2-of-8 Decoded Digit Display Map

Tone	*DS1*	*LED DS2*	*DS3*	*DS4*
1	0	1	0	1
2	0	1	1	0
3	0	1	1	1
4	1	0	0	1
5	1	0	1	0
6	1	0	1	1
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1
Ø	0	0	1	0
*	0	0	0	1
#	0	0	1	1
A	0	1	0	0
B	1	0	0	0
C	1	1	0	0
D	0	0	0	0

This output code may be used with a CD4556B as shown in Fig. 4 to result in a true 2-of-8 output. An MK5089 DTMF generator or pulse dialer IC can be driven directly by the CD4556B.

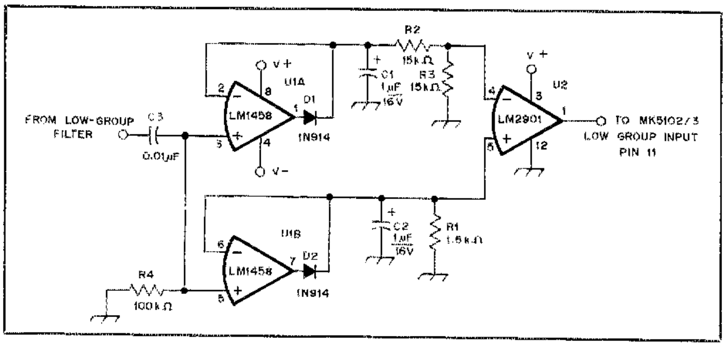


Fig. 5 — Envelope-decay detector schematic diagram. This circuit permits the DTMF receiver to operate at maximum speed by eliminating the effects caused by filter ringing and delay.

Install resistors and capacitors first, making sure the two electrolytic capacitors are polarized correctly. Sockets should be used for the MK5102/3 and CD4515B. The two CMOS parts should not be installed until just prior to board testing.[2] U7 should be installed if a 5-V supply external to the board is not to be used. C1 through C3 should be mounted on the board even if U7 is not used. DS1 through DS5 are placed at the board edge with the anodes pointed toward the outside continuous printed circuit run.

Audio Interface

Audio supplied to the DTMF Easy-Ceiver should have a flat response between 300 and 3000 Hz. If the response is not flat, it will lessen the dynamic range of the receiver. Should CTCSS (Continuous Tone Coded Squelch System) be used, receiver operation will not be affected since these subaudible frequencies are filtered out by the 3044 and 3045 filters. Audio derived from an fm receiver discriminator should be de-emphasized before it reaches the DTMF receiver. With proper interfacing, the dynamic range of the receiver should be in excess of 30 dB.

The ITT North filters have internal input-blocking capacitors, so audio from almost any source can be connected to the card. An audio level of 0 dB, approximately 0.7 volt as measured with a high-impedance VTVM, is sufficient. A typical set-up for an fm repeater system would involve setting levels while receiving a 3-1/2 kHz deviated DTMF signal. This assumes a nominal 5-kHz maximum peak deviation is being used. Wide-band systems should use about the same 70% ratio.

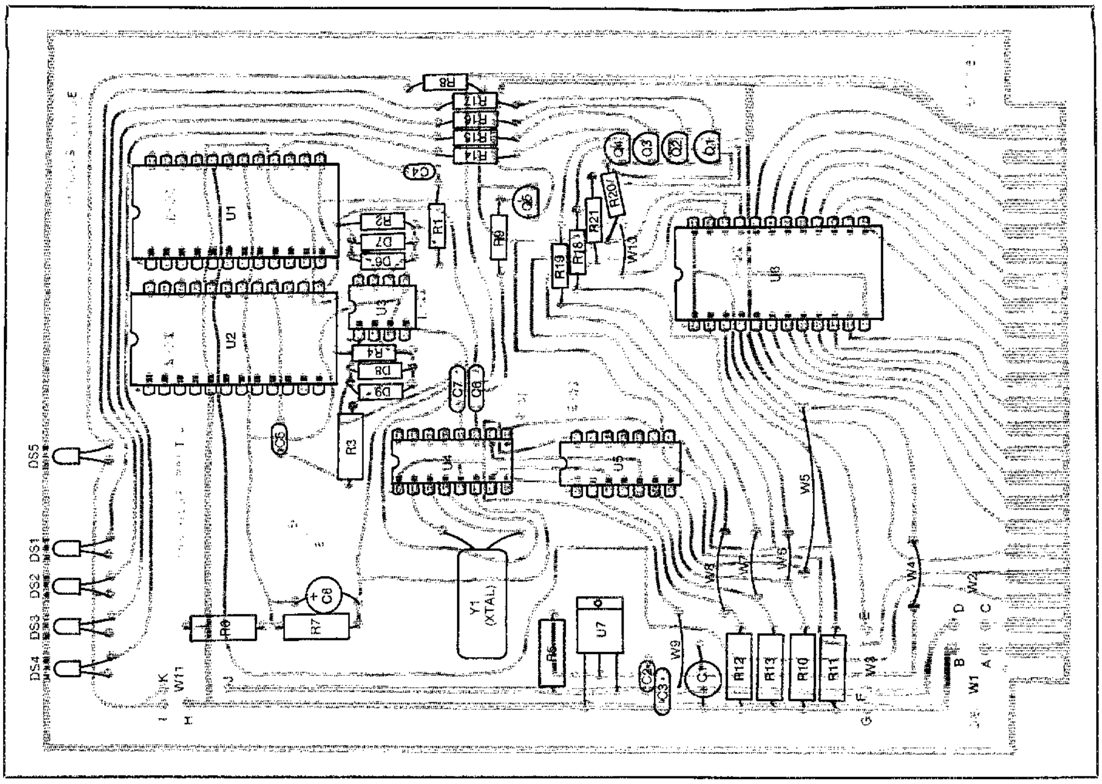
Operation

The only problem you may have with the operation of the DTMF receiver is that caused by clipping. If *any* stage between the DTMF generator and the receiver is driven into clipping, the receiver may not decode. It won't "false"; it just will not decode at all. Signal clipping causes the row tones (especially those of rows one and two) to produce second harmonics in the column tone-filter passband. These harmonics are passed by the high-group filter to the decoder. (Note that any stage that clips will produce these harmonics, and most fm transmitters have a clipper as part of their deviation-limiting circuit.)

The "fix" is simple — turn down the DTMF level feeding the individual transmitter. You'll find that deviation levels of below 2 kHz will work in a properly set up system. Incidentally, the reason a 567 PLL decoder will work with a clipped DTMF signal is the same reason it falses so badly. Think about it.

When removing or installing the Easy-Ceiver card, power should always be removed. Failure to do so could destroy the MK5102/3 and U6. All parts on the board may be damaged if the card is plugged in upside down. A sawed slot and card-edge key could save you some time, trouble and damaged parts.

This DTMF receiver design has been in use in fm repeater systems for over two years with excellent results. In one instance, the receiver replaced a Bell 247B that had a voice talk-off problem. The problem was eliminated by the Easy-Ceiver. While no DTMF receiver is totally voice glitch free, this design comes as close as any I have seen. It is gratifying to hear even noisy signals operate the control system. As long as signal levels are kept from clipping, few users have the "pad problems" so common with other DTMF receivers.



Parts-placement diagram for the Easy-Ceiver. Components are mounted on the nonfoil side of the board. Shaded areas represent copper on the foil side of the board. The circuit-board etching pattern appears on page 50.

I would like to thank Bill Martin, WA4LEN, for his help with artwork and photography, and Bill Dudley, WA4IBM, who talked me into writing this article. I also want to thank the users of the 60/00 repeater in St. Petersburg, Florida, for their patience during the testing of the prototypes of the Easy-Ceiver.

Notes

[1]A kit including an MK5103, filters, pc board and all other miscellaneous parts is available from Sun Coast Electronics, 1539 S. Dale Mabry Hwy., Tampa, FL 33607. Price is $150 including postage in the continental U.S. Write for cost of individual components. ITT North Microsystems filters may be obtained from ITT North Microsystems Division Customer Service, 700 Hillsboro Plaza, Deerfield Beach, FL 33441-1796. Cost for both filters is $60.80 plus shipping charges. [The MK5102(N)-5 is also available from Circuit Specialists, 1344 N. Scottsdale Rd., Tempe, AZ 85281 — Ed.] The ARRL and *QST* in no way warrant these offers.

[2]Caution: Use care in handling CMOS parts. You will probably receive them in an antistatic bag or shorting socket. They should not be handled or removed from their protective device until just prior to installation. When installing CMOS parts, make sure your body and the pc board are in contact and grounded. While CMOS part damage is rare, a dry day and a carpeted floor can cause static problems.

Strays

REMINISCENCE BEARS FRUIT

☐ Speaking before the Falmouth (Massachusetts) ARC, Dr. Yardley Beers, WØJF, a former physics professor, senior physicist with the National Bureau of Standards and well-known *QST* author, related a story about his youth that at least one member of the audience could identify with. Students at Phillips Academy weren't allowed to have electrical appliances in their rooms in those days. To get around that regulation, Beers decided to build a "lunchbox" rig. The results, he told the group, were admirable.

During the question-and-answer period, someone in the back of the room raised his hand and asked where the idea for the "lunchbox" rig came from.

"From a magazine, sir," Beers replied.

"The magazine perchance, wasn't *QST*?"

"Why yes it was. Why do you ask?"

Because, replied Edward Braddock, W1XV/W2BAY, "I was the author of that [July 1929] article!"

"How wonderful it is to meet you after all these years," Beers responded. "You set me on my life's course." With that, the entire club stood up and cheered. — *information courtesy Edward Braddock, W1XV/W2BAY, and the* Falmouth Enterprise

QST congratulates . . .

☐ Richard Frost, K1JVM, who was named one of the top entrants in a nationwide competition for computer projects, sponsored by Johns Hopkins University, to stimulate research in personal computing to aid the handicapped.

Ionospheric Scatter By Field-Aligned Irregularities at 144 MHz

The best 2-meter path is not always a straight line. You can use FAIs to work DX, if you know where to aim your antenna.

By Thomas F. Kneisel,* K4GFG

As a result of work conducted by a Stanford University research team, the scientific community first recognized Field-Aligned Irregularities (FAI) in the ionosphere 30 years ago.[1] Amateurs have made little intentional use of them for communication. In 1974[2,3] and again in 1979,[4] powerful ground-based transmitters "heated" localized sections of the ionosphere, producing scattering irregularities in the E and F layers. These scatterers aligned with the magnetic field of the earth and reflected Amateur Radio signals over distances of up to 1100 miles[5] on 2 meters and other vhf frequencies. The propagation was short-lived and disappeared when the heaters were turned off. Although these FAI were man-made, Victor Frank suggested that FAI also occur weakly in nature.

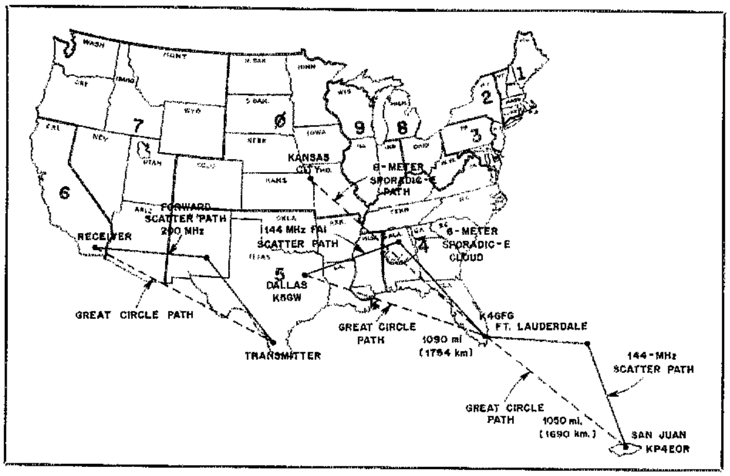


Fig. 1 — FAI scatter paths (solid lines) compared with great-circle paths (broken lines). The cloud over Alabama serves both the 6-meter sporadic-E circuit and the 144-MHz FAI path.

Early Studies

Radar echoes from field-aligned scatterers in the E layer were reported as early as 1955. Working with 17-MHz radar, the Stanford University team detected a rapidly fading signal backscattered from within the E layer almost every night during late spring and early summer in 1955.

In July of 1958, Heritage, Weisbrod and Fay used high-power transmitters and narrow beamwidth antennas at 200 MHz to study the features of field-aligned scattering in the E layer.[6] They employed a forward-scatter path from Texas to California as shown in Fig. 1. Note the deviation from the great-circle path. Signals were characterized by a rapid flutter and lasted as long as 1/2 hour. Most activity was found during the hours of darkness.

An extensive 5-year radar study of FAI was performed in the early sixties by Basu, Vesprini and Aarons.[7] They used a radar with frequencies of 19 and 49 MHz, located in Massachusetts, to observe the FAI and to correlate it with the occurrence of sporadic E. During evening hours, FAI accompanied sporadic E almost 50% of the time at 19 MHz. The FAI would last for perhaps an hour or more, becoming *more* intense as the sporadic E weakened. Daytime sporadic E, however, had no detectable FAI accompanying it. The FAI showed a strong summertime peak in activity, with a small peak in the winter, similar to sporadic E. At 49 MHz, similar seasonal and daily FAI peaks were observed; however, only one-third as much FAI was detected at this frequency.

Amateur Observations at 144 MHz

In the summer of 1978 I set up an evening schedule with Dave Ternent, KP4EOR. We tried to work the 1050-mile distance between Florida and Puerto Rico. Dave was running a kilowatt amplifier and four Yagis, and I had a kilowatt amplifier and two Yagis. This corresponds to a maximum allowable path loss of approximately 248 dB. At 2105 EDST on June 19, I received a telephone call from Doug Welcker, WB4KGY, in West Palm Beach. He reported hearing KP4EOR up the band, 3 kHz! The signals were weak and fluttery with a T5 cw note similar to that caused by aurora. Antennas at each end of the path peaked about 20 degrees north of the great-circle path (Fig. 1). The band stayed open for 2 hours 40 minutes while KP4EOR worked WA4OWC and W4WD, and heard WA4JID and K4DZP, all from south Florida. Schedules through early

[1]Notes appear on page 32.
*1600 SW 115 Ave., Davie, FL 33325

September yielded five similar contacts.

In the spring of 1979, we maintained more rigorous scheduling on half hours throughout the evenings. Forty-seven days of scheduling from May through August resulted in identification of 24 occurrences of this propagation (51%)! Signals were generally weak, but on six occasions the levels rose to 30 dB above the noise. Several stations in Florida and Puerto Rico with only 100 watts and single Yagis participated at times. We did not observe 144-MHz sporadic E.

On the evening of July 21 I noticed 6-meter sporadic E over the Gulf states. I aimed the antennas northwest and heard Gerald Williamson, K5GW (near Dallas, Texas) calling CQ on 144.200 MHz. The signal was weak and fluttery; our QSO lasted only a few minutes. He was quite surprised at the antenna heading required to work a south Florida station (Fig. 1). Another FAI opening from Florida to Texas early in August lasted 2-1/2 hours. I netted five contacts with stations from Dallas to Houston.

During July through September of 1980, I heard or worked the Florida-to-Texas FAI path 13 times. The first QSO was by chance. Chuck Stewart, N5AXP (in San Antonio, Texas) was running four Yagis but only 100 watts. I had only a single Yagi at the time. We consistently noted the auroral flutter and a beam offset to the north of the great-circle path.

On June 21, 1981, I worked a different type of FAI path. My antenna was aimed north to work WA4CQG in Auburn, Alabama. He also had to aim his antenna north and elevate it 35 degrees above the horizon! The scatterer was in the E-layer approximately 120 miles north of him. The reflected signal bounced back over his station towards Florida 600 miles to the south!

Comparing the Details

The most striking feature of FAI is the antenna offset from the great-circle bearing required to work this propagation mode. Repeated attempts to work the great-circle path failed. Geometry calculations confirmed scatterers aligned with the magnetic field and located in the E layer would produce the antenna offsets observed. The calculations fail to predict the observed azimuths when the scatterer is assumed to be at F-layer heights.

Antenna elevation tests with the help of the K5GW 16-Yagi EME array also confirmed that the scatterer must be located in or near the E layer. The measured signal arrival angle was essentially on the horizon. If the scatterer had been in the F layer, there would have been a 10- to 15-degree elevation.

The identifying feature of the FAI that sets it apart from sporadic E or tropo is the rapid flutter. It is similar to auroral propagation in sound, but not as disruptive. Frequency components of 30 to 100 Hz are typical. Ssb is quite intelligible when signals are somewhat above the noise. On two or three occasions, however, Texas and Puerto Rico stations reported that parts or all of 60-second Florida transmissions were clear — without the flutter. This remains unexplained. The signals do not exhibit the deep fades characteristic of tropo or sporadic E, but remain very consistent from minute to minute.

Our experience at 144 MHz tends to confirm the link between FAI and sporadic E observed by the early researchers. Intensive scheduling during February through April for FAI failed. May through early September yielded an abundance of FAI. Late September through October produced no FAI. Although we have done little scheduling at other times of the year, we believe the data tend to indicate a summertime peak similar to that of sporadic E. Our experiments occurred near the peak of a solar cycle, but others[5] were done nearer to solar minimums, indicating FAI occurs throughout the solar cycle as does sporadic E.

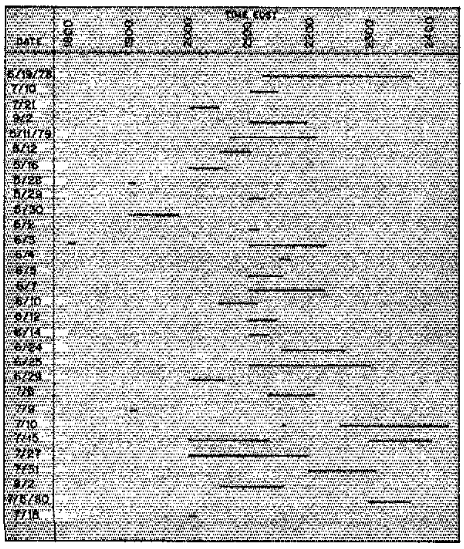
6-Meter Barometer

During 1980, 144-MHz FAI to Texas occurred on 53% of evenings having 6-meter sporadic E to the west or northwest of Florida. Fig. 1 shows 6-meter sporadic E to the northwest indicating the presence of ionization near the scattering location used to work Texas on 144-MHz FAI. The FAI generally appeared late in the evening after the sporadic E was well developed. Sometimes it appeared just after the 6-meter band had closed. Typically, the 144-MHz FAI outlasted the 50-MHz sporadic E by 30 minutes to an hour.

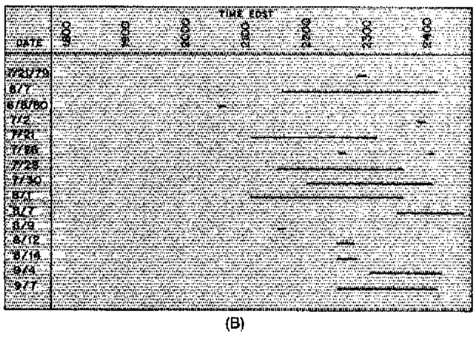
Fig. 2 shows the time of day of occurrences of FAI to Puerto Rico and Texas. Schedules were generally on the half hours, and although the data is biased by operating habits, it seems to indicate that many openings begin from mid to late evening.

Determining Antenna Bearings

The key to success with FAI is to predict the correct antenna headings for



(A)



(B)

Fig. 2 — At A, evening occurrences of 144-MHz FAI from Florida to Puerto Rico, 1978-1980. Scheduling generally began at 2000 local time. At B, evening occurrences of 144-MHz FAI from Florida to Texas, 1979-1980. Scheduling generally began at 2100 local time.

the particular path you want to work. As an example, a map of the U.S. (Fig. 3) depicts magnetic field direction. These are the short straight lines pointing toward magnetic north. Lines of equal magnetic inclination, or dip angle, have also been drawn across the country from east to west.

Let's choose a path that is to be worked, say Chicago, Illinois, to Denver, Colorado. The scattering center will be located somewhat north of the great-circle path; therefore we use a contour set for a 74-degree dip angle. These are the heavy lines with an X at the location of the scattering center.

The contours are labeled in degrees and represent the mathematical complement of the incident or reflected ray angle with respect to the scattering axis. When a station anywhere on the −5 degree contour transmits toward the scatterer, the reflected signal returns to earth not at one point, but along the entire arc of the +5 degree contour. Similarly, a station on the −2-1/2 contour can work a station anywhere on the +2-1/2 contour, and so on. A station on the 0-degree contour can work any other station on the 0-degree contour, including itself (the radar case).

Chicago on the +2-1/2 contour lines up with Denver on the −2-1/2 contour. The scattering center, located by the X, is over Fargo, North Dakota. Both operators must aim their antennas there to work each other.

For many paths, especially the shorter ones, there will not be just one unique solution, but a locus (curve) of points for the scattering center. Theoretically FAI at any of these points will support communications. Path length, elevation considerations and perhaps the angle of scattering may make one area yield stronger signals. Experiment with beam headings after contact is established. We have detected some movement of the scattering point during 144-MHz contacts.

Once you have the correct azimuth, check to see if antenna elevation is required to intersect the scatterer in the E layer of the ionosphere. Each contour has been extended to where the perimeter represents the maximum working range, which corresponds to the scatterer being located on the horizon. A partial circle has been drawn around the scatterer to indicate the distance that requires a 10 degree antenna elevation. If you don't have antenna elevation control, you may want to stick to the long east-west paths outside of the circle, as I did.

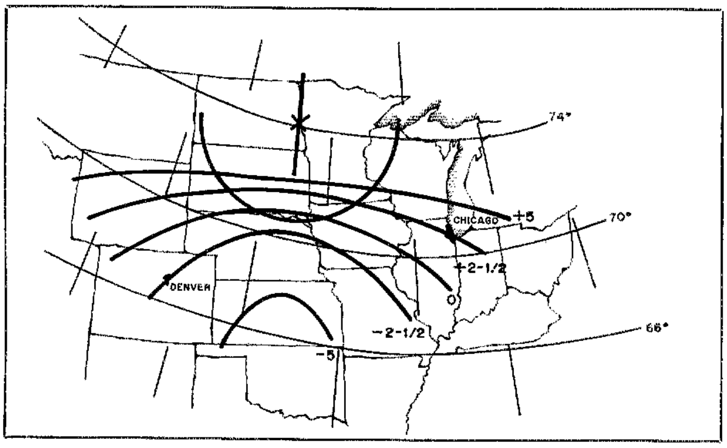


Fig. 3 — Alignment of contours for the Chicago-to-Denver path.

Station Requirements and Operating Tips

As with many other weak-signal modes of communication, best results will be obtained through persistent scheduling and the use of cw. Once you have chosen the station you want to work, determine the antenna headings, and set up a schedule. Four or five minutes of transmission at the beginning of each half hour throughout the middle to late evening is recommended. If both stations are able to monitor 6 meters, you may wait until sporadic-E clouds are formed above the appropriate area. Continue scheduling for at least an hour after 6 meters has closed, or you may miss an opening!

My statistics indicate that two Yagis (horizontally polarized), kilowatt amplifiers and a quiet location on each end produce results. You should be able to detect 144-MHz FAI on about half of the summer evenings that exhibit 6-meter sporadic E in the appropriate area.

On many evenings the signals may be barely detectable for 5 to 10 minutes, then disappear with little *real* communications possible. Several evenings per month they may be many decibels above the noise and may last for 2-1/2 hours or more. As station power and antenna gain is reduced, the result will be fewer QSOs of shorter duration. A station with a single Yagi antenna and 100 watts of output power should be able to work another station similarly equipped, but perhaps only a few times each summer when the FAI intensity is the strongest.

Other Frequencies

Basu, Vesprini and Aarons have observed FAI at 19 and 49 MHz.[9] Well-equipped amateur stations on the upper hf bands as well as 50 MHz should have no difficulty working FAI, and may already have done so without recognizing the mechanism. We have observed FAI at 144 MHz, with path-loss figures occasionally as low as 218 dB, which is easily within reach of amateur stations today. Heritage, Weisbrod and Fay observed FAI at 200 MHz with a *typical* path loss of 248 dB.[10] This is certainly within reach of better equipped 220-MHz amateur stations.

What about ionospheric scatter at 432 MHz? Given a boost by FAI, it may be possible. Although I have not found any direct measurements of naturally occuring FAI path loss for uhf, it is likely to be much higher than for 144 MHz.[11] EME capabilities on both ends of the path will almost certainly be required.

Acknowledgments

I would like to thank Doug Welcker for his contributing support and the many long hours of discussion of FAI during the past three years, and Dave Ternent and Chuck Stewart for scheduling night after night in quest of FAI. A special thanks to my wife, Kay, for her patience and understanding.

[Editor's Note: A map of the United States and a set of contour overlays along with the basic equations are available from ARRL Hq. for $3.] QST

Notes

[1]A. M. Peterson, O. G. Villard, Jr., R. L. Leadabrand and P. B. Gallagher, "Regularly-Observable Aspect-Sensitive Radio Reflections from Ionization Aligned with the Earth's Magnetic Field and Located Within the Ionospheric Layers at Middle Latitudes," *Journal of Geophysical Research*, Dec. 1955, pp. 497-512.
[2]V. R. Frank, "Scattering Characteristics of Artificial Radio Aurora," *Ham Radio*, Nov. 1974, pp. 18-24.
[3]V. R. Frank, R. B. Fenwick and O. G. Villard Jr., "Communicating at VHF via Artificial Radio Aurora, *QST*, Nov. 1974, pp. 27-31, 34.
[4]W. A. Tynan, "The World Above 50 MHz," *QST*, Aug. 1979, p. 86.
[5]km = miles × 1.6
[6]J. L. Heritage, S. Weisbrod and W. J. Fay, "Evidence for a 200-Megacycles per Second Ionospheric Forward Scatter Mode Associated with the Earth's Magnetic Field," *Journal of Geophysical Research*, Sept. 1959, pp. 1235-1241.
[7]S. Basu, R. L. Vesprini and J. Aarons, "Field-Aligned Ionospheric E-Region Irregularities and Sporadic E," *Radio Science*, March 1973, pp. 235-246.
[8]See note 7.
[9]See note 7.
[10]See note 6.
[11]See note 2.

A Simplified Procedure for Locating and Tracking the Moon

Track the moon? No, it doesn't leave footprints! But there's more to finding it than looking out the window. Some simple calculations will help you track it with your telescope or EME antenna.

By Arthur L. Barber, Jr.,* KC2BO

The best transceiver, low-noise preamplifier, power amplifier and high-gain antenna will produce only marginal results if you cannot locate and continuously track the moon during an EME QSO schedule. Moonbounce can be one of the most demanding modes of communication for the radio amateur. Valuable operating time ought not be wasted in detailed calculations, which are only a means to an end. A simple, straightforward method of precalculating the azimuth and elevation for aiming your EME antenna is described. This brief explanation will not make you an accomplished navigator or radio astronomer, but it will give you a better understanding of the theory behind the calculations.

The earth is an oblate spheroid, flattened at the poles, 24,875 statute miles[1] in circumference, with a radius of 3959 miles. It makes one complete rotation (360 degrees) every 23 hours 56 minutes on its polar axis, which is inclined at an angle of 23.5 degrees to its plane of orbit around the sun. During this time the earth revolves about 1 degree in its orbit around the sun. The earth must rotate slightly farther to catch up, producing our day of 24 hours. The tilt of the axis accounts for our change of seasons. When the axis is inclined toward the sun it is summer in the northern hemisphere and winter south of the equator. Distances north and south (latitude) are measured from the equator toward the poles (0 to 90 degrees). Distances east and west (longitude) are measured from the prime meridian, a great circle that passes through both poles and Greenwich, England. One degree = 60 minutes of arc = 60 nautical miles along the equator. Since 24 hours ≈ 360 degrees of arc, 1 hour ≈ 15 degrees of longitude. It then follows that there are 12 time zones west and 12 time zones east of the prime meridian. For example, New York City is approximately 75 degrees west, so when it is noon in New York, it is 5 P.M. in Greenwich. The time-angular difference between any two points on the surface of the earth is the basis of celestial navigation. By knowing the exact location of a radio station and the geographic position of the moon, it is possible, by calculation, to locate the moon accurately in terms of azimuth and elevation.

The moon, the only natural earth satellite, is 2162 statute miles in radius, and varies in distance from the earth between 223,000 miles at perigee and 253,000 miles at apogee during its 29.5-day synodic period of rotation about the earth. It has a sidereal rotation about its own axis of 27.3 days. The moon rises later each day, changes azimuth, altitude [this is the navigational term for the angle measured from the horizon to the celestial body, essentially the same as what amateurs call elevation angle — Ed.] and declination rapidly compared with the stars, and swings approximately 20 degrees north to 20 degrees south of the equator every 14 days.

Visualize a line drawn from the center of the earth to the center of the moon, as

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[1]Notes appear on page 35.

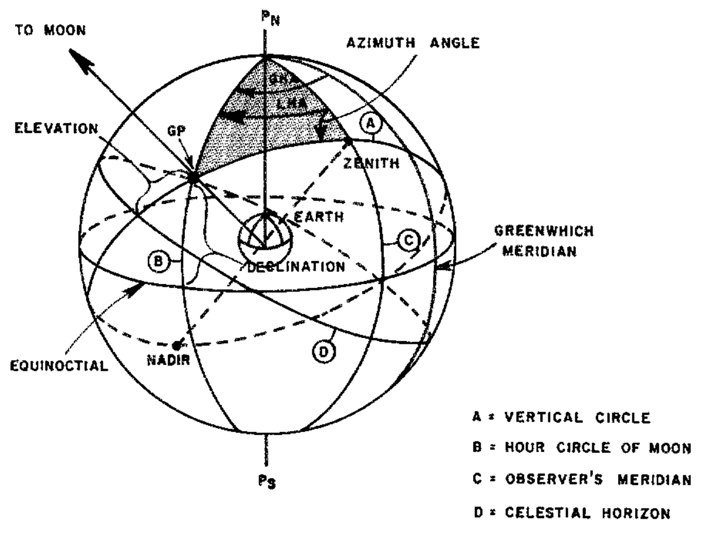

Fig. 1 — Spherical coordinate system for recording azimuth and elevation of celestial bodies.

shown in Fig. 1. The point this line makes as it intersects the earth's surface is known as the G.P. (geographic position) of the moon. The angle from the equator to this point is called declination. The angle measured from the Greenwich Meridian to the meridian going through the G.P. is called the Greenwich Hour Angle (GHA). The angle from the observer's meridian to the G.P. is called the Local Hour Angle (LHA).

The *Air Almanac*[2] will tell you whether the moon will be in a favorable position for a QSO at a proposed time. Your own position in latitude and longitude can be determined by referring to a map. The declination and GHA of the moon may be found in the almanac for the appropriate time (see Table 1), and LHA may be calculated. Subtracting your latitude and the declination of the moon respectively, from 90 degrees, you will see that you now have two sides and an included angle (LHA) of a spherical triangle (see Fig. 1).

Calculate the azimuth and altitude using Eqs. 1 to 4. The calculated altitude is easily corrected for paralax by inspection of the P. in A. (Parallax in Altitude) table in the *Air Almanac*. This takes into account the increment of error caused by an operator's geographic location when the moon is at low altitudes. This error decreases to zero as the altitude approaches 90 degrees.

A Typical Calculation

On Sunday, March 11, 1979, the author had scheduled an EME QSO with a friend in Jefferson City, Missouri, at 8 P.M. (2000) EST. UTC = 2000 + 5 ZD = 2500 − 2400 = 0100 UTC March 12 (ZD is zone description). This time had been selected as a mutual convenience after consulting the almanac for moonrise. The starting point of a moonbounce QSO is a determination of the relative position of the moon with respect to both stations. Low altitudes are undesirable, and the moon, when on the other side of the earth, is useless! It must be above the horizon for both stations, to establish contact. An inspection of the moonrise table of the daily page of the *Air Almanac* for March 11, at the latitude of the Missouri station, plus the ZD will define the UTC of moonrise with sufficient accuracy. Jefferson City, Missouri, has a latitude about the same as the author's QTH (Alpine, New Jersey), 40° 57′ (40.95°) N latitude and 73° 56′ (73.93°) W longitude. This QTH is almost on the 75th meridian, in the Eastern Time Zone. The time difference relative to UTC is 5 hours ZD. The ZD for the Missouri station is 6 hours.

Inspection of the Moonrise Table (Table 2) indicated that moonrise for 40° N latitude would occur at 1559 UTC. Moonrise for the Missouri station is found by: 1559 UTC + 6 hr ZD = 2159 UTC, March 11, 1979. This time is approximate, but close enough for our purpose. We see that the moon will be up for about 3 hours before the scheduled QSO. The relative position of the moon, and moonrise, can be estimated if it has been observed on previous days.

The position of the moon can be

Table 1

Part of the March 12 Daily Page from the 1979 *Air Almanac*.

GHA and dec of Sun, Aries, Venus, Jupiter and Saturn have been deleted to save space.

(DAY 071) GREENWICH
A.M. 1979 MARCH 12 (MONDAY) 141

GMT (h m)	○ MOON GHA (° ′)	Dec. (° ′)
00 00	17 23	N 9 56
10	19 49	54
20	22 15	53
30	24 40	· 52
40	27 06	50
50	29 31	49
01 00	31 57	N 9 48
10	34 22	46
20	36 48	45
30	39 13	· 44
40	41 39	42
50	44 05	41
02 00	46 30	N 9 40
10	48 56	38
20	51 21	37
30	53 47	· 36
40	56 12	34
50	58 38	33
03 00	61 03	N 9 32
10	63 29	30
20	65 55	29
30	68 20	· 28
40	70 46	26
50	73 11	25
04 00	75 37	N 9 24
10	78 02	22
20	80 28	21
30	82 54	· 19
40	85 19	18
50	87 45	17
05 00	90 10	N 9 15
10	92 36	14
20	95 01	13
30	97 27	· 11
40	99 53	10
50	102 18	09
06 00	104 44	N 9 07
10	107 09	06
20	109 35	04
30	112 00	· 03
40	114 26	02
50	116 52	9 00
07 00	119 17	N 8 59
10	121 43	58
20	124 08	56
30	126 34	· 55
40	128 59	53
50	131 25	52
08 00	133 50	N 8 51
10	136 16	49
20	138 42	48
30	141 07	· 47
40	143 33	45
50	145 58	44
09 00	148 24	N 8 42
10	150 49	41
20	153 15	40
30	155 41	· 38
40	158 06	37
50	160 32	35
10 00	162 57	N 8 34
10	165 23	33
20	167 49	31
30	170 14	· 30
40	172 40	29
50	175 05	27
11 00	177 31	N 8 26
10	179 56	24
20	182 22	23
30	184 48	· 22
40	187 13	20
50	189 39	19
Rate	14 33.4	S0 08.2

Lat. (°)	Moon-rise (h m)	Diff. (m)
N		
72	15 40	48
70	15 52	45
68	16 01	42
66	16 09	40
64	16 16	38
62	16 21	37
60	16 26	35
58	16 31	34
56	16 35	33
54	16 38	32
52	16 41	32
50	16 44	31
45	16 50	29
40	16 55	28
35	17 00	27
30	17 03	26
20	17 10	25
10	17 16	23
0	17 22	22
10	17 27	21
20	17 33	19
30	17 40	18
35	17 43	17
40	17 48	16
45	17 53	15
50	17 59	13
52	18 01	12
54	18 05	12
56	18 08	11
58	18 12	10
60	18 16	09
S		

Moon's P. in A.

Alt. (°)	+ Corr. (′)	Alt. (°)	+ Corr. (′)
0	54	57	29
9	53	58	28
14	52	59	27
18	51	60	26
21	50	61	25
24	49	63	24
26	48	64	23
28	47	65	22
30	46	66	21
32	45	67	20
34	44	68	19
36	43	70	18
38	42	71	17
40	41	72	16
41	40	73	15
43	39	74	14
44	38	75	13
46	37	76	12
47	36	77	11
49	35	78	10
50	34	79	
51	33		
53	32		
54	31		
55	30		
57	29		
58			

Sun SD 16′.1
Moon SD 15′
Age 14d

Table 2

Moonrise Data from the March 11 Daily Page

Lat.	Moon-rise
N	
°	h m
72	14 04
70	14 23
68	14 38
66	14 50
64	15 01
62	15 09
60	15 17
58	15 23
56	15 29
54	15 34
52	15 38
50	15 43
45	15 52
40	15 59
35	16 06
30	16 11
20	16 21
10	16 30
0	16 38
10	16 46
20	16 54
30	17 04
35	17 09
40	17 16
45	17 23
50	17 32
52	17 36
54	17 40
56	17 45
58	17 51
60	17 57
S	

predicted by the following equations:

$$LHA_{moon} = GHA_{moon} \begin{matrix} + East \\ - West \end{matrix} \text{ longitude} \quad \text{(Eq. 1)}$$

$$H_c = \sin^{-1}[(\cos LHA)(\cos dec)(\cos L) + (\sin dec)(\sin L)] \quad \text{(Eq. 2)}$$

$$Z = \cos^{-1}\left[\frac{(\sin dec) - (\sin H_c)(\sin L)}{(\cos H_c)(\cos L)}\right] \quad \text{(Eq. 3)}$$

$$Z_n = \begin{cases} Z\text{: when } \sin LHA<0 \\ (360° - Z)\text{: when } \sin LHA \geq 0 \end{cases} \quad \text{(Eq. 4)}$$

where

LHA = local hour angle
GHA = Greenwich hour angle
H_c = height calculated (elevation angle)
dec = declination angle
L = latitude of station (+N/−S)
Z = calculated azimuth
Z_n = actual azimuth at station location

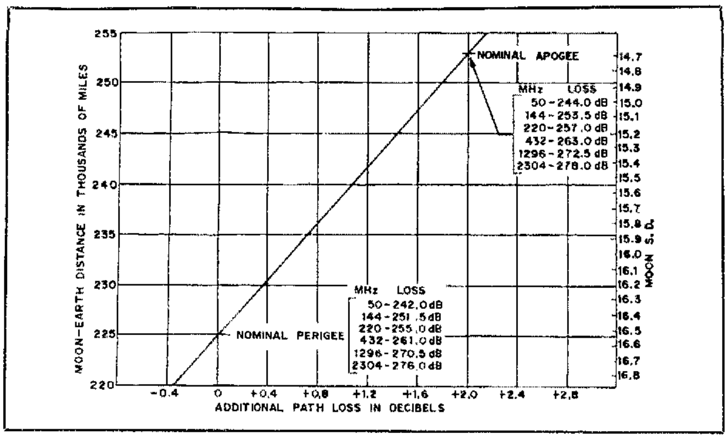

Fig. 2 — Variations in EME path loss can be determined by this graph, taken from *The 1981 Radio Amateur's Handbook.*

A calculator with trigonometric functions will make solving these equations easier. A programmable calculator with memory makes repeated calculations fast and easy.

See Table 1 for the entering arguments for our calculation. $GHA_{moon} = 31.95°$, $dec_{moon} = 9.8°$ N and L = 40.95° N. (Note that decimal angles have been used to make calculation easier.) By Eq. 1:

$$LHA_{moon} = 31.95° + (-73.93° \text{ W}) = -41.98°$$

and adding 360° to get the positive angle, 318.02°. Then by Eq. 2:

$$H_c = \sin^{-1}[(\cos 318.02°)(\cos 9.8°)(\cos 40.95°) + (\sin 9.8°)(\sin 40.95°) = 41.67°$$

A correction for horizontal parallax of the calculated altitude was found in the Parallax in Altitude table (P. in A.) of the daily page of the *Air Almanac* for March 12, 1979 (Table 1). Since H_c is between 41° and 43°, the required correction is −40′, or −0.67°. The correct elevation angle, then, is 41.67° − 0.67° = 41.00°. This correction is always subtracted.

Using Eq. 3 to calculate azimuth we get

$$Z = \cos^{-1}\left[\frac{(\sin 9.8°) - (\sin 41.67°)(\sin 40.95°)}{(\cos 41.67°)(\cos 40.95°)}\right] = 118.07°$$

From Eq. 4 we note that sin LHA = sin 318.02° = −0.669, which is less than 0, so $Z_n = Z = 118.07°$, the azimuth of the moon from true north, relative to the station.

The rate of change in azimuth and altitude was determined by a second calculation for one hour later (0200 UTC). It was necessary to know these rates to be able to track the moon continuously during the QSO. The following figures were obtained from Table 1 and Eqs. 2 and 3.

	Time UTC	*Altitude (corrected)*	*Azimuth*
	0200	49.87°	134.52°
(subtracting)	−0100	−41.00°	−118.07
	1 hr	8.87° arc/hr	16.45° arc/hr
	or	8.87′ arc/min	16.45′ arc/min

When the moon approaches or departs from within 30° of its highest point (zenith) it is best to make one or more additional calculations at half-hour intervals to correct for the decrease and then increase in the rate of change in altitude as the moon passes its zenith. The rate of change of azimuth will be almost constant over any reasonable period of transmission.

The daily pages of the *Air Almanac* tabulate GHA and declination of the moon for every 10 minutes of the day. These pages also indicate the age, phase and semi-diameter of the moon. Age relates to the 28-day cycle of the moon orbiting the earth, and semi-diameter is half the vertical angle formed between the upper and lower limbs of the moon. Semi-diameter may be used to determine the variation of EME path loss by Fig. 2. On March 12, 1979, the S.D. of the moon was 15′ of arc. The path loss was: 251.5 dB + 1.8 dB = 253.3 dB at 144 MHz.

That's all there is to it. Now isn't it quite simple? QST

Notes

[1]km = mi × 1.6093.

[2]The *Air Almanac* is prepared by the Defense Mapping Agency, Hydrographic/Topographic Center, Washington, DC 20315, in cooperation with the Royal Greenwich Observatory, Herstmonceux Castle, East Sussex BN27 1RP, England. It is sold through the U.S. Government Printing Office, Washington, DC 20402, stock no. 008-054-00077-1. Cost is $13 for an edition, which covers 1/2 year.

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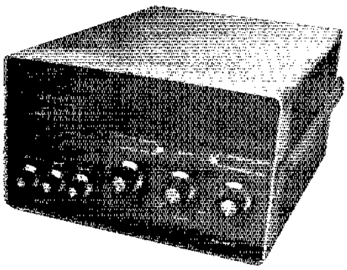


Now you can display received cw/ssb envelopes and transmitter trapezoidal patterns automatically — no knobs to twist!

By William K. Springfield,* AE4A

A Heath SB-614 monitor scope at my station is used primarily to display trapezoidal linearity patterns of the transmitted signal and to indicate output power during tune-up. Therefore, the front-panel mode switch is most often set to the TRAP position. In the past few years, the '614 has also been used to monitor the quality of received cw and ssb signals. Many visitors to the station get a kick out of seeing the received signal patterns. These types of displays require the scope mode switch to be placed in the SSB position. This prompted me to evaluate the possibility of automatically switching the '614 between the TRAP mode during transmitting periods and the SSB mode during receive. Certain criteria had to be met — low cost, no extensive circuit changes to the SB-614, no sophisticated transceiver/exciter/amplifier interconnections and no SB-614 front-panel deface-

*2607 Deerdell La., Reston, VA 22091

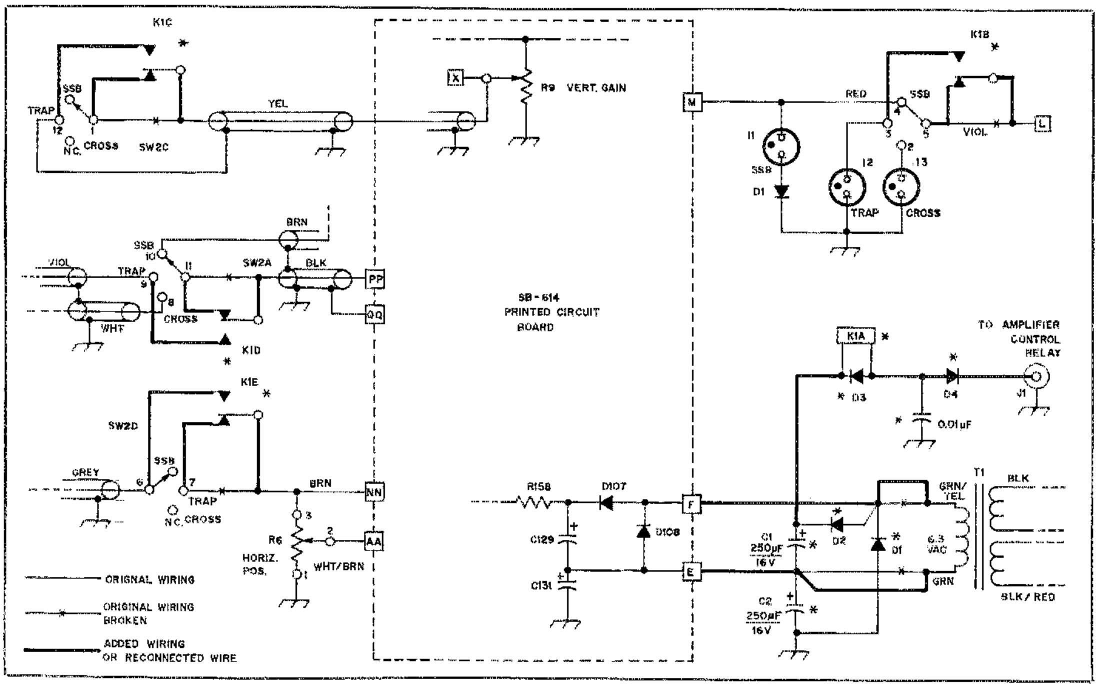


Fig. 1 — SB-614 monitor scope wiring modifications. Added components are indicated by an asterisk. Other component designations are those of the manufacturer.

D1-D4, incl. — Silicon, 50 PIV, 1 A, 1N4001 or equiv.

K1 — See text.

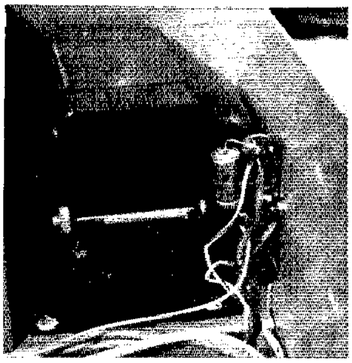


Fig. 2 — Physical positioning of the added power-supply components is shown here.

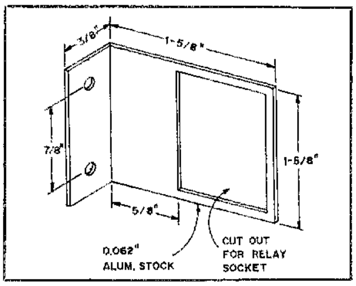


Fig. 3 — Relay assembly mounting bracket. Inches (") x 25.4 = mm.

ment. I also wanted the scope to be transparent to the modification when the new feature wasn't used.

Circuit Changes

Close examination of the '614 diagram suggested that a 4pdt low-voltage relay, correctly wired to the mode switch (SW2) and controlled by the exciter/transceiver amplifier control relay contacts, would do the trick. Fig. 1 shows how this is accomplished. The normally closed (NC) contacts of the relay are placed in series with the movable contact arms of the switch (terminals 1, 5, 7 and 11) so the scope operates as unmodified when the relay is de-energized. For automatic operation, the mode switch is set to the SSB position. When the relay is energized, the normally open (NO) contacts switch to the TRAP mode.

The relay I used (Radio Shack 275-214) has a 160-Ω, 12-V coil requiring a nominal current of 75 mA. This demand was found to be a bit stiff for the 9-V regulated supply of the '614, so an additional voltage-doubler rectifier/filter circuit was added using the existing 6.3-V winding of the power transformer. Components are mounted on a 4-lug terminal strip that is oriented vertically and mounted using 6-32 hardware and an existing hole in the aluminum side panel

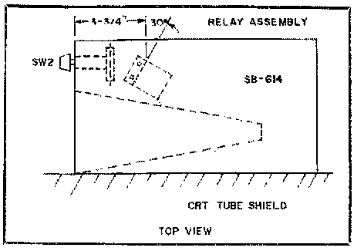


Fig. 4 — Physical placement of the relay assembly in the SB-614. The assembly is tilted approximately 30°. Inches (") x 25.4 = mm.

Fig. 5 — Mounting position of the added relay. Leads removed from the mode switch need not be lengthened, and the relay terminals are readily accessible.

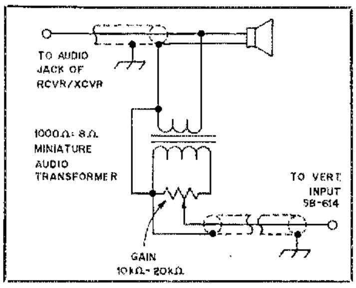


Fig. 6 — This simple circuit may be used to increase the level of the received signal for presentation on the SB-614 CRT.

close to the power transformer. See Fig. 2. I chose to remove the transformer leads (green and green/yellow) from the pc board to which they were originally attached and to connect them to the terminal strip. A twisted pair was connected from the terminal strip to the pc board. *Caution!* Make certain the 6.3-V leads are wired to similar points in the two rectifier/filter circuits, C129/C131/D107/D108 and C1/C2/D2/D3. Failure to wire this correctly will create a low-voltage, poorly regulated supply for the SB-614 amplifier circuitry.

Mechanical Installation

The 4pdt relay plugs into a socket (Radio Shack 275-221), which is mounted on a 0.062-in. (1.6-mm) thick aluminum mounting bracket as shown in Fig. 3. Mount the bracket using two 6-32 screws through holes drilled in the aluminum side panel of the scope close to the mode switch, SW2, as shown in Figs. 4 and 5. Incline the relay assembly about 30° from the vertical so that the solder tabs of the relay socket assembly near the CRT tube shield, ensure that enough room exists so that the relay can be removed readily.

Using this arrangement, it was not necessary to increase the length of any of the wires removed from SW2 and reconnected to the relay socket. To perform the wiring, SW2 must be removed from the front panel. The shaft end is pushed downward to expose the terminal wiring. Using the SB-614 wiring diagram, it is easy to identify the wires and to trace the switch numbering system. When soldering, use a low-wattage iron. Connect D3 and about 12 in. (305 mm) of wire to the relay coil terminals *before* mounting the assembly to the side panel. Install the wires to the operating arm, NO and NC socket terminals, in that order.

The control lead to K1 is routed along the cable harness and terminated at a 2-lug terminal strip mounted in the rear compartment (where the transformer primary and line cord are connected). The terminal strip is secured to the chassis using one of the two screws that fasten the pc card channel member. A phono jack is mounted directly opposite the terminal strip, and D4 is connected between them.

Received-Signal Amplifier

You may desire to increase the level of the received signal for presentation on the CRT in the SSB mode. With my TR7, a comfortable received audio level produces a CRT vertical deflection of only 1/4 to 1/2 in. (6.4 to 13 mm) when the '614 vertical gain is set to display a nearly full-scale trapezoidal pattern. The simple circuit of Fig. 6 compensates for this lack of amplitude. All components are mounted on a terminal strip located in the transceiver speaker cabinet.

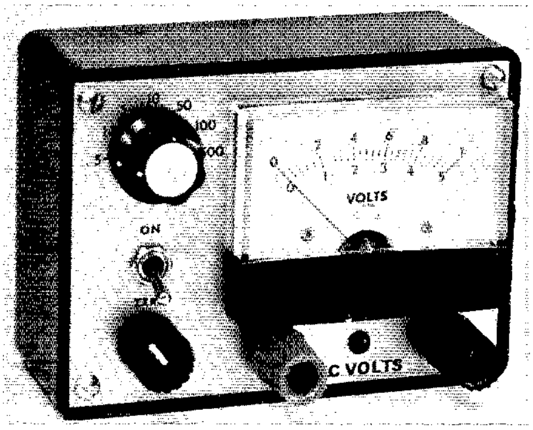
Operation

To operate K1, it will be necessary to gain access to the exciter/transceiver amplifier control relay contacts. If multiple connections to these contacts are required, the use of a quad phono jack assembly (Radio Shack 274-322) and phono plug equipped cables can provide an easy solution.

To use the automatic switching feature, place the SB-614 mode switch in the SSB position. K1 will transfer the circuitry of the scope to the TRAP mode when the transmitter is keyed. Set the '614 VERTICAL GAIN control for the required level while in the TRAP mode using the amplifier. If the circuit of Fig. 4 is used, set the potentiometer for the desired CRT display amplitude while listening to a clear signal at a comfortable audio level. Simple, isn't it? QST

Some Basics for Equipment Servicing

Part 2: Dc voltage measurements are fundamental to trouble-shooting amateur equipment. This month we'll look at how to make these measurements and show you a "hi-Z" voltmeter you can build in a weekend.



By George Collins,* KC1V

In Part 1 of this series we looked at a number of techniques for testing solid-state devices. With these basics under our belts we are ready to address the next question in troubleshooting: "Which components should I check first?" It's an important question. A modern transceiver may contain over 100 solid-state devices; to randomly test each of them would not be productive. We need to zero-in on the defective circuit so that our effort can be concentrated where it will do the most good.

Where to Look?

The first source of information to consider is the defect itself. If the RIT (receiver incremental tuning) stops working, we wouldn't begin testing transistors in the audio amplifier! Try to gain as much information as possible from the symptoms. "The RIT won't work" is a start, but you should examine the problem in more detail *before* you begin making measurements and testing components. Ask yourself questions. Does the RIT control affect the receive frequency at all? Does it change both the receive and the transmit frequencies, or does the frequency shift when the RIT switch is turned on, but the variable control fails to function? The answers to questions like these can provide valuable clues in tracking down the guilty component.

Some problems, like the RIT example, are fairly simple to isolate. In this case, the number of components is small, and the settings of other controls (band switch, rf gain and so forth) are not likely to affect the problem. We should have little difficulty locating the circuit and components causing the malfunction. When we encounter more complex problems (Murphy's law indicates that we will!) it is often helpful to make notes of exactly what the symptoms are. Later, when testing has begun, keep notes on what tests have been made and the results.

Voltage Measurements

One of the fundamental trouble-shooting techniques is to check the voltage present at various points in the circuit. The measured voltage is compared with the voltage we *expect* to find at that point. Knowing what to expect is important. If we don't have some idea of what the voltage should be, measuring it won't tell us very much. This is where our knowledge of the circuit pays off. "Okay, knowing exactly how a circuit works is great, but what if I don't know what to expect?" Remember rule no. 1 from Part 1? Purchase the factory service manual! Generally, the important voltages are shown on the schematic diagram. These values will give us a starting point for our investigation. Unfortunately, not every circuit voltage is given, and sometimes the service manual for a particular rig is unavailable. We must then rely upon our knowledge of how the various devices in the circuit function.

Fig. 1 shows a typical rf amplifier circuit that contains an npn transistor. If we suspect this circuit is malfunctioning, but don't have the circuit voltages, how do we proceed? All we need is Ohm's Law and a few basics about transistors, and we can determine all the important circuit voltages. For example, R1 and R2 form a voltage divider that supplies dc bias to the base of the transistor. To find the value of the base voltage we apply Ohm's Law:

$$E_b = \frac{12\text{ V}}{10\text{ k}\Omega + 2.2\text{ k}\Omega} \times 2.2\text{ k}\Omega = 2.2\text{ V} \quad \text{(Eq. 1)}$$

The voltage at the collector will be nearly

*Assistant Technical Editor

the supply voltage (12 V) because the voltage drop across L1 (which should have a low dc resistance) will be very small. The voltage at the emitter can also be estimated. For a transistor to act as an amplifier, the emitter-base junction must be forward biased. For an npn transistor, this means that the base must be at a more positive voltage than the emitter. Also, we know that the voltage drop across the junction will be about 0.7 V (for a silicon transistor) when it is forward biased. We have already calculated the base voltage, so the emitter voltage is simply:

$$E_e = E_b - 0.7\text{ V} = 2.2\text{ V} - 0.7\text{ V} = 1.5\text{ V} \qquad \text{(Eq. 2)}$$

We now have our "expected values" for the circuit. If we measure the voltages and find that the collector is at a potential of 12 V, the base at 2.5 V and the emitter at 0 V, we know immediately that there is a serious problem. It is likely that the base-emitter junction has opened. Now is the time to remove the transistor and confirm that it is defective by using the ohmmeter checks described in Part 1.

Before the defective transistor is replaced, it is wise to try to determine the cause of the failure. The base and collector voltages have already been found to be correct so we can eliminate them as the possible cause. With the transistor removed from the circuit, an ohmmeter can be used to check R3 and the 0.1-μF bypass capacitor. If a low resistance is found (less than the correct 82-Ω value for R3), one end of the resistor or capacitor can be disconnected so that the defective component can be isolated. (The capacitor should not provide a resistance reading.

Often the voltages we measure will not agree exactly with our expected values. Small variations are normal and do not mean that the circuit is not operating as it should. Component tolerance and meter errors are the primary causes for these variations. In the npn rf amplifier example we calculated that the base voltage should be 2.2 V. When measured, the value was found to be 2.5 V. Is this too far from the expected value to be considered within the range of normal variations? Generally, any voltage that is within 15 to 20% of the expected value is acceptable. In our example the measured value differed from the excepted value by only:

$$\frac{2.5\text{ V} - 2.2\text{ V}}{2.2\text{ V}} \times 100\% = 13.6\% \qquad \text{(Eq. 3)}$$

This is within the range of acceptable values and should not cause us any concern.

The same approach can be applied to circuits using JFETs or MOSFETs. As an example, let's look at the MOSFET i-f amplifier shown in Fig. 2. Again, using only Ohm's Law, we can determine approximately what the voltage should be at each point in the circuit. The gate 2 bias voltage is supplied by the voltage divider, R1 and R2. It is:

$$E_{g2} = \frac{12\text{ V}}{33\text{ k}\Omega + 100\text{ k}\Omega} \times 33\text{ k}\Omega = 3.0\text{V} \qquad \text{(Eq. 4)}$$

The drain potential is simply the supply voltage (12 V), and because it has no dc bias applied to it, gate 1 is at ground (0 V). Determining the exact value of the source voltage requires that we know the drain current under these particular circuit conditions. While this information could be obtained from the transistor data sheet, we don't really need to know the exact voltage. Having an idea of the range of voltages to expect will suffice. The drain current in a typical small-signal FET amplifier, as might be used as an rf or i-f stage in a receiver, will fall between 2 and 17 mA. This range of current will produce a potential of 0.2 to 1.7 V across the 100-Ω source resistor. Any value between those limits indicates that the circuit is likely to be functioning correctly. If the measured value is far from the expected range, such as 0 or 12 V, one or more of the circuit components is defective. Removing the transistor and testing each component with an ohmmeter will identify the defective part.

Voltmeter Loading Effects

The circuit in Fig. 2 brings up a problem often encountered when making voltage measurements on circuits using FETs. Because the impedance levels involved with FETs are very high, the bias circuits may require high-value resistors. The difficulty arises when we attempt to measure the bias voltage with a VOM (volt-ohm-milliammeter). A typical VOM will have a sensitivity of 20 kΩ per volt, while the more sensitive VOMs are rated at 50-kΩ per volt. The meter sensitivity multiplied by the full-scale voltage of the meter gives the impedance or resistance of the meter. A 50-kΩ-per-volt meter, used

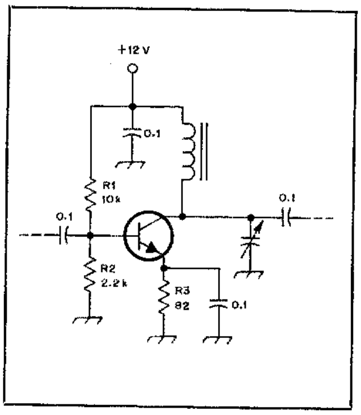


Fig. 1 — Schematic diagram of a typical rf amplifier. Circuits similar to this one are commonly found in transmitters and receivers.

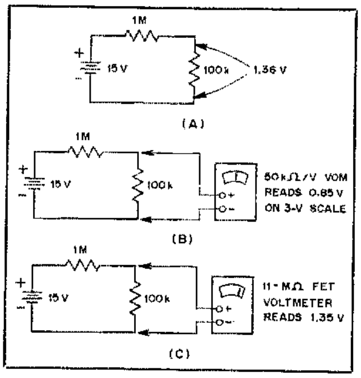


Fig. 3 — The circuit at A is a high-impedance voltage divider. Using a standard VOM (B) results in a 37% error because of meter loading. An 11-MΩ meter does not load the circuit appreciably; the error is less than 1% (C).

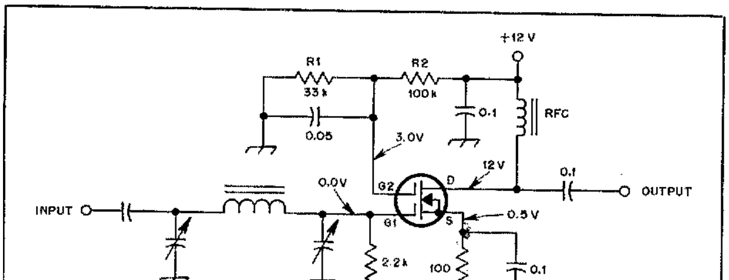


Fig. 2 — Another common rf amplifier circuit uses a MOSFET. Trouble-shooting this type of circuit is discussed in the text.

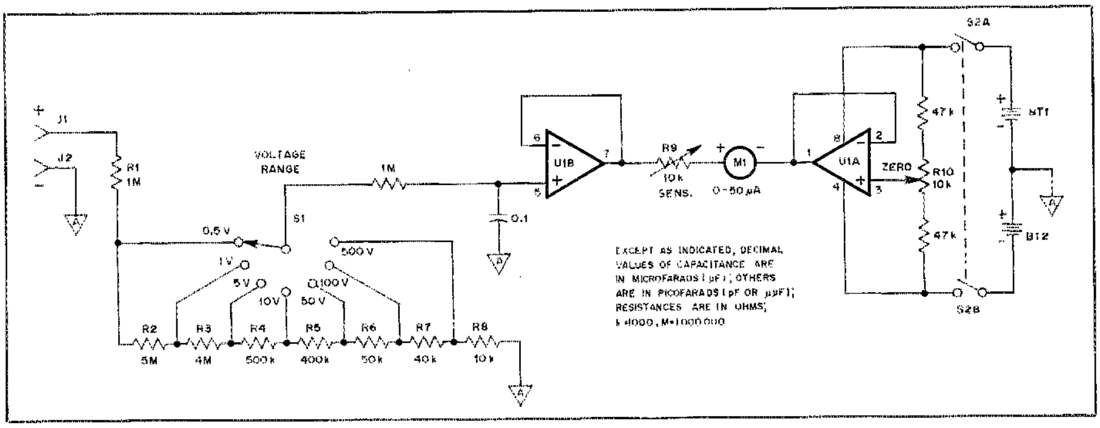


Fig. 4 — A high-impedance dc voltmeter need not be complex. This circuit uses a single IC.

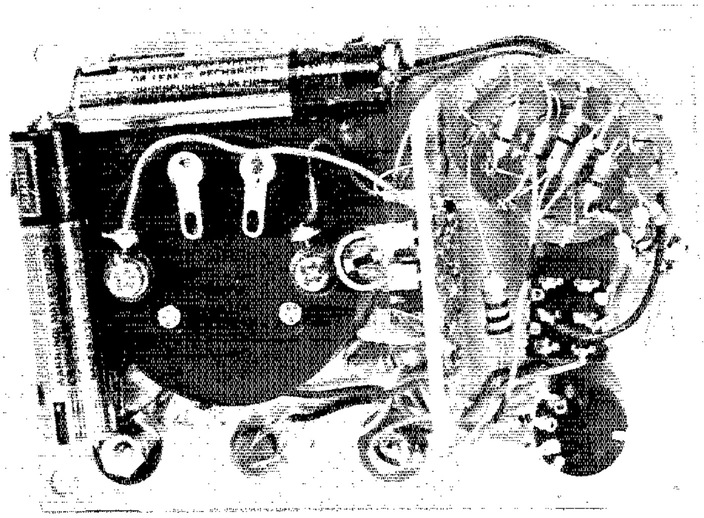
BT1, BT2 — 2 AAA (or AA) cells in holder or 9-V transistor radio battery (see text).
J1, J2 — Banana jacks, 500-V insulation (see text), RS 274-662 or equiv.
M1 — 50-µA dc meter movement, RS 270-1751.
U1 — LF353N dual JFET op amp, RS 276-1715 or equiv.
R1 — 1.0-MΩ, 1/2-W, 5% resistor.
R2 — 4.7-MΩ and 300-kΩ, 1/4-W, 5% resistors in series.
R3 — 3.9-MΩ and 100-kΩ, 1/4-W, 5% resistors in series.
R4 — 470-kΩ and 30-kΩ 1/4-W, 5% resistors in series.
R5 — 390-kΩ and 10-kΩ 1/4-W, 5% resistors in series.
R6 — 47-kΩ and 3-kΩ, 1/4-W, 5% resistors in series.
R7 — 39-kΩ and 1-kΩ 1/4-W, 5% resistors in series.
R8 — 10-kΩ, 1/4-W, 5% resistor.
R9 — 10-kΩ, 1/4-W PC-mount potentiometer, RS 271-218 or equiv.
R10 — 10-kΩ, panel-mount potentiometer, RS 271-1722.
S1 — 1-pole, 7-position rotary switch (see text), RS 275-1385 or equiv.
S2 — 2-pole, 2-position toggle switch, RS 275-614 or equiv.

on the 3-V (full-scale) range, for example, has an impedance of:

$$50\ k\Omega/V \times 3\ V = 150\ k\Omega \quad \text{(Eq. 5)}$$

This resistance is placed in parallel with the circuit resistance whenever we make a measurement. Often (when the circuit resistance is much lower than the meter resistance) it is unimportant, but when dealing with high-impedance devices like FETs we must be aware of the effects of meter "loading." Fig. 3 shows the type of error that can be caused by using even a 50-kΩ-per-volt VOM in a high-impedance circuit. If a high-impedance meter, such as an FET or vacuum-tube voltmeter, is used (Fig. 3C) the error caused by meter loading becomes very small.

This does not mean that a standard VOM is useless. For many measurements they serve well. They are versatile and, most important, inexpensive. While high-impedance (11-MΩ) VOMs are available, even the lowest-priced units are somewhat costly. By building our own FET voltmeter we can circumvent the high cost of a commercial meter and have some fun at the same time!



Inside view of the dc voltmeter. This version was built from an available parts kit. Other components and construction styles can be used as well.

A "Weekender" FET Voltmeter

Shown in Fig. 4 and the photographs is an easy-to-build, high-impedance dc voltmeter. All of the parts are readily available, calibration is simple and the cost is low. Construction of this meter can be considered as an easy weekend project. The input-impedance is 11 MΩ, and accuracy is better than 10%. With the rf probe shown in Fig. 5, this meter can be used to make reasonably accurate rf voltage measurements at frequencies up to 30 MHz.

Circuit Details

The input impedance of the meter is determined by the total resistance of the range-selector voltage divider (R1 through R8). The values of the individual resistors have been selected to provide the desired full-scale voltage ranges and a total resistance of 11 MΩ. Some of the resistance values needed for the divider are not found in the standard series of 5%-tolerance resistor values. To avoid having to buy expensive (and hard to find) 1% resistors, two 5% units are used in

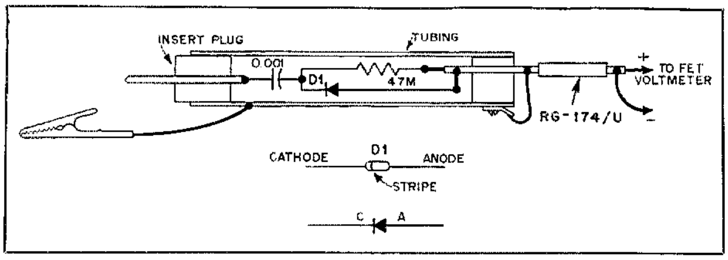


Fig. 5 — When used with an 11-MΩ voltmeter, this rf probe will allow you to measure voltages at frequencies up to 30 MHz. The maximum rf voltage applied to this probe should be limited to 35.

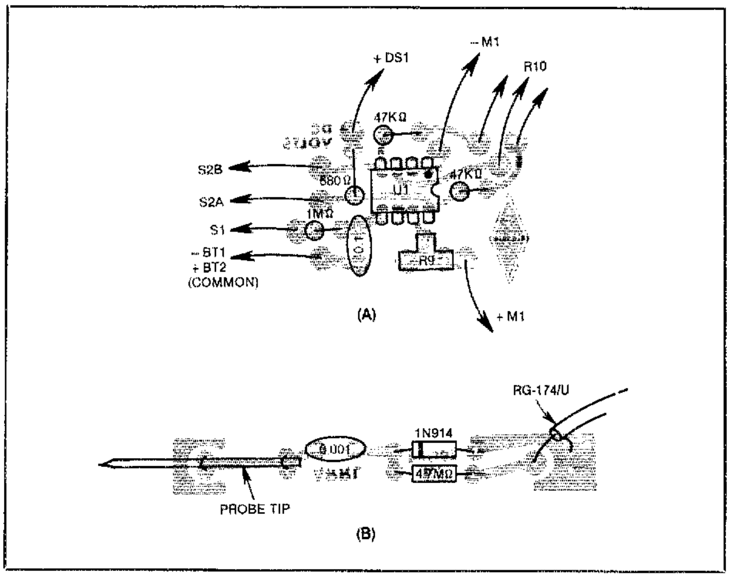


Fig. 6 — Parts-placement diagrams for the dc voltmeter (A) and the rf probe (B).

series for each of the nonstandard values.

To keep the meter movement from loading the 11-MΩ divider, an operational amplifier (op amp) with JFET inputs is used to drive the meter. The LF353N IC (U1) contains two of these op amps in the same package: U1B drives the meter movement, while U1A serves as an adjustable voltage reference point. Both of the op amps are connected as voltage followers.[1] This means that the input and output voltages are the same (a gain of 1). What makes the voltage follower useful is that the output can supply several milliamperes of current while the input draws a very small current (the input is high impedance).

By varying the voltage at pin 3 of U1 with R10, the zero setting of the meter can be adjusted to compensate for changes in battery voltage and room temperature. The fact that both op amps are in the same package helps reduce drift caused by temperature changes. R10 is mounted on the front panel so that the operator can adjust it easily. R9 is the calibration control; it adjusts the meter sensitivity. Once the meter has been calibrated, R9 does not require further adjustment, so it is mounted inside the case.

Two batteries are used to power the meter circuit. Any battery voltage between 3 and 9 V can be used without changes in the circuit. In the unit shown, four AAA penlight cells are used. These give the needed 3 V and have long life. Two 9-V transistor radio batteries will also work.

Construction

Almost any type of case can be used to house the voltmeter. The exact size needed will depend on the dimensions of the batteries, meter movement and switches used. A plastic case, only 2-7/8- × 4- × 1-5/8-inches (mm = in. × 25.4) houses the meter shown in the photographs. If a larger meter movement is used (such as the Radio Shack 270-1751), an enclosure measuring 2-5/8- × 5-1/6- × 1-5/8-inches will be more satisfactory. When using a case with a metal panel, it is best if the negative jack (J2) is *not* connected to the panel. This allows us to measure voltages below ground without having a potential on the voltmeter case.

The voltage-divider resistors are mounted on the range selector switch (S1). If the switch has any spare lugs, they can be used as tie points for the series-connected resistors. If no lugs are available, simply solder the leads together; the remaining leads will support the resistors. The other components can be mounted on a small printed-circuit board,[2] although any method of wiring can be used. A quick and simple way of wiring the IC is to use a general-purpose IC-prototyping board, such as the Radio Shack 276-159.

With the resistor values shown in Fig. 4, the highest full-scale range is 500 V. If this range is included, *be sure* that the input connectors (J1 and J2) and the range switch (S1) are rated for 500 V or more. J1 and J2 should be of the type with plastic insulation that passes through the panel. Only thin, fiber washers are used to insulate some types of jacks from the panel. These are fine for up to 100 V, but are not recommended for higher voltages. If the 500-V range is not needed, R7 and R8 can be connected in series or replaced by a 50-kΩ resistor (the same as R6).

The rf probe should be housed in a shielded case. Copper or brass hobby tubing of 1/2-inch diameter is good for this purpose. The cable from the probe to the voltmeter should be shielded. The shield braid is connected to the probe case and the ground lead. Small-diameter coaxial cable, such as RG-174/U, can be used for this lead.

Calibration

Only the sensitivity control, R9, needs to be adjusted before the meter can be used. A good method of calibration is to use two fresh carbon-zinc batteries in series to form a source of known potential. Each cell, when new, should produce 1.54 V. To adjust R9, turn the meter on, and set it to the 5-V range. With the meter leads shorted together, adjust the ZERO control (R10) so that meter shows zero volts. Connect the two cells to the meter, and adjust R9 so that the meter reads 3.1 V. This completes the voltmeter, and it is ready to use in your experiments or to troubleshoot the rig next time it develops a problem. QST

Notes

[1] For more information on op amps see G. Woodward, "A Beginner's Look at Op Amps," *QST*, April and June 1980, pp. 15-18 and 25-31. Anyone interested in learning more about op amps should consider these articles required reading.

[2] Printed-circuit boards and parts for the voltmeter and probe are available from Circuit Board Specialist, P.O. Box 969, Pueblo, CO 81002.

Product Review

Conducted By Paul K. Pagel,* N1FB

Yaesu FT-127 220-MHz FM Transceiver

It's time to get a 220-MHz fm rig when your QSO on 2-meter fm is interrupted by that chap who makes auto-patch every evening at precisely the same time to let the family know he's coming home — and you feel guilty about inconveniencing *him.*

It's time to get a 220-MHz fm rig when you and several DXer buddies aren't able to use 2-meter fm simplex to coordinate an evening's DX activity. Why? Because one of your friends has to wait half an hour to tell you that VKØ (Heard Island), which you need in order to make the DXCC Honor Roll, is on 10-meter cw. This delay is caused by a couple of locals who are giving a blow-by-blow description of the 200th rerun of a 20-year old episode of "The Mickey Mouse Club" television show!

It's also time for a 220-MHz fm rig when you feel the first twinges of "mike-fright," as you wonder how many thousands of ears are tuned in to your QSO on 2-meter fm with one of those "oh-so-affordable" programmable scanners. Most of those scanners cover the 146- and 450-MHz amateur bands, but not usually 220-MHz. *Burglars have scanners and Callbooks, and know when you are mobile!* Get the picture?

Problems

Okay, it is time to get a 220-MHz fm rig — no problem, right? Maybe or maybe not. The problem might be in trying to get the *right* rig. Of course, you could lay out some "big bucks," $400 and more, for a nice, synthesized 220-MHz rig. But for most of us who care to use only a couple of repeaters (and perhaps a simplex channel or two), that's overkill. A less expensive, crystal-controlled unit is just what the doctor ordered. Around here it takes a lot of looking to find a new 220-MHz xtal rig: A used one is just not available — they become family heirlooms and never make it to the used market! That's the problem.

Yaesu FT-127 220-MHz FM Transceiver Serial No. OHO10064

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency control: Crystal	Supplied with 223.50-MHz simplex.
Frequency display: 12-position channel selector.	As specified.
Receiver type: Double-conversion superheterodyne; 10.7-MHz 1st i-f, 455-kHz 2nd i-f.	As specified.
Receiver sensitivity (μV/20 dB quieting): Better than 0.35.	0.19.
Squelch sensitivity: Not specified.	0.1 μV.
Audio power output (8-ohm load): 1.5 W at 10% THD.	1.3 W.
Transmitter power output (50-ohm load): 10 W.	As specified.
Spurious emissions: At least −60 dB.	−60 dB.
Dimensions (HWD): 2.8 × 7 × 9.5 inches.	
Weight: 4.4 lb.	
Power requirements: 13.8 V dc (±10%), negative ground; 80 mA standby, 180 mA receive, 2.5 A transmit.	As specified.

Note: mm = inches × 25.4, kg = pounds × 0.4536.

A Solution

Enter Yaesu with a solution — the FT-127. [This transceiver should not be confused with the Yaesu FT-127RA 220-MHz *synthesized* radio that was reviewed in the August 1979 *QST* Product Review column. — Ed.] The Yaesu FT-127 is a 220-MHz, crystal-controlled fm transceiver, designed to operate within a 3-MHz spread in the 220- to 225-MHz band, factory aligned for the 222- to 225-MHz segment with a rated output of 10 watts. I guess most of us use 2-meter and 220-MHz fm for convenience; that is, the convenience of reliable communications and ease of operation. Also, there is the convenience of being able to use the rig in either a fixed- or mobile-station situation. The folks at Yaesu made sure that the FT-127 fulfills those needs.

Assuming you have a proper power supply, a 220-MHz antenna, and coaxial cable with a PL-259 connector, the FT-127 comes complete and could be put on the air very shortly after opening the shipping carton. No doubt the '127 was designed with some heavy-duty mobile use in mind. A deluxe mobile mounting bracket (which can be top or bottom installed) and mounting hardware are included with the transceiver. The mobile bracket slides into heavy-gauge metal channels on the sides of the FT-127, which allows the user about 4 inches of front to rear travel in which to position the unit. The mobile bracket also allows about 60° of up/down tilt positioning and a system for positively securing the rig in the position selected. That the FT-127 has, for the past several months, made the daily 50-mile round trip to work in my flivver, which is pushing 165,000 miles (original shock absorbers, too) and still functions perfectly, is in itself testimony to the ruggedness of the rig.

Description

The front-panel layout is simple and functional. There is a POWER ON/OFF toggle switch, VOLUME control and a SQUELCH control with full ccw detent to activate the Yaesu optional tone encoder/decoder feature. There is also a large, easy-to-grasp knob to select one of the 12 available crystal positions (the FT-127 comes with 223.50-MHz simplex crystals installed). The front panel of the '127 also sports three indicator lights as well as a back light for the channel selector, which are labeled: BUSY to show that squelch has been broken and a signal is being received, TONE SQ to indicate that the optional (if installed) encoder/decoder unit is in operation, and TX to inform you that the unit is in the transmit mode.

The internal speaker is on the front panel where it belongs, pointed at the user. I found that even while driving the highways with the windows open, the built-in speaker provided plenty of audio, although the FT-127 back panel has an external speaker jack, should it be needed. The audio has a "bassy" quality compared to the "tinny" audio quality of some other fm mobile rigs — an almost broadcast quality sound . . . very pleasant with a lot of *presence.*

Yaesu offers a TONE SQUELCH subaudible

*Assistant Technical Editor

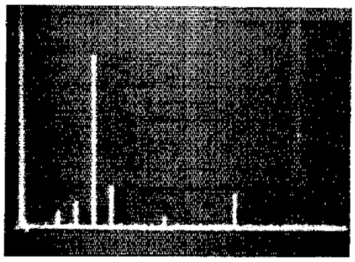


Fig. 1 — Spectral display of the FT-127. Vertical divisions are each 10 dB; horizontal divisions are each 100 MHz. The fundamental signal has been reduced in amplitude approximately 20 dB by means of notch cavities; this prevents analyzer overload. Power output is 10 watts at a frequency of 223.5 MHz. The close-in spur is approximately 60 dB below peak fundamental output. Tests were performed in the ARRL lab. The FT-127 complies with current FCC specifications for spectral purity.

tone encoder/decoder option for the FT-127. This assembly is on a small plug-in circuit board, which when installed and aligned will generate a subaudible tone on transmit and will allow the receiver squelch to be tripped only when receiving a signal with that same subaudible tone superimposed on it. Alignment of the tone option requires the use of an audio oscillator, a vhf signal generator and a frequency counter. Although the tone squelch unit was not supplied with the review model, there is no reason to believe that it would not perform as well as the transceiver.

The instruction manual included with the FT-127 is complete. There are sections on operation, circuit theory, transmitter and receiver alignment, TONE SQUELCH installation and alignment, component values and layout, and a schematic diagram.

From the time we took it out of the box and plugged it in several months ago, the FT-127 has seen almost daily service on simplex and the local repeater (WA1YHL/R) both from the fixed station and in mobile operation. The rig has worked flawlessly and gives every indication of working well for a long time to come. Since relative value is a question we all have to answer for ourselves, we'll simply say that if you want to go 220-MHz fm with a rig that looks good and works great, the Yaesu FT-127 is a way to go. The '127 is manufactured by Yaesu Electronics Corp., 6851 Walthall Way, Paramount, CA 90723. Price class: $350. — *Bill Jennings, K1WJ*

HAMTRONICS XV-4 TRANSMITTING CONVERTER

□ If you've been thinking of working OSCAR Mode U (much akin to its earlier Mode-B ancestors) on the upcoming Phase III-B, or simply trying your hand at terrestrial 70-cm (432-MHz) communication, the Hamtronics XV-4 is one alternative. The XV-4 is a *transmitting* converter. Hamtronics produces a companion receive converter that can be hooked in tandem with the XV-4 for two-way communication, or 435-MHz downlink reception, but this review deals strictly with the transmitting converter.

Description

The XV-4 transmitting converter is a linear translator that converts 1 mW of 28-MHz rf energy to 1 watt of PEP ssb, or 1-1/2 watts of cw or fm at 435 MHz. The unit incorporates two oscillators: the first is equipped with a crystal suitable for 435- to 437-MHz operation, the region used for several OSCAR uplink passbands; the second oscillator can be equipped with the crystal of your choice. You may wish to cover the 432- to 434-MHz terrestrial portion of the band, some other segment in our 70-cm allocation, or even to order special crystals that will allow the XV-4 to be driven from a CB rig.

As this transmitting converter is linear, it can be used on any mode of transmission — ssb, cw, fm or even ATV. Before purchasing the crystal for the second oscillator, decide what you'll be using the unit for and select the crystal that will put you in the right portion of the band. For example, 70-cm fm is usually used between 440 and 450 MHz.

Most 10-meter transmitters, transceivers or other types of exciters put out more than the recommended drive power. You'll need to reduce the output of your exciter to provide the required input levels. There are several solutions. Many modern transmitters or transceivers include transverter output jacks on the rear panel, which provide a small portion of 10-m rf energy before the final-amplifier stage. These levels vary from rig to rig, but the XV-4 comes equipped with an on-board attenuator circuit that will handle inputs of up to 500 mW. The instruction manual provides information useful in selecting the value of resistor, if any, that should be installed in the attenuator to bring the drive down to the appropriate level. For input levels above the 1/2-watt maximum, you'll need an outboard attenuator, the design of which depends on the amount of power that must be dissipated.

Those familiar with 70-cm operation will realize that the XV-4 1-watt output may be adequate for local work (though some openings may extend your communications range farther), but effective terrestrial DX work or Phase III satellite uplink transmission will require considerably more power.

Construction

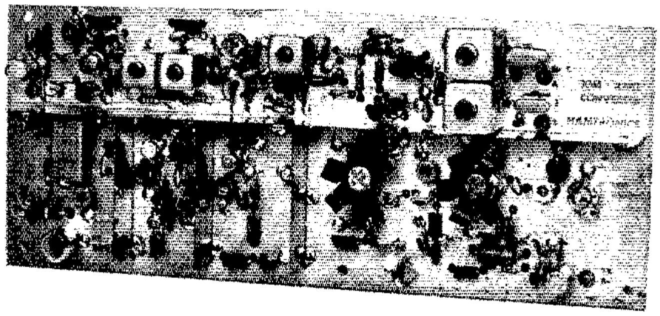
The XV-4 is available as a kit or wired and tested. The review unit was assembled from a Hamtronics kit. I found the kit unlike any I'd been accustomed to. You're not led by the hand, step by step; it's more like the procedure followed in magazine article construction projects. The manual is well written and provides more than enough guidance for the builder who reads the instructions at least once before plugging in the soldering iron. The kit consists of a double-sided, fiberglass circuit board, components (including the strips of metal used for shielding between stages), and a few incidentals such as a tuning tool. You'll need an enclosure (sold by Hamtronics and several other dealers) and a 13.6-volt dc supply, as well as a pair of coaxial cable patch cords to connect the unit to the exciter.

Despite the clarity of the instructions, Murphy can strike the builder who is "trying too hard." Don't make the mistake of winding the coils on the tuning tool handle when you are instructed to wind them on the thick portion of the tool shaft! You'll have trouble aligning the unit later. One very red face and countless disparaging comments from my Hq. compatriots later (something about a "short between my ears"), the coils were rewound and all tuned up as prescribed. The Hamtronics gang relayed that I was the first to have committed this "sin" (a dubious honor at best), and they have since changed the instructions for those who might suffer from a similar tendency to misinterpret clear directions.

The most common error in kit building is careless soldering: either "cold" solder joints

Hamtronics XV-4 UHF Transmitting Converter

Manufacturer's Claimed Specifications	*ARRL Lab Measurements*
Frequency coverage: 435-437 MHz (432-434 MHz with optional crystal), other portions of 70-cm band with suitable crystals.	As specified.
Rf input frequency: 28 to 30 MHz (27 or 50 MHz with suitable crystals.	As specified.
Input power: 1 mW to 500 mW with on-board attenuator.	As specified.
Output power: 3/4 W PEP on ssb, 1 W on cw and fm.	As specified.
Input/output impedance: 50 ohms.	Not measured.
Harmonic suppression: −60 dB.	−38 dB.
Third-order transmitter IMD: −30 dB.	−24 dB.
Oscillator frequency: 45.2222 MHz supplied for 435-MHz range; 44.8889 MHz optional for 432-MHz range.	As specified.
Size: HWD 1-1/4 × 7-1/2 × 3 inches (32 × 191 × 76 mm).	



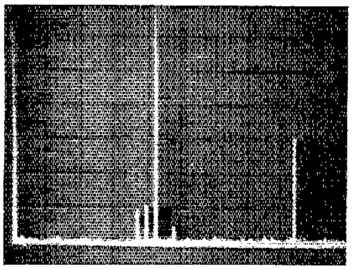


Fig. 2 — Spectral display of the Hamtronics XV-4. Vertical divisions are each 10 dB; horizontal divisions are each 100 MHz. Output power is approximately 1 watt at 432 MHz. The second harmonic is approximately 39 dB below fundamental output.

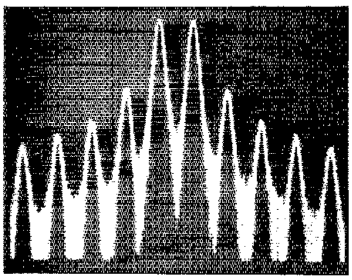


Fig. 3 — Spectral display of the XV-4 output during transmitter two-tone IMD testing. Third-order products are 26 dB below PEP output. Vertical divisions are each 10 dB; horizontal divisions are each 2 kHz. The XV-4 was being operated at 1/4-W PEP output at 432 MHz. H-P 8640B signal generators were used to supply the two-tone input.

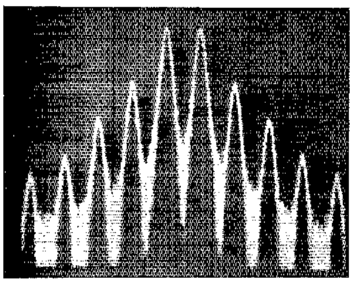


Fig. 4 — Spectral display of the XV-4 output while operating the unit at 3/4-W PEP output. Conditions of the test remained otherwise the same as that of Fig. 3.

or those insidious, almost invisible solder bridges between circuit-board traces. If worse comes to worst, factory service is available from Hamtronics for a modest cost; contact them before shipping any unit.

Alignment

When all the components have been loaded on the board and you've checked for shorts between circuit board traces, proper component placement and correct values, you'll be ready for the alignment procedure. For this you'll need the following equipment: a 2-watt, 50-ohm dummy load with low VSWR at uhf; a VTVM with a lowest dc range of at least 0.5 volt (0.15 V preferred); a relative rf output indicator (VSWR bridge or power meter); signal source at 28 MHz (a signal generator is not required — you can use 300 mV from your hf exciter); and a milliammeter capable of measuring 500 mA. A frequency counter, while handy, is not really needed.

The alignment procedure consists of adjusting a series of slug-tuned coils and variable capacitors stage-by-stage while monitoring the current level, checking various test points and component leads, and peaking the rf output. This procedure will pose little problem if you are careful and you complete each step successfully before going on to the next. Should the results not turn out as prescribed, consult the troubleshooting guide that is included in the manual. Typical beginners' mistakes and tables of nominal dc and rf voltages are listed.

The i-f input (28 MHz) is mixed with the output of a crystal oscillator multiplier chain in a doubly balanced mixer. For example, for 432-MHz coverage, a crystal oscillator at 44.8889 MHz is buffered, tripled twice to 404 MHz, then mixed with the 28-MHz signal from the exciter to yield 432 MHz. When the exciter VFO is tuned to 28.5 MHz the output of the XV-4 is at 432.5 MHz. This low level of 70-cm rf energy is then fed through a pair of rf amplifier stages, a driver stage and the final PA stage, yielding 432-MHz output.

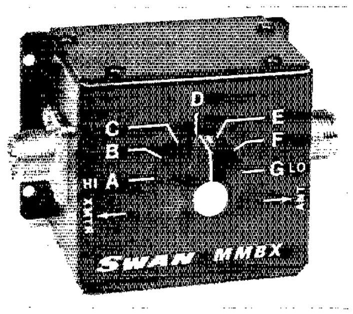
While using a frequency counter, we checked each step to determine that we hadn't tuned to the unwanted image frequency, 376 MHz. There are several ways to ensure that the transverter is tuned to the desired frequency, even without a frequency counter; they are clearly outlined in an addendum to the manual. Tuning to the image frequency is the most likely pitfall for the careless or impatient builder, though this problem can be avoided with caution.

As a transmitting converter, the Hamtronics XV-4 offers the potential 70-cm enthusiast an inexpensive alternative when equipping a station, and it will give the continuing satisfaction that comes from using a unit that you've assembled yourself. Price class: $100. Manufacturer's address: Hamtronics, Inc., 65 D Maul Rd., Hilton, NY 14468. — *Steve Place, WB1EYI*

THE CUBIC MODEL MMBX "MATCHBOX"

☐ Many hams, I'm sure, are excited at the prospect of working hf mobile, but run into problems when, try as they might, they can't get the VSWR of their mobile whips down to an acceptable level. This is especially frustrating if the transceiver has solid-state final-amplifier devices. A pi-network tube-PA rig is one answer, but it gets crowded in a small car when trying to use a rig such as the TS-820S! When I began using an Atlas 210X, the high-VSWR problem with my antenna was suddenly an enigma; however, the Cubic MMBX has provided an effective solution.

The MMBX is a multiple-tap, toroidally wound impedance transformer designed to match the typical lower impedance of a mobile hf whip to the nominal 50 ohms required by the transceiver. Cubic claims an rf power handling capability of 500 watts over a frequency range of 2 to 30 MHz. Under test in the ARRL lab, using a low-impedance load, Bird wattmeter, and a transmitter and amplifier capable of



1-kW dc input, the MMBX was subjected to 500-watts output. Cw and several minutes of key-down operation was attempted with no damage to the unit; heating of the toroid was only moderate. Certainly, the unit appears to be adaptable to high-power mobile operation, with ample reserve. The seven switched tap settings cover an impedance-matching range of approximately 3 to 50 ohms. The unit is wired in an unbalanced-to-unbalanced configuration.

Cubic suggests that the MMBX be mounted as close as possible to the base of the whip, using 18 inches of transmission line or less. This may be impractical for larger cars, but it has proved to be just right for my small car. Placing the unit just inside the trunk was ideal. The MMBX is housed in a durable steel box, but it's not weather-proof so outside mounting isn't recommended. SO-239 connectors on the unit make installation easy. Tuning is straightforward; once the mobile whip is tuned for lowest VSWR on the chosen band, the MMBX is inserted in the transmission line at the indicated point from the base of the whip, and the transmitter is keyed at low power on each of the seven tap settings. Log the position that gives the lowest VSWR indication, and the job is done. Cubic cautions against "hot-switching" the MMBX to avoid possible damage to the transceiver. If, by chance, the antenna impedance appears higher than that of the transceiver, the connections to the MMBX may be reversed to provide a step-up transformation. This I found was necessary for operation on 10 meters. I've kept a log of the tap settings for easy reference when changing bands and resonators.

The MMBX has taken care of my antenna mismatch difficulties, especially noticeable on 75 and 40 meters, and the small area of the unit — 2-1/2 × 3-1/2 × 2-1/2 inches HWD — takes up no appreciable space inside the car trunk. The MMBX is manufactured by Cubic Communications, 305 Airport Rd., Oceanside, CA 92054. Price class: $30. — *Sandy Gerli, AC1Y*

KENWOOD TR-8400 UHF FM TRANSCEIVER

☐ Compact! It is synthesized? Ten watts output? Well, it must be a "bare-bones job," isn't it? No? How did they manage to put *so much* into such a small package?

Features

The TR-8400 uses a microprocessor-controlled PLL synthesizer and covers 440 through 450 MHz. The primary method of frequency selection is by means of the main tuning knob located on the front panel, with the *operating* frequency displayed on an LED readout. This knob is connected to a rotary encoder shaft that permits the user to step the frequency up (clockwise) or down (counterclockwise). Two buttons (UP and DOWN) on the microphone can be used to change frequency without touching the front panel of the unit — a feature sure to delight the mobile operator.

The TR-8400 has what Kenwood calls a "two-VFO system" that functions as if there were two separate built-in oscillators. There are not really two VFOs, but rather two internal memories that control the oscillator. With the unit set for operation on VFO A, the user may select a particular frequency using the main tuning dial or the buttons on the microphone. Push one button, and the '8400 is operating on VFO B. The VFO B operating frequency is adjusted in the same manner as is the VFO A frequency. Pushing a button is all that is necessary to switch from VFO B to VFO A and back.

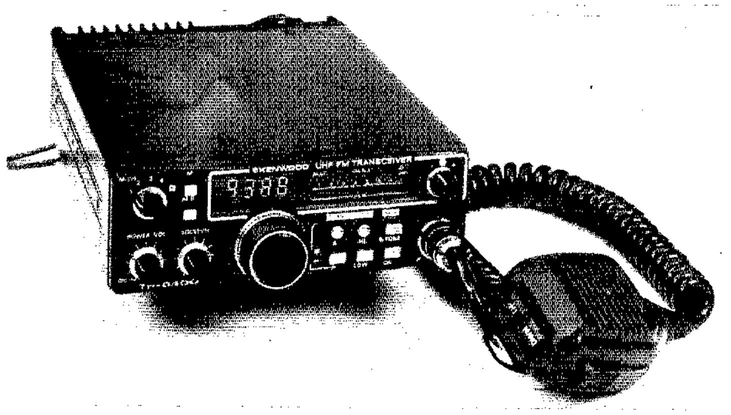
The TR-8400 has built-in repeater offsets of ±5 MHz, which makes it versatile. The operator sets the desired receiver frequency. Then the transmit offset switch is moved from S to − for transmitter operation 5 MHz below the displayed receive frequency or to + for 5 MHz above. This will handle most repeater requirements. However, Kenwood has provided a means for using the '8400 with a repeater having an "odd-ball split." One of the memory channels is specially equipped for this function.

Memory Channels?

It has memory channels, too? Four normal memory channels are included. A frequency from either VFO can be programmed into the memory at the touch of a switch. The user selects repeater or simplex operation for these memory channels with the transmitter offset switch, just as when using the VFOs. The fifth memory channel is different; the operator must program the receive and transmit frequency. Both may be any frequency in the range covered by the transceiver. (The microprocessor will disable the transmitter if an attempt is made to transmit outside the band.) This fifth memory channel will take care of any "odd-ball split."

The TR-8400 will scan the memory channels or the entire band. In either case, the transceiver will stop on any frequency at which the squelch opens, and remain there until the frequency is clear, when it will resume scanning. To retain a frequency that the scan function stops on, just press a front-panel switch (HOLD), or tap the PTT switch on the microphone. There are no provisions for the scan function to stop on an unused channel. It takes an appreciable amount of time to scan from 440 to 450 MHz in 25-kHz steps. We clocked it at 75 seconds! The time required to scan the five memory channels is much less. Perhaps a better method would have been to incorporate frequency limits on the bandscan function, as most repeater outputs are confined to the top or bottom 5 MHz of the band, depending on geographical area.

The '8400 does not have internal back-up batteries for retaining the memorized frequencies once the unit is completely disconnected from a power source. The memories require about 2 mA at 11 to 16 V to keep the stored information intact. Presumably, Kenwood felt that would make an internal NiCad back-up memory voltage source impractical. This would be of little concern to the mobile operator, but some operators are inclined to turn off everything, including power supplies, at the base station. The TR-8400 has an auxiliary jack on the rear panel for an external memory back-up supply.



Kenwood TS-8400 UHF FM Transceiver Serial Nos. 1060678 and 1060552

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: 440.000 to 449.975 MHz in 25-kHz steps.	As specified.
Mode of operation: Fm.	As specified.
Readout: 4-digit, red LED digital display.	0.375-inch digits.
S-meter: LED bar type.	As specified.
S-meter sensitivity: (Not specified).	3.2 μV for S9.
Receiver sensitivity: Better than 1 μV for 30 dB S/N.	0.28 μV for 20-dB quieting.
Audio power output (8-Ω load): 2.0 W.	1.3 W.
Transmitter rf power output: HI 10 W; LO 1 W (adjustable).	As specified.
Spurious suppression: Better than 60 dB.	As specified (see spectral photo).
Current drain: 0.45 A, squelched receiver; 3.4 A HI power transmit; 1.4 A LO power transmit.	As specified.
Size (HWD): 2 × 5-13/16 × 7-5/8 inches.	
Weight: 3.3 pounds.	
Color: Brown/gray.	

Tones

A rear panel jack is wired for tone-pad hookup. One jack pin has 9 V available when the transmitter is keyed. The '8400 has provisions for adding a Continuous Tone Coded Squelch System (CTCSS or PL as it is commonly called) encoder. A front-panel switch will turn the encoder on and off once it is properly installed. Some operators having no need for a CTCSS encoder have used the switch for other purposes.

Operating Impressions

Two transceivers were sent to Hq., and we reviewed both units. The authors agree on most points of the review. The '8400 is usually an enjoyable radio to operate. It is relatively simple to change frequency as one drives along, using the microphone-mounted switches. The area coverage is somewhat reduced from that of 144 or 220 MHz, but that is not a problem in this area, where there is an abundance of 450-MHz repeaters in close proximity. In other regions, operators may find it advantageous to add an external power amplifier.

Both transceivers would lock occasionally onto a phantom channel during band scanning. Each had a different symptom. On one unit the received signal sounded like that of a broadcast station (probably an intermod product), while the other just locked up on a full-quieting carrier (probably an internal spurious product).

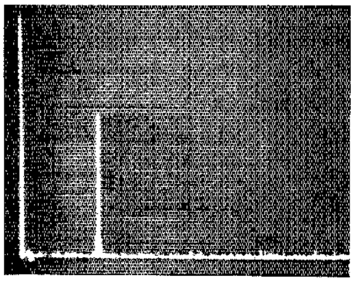


Fig. 6 — Spectral display of the Kenwood TR-8400. Vertical divisions are each 10 dB; horizontal divisions are each 200 MHz. Output power is approximately 9 watts at a frequency of 448.8 MHz. The fundamental has been reduced in amplitude by approximately 32 dB by means of notch cavities; this prevents analyzer overload. All spurious emissions are approximately 68 dB below fundamental output.

If you have been on 450 MHz for some time, chances are that you have a 40-lb "refugee" from the commercial service. The TR-8400 is an attractive alternative to the "boat anchors" of yesteryear. If you are thinking of moving up to 450 MHz, the TR-8400 is one way to travel in high style.

Price class is $500. Additional information can be obtained from Trio-Kenwood Communications, Inc., 1111 West Walnut St., Compton, CA 90220. — *Peter O'Dell, KB1N, and Gerald Hull, AK4L*

Conducted By
Doug DeMaw,* W1FB

MORE ON UNGUIDED LIGHT BEAMS

☐ In early 1963 while I was still at NASA Langley Research Center, one of the engineers in the Instrument Research Division, Numa E. Thomas, developed a passive optical communication system. He built a prototype, and I saw it in operation. It worked easily and well. Thomas subsequently got a patent on his system. It would be too long to describe in this letter, so I'm sending along a drawing of his system that illustrates the method (Fig. 1).

I asked the Patent Office at NASA about use of his patent, and was told there was no barrier to its use by others. If any amateur wishes to try it out, there is no problem, but credit should be given to Thomas if any publication results.

One of the applications Thomas had in mind was search and rescue, as well as field communications, since the end of the link at the user is entirely passive, small and light to carry. Two of the devices would be needed to ensure two-way communication. While Thomas demonstrated his device using voice, there is no reason why any other type of encoding could not be employed. I have always thought the device of Thomas would gain favor, and perhaps this note in *QST* will stimulate interest. Unfortunately, Thomas died shortly after his patent came to issue. — *S. L. Seaton, K4OR, 460 Windmill Point, Hampton, VA 23664*

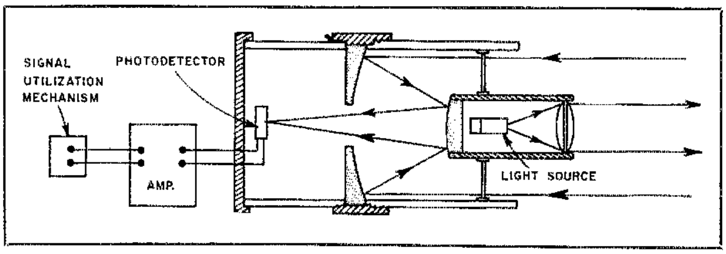


Fig. 1 — Mechanical details of the Thomas passive optical-communication mechanism.

SOLAR-ELECTRIC-POWER UPDATE

☐ Information in the amateur literature relative to solar-electric power generation seems to come in spurts. I thought this update, with excerpted information from the paper by P. Maycock and E. Stirewalt (*IEEE Spectrum*, September 1981, p. 40), would be of interest to *QST* readers. Although amateurs have been working with solar or photovoltaic panels for some years, nothing has been done on a grand scale. This is because the present-day costs for large arrays of solar-electric cells and compatible storage provisions (batteries) are beyond the practical and economic means of hams. However, large entities, such as the military, small communities and broadcast stations are finding the sun to be a worthwhile energy source.

Maycock and Stirewalt say that the largest independent solar-electric generator in the world is in place and operating at Natural Bridges National Monument in Utah. The 1712-square-meter photovoltaic array delivers an output of 210 A at peak sunlight. A quarter million solar-electric cells are contained in the array of this 100-kW generator. Lead-acid batteries provide a storage capacity of 600 kW hours. Thus far the batteries have not discharged below 40% of capacity. A fully charged system at this site yields one to three days of operation, depending on load conditions.

The authors go on to say that this system, since June 1980, has supplied ample energy for all of the electrical needs at the park. This includes water pumping, power service to several ranger residences, maintenance shops, a visitors' center and tourists' trailers. The quarter million cells in this system are divided into 4762 modules. A backup diesel power system is available, but is used only 0.4% of the time to boost batteries and to make up for poor isolation. They are used some 7% of the time for charge equalization.

The system was built under the sponsorship of the U.S. Department of Energy and the Department of the Interior at a cost of $4 million. It produces power at a cost of $1.49/kWh. The system designers think an improved version could be fabricated for somewhat less than $670,000, owing to cost-saving experiences gained while working with the prototype. This would drop the power cost to 25¢/kWh.

Other operating systems are being used at Papago Indian Reservation village Sil Nakya, 190 km west of Tucson, Arizona. A 3.5-kW solar-electric generator is used to light 15 houses for the 92 residents of the village. It also provides power for the fresh-water pumps, a washing machine, sewing machine and 15 refrigerators. Sil Nakya is 27 km from the nearest source of commercial electricity.

A 60-kW photovoltaic system is used to power the Air Force radar station on Mount Laguna, 80 km east of San Diego. I remember this site on Monument Peak from my association with the K6JCC civil defense group from Santee, California, during the late 1950s. We conducted some simulated evacuation/emergency drills from that radar site, with the kind permission of the Air Force. The elevation is approximately 6000 feet, and the air is clear (and crisp!), making the site ideal for the deployment of solar-electric panels.

The Mount Laguna system has been in operation since June of 1979, and on a typical day it will deliver some 45 kW for roughly 6 hours. The solar-power system has no storage batteries. It augments diesel power that is already in use. The output of the system is inverted to ac.

The demand for solar-electric power is expected to increase, and it is predicted that by the year 2000 as much as 30% of the nation's power will come from solar-electric systems. The demands for solar-electric cells will bring the cost down, which will no doubt encourage greater use by amateurs for repeaters, Field Day equipment and even home-station gear. — *Doug DeMaw, W1FB*

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EXPERIMENTAL ACTIVE KEY-CLICK FILTER

☐ I received local reports of severe key clicks while using my Trio/Kenwood 2-meter ssb/cw transceiver (TR-7010), even though the final amplifier was checked and found to be operating linearly. The original keying circuit is shown in Fig. 2. Although the TR-7010 may not be a widely recognized piece of equipment, this information on active click filtering may be helpful in treating other brands of gear.

I desired to use a high order key-click filter. Inductors could not be used because of limited space. With the circuit of Fig. 3 it is convenient to use op amps for the filter. A transistor has been added to provide some additional safety margin for the current that may be present in the keying circuit. R7 is used to prevent accidental damage from short circuiting.

The circuit was tested first without C1, but some bad overshoot was observed at the output of U1. The addition of C1 cured the problem. While the filter was designed to be a second-order type, it performs more like a third-order low-pass filter. It has been tested on the air, and no key clicks were noted up to above 1000 LPM (letters per minute),[1] which translates to 200 wpm. Above 1000 LPM I use a 1500-Hz, zero-crossing sine-wave oscillator, which is fed to the microphone input.

Another problem that arises at high keying

[1]On-the-air reports indicate that distortion is noticed as a slight reduction of the dot-dash ratio at 1500 LPM.

*Senior Technical Editor

speeds is ssb crystal-filter distortion. Even at 1000 LPM, the distortion is quite severe, as observed on an oscilloscope. This is only about 250 baud, and I wonder if anyone has thought about this problem when planning to use 600 or even 1200 baud on an ssb transmitter. Perhaps some type of equalizers will be used in amateur equipment soon. — *Jan Martin Noeding, LA8AK, Voielien 39/B, N-4620 Vaagsbygd, Norway*

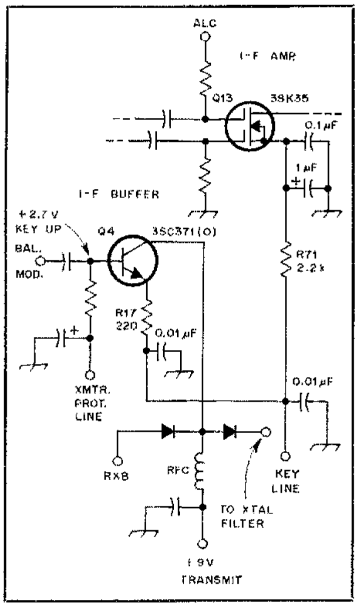


Fig. 2 — Original keying circuit of the Kenwood TR-7010.

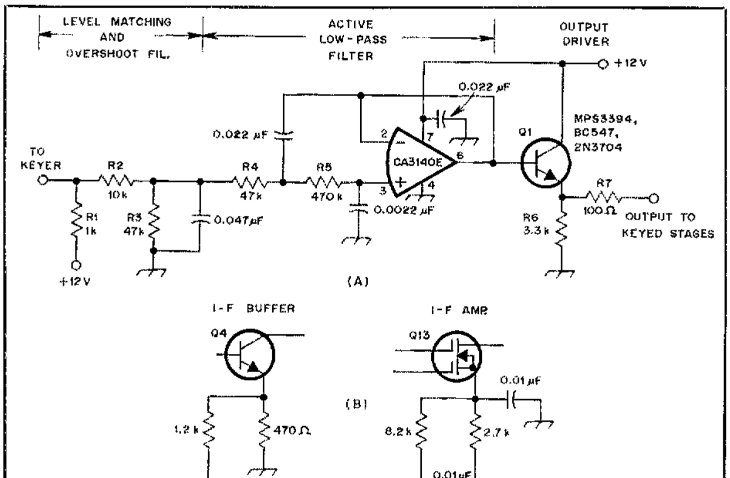


Fig. 3 — The LA8AK active key-click filter is shown at A. The circuit at B illustrates the original TR-7010 circuit after changes were made to the emitter and source resistors of Q4 and Q13.

IMPROVED FEED-HORN SUSPENSION FOR THE MONTGOMERY WARD DISH

☐ Recently, when I began copying horizontally polarized GOES CENTRAL and well as vertically polarized GOES WEST, the unwieldiness of the original unit[1] became very apparent. After a session at the drawing board a new suspension was devised and built. It corrected the former problems. Certainly other solutions are possible, but the present one is simple and effective.

The metal conduit supporting the can assembly in the original unit was cut off about 2 inches (in. = mm × 25.4) toward the can from the clamp/horizontal "mast" assembly (Fig. 4). Onto this stub was "epoxied" the threaded end of a 3/4-inch PVC female adapter. Into the PVC end was placed (PVC cement) a 1-1/2 inch length of PVC pipe, which in turn was cemented into the PVC end of another female adapter.

Into this latter female adapter is screwed the feed-can assembly. This unit is made from a male adapter, a 6-inch length of 3/4-inch PVC pipe and a disc cut from 2-inch foam insulation[2] that is pierced at the center to slide onto the PVC pipe (Fig. 1). The diameter of the disc should allow it to fit snugly into the anterior 2 inches of the feed can. The can and disc are adjusted for focus and then secured together with epoxy cement (PVC cement can't be used with the foam insulation).

The polarization is adjusted by rotating the can assembly where it is screwed into the dish assembly. To facilitate this adjustment, the PVC pipe is drilled to take a 3-inch length of wooden material to serve as a handle (optional). The focus is not adversely affected by the small adjustments necessary to obtain correct polarization. — *Lindsay R. Winkler, Rte. 1, Box 209, Walla Walla, WA 99362*

[1]Described in *QST*, March 1980, p. 48.

[2]Two-inch foam insulation is obtainable in 4- × 4-foot (m = ft × 0.3048) sheets at low prices. But what does one do with what's left over? If this is a problem, either scrounge some from a builder friend, or try using the odd-shaped pieces used in instrument packing.

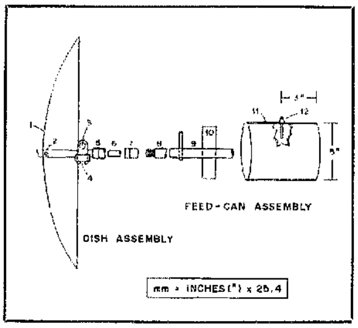


Fig. 4 — Details of the restructured feed system.

Feedback

☐ In "A Progressive Communications Receiver," November *QST*, Table 3 incorrectly shows a subhead labeled *C22 (turns)*. This should be changed to *C22 (pF)*. Also, author Hayward points out his error in equation 3 of the appendix, page 4. C_v should be changed to read C_u.

☐ Dennis Boyd, KC7BE, spotted an error in Bob Heil's "Experience 10-Meter FM Operation" (Fig. 6, p. 26, August 1981 *QST*). In redrawing the pattern for publication, we omitted the trace between pins 3 and 4 of U1.

☐ Dave Geiser, author of the Technical Correspondence item, "Wave Traps with Three Components" (November 1981 *QST*, p. 47), advises that he erred in the captions for the drawings at A and B of Fig. 2. Fig. 2A is actually a circuit with anti-resonance *above* the resonant frequency, while that in Fig. 2B is a circuit with anti-resonance *below* the resonant frequency. The text is correct.

☐ Some dimension errors crept into Fig. 1 of "The New Frontier" in November 1981 *QST*. The millimeters-to-inches conversion should read "in. = mm × 0.03937." Several dimensions that were converted to millimeters should have been expressed in inches: The waveguide hole shown at the top left of the drawing should be 1/8 in. The other hole should be 1/4 in. The Teflon or Mylar at the upper right should be 1/8 in. dia. Finally, the width in the top view should be 0.5 in. on either side of the hole.

☐ The photos of nostalgic transmitters shown in a December 1981 Stray, page 31, are reversed. The Hartley 201 should be on the left, and the 59 Tri-Tet and 801 should be on the right.

☐ The "*QST* Abbreviations List," December 1981, page 68, includes "THz — tetrahertz." This should read, "THz — terahertz."

☐ Items for Product Review, Index to Volume LXV—1981 (December *QST*, pp. 226-231), are listed under appropriate categories. The full list appears in this issue, page 91.

Hints and Kinks

Conducted By Larry D. Wolfgang, * WA3VIL

THE POCKET MAG MOUNT

☐ Looking for a small, efficient magnetic-mount antenna that complements the convenience and portability of your hand-held? If so, this inexpensive project may be for you.

You will need a magnetic mike holder (Radio Shack part no. 21-1130), a chassis-mount female BNC connector (RS 278-105) and a solder lug to fit over the threads of the BNC connector. You will also need a length of RG-174/U coaxial cable and a BNC male connector.

Use needle-nose pliers to bend the entire "finger" part of the holder up at a 45-degree angle. Next, bend the last half of this section so it is parallel with the magnet (see Fig. 1A). The last bend is made to bring the ends of the "fingers" a little closer together to form a partial loop (see Fig. 1B). Place the BNC connector through the opening, and tighten the nut to hold the solder lug and connector in place. You may have to squeeze the loop to ensure a better fit. Prepare the end of the coaxial cable, and solder the shield to the solder lug. Next, solder the center conductor to the connector pin. To provide strain relief, thread the other end of the cable through the space between the mike holder and the connector (see Fig. 1C). Seal the exposed connections for weather protection, and install the male BNC connector on the remaining end of the coaxial cable.

You can now use your "rubber duckie" on the mag mount, or you can make a 1/4-λ antenna using another male BNC connector and 19 inches of wire. The mount serves nicely as a highly flexible patch cord when using the hand-held with additional equipment or antennas. Results have been gratifying. When not in use, the mag mount can be stored in the glove compartment of the car, or carried in your pocket. — *Steve Brtis, WA6FGW, Woodland Hills, California*

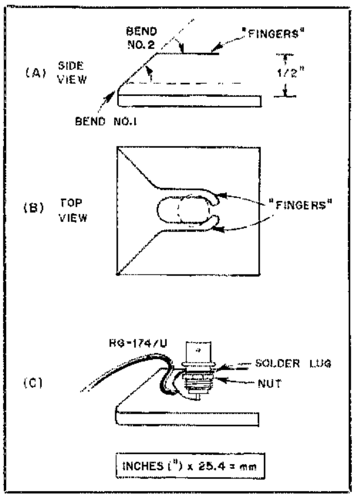


Fig. 1 — (A) Details showing how the mike holder is bent to form the base of the pocket mag mount. (B) Top view, showing the mike-holder fingers bent to hold the BNC connector. (C) Final assembly of the pocket mag mount.

COAXIAL-CABLE WIRE STRIPPER

☐ I have found that discarded RG-59/U cable (as obtained from cable TV sources) makes an excellent source of braid for ground-strap material. The wire can be used for ground radials or even for dipole antennas.

I made a simple device to remove the outer insulation. Use a scrap piece of pine "two by four," about 6 inches long (mm = in. × 25.4). Drill a 1/4-in. hole about 3/4 in. from one end. With the block fastened in a vise, drive a disposable steel blade used in a "sheet rock" (or "utility") knife into the wood, with the grain. Drive the blade nearly into the hole, being careful to keep the blade parallel to the hole. Now carefully tap one end of the blade into the hole as shown in Fig. 2.

Insert the coaxial cable, and pull it through from the other side with pliers. Watch your fingers! Adjust the cut by tapping the blade slightly deeper into the hole to ensure cutting the insulation but not the braid. Many feet of cable can be pulled through in a short time. — *P. K. Hurlbut, N5DHN, Midland, Texas*

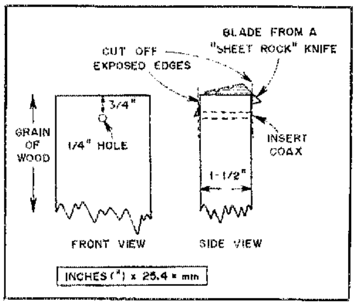
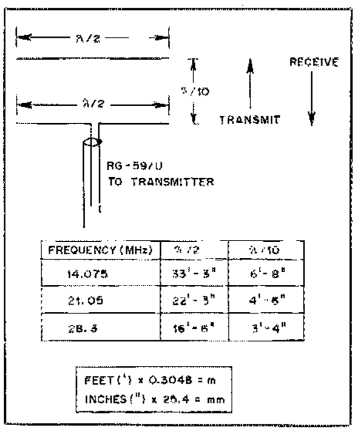


Fig. 2 — Construction details of a jig for stripping the outer insulation from large amounts of coaxial cable. [Exposed edges of the blade could be cut or ground off as a safety measure — Ed.]

A TWO-ELEMENT INDOOR ANTENNA

☐ Faced with indoor-only antenna restrictions, and knowing: (1) the antenna is more important than transmitter power, and (2) a multielement antenna is better than single-element types, I decided to build an indoor two-element wire beam. A two-element beam is only two parallel conductors separated by some fraction of a wavelength. Under ideal conditions it provides about 6-dB of gain (four times the power) and a lower angle of radiation than a dipole. Using data from *The ARRL Antenna Book*, I made the wire beam from no. 18 wire and hung it from the ceiling of the apartment. I used a 20-meter version, but dimensions are given for three hf bands. This two-element indoor antenna is a significant improvement over the dipole it replaced. Fig. 3 shows the construction details. — *John Gallagher, K4GXY, Dhahran, Saudi Arabia*



FREQUENCY (MHz)	λ/2	λ/10
14.075	33'-3"	6'-8"
21.05	22'-3"	4'-5"
28.5	16'-5"	3'-4"

Fig. 3 — Construction details and dimensions for two-element indoor antennas for three hf bands.

LEFT-HANDED KEYER

☐ Here may be an idea of interest to left-handed cw operators — a simple adapter I wired when teaching a left-handed person how to send cw with a keyer.

For right-handers the convention is dots on the thumb, apparently because of its agility. Some "southpaws" learn on right-handed keyers, but when teaching a local ham to use a keyer, I thought I would give him the advantage of the thumb on the dot. Changing the wires at the keyer required disassembly. To get around this problem I wired an adapter with a three-wire shielded phone plug on one end, and a similar jack on the other end. The ground is common, but the tip of the plug connects to the ring of the jack, and vice versa. By plugging the paddle into the adapter and plugging the adapter into the keyer, the dot and dash wires are interchanged. Now switching from right- to left-handed keying is as simple as adding an adapter. — *Bill Conwell, K2PO, Atlanta, Georgia*

CLIPPERTON-L 60-Hz HUM

☐ The monitor 'scope showed considerable 60-Hz amplitude modulation when my Clipperton-L was switched in. Signal reports on cw and ssb confirmed the condition. A friend's Clipperton-L, in an identical set-up, behaved the same way.

The linear-amplifier schematic showed no filament winding center tap for the directly heated 572Bs. The bias Zener diode (D1) was connected to one side of the power transformer

*Assistant Technical Editor

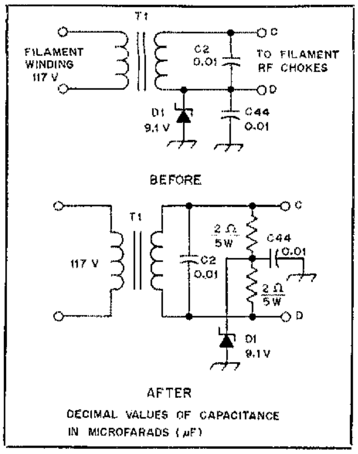


Fig. 4 — The addition of two 2-ohm resistors cures 60-Hz hum problem in the Clipperton-L amplifier.

filament winding. This effectively cathode-modulated the linear amplifier with the filament voltage.

I returned the amplifier to Dentron, and they cured the problem by modifying the circuit as shown in Fig. 4. The 2-ohm resistors create a 60-Hz balance to ground for the filaments and eliminate the 60-Hz hum.

If the Clipperton-L is loaded beyond about 500 mA on cw, 120-Hz ripple may be seen on the 'scope. This is caused by the normal ripple of the full-wave voltage doubler power supply when heavily loaded. I reduce the drive to the amplifier until the waveform on the 'scope is clean. This still produces 700 to 800 watts of dc input power. — *Manny Block, WØPIG, St. Paul, Minnesota*

HALLICRAFTERS HA-5 VFO IMPROVEMENTS

☐ The Hallicrafters HA-5 VFO exhibits a rapid change in frequency during the first few seconds of each transmission. This effect is caused by poor voltage regulation in the power transformer (T1), which causes a drop in filament voltage when the B+ supply is loaded during keying.

The cure for the problem is to disconnect the filament of the 6U8A oscillator, V1, from T1 and power it from a separate source. This can be a small 6.3-volt transformer capable of supplying 0.5 ampere. This transformer can be mounted on the grounding stud on the rear panel. The primary can be connected in parallel with that of T1, or ahead of switch SW1-F to keep the V1 filament powered when the VFO is turned off, which will reduce warm-up drift. The VFO in the Hallicrafters HT-44 transmitter has the same problem.

The HA-5, normally cathode-keyed, can be converted for use with grid-block-keyed transmitters with −80 volts or more on the keying lines, without making irreversible changes or drilling holes in the chassis.

The changes consist of disconnecting the cathode resistors, R12 and R21, from the orange lead of the CAL-OFF switch and grounding them to the chassis. Disconnect the ungrounded ends of R5, R7, R10 and R22, leaving them bent out of the way. Install new resistors of the same values, respectively, for R5, R7 and R10, so the long leads will reach to connect with the orange CAL-OFF lead.

The grid-block-keyed transmitter negative lead then goes to the terminal marked "+", and the transmitter ground connects to the terminal marked "⏚" on the VFO keying terminal strip. — *Tuckerman Jalet, AA1C, Stamford, Connecticut*

A DESK-TOP HOLDER FOR HAND-HELD TRANSCEIVERS

☐ This desk-top holder for my Kenwood 2400 has been a handy item. The base is made of 3/4-inch pine. The hole for the radio is cut with a saber saw. Strips of foam rubber are glued to the front and back of the opening to provide a secure fit. Rubber feet are added for additional stability. Fig. 5 shows construction details. — *G. Stewart King, KF8S, Tipp City, Ohio*

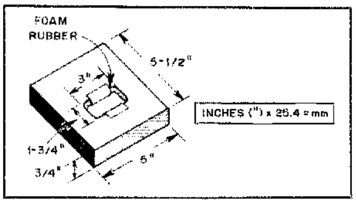


Fig. 5 — Construction details for the desk-top holder. Dimensions can vary to fit the shape of your radio.

NEEDLE-NOSE PLIERS VISE

☐ An alternative to the May 1981 *QST*, page 45, Hints and Kinks problem requires no drilling and tapping of the tool handle. Just stretch a rubber band, and wrap it tightly around the handle as shown in Fig. 6. This vise is useful for holding small items during assembly, or holding wires for soldering. — *Jack Rosen, KA8LFX, Farmington Hills, Michigan*

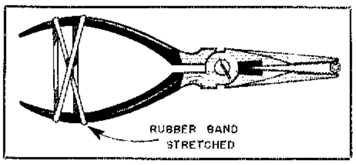


Fig. 6 — Using a rubber band to make a needle-nose pliers vise.

SECONDS SET FOR THE HEATHKIT GC-1107 DIGITAL CLOCK

☐ The Heathkit Model GC-1107 digital clock makes an attractive, electrically quiet addition to the shack. As it comes, it is impossible to set the seconds exactly, or even to view them. This can be corrected easily by placing a jumper wire from pin 24 to the unused pin 32 on the clock chip, IC1. To set the clock, first push the SNOOZE switch. The seconds and the least-significant-minute digit will be displayed. Keeping the SNOOZE switch depressed, push the FAST SET switch. The seconds will be zeroed, and the clock stopped. Simply release the FAST SET switch on the minute, and then the SNOOZE switch. Using the SLOW SET instead of the fast will stop the clock without changing the display. The other clock functions, including the alarm, are as before. It is common practice to use a full-feature clock chip with only the basic features used in inexpensive clocks. Check the pins on your particular chip to see if you can expand the features of your clock. — *Alan Biddle, WA4SCA, Huntsville, Alabama*

SELF-ADHESIVE EQUIPMENT FEET

☐ I have tried all of the usual methods — screws, carpet tape, rubber cement, and so on — for preventing small items such as keys and calculators from sliding around, but was never happy with the results. The equipment couldn't be moved easily, and either holes or adhesive residue were left behind.

The J. I. Morris Co. sells self-adhesive equipment feet disguised as eyeglass nose pads. They're great. I have even placed them on the regular rubber feet on my bug. The equipment will not slide! If I want to move it I have to pick it up. They cost about 10 cents each in packages of six.

Prior to installing these pads, clean the surface to which they will be applied with fine sandpaper or emery cloth. — *Dan Ringer, K8WV, Morgantown, West Virginia*

GARAGE-DOOR OPENER — THE KEY TO A TVI PROBLEM

☐ Interference on channels 2 and 6 persisted over a period of several years to the family color TV set whenever my amateur equipment was operated on 10 or 15 meters (especially on 10 meters). Considerable expense and effort was expended to add low- and high-pass filters, in addition to wrapping power cords around ferrite rods. Various transmitting antennas, antenna tuners and assorted commercially manufactured amateur transmitters in the 150-to 250-watt class were tried, but the TVI persisted. The logical conclusion was that some device external to the amateur equipment and the TV set was reradiating the transmitted wave with distortion. But what?

I remembered that several years ago the garage door would open, apparently without cause. To protect the family security, a more sophisticated radio-controlled garage-door system was installed. This add-on system (Sears 139.653300) operates near 390 MHz, and it should not be responsive to amateur transmissions below 30 MHz.

Suspicion dwelled in my mind about the 35-foot length of zip cord connecting the garage door opener to the actuating push button. The rf voltage, induced at the garage-door receiver, could be high enough to cause some nonlinear functioning.

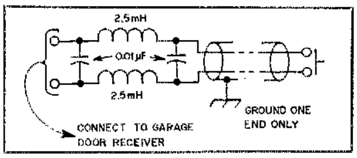


Fig. 7 — An annoying case of TVI was traced by John Hartung, W7THY, to his garage-door opener. Installation of a simple pi network, as shown here, and some shielded cable brought the TVI chase to a happy ending.

Temporary removal of the garage-door electronics to a shielded enclosure (the microwave oven — *not* turned on!) provided *clear* TV reception when the transmitter was operated.

Subsequently, the zip cord was replaced by a "shielded pair," and the connection to the replacement garage-door receiver was equipped with a pi network consisting of an rf choke in each lead and with 0.01-μF bypass capacitors, as shown in Fig. 7. This cured the interference!

The TV antenna is located only 7 feet from the garage-door receiver, and that may account for the severity of the interference. Fortunately, no TVI complaints were received from the neighbors. My experience may serve to alert other amateurs to another source of interference to TV reception. — *John W. Hartung, W7THY, Glendale, Arizona*

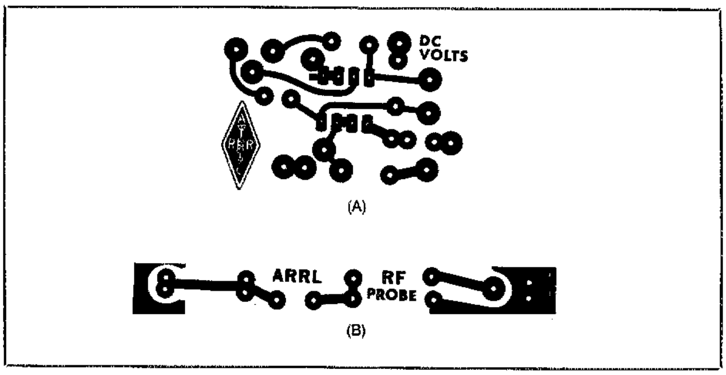
NICKED WIRE CAUSES TROUBLE IN KENWOOD 180S-DFC

☐ Periodically my newly purchased Kenwood 180S-DFC failed to operate. I traced the trouble to the B+ control lead connected to the ON-OFF switch. The insulation had been cut by the edge of a metal partition. The area affected is just to the left of the filter unit (X51-1180-00) as seen from the top and rear of the transceiver. See page 37 of the manual.

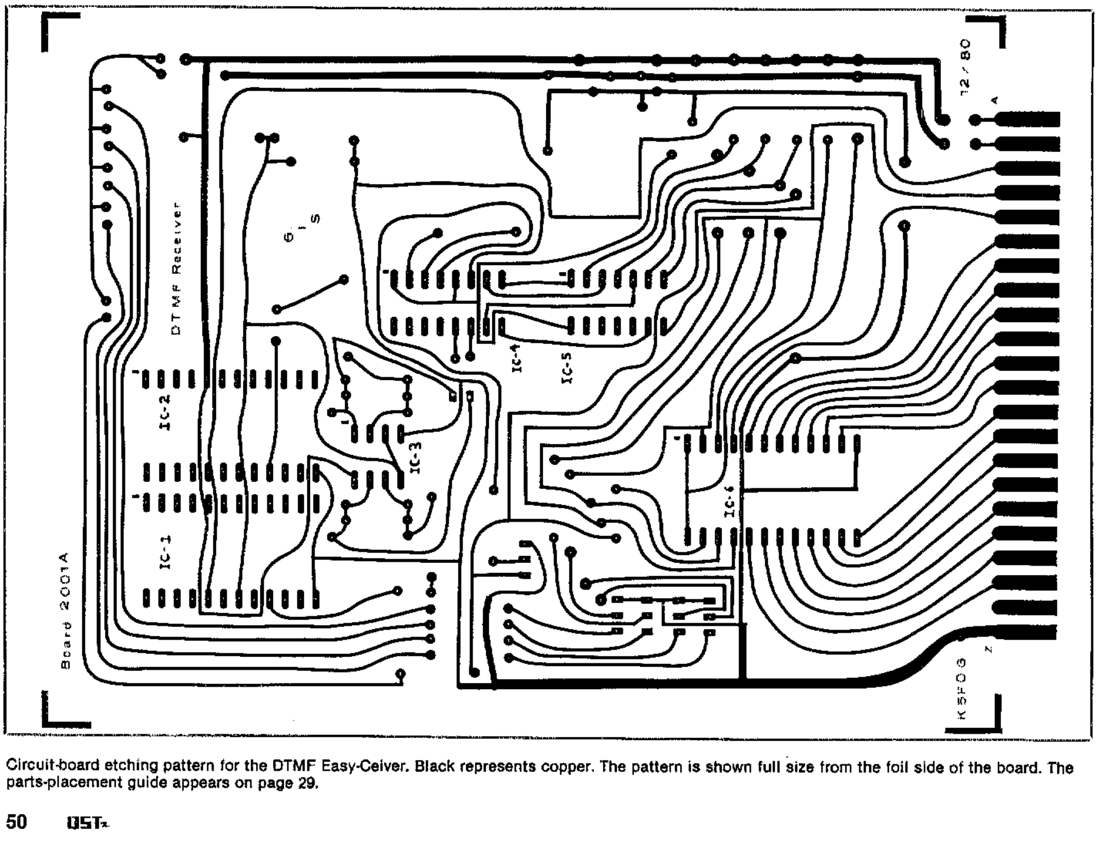
Since the insulation was nicked on other wires in the cable, I placed a piece of fish paper between the metal partition and cable harness. I hope this may help other 180S owners who may experience a similar difficulty, especially those who operate mobile — a situation which could aggravate this condition. — *J. M. Clarke, W6VBI, Sacramento, California*

TEN-TEC DELTA PARASITIC OSCILLATION

☐ The dc current limiter was shutting down my Ten-Tec Delta rig as I attempted to load it with a feed line that had a low SWR. My guess was that there was some connection between the parasitic oscillation and the load. There is a one-turn coil on a ferrite bead on the dc line to the final amplifier. In my unit the bead was about 1 inch (25 mm) from the final-amplifier compartment and was touching the case top. By pushing the bead along the wire closer to the final amplifier and bending the wire away from the case, I eliminated the problem. In my case, changing the length of the feed line might have helped also. — *Roger Graves, W1TZ/VE7, Victoria, British Columbia*



Scale pattern for the FET voltmeter (A) and rf probe (B). Components are mounted on the nonfoil side of the board. The black areas are unetched copper viewed from the foil side of the board. A parts-placement diagram appears on page 41.



Circuit-board etching pattern for the DTMF Easy-Ceiver. Black represents copper. The pattern is shown full size from the foil side of the board. The parts-placement guide appears on page 29.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devoted entirely to Amateur Radio
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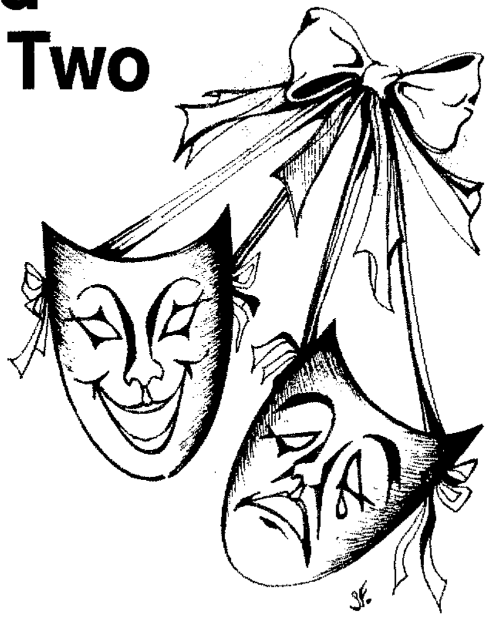
THE COVER

Plaques such as this one will be awarded to many of the top operators in the 1982 ARRL International DX Contest, the largest, most prestigious DX event in Amateur Radio. See page 77.

Contents

Entertainment and Interference: The Two Faces of CATV



Heard any good TV on 2 meters lately? Are the neighbors watching your transmissions? Here are the ins and outs of cable television.

By Robert V. C. Dickinson,* W2CCE

Cable television (CATV) was known originally as "community antenna television." Today it represents the broad area of entertainment and other services carried over coaxial cable networks to various subscribers. As implied by the name, the original purpose of CATV was to serve communities with entertainment television service where TV reception was poor. The idea was to find one good receiving site, pick up signals from local and distant TV transmitters, and relay these signals by way of coaxial cable to residents of the community. This concept was applied widely, and many people enjoyed satisfactory TV reception through these systems.

In the early days a few channels were distributed within the vhf band. The limit was generally the 12-channel capacity of the standard vhf television receiver. Many 12-channel cable systems are still in operation. Cable television has not always been an economic success. Therefore, in recent years, systems have been enlarged to carry many more channels with particular emphasis on premium entertainment services such as Home Box Office and Show Time.

Today, sophisticated CATV installations offer high capacity and quality in essentially closed communication systems. A wide variety of quality equipment is available from a number of manufacturers to construct the systems and implement the services. CATV systems serve mainly residential subscribers; they are installed on a franchise basis in each community. There are nearly 20 million cable homes across the United States. Cable TV systems have also proved popular in Canada. Large CATV installations can be found in various other countries around the world.

Many of the recent franchise requirements have called for increasingly sophisticated systems with high capacity and interactive services. In order to better understand the relationship of the amateur operator to CATV, we will look at a typical system. We will then look at the possibilities of interference to and from Amateur Radio.

*E-Com Corp., 320 Essex St., Stirling, NJ 07980

Typical CATV System

A typical cable television network is illustrated in Fig. 1. This simplified drawing illustrates the principles of CATV. At the headend, off-air television signals are received and processed. The processing involves filtering to eliminate out-of-band signals, adjustment of the sound carrier level (which is regulated by the FCC to be 15 ±2 dB below the video carrier), and frequency translations as required to carry a uhf signal in the vhf band. In addition to the off-air signals, satellite receiving stations are often used to pick up the satellite premium entertainment packages. More than 30 of these packages are now available. Additional program material may include local originations plus information channels using alphanumerics, graphics and the like.

At the headend the signals are properly processed and formatted; all signals are then combined and broadcast throughout the CATV system to the subscribers. From the humble beginning of 12 channels, CATV formats have gone to 20, 26, 30, 36 and now as high as 55 channels. CATV systems with more than 12 channels employ "converters" to expand the subscriber TV set capacity. These converters are merely tuners that can select any channel in the system and convert it to a single TV channel. Converter output is usually on channel 3 or 4. Fm broadcasts may also be carried, often in the standard 88- to 108-MHz fm band.

Once inside the coaxial cable, the signals are routed throughout the community. Obviously, there are losses where the signals are split in power dividers as well as losses in the cable itself. The cable losses are greater at higher frequencies. Tilt equalizers are used to attenuate the low-frequency end, restoring a flat response; amplifiers then restore the operating levels.

The main distribution path of the cable

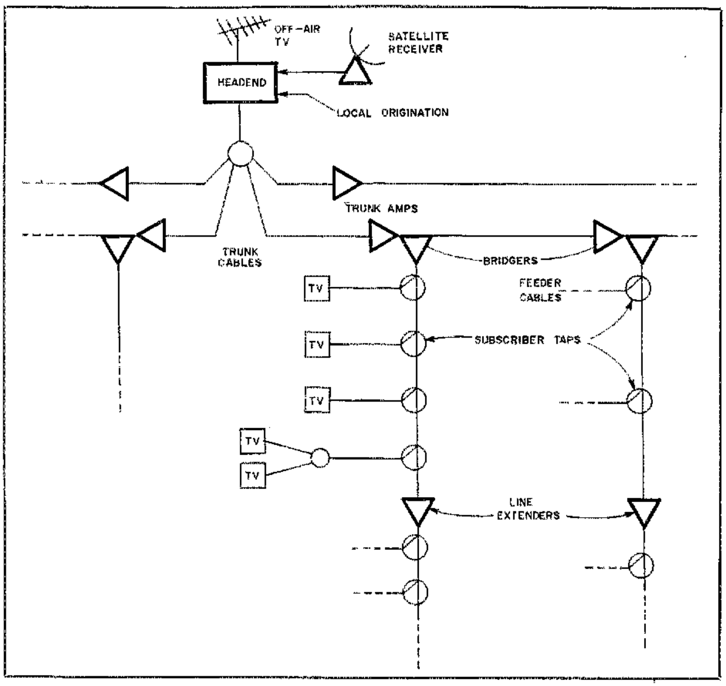


Fig. 1 — A typical CATV installation consists of the headend, trunk and distribution systems. Cable signals originate at the headend. The trunk system carries the signals to the various parts of the service area. Individual subscribers receive their signals from the distribution system.

network is known as the trunk system. A trunk system carries the signals to the various areas of the community but does not feed subscribers directly. Trunk amplifiers are appropriately placed to make up for cable or system losses and to maintain the signal quality. Normally, signals for distribution to subscribers are extracted by power division and reamplification. This is accomplished by bridger amplifiers that are located inside the same housing as the trunk amplifiers.

The bridgers feed the distribution system, which is tapped with passive directional couplers to supply the subscriber drops. At the point where the losses in a distribution leg reduce the signal to a predetermined level, distribution amplifiers commonly known as line extenders are added. The CATV trunk system may extend for many miles and employ dozens of amplifiers. The distribution system, on the other hand, seldom uses more than two or three line extenders in any leg. The line extenders are operated at levels 10 to 20 dB above the trunk amplifiers. Transmission of analog signals, such as television, requires that signal levels be run as high as possible to obtain the best carrier-to-noise ratio. The limiting factor on the level is the distortion in the broadband amplifiers. There is a noise contribution by each amplifier so that the noise floor increases as the number of cascaded amplifiers increases. The levels of operation along the trunk system are such that the distortion buildup and the noise buildup both become objectionable with about the same number of amplifiers in series. This obviously is the maximum useful system length. In the distribution system, high-quality signals are delivered by the trunk. The line extenders can be run at higher levels than the trunk since very few series line extenders are employed. Higher levels allow feeding more customers per amplifier and hence have economic advantages.

There are many different cables available for CATV, all having a 75-ohm characteristic impedance. The trunk and distribution cables have solid aluminum outer conductors; they range from less than 1/2 inch[1] to approximately 1 inch in diameter. This choice allows the system designer to optimize performance and cost. The final feed to the subscriber generally uses RG-59/U or RG-6/U flexible cable, supplied usually with several layers of shielding. The shielding may be braid or foil, or various combinations of the two.

One of the greatest achievements of cable television technology is the ability to amplify a broad band of frequencies. A 36-channel system generally occupies the frequency range of 54 to 300 MHz; 55-channel systems range from roughly 54 to 440 MHz. CATV amplifiers are able to amplify this spectrum with very low ripple in the response. Many semiconductor developments have contributed to this. The most important is probably the development of hybrid amplifier modules.

It is important to be aware of the levels at which signals are carried on the cable system. In CATV a new unit of measure has been established. This is the *dBmV*, which is the voltage level in decibels referenced to 1 millivolt across 75 ohms. (Since the impedance is fixed, this also represents a reference power level.) The signal arriving at the subscriber TV set is required by the FCC to be equal to or greater than 0 dBmV. This equals -48.75 dBm, where 0 dBm is equal to 1 mW. The TV signal carrier level arriving at the customer set, therefore, is in the range of 0.013 microwatt to a little less than 1 microwatt — not very much power. It is possible to see in a TV picture interfering signals that are as much as 65 dB below the visual carrier level. Minus 65 dBmV is approximately 4×10^{-15} watts or 4×10^{-9} microwatts — an exceedingly small power level. The level of a TV signal at the output of a bridger amplifier or line extender is in the range of +38 dBmV to perhaps +50 dBmV, and that at the output of a trunk amplifier in the order of +30 dBmV. The point of this is that CATV works on low power levels, particularly when compared with transmitters running 1000 watts (+60 dBm or +108.75 dBmV). Gain antennas concentrate power and can further compound the situation.

CATV Channels

When off-air signals are carried on the broadcast frequencies, interference from or to an amateur station is generally not experienced. The frequency relationship of amateur signals to the CATV channels are the same as those to the off-air channels so that any disturbances are generally caused by harmonics or overloads. Because of the shielded system this does not usually occur. When the CATV coverage is virtually continuous from 50 to 300 or 450 MHz, a number of amateur frequencies are utilized inside the cable. It is helpful to know the frequency locations used on the cable system. Table 1 shows three commonly used channelization plans. A channelization plan is selected by the cable operator.

The plan of channelization designated as "standard" is based on the standard broadcast frequencies of the low and high vhf channels and is very commonly used. Even the small amount of harmonic and intermodulation distortion in a CATV amplifier causes products to occur at the sum and difference frequencies of the various signals. In the standard plan these distortion products often fall at frequencies that cause visible interference to the

[1] mm = in. × 25.4

Cable Television Regulations

Conducted By Richard K. Palm,* K1CE

The preceding article presents a tutorial on the technical and operating facets of cable television (CATV) as well as a discussion on systems' interference potential. This special edition of "Washington Mailbox" covers the matter of federal intervention in these areas.

As with the Amateur Radio Service, the Cable Television Service is regulated in this country by the Federal Communications Commission. The FCC is the government agency charged with the task of rulemaking in the CATV service and enforcement of the standards and regulations applicable to systems operation. As the familiar Part 97 affects amateurs, it is Part 76 of the Commission's rules that concerns cable system operators.

Q. How is cable TV defined by the Commission?

A. FCC defines a cable plant as follows:

> Cable Television System. A nonbroadcast facility consisting of a set of transmission paths and associated signal generation, reception and control equipment, under common ownership and control, that distributes or is designed to distribute to subscribers the signals of one or more television broadcast stations, but such term shall not include (1) any such facility that serves fewer than 50 subscribers, or (2) any such facility that serves or will serve only subscribers in one or more multiple unit dwellings under common ownership, control or management.

Key words include *nonbroadcast facility*; e.g., cable systems do not broadcast programming to subscribers. Programming is distributed by a closed system of cables and associated equipment — pathways which, by definition, do not utilize the airwaves.

The purpose of Part 76 is detailed in Section 76.1:

> The rules and regulations set forth in this part provide for the certification of cable television systems and for their operation in conformity with standards for carriage of television broadcast signals, program exclusivity, cablecasting, access channels and related matters.

Q. What is the substance of Part 76?

A. Subpart A provides the aforementioned purpose of the rules as well as a reference to applicable rules contained in other Parts. Definitions of key terms, information on special relief petitions and discussions of enforcement actions are also included in Subpart A.

Other subparts are concerned with registration and certification, federal-state/local regulatory relationships, carriage of TV broadcast signals in various market situations, nonduplication protection and syndicated exclusivity, cablecasting, diversification of control, forms and reports, technical standards and operation requirements. While discussion of most of these areas is beyond the scope of this treatise, subpart K, the technical standards portion, is of interest to amateurs in the matters of CATVI.

Q. What are the technical standards?

A. Just as amateurs are required to ensure that their operations meet certain technical standards, cable system operators must also comply with similar federally imposed standards.

The frequency boundaries for CATV channels are found in Section 76.605(a)(1) and generally conform to television (broadcast service) channel arrangements. However, other configurations may be approved by the Commission.

The limits for allowable radiation from a cable system are contained in Section 76.605(a)(12) of the rules:

Frequencies	*Radiation Limit (μV/m)*	*Distance*
Up to and including 54 MHz	15	100
Over 54 up to and including 216 MHz	20	10
Over 216 MHz	15	100

The rules also provide for the method of measurement of these parameters.

Section 76.609:

> (h) Measurements to determine the field strength of radio frequency energy radiated by cable television systems shall be made in accordance with standard engineering procedures. Measurements made on frequencies above 25 MHz shall include the following:
>
> (1) A field strength meter of adequate accuracy using a horizontal dipole antenna shall be employed.
>
> (2) Field strength shall be expressed in terms of the rms value of synchronizing peak for each cable television channel for which radiation can be measured.
>
> (3) The dipole antenna shall be placed 10 feet above the ground and positioned directly below the system components. Where such placement results in a separation of less than 10 feet between the center of the dipole antenna and the system components, the dipole shall be repositioned to provide a separation of 10 feet.
>
> (4) The horizontal dipole antenna shall be rotated about a vertical axis and the maximum meter reading shall be used.
>
> (5) Measurements shall be made where other conductors are 10 or more feet away from the measuring antenna.

Q. What are the rules pertaining to interference?

A. Section 76.613 regulates interference from cable television systems. Paragraph (a) defines harmful interference as "any emission, radiation or induction which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with this chapter."

Of critical significance as far as amateurs experiencing CATVI are concerned is paragraph (b):

> *(b) The operator of a cable television system that causes harmful interference shall promptly take appropriate measures to eliminate the harmful interference.*

Paragraph (c) provides authority to an FCC engineer-in-charge (EIC) for the suspension of a cable system operation should harmful interference to radiocommunication involving the safety of life and protection of property not be promptly eliminated by the application of suitable techniques. Paragraph (d) states that "The cable television system operator may be required by the EIC to prepare and submit a report regarding the cause(s) of the interference, corrective measures planned or taken and the efficacy of the remedial measures."

Q. What should I do if I experience CATVI?

A. The first step is to determine the origin of the interfering signals: Where is the leak? Then, write a letter to the system operator outlining the problem and the steps you have taken thus far, and reminding him of his obligation under the rules to clean up the interference. Try to seek out someone within the company who has the technical background necessary to deal effectively with the problem. If possible, enlist the support of other amateurs who are experiencing similar interference. Should the cable company adopt an unresponsive or uncooperative attitude, write again, outlining the continuing problem, and send a copy to the local FCC district office and to the municipal government exercising local control over the company's operation. It is normally in the best interest of the company to be responsive to complaints, as it can face federally imposed fines and local enforcement action by towns' authority in franchise agreements.

The ARRL is becoming increasingly concerned with the escalating incidence of CATVI. On page 9, you will find an editorial treatment of the problem and a description of the measures taken and proposed by the League. Your input is invited in this matter; please direct any information or questions to K1CE, CATVI Desk, ARRL, 225 Main St., Newington, CT 06111.

*Assistant Manager, Membership Services, ARRL

Table 1

Common Channelization Plans

Channel Name		*Visual Carrier Frequency* *Standard*	*HRC*	*IRC*
2		55.25	54.0	55.25
3	Low	61.25	60.0	61.25
4	VHF	67.25	66.0	67.25
5		77.25	78.0	79.25
6		83.25	84.0	85.25
A-2		109.25	108.0	109.25
A-1		115.25	114.0	115.25
A		121.25	120.0	121.25
B	Mid	127.25	126.0	127.25
C	Band	133.25	132.0	133.25
D		139.25	138.0	139.25
E		145.25	144.0	145.25
F		151.25	150.0	151.25
G		157.25	156.0	157.25
H		163.25	162.0	163.25
I		169.25	168.0	169.25
7		175.25	174.0	175.25
8		181.25	180.0	181.25
9	High	187.25	186.0	189.25
10	VHF	193.25	192.0	193.25
11		199.25	198.0	199.25
12		205.25	204.0	205.25
13		211.25	210.0	211.25
J		217.25	216.0	217.25
K		223.25	222.0	223.25
L		229.25	228.0	229.25
M		235.25	234.0	235.25
N	Super	241.25	240.0	241.25
O	Band	247.25	246.0	247.25
P		253.25	252.0	253.25
Q		259.25	258.0	259.25
R		265.25	264.0	265.25
S		271.25	270.0	271.25
T		277.25	276.0	277.25
U		283.25	282.0	283.25
V		289.25	288.0	289.25
W		295.25	294.0	295.25
AA		301.25	300.0	301.25
BB		307.25	306.0	307.25
CC	Hyper	313.25	312.0	313.75
DD	Band	319.25	318.0	319.25
EE		325.25	324.0	325.25
.		.	.	.
.		.	.	.
.		.	.	.
UU		421.25	420	421.25
VV		427.25	426	427.25
WW		433.25	432	433.25
XX		439.25	438	439.25
YY		445.25	444	445.25
ZZ		451.25	450	451.25

TV picture. In the harmonically related carrier system (HRC) all of the visual carriers are related harmonically (normally with a 6-MHz separation). The major distortion products fall on the carrier frequencies and are, therefore, less visible. The HRC system is being used increasingly in systems with 36 or more channels. The IRC or incrementally related carriers system performs somewhat better than the standard system, but is not as effective in reducing beats as the HRC system. In Table 1 the "Channel Name" column gives only one of the various designation systems that are used. When you are dealing with a CATV interference complaint it may be hard to know which cable channels are involved, much less the actual frequencies. For instance, it is not unusual for a cable system to take an off-air channel from uhf and put it on some midband vhf channel (120 to 174 MHz) so that channel 58 might now be called channel G. As you can see, things could become extremely frustrating without some knowledge of the facts.

Interference

CATV-related interference is a two-edged sword. As with normal TV interference the amateur can be the cause of picture disturbances experienced by CATV subscribers. It is also possible that leaks from the CATV system will produce interference signals in the amateur bands such as channel E in 2 meters, channel J and K in the 220-225 MHz band, or channels UU, VV, WW, XX, YY in the 432-450 MHz band. There are yet more possibilities, as we will see later.

As was said before, the cable system is, or at least should be, a closed system. Interference is usually caused by a leak in the CATV system that allows signals to escape from the system or to get in from the outside. The biggest offender is generally the flexible drop cable from the pole to the home. The shielding is less effective than the solid aluminum cable on the pole. The drop cable encounters more mechanical motion since it is flexible and moves in the wind. The F connectors used in CATV are low-cost items (about 10 cents each), and are subject to certain difficulties. These difficulties are usually caused by poor installation rather than a connector fault. They may be the result of physical damage, such as caused by pulling sharply on the coaxial line and thus separating the shield from the connector body. A recent survey by the Federal Communications Commission found that a high percentage of the leakage in cable systems occurs on customer drops. (Some have run a piece of 300-ohm twin-lead to their neighbor's house. Other "modifications" may result in the same kind of leakage.) Self-made taps and extensions on the cable drop should never be made. Not only are they morally wrong, they also open the door to interference problems.

Other problems result from poor connections arising from corrosion. The subscriber drop leaving the line normally comes to a hanger under the eave of the house, down the side of the house through a grounding block. Two types of grounding blocks are shown in Fig. 2. The shield is connected through a heavy copper wire to a ground in the electrical system, the cold water system or some other ground point accepted by utilities or the state regulatory agency. Rules and codes vary widely throughout the United States. Corrosion of the fittings on either side of the grounding block or poor ground connections often cause leakage or rectification of strong local signals.

The distribution and trunk sections of the CATV system are usually much tighter than the subscriber drops. There are, however, two major areas of leakage. The first is related to the use of old-style connectors that provide no clamping support for the sheath of the aluminum cable. This is true for both splices and connectors where the cable enters the housing of amplifiers or passive components (power dividers, directional couplers and so forth). Mechanical motion caused by the wind will often cause cold flow in the aluminum and hence a poor or intermittent connection. Leakage may also arise from cracks in the outer shield of the cable. This condition is less frequent in newer systems because improved installation techniques are used.

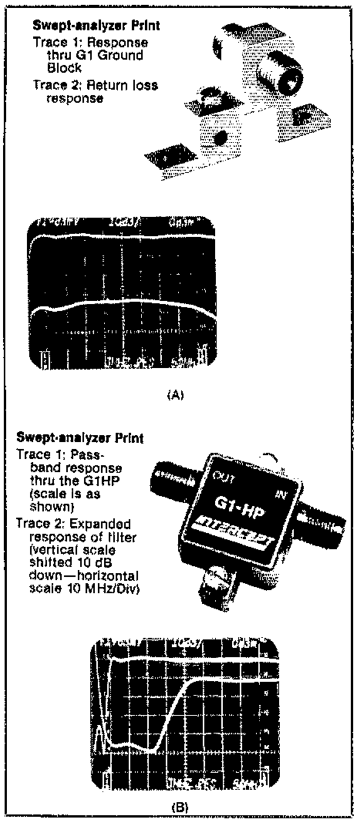


Fig. 2 — Grounding blocks are used at the subscriber drops. A typical unit is shown at A. The version at B contains a high-pass filter. *(photos courtesy of Intercept Corporation)*

A subscriber drop cable leaves the distribution line from a housing that includes passive directional couplers. The latter are used to tap off the proper amount of power to feed the subscriber's TV set. Usually there are four drops from each housing, which is called a "four tap." When an amateur experiences interference from pickup of his high-power radiation, it is possible that one or more of these taps is unused but not terminated. Tap terminations cost but a few cents since they are merely an F fitting with a 75-ohm resistor soldered inside. Resistors sometimes have their leads shaped and are plugged in without the use of an F fitting or solder. This procedure is suspect. The addition of the F connector (for 10 cents) by maintenance personnel is recommended.

The ultimate problem of amateur interference to CATV probably occurs when an amateur runs high power into a beam antenna directed at a portion of the cable system. In this case connectors and housings for amplifiers and taps may not have enough shielding. Since the power differential can be over 150 dB, it may be too much to ask that the cable system shield against this enormous differential. The potential for interference seems to be largely in the vhf region where amateur power may be somewhat lower, and where it is a lot easier to get antennas up higher (over the CATV system).

In some cases amateur interference is picked up on the connecting cable between the converter and the TV set. The viewer then sees the interference on all channels. The solution to this problem generally follows standard TVI elimination procedures. It is not directly related to the CATV system.

Two-Way Cable

The newest CATV systems provide bidirectional capability. If the description of a typical system did not excite your interest, notice that we are now adding an upstream path from every subscriber to the headend. All kinds of two-way services may now be implemented. Currently these include home security, power company load control, meter reading, traffic control, point-to-point communications, surveillance camera control and a host of others including the broad scope of interactive services to the home. These services will include banking, shopping, graphics, home computer services, catalog displays and services that have not yet been conceived.

To provide bidirectional transmission, the cable is fitted with reverse amplifiers, usually covering the range of 5 to 30 MHz. The configuration of 50 to 300 MHz or more downstream (from the headend) plus 5 to 30 MHz upstream is referred to as a "subsplit" CATV system. In cases where there are numerous industrial users or multiple residential cables, the "midsplit" system is often employed. Typical frequencies for a midsplit system are 5 to 120 MHz upstream and 174 to 300 MHz or more downstream.

Perhaps you begin to sense a potential problem. Some CATV systems are now operating in all of the amateur frequencies from 7 to 28 MHz where high power and large antennas are generally employed. One of the worst problems that operators of two-way cable systems have had to date is with citizens band transmissions. There are many CB transmitters, mostly mobile, making it difficult to locate the source of the interference. The matter of leakage from the cable system to the amateur on the upstream frequencies so far has been almost nonexistent because of limited use of two-way operation to date.

Interference entering the cable system on upstream frequencies results in an interesting problem. In the earlier description a typical system was shown to resemble a tree whose root is the headend. The system branches to feed different areas until finally it reaches the subscriber, which you might liken to the end of the twig on a branch. Consider signals being transmitted from subscribers to the headend. There is a situation where there can be thousands and thousands of "twigs" generating signals that all come together at the headend. Should an interfering signal enter the system, it is impossible to tell where it originated. This means that curing the interference may take a long time. In that time it can do a lot of damage since an intruding signal in an upstream data channel can totally obliterate the service. Cable operators are becoming aware of this problem and are taking steps to avoid it. The most flexible solution utilizes remotely controlled switches to selectively divide the system into areas. This technique can be used to locate the vicinity of interference entry. This section is then shut off, allowing the rest of the system to function while corrective action is taken.

Responsibility and Assistance

The responsibility of the cable system operator is defined directly and indirectly by FCC regulations. There has been a great deal of attention given to leakage from cable systems that might cause disruption of aircraft navigation and communications channels. These include the frequencies of 73.5, 108 to 136, and 225 to 440 MHz. Part 76 of the FCC regulations defines the leakage allowed. This is presently 15 microvolts per meter at 100 feet at frequencies up to 54 MHz, 20 microvolts per meter at 10 feet from 54 to 216 MHz, and 15 microvolts per meter at 100 feet above 216 MHz. The extra attention given to the FAA services had led to numerous other regulations and will doubtlessly lead to change (possible loosening) of the limits cited. A leak of 20 microvolts per meter at 10 feet can certainly be received by nearby amateur equipment, although this amount of leakage from a single point is not significant at relatively long distances. A leak of this magnitude will permit significant signal entry from a nearby high-power amateur transmitter.

The legal responsibility of the amateur in regard to cable television is no different than that of any other service. FCC regulations do not preclude all interference from amateurs to CATV viewers nor all interference to the amateur service from minor CATV system leaks. The amateur's role should be that of a diplomat and an ambassador for a fine and highly respected technical fraternity.

There is one major difference in dealing with CATV problems rather than complaints from neighbors. When the cable TV viewer has a complaint he will go to his cable system operator. When the amateur has a complaint he will go to the same operator. The cable-system operator is at least one, if not many, technical levels above the average neighbor. He runs a sophisticated communications network and can be expected to understand much of what the amateur has to say. As a matter of fact, there are many Amateur Radio operators in the CATV business. All in all, amateurs are at least one leg up when dealing in this environment. The CATV operator may also have a good deal of sophisticated equipment and personnel who know how to operate it. They generally have convenient devices such as portable field-strength meters and spectrum analyzers. Perhaps most important, they have legal, economic and moral incentives to recognize in satisfying their viewers. It is quite likely that one of your best friends in the community could be the chief technician of the cable company. You can help him make his service better, and he can help make your hamming more enjoyable.

There are industry groups in the cable business that can be helpful in providing technical information and even specific assistance in knotty cases. These include the National Cable Television Association, 1724 Massachusetts Ave., N.W., Washington, DC 20036; The Society of Cable Television Engineers, P.O. Box 2665, Arlington, VA 22202; and Community Antenna Television Association, 1100 17th St., N.W., Washington, DC 20036. All of these groups have strong ties with both the cable industry and the Federal Communications Commission.

It is also well to note that the local cable operator has some responsibility to represent the community and often to produce programming for his network. By working with the CATV operator in your community you may be able to do much for Amateur Radio (in terms of public relations).

In summary, we can say that cable television does bring a potential new set of problems for the amateur operator in this world of congested communications. On the other hand, location and elimination of these problems may well be more easily handled than those of normal RFI because of the opportunity to work with a technically oriented group that has a vested interest in getting to the bottom of the problem.

Let's Make the "Hentenna"

No, this antenna won't lay eggs, but it will produce an excellent signal at your fixed or portable location.

By Koji Sugihara,* JJ1UMS

Have you heard of the Hentenna? This antenna is very popular in Japan, especially on 6 meters. A recent survey revealed that 10% of hams active on 50 MHz in Japan are using the Hentenna.

At first glance, a reader might assume this antenna is somehow related to a female chicken. This is not the case, however, as the "hen" in the name is a transliteration of the word "interesting" or "unusual" in Japanese. Let's take a look at the Hentenna and see why it got its name.

The Antenna

Fig. 1 shows the basic design of the Hentenna. On inspection, it would appear that the Hentenna is vertically polarized. Not so! The antenna is *horizontally* polarized. This is the first unusual aspect of the Hentenna.

Another oddity is its dimensions — a 5- to 10-percent variation won't adversely affect the performance of the antenna; in fact, a "fork" Hentenna is only half of a Hentenna. Mr. Ota, JJ1CCH, constructed a 11.5-foot-high[1] Hentenna for 50 MHz, and it still worked well. Distances of 280 miles have been covered on 6 meters with 1-1/2 watts and a Hentenna. This performance is outstanding considering the simplicity of the antenna.

The Hentenna structure is fairly simple, which lends it to portable operation; the few components for construction are relatively small and easy to carry. Set-up, adjustment and disassembly can be accomplished in a few minutes, which can be handy if rain or lightning threatens while operating in the field.

The radiation pattern of the Hentenna is shown in Fig. 2; the main lobes are broadside to the element, with nulls appearing off to the sides. To fully realize the performance benefits, some method of rotation must be employed. This should not pose too great a problem, as wind loading is negligible because wind tends to blow *through* the element rather than acting on it. The author uses the "Armstrong" method of rotation, although any small TV rotator should handle the job.

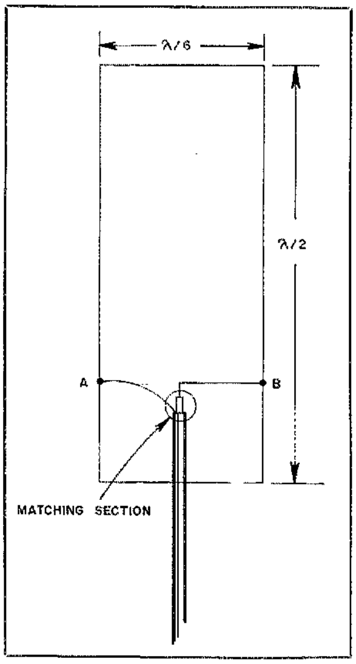


Fig. 1 — The Hentenna is fed through a Bazooka match coupled to the element at points A and B.

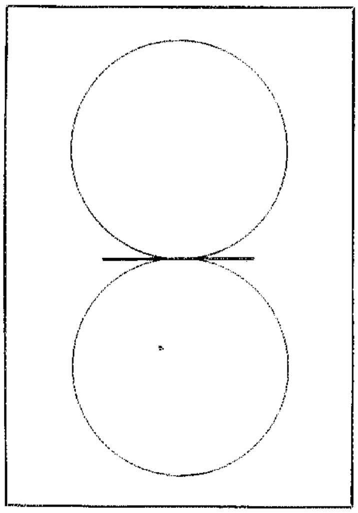


Fig. 2 — Directivity of the Hentenna. The pattern shown is perpendicular to the element plane.

Construction Methods and Details

There are three methods commonly used in Hentenna construction. The first is to use a bamboo framework and attach the wire element to it. This is the simplest method, and the technique will be explained later in this article.

A portable version of the Hentenna can be constructed with aluminum tubing for the top and bottom of the element, with wire employed at the sides. While this method is more difficult than that of the wooden framework, it is much easier to set up and break down after initial construction.

Above 50 MHz it becomes practical to construct the entire element from aluminum tubing. This technique is commonly used for construction of Hentennas for 144 and 430 MHz.

The simplest method of construction will now be explained. First, firmly attach the top and bottom supports to the mast at the appropriate places. These supports must be attached securely to ensure the durability of the installation. Next, connect both ends of a 26-1/4 foot piece of stranded no. 14 wire together to form a closed loop. Firmly connect the wire loop to the framework. Strong string or wire should be used to keep the loop attached to the framework during adverse weather conditions.

The Hentenna may be fed with 50- or 75-ohm coaxial cable. A bazooka match is

[1]M = ft × 0.3048; km = mi × 1.6; mm = in. × 25.4.

*27-3-404 Matsugaya, Hachio ji Tokyo, 192-03 Japan

recommended. To make one, remove a 1/2-inch-wide strip of insulation 40.6 inches from the end of the feed line, as shown in Fig. 3. A length of braid, sufficient to cover 39 inches of the cable, is carefully soldered to the point where the insulation was removed. Use a soldering iron of sufficient size to quickly flow the solder before the inner dielectric of the cable melts. Slide the braid toward the end of the cable and neatly trim it 1-1/4 inches from the end of the cable. The other end of the coax should now be fitted with a suitable connector for coupling to the transmitter. A continuity test is recommended at this time to ensure that both the matching section and connector have been attached properly. Tape both ends of the braid to prevent water from entering the coax at these points. Take your time and do a neat job — the better the seal, the longer the cable will last.

The feed line may now be connected to the element. Cut a 55-inch length of tinned antenna wire in half and attach one end of each to a center insulator. Solder the prepared end of the coaxial cable to the insulator, making sure the cable is not heated sufficiently to melt the center dielectric. Attach the tinned wire to the element with alligator clips, making sure the wire is pulled taut.

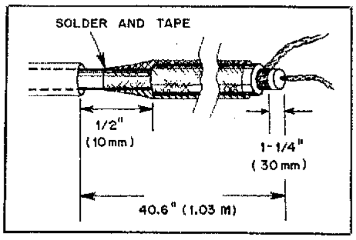


Fig. 3 — Bazooka matching section for the Hentenna. After construction, both ends should be taped and the entire length weatherproofed.

Adjustment

Tune up of the antenna is straightforward. It is set up on a short mast, the coax attached to the output side of an SWR bridge and power applied to the antenna. The clips are now moved up and down the element until the best match (lowest SWR) is obtained. Remove the clips and solder the wire to the element at these points. The antenna is now ready for permanent installation, either atop a tower or TV mast. Once in place, the Hentenna can provide years of operating pleasure.

[Editor's Note: After this article was prepared for publication, the author informed us that his original design was for 28 MHz.]

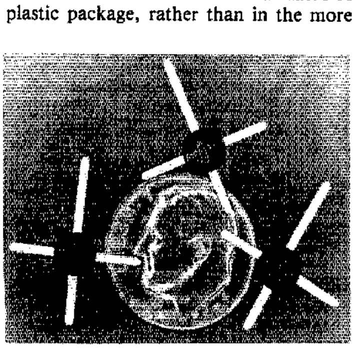
New Products

NEW MOTOROLA SEMICONDUCTOR

□ The slogan is "Performance up, cost down," in new low-power rf transistors, as noted in some recent Motorola promotional literature that describes the MRF559 0.5-watt bipolar transistor which has a recommended operating range of 250 MHz to 1.5 GHz.

Effective emitter ballasting (protection against hotspotting) is ensured by the current techniques in geometry, processing and packaging. This type of design in overlay transistors improves the operating linearity and enhances the reliability of the device. The metalization of the semiconductor "sandwich" uses nichrome, titanium, tungsten and gold to eliminate the corrosion malady that is referred to in the industry as "purple plague." This is said to improve the transistor longevity by a factor of 10.

The MRF559 is contained in a Macro-X plastic package, rather than in the more familiar TO-39 case. Four 10-mil-thick, silver-plated copper leads extend at 90-degree increments from the case, and aid cooling of the semiconductor junction.



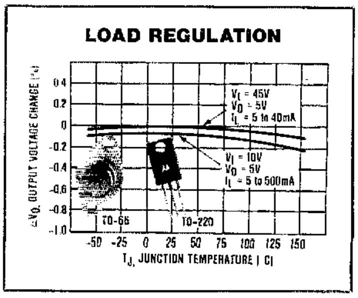
Although the new transistor is characterized mainly for use in MATV/CATV systems, it should be excellent for amateur applications at vhf and uhf. Its ratings at 870 MHz are: P_o = 0.5 W; Gain = 8 dB (min); Eff. = 50%; V_{cc} = 12; 1-dB compression greater than +20 dBm (typ). The f_T is rated at 3 GHz and the noise figure at 1 GHz is 4 dB [I_c = 40 mA (3 dB at 500 MHz)]. P_D is 2 watts at a case temperature of 50° C. Price class: $1.80 in 100-999 lots. Available from Motorola distributors or the factory in Phoenix, AZ 85036. Phone Tom Bishop at 602-244-6394 for additional information. — *Doug DeMaw, W1FB*

MOTOROLA LINEAR VOLTAGE REGULATORS

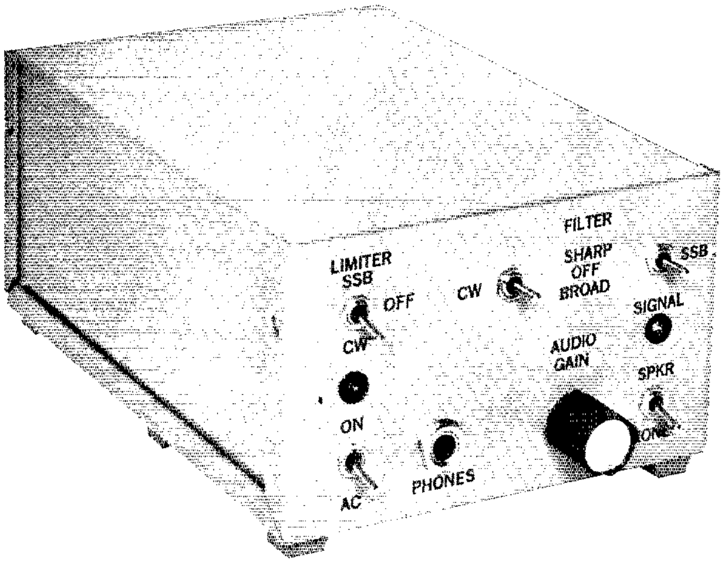
□ The LM117M/217M/317M are adjustable, three-terminal linear voltage regulators. These devices are capable of supplying in excess of 0.5 A over an output-voltage range of 1.2 to 37 V. The regulators are very easy to use and require only two external resistors to set the desired output voltage. They employ internal current limiting, thermal shutdown and safe-area compensation, making them virtually failure proof.

Serving a wide variety of applications including local, on-card regulation, the devices also make simple adjustable switching regulators and programmable output regulators. By connecting a fixed resistor between the adjustment and output terminals, the units can be used as precision current regulators.

These devices are available in TO-66 and TO-220 cases; three temperature ranges are offered. The TO-220 plastic package is available only in the lower temperature range of 32° to 257° F (0° to 125° C). Device variations and pricing in 100 to 999 quantities are: LM317MT, 32° to 257° F (0° to 125° C), TO-220 case, $0.80; LM317MR, 32° to 257° F, TO-66 case, $1.25; LM217MR, −77° to 300° F (−25° to 150° C), TO-66 case, $3.57; LM117MR, −130° to 300° F (−55° to 150° C), TO-66 case, $5.07. For further information, contact Mr. Roger Janikowski at Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036, tel. 602-962-2124. — *Paul K. Pagel, N1FB*



Build an Audio Filter With Pizzazz!



Ssb and cw enthusiasts. . . STOP!. . .LOOK!. . . and LISTEN (finally) to what you want to hear.

By Robert E. Lee,* K2TWK

Here's an ssb/cw audio filter with a lot to offer. It provides variable degrees of cw and ssb audio selectivity and a means of limiting the audio level at your ears without the need for constantly adjusting the receiver audio gain control. The annoying effects of cw key clicks and static crashes are reduced or eliminated by a limiter circuit. When operating cw, a panel-mounted LED blinks in unison with the received signal when it is centered in the filter passband. An external sidetone may be mixed with the incoming receiver audio, and level adjustments are provided.

Description

Fig. 1 is a block diagram of the unit. Audio is taken from the speaker output jack and may be passed around or fed through a limiter circuit. The signal is then delivered to a cw bandpass-filter section or to a high-pass/low-pass filter section for ssb operation. During cw operation the signal is also passed to another filter that feeds the signal-indicating LED driver. A tone/summing amplifier follows the filter circuits. Here, sidetone from an external source can be added to permit monitoring cw transmissions. An audio amplifier provides for speaker or headphone operation and a tape recorder take-off point. Power for the unit is taken from a well filtered and regulated 12-volt supply.

The cw filter is designed for a center frequency of 750 Hz. If your equipment has a different frequency offset, the filter center frequency will have to be changed. Information for such changes is given in the Appendix.

Operational Theory

U1 of Fig. 2 is an inverting unity-gain amplifer. Diodes can be switched across the feedback resistor between pins 2 and 6 to provide limiting action. Limiting occurs at 0.4 V peak-to-peak (p-p) with the LIMITER switch in the CW position and 1.2 V p-p in the SSB position.

The cw filter employs U2 as a 4-section, 8-pole, multiple-feedback, active bandpass filter with unity gain. It has a center frequency of 750 Hz. The bandwidths at the −6 and −60 dB points of the filter are 120 and 1125 Hz, respectively.

For ssb, U3 is used as a 4-section series of 3-pole unity gain, multiple-feedback Butterworth-response filters. U3A acts as a high-pass filter with a 300-Hz −6 dB point. U3B, C and D are low-pass filter sections with −6 dB points at 2.2-, 2.0- and 1.5-kHz, respectively. Each filter section exhibits a roll-off of 18 dB per octave.

U4 and Q1 are part of the signal-indicator circuit. The IC operates as a 2-pole multiple feedback active filter with a gain of 10 and a center frequency of 750 Hz. The U4 output drives Q1, which has the SIGNAL LED in the collector circuit. The resulting bandwidth of this filter when cascaded with the cw filter (U2), is approximately 40 Hz.

An external sidetone signal may be fed to U5A. This permits the amplitude of the sidetone signal to be adjusted to a comfortable level for speaker or headphone operation. U5B performs as a unity gain summing amplifier. It is used to mix the sidetone signal and incoming receiver audio.

U6 provides over 1 watt of audio power output. The frequency response of the amplifier has been limited to a range of 340 to 3900 Hz at the −3 dB points. The basic design of this amplifier was done by Robert Sherwood.[1] C1 and R3 were added to provide feedback and ensure stability.

*89 Kinderkamack Rd., Park Ridge, NJ 07656

[1]R. Sherwood, "New Audio Amplifier for the Drake R-4C," *Ham Radio*, April 1979, p. 48.

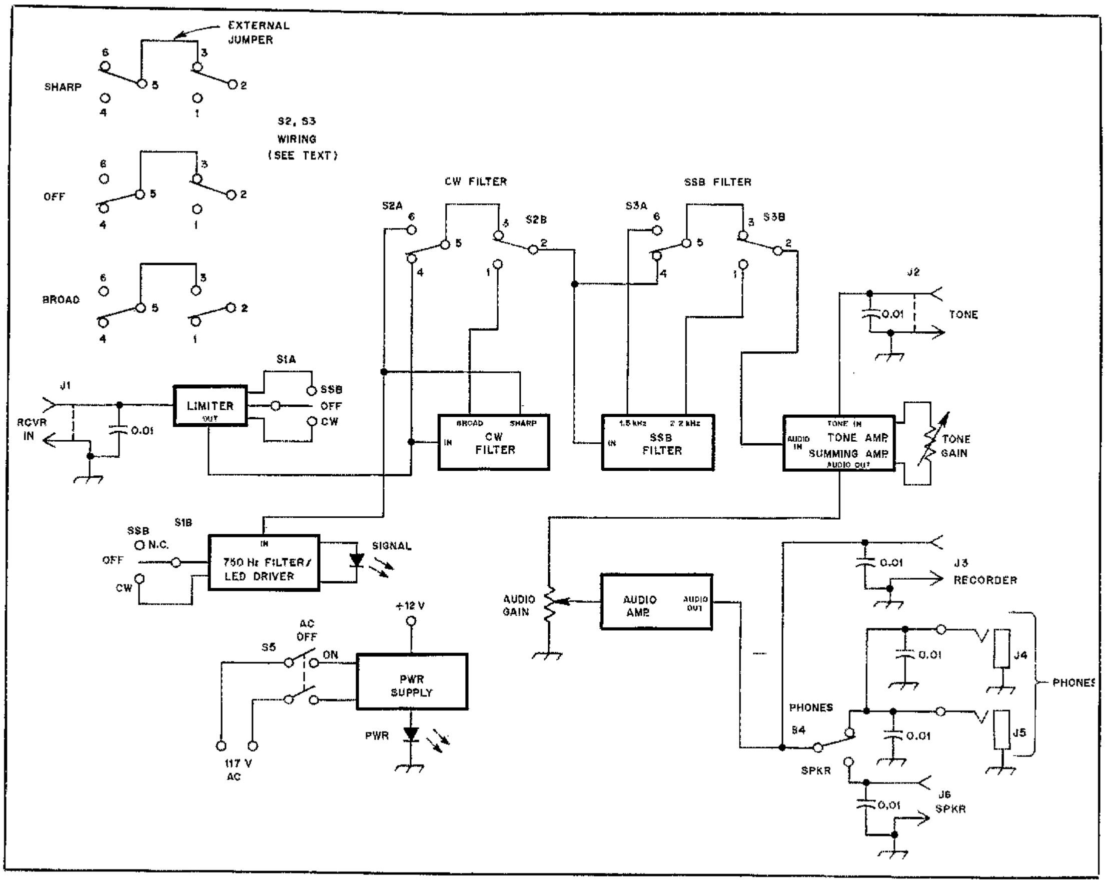


Fig. 1 — Block diagram of the audio filter. S2 and S3 are shown in the OFF position. These switches are special types that are not operated as ordinary dpdt toggle switches.

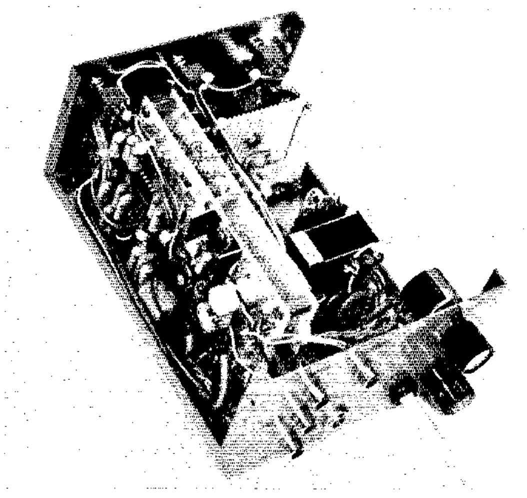
Power for the unit is supplied by a full-wave bridge rectifier. An LM-340T-12 provides voltage regulation.

Construction

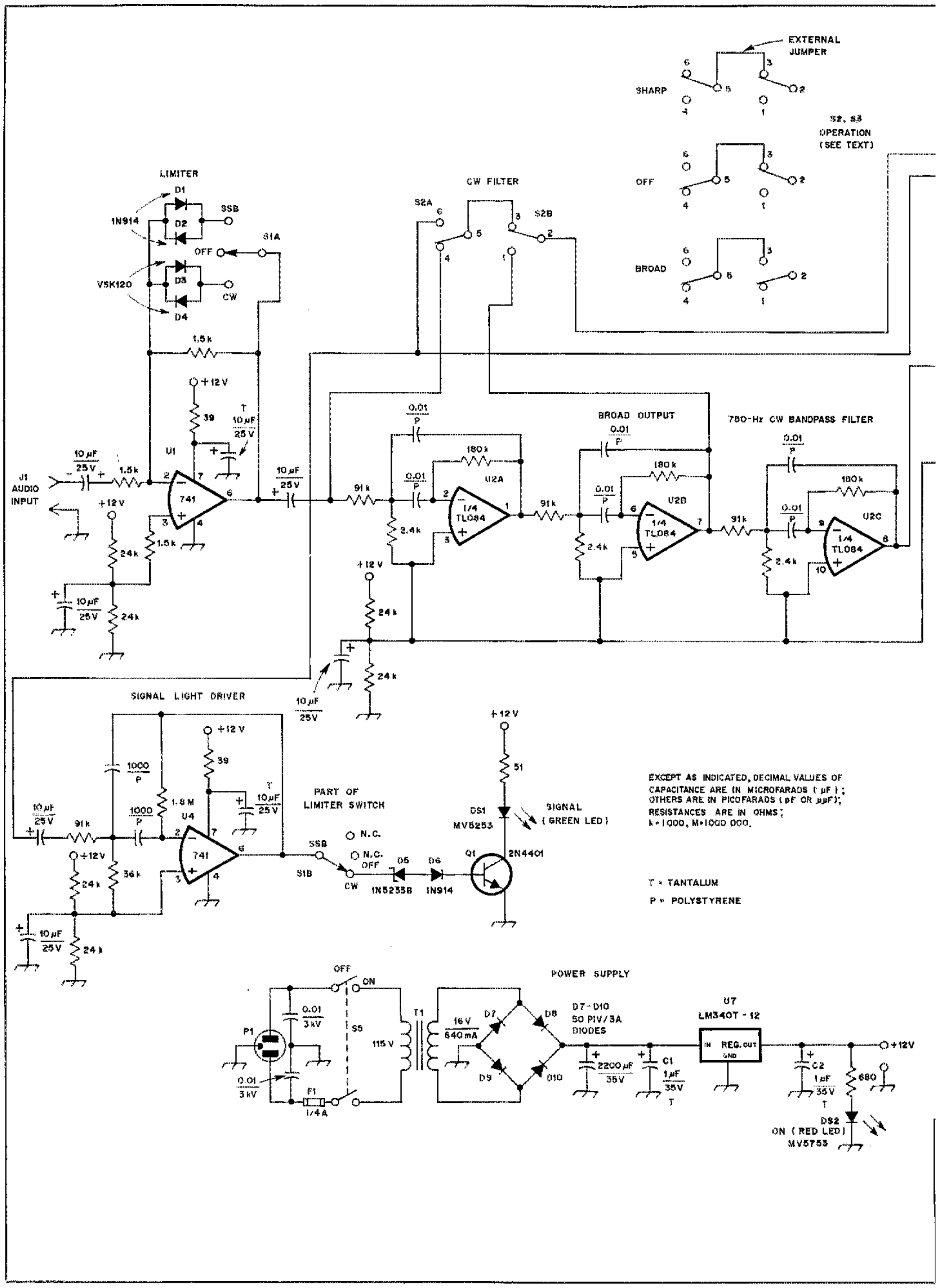
The filter unit must be constructed in a shielded enclosure. I used a 7 × 5 × 3-inch (mm = inches × 25.4) Bud box (CU-2108-B), but would recommend use of a larger enclosure. Three perf boards hold the circuit components. The power transformer is mounted on the box bottom. All transformer and ac wiring should be kept as far away as possible from the filter/amplifier boards. This will prevent 60-Hz hum pick-up. Small heat sinks should be used on U6 and U7.

When wiring the unit, follow good construction practices and keep leads between the switches and boards short. The audio-amplifier layout should follow that described in the original article. AUDIO GAIN control wiring should be done using small-diameter shielded audio cable with the low side of the AUDIO GAIN control connected to the cable shield and the shield connected *only* to pin 3 of U6. C3 should be connected between pins 3 and 4 of U6 using 3/4-inch lead lengths.

The switches used for S2 and S3 are not ordinary dpdt toggle switches. These switches have a special toggling arrangement. This permits them to be used as 3-way toggle switches when an external jumper wire is added between terminals 3 and 5. Use of these switches instead of rotary types enhances compact construction.



An inside view of the filter. The two large boards to the left of the unit contain all of the filter components. Power supply components are mounted on the small perf board toward the front of the enclosure.


EXTERNAL JUMPER
SHARP
OFF
BROAD
S2, S3 OPERATION (SEE TEXT)
LIMITER
D1
D2
D3
D4
1N914
VSK120
SSB
OFF
CW
S1A
CW FILTER
S2A
S2B
1.5 k
+12 V
39
T 10 µF 25 V
U1
741
J1 AUDIO INPUT
10 µF 25 V
24 k
BROAD OUTPUT
750-Hz CW BANDPASS FILTER
0.01 P
180 k
91 k
2.4 k
U2A
U2B
U2C
1/4 TL084
SIGNAL LIGHT DRIVER
1000 P
1.8 M
U4
36 k
PART OF LIMITER SWITCH
N.C.
S1B
D5
D6
1N5235B
1N914
Q1
2N4401
+12 V
51
DS1
MV5253
SIGNAL (GREEN LED)
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (µF); OTHERS ARE IN PICOFARADS (pF OR µµF); RESISTANCES ARE IN OHMS; k = 1000, M = 1000 000.
T = TANTALUM
P = POLYSTYRENE
POWER SUPPLY
OFF
ON
P1
0.01 3 kV
S5
F1 1/4 A
115 V
T1
16 V 640 mA
D7
D8
D9
D10
D7-D10 50 PIV/3A DIODES
2200 µF 35 V
C1 1 µF 35 V T
U7
LM340T-12
IN REG. OUT GND
C2 1 µF 35 V T
680
DS2
ON (RED LED)
MV5753

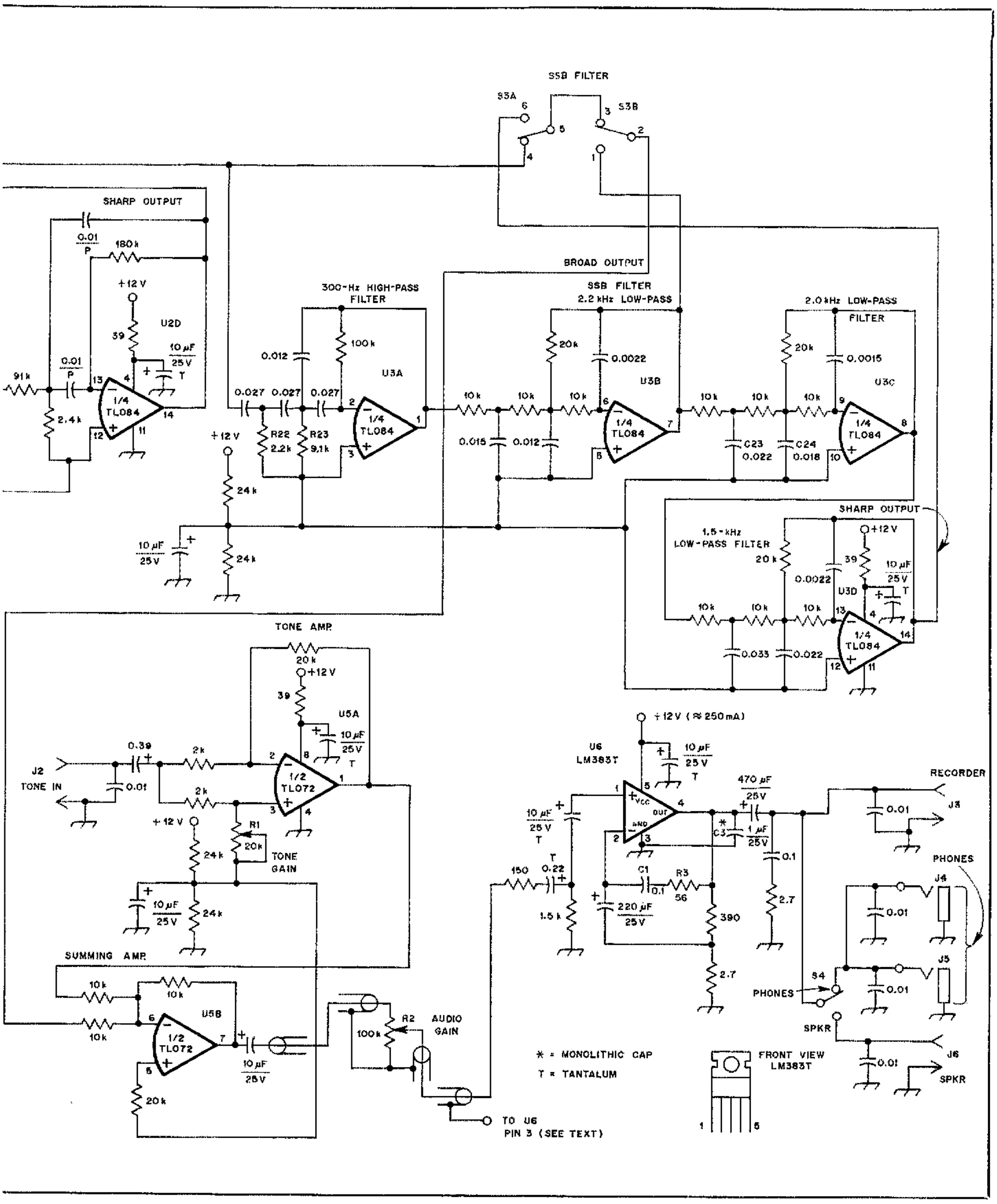


Fig. 2 — Schematic diagram of the unit. Information is given in the text that will allow the builder to alter the cw filter center frequency. All resistors are 1/4-watt carbon composition or film types. Note: Part numbers in parentheses are Radio Shack.

C3 — 1 μF Monolithic ceramic. Sprague 5CZ5U10SX-0050C5 or equiv.
D3, D4 — 1-A/20-V Shottky diodes, Vero VSK120, 1N5817 or equiv. (Available from Fuji-Svea, Inc., P. O. Box 40325, Cincinnati, OH 45240.)
J1-J3, J6 — Phono jack.
J4, J5 — Open-circuit phone jack.
R1 — 20-kΩ linear-taper potentiometer.
R2 — 100-kΩ audio-taper potentiometer.
S2, S3 — C & K 7211SYZQ 3-way toggle switch. (Available from Gerber Electronics, 128 Carnegie Row, Norwood, MA 02062.)
T1 — 16-V/640 mA secondary, 115-V primary, Signal DPC 16-640 with 10BR mounting bracket or equiv. (Available from Signal Transformer Co., Inc., 500 Bayview Ave., Inwood, NY 11696. Single-lot purchases require payment in advance.)
U1, U4 — 741 op amp (267-007).
U2, U3 — Quad bi-FET op amp, TL084CN or equiv. (276-1714).
U5 — Dual bi-FET op amp, TL072CP, LF353N (276-1715) or equiv.
U6 — LM383T audio amplifier (276-703).

Mallory SXK (or equivalent) polystyrene capacitors are recommended for use in the cw and signal-light driver filter sections. The other capacitors in the low-pass/high-pass filter sections can be Sprague type 225P or equivalent. Polarized capacitors can be electrolytic or tantalum types. Be sure to use tantalum capacitors at C1 and C2, and use a monolithic ceramic capacitor at C3. The remainder of the capacitors can be disc-ceramic types. Resistors used in the filter sections should have a 5% tolerance and be matched, using an ohmmeter. Other resistors can have a 10% tolerance.

Operation

This is the procedure I follow to set up my Drake C line for cw transceive operation. Turn on the CALIBRATOR and peak the PRESELECTOR on the calibrator signal. Connect the filter to the speaker jack on the rear of the receiver and connect the speaker to the jack on the rear of the filter unit. Place the receiver MODE switch in the maximum cw selectivity position and adjust the PASSBAND tuning control for lsb operation with a beat note of 750 Hz (the frequency offset used with the C line). Place the LIMITER switch in the CW position. The receiver RF GAIN should be set at maximum and the AUDIO GAIN at the 11 o'clock position. Adjust the filter unit AUDIO GAIN for the desired audio level. If the unit is operating properly, the SIGNAL LED should illuminate as you tune the receiver across the calibrator signal. Slow tuning is required because the bandpass of the SIGNAL LED filter circuit is narrow — approximately 40 Hz. The PASSBAND control is then adjusted for a maximum S-meter reading while the LED is lit. Do not readjust the PASSBAND control after it has been set up as described. The C line is now ready for proper cw transceive operation.

For separate receiver/transmitter cw operation, use the following procedure. Place the transmitter in the SPOT mode and adjust the tuning until the LED lights. Both the receiver and transmitter will then be on the same frequency.

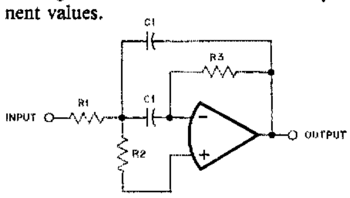
When sharp audio selectivity during cw operation is not required, I place the filter switch in the SSB NARROW position. Otherwise, the cw signal will sound distorted because of limiter action with no filter section in operation. When more audio selectivity is desired, the cw filter can be placed in the BROAD or SHARP position to give the required amount of *selectivity*. With the limiter circuit in operation, you can tune across the cw portion of the band and not have to adjust the AUDIO GAIN control to protect your ears from the effects of strong signals.

In the SSB mode, the LIMITER can be switched on to help reduce the effect of static crashes or other such annoyances. The required amount of audio selectivity is then chosen. Do not leave the LIMITER in the CW position when operating ssb: Severe distortion of the audio signal will result.

With the audio-filter unit, both cw and ssb operation become more relaxing. Hum, high-frequency noise, static crashes and key clicks are reduced or eliminated. I know you'll find the use of this filter a boon to cw and ssb operation. Should you desire more information, I'll be glad to answer questions, provided an s.a.s.e. is enclosed.

APPENDIX

Use these formulas to determine the cw and signal indicator filter circuit component values.



1) Select A_o — gain at filter center frequency.
   Select f_o — filter center frequency.
   Select Q.
2) Select R1 for desired input resistance.
3) Calculate R1:

$$R1 = \frac{Q}{(2Q^2 - A_o)\,2\pi f_o C1} \quad \text{(Eq. 1)}$$

4) Calculate R3:

$$R3 = 2A_oR1 \quad \text{(Eq. 2)}$$

5) Calculate C1:

$$C1 = \frac{Q}{2\pi f_o A_o R1} \quad \text{(Eq. 3)}$$

6) Calculate R2:

$$R2 = \frac{A_oR1}{2Q^2 - A_o} \quad \text{(Eq. 4)}$$

The following example will demonstrate how to determine the filter component values for a filter center frequency of 800 Hz. This particular frequency is used in many popular transceivers, such as the Kenwood TS-830S.

1) $A_o = 1$ (sets the gain at unity)
   $f_o = 800$ Hz
   $Q = 4$

2) Because it is easier to select resistor rather than capacitor values, C1 is chosen, and R1, R2 and R3 are then calculated. Thus, with a value of 0.01 µF for C1

$$C1 = \frac{Q}{2\pi\, f_oA_oR1} \quad \text{(Eq. 5)}$$

becomes

$$R1 = \frac{Q}{2\pi\, f_oA_oC1} \quad \text{(Eq. 6)}$$

and

$$R1 = \frac{4}{(2\pi)(800)(1)(1 \times 10^{-8})} = 79.6\ \text{k}\Omega \quad \text{(Eq. 7)}$$

The nearest standard value of 82 kΩ is used.

3) $R3 = 2A_oR1$ (Eq. 8)

$$R3 = (2)(1)(79.6\ \text{k}\Omega) = 159.2\ \text{k}\Omega \quad \text{(Eq. 9)}$$

A 160-kΩ resistor is used for R3.

4) $$R2 = \frac{A_oR1}{2Q^2 - A_o} = \frac{(1)(79.6\ \text{k}\Omega)}{(2)(4)^2 - 1} = 2.56\ \text{k}\Omega \quad \text{(Eq. 10)}$$

Use a 2.4-kΩ resistor for R2.

Determination of the signal indicator filter circuit values uses the same procedure. A value of 1000 pF is used for C1 and an A_o of 10. This nets values of 82 kΩ for R1, 1.6 MΩ for R3 and 33 kΩ for R2.

The "Lowbander's" One-Antenna Farm

Not enough area for a full-size 160-meter antenna? You may have more room, electrically, than you realize — with plenty of space for 80- and 40-meter antennas, too.

By Lee Aurick,* W1SE, ex-K3AZ

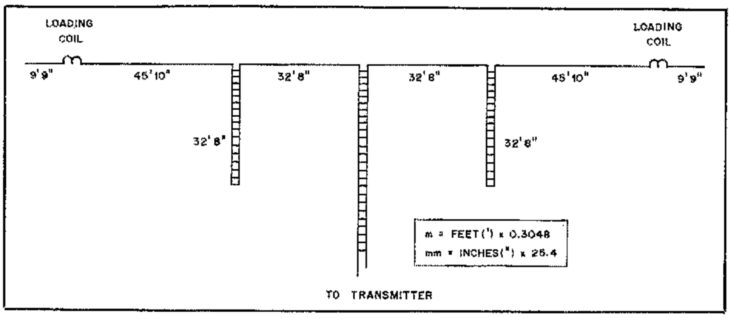


Fig. 1 — Diagram of the three-band antenna system. Forty-meter loading coils, used at W1SE to reduce the physical length of the antenna to 176.5 feet, are Van Gordon Engineering units. The phasing stubs and feeder are 450-ohm open-wire line.

An earlier article[1] described an antenna system for 80, 40, 20 and 15 meters that was simple and inexpensive, provided gain and was easy to construct. That antenna has been duplicated by hundreds of amateurs, with excellent results. A new transceiver that covered 160 meters provided the impetus to see if the principles could be applied to an antenna system for this band, as well as benefiting the 80- and 40-meter bands. Other antennas at my station presently provide coverage for 20, 15 and 10 meters, so this new approach had to deal only with our lower three bands.

This system offers a good antenna for each band without having a yard and house festooned with wire. Accomplishing this in suburbia without arousing the ire of the neighbors, not to mention that of your spouse, is an achievement. The antenna works well on three bands, so the design objectives were met.

The first effort was toward achieving the best 40-meter antenna design for property size, efficiency and economy. This was the band of greatest interest, even though it would place a performance limitation on the other two bands. The antenna would resonate close to desirable frequencies on these bands, but would not be "right on."

A system emerged that, according to the textbooks, offers some gain on each of the three bands. However, no claim about gain will be made here. The use of open-wire phasing sections brings the collinear elements too close together to provide much gain, and the phasing sections radiate on the two lower-frequency bands, thereby distorting the radiation pattern. In addition, the antenna is not mounted as high as it might be ideally. The complete antenna system is shown in Fig. 1, but it will perhaps be easier to understand how it functions if a band-by-band explanation is made.

40 Meters

The system functions at 7 MHz as three half waves in phase. Each horizontal section represents a half wavelength on 40 meters. Open-wire phasing sections reverse the phase of the voltage and current from what would be expected if they were not included. These phasing sections are 1/4 wavelength long on 40 meters (each section totals 1/2 wavelength of wire) so that each horizontal section has the same direction of current flow and voltage polarity as its neighbor (in-phase relationship). The phasing sections are constructed of 450-ohm open-wire line, as is the feeder.

80 Meters

On 80 meters the antenna *includes* the phasing sections. They add to the total length of wire, so you now have 5/8 wavelength each side of center. How many people do you know who have even *one* 5/8-wavelength antenna on 80 meters? This new antenna replaces a single 5/8 wavelength on 80 meters, and while it is impractical to compare antennas when used several weeks apart, the new antenna appears to work as well as the earlier one. Many 5-9 reports have been received from Eastern European stations while I was operating "barefoot," on sideband and cw.

160 Meters

Although this band doesn't offer the daily DX opportunities found on our other bands, it is difficult not to feel a little reverence when preparing to operate here. After all, "pioneers" operated on this band, and some of them are still around. It's a band that requires colossal antennas if they are to be full size. Even a quarter wavelength at 1.9 MHz is 123 feet (meters = feet × 0.3048). However, this antenna provides 307 feet of wire, center fed, just waiting to be loaded up! A 5/8-wavelength antenna won't beat four phased quarter-wavelength verticals, but if you can be satisfied with a respectable

[1]Notes appear on page 24.

*Advertising Manager, *QST*

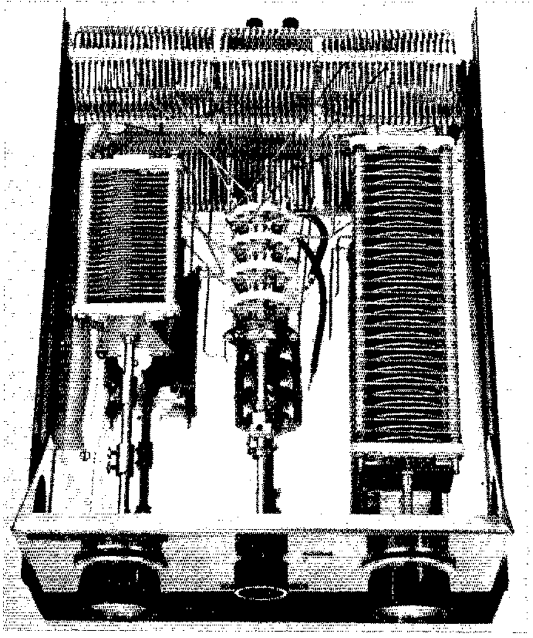


Fig. 2 — Photograph showing the interior construction of the link-coupled network used to match the antenna to 50-ohm coaxial cable.

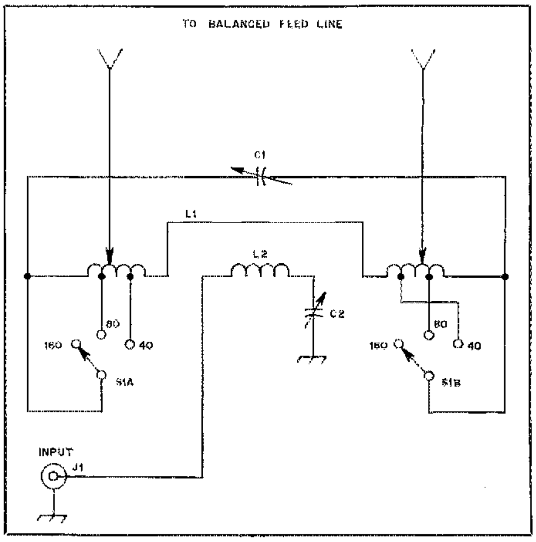


Fig. 3 — Schematic diagram of the link-coupled matcher. The arrows indicate taps that must be found experimentally, because each system will have different requirements.
C1 — 210 pF, with spacing greater than that of the final tank-circuit capacitor.
C2 — 350 pF, spacing not critical for low power.
L1, L2 — See text.
S1 — Two-pole, three-position ceramic rotary switch.

signal throughout the U.S., and occasional DX, this could be the system for you.

Feeding The Antenna

The use of open-wire line requires conversion from balanced line to unbalanced coaxial cable. Why not feed the antenna with coaxial cable? Well, coaxial cable is great — *if* the antenna you plan to feed *always* exhibits the same impedance at its feed point as the characteristic impedance of the line you are using — 50 ohms for example. If the antenna doesn't meet this criterion, you can expect something other than unity (1:1) SWR.

Coaxial cable doesn't handle high SWR very well; open-wire line does. Accept the fact that the SWR is going to be high with this antenna — perhaps 10:1 on 80 meters. No matter: The matching system described here will permit your rig to look at unity SWR, and everything will be fine. The feed-line radiation is cancelled as a result of the balanced feeders (equal but opposite voltages and currents), leaving you with just the normal I^2R (power) loss in the wire.

I decided to build a link-coupled matcher (1981 *Radio Amateur's Handbook*, p. 19-13), for the three bands covered by the antenna. Fig. 2 shows how I constructed the coupler. The layout is not critical. A large cabinet is required to house the big components needed to achieve resonance on 160 meters. Fig. 3 shows the schematic diagram of the circuit. L1 and L2 are made from one 10-inch (mm = inches × 25.4) length of B&W Air-Dux 2406T. Cut the coil wire 20 turns in from each end. Remove one turn from each side of the center portion. The two sections of L1 are then connected to form a single inductor of 40 turns, 3 inches in diameter. The center portion of the coil is used as L2. L1 is resonated by means of C1. Resonance on 160 meters occurs at nearly maximum capacitance, while resonance for the other bands occurs at approximately half capacitance. This can vary, depending on where the taps for each band are placed. In my unit the taps are at 14 and 18 turns from each end for 80 and 40 meters, respectively. The taps are selected by a ceramic-wafer switch that progressively shorts turns from the ends of the coils as you change to each higher-frequency band. Wafer-switch sections were originally provided for the 14-turn link, L2. However, it was unnecesary to tap this coil because a proper match was achieved on each band with the 500-pF capacitor I used for C2. Anything more than 350 pF is satisfactory. C2 may be of the broadcast-receiver type, unless high-power operation is contemplated. L1, L2 and C1 must be insulated from the chassis.

The antenna is tapped onto the coil at 10 turns from each end. This position of the taps permitted the antenna to be matched and loaded fully on each band. These points may be different in other installations and will depend largely upon the length of the feed line and, to some extent, on the antenna height.

Summary

At W1SE, there was insufficient room for the 196-foot length required for the three half waves in phase on 40 meters. Consequently, 40-meter loading coils were used in each of the outboard sections to reduce the size of the antenna to 176.5 feet. These loading coils have a small effect on 80/75 meters, and even less on 160 meters. The dimensions shown in Fig. 1 provide resonance at 7.15, 3.8 and 1.9 MHz. The coils used at W1SE are Van Gordon Engineering Coils, but any commercial 40-meter loading coils should work.[2]

The antenna system described provides good coverage of the top bands, and does it without making suburbia look like the Voice of America antenna site! Also, no balun is needed in this system. The link-coupled matcher permits conversion between the *bal*anced feeder and *un*balanced transceiver, and provides the impedance match that no practical balun could.

Notes

[1]L. Aurick, K3AZ, "The AZ Special," CQ, Sept. 1975, pp. 35-37.

[2][Editor's Note: These coils were measured in the ARRL lab and were found to have an inductance of 10.3 μH, and a Q of 170 at 7.1 MHz. One 10-inch piece of B&W Air Dux 1008T coil stock could be cut in half to make a pair of loading coils. Some method of strain relief would be required. A second alternative would be to "roll your own" using information found in *The Radio Amateur's Handbook*, page 2-11.]

New Books

☐ *An Amateur Radio Telescope,* by George W. Swenson, Jr., published by Pachart Publishing House, 1130 San Lucas Circle, P. O. Box 35549, Tucson, AZ 85740. Softbound, 6 × 9 inches, 58 pages, $6.95.

In the radio sky, stars and galaxies shine with an intensity that often differs surprisingly from the brightness of their visible counterparts. Cassiopeia and Cygnus are like beacons in the sky, and the Milky Way blazes through broad daylight to leave its imprint across the face of a chart recorder. Silent to our own ears, the unending procession of celestial objects that passes overhead appears as a howling rage of activity to radio ears. In his book, *An Amateur Radio Telescope,* G. W. Swenson, Jr. shows us that radio astronomy need not be the province of government researchers and large universities alone. The detection and study of extraterrestrial radio sources is within the grasp of the inquisitive radio amateur. A compilation of a series of articles originally published in *Sky and Telescope* magazine, Swenson's book is an excellent and practical introduction to a field that owes its birth to the pioneering work of an Amateur Radio operator over 40 years ago.

Underscoring the amusing fact that one man's noise is another man's signal, the book takes us out of the comfortable, conventional world where narrow-bandwidth circuits squeeze every last decibel of signal out of the surrounding noise in order to maximize the intelligibility of voice or code transmissions. We enter a strange world where the cosmic noise *is* the desired signal, and the radio astronomer's objective is to maximize his receiver bandwidth in order to capture as much noise power as possible from those distant sources. With the exception of that twist, however, Swenson leads us through the design and construction of pre-amplifiers, mixers, noise and signal generators, attenuators, and other devices and techniques that should be familiar territory to every radio amateur. The concept of interferometry is discussed in some detail. A technique all but unknown to many radio amateurs (yet an indispensable tool to the radio astronomer), interferometry has practical application to OSCAR satellite tracking. In a refreshing treatment of these topics, and with a minimal amount of math, the book details the assembly of a practical 73.8-MHz radio telescope from the antenna to the output recording device. The book includes a list of easily identifiable radio sources "visible" to the amateur observer in the northern hemisphere. Prominent on this list is our own sun. Directly monitoring solar radio emissions should appeal to the observant radio amateur with an interest in "homebrew" ionospheric propagation prediction.

If any criticism can be leveled at the author, it is that he has presented his material so skillfully that we want to see more — more detail on the design of the detector circuits that integrate over minutes instead of milliseconds, and more information about his experimental results and their interpretation. Swenson has told his story expertly and engagingly. His book will prompt many readers to explore a world where the signals that induce such feeble voltages in our antennas have been traveling for untold millenia. — *Ed Kalin, K1RT*

☐ *Designing with Field-Effect Transistors,* edited by Arthur D. Evans and written by Arthur Evans, Walt Heinzer, Ed Oxner and Lee Sheffer of the Siliconix Incorporated staff. Published by McGraw-Hill, New York, NY 10020. Hardcover edition, 6 × 9 inches, 293 pages including index, $24.50.

This informative textbook was written by the applications staff of Siliconix and includes coverage of FET theory, parameters and specifications, low-frequency circuits and high-frequency circuits. There are also sections on analog switches, voltage-controlled resistors and FET current sources. Chapter 7 treats power FETs. The subject of FETs in integrated circuits is illuminated in Chapter 8.

The text is not riddled with lofty terms and nebulous engineering jargon. Rather, the narrative is down-to-earth for all who understand the fundamentals of electronics. But the professional engineer or technician need not feel that the material is too fundamental. To the contrary, the theory and practical data are keyed specifically to the professional in electronics.

There is a substantial amount of valuable tabular data in the book, plus myriad practical circuit diagrams. It is encouraging to note that the writers made no effort to dazzle the readers with endless equations and hypothetical dissertations. This book has "meat," and should be very useful to amateurs who design their own equipment. Those who are interested purely in how FETs operate will also find this volume worthy of being added to the personal technical library. — *Doug DeMaw, W1FB*

☐ *World Press Services Frequencies,* by Thomas Harrington, W8OMV. Published by Universal Electronics, Inc., 1280 Aida Dr., Reynoldsburg, OH 43068. Second edition, 1981. Soft-bound volume, 8-1/2 × 11 inches, 72 pages, $5.95.

Most RTTY-equipped Amateur Radio stations don't limit themselves to copying RTTY signals solely within the amateur bands or on MARS frequencies. Eventually, the operator can't resist the urge to see what's happening on other frequencies and to do a bit of eavesdropping, copying some of the many RTTY signals that fill the airwaves. At first, this may be a "hit or miss" operation. Before long, it blossoms into something a bit more serious, and the need for more information concerning stations and frequencies becomes apparent. It is for these operators and SWLs that this book is intended.

The author begins by covering RTTY reception basics and by briefly describing a limited range of modern commercial RTTY gear. Harrington points out that most news services use a 425-Hz shift and a 50-baud (66-wpm) sending rate. While the present trend is toward video displays, many mechanical teleprinters are still in service. Some emphasis should have been placed on the mechanical speed restrictions of these machines, including some information regarding speed coverters. Similarly, while the commercially manufactured TUs shown are attractive, referencing more simple (and less expensive) homemade units would have been a beneficial addition.

An abbreviated list of equipment manufacturers and their addresses is presented in the third chapter. There are three lists in chapter 4 that provide times of transmission, operating frequencies and the ITU list of over 50 different news services in all parts of the world. This is the "meat" of the book. You'll also be able to tell who you're "printing" by referring to the listing, neatly arranged in chapter 5, of the abbreviations used to identify the various world press services. Additional information concerning RTTY reception, other sources of RTTY station lists, a description of "utility" stations and a listing of several interesting RTTY frequencies to monitor comprise the sixth chapter.

The last page of the book consists of two forms. One is a contributor's form, which you may use to submit candidates for inclusion in the next revision of the listings. The other form is a request for the planned updated frequency lists as they are published. If you're one of the "green keys" set who's enjoying the thrill of getting the news before it hits the TV screen, the data in this book might make your search for the right source a bit easier. — *Paul K. Pagel, N1FB*

Designing a Microprocessor-Based RTTY Speed and Code Converter

Part 2: Software design should be approached with as much care as hardware design. The procedures outlined here are important if programs are to be written efficiently.

By Greg McIntire,* AA5C

Designing a microprocessor-based project involves both hardware and software. The hardware portion of this project was described in Part 1. Transition to the software portion can best be made by describing how the software interacts with the hardware, specifically the I/O ports.[1] Fig. 5 details the input- and output-port bit assignments. Judicious choice of these assignments helps simplify the software. Notice that by making the bit positions for the data I/O the same as for the teleprinter, a software multiplexer has been created.

The programming language chosen for this design was PLM/80,[2] a high-level language used by Intel that is similar to PL1 or BASIC. Using a high-level language frees the programmer from worrying about the details of the processor being used, and provides a program listing that is easy to read and understand. The disadvantages are that a compiler is needed to generate the object code (the code loaded into the EPROM), and a high-level language is usually not as efficient at code generation as carefully written assembly language.

A "top-down" procedure was followed in the software design. The main modules necessary to solve the problem were identified, and the structure linking them was written first. Detailed tasks were filled in later. This procedure allows one to grasp the whole problem without getting bogged down in the details.

Program Subroutines

The calling structure for the routines used is shown in Fig. 6. The DRIVER routine is the taskmaster of the software system. It alternately calls the RCVLOOP and TXCNTRL routines and monitors the MODE, TXRX and SELCAL input lines. A change in these lines causes a call to the SETUP routine.

The SETUP routine is used to initialize the software parameters of the system. These parameters are:

1) Data bit positions in the I/O ports.
2) Timing counts for one-half and one received data bit interval.
3) Number of receive data bits.
4) Shift count used to correctly position the received character.
5) Timing counts for the transmit data and stop bit intervals.
6) Number of transmit bits.

This may seem like a lot of parameters to keep track of, but they are the key to the flexibility of the software system. There is only one receive routine and one transmit routine, regardless of the mode or direc-

[1]Notes appear on page 29.

*5232 Aztec Dr., Box 77512, Lewisville, TX 75056

Input Port Bit Definition

Address ØØØ$_H$

Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Ø |
(MSB ... LSB)

Bit Ø:	Demodulator Input	0 = Mark,	1 = Space
Bit 1:	Input From Current Loop	0 = Mark,	1 = Space
Bit 2:	Tx Key Line	0 = Transmit,	1 = Receive
Bits 3-4:	Mode		
Bits 5-6:	Unused		
Bit 7:	Selective Calling	0 = Activated,	1 = Deactivated

(A)

Output Port Bit Definition

Address ØØ4Ø$_H$

Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Ø |
(LSB)

Bit Ø:	Output to Current Loop	0 = Space,	1 = Mark
Bit 1:	AFSK Generator Output	0 = Space,	1 = Mark
Bit 2:	Buffer Overflow Output	0 = No Overflow,	1 = Overflow
Bit 3:	Buffer Empty Output	0 = Not Empty,	1 = Empty
Bit 4:	Motor Enable	0 = Motor Off,	1 = Motor On
Bits 5-7:	Unused		

(B)

Fig. 5 — The assignment of signal lines to the bits of the input port is shown at A, while the output port assignments are given at B.

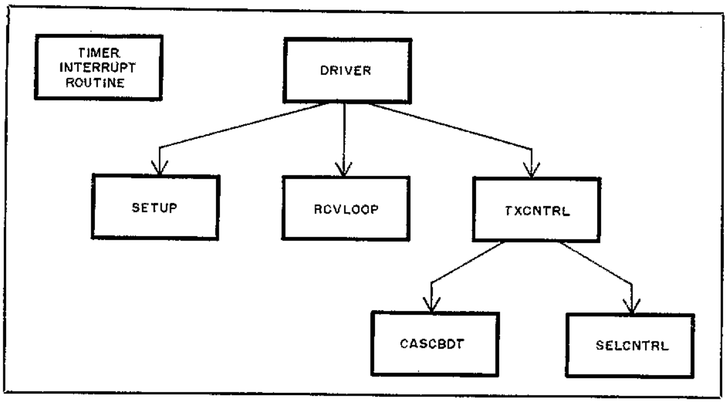


Fig. 6 — The software subroutine call structure. The timer subroutine is interrupt driven. It is called each time the processor is interrupted by the external 2.00-kHz clock.

tion of operation. The SETUP routine is called only if there is a change in the mode, transmitter status or selective-calling inputs.

Fig. 7A details the timing of a 60-wpm Baudot character as it would appear in the incoming data stream. A 100-wpm character is similar except that the data and stop bit intervals are 13.5 and 19 ms respectively, resulting in a total character length of 100 ms. The timing of a 110-baud ASCII character is shown in Fig. 7B.

The incoming data stream is sampled by the RCVLOOP routine. This is a state-driven routine; certain events cause it to go from one state to subsequent states. In state 0, the input is monitored until a space occurs, signaling the start of a new character. The transition to a space causes the routine to go into state 1, where it times to the center of the bit interval. If the space is still present at that time, the routine goes into state 2; otherwise it returns to state 0. State 2 is the main sampling loop: Here each data bit is sampled at the center of the bit interval to determine if it is a mark or a space. Once all of the data bits have been sampled, the routine goes into state 3. In this state, the input is monitored until a mark occurs. The transition to a mark causes the routine to enter state 4 where the presence of the mark is verified one-half bit interval later. Detection of a valid mark causes the routine to load the received character into the queue and then return to state 0 to await the next character.

The queue is a 900-byte block of RAM into which new characters are loaded. The queue location where the next character is to be loaded is maintained by a queue load pointer. A queue unload pointer maintains the location from which the TXCNTRL routine is to fetch the next character for output. The RCVLOOP routine examines these pointers and if a queue overrun is imminent, the buffer-overflow LED is illuminated. Data can be loaded into the queue at one speed and removed at another. This is the key to the speed conversion portion of the project.

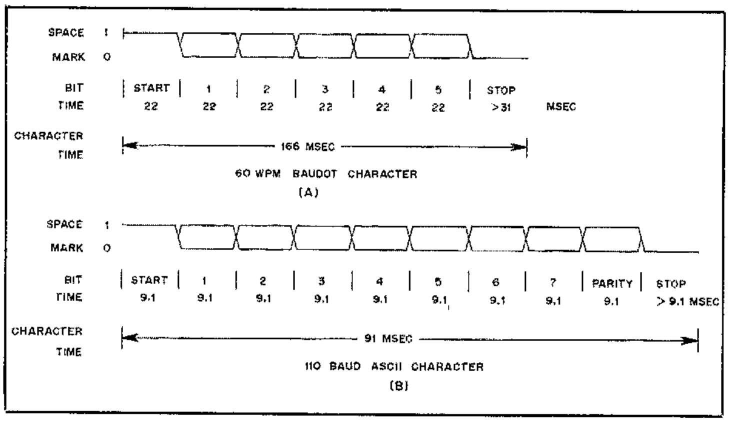


Fig. 7 — Shown at A is the timing of a 60-wpm Baudot character. The timing of a 110-baud ASCII character is shown at B.

The TXCNTRL routine, also state driven, is used to output characters from the queue. In state 0, the routine is looking for a difference between the queue load and unload pointers. No difference between the pointers means that no new characters have been added to the queue by the RCVLOOP routine, so the queue empty LED is illuminated. A difference causes the character pointed to by the unload pointer to be fetched. If the converter is in a code-conversion mode, the CASCBDT routine is called to convert the character from ASCII to Baudot, or vice versa. The SELCNTRL routine will also be called if the selective-calling feature is active. Once the character to be transmitted has been derived, a space is output, and if the pointers now match, the queue empty LED is extinguished. The routine then goes into state 1, where each data bit is output. When all the data bits have been transmitted, a mark is output, and the routine goes into state 2. State 2 terminates when the mark bit has been timed, and the routine then goes into state 0 to determine if there are more characters to be output.

The CASCBDT routine is used to convert ASCII characters to Baudot, and vice versa. The direction of transmission determines the direction of the conversion. The routine consists primarily of two look-up tables. The received character is used as an index into one of the tables, and the character pointed to is the converted value. The converted character replaces the character fetched from the queue, and the routine returns to the TXCNTRL routine.

The circular queue avoids one of the pitfalls of many code-conversion routines, the handling of the figures and letters characters. Converting from Baudot to ASCII is no problem as each Baudot character has a corresponding ASCII character (except letters and figures). Converting from ASCII to Baudot, however, requires the detection of a change of case and the insertion of the appropriate character (letters or figures), followed by the character that caused the change. The CASCBDT routine handles this by simply preventing the queue unload pointer from being incremented when the case character is output.

The SELCNTRL routine is called by the TXCNTRL routine if the selective calling feature is activated. This state-driven routine looks at the characters being transmitted, and a match to one of the characters that starts an activation sequence causes the queue pointer to be saved and the next character in the activation sequence to be looked for. This comparing continues until the value completion of an activation sequence. The motor is then turned on, and the queue pointer is reset to the character position that started the sequence so that it can be printed. Transmission of the sequence NNNN causes the motor to be turned off.

The TIMER routine performs one operation — it increments a reference counter each time it is called by the RST7.5 interrupt. When the maximum count has been reached, the counter automatically resets itself to 0. Time in the system is referenced by adding offsets to the current count. When the counter reaches that value, a given length of time has elapsed.

Bringing Up the System

Testing a microprocessor-based project can be a problem for the amateur who does not have access to in-circuit-emulators or other sophisticated development equipment. Power is applied to the circuit, and it does not work — what then? This problem can be minimized by planning for the testing phase during the hardware and software design. A thorough understanding of what the outputs should be doing, based upon the given input conditions, proved to be enough in my case. An LED that is flashed at a 1-hertz rate, or some other indicator, should be included in any microprocessor project to give the builder some feel for whether or not the program is executing.

The bare minimum of test equipment for projects of this nature is a logic probe and frequency counter. The schematic diagram of a logic probe and "glitch-catcher" is shown in Fig. 8. A two-color LED in the logic probe section indicates the state signal. Red indicates a logic 0, and green indicates a logic 1. A yellow color is visible for transitory signals, the exact shade being determined by the duty cycle of the signal.

Signals with very low duty cycles are not indicated well by this type of logic probe, and that is where the glitch-catcher portion of the circuit comes in handy. A fast flip-flop forms a two-bit counter, the outputs of which are displayed by LEDs. The flip-flop trigger sense is switch selectable, and a reset button allows the counter to be cleared. Infrequently occurring signals can be verified by this portion of the circuit.

The first step in testing the converter circuit should be a thorough point-to-point wiring verification. Most hardware problems result from wiring errors, and the time needed to verify the wiring is well spent.

A reverse-biased power diode between the Vcc and gnd is a cheap safeguard to include before power is applied. With this in mind, apply power to the circuit and verify the CLOCK OUT signal from the processor (U1, pin 37) with a logic probe or oscilloscope. Next verify that grounding the RESETIN input (pin 36) causes the RESETOUT line (pin 3) to go low.

Execution of program memory instructions can be verified by first looking at the hold acknowledge line (HLDA, pin 38). The 8085A has the capability of allowing other devices to become the bus master. This is accomplished by raising the HOLD input (pin 39) to a logic one or by executing a software HALT instruction. The software for the converter does not contain a HALT instruction, and the HOLD input is wired disabled so the 8085A should never place the buses in the high-impedance state. The execution of a HALT instruction will be indicated by the S0 and S1 outputs (pins 29 and 33) being at logic 0. Next look at the ALE signal (pin 30) with the glitchcatcher. This line will be low most of the time, but it goes high to latch the LS byte of the address. The WR and RD lines (pins 31 and 32) should also be checked. Both lines are normally high, but go low to indicate those operations.

Communication of the 8085A with the devices on the bus can be verified by looking at the address decoder. Pins 15, 13, 11 and 9 on the 74LS138 (U6) should normally be high with low-going transitions. Pins 14, 12, 10 and 7 should always be high.

The 555 timer should be set to 2.00 kHz ± 25 Hz. The duty cycle is immaterial as the edge-triggered RST7.5 interrupt of the 8085A is used. Normal quiescent inputs to the system are a low on the DEMODIN line and a low on the MARKIN line (a mark in the current loop).

These conditions should cause the BUFFER EMPTY LED to be on and the BUFFER OVERFLOW LED off. The MARKOUT and the AFSKOUT lines should be high for these input conditions. A valid input character should cause the BUFFER EMPTY LED to flash and the MARKOUT line to toggle if the TXRX line is high (teleprinter receiving). The AFSKOUT line should be unaffected. A valid character from the teleprinter should also cause the BUFFER EMPTY LED to flash if the TXRX line is low (teleprinter transmitting). This time the AFSKOUT line should toggle, and the MARKOUT line should be unaffected.

The selective calling feature, if used, can be tested by monitoring the MTRENB line on the output port. With the TXRX and SELCAL lines low, transmit a valid activation sequency from the teleprinter. This should cause the MTRENB line to go high. The transmission of the sequence NNNN should then cause the MTRENB line to go low.

Conclusion

The design of a microprocessor-based

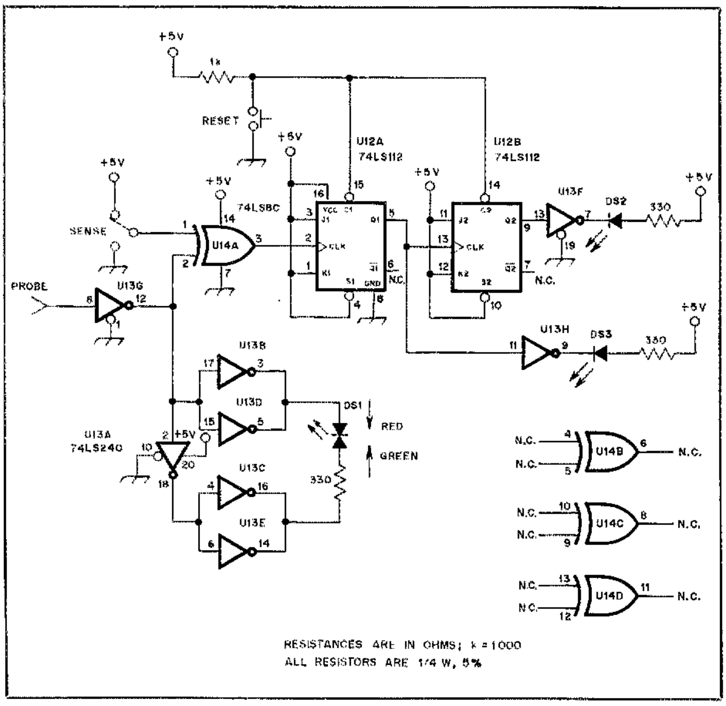


Fig. 8 — A logic probe and "glitch catcher" is useful when testing microprocessor and other digital circuits. The "glitch catcher" will indicate the occurrence of a single pulse. This circuit was designed by Tom Leete. DS1 is a two-color LED (red and green), and S2 is a normally open push-button switch.

project should not be viewed as a mysterious and complicated task. Rather, it should be thought of as a logical progression of steps followed to arrive at a solution. I have attempted to illuminate the following points relative to designing microprocessor systems:

1) Define the system requirements before designing the hardware or software. Get a good grasp of the whole problem before starting the detailed design. Describe in detail what you expect the system to do.

2) Choose the microprocessor. Available software support should be a major factor in this choice. Study the manufacturer's data sheets in detail. The program memory in most small projects is EPROM, so plan for some means of programming them.

3) Block out the hardware required and include the circuitry necessary to convert the I/O signal levels to those required for the microprocessor. Then proceed with the detailed design of the hardware. Try to consider how the software can be simplified by the choice of the bit assignments for the I/O ports. Plan on adding a little extra hardware and software for testing.

4) Design the software using a top-down approach no matter what language you choose to use. Concentrate on the high-level program structure first and simply include program stubs for the lower-level routines. These can be filled in once the high-level structure has been completed.

5) Thoroughly test the system. Some hardware and software testing should be done during construction, but once the system is all together, test all modes to verify that it fulfills the design requirements of step 1.

This project has provided me with a very flexible solution to the speed-conversion problem. It has the added features of multiple speeds, ASCII-to-Baudot conversion and selective calling, all for about the same cost as a new set of teleprinter gears. This flexibility is the main reason microprocessors are so useful in solving many problems. In the future, more and more products used by the amateur will contain microprocessors. Why not jump on the bandwagon and find out how exciting it can be to solve problems with microprocessors?

Notes

[1]Software is currently available for use with a 60-, 67- or 100-wpm Baudot or 110-baud ASCII teleprinter. A complete listing of the PLM/80 source and hex object code is available from ARRL for $3. The object code listing is available for 50 cents and an s.a.s.e. Be sure to specify the teleprinter type that is to be used with the converter. A programmed 2716 EPROM can be obtained from the author for $25. The ARRL in no way warrants this offer. Details regarding the EPROM can be obtained from the author (inquires must include an s.a.s.e.).

[2]*Intel PLM/80 Programming Manual*, available from Intel Corp., Literature Dept., 3065 Bowers Ave., Santa Clara, CA 95051.

New Books

☐ *Amateur Radio, Super Hobby!* by Vince Luciani, K2VJ, published by Cologne Press, Cologne, New Jersey. First printing, 1980; softcover, 8-1/2 × 11 inches, 144 pages.

Author Luciani set out to do with *Amateur Radio, Super Hobby!* what few before him have been able to do with much success: write an interesting and easy-to-understand book about Amateur Radio for the layperson. What emerged, however, is a book riddled with flaws that falls short of its mark.

Like a doctor about to stick a patient with a needle, Luciani uses a light and breezy narrative to set his readers' minds at ease, while he administers his own injection of Amateur Radio. His use of the first person singular, a personal touch to offset a subject often thought of as too technical, could have been a refreshing change from the drab, textbook approach used in most books on ham radio. But early on, Luciani lets this attempt at creativity get the better of him, and the book becomes more of a showcase for the author (and son Jim, who is often mentioned) and less of a lesson in Amateur Radio.

Too often the book becomes bogged down with the author's self-indulgences, and the reader must muddle through trite phrases like "cool the exam" and "take my word for it" to find something of substance. At one point the author pleads with the reader (who Luciani openly fears will be easily discouraged by any of several methods of learning Morse code): "Try another, please."

What information Luciani does give his readers is sufficient for a general, albeit surface, understanding of Amateur Radio, at an eighth-grade level. Most of the interesting facets of the hobby are introduced — from emergency preparedness to contests and QSLs — to inspire the reader to get a Novice license. Sometimes, though, Luciani's eagerness to swell the Novice ranks smacks of the "hard sell" and may seem offensive. In one instance, he tells parents to get their children involved in the hobby because "they wouldn't want to deprive them (children) of that pleasure."

One glaring deficiency in the book is its poor organization, which is surprising for an author with a technical-writing background. Some chapters begin with one subject and end with another. In others, the reader is introduced to a new idea, only to be told that it will be discussed in a later chapter. Still other chapters seem totally out of place. A chapter about women in Amateur Radio is mysteriously squeezed in between benefits of the hobby and repeaters, when 19 chapters later there is one called "YL Profiles."

Much of the book is loaded with extraneous material, which seems to have been included to stretch what would have been a short book into 144 pages. Sixteen chapters, covering nearly 40 pages, are devoted to profiles of hams, most of whom may be known to hams but not to nonhams. Fewer and better examples would have made the point, not belabored it. Add to that the pages given to lists of FCC field offices, manufacturers, publishers — all of which were mentioned in the body of the book — and the 8-page, 101 question-and-answer test at the back of the book (which, by the author's own admission, bears little resemblance to questions found on the Novice exam). The liberal use of white space and large type also helps extend the book past its otherwise short length.

One particularly irritating feature of the book is the cartoons that, aside from eating up lots of space, serve no constructive purpose. Most of them are corny, and do little to complement the text. In the beginning of the book, the author tells his readers that he "resisted the terrible temptation to fatten the book with photographs." Yet, he has absolutely no qualms about fattening the book with dozens of cartoons, some of which take up an entire page.

If the book has any redeeming features, they are a 5-page glossary, which gives concise, easy-to-understand meanings to frequently used Amateur Radio jargon, and the fact that the book can be easily read in one evening. — *Andrew Tripp*

☐ *Motorola Optoelectronics Device Data*, published by Motorola Semiconductor Products, Inc., P. O. Box 20912, Phoenix, AZ 85036. Softcover, 7 × 9-1/4 inches, 286 pages, $3.25.

This manual provides detailed device data sheets, selector guides, cross references and applications information for optoelectronics and fiber-optics devices. Concentration has been placed on infrared GaAs emitters, silicon detectors, high-technology opto-coupler/isolators, and an innovative approach to fiber-optic components, modules and links. Coverage includes the entire family of high-technology, opto-triac drivers and the new SCR couplers.

A fiber-optics section principally addresses the application of this system to the computer, industrial control and medical electronics fields, and discusses its consumer and automotive applications. While not geared specifically toward the Amateur Radio enthusiast, the related information certainly can be used in this area as well. The manual points out that analog and digital modulation schemes, at bandwidths through 50 MHz and system lengths through several miles, may be achieved using currently available Motorola fiber-optic devices. — *Paul K. Pagel, N1FB*

Practical 75- and 300-Ohm High-Pass Filters

Having TV-receiver overload problems? Build one of these simple, inexpensive modern-design filters for an up-to-date solution to an old problem.

By Edward E. Wetherhold,* W3NQN

According to a recent FCC report,[1] a significant part of the TVI problem is front-end overload caused by CB radio and (to a lesser extent) Amateur Radio. This particular problem is estimated to be the source of 25% of all interference complaints received by the FCC. Because of this, the radio amateur should have access to up-to-date design information on high-pass filters suitable for preventing TV receiver overload. Unfortunately, most present high-pass filter construction data is based on designs that are more than 25 years old.[2,3,4] For example, this data is practically indentical to that published in 1957 and 1951.[5,6]

During the past quarter century, there has been considerable change and progress in Amateur Radio design and construction techniques. The old image parameter filter-design procedure has been largely replaced by that of modern filter design (also known as *network synthesis)* in which computer-generated tables provide simpler designs with performance equivalent to that of the image parameter designs. In addition, modern components such as iron powder or ferrite toroidal cores and high-stability, low-loss monolithic ceramic capacitors permit the construction of compact, high-performance filters that were not possible 25 years ago. Modern test equipment such as spectrum and network analyzers with computer-controlled plotters now allow filter performance to be quickly and thoroughly documented.

The old image parameter filter designs using air-core coils served adequately in the past. But now it is time for modern filter-design procedures and components to be used to obtain filters that are easier to build and are less costly than filters of yesteryear. This article presents several types of inexpensive modern-design high-pass filters that are suitable to protect against TV receiver overload.

[1]Notes appear on page 34.

*Honeywell Inc., Signal Analysis Center, P.O. Box 391, Annapolis, MD 21404

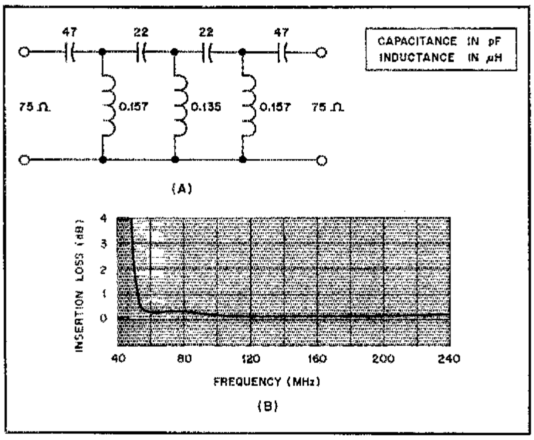


Fig. 1 — The schematic diagram of a 75-ohm Chebyshev filter assembled on pc board is shown at A. At B, the passband response of the 75-ohm filter. Chebyshev filter design parameters: reflection coefficient = 5.6%, F-A_p = 54.07 MHz, $F_{3\,dB}$ = 47.7 MHz, $F_{30\,dB}$ = 34.9 MHz. Design Inductances: 0.157 µH: 12 turns no. 24 wire on T44-0 Micrometals core. 0.135 µH: 11 turns no. 24 wire on T44-0 Micrometals core. Turns should be evenly spaced, with approximately 1/4 inch between the ends of the winding. If T37-0 cores are used, wind 14 and 12 turns, respectively.

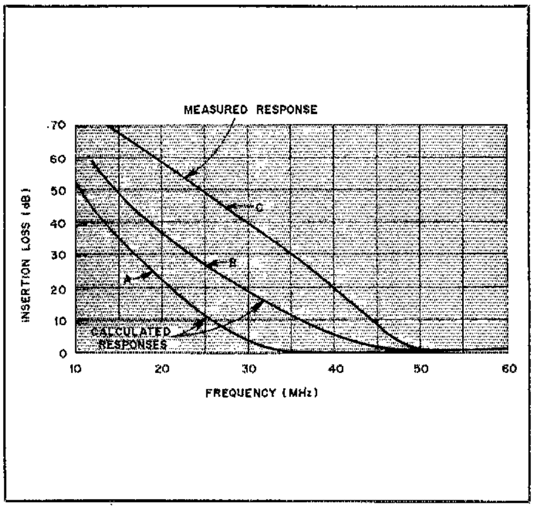


Fig. 2 — At A, computer-calculated insertion loss for a 5-element design from *The Radio Amateur's Handbook*, p. 15-12. B shows the computer-calculated insertion loss for a 5-element design from *The Radio Handbook*, 1978, p. 16.3. At C, measured insertion loss for the 7-element Chebyshev filter of Fig. 1.

The transmission line connecting the TV antenna to the receiver can be 75-ohm unbalanced-to-ground coaxial cable or 300-ohm twin-lead. The type of antenna lead-in will determine which of the following filter types to use.

75-Ohm High-pass Filter for Coaxial Cable

Fig. 1 shows the schematic diagram and the measured passband response of the filter design selected for installation in a 75-ohm coaxial cable antenna system. The measured stopband response of the new filter compared with the computer-calculated responses of two currently published designs is shown in Fig. 2. Fig. 3 is a photograph of the completed filter, with and without its tinned-steel container.

Filter Design

A 7-element Chebyshev design was used instead of a 5-element design because it provides over 12 dB per octave more attenuation than a 5-element filter. To simplify construction, a design using only standard-value capacitors was selected from a previously published table of precalculated designs.[7] Although the precalculated designs are based on an impedance of 50 ohms, a simple scaling procedure was used to get a 75-ohm design using standard-value capacitors.[8] A design having an F-A_p cutoff frequency of 54.07 MHz [F-A_p is the frequency at which the passband attenuation level first exceeds the peak amplitude of the passband attenuation ripple — Ed.], and a reflection coefficient of 5.6% was selected mainly because the 22- and 47-pF capacitor values are common and therefore easy to obtain. This value of reflection coefficient is low enough to provide a low maximum VSWR (1.12:1) while also providing a reasonable rate of increase in the stopband attenuation. Several other designs between 48 and 54 MHz having reflection coefficients between about 1 and 6% also could be used, but the capacitor values may not be as commonly available as the two values used in the design shown in Fig. 1. Table 1 shows four other designs that are suitable for this application.

Filter Construction

The capacitors used were ERIE "Red Caps," an ultrastable COGO (NPO) ceramic type for use in circuits requiring good capacitance stability and low loss over a broad temperature and frequency range. Other types of NPO ceramic capacitors having similar characteristics should be equally satisfactory. The inductors were wound on Micrometal, Inc. toroidal powdered-iron cores, which are available from Amidon or Palomar in small quantities.[9,10] This inductor type is inherently self-shielding, and a compact filter assembly is possible without undesired interstage coupling between inductors. The measured unloaded Q at 25 and 50 MHz was 66 and 80, respectively. Winding details are given in Fig. 1.

Double-sided 1/16-inch (mm = inches × 25.4) Teflon-fiberglass pc board [available in small quantities from Alaska Microwave Labs, 4335 E. 5th St., Anchorage, AK 99504 — Ed.] was used as a base for the filter components, but any other type of pc material should be equally satisfactory. The copper on the bottom of the board served as a ground plane. A section of copper on the top was stripped away on both sides of center to approximate a 75-ohm micro-strip line about 3/32 inch wide (see Fig. 3). Both sides of the top copper foil (at the edges) were connected to the ground plane underneath with eyelets or rivets inserted through the board. Two Radio Shack 75-ohm coaxial connectors (278-212) were modified by slicing off the extruded insulation around the solder pins to allow the connectors to butt directly against the pc board. Next, the shells of both connectors were soldered to the ground plane, and the center pins soldered to the micro-strip line. The micro-strip line was cut in four equally spaced places, and the capacitors were mounted across the spaces. The inductors were tack-soldered between the capacitor junctions and the ground plane on the top of the board. T44-size cores were used because they were on hand, but the smaller T37 cores should work equally well to give a more compact assembly. [A filter built in the ARRL Lab used a scrap of G10 epoxy-glass board and T37-0 cores. The performance of this filter was essentially the same as one submitted by the author — Ed.] To provide additional body and strength to the solder joints between the connector shells and the underside of the ground plane, a 1/2-inch length of Solder Wick was placed over the previously soldered junction. The braid was shaped to conform to the shape of the connector circumference, and then the wick was flooded with solder. This must be done quickly before the polyethylene insulation inside the connector gets too soft. The shielding provided by a metal case is probably unnecessary, and it may be omitted to minimize cost; however, it might be advisable to add something to protect the components from dust, dirt and physical abuse. The filter could be put in a plastic box, or it could be wrapped loosely with tape to give some protection to the components.

Filter Performance

Satisfactory filter performance for both low- and high-pass types is much more difficult to achieve in the frequency range above rather than below the cutoff frequency. This is because the stray inductance and capacitance associated with the filter components become progressively more significant and difficult to control as the frequency increases. Consequently, it is more difficult to get a satisfactory passband response than a stopband response in a high-pass filter. Fig. 1 shows that the measured passband insertion loss is less than 1 dB from 54 to 240 MHz, so the TV signal level should be relatively unaffected by the addition of the filter to the transmission line. When this response was measured, BNC coaxial connectors were used (because of their low loss) to indicate more clearly the effect of the

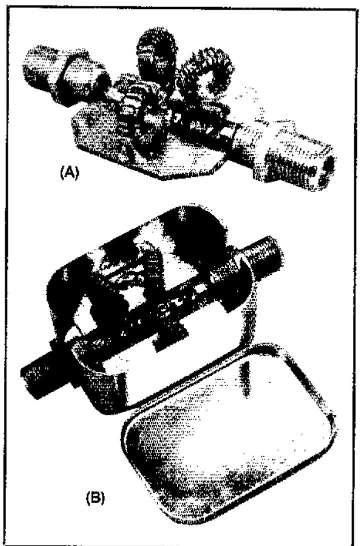


Fig. 3 — At A, photo showing construction of the 75-ohm unbalanced filter. At B, filter installed in a tin-dipped steel case for protection of the components.

Table 1
75-Ohm High-Pass Fitlers Using Standard-Value Capacitors

Filter Number	*Frequency (MHz)* A_p	*3 dB*	*30 dB*	*50 dB*	*Reflection Coefficient (%)*	*C1,7 (pF)*	*C3,5 (pF)*	*L2,6 (μH)*	*L4 (μH)*
1	48.3	37.2	25.6	19.1	1.00	82	30	0.209	0.165
2	49.4	43.7	32.0	24.5	5.78	51	24	0.171	0.148
3	50.0	40.7	28.6	21.5	1.93	68	27	0.187	0.152
4	53.0	45.0	32.2	24.4	3.27	56	24	0.167	0.140
5*	54.1	47.7	34.9	26.7	5.60	47	22	0.157	0.135

*This design was constructed and tested. See Figs. 1, 2 and 3. The frequencies listed above were computer calculated based on the given reflection coefficient. The plotted insertion-loss values in Fig. 2 may be different from the calculated values because of component tolerance and losses.

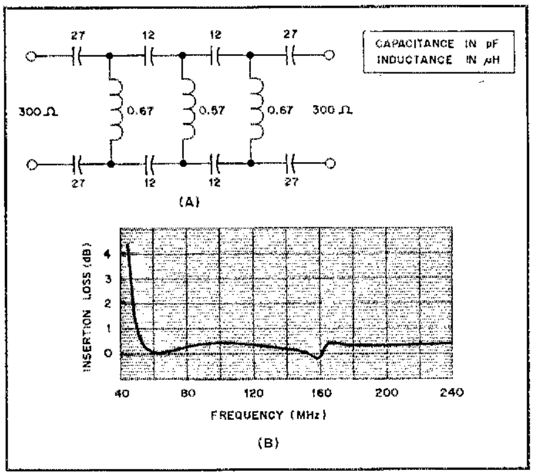


Fig. 4 — At A, schematic diagram of a 300-ohm balanced Chebyshev filter assembled on perf-board material. The passband response of the 300-ohm filter is shown at B. Design parameters: reflection coefficient = 4.111%, F-A_p = 51.6 MHz, F_{3dB} = 44.5 MHz, F_{30dB} = 36.0 MHz. Design inductances: 0.67 µH: 13 turns no. 24 wire on T44-10 Micrometals core. 0.57 µH: 12 turns no. 24 wire on T44-10 Micrometals core. Turns should be evenly spaced, with approximately 1/4 inch between the ends of the winding. If T37-10 cores are used, wind 15 and 14 turns, respectively.

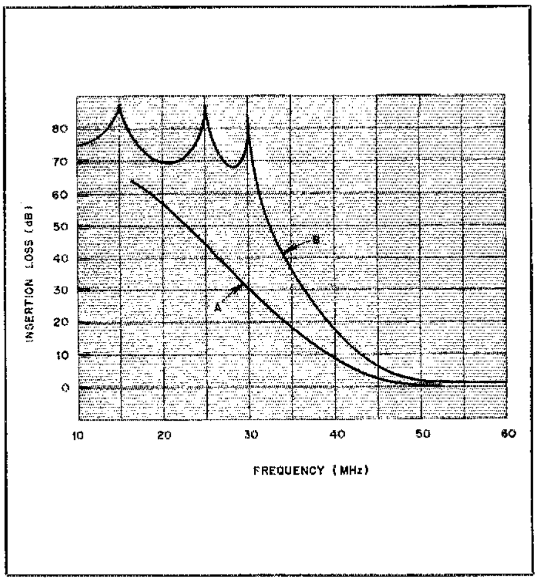


Fig. 5 — Stopband insertion loss of 300-ohm balanced high-pass filters. At A, Chebyshev design on perf-board using NPO ceramic capacitors. At B, elliptic design with pc-board capacitors.

capacitor and inductor losses. When the Radio Shack connectors were used, the insertion loss above 150 MHz gradually increased to 1 and 2 dB at 175 and 240 MHz, respectively.

The measured passband and stopband responses were obtained with the following Hewlett-Packard equipment: 8444A-H59 (0.5-1500 MHz) tracking generator, 8568A digital spectrum analyzer and 9825A desktop computer with a 9872A plotter. The digital spectrum analyzer has memory storage so that the filter response with connecting cables and 50/75-ohm matching pads could be measured and stored. After the filter was removed, the cable and pad losses were measured and then subtracted from the previously stored responses to give the exact response of the filter by itself. The calculated insertion loss graphs in Fig. 2 were obtained by using the component values with a BASIC network analysis computer program. Many years ago, it was not feasible to obtain this data, but now, with modern test equipment, the most complex filters can be tested quickly and conveniently.

High-Pass Filters for 300-Ohm Twin-Lead

Fig. 4 shows the schematic diagram and the measured passband response of the Chebyshev 300-ohm balanced filter. Fig. 6 shows the filter components assembled on a small piece of perfboard. The filter design is based on a 7-element Chebyshev design with an F-A_p cutoff frequency of 51.6 MHz, and a reflection coefficient of 4.111%. Because the 300-ohm impedance level is four times greater than that of the 75-ohm filter, the inductance values of the 300-ohm filter are about four times greater than those of the 75-ohm design. Consequently, a different type of toroidal core is used for the 300-ohm filter to get optimum results. See Fig. 4 for capacitor and inductor values. As before, high-stability, low-loss NPO ceramic capacitors were used.

Fig. 6 — Construction of the perf-board 300-ohm Chebyshev high-pass filter. Twin-lead connections are tack soldered to the two eyelets at each end of the board.

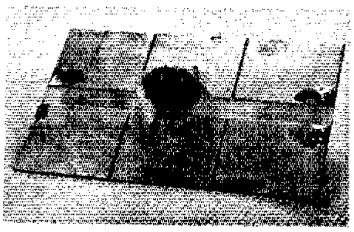
The passband response (Fig. 4) shows an insertion loss less than 1 dB over the 54- to 240-MHz range. However, there are discontinuities in the insertion loss slope and a slight insertion gain between 150 and 161 MHz. This anomaly may be associated somehow with an interaction between the filter and the 75/300-ohm baluns used in the measurement test setup. In any case, the filter passband attenuation is relatively low and flat, and extends beyond 240 MHz.

The stopband response of this filter is 10 dB poorer at 30 MHz than the 75-ohm filter (see Figs. 2C and 5A), but in most cases this attenuation level will still be adequate. If greater attenuation is needed, then the elliptic design (Fig. 5B) should be used. A suitable elliptic design will be discussed later.

Printed-Circuit Board Construction

While reviewing the various publications for background material on high-pass filter design, I came across an interesting reference in which a pc board was used to fabricate the capacitors in a high-pass filter.[11] I used this pc-board capacitor technique in an attempt to duplicate the previously discussed 300-ohm perf-board filter. Photographs of the top and bottom of the pc-board filter are given in Fig. 7. The construction details for this filter are given in Fig. 8. The passband and stopband responses of the filter with printed-circuit-board capacitors were virtually identical to that of the 300-ohm perf-board filter. Above 100 MHz, the passband loss gradually increased from 1 to 2 dB. This is attributed to the higher losses of the pc-board dielectric material compared with the lower loss dielectric of the ceramic capacitors used in the perf-board filter construction.

G10 epoxy-glass double-sided copper-clad board with a thickness of 1/32 inch was selected because its capacitance versus area gave a convenient overall size. The capacitance of this board may vary as much as 20% from batch to batch. If a capacitance meter is available, start with a piece of material 44-mm wide × 80-mm long and trim the length to obtain a capacitance of 180 pF ± 10%. The individual capacitors should then be trimmed to the design values. The



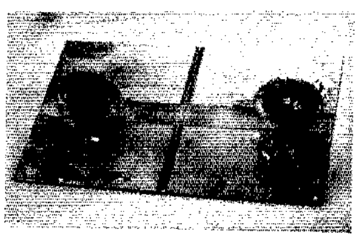


Fig. 7 — At left, top view of the 300-ohm filter using pc-board capacitors. The twin-lead is tack-soldered at the left and right ends of the board. The bottom view of the filter is shown at right.

capacitors are cut slightly undersize to compensate for fringing effects at the edges, which tend to increase the capacity. Thus, the capacitance calculated from the given pc-board dimensions is less than the specified value, although the actual capacitance (measured with a digital capacitance meter) is as given in Fig. 8. The two filter halves are separated by almost 1/4 inch to minimize capacitive coupling. A separation equal to approximately eight times the board thickness was believed to be adequate. These cuts are best made with an X-Acto knife, and the

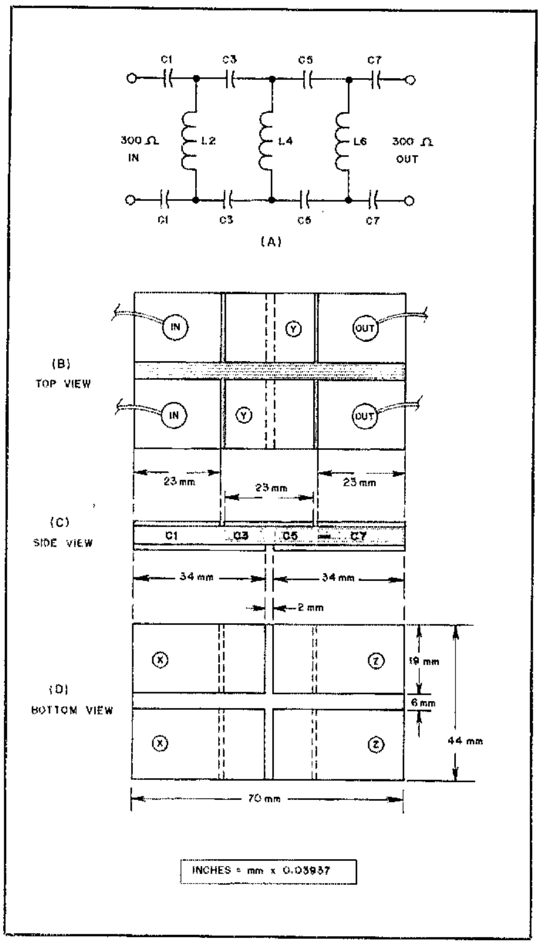


Fig. 8 — Schematic and pictorial diagrams of the 300-ohm balanced high-pass filter with pc-board capacitors. Shaded areas indicate where copper has been removed. Dimensions are given in millimeters for ease of measurement. This pc-board material has a capacitance per unit area of 0.057 pF/mm^2. L2 leads connect to the points marked (X). L4 connects to the points marked (Y) and L6 connects to the points marked (Z) on the pictorial. Design parameters for a 7-element 300-ohm Chebyshev high-pass filter: reflection coefficient = 8.8%, F-A_p = 42.3 MHz, C1 = C7 = 26 pF, C3 = C5 = 13.2 pF. Design inductances: L2 = L6 = 0.788 μH; 14 turns no. 26 wire on a T44-10 core. L4 = 0.693 μH; 13 turns no. 26 wire on a T44-10 core. Turns should be evenly spaced, with approximately 1/4 inch between the ends of the winding. If T37-10 cores are used, wind 16 and 15 turns, respectively.

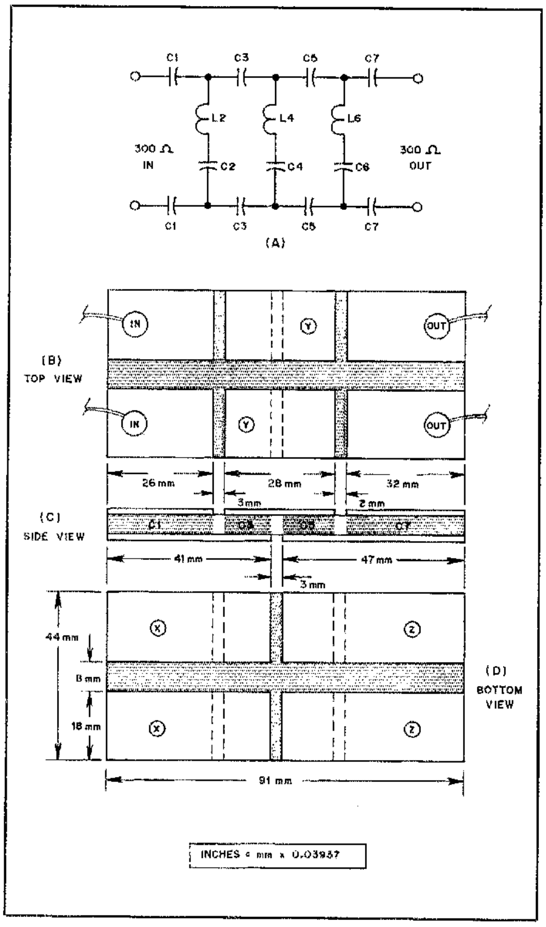


Fig. 9 — Schematic and pictorial diagrams of the 300-ohm balanced elliptical high-pass filter with pc-board capacitors. Shaded areas indicate where copper has been removed. Dimensions are given in millimeters for ease of measurement. L2-C2 connects between the points marked (X). L4-C4 connects between the points marked (Y) and L6-C6 connects between the points marked (Z) on the pictorial. Design parameters for a 7-element, 300-ohm, elliptical high-pass filter: reflection coefficient = 5%, F-A_p = 50.2 MHz, A_s = 68.8 dB, C1 = 28.0 pF, C3 = 14.0 pF, C5 = 14.8 pF, C7 = 34.2 pF, C2 = 162 pF, C4 = 36.0 pF, and C6 = 46.5 pF. Design inductances: L2 = 0.721 μH: 14 turns no. 26 wire evenly wound on a T44-10 core. L4 = 0.766 μH: 14 turns no. 26 wire bunched as required on a T44-10 core. L6 = 0.855 μH: 15 turns evenly wound on a T44-10 core. These coils should be adjusted for resonance at 14.7, 30.3 and 25.2 MHz.

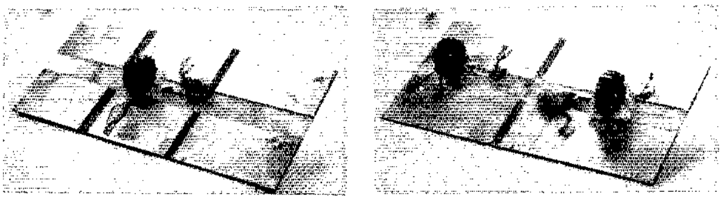


Fig. 10 — A top view of the 300-ohm elliptic filter using pc-board capacitors is shown at left. Twin-lead is tack soldered at the left and right ends of the board. At right, bottom view of the filter.

strips peeled off. Heating with a hot soldering iron will help the strip lift easier. Etching is not necessary for such a simple pattern. This pc-capacitor-forming technique makes it very easy to assemble an inexpensive but effective high-pass filter.[12]

300-Ohm Elliptic-Filter Design

Because the attenuation performance of the Chebyshev pc-capacitor filter was so satisfactory, the same technique was used to construct an elliptic filter for greater attenuation at 30 MHz and below. An elliptic design is distinguished from a Chebyshev design by its resonant sections that cause a more abrupt increase in stopband attenuation. Fig. 9 shows the schematic diagram and component values of this filter. Fig. 10 is a photograph of the top and bottom of the filter. The same type of pc-board material was used for this filter as for the 300-ohm Chebyshev filter.

Another important characteristic of the elliptic design compared with the Chebyshev is that C1, C3, C5 and C7 are all different values. Normally, this would cause a problem in matching the design values to standard capacitor values, but in this case, any capacitor value can be easily obtained by correctly partitioning the pc board to the required dimensions. Thus, the pc-board filter technique is ideally suited to provide the eight series capacitors in the balanced 300-ohm elliptic filter. The capacitors in the three shunt-tuned circuits are conveniently realized with NPO ceramic capacitors.

The passband response of the elliptic filter was virtually identical to that of the Chebyshev pc-board filter, and consequently, the related plot is omitted. The elliptic filter stopband response is shown in Fig. 5B, and the characteristic stopband attenuation peaks at 30, 25.5 and 15 MHz are apparent. These measured stopband attenuation peaks and the measured minimum stopband attenuation (A_S) of 68 dB agree very well with the calculated values given in Fig. 9. This design should suffice for those situations where greater attenuation is needed to prevent TV-receiver front-end overload.

Conclusion

These high-pass filter designs have significantly improved performance and ease of construction compared with designs originating more than 20 years ago. I expect these modern designs to be improved and simplified, but hopefully this will occur more promptly than in the past. Improvements to these high-pass modern designs can be expedited if those who build and install the filters will communicate their experiences and comments to the author and the ARRL. This will help make it possible for the corrections and improvements to be shared by all radio amateurs.

The author wishes to acknowledge the assistance of Joseph Gutowski of EWC, Inc., and Rex Cox of Honeywell, Inc., for the review of the manuscript. The author is also grateful to Honeywell, Inc., for making it possible to use the equipment needed for the filter evaluations.

Notes

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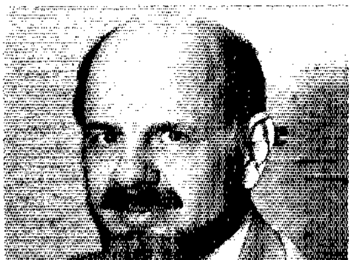
Strays

TA PROFILE

☐ We certainly appreciate the many services rendered by ARRL Technical Advisor Robert V. C. Dickinson, W2CCE, of Berkeley Heights, New Jersey. A professional expert on CATV/CATV leakage problems, Bob has written the material for the CATV Interference chapter of our new (revised) edition of *Radio Frequency Interference*, available now from ARRL or your local dealer.

Bob was first licensed in 1947 and now holds an Extra Class license. Over the years he has worked the hf and vhf bands, with emphasis on antennas, RTTY and missionary traffic. He is a longtime member of the Amateur Radio Missionary Service. As a professional engineer, Bob has been involved in various areas of radio communications, radar, navigation systems, electronic countermeasures and international broadcasting. Much of his time during the last 10 years has been devoted to several areas of cable television.

Bob is the recipient of a Mechanical Engineering degree and an MSEE degree in computer science from the Stevens Institute of Technology. He is the President of E-Com Corporation of Stirling, New Jersey, a firm that designs and manufactures equipment for data transmission and special services on CATV networks. — *Marian Anderson, WB1FSB*

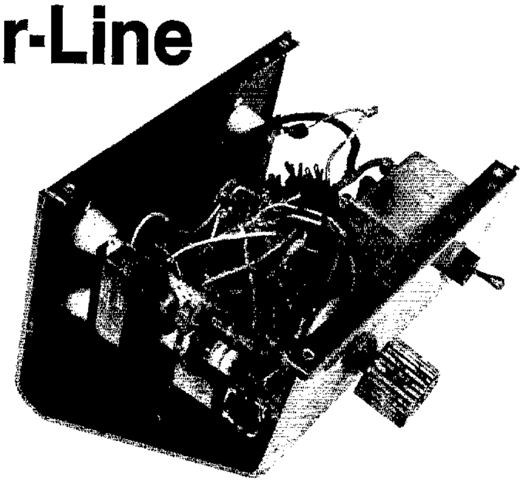


TA Bob Dickinson, W2CCE

I would like to get in touch with . . .

☐ anyone with a circuit diagram for a XETEX (also identified as Advance Instrument) OS15 oscilloscope. Walt Jackson, KB3LH, 281 Irish Road., Berwyn, PA 19312.

Protect Your Equipment from Damaging Power-Line Transients



Your rig getting spiked? Probably 50 to 100 times a day! Get on the MOVs. Protect your sensitive radio today.

By Ken Stuart,* W3VVN and Gene Collick,** W8LEQ

Several years ago I designed and built an automatic dimmer for photoflood lamps. Even though the dimmer worked flawlessly, I would occasionally come into the room after a violent thunderstorm to discover an odor of charred components and would find the circuit breaker on the dimmer had tripped. Investigation always revealed that a bridge rectifier, which was connected directly across the 117-V line inside the dimmer and rated for at least 600 V, had shorted. After replacing the bridge four or five times in as many years, the dimmer was retired from service. Obviously, line-voltage transients of sufficient magnitude to exceed the 600-V PIV rating of the diodes were causing destruction of the diodes and surrounding parts (See photo).

Back in the "good ole days" of radio, semiconductor junctions were used only for detectors in radio receivers or for similar applications such as gate diodes in automatic noise limiters. All of the power-rectification functions were handled by vacuum or gas-filled tubes. These tubes were capable of withstanding short-duration overvoltages and internal arcs caused by power-line transients. In fact, most line transients, even those occurring during equipment operation, were not likely to cause equipment damage and probably went unnoticed. Only large transients, such as those caused by nearby lightning strikes, would cause notable damage, usually as a result of arcing to ground or across open switch contacts

When the semiconductor age arrived the bulky tube rectifier gave way to the tiny solid-state diode, which had the ability to handle much higher levels of forward current with almost no voltage drop.

This reduction in active-device size over the years has given rise to problems of transient protection. Semiconductor junctions are easily destroyed by voltage or current transients of less than a millionth of a second (microsecond) duration. In fact unprotected MOSFETs and integrated circuits containing unprotected MOS devices can be destroyed simply by picking them up. The small static-voltage difference between the human body and the device can arc across the gate-insulation layer. Since ICs and MOS transistors are standard equipment in Amateur Radio transceivers, we need to better understand the transient problems that can (and do) exist on our household and automotive power systems and the ways to protect against equipment damage.

Power-line transient voltages are generated in many ways including the natural phenomenon of lightning, switching inductive loads and ground-fault clearing. Depending on the conditions, the transient energy may vary from mild to severe, from microjoules to kilojoules.

Lightning

Of course all hams disconnect their antennas from their rigs at the end of each operating period to protect equipment from lightning strikes (don't they?). But how many disconnect the rig in the car from the mobile whip when it is not in use? My neighbor didn't. The largest pieces of his fiberglass whip antenna we were able to find were slivers less than three inches in length. I won't go into detail about the charred remains of his rig: He might read this article and the memory is still painful to him.

Exposure to lightning effects is always a matter of probability because of the very nature of this unpredictable phenomenon. A single stroke can have a length of over 4 kilometers (miles = km × 0.62) with peak currents of 400 kiloamperes. Typically, the highest peak currents occur for the tropical regions of the world because of the greater height of the bottom of the thundercloud. Peak currents in the temperate zones are in the range of 250 kiloamperes. Distribution of peak currents for lightning strokes occur over a broad current range as shown in Fig. 1.[1] From this graph, you can see that 50% of the strokes are less than 20 kiloamperes, 10% of the strokes are greater than 65 kiloamperes and only 2% of the strokes

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[1]Notes appear on page 38.

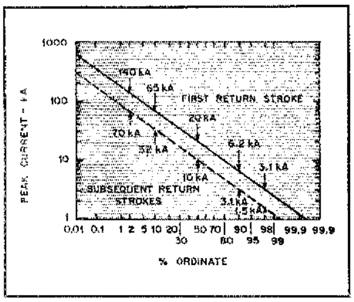


Fig. 1 — Distribution of peak currents for the first and subsequent return lightning strokes.

are greater than 140 kiloamperes.

Lightning can also cause problems even when the strike is nowhere near the antennas and equipment. Lightning produces both electric and magnetic fields that vary with distance, frequency and time. These fields are important since they can couple into power-transmission lines and destroy electronic circuits. Frequencies of radiated fields range from a few kilohertz up into the gigahertz region. The greatest magnitude is caused by the high-current return stroke, which radiates at a frequency of about 5 kHz. A strike at a distance of one kilometer can easily produce a field of 100 volts per meter (feet = m × 3.28). With fields of that magnitude, and long commercial power lines acting as antennas delivering that power into the house, very high transient voltages can appear at the power cord of your rig (remember my dimmer).

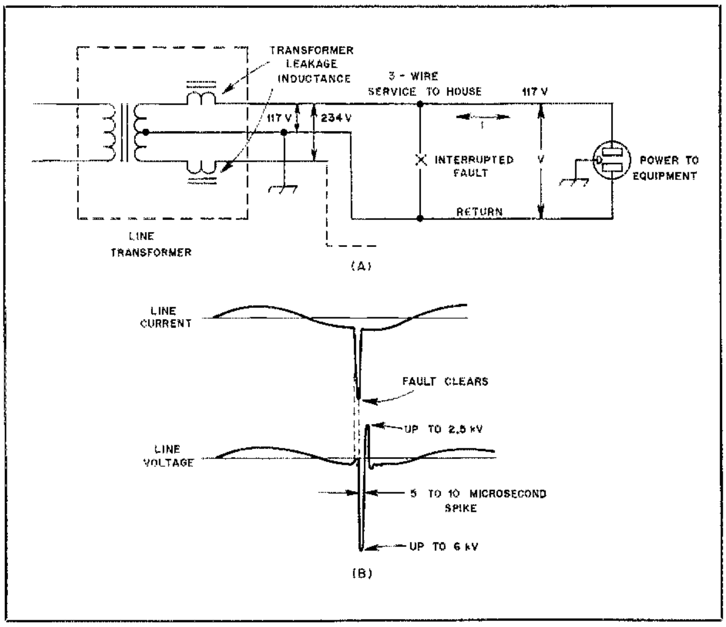


Fig. 2 — (A) A circuit showing the production of a transient spike when a short-circuit fault is cleared. (B) A drawing of the current and voltage waveform as the fault develops and is cleared.

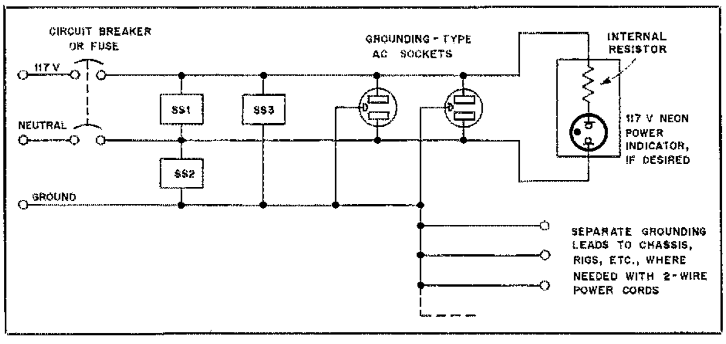


Fig. 3 — A suggested "shack" wiring diagram, including a main power-disconnect switch and transient-protective devices. SS1, SS2 and SS3 are bi-directional surge suppressors, with a minimum clamping voltage of 180-V peak and a maximum of 200-V peak.

Fault Clearing

When a very large current is drawn abruptly from an electrical system under conditions such as a short circuit, clearing of this fault by the blowing of a fuse or circuit breaker can result in an extremely high voltage spike. This spike results from the collapsing magnetic field in the power-distribution transformer (or "pole" transformer), which occurs when the high current fault condition is cleared. With 117-V ac power-line systems, a transient voltage of up to 6 kilovolts having a duration of approximately 5 to 10 microseconds can occur, as shown in Fig. 2.

Switching Inductive Loads

When the current is interrupted in an inductive load (such as an electric motor) a voltage is induced in the windings by the collapse of the magnetic fields. This voltage can be on the order of thousands of volts and can arc across the open contacts of the line switch, thereby generating a transient on the ac line.

The waveform of induced-voltage transients is usually oscillatory in nature and is caused by the gap between the contacts in the switch alternately sparking over and extinguishing. As the switch is opened the current in the inductor continues to flow, charging the distributed capacitance in the windings until the voltage is sufficient to spark across the switch gap. When the arc occurs, the induced voltage stored in the winding capacitance is discharged back onto the power line until the arc extinguishes, at which time the voltage build-up is repeated. This oscillation continues until there is insufficient energy available to restrike the arc.

One case history in a study performed on commercial and residential power-system transients involved a report of complaints of sparking in a light fixture. "With the (light) switch in the ground wire, and the frame attached to a grounded pipe, flashover at 1700 V was observed in correlation with the start of an oil burner in the house. This defective light fixture was acting as a voltage-limiting gap for the house."[2] This transient was apparently being produced by the automatic disconnection of the high-current starting windings of the burner motor when it approached operating speed.

Transients in the Home

Just as transients on the household power lines can be caused by various sources, the way in which the pulse is delivered to your gear can also vary. The pulse can exist from line-to-line (dif

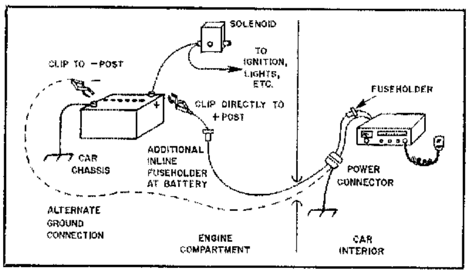
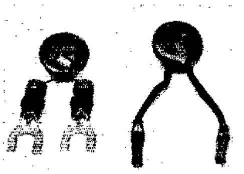


Fig. 4 — The suggested method of connecting a mobile rig to your car battery is shown.



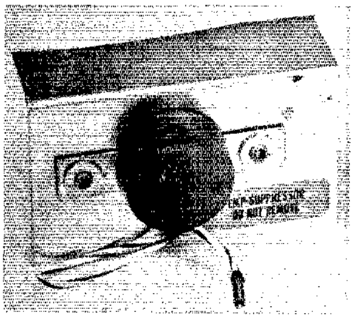


Fig. 5 — Left: Typical LA series MOV protectors, with various connectors on the leads. Right: A PA series MOV shown as it might be mounted in a service-entrance box.

ferential or transverse mode) or line(s)-to-ground (common or parallel mode). Therefore, even with a 2-wire, 117-V connection there are three possible paths for transients to follow. The problem is further complicated by capacitance in the household wiring, which can couple the transient from one wire to another thereby creating combinations of both modes at once.

To be completely effective then, transient protection must be applied at the station power receptacle and must be tied to the chassis of the rig as well (see Fig. 3). It is also desirable to include a local circuit breaker on the incoming power side of the protectors so the power line can be disconnected completely when the station is not in use.

Transient Protection in Mobile Installations

An automobile can be a very hostile environment for your rig. Currents as high as 300 A (starting motor) are switched regularly, and this can produce voltage spikes of up to −210 V on the electrical system.[3] However, the car does have two advantages normally lacking in the home: Lightning influence on the power system is almost never a problem, and the car battery is a natural surge suppressor. To take advantage of the protection afforded by the battery, however, the rig must be connected directly to the battery posts — not to intermediate junction points, under-the-dash or firewall fuse blocks, or auxiliary contacts on the ignition switch. (You may also want to try isolating the transceiver case from the car chassis and running a separate ground lead to the battery, especially if alternator whine is a problem.)

Protection of your mobile system can be summed up as follows:

1) Disconnect the antenna when the rig is not in use.

2) Provide power for the rig directly from the car battery. Use an in-line fuse holder at the battery-clip end of the positive lead to prevent damage or fire from accidental shorts, as shown in Fig. 4.

3) Turn off the rig and all other audio and radio equipment when starting the engine.

If you are concerned about accidentally trying to operate with the antenna disconnected, I would suggest that you mount a small aluminum bracket under the dash with a 2- or 3-pin female Cinch-Jones connector and a chassis-mount BNC connector spaced close together. Solder the power leads to the Cinch-Jones socket and the coaxial cable from the antenna to the BNC connector. Make short lengths of power and coaxial cables, using the appropriate mating connectors, to reach between the rig and the bracket. Since these wires will stay with the rig, you may wish to mechanically secure the cables to the case. Tying the free ends of these cables together will facilitate easy removal and reconnection of the antenna and power cables. A bracket and connector arrangement in the "shack" will make for fast and easy transfer of the rig from house to car and vice versa.

One final thought on mobile installations. The pointers for cars are equally applicable to boats and planes.

Transient Protection in the Home

The material in this section, written by Gene Collick, W8LEQ, provides specific information about transient-protective devices and their installation. By following his suggestions your equipment will have a high degree of protection against the transients described by Ken Stuart, W3VVN, in the first part of this article — Ed.

Protective Devices

The General Electric Home Lightning Protector® is designed to prevent lightning surges (entering through the wiring) from damaging electrical wiring and/or appliances. The protector is a two-pole, three-wire device designed primarily for single-phase 117/234-V grounded-neutral service. It mounts via a 1/2-inch pipe-thread connection through a knockout in the service-entrance box, or preferably, at the weatherhead or within the meter housing. The purpose of this device is to reduce the amplitude of large transients.

TransZorbs® are silicon devices manufactured by General Semiconductor Industries for transient suppression. They contain a large-area PN junction having integral heat sinks and are capable of handling short-duration, high-power pulses (typically 1500 watts for 1 millisecond and 100,000 watts for 100 nanoseconds). The TransZorb® protects by clamping transient voltages to a safe level, with sub-nanosecond reaction time.

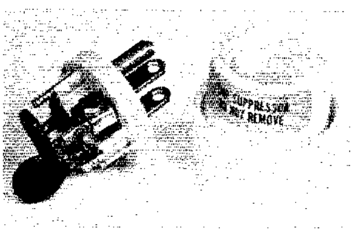


Fig. 6 — Construction of a plug-in protector. Install a V130LA10A MOV across the brass and silver terminals and another across the silver-to-green terminals.

A metal-oxide varistor (MOV) is a bulk semiconductor device whose resistance varies with the magnitude (but not polarity) of the applied voltage. At extremely low currents, a varistor acts like a linear resistor with a resistance that can exceed hundreds of megohms. At higher currents, the voltage-current relation is nonlinear, and at extremely high currents the device acts like a constant resistor with a very small value (typically about one ohm). Varistors can respond in low-nanosecond times, with clamping-treshold voltages ranging from 10 to 1500 V, with continuous power from 0.5 to 5 watts and with peak energy of more than 600 joules. MOVs have a capacitance that is a device parameter, and this should be considered for high-frequency applications. GE manufactures devices with wire leads (LA series) and the heat sink type (PA series). I prefer the PA type for service-entrance box and fuse-box mounting and use the LA units for coils, solenoids and such within the equipment. See Fig. 5.

Installation

The first protective device you can install is a secondary low-voltage lightning

Fig. 7 — Ken Stuart's outlet strip with built-in transient protection. A 1N6072 TransZorb® is shown connected between the hot and neutral sides of the strip. GE V130LA10A MOVs are connected from each side of the line to ground. The braid strap connects to the transceiver ground lug.

arrestor rated at 650 V (a typical device is a GE Thyrite type 9L15BC002). Power should be removed from the feed to the house, and the device should be installed ahead of the service-entrance box by a qualified electrician. The black leads (2) are connected to each hot leg, with the white lead terminated to the meter box (be sure the meter box is directly connected to the service-entrance box). The reason the white lead is terminated to the box rather than the electrical circuit neutral is that the device is being installed to protect against the common-mode (phase-to-case ground) transient.

The second device to be installed is a low-voltage surge arrestor such as a GE V130PA20A MOV. These should be connected from each hot leg to case ground. The arrestor should be located in a way that provides minimum lead length. These can be installed with an active power feed to the house, but with the main breaker turned off. Connect the MOVs on the load side of the main breaker.

The ac input to the transmitter can be protected by one of two methods. I didn't mind modifying the transmitter, so I installed a V130LA10A MOV across the ac input and another one from neutral to case ground. If you do not want to modify the transmitter, a plug-in protector can be purchased or constructed (see Fig. 6). This device is then plugged into the duplex receptacle feeding the transmitter. This method should be ideal for renters, for portable operation or to provide some protection for those who can't afford an electrician to install the other devices. Receivers, transceivers, TV sets and other electronic equipment should all be protected in a similar fashion. An alternative would be to wire an outlet box or strip as was done by Ken Stuart (Fig. 7).

Rotator protection consists of installing a plug-in MOV device in one side of the duplex receptacle that the rotator remote-control unit is plugged into. The rotator control cables should terminate in a grounded metal box. Each control cable conductor should have a GE V56ZA2 MOV connected across it to case ground. My control cable was not shielded, so the same type of protective devices were installed within the rotator. If shielded cable is used, the devices inside the rotator would not be needed. Check the voltage on the control cable and select a value of MOV rated for a safe operating voltage above the control voltage.

Table 1

Transient-Protective Device Cost and Selection Data

General Electric Co., Semiconductor Div., W. Genesee St., Auburn, NY 13021

"Home Lightning Protector"	
GE Thyrite 9L15BCB002	$15
"Metal Oxide Varistors"	
V130LA10A	$1.75
V130PA20A	$4.70
V39ZA6	$1.75
V56ZA2	$1.04

The numbers after the V indicate the normal operating voltage (rms) of the circuit. Voltages at a preset value greater than that will cause the device to conduct heavily, clamping the voltage.

General Semiconductor Industries, P.O. Box 3078, Tempe, AZ 85281

TransZorbs®

1.5KE6.8	$1.86
1.5KE7.5 to 47	$1.68
1.5KE51 to 110	$1.95
1.5KE120 to 150	$2.60
1.5KE160 to 200	$2.90
1N6072	$6.90

Bidirectional, for connection directly across 117-VAC line.
The numbers after KE are the approximate breakdown voltage of the device.

Table 1 provides information to help you select the proper transient-protective devices and to give you an idea of the cost of protecting your expensive equipment. Newark Electronics, 500 N. Pulaski Rd., Chicago, IL 60624, sells most of these units. TransZorbs are available by mail from Technico, Inc., 9051 Red Branch Rd., Columbia, MD 21045. You can also check with your electrical supplier or contact the manufacturer for the devices you need.

This concludes the transient protection of a basic amateur station. The intent of this article is to provide some basic concepts about transients and methods of protection from them. We hope you have found it both useful and interesting. QST

Notes

[1]Transient Suppression Seminar, Supplementary Notes, O. Melville Clark, General Semiconductor Industries, Inc.
[2]*Transient Voltage Suppression Manual* (General Electric, 1976), p. 68.
[3]*Transient Voltage Suppression Manual* (General Electric, 1978), p. 8.

Strays

TA PROFILE

☐ Many of you should recognize the amateur in the accompanying photograph because of his participation in seminars and forums during local, regional and national ham conventions at more than 90 locations. He is ARRL Technical Advisor Al Markwardt, W5PXH, whose field of expertise is antennas and RFI. Al's services as a TA (since 1978) are deeply appreciated.

Al has an Extra Class license (he was first licensed in 1932), and he also holds a Radiotelephone First Class license. His Amateur Radio interests include operating hf ssb/cw, 2-meter fm, electronics theory, and the design and construction of ham-band antennas (especially quads). Al spends a great deal of time assisting amateurs with RFI, TVI and other interference problems.

He is a member of ARRL, IEEE, QCWA, the Richardson Wireless Klub and the Toastmasters International. He earned the Distinguished Toastmaster degree (DTM) in 1970.

As a Communications Engineering graduate from Missouri Technical Institute, Al continued his education at the State University of New York and the University of Texas.

Residing in Richardson, Texas, he is employed by Northern Telecom and is a technical-training instructor on the subject of specialized common-carrier tandem switches. His other areas of professional specialty are sales, management, electronic technical instruction and public speaking. Al has patent-disclosure papers issued on Teletype message switching techniques. Despite his busy schedule, Al finds time to enjoy bicycling, gardening, house maintenance and listening to Nashville Brass musical recordings. — *Marian Anderson, WB1FSB*

TA W5PXH, relaxed, happy and ready for his next QSO.

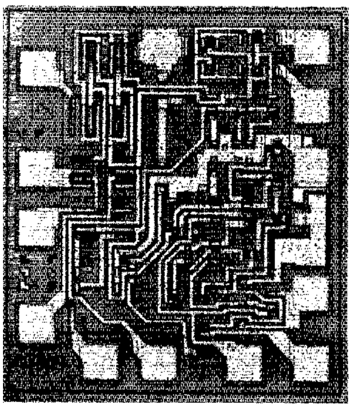
New Products

MINIATURE TV SIGNAL TRANSMITTER

□ A complete, miniature, precision transmitter capable of generating a high-quality television signal for transmission on a 75-Ω cable has been introduced by Motorola. The 14-pin plastic MC1374 is aimed at applications where a professional quality rf signal is required. With 30 mV rms output, the new device can easily handle a vestigial sideband filter and still deliver a "snow-free" signal to half a dozen TV receivers. While primarily characterized for the FCC-guarded channel 3 and channel 4 operation, the balanced design and high-frequency processing make special applications feasible. For example, the rf oscillator and modulator can be operated at over 100 MHz.

Each package contains the rf oscillator, balanced rf modulator, sound-carrier oscillator and fm modulator, arranged to permit "clean" pc-board layout and good isolation of sound and video circuits. The rf modulator resembles the earlier MC1496, complete with dual inputs and adjustable gain. The rf oscillator is internally connected to the modulator, and has only two external pins, which can be used for L-C tuning or crystal control. A standard signal from video of either polarity, and levels of 0.5 to 2.5 V pk-pk may be generated by the modulator. Dual inputs permit separate insertion of video and a modulated 4.5-MHz sound carrier, thereby reducing the possibility of cross talk and unwanted mixing products. According to the manufacturer, the performance of the rf modulator exceeds the accuracy of most available detectors with regard to variations in linearity (less than 2%), differential phase (less than 2°) and differential gain (less than 5%). Unwanted intermodulation is very low.

The sound oscillator and fm modulator are one inseparable circuit within the IC.



Two pins are brought out for the tuning components that establish the nominal carrier frequency. A third pin is used for audio input and, if desired, dc frequency control (afc) of the sound oscillator. Also, the sound oscillator power-supply pin is brought out separately, permitting the sound section to be disabled.

The low distortion of this fm system is a significant improvement over the more common varactor system; it is also less expensive. Only one resistor and capacitor are needed to couple the sound subcarrier to the input of the rf modulator to complete the composition of a professional-quality TV signal.

The MC1374 is designed to operate over a power-supply range of 5 to 12 V at a current level of 15 mA. In 100-up quantities, the price is $2.88. For further information, contact Peter Whatley, Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036, tel. 602-962-3103. — *Paul K. Pagel, N1FB*

ALPHA DELTA COMMUNICATIONS TRANSI-TRAP

□ Any Amateur Radio station that is operated wisely includes provisions for protection from lightning discharges. While not much can be done about a *direct* lightning stroke, negating the effects of nearby discharges on radio equipment should be a concern of all station operators, amateur or professional. Solid-state receivers and transceivers are more prone to electrical-discharge damage from distant storms than are their vacuum-tube counterparts.

Don Tyrell, W8AD, of Alpha Delta Communications, investigated the performance of standard airgap lightning arrestors. He found them ineffective for use with solid-state equipment: They fire too slowly and at too high a pulse-voltage level. And, when the air-gap arrestor does fire, a 30- to 80-volt potential still exists across the firing arc. Because of the typically high (3-kV to 5-kV) firing level of the air-gap devices and the firing delay (1 ms), a sufficient amount of voltage exists that will damage semiconductor junctions.

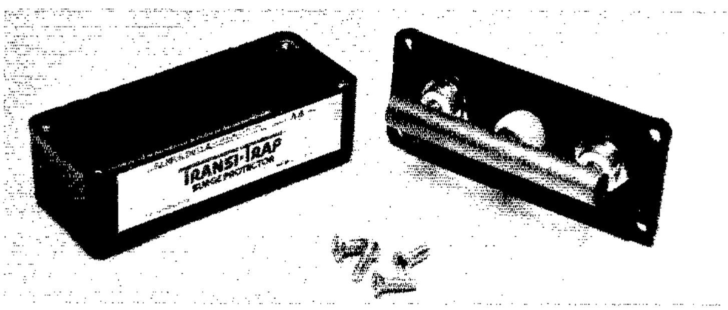
According to the manufacturer, the Transi-Trap employs a gas-filled ceramic tube that is constructed to provide a fast-firing (100-ns) characteristic. This is coupled with a low-level firing voltage that depends on the Transi-Trap model used. The model R-T fires at a 200-V dc/750-V pulse level, and the model HV operates at levels of 1 kV and 2.25 kV, respectively. R-Ts are designed for use with solid-state receivers and transceivers (or transmitters) operating at power input levels up to 200 watts. They are designed for use in 50-ohm systems at frequencies up to 500 MHz. Insertion loss at 500 MHz is 0.15 dB, with a corresponding VSWR of 1.22.[1] An HV unit is designed for use with equipment lineups that employ amplifiers operating at inputs up to 2 kW.

Transi-Trap Surge Protectors are encased in black die-cast aluminum boxes fitted with SO-239 connectors; either connector may be used for the input or output port. The field-replacable Arc-Plug cartridge is equipped with hardware to permit attachment to a ground wire. A ground wire is absolutely essential to the proper operation of the protectors and it should be kept from contacting other metallic objects.

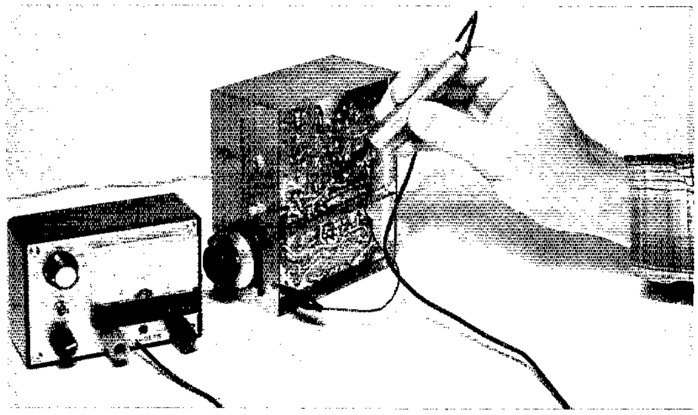
Early models of the Transi-Trap employed a brass wire connected between the two connectors. The manufacturer now uses a piece of brass tubing. This improved the vhf operating characteristics of the units.

While designed primarily for indoor use, the Transi-Trap may be used outdoors if proper weatherizing precautions are taken. Transi-Trap Surge Protectors are manufactured by Alpha Delta Communications, 116A North Main St., Centerville, OH 45459. Price class: model R-T, $30; model HV, $33. Add $4 for shipping and handling charges. — *Paul K. Pagel, N1FB*

[1]Verified in the ARRL lab.



BEGINNER'S BENCH



Some Basics for Equipment Servicing

Part 3: Using the proper techniques can speed equipment servicing. The methods are easy, and you can build the test gear!

By George Collins,* KC1V

In Parts 1 and 2 of this series, we presented the basic troubleshooting methods of dc voltage and resistance measurement, and semiconductor testing. These are very effective techniques for determining which component in a particular circuit has failed. If the symptoms of the problem provide us with enough information to locate the trouble area, a check of a few dc voltages may be all that is needed to pinpoint the problem. Unfortunately, we will often face situations in which the symptoms alone are not sufficient to locate the trouble area. This month we will look at some additional methods the amateur can use to make service work less difficult and not so time consuming.

Signal Tracing

Fig. 1 is the block diagram of a typical amateur receiver. If the receiver "dies," what do we do? First, see if the symptoms indicate where the problem is located: when the receiver is turned on, we hear the normal hiss from the speaker, but do not hear any signals as we tune across the band (the antenna is connected!) Applying a strong signal to the antenna input also results in nothing but hiss. So far, all we have learned is that it is likely that the audio stages and power supply are functioning. Noting that there is no S-meter indication when we tune across the frequency of the input signal, we can conclude that the signal is not reaching the agc or detector circuits. We have been able, tentatively, to eliminate four or five stages, leaving us with nine more possibilities!

At this time we could begin measuring the dc potentials at various points in each stage. While this approach should eventually lead us to the defective stage, it could be a time-consuming process. If we can reduce the number of possible stages to one or two, we should have the receiver back in working order much more rapidly. One way we can do this is by *tracing* a signal through the receiver. The general technique is to apply a signal to the input of the unit, and then check for the presence of the signal at the input and output of each stage. When we find a stage with input but no output, chances are we have found the problem area.

Equipment

Before we can begin signal tracing, we must have a signal source of appropriate strength and frequency. A tunable signal generator with adjustable output is ideal, but simple, low-cost substitutes will serve as well. A crystal oscillator, which we will look at later, makes a good signal source for this type of work.

A second requirement is that we have some means of detecting the signal. A high-frequency oscilloscope is an excellent instrument for this application and many others. The drawback is that a good oscilloscope is expensive. An alternative to the oscilloscope is a VTVM or FET voltmeter equipped with an rf probe. The FET voltmeter and probe shown in Part 2[1] (or any similar unit) will be more than adequate for basic signal tracing. With the necessary test equipment at hand, we can begin to track down the cause of the receiver problem.

The signal applied to the receiver input should be no greater than necessary to produce a reading on the voltmeter. Most meters will show a satisfactory reading with a 0.1-V rms signal. This is a strong signal (about 60 dB over S9), but it will not harm the receiver. Avoid input signal levels greater than 0.5 V rms, because

*Assistant Technical Editor

[1]Notes appear on page 44.

some receivers could be damaged at that level. The characteristics of the diode used in the rf probe limit the accuracy at these low (less than 0.5-V) signal levels. This need not concern us, since we are looking for relative signal levels and not specific voltages. The exact voltages will depend on the circuit impedance and the type of stage being tested.

With a 0.1-V signal applied to the receiver, we can begin tracing the signal by first checking the voltages at the preselector network input and output. These voltages may be the same, but in general the preselector output voltage will be higher than the input (the preselector may be providing an impedance step up).

Next, we move to the rf (radio frequency) amplifier output. Normally this stage will show some voltage gain (output voltage is greater than the input). If the signal is still present, we can assume that the amplifier is functioning and proceed to the next stage, the first mixer. This stage, as the name implies, mixes two input signals to produce the output signal. In this case the inputs are the signals from the rf amplifier and the heterodyne-frequency oscillator (HFO). If either is absent, the mixer will not operate correctly.

Our next step is to confirm that the rf amplifier and HFO output signals are reaching the mixer. If they are, and rf voltage is found at the mixer output, can we conclude that all is well up to the i-f (intermediate-frequency) amplifier? Probably, but one additional test should be made. In some mixer circuits the HFO signal may appear at the output. To ensure that the rf voltage we found at the mixer output is the i-f signal (and not the HFO) we should check to see if the mixer output drops when the signal generator is removed from the receiver. If the mixer stage is found to be functioning, we can proceed to test the following stages in the same manner.

As we move closer to the detector, the signal level will normally increase. The rf input to the receiver should be reduced to prevent overdriving one or more of the stages. A signal generator output level that yields a reading of about 0.5 V at the stage being tested is all that is needed.

Transmitter Circuits

The same basic method can also be applied to troubleshooting transmitter circuits. The primary difference is that we normally do not need to apply an input signal; the circuit generates the signal, and we simply follow it from one stage to the next. Because the oscillators in the transmitter will serve as our "signal sources" (a modern transmitter will have several) they are the logical places to begin signal tracing. A representative variable-frequency oscillator (VFO) and buffer amplifiers are shown in Fig. 2. The voltages shown are the rms values measured with the circuit operating normally. While the values will vary from one

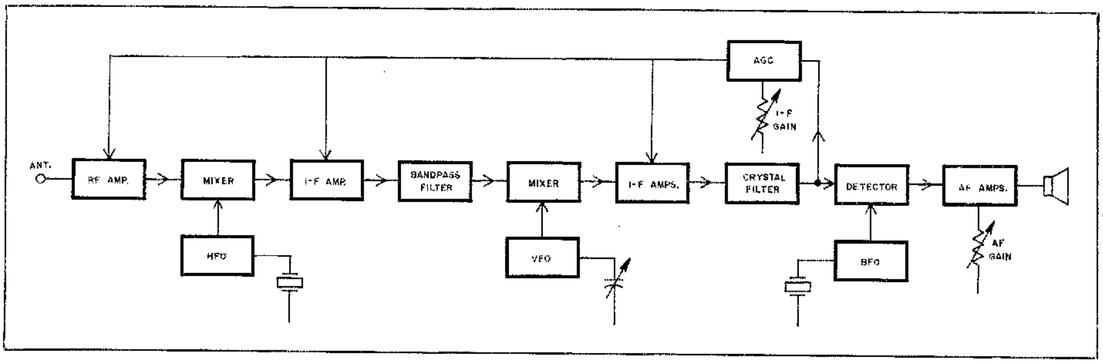


Fig. 1 — Block diagram of a typical amateur receiver.

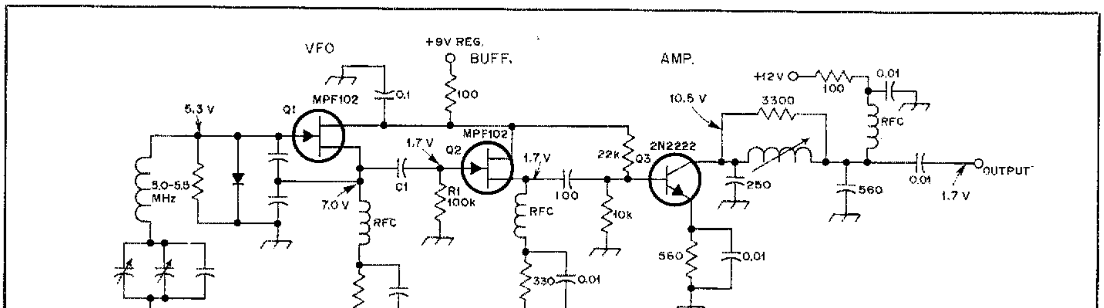


Fig. 2 — This VFO circuit is similar to that used in many transmitters and receivers. The voltages shown were measured with an rf probe and FET voltmeter.

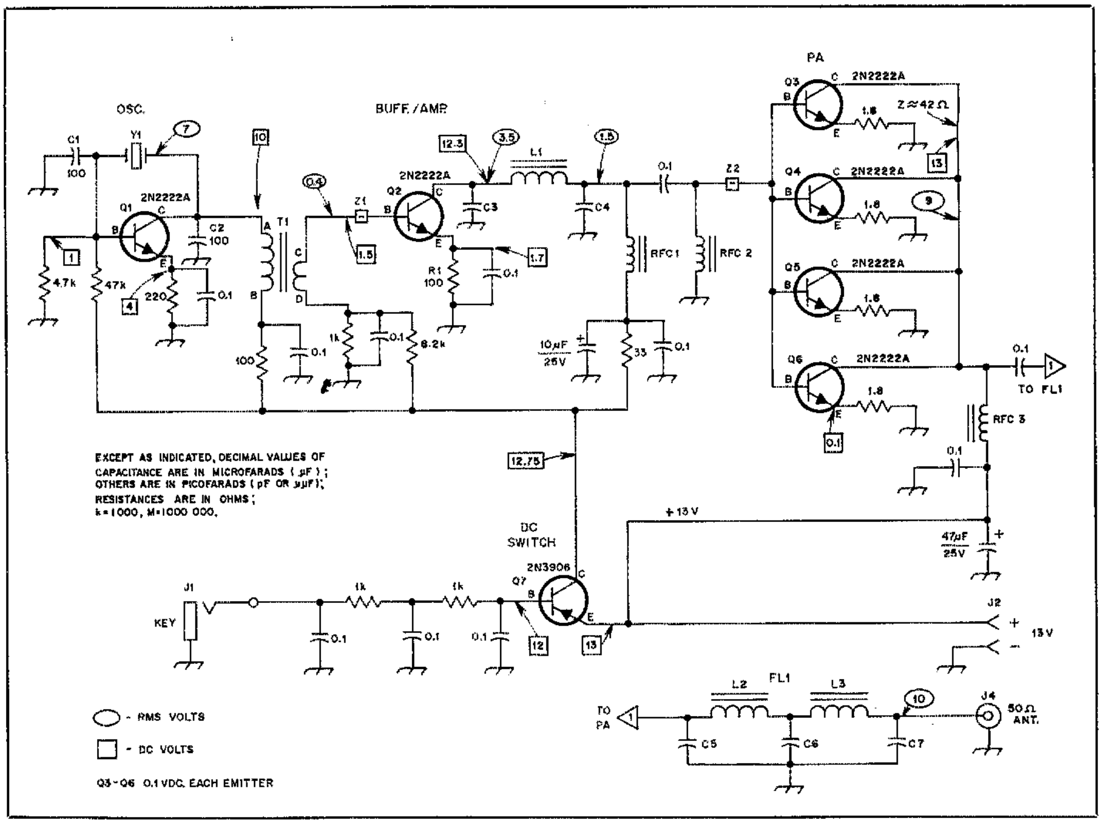


Fig. 3 — A simple low-power transmitter. The voltages were measured with an rf probe and FET voltmeter. The basic techniques used to troubleshoot a simple circuit like this can be applied to more complicated equipment.

circuit to another, the voltages shown point out some important circuit features. For example, the voltage across the tank circuit is fairly high (about one half the supply voltage), and the source voltage is also high. Capacitor C1 and the 100-kΩ resistor (R1) form a voltage divider between the source of Q1 and the gate of Q2. This results in the gate voltage being much lower than the source voltage at Q1. Buffer amplifier Q2 is operated in the source-follower configuration; thus the input and output voltages will be nearly the same. If we overlook the fact that the voltage gain of this stage *should* be only 1, we might think the stage was defective when it is actually operating correctly. The more we know about the circuits we are troubleshooting, the more likely we are to be successful in servicing our equipment.

The low-power transmitter shown in Fig. 3 provides an example of how we can apply our knowledge of circuit fundamentals to help us while signal tracing. We can

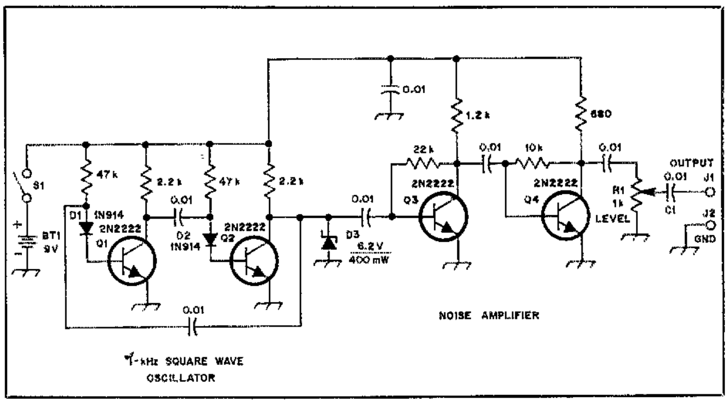
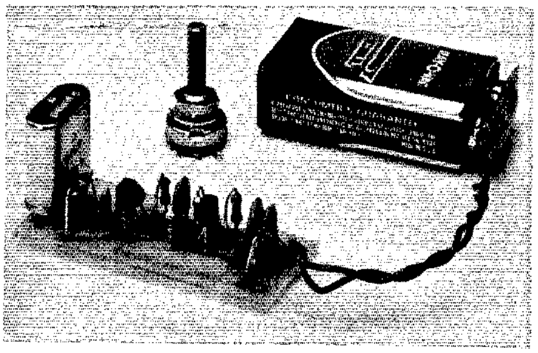
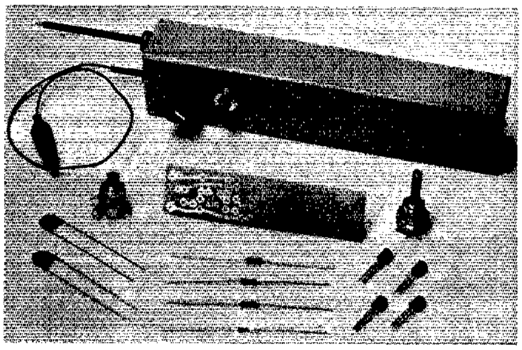


Fig. 4 — Schematic diagram of the af/rf signal injector. All resistors are 1/4 W, 5% carbon types, and all capacitors are disc ceramic.

BT1 — 9-V transistor radio battery.
D1, D2 — Silicon switching diode, 1N914 or equiv.
D3 — 6.2-V, 400-mW Zener diode.
J1, J2 — Banana jack.
Q1 - Q4 — General purpose silicon npn transistors, 2N2222 or equiv.
R1 — 1-kΩ panel-mount control.
S1 — Spst toggle switch.



Printed circuit board construction was used for this version of the crystal-controlled signal source.



The Signal Injector, housed in a homemade enclosure of circuit-board material, is a convenient, hand-held signal source.

expect the rf-voltage level at the oscillator (Q1) collector to be near that of the supply voltage; in this case we find 7 V at that point. T1 provides an impedance match between the relatively high value needed at Q1 and the lower impedance at the base of Q2. Because of this, we should expect the voltage at the base to be considerably lower than the Q1 collector voltage. Impedance matching between Q2 and the power amplifier (PA) is provided by an LC network made up of C3, C4 and L1. Again, the voltage at the low-impedance input to the PA is less than the voltage at the high-impedance side of the network.

Signal Injection

A troubleshooting technique related to signal tracing is signal injection. This method does not require a signal detector (such as the rf probe used in signal tracing) because the receiver being tested serves as the "detector" of the injected signal. Starting at the receiver output (the speaker) an audio signal is applied; if the signal is heard in the speaker, we move the injection signal to the input of the last audio amplifier stage. We continue this procedure until moving from the input of one stage to the preceding stage results in loss of audio output.

At that point we have found the defective stage. When the input to the detector is reached, we must use an injection signal at the receiver i-f rather than the audio signal used earlier. The injection-signal frequency used at the input to any rf stage must be the same as the normal signal frequency. If a wide-range tunable signal generator is available it can be used for this type of testing. If such an instrument is not part of your shop equipment, a simple "signal injector" can be used in place of the tunable generator. A signal injector generates an output signal that contains a broad spectrum of frequencies. Thus it can be used for testing audio, i-f or rf stages. The advantage in using a signal injector is the low cost of the device — it should not be considered as a replacement for a high-quality signal generator. Inexpensive signal injectors can be purchased for less than $6 or constructed at home. Fig. 4 shows the circuit of a low-cost, but effective, signal injector that can be constructed in a short time.[3] Many experimenters may have the necessary parts in their junk box.

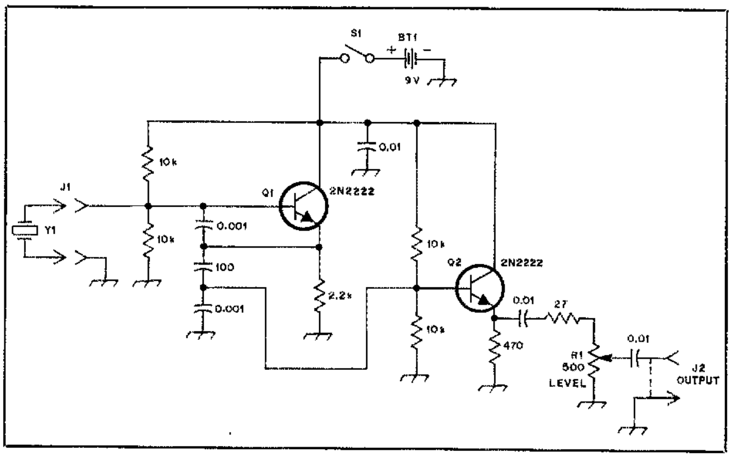


Fig. 5 — Schematic diagram of the crystal-controlled signal source. All resistors are 1/4 W, 5% carbon types, and all capacitors are disc ceramic.

BT1 — 9-V transistor radio battery.
J1 — Crystal socket to match crystal type to be used.
J2 — RCA phono jack or equiv.
Q1, Q2 — General purpose silicon npn transistor, 2N2222 or equiv.
R1 — 500-Ω panel-mount control.
S1 — Spst toggle switch.
Y1 — 1- to 15-MHz crystal.

A Crystal-Controlled Signal Source

The crystal oscillator and amplifier shown in Fig. 5 and the photograph was built as a general-purpose signal source and will serve very well for signal-tracing work. The output level is variable from 0 to more than 1 V rms into a 50-Ω load, and almost any crystal in the 1- to 15-MHz range can be used.

Q1 forms a Colpitts oscillator with the output being taken from the emitter. A capacitive voltage divider (across the 2.2-kΩ emitter resistor) reduces the voltage applied to the buffer amplifier, Q2. The buffer, an emitter follower, provides the low output impedance necessary to drive 50-Ω loads.

Construction is simplified by the use of a printed-circuit board, but any wiring method can be used. J1, the crystal socket, should be selected to match the crystals you intend to use. Multiple sockets can be wired in parallel so that any style of crystal (HC-6/U, FT-243, etc.) can be used (an HC-6/U style crystal can be soldered directly to the circuit board). The oscillator packaging is left to the discretion of the builder. A small box

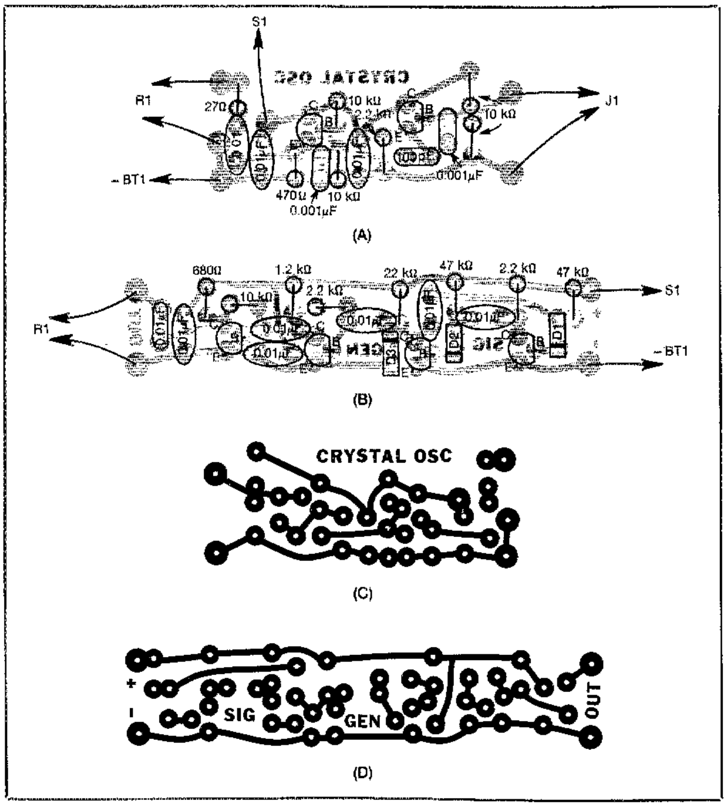


Fig. 6 — Parts placement diagram for the crystal-controlled signal source (A) and the signal injector (B). Gray areas are unetched copper, viewed from the component side of the board. Scale circuit-board etching patterns for the crystal-controlled signal source (C) and the af/rf signal injector (D).

(such as the Radio Shack no. 270-235), or an enclosure made of circuit-board material, will serve nicely.

AF/RF Signal Injector

Shown in Fig. 4 is the diagram of a simple signal injector. This device will generate detectable signals from the audio range to over 30 MHz. It consists of three basic stages: a square-wave oscillator (Q1 and Q2), a noise generator (D3) and a two-stage amplifier (Q3 and Q4). R1 is used to adjust the output level to that needed for the stage under test.

When the signal injector is applied to the antenna input of a receiver, a hissing noise should be heard. If the injector is used to test audio stages, a tone of approximately 1 kHz will produced.

The unit shown in the photograph was constructed on a printed circuit board and is housed in a homemade circuit-board box. A prototype was constructed "bread board" style on a scrap of unetched copper-clad board, and the results were the same as when the circuit board was used. The builder may select either method, and should obtain good results.

With these techniques and tools in your troubleshooting "bag of tricks" you will be able to track equipment problems easily and more rapidly. In Part 4 of this series, we will look at the use of the oscilloscope in troubleshooting and equipment servicing.

Notes

[1]G. Collins, "Some Basics for Equipment Servicing — Part 2," *QST*, Jan. 1982, pp. 38-41.

[2]Parts kits and printed circuit boards for the crystal-controlled signal source and the signal injector are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002.

Strays

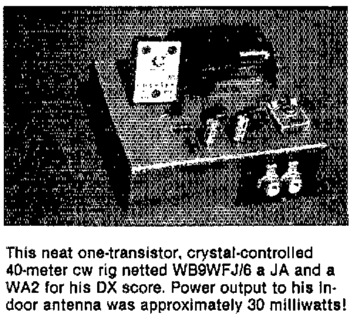
QRP TRUE GRIT!

☐ Basic Amateur Radio for September 1981 *QST*, entitled "Experimenting for the Beginner," dealt with simple cw transmitters and circuits. The "simplest transmitter," depicted schematically in Fig. 1, contained a single 2N2222 bipolar transistor, crystal controlled on 40 meters. Output power at 12 V is on the order of 50 mW. The article asked for details on on-the-air results from those who built the one-stage transmitter.

A letter from Mike Weber, WB9WFJ, of Costa Mesa, California, arrived at Hq. in December 1981. It was a study in tenacity and success. Mike built the 2N2222 rig of Fig. 1 in the *QST* article, plugged in a junkbox crystal for 7067 kHz, then connected a 9-volt battery to the transmitter. No doubt the power output was more like 25 to 30 mW with a 9-V power supply! To complicate matters even more, Mike used an indoor 40-meter antenna. His rig is shown in the accompanying photograph (nice work!).

He spent one hour per day (prime time for JA openings) for two weeks calling *CQ*. Finally, he worked JA2DYI. WA2NRC was his DX to the east. He sums up by saying, "The many hours of boredom and frustration paid off. It was worth it!"

It would be interesting to see what Mike could do with an outdoor antenna, high in the air! Hats off to this QRP enthusiast. Many of us would have given up the long vigil while running *100 watts!* — *Doug DeMaw, W1FB*



This neat one-transistor, crystal-controlled 40-meter cw rig netted WB9WFJ/6 a JA and a WA2 for his DX score. Power output to his indoor antenna was approximately 30 milliwatts!

Product Review

Conducted By Paul K. Pagel,* N1FB

Heath IT-2250 Auto-Ranging Capacitance Meter

How many times have you looked at the pile of assorted capacitors in your junk box and told yourself you'd get to checking them "some rainy day," but the required month of continuous rain never materialized? Are you tired of using a dip meter and a reference inductor for measuring capacitance? Ready to take a course in Egyptology in order to decipher the capacitor manufacturer's hieroglyphics? Whatever the reason, it's good enough to consider adding an honest-to-goodness capacitance-measuring instrument to the workbench.

The IT-2250 is a hand-held battery-operated, auto-ranging capacitance meter that will measure capacitance values from zero to almost 200 mF (that's 200 *millifarads* or 200,000 µF). The key word is "auto-ranging." When making simple capacitance measurements, there's no need to push a button to select a "guesstimated" range, just plug the capacitor into the meter terminal strips or connect it to the meter by means of the supplied cable assembly, and the '2250 does the rest.

Leakage measurements can also be made. The procedure is outlined in the accompanying manual and basically amounts to comparing the numerical readings obtained when using the LEAKAGE TEST switches. Both readings should agree in value within approximately 5% of each other. A greater percentage of difference indicates the capacitor under test exhibits excessive leakage. A nomogram is supplied that may be used to determine the approximate leakage value in ohms based on the test readings obtained.

The innocuous exterior of the '2250 is rather deceptive. Beneath its plastic "skin" lies a total of 31 ICs and 19 discrete transistors! Three circuit boards contain all the components. With the exception of two LSTTL devices, all ICs are CMOS types.

Heath IT-2250 Capacitance Meter

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Range: 0 pF to 199.9 mF (0.1999 F).	Selected values to 125,000 µF measured (see text).
Accuracy (using Heath-supplied standards, within a temperature range of 67° to 77° F)¹: 0 to 199.9 nF, ±0.5% of reading + 1 count + 0.5 pF; 0.1999 µF to 199.9 mF, ±5% of reading + 1 count.	As specified (see text).
Display rate: Values up to 1999 µF, less than 1.5 seconds; values up to 199.9 mF, less than 10 seconds.	
Display type: 3-1/2 digit LCD.	As specified.
Dimensions (HWL): 2 × 3-1/4 × 7-1/2 in.	
Weight: With battery, 16 oz.	
Price class: $158.	
Options: IMA-2215-1 leather carrying case, $15; PS-2350 120-V ac battery eliminator, $8; PS-2450 240-V ac battery eliminator, $15.	
Manufacturer: Heath Company, Benton Harbor, MI 49022.	

¹mm = in. × 25.4; g = oz × 28.35.

Construction

A total of nine corrections had to be made to the instruction manual before proceeding with the unit assembly. If you're baffled by what appear to be "extra holes" in the pc boards, don't be: These are plated-through holes that act as jumper wires between the foils on the opposite sides of the pc board. With that in mind, be sure you place the component leads in the proper holes and not into a nearby plated-through hole.

Heath has thoughtfully supplied a small magnifying glass for use during kit assembly, but I opted to use a pair of magnifying binoculars secured by a head strap. They're relatively inexpensive, eliminate eye strain and are a boon to the assembly of heavily populated pc boards.

It took me a total of nine hours to complete the construction of the '2250. And, much to my pleasure, it worked the first time (that's always such a relief!). Calibration was completed in a matter of minutes using the Heath-supplied capacitance standards. These capacitance standards have been measured accurately, and their values marked on the envelope. When you're finished using them, store them in the envelope in a secure place so they'll be available for periodic calibration checks.

Circuit Description

A complete description of the circuit operation occupies approximately three instruction manual pages. Basically, the meter measures the unknown capacitance by measuring the time required to charge the capacitor from a fixed reference voltage to another fixed reference voltage and then discharge the capacitor to the original reference voltage. The time count is obtained from a crystal-controlled time base generator having a base frequency of 3.58 MHz. A selection of five clock frequencies is made by a range counter. The time required for the capacitor charge/discharge cycle is directly and linearly proportional to the capacitance value.

In Use

The IT-2250 may be powered by an internal, user-supplied, 9-V battery (alkaline types are recommended) or by one of two optional Heath battery eliminators (120- or 240-V models). The external supplies connect to the meter by means of a subminiature phone plug that is inserted into a jack mounted on the side of the meter case. If the internal battery is used, a LO BAT indication appears when the battery potential has dropped to approximately 5 volts.

Meter protection is provided by an internal resistor placed across the input jacks when the instrument is switched off. With power applied, clamping diodes and a 1/4-A fuse offer

*Assistant Technical Editor

assurance against damage. The fuse is mounted on fuse clips secured to the input circuit board, and case disassembly (removal of three screws) is required to replace either the fuse or internal battery.

There are four LED annunciators that inform the operator which one of the ranges is being used during display of the capacitance value measurement. A thumbwheel at the center of the instrument allows meter zeroing. The capacitor to be measured (or the remote cable assembly) plugs into the terminals at the bottom front of the unit. These terminals are strips of copper that permit ease of insertion and retraction — no need to find a little hole for the capacitor lead.

The remote cable consists of a pc card with four lengths of small-diameter coaxial cable attached to it. It is used for connecting the meter to capacitors that cannot be plugged directly into the meter terminals. (When making measurements in the picofarad range, it is important to take into consideration the stray capacitance offered by the cable, approximately 30 pF.) I found the remote cable assembly to be both esthetically unappealing and awkward to use. The pc board can be easily pulled from the socket during use, and handling four leads is uncomfortable. Banana jacks and plugs would offer a more solid mechanical approach in my opinion, but two dual units would be required to be compatible with the existing circuit arrangement. Nevertheless, the cable assembly does perform the designed task.

The action of the ZERO control is adequate, but not quite as smooth a vernier type as that of the Data Precision 938[2] used in the ARRL lab. Comparison capacitance measurements were made using the IT-2250 and the '938. Measurements agreed with the specifications given by Heath up to the maximum capacitance range of the '938 (2000 µF). At that point, the '2250 kept on measuring capacitance as I tacked a total of 125,000 µF to the leads, still short of the top end of the range.

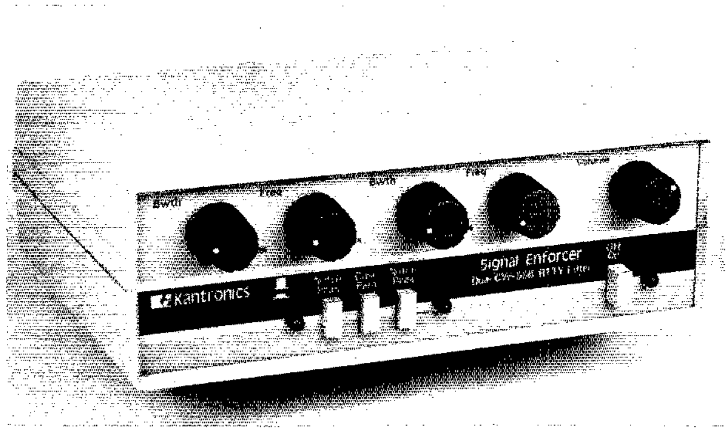
The accompanying construction/instruction manual is complete in every detail. A large, fold-out schematic diagram is included, as are a flow chart and a table of waveforms that appear at various points in the circuit.

With the IT-2250 in hand, you can make short work of that pile of capacitors you've been meaning to sort. Now let's see. . . where's that variable I wanted for the VFO? — *Paul K. Pagel, N1FB*

KANTRONICS SIGNAL ENFORCER

□ Today, active audio filters range from simple, fixed-tuned types to elaborate, multisection filters with adjustable bandwidth and frequency. The Kantronics Signal Enforcer falls into the latter category.

The most prominent feature of the Signal Enforcer is that it has two independent filter sections. Either section can function as a peak or a notch filter, and both are adjustable in bandwidth and frequency. In the peak mode, a band-pass response is produced. No provisions are made for low-pass or high-pass responses. A front-panel switch is used to place the filter sections in series or parallel with each other. Combined with the peak/notch option, this allows the user to select a wide variety of filter configurations. For example, by placing the filters in series and selecting the notch mode for one and the peak mode for the other, a cw signal can be peaked while an interfering heterodyne is notched. If the sections are placed in parallel, both in the peak mode, signals of two different frequencies can be peaked simultaneously. The cw operator is likely to find that the most useful configuration results when both sections are in the peak mode and are placed in series; this produces maximum selectivity.



Other features include a self-contained power supply (117/234 V ac) and audio amplifier. Jacks are provided for headphones and an external speaker. When using narrow bandwidth settings, tuning of the filter center frequency becomes critical. To make the adjustment easier, each filter section contains an LED tuning indicator. To center a signal in the filter passband, you simply adjust the frequency control until the LED lights when the desired signal is present. The power switch and indicator and the volume control complete the complement of front-panel controls. The power switch, in the OFF position, feeds the incoming signal directly to the output jacks so that the unit need not be removed from the audio line when not in use.

A unique feature of the Signal Enforcer is the demodulator output (DEMOD OUT). The instruction manual supplied with the filter states that the demodulator output is "basically a filtered square wave that can be used to interface with other equipment." From on-the-air use, it appears that there is more to the operation of the DEMOD OUT signal than the manual indicates. If you wish to demodulate a cw signal you can use only one filter section. The other must be adjusted so that the tuning indicator remains off. The signal from the DEMOD OUT jack will then be a square wave that follows the input cw signal. With an RTTY signal, proper adjustment will result in mark demodulation with anti-space. If the mark and space tones are both absent, the demodulator output will be in the mark condition. This prevents the teleprinter from "running open" when no RTTY signal is present. It would be unfair to compare the demodulator output feature of the Signal Enforcer to more elaborate RTTY terminal units (TUs), as it does not provide the degree of filtering, limiters or automatic threshold circuits found in TUs designed for optimum hf RTTY operation. The demodulator output does provide an easy way to interface your rig to a personal computer or teleprinter for vhf and casual hf operation. A transistor switch to ground, with an internal pull-up resistor to 5 V, is used to generate the demodulator output, making it TTL compatible. A loop supply and additional interface circuit is required if the demodulator output is to drive a standard teleprinter.

Performance

The Signal Enforcer was used at my home station during cw, ssb and RTTY operation, the most-used mode being cw. When the transceiver ssb filter was used for cw operation, the Signal Enforcer provided a significant improvement in reception. There is a major drawback to using the Signal Enforcer (or any audio filter of this type) as a replacement for an

Kantronics Signal Enforcer

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Bandwidth: Variable from less than 30 Hz to greater than 1000 Hz.	As specified.
Frequency range: Variable from less than 150 Hz to greater than 3000 Hz.	340 Hz to 3500 Hz.
Audio power output: Variable, 2 W maximum.	As specified.
Power requirement: 115 V at 60 Hz; 230 V at 50 Hz; or 12 to 18 V dc at 200 mA.	As specified.
Size: 2-1/2 × 8 × 6 in.	As specified.

[2] "Data Precision Model 938 Digital Capacitance Meter," *Product Review, QST*, Nov. 1979, p. 51.

i-f cw filter: The wide ssb passband will allow strong nearby signals to control the receiver agc. Even though the audio amplitude of these nearby signals is decreased to a low level by the af filter, the reduction in gain makes it impossible to copy weak signals. Turning off the agc will improve copy under some conditions, but I find that to be an uncomfortable way to operate.

When a 500-Hz i-f bandwidth is used, an audio filter can improve the overall signal-to-noise ratio by reducing the wide-band noise generated in the i-f and af stages of the receiver. When used at medium bandwidth settings, the Signal Enforcer performs this function well. By using the minimum bandwidth settings, a very narrow (less than 50-Hz) bandwidth is produced. In normal operation, these narrow settings are difficult to use. Anything less than about 150-Hz bandwidth (at the 6-dB points) severely taxes the stability of most rigs. I found that using the filter sections in series, with the bandwidth controls at about the 10 o'clock position, produced the most usable cw response. By slightly offsetting the center frequencies of the sections, a wider passband is obtained (this does reduce the skirt selectivity). Later laboratory tests showed that this configuration yields a 6-dB bandwidth of 200 to 400 Hz, depending on the exact settings of the filter controls. This is adequate to reduce wide-band noise and does improve the system selectivity.

A possible problem for the cw operator should be noted: If the cw note you like to copy differs from the sidetone frequency of your rig, the filter will attenuate sidetone as well as received signals of that frequency. Solving this problem may require sidetone oscillator modification. I found the notch filter handy when operating ssb; the good null depth allows broadcast-station carriers to be eliminated.

The Signal Enforcer is housed in a two-piece, plastic cabinet (the front and rear panels are aluminum). All circuitry is contained on two double-sided printed circuit boards. Construction and component quality appear to be high. This should lead to long, reliable service. Manufactured by Kantronics, Lawrence, Kansas, the price class of the Signal Enforcer is $170. — *George Collins, KC1V*

Maggiore Hi Pro Mk I Repeater

Manufacturer's Claimed Specifications	*Measured in the ARRL Lab*
Transmitter output power: 15-W minimum.	18 W.
Duty cycle: 100% at 90° F.	Same, room temperature.
Receiver sensitivity: 0.3 µV for 20 dB of quieting.	0.3 µV for 20 dB of quieting.
Squelch sensitivity: 0.2 µV.	Less than 0.1 µV.
Size: 5-1/4 × 19 × 13 in.	
Weight: 6 lb.	
Color: Gray.	

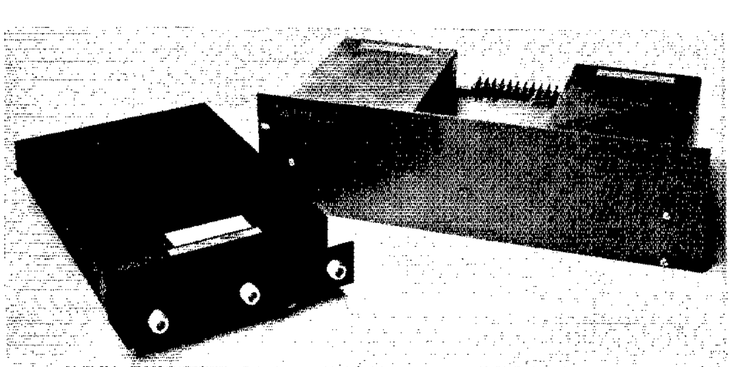
MAGGIORE ELECTRONIC LABORATORY HI PRO MK I 220-MHz REPEATER

☐ Quality! Often mechanical construction foretells the electrical performance of a piece of equipment. That is definitely the case with the Hi Pro Mk I. Both receiver and transmitter strips are mounted in heavy-duty cast aluminum boxes that provide excellent shielding. The remainder of the circuit is arranged neatly on a heavy-duty chassis. Throughout, the construction techniques and choice of materials speak of craftmanship and attention to detail.

The repeater has been in service for some months now at W1AW/R near ARRL Hq. It has performed flawlessly. Unfortunately, a repeater system requires more than a repeater to function smoothly. On several occasions I made a trip to the repeater site after performance degraded. Each time I found the Hi Pro Mk I operating into an infinite VSWR. Each time I worked with hardline connectors and jumper cables, and apparently "fixed" the problem.

After several of these trips, I removed the antenna from the tower and brought it back to the lab. Once the loading coil housing was removed, Chuck Hutchinson, K8CH, and I found the trouble. A wire from the center pin of the coaxial connector to the antenna loading coil had not been soldered to the connector. The manufacturer had packed enough RTV compound around it to hold it in place. Acid, formed as the RTV cured, had caused corrosion of the wire and the connector pin. Sometimes the two surfaces made good electrical contact; sometimes they did not. The repeater had operated for several months with a load that changed from moment to moment, and survived this "trial by fire" unscathed! It is hard to imagine a more torturous test of durability.

Power and control connections are made at the terminal strip at the chassis rear. Metal boxes on the chassis house the receiver and transmitter strips; the control circuit is located on the underside of the chassis. The front panel is designed for standard 19-inch rack mounting.



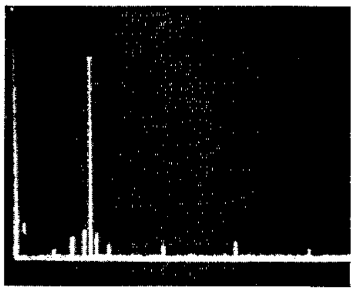


Fig. 1 — Spectral display of the Hi Pro Mk I 220-MHz transmitter output. Vertical divisions are each 10 dB; horizontal divisions are each 100 MHz. The fundamental has been reduced in amplitude approximately 15 dB by means of notch cavities; this prevents analyzer overload. Power output is 18 watts at a frequency of 224.84 MHz.

Repeated audio is excellent. Controls are available for adjusting the volume, speed and tone of the built-in identifier, the time-out timer and the "hang" time. The repeater and matching duplexer are completely assembled and ready for installation. All that is needed is a power supply (12 V dc at 3.5 A) and an antenna. (Actually, as we unintentionally found out, the repeater performed reasonably well without an antenna!) We have observed no indication of intermod or desense during the six months that it has been in service.

At one point during a testing in the ARRL lab, we kept the transmitter keyed for over 30 minutes (into a dummy load, of course!). We observed no change in power output level during the test. There was a barely detectable increase in the chassis temperature near the PA stage — the Hi Pro Mk I seems to have a more than adequate heat sink.

If your repeater group is in the market for a moderately priced repeater, I suggest you give serious consideration to the Hi Pro Mk I. A deluxe version with built-in power supply, front panel controls, metering and accessories is also available at a higher price.

Price class of the basic repeater with crystals, flat-pack duplexer, cables and helical resonator is $1000. More information can be obtained from Maggiore Electronic Laboratory, 845 Westtown Rd., West Chester, PA 19380 — *Peter O'Dell, KB1N*

THE CENTURION TUF DUCK "MINI" 2-METER ANTENNA

☐ Miniaturization of electronic components has enabled the production of smaller and smaller transceivers. This has been particularly noticeable in the 2-meter fm market. The one thing that hasn't gotten smaller — until now — is the antenna. Centurion has introduced a short version of the "rubber duck" antenna.

Comparison

Excluding the BNC connector and ignoring any tapering, the typical "rubber duck" is roughly 6-1/4 inches long. The TUF DUCK is about 3-1/2 inches long. A typical "rubber duck" is approximately 3/8 inch in diameter, while the TUF DUCK measures 5/8 inch in diameter. This difference in proportion makes the TUF DUCK appear squat.

Physically short antennas operating over imperfect ground systems are often inefficient. I was curious about a comparison between the TUF DUCK and a stock "rubber duck" antenna, so I did an informal, unscientific survey of existing "rubber duck" antennas at Hq. Two tests were conducted comparing the TUF DUCK to a regular "rubber duck" antenna. With a receiver tuned to a moderately strong signal from a repeater, I compared the apparent received signal strength using the two antennas. A step attenuator with 1-dB resolution was connected between the antennas and the receiver. Results indicated that the regular "rubber duck" delivered about 3 dB more signal to the receiver than did the TUF DUCK.

Mike Kaczynski (W1OD) and I conducted similar tests using the two antennas for transmitting. Again, we connected the step attenuator to the receiving station and adjusted it to produce equal S-meter readings for both antennas. The results corresponded with those of the receiving tests: An ordinary "rubber duck" appeared to be about 3 dB better on transmit than the TUF DUCK.

I also checked the SWR of the antennas and found that it is over 2:1 for both at the center of the 2-meter band. The TUF DUCK did become warm to the touch at a power level of about 20 watts. This heating effect was not observed at more "reasonable" power levels.

Conclusions

A 3-dB difference is barely discernible to the casual observer. Also, the testing standards are far below laboratory specifications (ARRL does not have an antenna testing range). I conclude that the TUF DUCK could be used in place of "rubber ducks" by most amateurs with almost no one noticing the difference. Probably the only one who would notice a difference is someone whose signal is marginal to begin with. If you want to make your small rig "smaller," then consider the TUF DUCK. The TUF DUCK is available with all standard connectors. Additional information can be obtained from Centurion, Box 82846, Lincoln, NE 68501. Price class: $11. — *Peter O'Dell, KB1N*

BENCHER INC. XZ-2 ACTIVE FILTER

☐ How many gee-gaws are needed to make an RC active audio filter worth the price? Is a band-pass response adequate, or should we be able to select high-pass low-pass responses? The need for additional features will depend upon the kind of operating that is contemplated. The Bencher XZ-2 filter has only a band-pass response, which for me is entirely adequate for cw operation. An ssb selectivity position can be set from the front panel, along with three degrees of cw selectivity. The BANDWIDTH switch selects passbands of 90, 115, 150 and 250 Hz on the response curve 6-dB points. A frequency (TUNE) control located on the front panel adjusts the filter center frequency. In conjunction with the receiver tuning, it can be set to provide the desired cw pitch. Ideally, it would be adjusted to the receiver cw-offset frequency, which is typically between 600 and 800 Hz.

The advantage of a filter with so few controls is adjustment ease. The user simply tunes in the desired signal (filter turned off), turns the filter on and adjusts the TUNE control for maximum signal in the speaker or phones. The degree of selectivity used will depend on band conditions (QRM) and personal preference. I use maximum selectivity (90 Hz) at all times, even when copying loud signals. No annoying "ringing" has been noted when utilizing maximum selectivity, except during severe storms: The QRN peaks will tend to yield a ringing effect.

Those who use audio filters extensively are apt to become addicted to them, for the quality of the receiver output is enhanced by the filtering action — assuming the filter is designed well and functioning correctly. Some filters are very noisy and may introduce audio distortion when driven to a comfortable listening level. The Bencher filter is capable of providing extremely clean audio output, more than is needed for a normal operating environment. The user can attach headphones or an external speaker to the XZ-2.

The circuit has some interesting innovations that set it apart from other commercial audio filters. The manufacturer has asked that the circuit details be kept confidential. It can be said, however, that the engineering was done well.

Filter bypassing is achieved by turning the BANDWIDTH switch to the OUT position. There is no need to patch around the unit, as had been the case with some other filter brands. There has been no indication that the circuit is susceptible to rf energy. It has operated properly from 160 through 10 meters while using 1 kW of dc input power at W1FB (100 W on 160 meters).

The manufacturer states that a potential grounding problem may exist with the first few hundred units that were sold. A common ground does not exist between the AUDIO INPUT and SPEAKER phono jacks on the rear panel although the jacks are part of a single assembly. One of the jacks has a wire connected to the pc-board ground foil. A jumper wire connected between the two jack ground terminals will avert any possible grounding problems.

An RC active audio filter is a valuable station accessory because it reduces wide-band noise from the receiver. This provides an effective improvement in the signal-to-noise ratio. It also enables the operator to lift otherwise unreadable weak signals above the noise for Q5 copy. This type of filter is especially useful for weak-signal cw work. Few DX chasers on 160 meters would consider operating cw without a good audio filter. I'm convinced that the Bencher XZ-2 is indeed a "good audio filter."

An external 12-V dc power supply is required to operate the filter. It is available as an accessory for $9.95. The XZ-2 sells for $69.95. The box dimensions are 2-1/2 × 5-1/4 × 6-1/2 inches. The manufacturer is Bencher, Inc., 333 West Lake St., Chicago, IL 60606, tel. 312-263-1808. — *Doug DeMaw, W1FB*

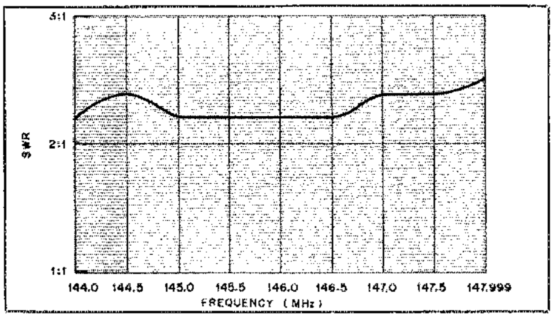
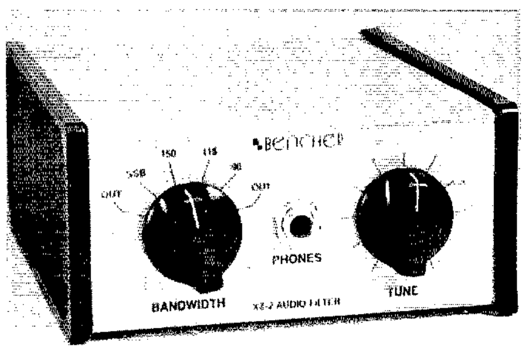


Fig. 2 — SWR curve for the TUF DUCK miniature 2-meter antenna. This curve is similar to those obtained with the conventional type "rubber duck" antennas.



Conducted By Larry D. Wolfgang, * WA3VIL

HF ADAPTER FOR NARROW-BANDWIDTH OSCILLOSCOPES

☐ Here is a simple piece of test equipment that will allow you to display signals that are beyond the normal bandwidth of your oscilloscope. I wanted to monitor my modulated 10-meter signal on a scope that had a 5-MHz upper-frequency limit. I began by using a Mini-Circuits Laboratory SRA-1 Mixer. Any stable oscillator or VFO with an output of 10 dBm can be used for the local oscillator (LO), which mixes with the hf signal to produce an i-f in the range of the oscilloscope. The complete schematic diagram is shown in Fig. 1.

The mixer can handle rf signal levels up to − 3 dBm without clipping, so this was set as an upper limit for the rf input. I constructed a toroidal-transformer coupler by winding a 31-turn secondary of no. 28-AWG wire on a 3E2A core, which has a 0.380-inch' diameter. The Amidon FT-37-75 is an equivalent core. The primary is a piece of coaxial cable through the core center. This coupler is described in *The Radio Amateur's Handbook*, 1981 edition, p. 16-31. The coupler gives 30-dB attenuation and was found to have a flat response from 0.5 to 100 MHz. My calculations indicated that an additional 20-dB attenuation was needed, for a total of 50 dB before the mixer. One-watt resistors will do fine for the attenuator. The completed adapter should be built into a shielded box.

This circuit, with the 25-MHz LO frequency, is useful on frequencies in the 20- to 30-MHz range with transmitters of up to 50-W power output. By changing the frequency of the LO, any frequency in the range of the coupler can be displayed on a 5-MHz bandwidth oscilloscope. More attenuation will be required for higher-power transmitters. — *Kenneth Stringham, Jr., AE1X, Attleboro, Massachusetts*

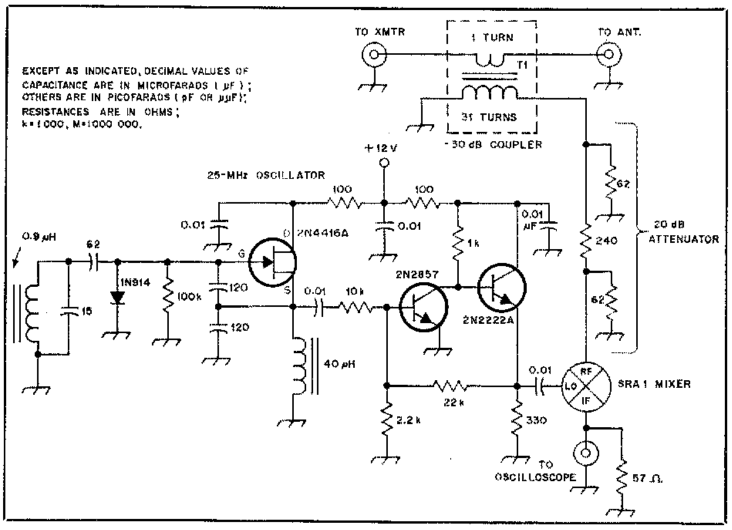


Fig. 1 — Schematic diagram of an adapter to display rf signals on a narrow-bandwidth oscilloscope, including a 10-dBm 25-MHz LO, −30-dB coupler, 20-dB attenuator and a diode-ring mixer.

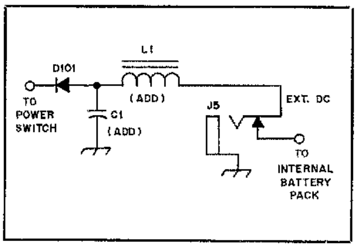


Fig. 2 — This simple alternator-whine filter was added to a Kenwood TR-2200A by WAØMRG. This circuit should be applicable to other rigs. C1 is a 470-µF, 25-V electrolytic capacitor. L1 is a dc power-supply choke.

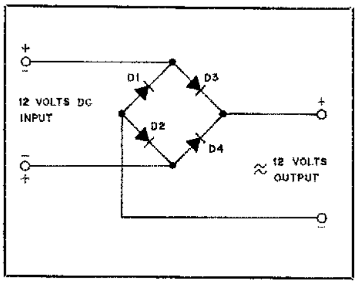


Fig. 3 — A bridge rectifier can provide positive protection against reverse-voltage connections to your rigs.

ALTERNATOR-WHINE FILTER

☐ The standard solution for alternator whine is a choke-and-capacitor filter. Unfortunately, when the rig is shuttled between different vehicles, a separate filter is needed for each one. With this in mind, I put the filter inside my rig (a Kenwood TR-2200A).

The modification was easy and took only a few minutes. Finding space for the components may be the most difficult part of the task. Fig. 2 is the schematic diagram of the filter I added to my TR-2200A. A small iron-core choke was "liberated" from an old CB unit and placed under the spacer in the battery compartment. The tight fit holds it in place. The capacitor was mounted behind the speaker, with the ground lead on the capacitor soldered directly to the pc board.

Space is at a premium, but with attention to the physical size of the choke and capacitor this filter should be adaptable to most mobile rigs. One precaution: be sure the choke is capable of handling the current drawn by the rig. — *Dallas Williams, WAØMRG, Sedgwick, Colorado*

REVERSE-POLARITY PROTECTION

☐ Stop worrying about reverse-polarity voltage on your mobile rigs. This circuit will make reverse polarity an impossibility. I use a 25-A bridge rectifier. The output of the bridge rectifier is connected to the rig permanently, observing the correct polarity. A 12-V supply is connected to the ac input of the bridge, and polarity is not important. The voltage to the rig will be slightly less than the input voltage, depending on the voltage drop of the diodes. See Fig. 3. — *Henry Leggette, WB4MNW, Memphis, Tennessee*

RECTIFIER HASH FROM THE POWER SUPPLY

☐ I decided to try an old trick and use just the center of the coaxial feed line on my 80- and 40-meter dipole to load up on 160 meters. I slid the coaxial-connector sleeve off the back of my KWM 380 and found that the antenna loaded very nicely (low VSWR). However, I noticed a loud buzz in the receiver! I grabbed a portable a-m radio and started searching for the noise source, since it sounded close. It was obviously on the ac mains somewhere, so I started turning off everything in sight. I noticed that unplugging the dc supply to the 2-meter rig reduced the noise. But the switch was off! That didn't make any sense at all. I turned on another receiver and tuned to 160 meters. There it was, from bc on up to about 2 MHz. Anything that I unplugged or plugged into the ac line had an effect. Then I turned the KWM 380 off ... and so went the noise!

I remembered having the same trouble with a TR7 once — the power supply! The problem was caused by hash from the low-voltage rectifiers. Placing a 0.05-µF capacitor across the secondary of the power transformer eliminated the hash. Apparently this is a common problem

'mm = in. × 25.4; m = ft × 0.3048.

*Assistant Technical Editor

with low-voltage, high-current dc supplies. The hash is transmitted into the ac mains.

The noise had been there all the time, but using a shielded feed line prevented me from hearing it. When the shield was lifted, the antenna lead was exposed to the radiation from the ac line. Simple problem, simple cure; but sometimes those "simple" problems can make you feel "simple minded"! — *James Beckett, WA2KTJ, Horseheads, New York*

MOBILE POWER SUPPLY FOR YOUR 2-METER HT

☐ Tired of recharging those NiCad batteries after using your HT for mobile operation? Try this circuit that I have used with my Yaesu FT-207R for about a year. Only a single coaxial cable is needed to supply dc power to the rig and carry the rf signal to my mobile amplifier. The modification cost about $5 for all new parts. See Fig. 4 for circuit details.

To modify an FT-207R, remove the rear cover and connect the battery pack. Be sure the radio is turned off. Connect voltmeter leads between the ground side of the BNC jack and the terminals on the back of the VOLUME/ON-OFF switch to determine which terminal receives the positive voltage from the battery. The cathode of D1 will connect to this terminal (remove the battery pack first).

Disconnect the wires that are soldered to the center feed of the BNC connector. Insert C1 between the BNC center terminal and the wires just removed. Connect choke L1, C2 and the anode of D1, as shown. The other end of C2 connects to ground at the BNC jack.

Follow the schematic diagram for modification of the amplifier. Capacitors C1 and C4 are used to couple the rf signals to and from the coaxial cable. If your amplifier has an ac coupling capacitor you may omit C4. The rf chokes L1 and L2 couple the dc power source to the rig, and at the same time offer almost no rf load to the coaxial line. Capacitors C2 and C3 provide additional rf filtering.

Diode D1 serves two purposes. It drops the line voltage approximately 0.6 V when the rig is powered externally. It also prevents current drain on the NiCad battery when a grounded external antenna is connected. Diodes D2, D3, D4 along with D1 drop the 13.8 V auto-battery voltage to be approximately 11.4 V at the transceiver ON/OFF switch. As with any rf circuit, all leads should be kept as short as possible. — *Glen Day, AB8W, Gambier, Ohio*

SPEAKER "THUMP" IN THE HW-101

☐ After constructing my HW-101 I noticed an intense "thump" in the speaker when going from receive to transmit. This was quite annoying, so I contacted the Heath Co. people for help. They suggested soldering a 0.1-μF capacitor from lug 2 of R12 to ground, but this didn't help.

I quieted my T-R problem by increasing the value of bypass capacitor C322 to 0.1 μF and changing R337 to 470 kΩ. This will give the same time constant as the original values. I also changed R338 to 680 kΩ to provide about the same blocking voltage to V14A so the audio amplifier will remain cut off during transmit (Fig. 5). If anyone has any "mods" to the HW-101 that they would like to share, please write to me. — *Jim Flanagan, WB5KYE, 1032 Southcliff, Portland, TX 78374*

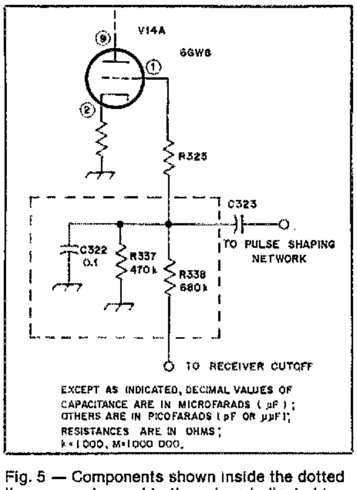


Fig. 5 — Components shown inside the dotted lines were changed to the values indicated to eliminate a loud thump in the HW-101 speaker when going from receive to transmit.

FREQUENCY JUMPS IN THE TS-820S

☐ I was experiencing a frequency jump of up to 500 Hz with my TS-820S VFO. An on-the-air discussion with Al Fischer, W7OA, revealed that he had solved the same problem with his TS-820S. Kenwood had advised him to clean all of the pins on the plugs above and below the chassis with rubbing alcohol and a brush. This must be done gently, and the plugs must be reinserted carefully. The VOX relay must also be removed, the protective cover taken off and the contacts cleaned carefully with a brush and alcohol. This cleaning operation eliminated the frequency jump of the VFO, and my receiver is stable again. — *Jerry Dolezal, W9NSC, Franklin, Wisconsin*

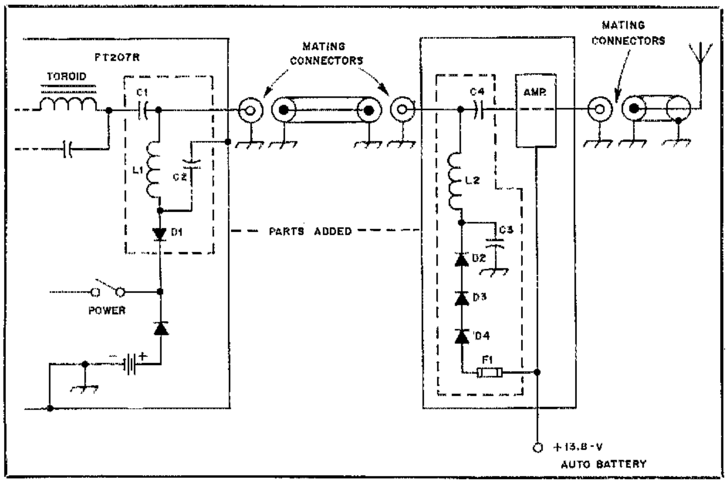


Fig. 4 — Supply the operating voltage to your HT through the coaxial cable from your mobile amplifier using this circuit. L1, L2 — a single-layer coil of no. 30 to 34 magnet wire covering the entire body length of a 5- to 20-megohm, 1/4-watt resistor.
C1, C4 — 0.01 μF, 50 V miniature disc.
C2, C3 — 0.1 μF, 50 V miniature disc.
D1 through D4 — 1N4001 or 1N4007 rectifier diode (any 1 A silicon diode).
F1 — 1/4 A fast-blow fuse.

HW-101 LOADING CAPACITOR PROTECTION

☐ Recently the loading capacitor in my aging HW-101 failed. This failure was the result of constant upward pressure placed on the capacitor rotor shaft by the rubber belt-drive mechanism. Eventually this caused the bearings to wear down, allowing the rotor shaft to tilt and short the plates.

After replacing this capacitor at a cost of $12.15, plus the shipping and handling (the part used to cost $2.85), I decided to protect my investment by making a thrust bearing, which mounts on the front of the rf-cage assembly. This bearing will absorb the pressure placed on the rotor shaft, protecting the capacitor bearings. It is made from 3- × 3/4- × 1/16-inch aluminum bar and a nylon bushing (Heathkit part no. 455-44). Fig. 6 shows the mounting details. — *John E. Brush, WA3CAS, Coraopolis, Pennsylvania*

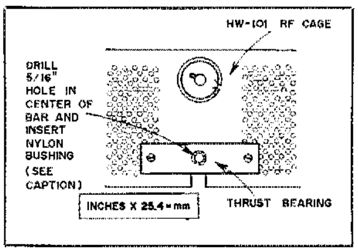


Fig. 6 — This thrust-bearing assembly reduces excessive wear on the loading-capacitor bearing in an HW-101. After placing the thrust-bearing assembly over the rotor shaft, mark mounting holes A and B to align with holes in the rear of the rf cage. Drill A and B with a 1/8-inch bit. Mount the assembly on the rf cage with no. 6 hardware.

Technical Correspondence

Conducted By
Doug DeMaw,* W1FB

The publishers of QST assume no responsibility for statements made herein by correspondents.

ADVICE ON TRANSMISSION-LINE INDUCTORS

☐ Two otherwise excellent articles in *QST* have incorrectly shown the electrical schematic for the coaxial transmission-line inductor.[1,2] As shown, the two terminals of the inductor are at the opposite ends of the shorted transmission line. In this case, the fact that a coaxial line is used is immaterial, since the inductance is determined by the physical length and configuration of the line as a single conductor between the two terminals.

Both terminals of the inductor should be at the input, or unshorted, end of the line. In this case, the inductance is determined by the electrical length of the line, and is independent of the physical configuration or grounds to the pc board, in addition to the ground at the input end.

The inductance of a short-circuited 50-ohm cable with TFE dielectric material (ϵ = 2.1) can be calculated with the equation

$$L_{\mu H} = \frac{7.96 \tan (1.74\, f\ell)}{f} \dagger$$

When the VCOs described in the two articles are built, the input end of each line should be soldered to the pc board and not left floating, as shown on the electrical schematics — *Jack Priedigkeit, W6ZGN, Menlo Park, California*

"APPARENT VSWR" — WHAT IS IT?

☐ The VSWR measured at the station end of a transmission line is indicative of the VSWR at the antenna feed point only if the transmission line is lossless. When there is a loss in the line (and all lines have some loss) the true VSWR is disguised at the transmitter end of the cable in accordance with the line loss in decibels.

I have visited amateur stations at which substantial power loss occurred in the transmission line. The operators were happy with the VSWR readings they obtained in the shack, even though a significant mismatch existed at the antenna. For example, assume that a particular station operated at 146 MHz and was equipped with 100 feet (30.4 m) of RG-58/U line for feeding a 2-meter antenna. A 6-dB feeder loss would result under the specified conditions. If the VSWR measured at the transmitter was, say, 1.25:1, the actual VSWR at the antenna would be 3:1. This is illustrated by the curves in Fig. 1, which show clearly that the lower the line loss the more closely matched are the VSWR numbers. One might conclude correctly that a highly lossy coaxial cable serves

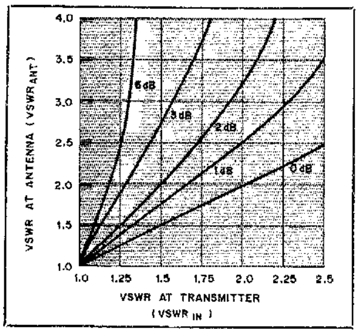


Fig. 1 — Curves that illustrate the effect of the line loss on the accuracy of VSWR readings taken at the station end of a feed line. The resolution is not perfect for these curves. The equation given in the text will provide more accurate comparisons.

admirably as an "air-cooled dummy load." Now, if the feed line of this station had a 1-dB loss per 100 feet, and if the VSWR in the shack read 1.25:1, the actual VSWR would drop to 1.5:1. When the line loss[3] and the input VSWR are known, the VSWR at the antenna can be obtained from

$$VSWR_{ant} = \frac{A + B}{A - B} \text{ derived from}$$

$$A = \frac{VSWR_{in} + 1}{VSWR_{in} - 1} \text{ and } B = 10^{\frac{dB}{10}}$$

where dB is the line loss under a matched-load condition.

Some amateurs have reported that the VSWR of their antennas has actually "improved with time," for unknown reasons. This phenomenon suggests strongly that the line is old and has become contaminated, and hence is very lossy. It is wise to replace cables that exhibit this characteristic. Remember that even a 3-dB line loss equates to wasting one half of the transmitter power, while at the same time confusing VSWR accuracy when it is read at the transmitter end of the line. — *Doug DeMaw, W1FB*

ANTENNA FEED LINES FOR PORTABLE USE

☐ The 1981 *Handbook* recommends the use of twin-lead-fed folded dipoles for portable operation, noting that RG-58 and -59 are "quite heavy and bulky for backpacking," and RG-174 is "too lossy."[4] Always eager to improve my portable station, but leery of the ability of twin-lead to perform under typical backpacking-type portable conditions, I purchased 100 feet (m = feet × 0.3048) of Belden 8230 300-ohm TV lead for test material. The feed line was strung around my wooden deck (several feet above the ground) and supported by TV standoff insulators, so that the line didn't contact the deck. Far from being typical backpacking conditions, this would simulate near-ideal circumstances.

Next I built two 4:1 baluns on large ferrite cores, putting one at each end of the twin-lead. My 50-ohm dummy load was used to terminate the system, so the cable was running with a 1.5:1 SWR. Cable loss was determined by measuring the power delivered to the load and comparing that to the *net* forward power (i.e., "forward" minus "reflected" power) measured at the input end with a Bird model 43 wattmeter. The balun losses (0.4 dB total) were measured separately at the same power level and subtracted from the result. The frequency for all tests was 21 MHz.

Dry twin-lead measured 0.8 dB loss, about the value given in the *Handbook* for RG-8 foam-insulated line. After about two weeks of dry weather (during which Mount St. Helens did *not* erupt!), a light rain fell, increasing the line loss to 3.7 dB, about twice that of RG-58! Later, when hard rain fell, loss was measured at 2.4 dB, slowly decreasing to 1.5 dB as the cable got "washed." Laying it on the wet deck increased loss to 2.6 dB, and coiling the cable resulted in 4.4 dB loss.

I can only conclude that 300-ohm flat twin-lead is a viable choice for feed line only if it can be kept clean, dry and uncoiled, and out of contact with trees, brush and the ground. These conditions could seldom have been met on trips *I've* taken in the past!

I would expect that tubular twin-lead would be less susceptible to dirt and water, but it would still have to be kept uncoiled and in the clear (what does one do with excess feed line?), and the potential advantages of bulk and weight would be largely lost.

Since coax isn't sensitive to being coiled (unless coil diameter is very small), wet or dirty, let's take a careful look as some possible candidates. First, I weighed some cables, with the following results (coax types include two BNC connectors):

Cable	*Weight (lb) per 100 feet*
Surplus RG-174/U-type	0.9
Columbia 1188 RG-58/U-type foam	2.4
Essex 21-024 RG-58/U	2.4
Belden 8230 300-ohm twin-lead	1.5

The *Handbook* shows a loss of about 2 dB per 100 feet for RG-58/U at 21 MHz,[5] so it would seem to be a good choice for the higher amateur hf bands, or when the feed line must be long. The 60% increase in weight over twin-

[1] A. Helfrick, "A High-Performance Synthesized 2-Meter Transmitter," *QST*, Sept. 1980, pp. 17-21.
[2] A. Helfrick, "The Universal Synthesizer," *QST*, Sept. 1981, pp. 18-23.
† Where f is the frequency in MHz, and ℓ is the line length in meters.
*Senior Technical Editor

[3] See the ARRL *Handbook* and ARRL *Antenna Book* for charts and tables that provide line-loss information in decibels for various types of coaxial cable.

[4] *The Radio Amateur's Handbook*, Fifty-eighth ed. (1981), ARRL, p. 10-14.
[5] *Handbook*, Fig. 31, p. 19-15.

lead may be a good trade for the predictability of the loss under backpacking portable conditions.

RG-174/U is attractive from a weight standpoint, and it can be packed into a much smaller volume than even TV twin-lead. The *Handbook* shows about 5.3 dB loss per 100 ft at 21 MHz. This may be on the high side; Belden 8216 RG-174/U cable is specified at 8.8 dB loss at 100 MHz[6] (the *Handbook* shows about 11 dB at this frequency). Using the approximation that loss in decibels is about proportional to the square root of frequency, we could expect the Belden cable to have a loss of about 4.0 dB per 100 feet at 21 MHz. Some time ago I obtained a quantity of surplus RG-174/U style cable which has a silver-plated solid center conductor and a silver-plated shield. It measured 3.3 dB/100 ft at 21 MHz. Naturally, the loss of all lines decreases at lower frequencies, making RG-174/U more attractive for such use.

So what do I recommend for backpacking-type portable feed line? I recommend that you weigh the advantages and disadvantages of each kind, and determine which is best for *your* particular application. I hope that this brief analysis provides information to aid your choice. — *Roy W. Lewallen, W7EL, Beaverton, Oregon*

THE MERITS OF FM VS. SSB

☐ On several occasions I have heard discussions about the relative merits of fm and ssb for vhf communications. Most experiments contrived to settle the issue show that fm is "better."

A good theoretical analysis can be found in ref. 1, chapters 9 and 10. Eq. 9.2-22 is of special interest:

$$\gamma_{fm} = \frac{S_o/N_o}{S_i/N_m} = \frac{3\beta^2}{2}$$

where

γ_{fm} is the communication efficiency referenced to a baseband system.

S_o/N_o is output signal to noise.

S_i is signal power at the limiter input.

N_m is noise power in the information bandwidth at the limiter input.

β is the modulation index.

Note that γ_{ssb} = 1 (ssb is frequency translated baseband); therefore, γ_{fm} is the improvement factor for fm over ssb. Applying this to a 5-kHz deviation, 3-kHz bandwidth system:

β = 1.67 and

γ_{fm} = 4.17 or 6.2 dB

In practice fm is about 3 dB better because of the 75 μs deemphasis, lowering the effective audio bandwidth for noise (see ref. 2, page 21-12, for math). This gives an fm-system advantage of about 9 dB over an ssb system for strong signals.

An fm system shows a threshold effect that causes the performance to degrade rapidly below 7 dB input signal-to-noise ratio. The fm i-f filter is about four times as wide, or 6 dB wider, so the ssb system has 13 dB signal-to-noise ratio at the fm threshold. Ref. 1 covers threshold effects in chapter 10. The following experiment verifies the behavior predicted by the theoretical analysis.

Fig. 2 shows the setup for the experiment. The agc in the Drake 1A receiver was disabled to allow reliable signal-to-noise measurements. The i-f strip from a Motorola H23 was retuned to 28.120 MHz and used as the fm i-f in the experiment. The H23 strip had a 5-kHz deviation i-f filter.

Fig. 3 is a graph of the measured S + N/N vs. input level for both systems. The theoretical graphs are S/N and the measured graphs are S + N/N. This causes a slight difference at low levels. Note that above the 20 dB quieting point fm provides significantly better system performance, and below that becomes noisy very quickly. The ssb system remains usable about 8 dB below the level at which the fm system becomes unusable. This means about six times the power level needed for marginal ssb communications is needed for fm. The minimum level that can be detected is about 12 dB lower for ssb. This is important because it can be a clue to rotate your antenna toward the other station. On long paths, multipath distortion can render fm unintelligible, while ssb would be almost unaffected.

Besides offering better signal-to-noise ratio, an fm signal also lends itself nicely to reliable squelch circuits because of its constant total power. A Touch-Tone pad signal would not survive the small frequency errors typical of ssb systems. One should note that both systems have their unique advantages and disadvantages, and both systems play important parts in today's vhf bands. — *Bruce Randall, WD4JQV, Alpharetta, Georgia*

[6]Belden Electronic Wire and Cable Catalog No. 878, 1978.

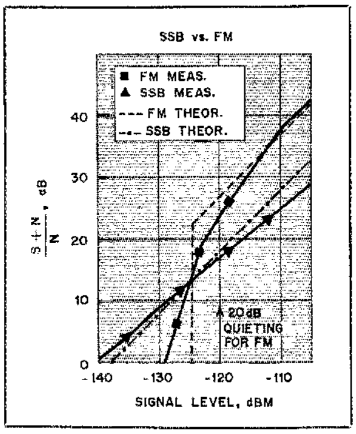


Fig. 3 — Curves for the measured signal-to-noise ratio versus the signal input level for both systems discussed in the text.

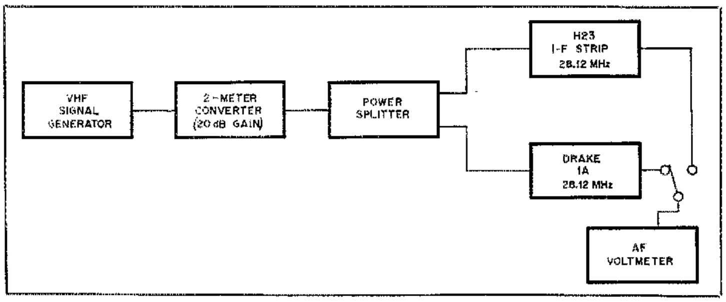


Fig. 2 — Block diagram of the test setup used for the experiment described in the text.

References

[1]Taub, H. and D. L. Schilling, *Principles of Communications Systems*. (New York: McGraw Hill Book Company, 1971).

[2]*Reference Data for Radio Engineers, Fifth Ed.* Indianapolis: Howard W. Sams & Co., Inc., 1969).

Feedback

☐ Two diagrams are reversed in the Technical Correspondence item, "Wave Reflections in Attenuators, Filters and Matching Networks," by Walt Maxwell, in November 1981 *QST*. The diagram and graph shown as Fig. 4 should be Fig. 5, and vice versa. Tables 1 and 2 will correlate correctly with the attenuation curves when this correction is made.

☐ Bill Fisher, W2OC, points out an error in the schematic diagram of his "Digital Frequency Filter for Repeater Inputs" (December 1981, p. 42). C1 has been shown incorrectly with a polarity marking. As is mentioned in the text, C1 must be a nonpolarized type.

☐ The December 1981 Product Review of the Cubic Astro 102 BXA transceiver incorrectly showed the 80-meter third-order intercept to be − 10 dBm. The figure should have been + 10 dBm.

☐ Fred Brown advises that as the result of an oversight in the original text for his Dec. 1981 *QST* article, "An Introduction to the Bilateral Transverter," the last two sentences of the first paragraph under "Tuning" (p. 38) should read: "L8 should be adjusted to maximize this current. L9 is adjusted for maximum collector current of Q7, and C9 for maximum Q8 collector current."

Also, the resonating technique for C16 and L14 is similar to that for C4 and L5 (p. 35). L14 is a hairpin loop of no. 18 wire. The position of C16 on L14 determines resonance. Lead length of C16 is virtually zero.

☐ In November 1981 Correspondence, Dick Schellenbach's call sign should have been printed as W1JF.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QST

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THE COVER

With no neighbors, no regular mail service and no electricity, the Mueller family was cut off from civilization — except for Ann's hastily developed operating prowess, and Dwight's ingenuity. See page 54. *(Photo by Dwight Mueller)*

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A Digital Readout System for the Visually Impaired Operator

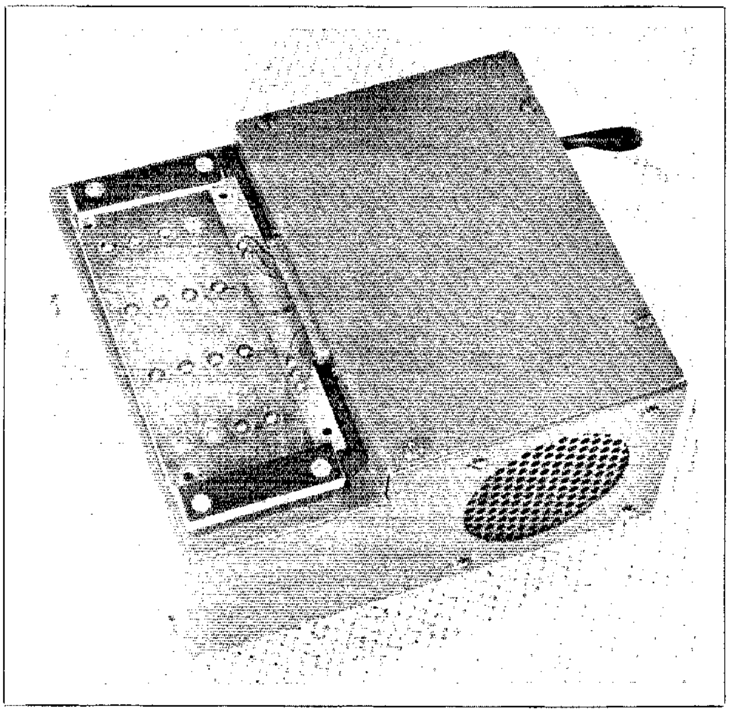
Simple, easy-to-construct pad and digital techniques combine to enable the blind amateur to change operating frequency quickly and efficiently.

By J. C. Swail,* VE3FK

Most modern amateur transceivers display dial readings in digital form. It is almost essential for a blind operator to have a reliable, inexpensive and easy-to-use system that he or she can read. Several articles have described methods of presenting digitally displayed information to the visually impaired person. Some systems utilize synthetic speech output or an arbitrary audible code — usually, but not always, Morse code. I must use some such system to read the frequency of my transceiver.

Although any of the methods work well enough to indicate the frequency to which the equipment is tuned, they are cumbersome when trying to put a rig on a given frequency, such as a net or "sked" channel. The problem results because with these audio systems it is necessary to listen to the readout announcement repeatedly while making adjustments closer and closer to the desired point.

In the system I have devised, a combination of touch and sound are used to display the digits to the operator. All the dots that are required to display are permanently available; no moving parts are involved. These dots are arranged in rows of four to represent the binary-coded decimal (BCD) format. When a dot is touched, the sounding of a tone indicates the presence of the displayed digit. Thus, a desired frequency can very rapidly be dialed up by placing the fingers on the correct dots and rotating the knob to the required point.



Operation

In operation, BCD information is obtained from the appropriate point in the transceiver readout counter, i.e., at the input to the BCD-to-seven-segment LED driver. This information feeds to the touch-sensitive readout interface. The pads, which comprise the actual tactile readout, are formed as insulated islands on the circuit board, and are surrounded by bare copper. To construct the pads, drill a small hole in the center of each island, placing a very short piece of wire in the hole. Then build up the circle with

*National Research Council of Canada, Ottawa, ON K1A 0R8

solder to form a rounded dot.

The dots, arranged in columns of four, represent digits. These dots indicate, from top to bottom of a column, 1-2-4-8 (BCD). In the units built at VE3KF, the counter translates only four digits, the hundreds, tens, units and tenths of kHz. The operator should know the position of the band switch and thus the first two digits.

Touching a pad forms a high-resistance path between it and the main copper field of the board. This closes a solid-state switch. If that particular pad is involved in the representation of the digit then being displayed, a gate will be closed, initiating an audible tone. If the pad is not involved in that specific digit, the gate does not close, the tone does not sound and that pad is ignored. For instance, if the first and second dots sound, and the third and fourth are silent, then the number represented is three. On the other hand, if the first and fourth sound, while the second and third are silent, the number is a nine, and so on.

In one variation of the circuit, the BCD information is fed through a 1702 EPROM to convert it into the Braille code. Although Braille is formed from a 2 × 3 six-dot matrix, all the numbers 0 - 9 are formed from a 2 × 2 four-dot matrix. Thus, in this case, instead of printing vertical rows of four dots, they are printed in squares. However, experience with both systems has shown that most blind people adapt to the BCD representation quickly; it is certainly much simpler to design and build the circuits.

Circuit Description

Fig. 1 shows the simplest form of the system. This interface was used with a Yaesu FT-501 transceiver and YC355D frequency counter, as well as on a Heath IB-1101 counter. These units employ neon-type displays that are not multiplexed. Each digit has a separate BCD drive available. A 17-conductor ribbon cable connects the counter to the interface.

Each BCD input from the transceiver connects to the first input of a separate CMOS two-input NAND gate. The second input of each NAND gate goes to the dot corresponding to the appropriate BCD connection.

The 16-gate outputs combine in two eight-input OR gates, type 4048. These control the audio tone generator, and hence the speaker output. It is essential that the gates associated with the dots be the CMOS type; the resistance of a finger may be as high as 10 megohms — much too high for TTL circuitry.

Fig. 2 shows the circuit devised to interface with a multiplexed readout. This circuit works with my Yaesu FT-901DM. The NAND gates must be triple-input types because they must also receive information from the multiplex outputs of the

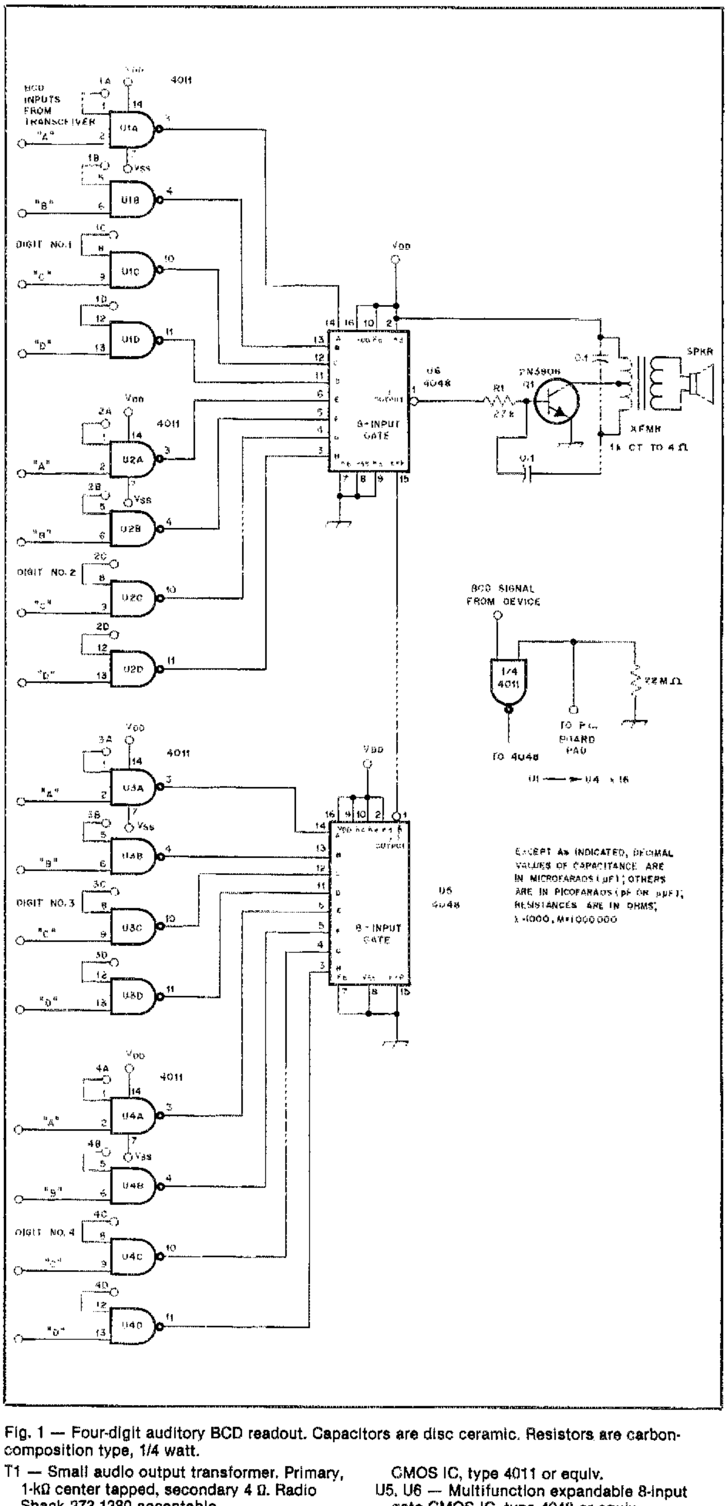


Fig. 1 — Four-digit auditory BCD readout. Capacitors are disc ceramic. Resistors are carbon-composition type, 1/4 watt.

T1 — Small audio output transformer. Primary, 1-kΩ center tapped, secondary 4 Ω. Radio Shack 273-1380 acceptable.

U1-U4, incl. — Quad two-input NAND gate CMOS IC, type 4011 or equiv.

U5, U6 — Multifunction expandable 8-input gate CMOS IC, type 4048 or equiv.

counter. When a pad is touched, the gate will not close unless both the appropriate BCD signal and the multiplex signal for that digit are simultaneously present. Again, two eight-input OR gates (4048s) combine the 16 NAND gates. It is not necessary to provide an audio generator, because the multiplexing frequency of a few hundred hertz will provide a tone; thus, the gates drive the audio amplifier directly.

In some transceivers it is difficult to get at the BCD information. The seven-segment information at the LEDs may be converted into BCD through the use of a Signetics 74C915 seven-segment-to-BCD converter. Fig. 3 shows a variation of the multiplex readout that was developed by Joe Blanchett, VE3BAD, for Bob LaRose, VE3EEK. This circuit interfaces Bob's FT-101ZD to a touch output. In this instance the multiplex pulses were too short for the reliable operation of the touch-sensitive system. Joe installed a pulse-stretching circuit. He also used the less expensive 4068 eight-input chips to combine the gates. In this case, it is necessary to use another two-input gate to combine the 4068 signals.

Interfacing the FT-707

Most of the counter functions in the FT-707 are accomplished by a single 40-pin IC. Frequencies from the VFO, carrier and mixing oscillators are combined in this chip and the output is the seven segment and multiplex signals that go directly to the LED transistor drivers. At this point several problems arise, at least as far as our interface is concerned.

First, BCD information is not available from the counter IC; second, the signals are inverted; that is zero is plus 5 volts and one is 0 volts. Last, in most LED displays, the number 7 is formed by lighting segments A, B and C; Signetics 74C915 seven-segment-to-BCD decoder chip is programmed in this way. However, Yaesu has chosen to represent 7 by adding the F segment to the A, B and C segments. The 74C915 decoder IC will not recognize it as a valid number.

Fig. 4 depicts a simple solution to this problem. The 11 signals from the counter, that is, the seven segment and four multiplex signals, pass through inverters to provide the right polarity for our purpose. The segment signals go to the decoder, with the exception of the F-segment signal. The inverted multiplex signals go to the gates, as in the other circuits.

Remember the extra F segment in number 7; we must arrange to present F to the 74C915 for the numbers 4, 5, 6, 8, 9 and 0, but not 7. Either segments D or G, or both, occur in all but 7. Thus, we apply D and G signals to the inputs of an OR gate, which will go to a 1 state if either or both of these is present. The output of this gate feeds one input of a NAND gate with

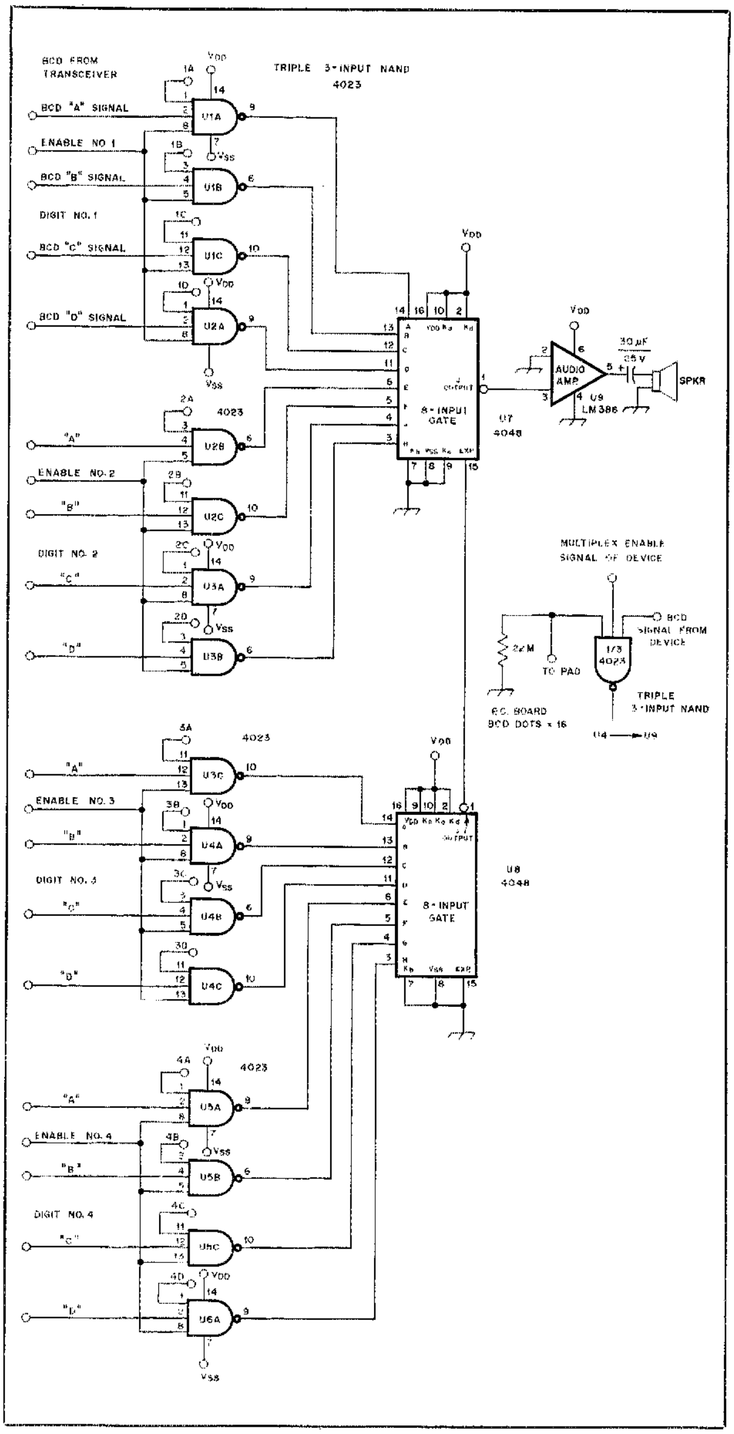


Fig. 2 — Four-digit auditory BCD readout for multiplexed signals. Capacitor is electrolytic. Resistors are carbon-composition type, 1/4 watt.

U1-U6 — Triple three-input NAND gate CMOS IC, type 4023 or equiv.
U7, U8 — Multifunction expandable 8-input gate CMOS IC, type 4048 or equiv.
U9 — Low-voltage audio power amplifier IC, type 386 or equiv.

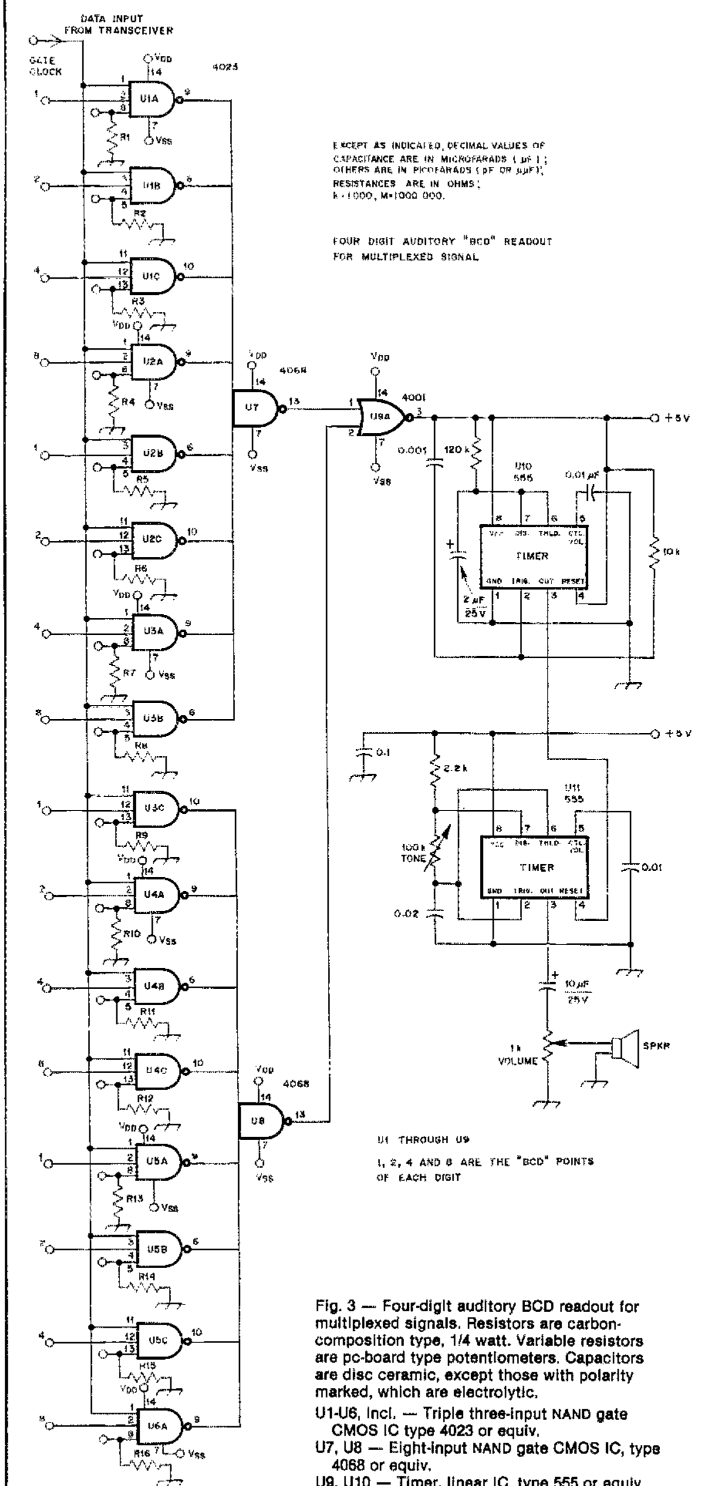


Fig. 3 — Four-digit auditory BCD readout for multiplexed signals. Resistors are carbon-composition type, 1/4 watt. Variable resistors are pc-board type potentiometers. Capacitors are disc ceramic, except those with polarity marked, which are electrolytic.

U1-U6, incl. — Triple three-input NAND gate CMOS IC type 4023 or equiv.

U7, U8 — Eight-input NAND gate CMOS IC, type 4068 or equiv.

U9, U10 — Timer, linear IC, type 555 or equiv.

Fig. 4 — BCD printed circuit board interface for Yaesu FT-707 transceiver with multiplexed signal. Capacitor is electrolytic. Resistors are carbon-composition type, 1/4 watt.

U1, U2 — Hex buffer/converter, inverting type, CMOS IC, type 4049 or equiv.

U3 — Seven-segment-to-BCD converter CMOS IC, type 74C915 or equiv.

U4-U9 — Triple three-input NAND gate CMOS IC, type 4023 or equiv.

U10, U11 — Multifunction expandable 8-input gate CMOS IC, type 4048 or equiv.

U12 — Low-voltage audio power amplifier IC, type 386 or equiv.

U13 — Triple three-input OR gate CMOS IC, type 4075 or equiv.

the other input being fed by the F signal. Thus the NAND gate will not switch if F only is present, but will switch if F is present together with either or both D and G. The output of the gate is inverted to reestablish correct polarity before going to the decoder.

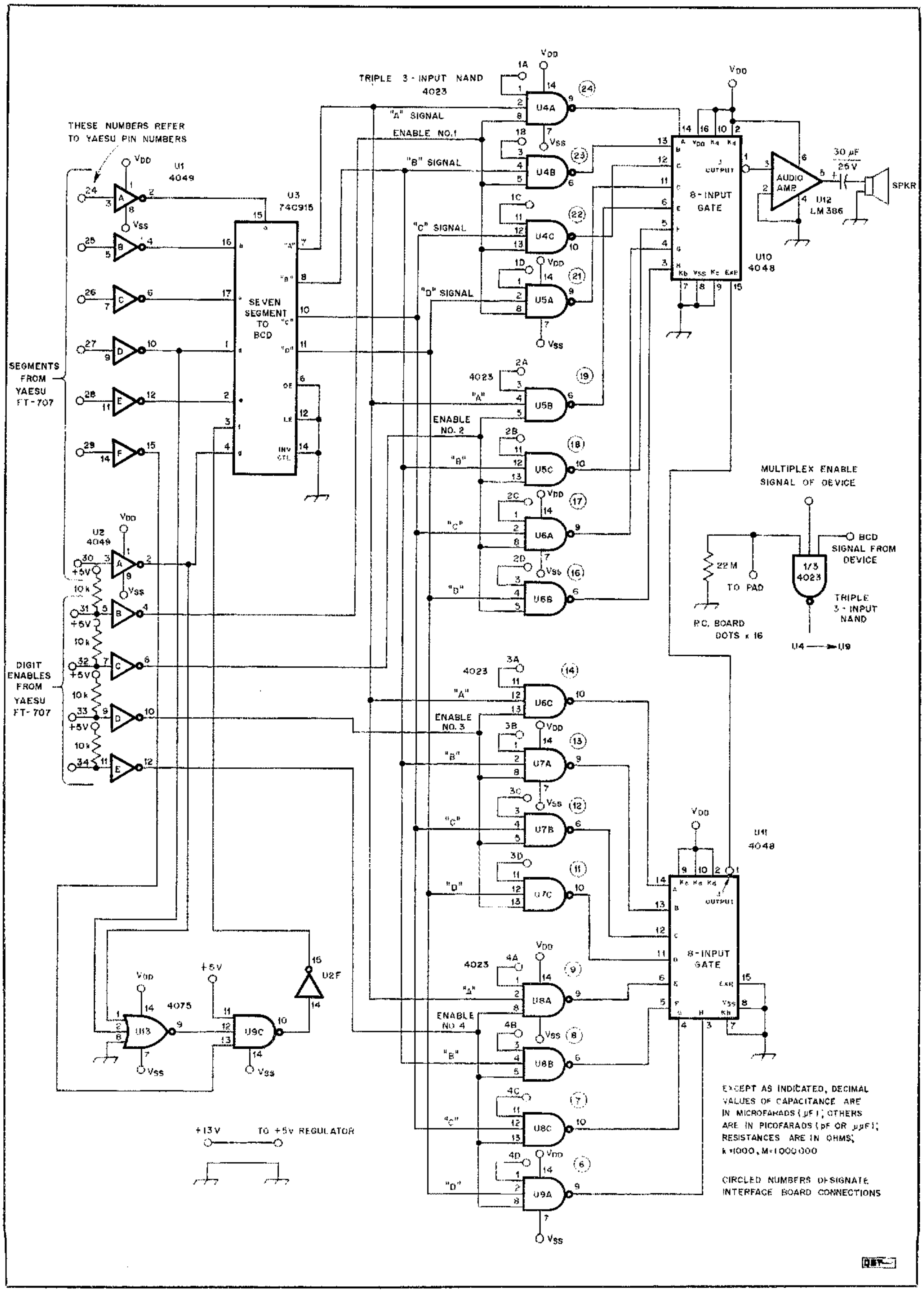
The readout connects to the transceiver by a 13-wire flat ribbon that may be passed into the unit through a small space under the top cover at the right rear. Solder it to the underside of the counter board.

Conclusion

Although each model of transceiver or other digital instrument presents its own circuit problems, I believe the sample circuits shown will enable hams to work out variations to suit their requirements. Although the circuits may appear complex, all of the ICs are cheap, and the circuit arrangement is straightforward. This system is now in use by a number of Canadian amateurs, on calculators as well as on transceivers. I hope in the near future that customized counters incorporating this readout system will be available on the market.[1]

Jim Swail, born and raised in Montreal, lost his sight in an automobile accident at age four. In 1946, the same year he graduated from McGill University (BS), he was licensed as VE2TU. Shortly after graduation he began working for the National Research Council in Ottawa, where he changed his call sign to VE3KF. Jim's first project with NRC was working on time and frequency equipment. He designed the first digital control system for CHU. Since 1965 he has been fully engaged in developing vocational aids for the handicapped. He is married and has four grown children.

[1]For information, write J.C.U. Electronics, 7007 Huntridge Hill, N.E., Calgary, AB Canada.


TRIPLE 3-INPUT NAND
4023
THESE NUMBERS REFER TO YAESU PIN NUMBERS
U1
4049
U3
74C915
SEVEN SEGMENT TO BCD
"A" SIGNAL
ENABLE NO.1
"B" SIGNAL
"C" SIGNAL
"D" SIGNAL
U4A
U4B
U4C
U5A
U5B
U5C
U6A
U6B
U6C
U7A
U7B
U7C
U8A
U8B
U8C
U9A
U9C
U10
4048
8-INPUT GATE
AUDIO AMP
U12
LM386
30 µF
25 V
SPKR
SEGMENTS FROM YAESU FT-707
DIGIT ENABLES FROM YAESU FT-707
U2
4049
ENABLE NO. 2
ENABLE NO. 3
ENABLE NO. 4
MULTIPLEX ENABLE SIGNAL OF DEVICE
BCD SIGNAL FROM DEVICE
1/3 4023
TRIPLE 3-INPUT NAND
22 M
TO PAD
P.C. BOARD DOTS x 16
U4 → U9
U11
4048
U13
4075
U2F
+13V
TO +5V REGULATOR
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (µF); OTHERS ARE IN PICOFARADS (pF OR µµF); RESISTANCES ARE IN OHMS; k=1000, M=1000 000
CIRCLED NUMBERS DESIGNATE INTERFACE BOARD CONNECTIONS

Doughnuts for the Tennessee Valley Indians

Indians on the warpath? Try a powwow with coffee and doughnuts. (Drink the coffee, but don't eat the doughnuts.)

By John A. Wick,* W1HIR

TVI in a cable-TV area? How can my neighbor be having TVI when my own sets, fed from the same cable drop, are clean? Not only was my neighbor hearing funny sounding voices from his TV set when I was running my ssb 1-kw rig on 15 or 20 meters, but he was also hearing the other hams in the neighborhood. This made it harder to solve the problem initially because no correlation could be found between the operating habits of any one ham and the time the interference was noted. Finally, I ran a controlled test, using the telephone, with my neighbor observing his TV set while I operated the rig on 20 meters. It didn't take long to determine that my neighbor was receiving my transmissions very well! My antenna was closest to the problem set, so I decided that by eliminating the susceptibility of the TV set to my transmitter, I probably would be able to eliminate all of the strange voices he was hearing.

The problem was quite perplexing. Both houses were fed from the same cable drop and if my transmissions were getting into the CATV system, I should be able to detect spurious rf on my cable. There was nothing on the line that wasn't supposed to be there. The classic fix for TVI, the high-pass filter, would not work in this case because it had nothing to filter!

The Cause Emerges

How was the rf getting into the neighbor's TV set if I couldn't see it on the cable? After some thought and discussions with a local ham, Lloyd Ford, K1YSE, an explanation for the interference started to take shape. I was looking for the interfering signal in the wrong place! I had been looking for the signals between the center conductor and the shield of the CATV cable. Where I should have been looking was between the shield or center conductor of the cable and the power line at his TV set.

We commonly think of signals in terms of voltages existing between conductors. It is also possible for cables to act like antennas with the same voltage on both conductors. When this happens, the signal is referred to as a common-mode signal, in contrast to the signal existing between the conductors, which is referred to as the differential-mode signal.

The combination of power line and CATV cable was serving as an antenna, with the interference being a result of the common-mode antenna current flowing through the chassis of the TV set rather than differential-mode signals on the CATV cable.

Since the beginning of radio it has been known that two things are necessary to receive radio signals: an antenna and a detector. Some sort of tuner is needed only if selectivity is required. Reflection upon this brought to mind the old Marconi antenna system shown in Fig. 1. The configuration appeared a lot like the situation shown in Fig. 2. It's your choice whether the power line or the CATV cable is the antenna. With the Marconi antenna, the detector receives a signal because rf is flowing between the antenna and the counterpoise. If either is disconnected, current flowing through the inductor is greatly decreased, since only capacitance to ground remains for a current path.

Signal Detection

In the early days of radio, the detector coupled to such an antenna was some sort of nonlinear junction between two dissimilar materials, often a galena crystal and a metal "cat's whisker." In the case of a vulnerable TV set, at least one of the amplifying devices within the set has a signal region over which it is nonlinear. If strong signals are coupled to it through the wiring inside the TV set, it will demodulate the rf. With sideband, a distorted audio signal will be heard and, if the sideband signal is not too strong, interference will only be experienced on audio peaks. In such cases, no interference is noted when operating at lower power levels.

Eliminating rf rectification in a nearby TV set is probably not the most desirable way to prevent the reception of unwanted signals. Unless internal modifications are

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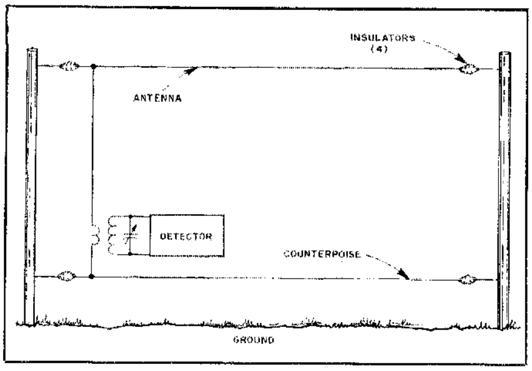


Fig. 1 — Marconi antenna with counterpoise.

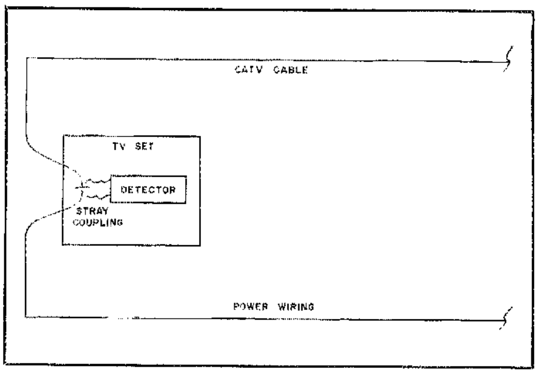


Fig. 2 — The CATV equivalent of a Marconi antenna.

made by a recognized TV service organization, the ham is immediately open to blame if anything goes wrong with the TV set. Reducing transmitter power, although effective in some cases, reduces the effectiveness of amateur communications and is undesirable. Since the presence of the signal on both the shield and center conductor of the cable is an antenna effect rather than cable leakage, installation of low-leakage coaxial cable will have no effect on the interference.

Breaking the Path

The common-mode path between the antenna cable and line cord could be broken by physically cutting either the power cord or the antenna lead of the TV set. While this would definitely eliminate the undesired reception of amateur signals, it might also make the TV owner very unhappy!

What we need is a way of breaking the antenna lead or the power-line lead for the common-mode currents without disrupting the TV signals on the CATV cable, or depriving the set of power. One way of doing this was described in a recent *QST* article.[1] A resonant trap, or breaker loop, is inductively coupled to the TV line in this approach. At the resonant frequency of the loop, a high rf impedance is coupled to the TV line so that it approximates an open circuit to the common-mode antenna currents. Since the TV cable is not cut or interrupted, the presence of the breaker loop has no effect on the normal TV signals. To protect a vulnerable TV set from multiband operation, it is necessary to install one loop for each frequency band on which TVI is a problem.

Another way to introduce such a high series impedance would be to install rf chokes in series with both the shield and center conductor of the antenna cable. While this would stop the interfering common-mode currents, it would also stop the TV signals very effectively. If rf chokes of sufficient current-carrying capacity were available, they could be installed in the line cord to disrupt the common-mode antenna currents there also.

Wouldn't it be nice if one could easily turn the antenna cable or the power cord into an effective rf choke without having to cut or modify it in any permanent way? A creative coffee break led to the inspiration that a doughnut might be able to solve the problem. No, the idea was not to use a sugar doughnut to bribe an irate TV viewer but to use a large lossy toroid and the existing TV set antenna cable or power cord to make an rf choke. A large toroid was used so that it would be possible to wind five or six turns of the line cord or antenna cable around it without having to remove and reinstall connectors. In practice, it is generally easier to wind the line cord on the core than it is to wind the toroid with the stiff coaxial antenna lead. Because the choke is being used to break a current path, it generally doesn't matter which lead it is installed in (see Fig. 3).

In particularly severe cases of interference, the effectiveness of the toroid may be quadrupled if the antenna and power leads of the set are both wound on the core. It is important that they be wound in opposite directions so that the coupling of the rf common-mode current into the toroid is maximized (see Fig. 4). If there is any doubt about which way to wind the second cable on the core, try it both ways. The difference in effectiveness will be astounding! If there are wires other than antenna and power leads connected to the set, more experimentation and possibly more than one toroid may be required. Remember that the toroids are being used to break rf-current paths and that any wire of appreciable length may function as an antenna.

Many TV sets use 300-ohm twin-lead instead of coaxial cable either to the antenna or master antenna system. Everything that has been said about the use of toroids on coaxial leads applies to their use on 300-ohm antenna leads as well. Tests indicate that the TV signals are not attenuated or affected by winding the twin-lead on a toroid in the manner described here.

In the case of my neighbor's TV set, two toroids were required. Not only was I dealing with an old TV set, but also with an add-on, remote-control unit. It seems that the remote-control tuner had been added to compensate for the demise of the tuner in the set. Watching my neighbor's face as the doughnuts were being installed on his set gave me the impression that he thought hams practiced black magic. When tests revealed that all interference had been eliminated, it was obvious that he was ready to believe in whatever witchcraft I had to offer. The public relations aspects of an interference-suppression device that can be installed simply by wrapping the line cord of the TV set around it can be quite significant. The set owner is not likely to blame you for future failure of the set or for poor reception if you never opened the back of his set or touched the antenna connections. After all, what harm could a "doughnut" on the line cord do to a set?

Buying Doughnuts

To be effective, the "doughnut" needs to be a bit fancier than the sugared kind you get at the local coffee shop. You want to create a high, lossy impedance (at hf) in series with the line cord. To do this without having to wind many turns on the toroid, you need a core with high permeability. An rf toroid of the type normally used to construct antenna baluns is not what is needed here; a high-permeability device is required. A toroid designed for use at very low frequencies is ideal for this application. For example, the toroid found in an old TV deflection yoke can be used.

A commercial toroid that I found to be very effective is a ferrite core with an outside diameter of 2.4 inches (mm = inches

[1]Notes appear on page 19.

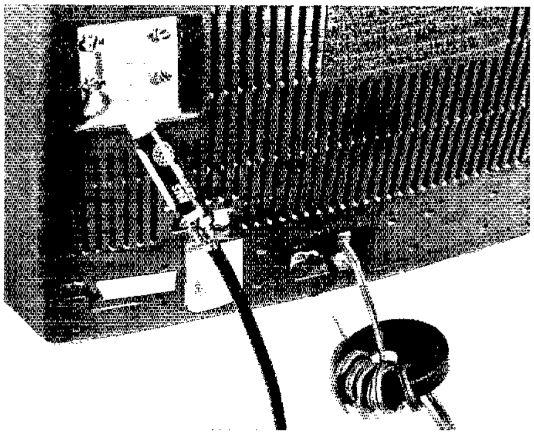


Fig. 3 — The ease of installation is shown by the toroid on the power cord of this TV.

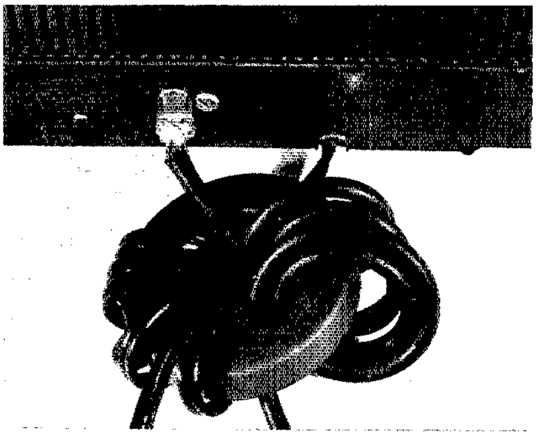


Fig. 4 — Both the antenna lead and the power cord may have to be wound on the toroid in severe cases.

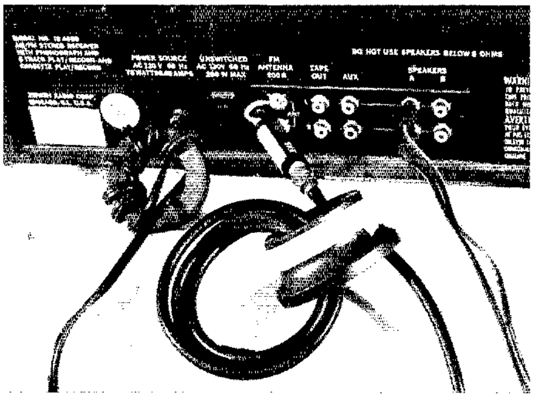


Fig. 5 — The author used the toroid from a TV deflection yoke as a core for an rf choke on the antenna lead of his stereo.

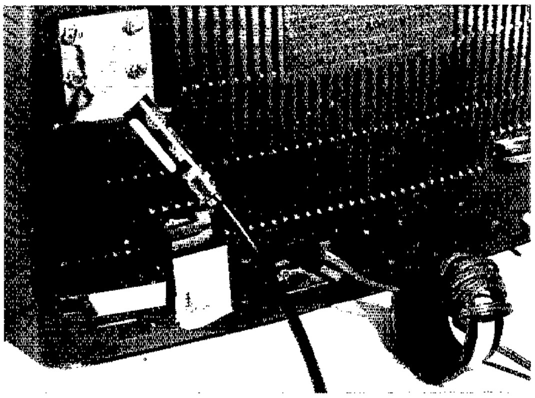


Fig. 6 — A salvaged TV deflection-yoke toroid can be used as the core of an rf choke wound in the power cord of a TV.

× 25.4). It is a low frequency toroid with a permeability of 850. The toroid was a PERMAG no. F-568-1-H. These toroids are not currently available to the amateur community on a small-lot basis, so Joe Reisert, W1JR, has agreed to serve as a distributor for them.[2]

A smaller toroid is also available that can be used when you want to install the choke inside the set. Modification of internal wiring to include a section of cable wound on the toroid is required. This smaller core has an outside diameter of 0.875 inches and a stock number of F-624-19-H. (Amidon cores FT-240-43 and FT-82-43 should be acceptable substitutes. — Ed.)

Other Uses for Doughnuts

Use of a "doughnut" is not limited to TVI problems. Home stereo equipment may also be vulnerable to interference if the speaker leads function in conjunction with the line cord to form an antenna. If this is occurring, shielding and bypassing the speaker leads will not reduce the level of interference. A "doughnut" installed on the line cord or speaker leads may be all that is necessary to clear up a frustrating interference problem.

Toroids may also find application in the ham shack when rf shows up where it isn't wanted. In some cases, winding the coaxial-cable antenna lead and the equipment power leads around toroids might break common-mode currents responsible for rf on equipment panels and instability problems. Also, the installation of a toroid on the phone line leading to a phone patch might help clear up some sticky RFI problems.

My stereo is located directly below the base of my five-band trap vertical and, as would be expected, it suffered from rf rectification. Fig. 5 shows how this problem was solved. Interestingly enough, the color-TV console that normally holds the stereo has always been completely clean, indicating that it is possible to build consumer equipment that is tolerant to rf.

Fig. 6 shows how a core from a TV deflection yoke was used to tame a problem set. The core used here was removed from a junk black-and-white TV set by cutting away the deflection-coil wire. The two ferrite segments found in the coil were taped together to make the core. TV service shops routinely discard these ferrite segments after removing the wire for scrap, so cores should be readily available from this source. Tests conducted by the author showed that the TV deflection-coil core was slightly less effective than the *commercial toroid*, and was considerably less expensive. The core from a color-TV deflection coil was also tried and found to be useful. This core is much larger than the one found in a black-and-white set and may be too large for many applications. However, it might be useful in breaking parasitic antenna currents on large-diameter coaxial lines.

Get Your Own House in Order

When dealing with interference to any consumer device the ham must first verify that the transmitter is clean and is not flat-topping or emitting parasitic signals. While the use of a spectrum analyzer provides the most convincing proof that a transmitter is clean, most amateurs are not fortunate enough to have access to one. An on-the-air examination of the transmitted signal by another local amateur should reveal any problems. If no interference is noted in any consumer electronic equipment in the ham's own home, it is reasonable to assume that the neighbor is the unfortunate owner of electronic equipment that was not designed or installed as well as it might be from an RFI standpoint.

With his own house in order, the ham must next tactfully enlist the assistance of the set owner. The first item of business should be a thorough inspection of the antenna system. If twin-lead is used, it is important that both sides of the line provide a low-resistance signal path from the antenna to the TV set balanced input. It is also important to verify that if a coaxial line is used, the line is coupled either to a cable-input jack or that a transformer is used between the coaxial cable and the balanced 300-ohm antenna terminals on the set. Any inspection of a receiving installation should result in the elimination of rusty or corroded joints between metal parts, which could serve as rectifiers.

At this point, it greatly simplifies the process if another ham can be enlisted either to operate the transmitter or to observe the interference. Hand-held vhf radios are quite useful during this process, especially as a means of verifying that the transmitter is on the air after an effective fix has been installed!

While the author has found that most TVI problems can be cured using toroids at the set, other techniques may have to be used as well. The case of the mast-mounted preamplifier is a good example. Here, it may be necessary to install filtering or a toroid at the input of the preamplifier. A toroid may also be needed at the output of the preamplifier. A change in the interference level when power is removed from the preamplifier is a good clue as to the location of this sort of problem.

Before attempting to solve any RFI problem, you should be thoroughly familiar with the section of the ARRL *Radio Amateur's Handbook* dealing with RFI, *Radio Frequency Interference* by ARRL and other similar literature. The common-mode interference discussed in this article is not the only type of TVI you might encounter. This cure applies only to those cases in which a transmitter operating considerably lower in frequency than the TV is inducing parasitic signals on the antenna feed line and the power line.

Notes

[1] C. Eichenauer, "Color TVI — A Solution," *QST*, March 1981, pp. 22-24.

[2] Joe Reisert, W1JR, will take orders for the PERMAG toroids. The large toroid, F-568-1-H, costs $11.50 plus $1.50 for postage and handling. The small toroid, F-624-19-H, costs $3.50 plus $.75 postage and handling. Address orders to: Joseph Reisert, 17 Mansfield Dr., Chelmsford, MA 01824. The ARRL and *QST* in no way warrant this offer.

New Books

☐ *The Gunnplexer Cookbook*, by Bob Richardson, W4UCH. Published by the Ham Radio Publishing Group, Greenville, NH. First edition, 1981. Softbound, 6 × 9 inches, 335 pages, $9.95.

In the author's own words, "This is a 'Cookbook' — it is neither a textbook nor a handbook. Cookbooks provide the user with 'recipes.' " Indeed that is what this book does and does quite well. Written on a level that even an inexperienced amateur constructor can follow, it requires no knowledge of microwave techniques. Circuits described generally use low-cost, easily obtained components or kits, and require basic test equipment. This approach contributes much to the practical usefulness of the book. Starting from a basic Gunnplexer, Richardson describes power supplies, modulators, techniques for power and frequency measurement, afc, i-f amplifiers, weak-signal sources, phase-locking systems and video techniques — in short, everything you need to know to get a Gunnplexer system on the air. He also describes the mechanical details of building weatherproof enclosures, parabolic dishes and mounts, and proportional temperature control ovens for Gunnplexers.

I was pleased to see an emphasis on Gunnplexer communications techniques to narrow bandwidth using both afc, which can contribute about 10 dB to the path-loss capability of a system by reducing i-f bandwidths from 200 kHz to 20 kHz, and phase locking to a crystal, which can provide about 20 dB of improvement over a wideband Gunnplexer system.

As mentioned earlier, this is a "Cookbook," without much explanation of fundamentals. In several places the author mentions the possibility of a second volume. If this comes about I would like to see perhaps a little more basic microwave information along with the "how" of Gunnplexer operation. For example, no mention is made of the fact that Gunnplexer systems are wide open on their image frequency, leading to a sensitivity loss, nor is the effect of crystal oscillator noise in phase-locked systems commented on. One other fact that might be included is that there is an international narrow-band frequency for crystal stabilized simplex operation on the 10-GHz band at 10.368 GHz. If we can all get on the same frequency, we one day may work each other!

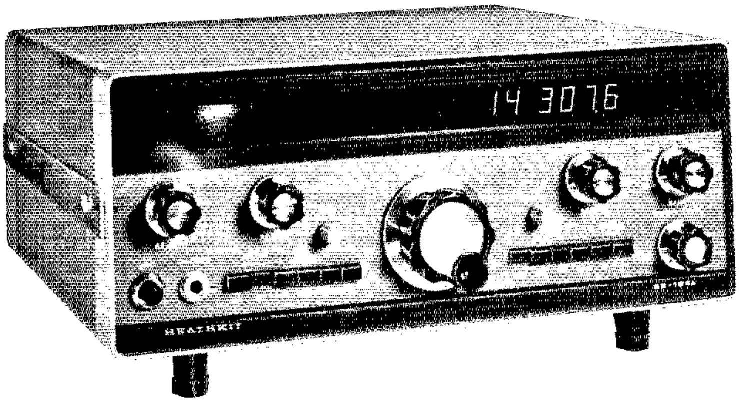
I did notice a couple of errors while reading through the text. On page 156, the gain of a parabolic dish is said to increase or decrease by 3 dB each time its diameter is doubled or halved. This should, of course, be 6 dB (as is stated elsewhere). A less important error is on page 182 where, in a description of how to calibrate accurately azimuth bearings for a large (96-inch) parabolic dish to ±0.2°, the assumption is made that Polaris (the pole star) has an azimuth of 0°, i.e., is true north. In fact, the azimuth of Polaris depends on when and where the measurement is made, and it can vary (typically) by 1° either side of true north. The azimuth of Polaris is given in tables in the *Nautical Almanac*. For most practical purposes the error introduced by assuming Polaris to be true north would be of little consequence, but for accurate work using large dishes, readers should be aware of it.

This book would be a valuable addition to the library of anyone working, or even considering working, with Gunnplexers for audio, video or data transmission. — *Bob Atkins, KA1GT*

Refining the SB-104

Want to improve the performance of your favorite rig? Perhaps these ideas are just what you've been looking for.

By David Palmer,* W6PHF



Introduction of the Heath SB-104 hf transceiver in 1976 provided a product of solid-state engineering at a price attractive to many hams. Completely solid state (except for the digital frequency counter displays), it made efficient portable and mobile operation possible. However, after a few hours of use in the real world of weak signals and crowded bands, and the occasional "rock crushing" signal from the kilowatt down the block, a few deficiencies became apparent. Cross-modulation, intermodulation and desensing (blocking) of the receiver in the presence of strong signals are particularly annoying with the original receiver front-end board. Although the 40673 dual-gate MOSFET mixer used in the '104 is better in many respects than the vacuum tube pentagrid mixer, a major weakness exhibited is that of relatively poor dynamic range.

In 1977,[1] Heath released a series of modifications that included a new receiver front-end board, thus creating the "A" model. Discrete component doubly balanced mixers (DBMs) replaced the two 40673 mixers, and redesigned, prealigned bandpass filters for each band resulted in improved performance.

But, for those like me, whose primary interest is chasing cw DX, the new receiver front-end board was a disappointment since the noise floor had not been lowered and additional spurs were evident. Masking of weak cw signals occurred when the 400-Hz crystal filter and an active audio filter were used. An examination of the receiver suggested poor gain distribution, and modifications to several of the circuit boards ensued. What follows is a description of the steps I took in an effort to improve the performance of my SB-104. Physical placement of the required components is left to the discretion of the owner/modifier.

Receiver Front-End Board Modifications

An article by Cheadle[2] suggested that the poor balance of the discrete DBMs is the source of the intermodulation and cross-modulation problems, and part of the blocking problem. Apparently, precise DBM balance using discrete components is difficult to achieve. This results in the creation of in-band mixing products from the combined presence of strong signals and the LO emission which, in the SB-104A, exceeds 20 microvolts on 20 meters. Consequently, I installed two Mini-Circuits[3] SRA-1 DBM modules on the circuit board with suitable terminations for the ports.[4]

Refer to Fig. 1. The first mixer i-f port is terminated with a 24-MHz diplexer, and the hf injection level is increased to approximately +7 dBm by changing C441 (a 33-pF mica capacitor on board D) to a 56-pF unit.[5] Installation of another SRA-1 DBM at the second mixer requires the addition of a 10-MHz diplexer that is constructed from 5%-tolerance silver-mica capacitors and an rf choke. Somewhat improved performance can be realized by replacing the rf choke with a toroidal inductor. A VFO buffer/amplifier is built on the circuit board to increase the injection level to +10 dBm and to reduce the mixer insertion loss. An L network is used to maintain a 50-ohm impedance match with the DBM LO port.

Better receiver performance resulted from the installation of the two DBMs, but the noise floor was still too high. Increasing the i-f gain after the second mixer is accomplished by installing a CA3028A cascode amplifier mounted in an eight-pin TO-5 IC socket in the area near the 8-MHz bandpass filter. The RF GAIN control (R15A) is replaced with a dual, concentric-shaft 10-kΩ linear taper potentiometer. The front section is used to ad-

'Notes appear on page 26.

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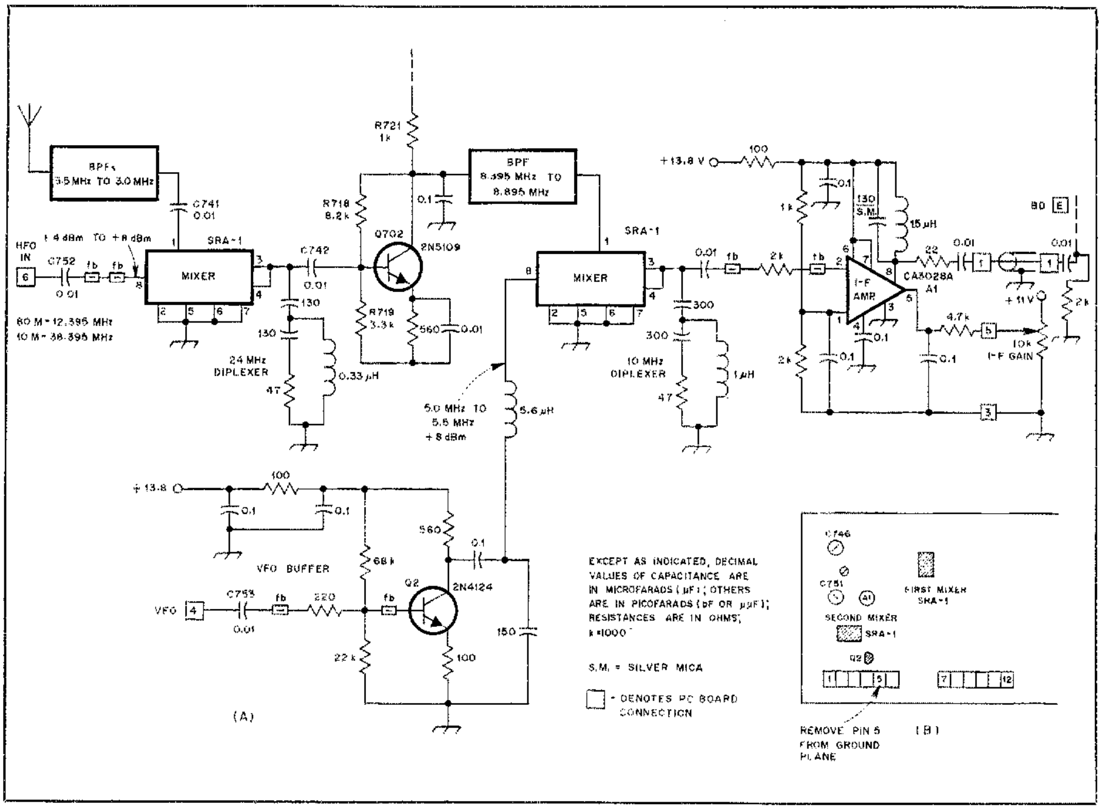

Fig. 1 — Schematic diagram of changes made to the SB-104 receiver front-end board (G). Pin 5 is removed from ground and used as a terminal for the I-F GAIN control. Heath component identification has been retained. All resistors are 1/4-watt, 5% types; capacitors are 50-V units.

just the i-f amplifier gain (board F) and the rear section is wired to board G terminal 5, which is first disconnected from the ground plane. The increased i-f gain markedly lowers the noise floor; this is particularly noticeable when using the 400-Hz cw filter.

Carrier Generator/Crystal-Filter Board Changes

The series noise blanker system used by Heath considerably degrades receiver performance. Therefore, Q601 was replaced by a 40673 MOSFET. This permits the attachment of a shunt type of noise blanker to gate 2 of the device (see Fig. 2).

In the cw mode, a "beep" was heard in the speaker during the transition from transmit to receive. This is caused by a long time constant on the V_{cc} bus of Q611, the CW GENERATOR. Changing C635 from a 22-µF capacitor to a 0.1-µF unit solves the problem by permitting the CW GENERATOR to turn off during the transmit/receive changeover interval.

Difficulty in achieving a good carrier null in the balanced modulator was caused by poor carrier-frequency bypassing at the

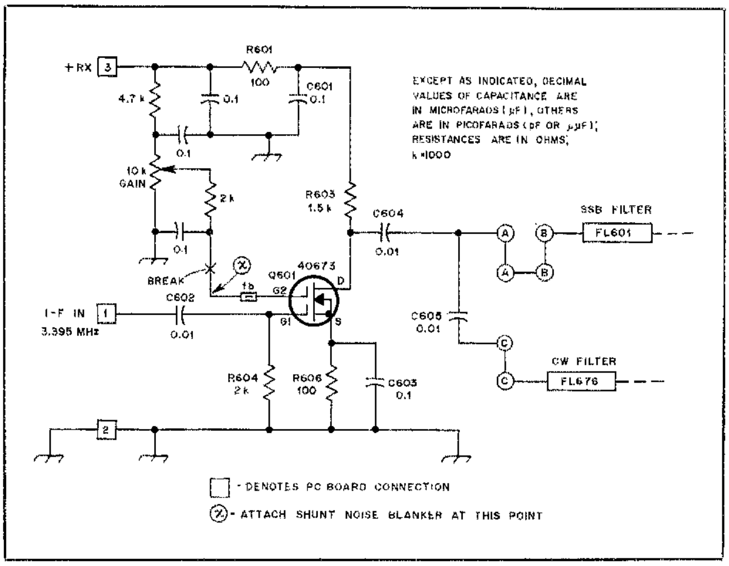

Fig. 2 — Carrier generator/crystal filter board (E) changes. A shunt type noise blanker may be attached at point X. The bipolar transistor (Q601) has been replaced by a dual-gate MOSFET.

modulation input port. Replacement of C646 (a 4.7-µF tantalum capacitor) with a 0.1-µF ceramic capacitor and series-connected 47-ohm resistor produces better suppression.

Receiver I-F/Audio Board

The first modification to be made (see Fig. 3) provides additional receiver gain by tuning L501 with a 10- to 60-pF trimmer capacitor. A gain improvement of approximately one S unit should be noted.

During cw operation an annoying wide-band audio hiss was noted in the receiver. It was discovered that the IC502 low-pass filter section turnover frequency was approximately 15 kHz rather than the 1.5 kHz it should be to match the ssb crystal-filter passband. After some discussion with Bob Warmke (W6CYX), the entire active filter was redesigned and the IC502 high-pass filter section was converted to another low-pass filter. Both filters were modified as shown in Fig. 4 to low-pass filters with 2-kHz turnover frequencies.

Attempts to properly decouple the AF board inputs to eliminate af feedthrough during transmit proved ineffective because of a ground loop. Therefore, a transistor switch was built between board terminals 12 and 16, with the transistor base connected through an RC filter to the + XMT bus. In the transmit mode, the base is pulled high and the transistor saturates, effectively shorting the filter output.

While using the HP-1144 power supply, an annoying 60-Hz hum was noticed. The hum pickup was traced to the two shielded wires that connect from terminals 15 and 16 on board F to the AF GAIN control. These two wires are in the same harness as the 117-V ac wiring to power switch S3F. Using a separate twisted pair of shielded wires, connected from the AF GAIN control to the appropriate terminals on board F, eliminated the hum.

A preamplifier to drive a cw active audio filter was constructed on the board

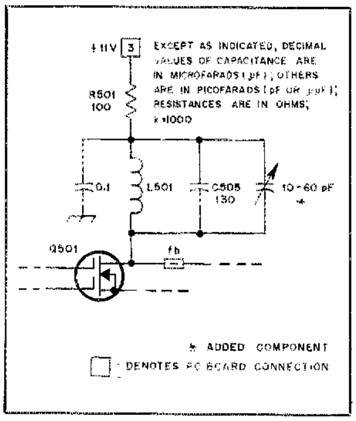

Fig. 3 — A trimmer capacitor is used to tune L501 on board F to obtain additional receiver gain.

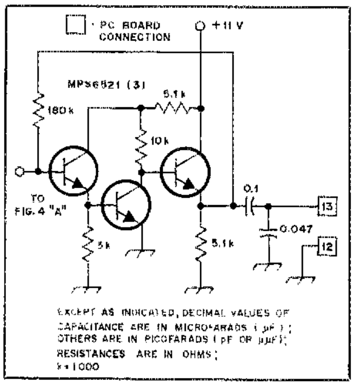

Fig. 5 — Schematic diagram of the audio preamplifier added to board F. Resistors are 1/4-watt, 5% types; capacitors are 50-V units. Pads for mounting Q1 through Q3 may be cut into the existing ground plane.

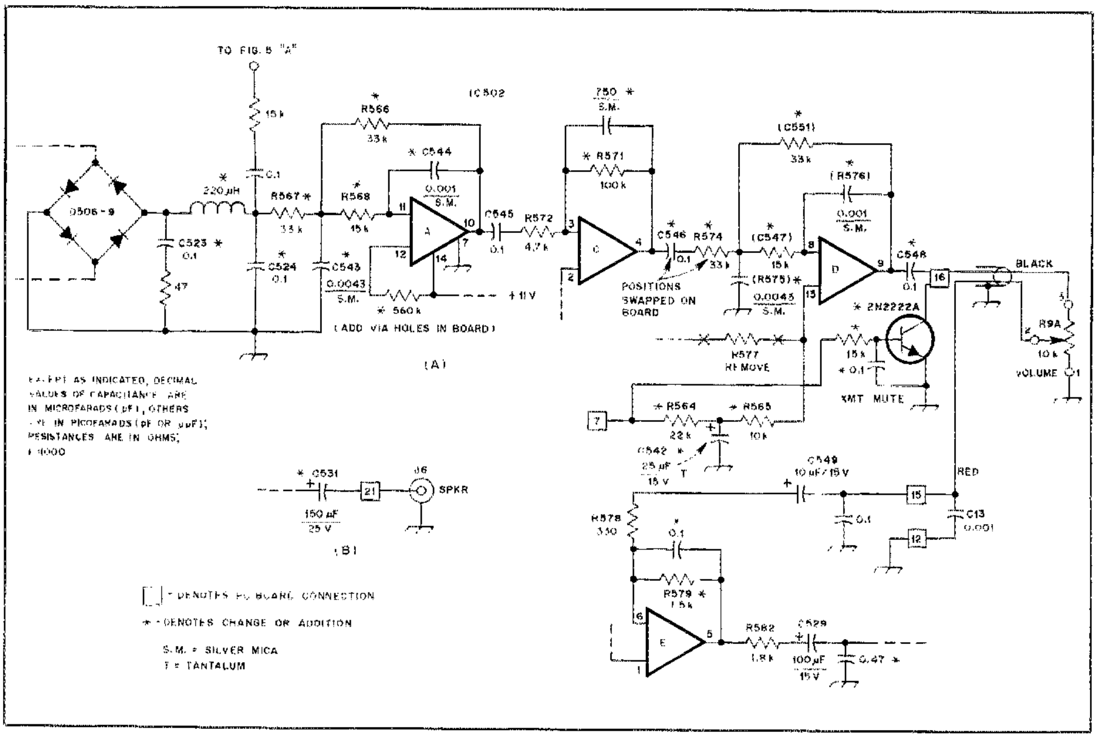

Fig. 4 — Other changes made to the receiver i-f/audio board (F) are shown here.

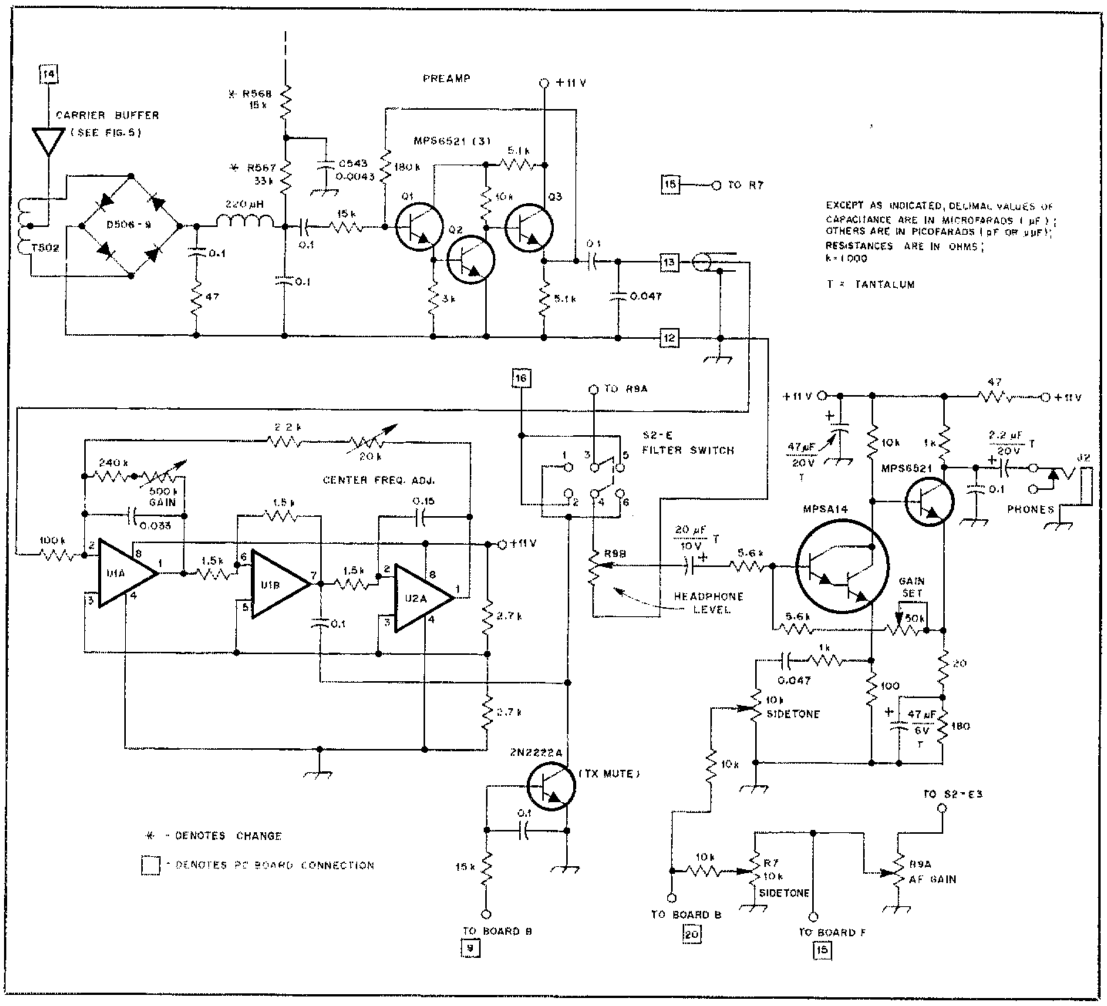

Fig. 6 — An adjustable active cw band-pass filter and headphone amplifier are assembled on a piece of perf board and interconnections made as described in the text. R9 is replaced with a dual potentiometer.

in the area between the i-f strip and the audio amplifier. Terminal 13 is removed from ground and a shielded cable is connected to the filter board. This is shown in Fig. 5.

Active CW Filter and Headphone Amplifier

Having used an HRO-60 with a sharp crystal filter, it soon became apparent that the SB-104A cw filter was not adequately separating weak cw signals from the noise. A biquad active audio filter[6] (Fig. 6) was assembled on a piece of perf board along with a low-noise, low-distortion headphone amplifier. One advantage of the filter is that both the frequency and bandwidth can be adjusted to suit the operator's preference. Wideband noise generated by the high-gain i-f amplifier is also eliminated, considerably improving the overall cw noise figure.

Because of a personal preference, the headphone amplifier was wired directly to the PHONES jack, and the af power amplifier was wired to the rear panel SPKR jack. S2E was then rewired to connect the cw or the ssb audio filter to the headphone amplifier or speaker power amplifier. The AF GAIN control (R9) was replaced with a dual, concentric-shaft 10-kΩ audio-taper potentiometer to permit independent control of the headphone and speaker audio levels.

Carrier Buffer Amplifier and Product Detector

Distorted audio, particularly noticeable on weak signals, was caused by insufficient carrier level being fed to the product detector. A scope at the LO port of T502 (see Fig. 7) revealed a 150-mV peak-to-peak sine wave indicative of inadequate drive. A buffer amplifier consisting of a transistor and an LC matching network was constructed on the circuit board using point-to-point wiring. The transistor is mounted in a 3-pin socket and the other components are wired to it. The trace from terminal 14 (CARRIER INPUT) is severed at the terminal and then connected to the board ground plane. A short length of RG-174/U is then connected to the terminal, the shields are grounded and the center conductor is soldered to the 0.01-μF ceramic capacitor in series with a 1.5-kΩ resistor at the base of the tran-

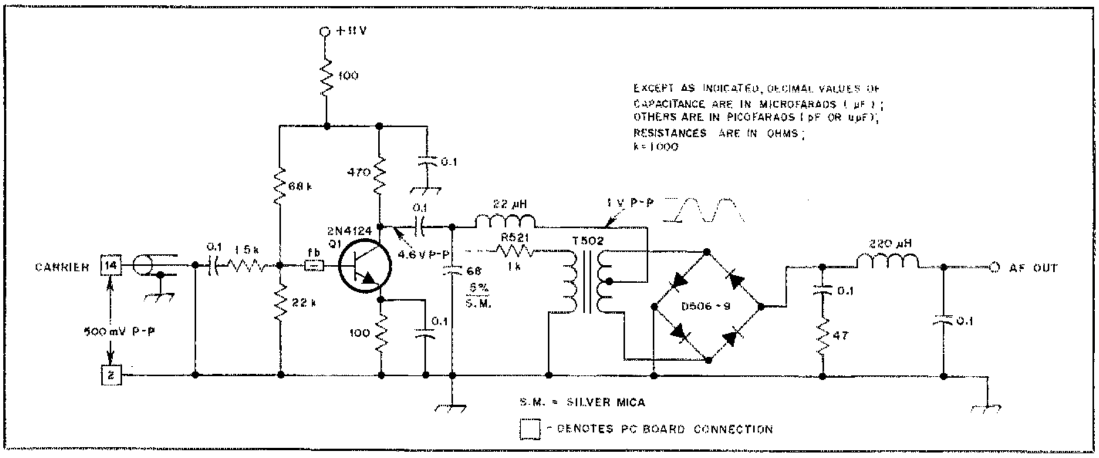

Fig. 7 — Point-to-point wiring is used to construct a buffer amplifier on board F. C522 (between T502 secondary center tap and terminal 14) must be removed.

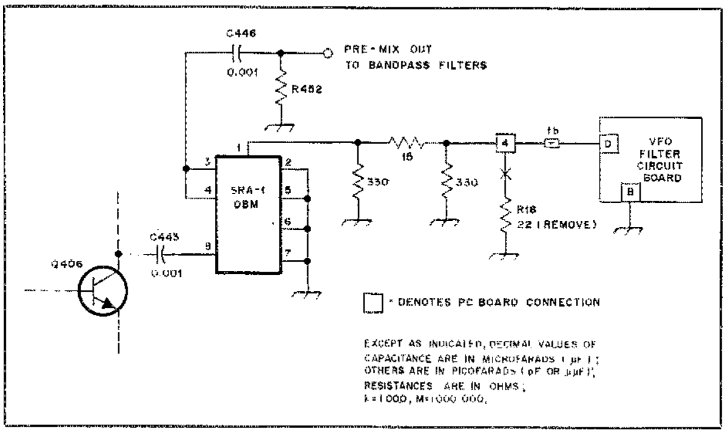

Fig. 8 — Schematic diagram of the additions and changes made to the HFO/premix board (D).

sistor. An LC impedance-matching network consisting of a 68-pF silver-mica capacitor and 22-µH rf choke couples the carrier signal to the product detector. A 900-mV pk-pk sine wave with symmetrically clipped peaks observed at the LO port indicated the correct drive level had been obtained.

Proper diode ring termination is accomplished by installing a series RC network comprised of a 0.1-µF capacitor and a 47-ohm resistor. A low-pass filter made from a 220-µH rf choke and 0.1-µF capacitor prevents the carrier signal from entering the audio circuits. The resulting recovered audio is best described as crisp and clean with negligible intermodulation distortion. As a final step, remove C519 (0.01 µF) to prevent leakage of the carrier signal to other receiver sections.

HFO/Premix Board

As in other systems that use multiple oscillators and mixers, the SB-104A has a few in-band mixing products — "birdies" — that pass through the chain and can create problems. Spurious emissions can occur in the transmitter output where band-pass filters cannot attenuate them, and receiver spurs will often interfere with the reception of a desired signal. Several spurs were traced to the pre-mixer on board D. Refer to Fig. 8. Installing a 2-dB H pad at the LO port to terminate both the DBM and the VFO filter properly did reduce the amplitude of the spurs, but did not eliminate them. The original DBM was removed and an SRA-1 DBM mounted directly on the board. If your SB-104 has been modified to the "A" version by the installation of a new VFO filter board (part no. 85-1930-1), remove the 22-Ω resistor wired between the edge connector terminal 4 and chassis ground.

Transmitter I-F Board

Transmitter output measurements revealed several in-band spurs generated by the mixer on board C. After removal of the original mixer components, an SRA-1 DBM was installed (as shown in Fig. 9) directly on the circuit board. Some modifications were made to the circuit to accommodate the new mixer. The Q301 emitter-bias network was removed from ground and wired between the emitter pad and terminal 1 of the DBM module. C314 was changed from 0.01 µF to 0.1 µF because of the low impedance of the rf port.

To terminate the LO port properly, a 2-dB H pad was constructed from R326 (changed to 430 ohms), R325 (unchanged), and another 430-ohm resistor, soldered between terminals 7 and 8 of the DBM module. An undesired low power output condition can often be solved by increasing the i-f signal level at IC301 pin 4 by reducing the resistance of R318 from 1.8 kΩ to 470 ohms.

I-F Buffer Amplifier

The omission of a wideband, low level i-f output from the SB-104A precludes the use of a Heath Scanalyzer or other i-f spectrum display. A buffer amplifier (Fig. 10) consisting of a CA3028A cascode amplifier, a toroidal transformer (T1) and a few other components was built on a piece of perf board and mounted on the underside of the chassis between circuit board sockets F and G. A 3/4 ×

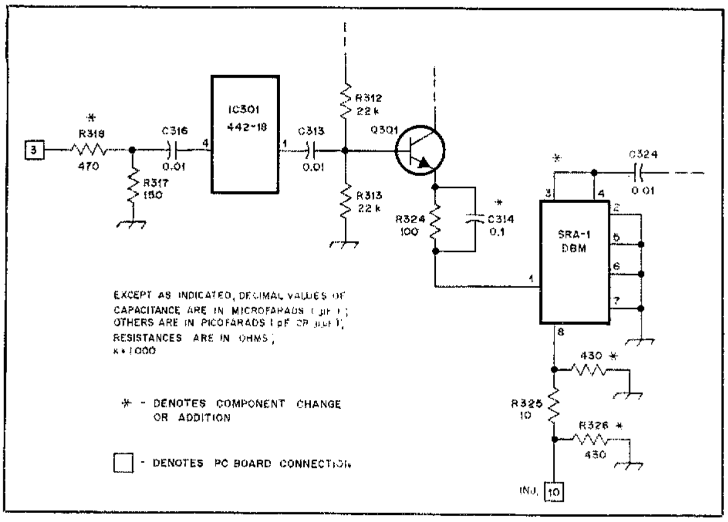

Fig. 9 — A modular DBM replaces the discrete component mixer on the transmitter i-f board (C), and some existing component values are altered.

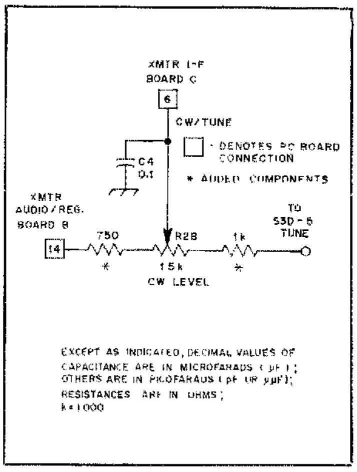

Fig. 12 — Independent adjustment of the MIC GAIN and CW LEVEL controls requires R2 be replaced by a control with concentric shafts. R2A (MIC GAIN) is not shown. Added resistors are 1/4-watt, 5% carbon types.

2-1/2-inch (mm = in. × 25.4) board will easily accommodate all components and allow space at one end of the board for the installation of a 6-32 spade lug for mounting purposes. Connect the output of the buffer amplifier to terminal 1 of board G and solder the coaxial cable removed from terminal 11 of board G to the low-impedance secondary winding of T1.

ALC Relay Switching

During operation, I noticed that a pulse was being placed on the alc bus when the transmitter was keyed. The transient was generated by the opening of the bus by the T-R relay. Moving the switching function from the relay to the unused half of the HI-LO power switch, S3E, as shown in Fig. 11, solves the problem.

Cw Level/Mic Gain

Independent control of the CW LEVEL and MIC GAIN functions was desired. So, R24A was replaced by a 100-kΩ/1-kΩ dual, concentric-shaft potentiometer. To obtain better control of the CW LEVEL, the range of the control was reduced as shown in Fig. 12.

VOX Instability

Rf feedback on the +11-V bus of circuit board B can result in the VOX circuit malfunctioning when using an amplifier.[7] A 0.1-μF ceramic capacitor connected between pins 7 and 14 of IC201 eliminates the feedback.

Another source of erratic VOX operation can be cured by substituting a

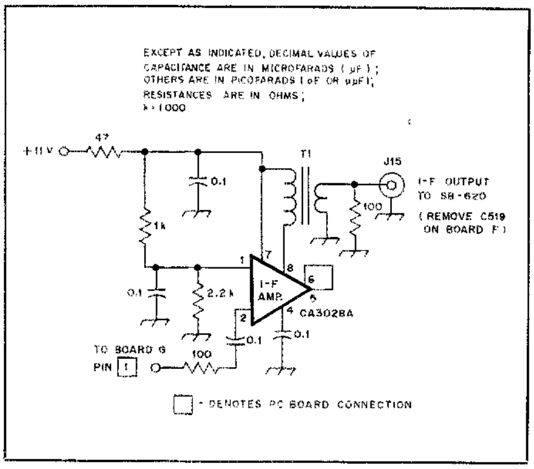

Fig. 10 — Schematic diagram of the i-f buffer amplifier added to the SB-104 to permit use of an i-f spectrum display. All resistors are 1/4-watt, 5% types; capacitors are 50-V units. T1 consists of 20 primary turns and 4 secondary turns wound on a T50-2 core.

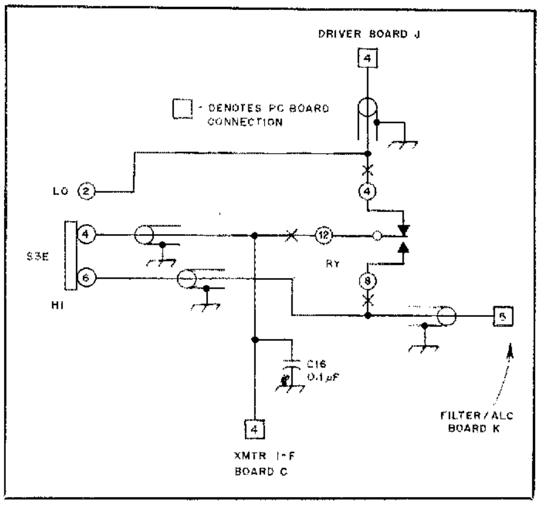

Fig. 11 — Alc/output board (K) changes. Heath component identification is used in the schematic diagram.

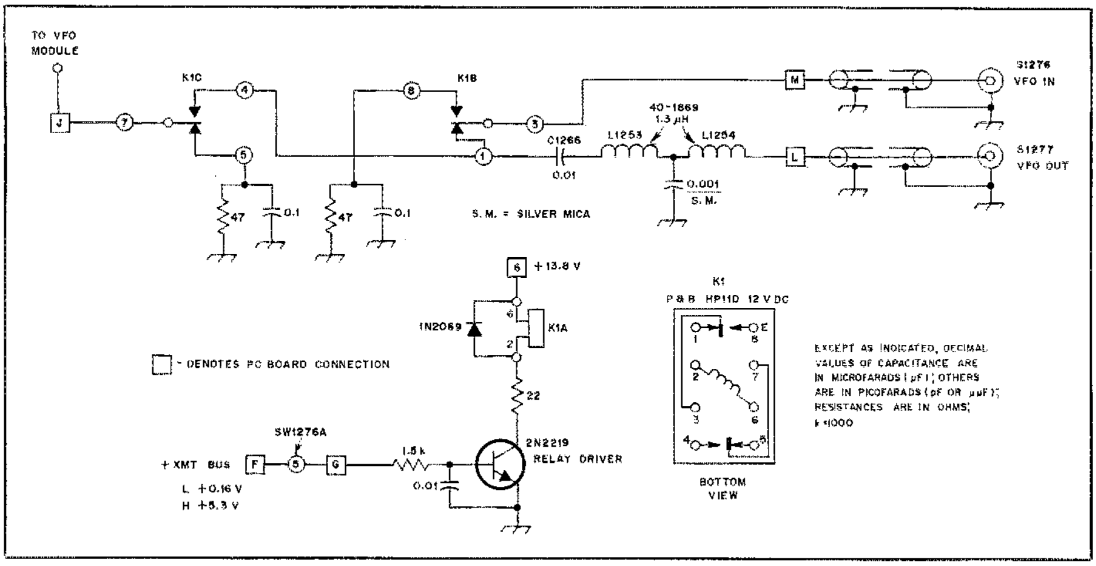

Fig. 13 — A relay replaces the transistor switches used in the SB-644 remote VFO. Resistors are 1/4-watt, 5% carbon composition types; capacitors are 50-V units.

Darlington pair for Q203 on board B. Relay driver Q207 can fail because of high voltage transients should D204 fail. A 0.1-µF capacitor between the collector of Q207 and the board ground plane will dampen any such transients.

Diode Substitution

Replacement of the four discrete DBMs will free 16 FH-1100 hot-carrier diodes (part no. 56-87). Twelve of these should be used to replace the band-pass filter switching diodes (part no. 56-24). A noticeable improvement in receiver sensitivity and noise figure will result, as the hot-carrier diode has significantly less internal capacitance and a much lower conduction voltage. After substituting the diodes, realign the receiver front-end filters using a sweep generator or a noise source.

SB-644 VFO Modifications

Conversion of the SB-104 to the "A" version creates a switching interface problem when using the SB-644 remote VFO. The SB-644/A assembly manual (part no. 595-2055-02) suggests a simple way of solving several quirks in the original unit. The necessary components to make the conversion, including a new circuit board and the toroidal inductors for the low-pass filter, were purchased from Heath and installed.

A significant reduction of VFO harmonics and a considerable improvement in VFO isolation can be achieved by replacing the transistor switches with a Potter and Brumfield HP11D dpdt 12-V dc relay. See Fig. 13. As the fixed-frequency feature of the transceiver was not used, the relay was mounted directly on the circuit board in the space intended for the crystal-oscillator circuit.

HP-1144 Overvoltage Crowbar

One unfortunate experience of a few SB-104 owners involves a collector-to-emitter short in one of the power supply series pass devices, which places approximately 22 volts on the 13.8-V bus. Component destruction is immediate and expensive, and repair is difficult.

In 1977, Heath offered a crowbar field-retrofit kit (part no. 830-33) that will protect the transceiver should an over-voltage condition occur. This modification should definitely be made, as it will eliminate a possible source of grief. If rf hash is created by the power supply, a 0.02 µF/100-V ceramic capacitor should be wired in parallel with each bridge-rectifier diode to act as a transient bypass.

Addendum

When instability is encountered in the high-gain rf and af amplifier stages used in the transceiver, it can often be traced to inadequate shielding and bypassing. Several rf and i-f circuits in the SB-104 were found to be at the threshold of oscillation during the transition from receive to transmit. Usually the problem can be solved by improving the circuit decoupling from the V_{cc} bus. A number of 0.1-µF and 0.001-µF/50-V ceramic capacitors were eventually installed in several circuits.

Every circuit board terminal with a dc function was bypassed with a 0.1-µF ceramic capacitor where it entered the board. Some of the 0.01-µF capacitors in the original circuit were replaced with 0.1-µF units. Distribution points for the +5-, 11- and 13.8-V dc sources were bypassed with a parallel capacitor combination consisting of a 15-µF/20-V tantalum and 0.001-µF ceramic units. The alc bus and all unshielded rf and af signal wires were replaced with lengths of RG-174/U coaxial cable, with the shield grounded only at one end.

I hope the preceding modifications will be of help to other SB-104 owners. The resulting improved performance should increase your operating enjoyment considerably. Please include an s.a.s.e. with any correspondence.

Notes

[1]Heath Co., SB-104A modification kit (part no. SBM-104-2).
[2]D. Cheadle, "Selecting Mixers for Best Intermod Performance," *Microwaves*, November and December 1973.
[3]Mini-Circuits, 2625 East 14th St., Brooklyn, NY 11255.
[4]W. Hayward and D. DeMaw, *Solid State Design for the Radio Amateur* (Newington: ARRL, 1977).
[5]R. Jefferis, WB6OQP; private communication.
[6]J. Rohler, "Biquad Bandpass Filter for CW Use," *Ham Radio*, June 1979, p. 70.
[7]See note 4.

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DeMaw D. and G. Collins, "Modern Receiver Mixers for High Dynamic Range." *QST*, January 1981, p. 19.
Tashner, R. "Improved Receiver Performance for the Heathkit SB-104A." *Ham Radio*, April 1981, p. 78.
Woodward, G., ed. *The Radio Amateur's Handbook*. Fifty-ninth edition. Newington: ARRL, 1982.

Dual Full-Wave Loop Antenna

By John Griggs,* W6KW

Achieving gain from an antenna at 7 and 3.5 MHz normally requires a rather large piece of real estate, a high tower or both. To obtain significantly improved performance over a dipole at these frequencies, and to do it inside an average city lot, is a goal worth pursuing! With this in mind I decided to replace my inverted-V dipoles on 7 and 3.5 MHz with a dual full-wave loop antenna, one inside the other.

I had noticed the strong signals on 7 MHz from Pat Kearins, W7UI (now a silent key), and from Carl Winter, W6OAW, on 3.9 MHz, and was interested to find that both were using full-wave loops. Both signals would pin my S-meter, and my QTH is well over 200 miles (km = miles × 1.613) from either station. The antenna at W7UI was a loop suspended by a very high supporting structure. This loop resembled a square, with one corner facing up, one facing the ground, and the other two corners pulled outward by guy wires.

My attention was attracted to a horizontal loop antenna used by another ham on 3.9 MHz that produced extremely strong signals. It was a square loop, 65 feet (meters = feet × 0.3048) on a side, with each leg parallel to the ground but only 14 feet high. Fed by a tuned line, it functioned well, but it was most effective for relatively short ranges, up to 200 miles or so.

Of more interest to me, however, was the 75-meter rectangular loop used at W6OAW. I learned that this was a dual antenna, i.e., a full-wave rectangular loop for 3.9 MHz suspended about 40 feet above ground, with another full-wave loop for 7 MHz inside the first, in the same plane. The 3.9-MHz loop is a closed circuit, whereas the 7-MHz loop is an open circuit. This permits operation on 10, 15 and 20 meters as well as 40 meters when used with open-wire feed line and a matching network. The outer loop is fed with coaxial cable.

Design Planning

In considering loop antennas for my lot, which is 75 feet wide by 125 feet deep, I found that I could use two 40-foot high pipe masts, 130 feet apart along a diagonal across my lot. I duplicated the W6OAW arrangement, except that I hung the antenna vertically and made both loops closed-circuit designs. I could use them only on the bands for which they were cut, 7.2 MHz and 3.8 MHz. Each is fed with a quarter-wave matching section of RG-59/U, which provides a 50-ohm match for the RG-8/U cables leading in to my operating position.

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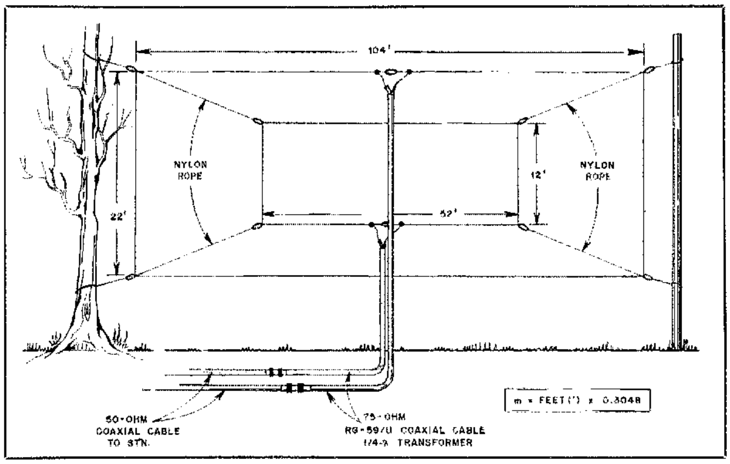


Fig. 1 — Dimensions for the dual full-wave loop antenna. Input impedance is on the order of 104 ohms. A quarter-wave matching section of RG-59/U is used to provide a match to 50 ohms.

Construction

See Fig. 1 for construction details and dimensions. Matching the 104-ohm antenna impedance to the 50-ohm line impedance requires a quarter-wave coaxial line having a characteristic impedance of 72 ohms. The formula for a 1/4-wave section is:

$$\frac{246}{f(\text{MHz})} = \ell(\text{ft}) \qquad \text{(Eq.1)}$$

This result must be multiplied by the velocity factor of the coaxial cable, 0.66 for RG-59/U 73-ohm cable. The quarter-wave section was determined to be 42.7 feet for 3.8 MHz and 22.6 feet for 7.2 MHz. These connect to RG-8/U cables for a 50-ohm match to the transceiver.

The top section of the 3.8-MHz loop is fed at the center because of the length of the quarter-wave line, but the shorter matching section for the 7.2-MHz loop allows me to feed the bottom portion of that antenna.

The inner loop is supported from the corners of the outer loop by means of nylon rope and suitable insulators. It is best to use lightweight, high-quality insulators and wire no larger than no. 14 to reduce the weight of the array. Pulleys (and rope) will be required at the tops of the 40-foot poles and also at the 18-foot level. The fact that the bottom horizontal section of the antenna narrowly misses the top of my house roof seems to have no deleterious effect on its operation.

Measure the antenna sections carefully, and cut them to length. Pay particular attention to locate the feed point at the exact center of the horizontal wire sections. This provides horizontal polarization. Feeding the loop at the center of either vertical section will provide vertical polarization.

Tuning

If trimming is needed to resonate the antenna to your favorite operating frequency, cut or add equal length pieces at each vertical section. Do not shorten the sides to the point at which the top and bottom sections are less than 0.1 wavelength apart. Careful pruning of the horizontal sections would be required if such a problem develops.

Information given to me by those using this antenna seems to confirm my results. A typical comment is "Boy are you ever loud!" A gain of 1.8 dB over a dipole is claimed for this type of antenna. The principal difference appears to be a lower angle of radiation. While it is possible to work stations off the ends of the antenna, maximum radiation occurs broadside to the element. What I like about the antenna is the ability to hear weak stations. It is outstanding in this regard.

Assembling Big Antennas on Fixed Towers

How do you get an ungainly mass of DX-getting aluminum to the peak of a metallic mountain? This offset boom-mounting method makes a tough job safe and simple.

By Bob White,* W1CW, Ellen White,* W1YL and Jim White,** K1ZX

An irresistible offering at the Florida Hamboree flea market led to the family acquisition of seven rugged tower sections. That purchase resulted in a fixed 70-footer[1] decorating the "back 40." Our ham-oriented family now decided to buy that long-yearned-for *big* antenna, get it up and start working DX from the reputedly fabulous south Florida latitude.

A KLM 6-element tribander was speedily acquired. Soon thereafter (with lots of anti-seize compound under our fingernails) our efforts produced an imposing structure: a really beautiful sight — six elements on a 32-foot boom — lying on the ground! Somehow this monster antenna had to be placed at the top of the 70-foot tower. Without access to cranes, "cherry pickers," hot-air balloons, helicopters (or any one of many other suggestions that wouldn't be appropriate to repeat here), what to do? Obviously, there was only one practical answer: The antenna had to go up *in pieces*. The remaining question was how to engineer the operation to make it safe and as easy as possible for those "lucky volunteers" who would be atop the tower doing the actual assembly.

The PVRC Mount

The answer was found in an adaptation of what to some is known as the "PVRC mount." Many members of the Potomac Valley Radio Club have successfully used this method, though the literature on the details of just how it's done is surprisingly sparse. Simple and ingenious, the idea involves offsetting the boom from the mast to permit the boom to tilt 360° and rotate axially 360°. This permits the entire length of the boom to be brought alongside the tower, allowing the elements to be attached one by one.

As the photos show, the mount itself consists of a short length of pipe of the same (or greater) diameter as the rotating mast, a steel plate and the hardware to hold it all together. The plate is drilled for eight U bolts: four to attach the plate to the mast, and four to attach the pipe to the antenna boom-to-mast plate. Additionally, four pinning bolts are used to ensure that the antenna ends up level and parallel to the ground. Two pinning bolts pass through the mast, two through the horizontal pipe. When the horizontal pipe pinning bolts are removed and the U bolts are loosened, the boom-to-mast plate can be tilted 360°, allowing either half of the boom to come alongside the tower.

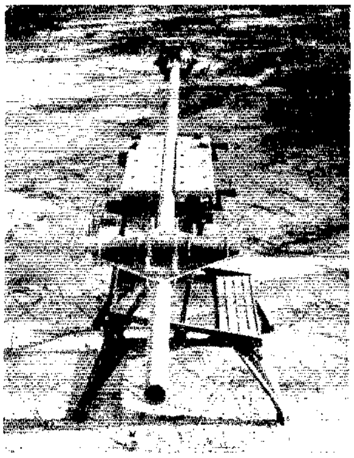
Up It Goes

After we carefully marked all critical dimensions, the antenna elements were removed from the boom. Once the rotator and mast have been secured to the tower, a gin pole is used to bring the adapter plate and pipe to the top of the tower. There, the "top crew" unpins the horizontal pipe and tilts the antenna boom-to-mast plate to place it in the vertical plane. The boom is attached to the boom-to-mast plate at the balance point *of the assembled antenna*. It is important that the boom be rotated axially so that the bottom side of the boom is closest to the tower. This will ensure that the antenna elements will be parallel to the side of the tower during installation, allowing the boom to be tilted without the elements striking the tower.

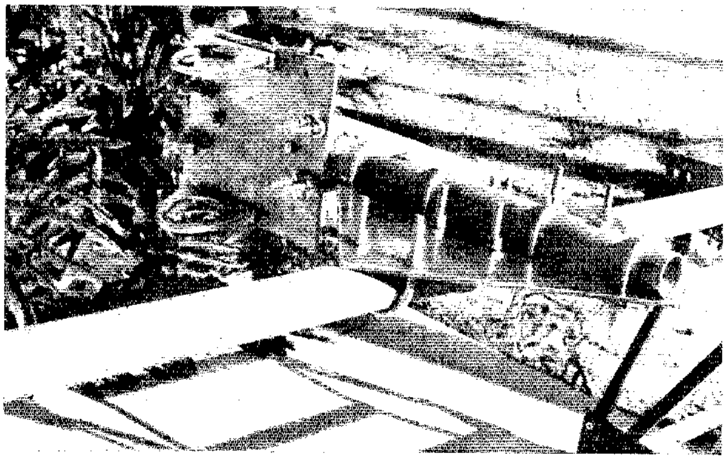
During our installation, it was necessary to remove temporarily one guy wire to allow for tilting of the boom. As a safety precaution, a temporary guy was mounted to the same leg of the tower just low enough so that the antenna would not hit

[1]m = ft × 0.3048

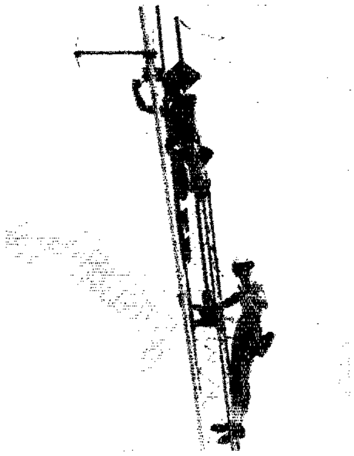
*19620 SW 234 St., Homestead, FL 33031
**15440 Hayes Ln., Leisure City, FL 33033



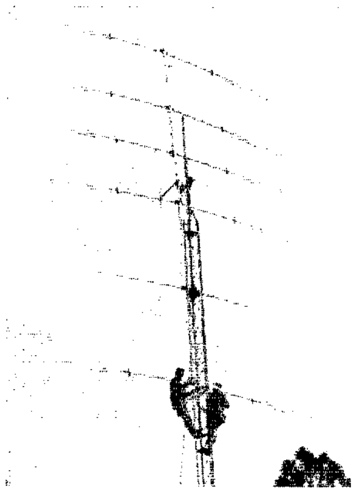
The PVRC mount, boom-to-mast plate, mast and rotator ready to go. The mast and rotator are installed first.



Close-up of the PVRC mount. Two of the four locking pins (bolts) may be seen at the midline of the left-hand vertical plate. The other two pins are located along the axis of the short pipe section; the head of the right-hand bolt blends in with the U-bolt lock nut to the rear.

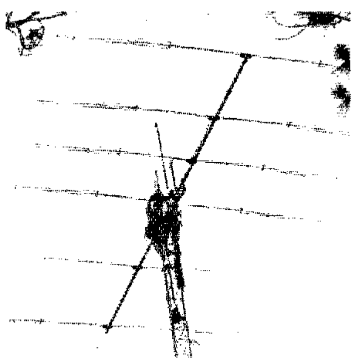


Jim (K1ZX) and Dave (KA5CRL) working at the 70-foot level. A gin pole makes pulling up and mounting the boom to the boom-to-mast plate a safe and easy procedure.



Mounting the last element prior to positioning the boom in a horizontal plane.

The mast-to-pipe U bolts are loosened and the boom is turned to a horizontal position. This puts the elements in a vertical plane. Then, the pipe U bolts are tightened and pinning bolts secured. The boom U bolts are then loosened and the boom turned axially 90°.



Tighten all the nuts, attach the coaxial cable and you're ready to crack the pileups!

it. (In this particular tower installation, three sets of guys were employed and the removal of one top guy presented little hazard.)

The elements are assembled on the boom starting with those closest to the center of the boom, working out alternately to the farthest director and the reflector. This procedure *must* be followed. If all elements are put first on one half of the boom, it will be dangerous (if not impossible) to put on the remaining elements. By starting at the middle and working outward, the antenna weight will never be so far removed from the balance point that tilting of the boom becomes impossible.

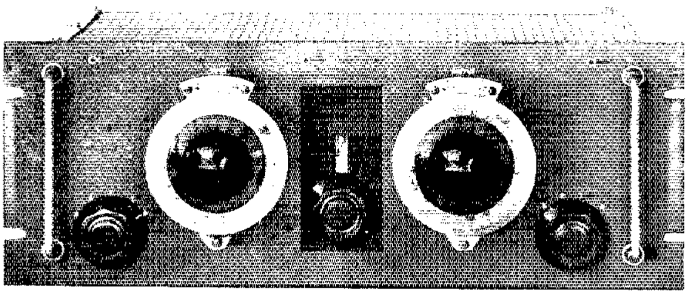
When the last element is attached, the boom is brought parallel to the ground, the horizontal pipe is pinned and the U bolts tightened. All the antenna elements are now positioned vertically. Next, loosen the U bolts that hold the boom and rotate the boom axially 90°, bringing the elements parallel to the ground. Then tighten the boom U bolts and double-check all the hardware.

Summary

Many long-boom Yagis employ a truss to prevent boom sag. With the type of mount just described, the truss must be attached to a pipe that is independent of the rotating mast. A short length of pipe is attached to the boom as close as possible to the balance point. The truss will now move along with the boom whenever the boom is tilted or twisted.

With the participation and enthusiasm of family members and friends like Jim, WA4AMG, and Dave, KA5CRL, projects like this "get off the ground" easily. Have you got a similar tower/antenna situation facing you? Give the PVRC system a try — we recommend it!

Build This L-Match



Is a narrow-bandwidth antenna cramping your style? Broaden your operating range! Dig into your junkbox and build this L-Match.

By Harry R. Hyder,* W7IV

My antenna is sufficiently broadband at 7 MHz and higher to be within the range of the output network of my transceiver. On the 3.5-MHz band it is a different story. My antenna is a trap vertical, and when the trap has been adjusted for some particular frequency, departures of more than 50 kHz on 80 meters are beyond the matching capabilities of the rig. Since I like to operate both phone and cw on the 3.5-MHz band and have plans to load the vertical on 1.8 MHz, a matching network is obviously needed.

What a ham builds is usually influenced by the parts on hand and the personal station arrangement. A five-gang receiving variable capacitor and a number of high-voltage mica capacitors were on hand, and fitted in nicely with an L network, so that is what I built.

Nothing more elaborate than an L network should ever be needed for impedance matching. PI and T networks are capable of giving greater harmonic attenuation, but TVI problems on 1.8 and 3.5 MHz are minimal, and they were to be the primary bands of operation for the L-Match. There is no reason why the L-Match can't be used on higher frequencies; it just was not built with that in mind.

There are eight possible L-network configurations; these are shown in Fig. 1. No single configuration will handle all possible mismatches, but those shown in Figs. 1A and 1B together can match any impedance.

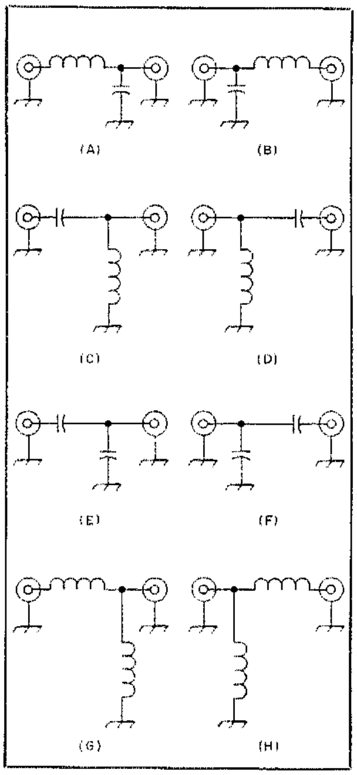


Fig. 1 — The eight possible L-network configurations.

Construction of the L-Match

The L-Match is reversible. That is, to change between the Fig. 1A and 1B configurations, the input and output are interchanged. In my station this is accomplished by an antenna switch in the station control panel, wired as shown in Fig. 2. One switch position bypasses the L-Match.

Component values depend on the degree of mismatch to be accommodated and on the operating frequency. I decided to limit its range to a VSWR of 10 at 1.8 MHz. For these conditions a capacitance of almost 6000 pF and a maximum inductance of 16 µH are needed. Obtaining the necessary inductance was no problem; a surplus roller inductor of 28 µH was on hand. The required capacitance was obtained from the five-gang, 410-pF-per section variable unit and two banks of capacitors, each with five 400-pF, 2500-V mica capacitors in parallel. This provided more than 6000 pF.

Hams may be skeptical of using mica capacitors in circuits carrying heavy rf current, but this is standard commercial practice. In fact, the surplus BC-375 tuning units from which these capacitors had been removed used them in just that way. These capacitors actually have an rf current rating of 1.0 ampere at 3.0 MHz. This is for continuous duty in an extreme environment; for ham use it can be stretched safely to 2 or 3 amperes.

*1638 W. Inverness Dr., Tempe, AZ 85282

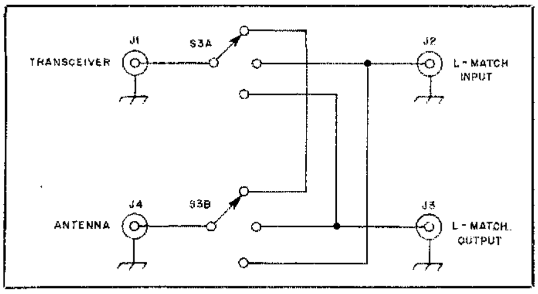


Fig. 2 — Antenna switch in the station control panel used to change the L-Match network from that of Fig. 1A to Fig. 1B. S3 is a two-section ceramic wafer switch.

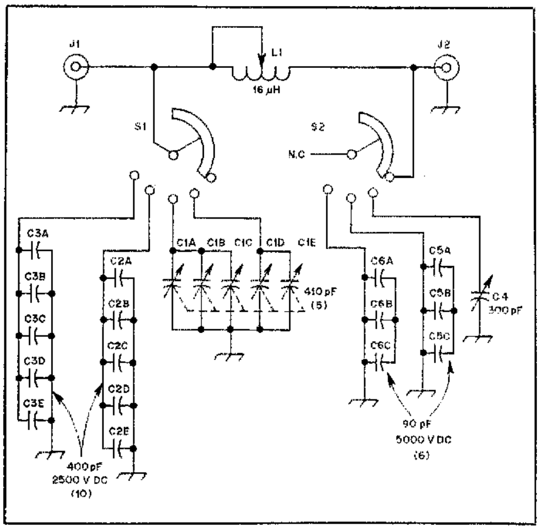


Fig. 3 — Schematic diagram of the L-Match.
L1 — 16-µH (or greater) roller inductor.
C1 — Five-section, 410-pF-per-section variable capacitor.
C2, C3 — 400-pF, 2500-V mica capacitors (CM-55 style), five capacitors each.
C4 — 300-pF variable capacitor.
C5, C6 — 90-pF, 5000-V mica capacitors (CM-65 style), three capacitors each.

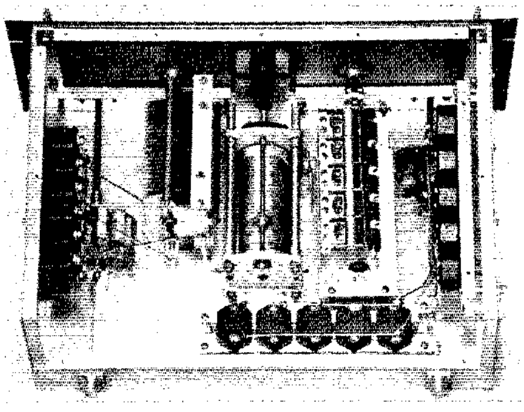


Fig. 4 — Interior view, showing construction details of the L-Match.

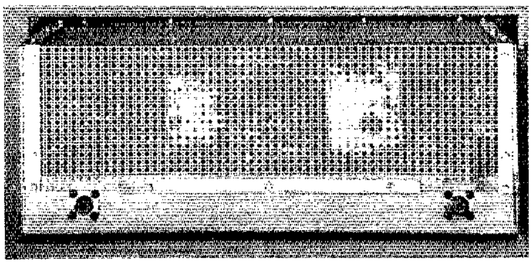


Fig. 5 — Method of attaching the cover, using 1/2-inch-wide aluminum strips.

Fig. 3 is a schematic diagram of the L-Match. One question that will be asked is why the schematic diagram and photograph show two sets of capacitors if only one is needed in an L network (see Fig. 4). This is another example of designing for a specific set of conditions at a particular ham station. When the network of Fig. 1A is used, with the capacitor on the antenna side of the network, the rf voltage will be higher than at the input, and generally less capacitance will be needed.

My rf power is normally 150 watts. With a VSWR of 10, the peak voltage across the capacitor would be about 400 volts, safe for the receiving capacitor used. I occasionally use an amplifier with an output of 600 watts. The peak voltage could then be 800, and this seemed to be asking too much of the capacitor. Since the 300-pF transmitting variable and the 5000-V mica capacitors were on hand, they were added for safety. The net capacitance is about 850 pF. This is not enough to accommodate all possible VSWR values at 1.8 MHz, but my amplifier does not work on 160 meters. The capacitance is high enough to handle the majority of cases at 3.5 MHz and higher.

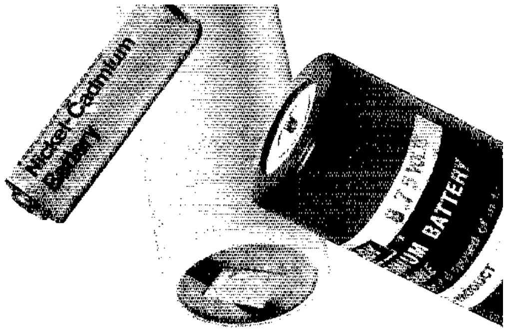
For 200 or 300 watts, receiving capacitors are adequate, and the second bank of capacitors is not needed. In this circuit one or the other bank of capacitors is used — never both. Switch positions remove either bank. The capacitor switches were taken from BC-375 tuning units, and are ideal for the purpose since they progressively short-circuit contacts as they are rotated. S1 was modified by adding a braid pigtail to the rotor and by filing another notch in the detent disk.

Packaging

Most of my homemade gear is designed to be rack mounted. The L-Match uses a 7 × 19-inch panel (mm = inches × 25.4); the chassis is 2 × 12 × 17 inches, employed upside down. The side walls are aluminum, 6-1/2 × 12 inches. The cover is fastened to 1/2 × 1/2 × 1/16-inch aluminum angle stock inside the walls. The cover is aluminum "cane" material, sold in many "do-it-yourself" stores. This material is rather flimsy, so it is held down with 1/2-inch-wide aluminum strips and sheet-metal screws (see Fig. 5).

If you don't have the exact parts described in this article, build an L-Match anyway. Use the parts you have. Isn't that one of the things ham radio is all about?

Nickel-Cadmium Pandemonium



Is the flood of information and misinformation about NiCad batteries driving you to confusion? Then let this treatise show you how to get the most from your NiCad battery pack.

By Budd Meyer,* K2PMA

There has been a marked increase in the utilization of nickel-cadmium (NiCad) batteries in the years since I first addressed the subject in my article, "Charge It," published in March 1977 *QST*. Since then I have read many articles that contain all sorts of ideas and circuits to help us keep our HTs operating. The more sophisticated circuits that I've seen are great fun to use and will do the job admirably but at a cost in complexity and reliability.

Misunderstandings About NiCads

The use of a device to completely discharge and then fully charge NiCads with controlled timing is not a new idea, nor is it a particularly good idea for amateur use. These "cyclers" are used extensively in the operation of model airplanes. They are commercially available for that purpose. Model airplanes, in contrast with Amateur Radio, require comparatively short-term but reliable applications of power.

We are told that NiCads can be cycled up to 1000 times under ideal conditions. A cycle is a complete charge and discharge event. We must not, however, lose sight of the fact that NiCads are, in effect, a sealed chemical factory with finite capacity to supply power. The drawback in using one of the model airplane cycling devices is that, by definition, some of the finite capacity of NiCads is lost by heating the atmosphere and not in communicating with another amateur.

There is nothing electronically wrong with using a cycling charger on your HT battery. The good cyclers will most certainly give you the assurance of having a battery that is fully charged. Understand, however, that the number of times you will be able to use that battery will be reduced. You reduce by one the number of cycles remaining to power your radio every time you discharge the battery into the cycler load resistors.

With the rise in popularity of battery-powered radios, there has been an increase in the variety of chargers that are available. Whether you buy or build a NiCad charger, you must be careful in selecting the device. *Do not* use a battery *eliminator* as a battery *charger*. The eliminator is a constant voltage device, probably using a 7808 or 317 monolithic regulator circuit. Nickel-cadmium batteries require a constant-current charger, as described later. If you bought or built a battery eliminator, use it for the purpose for which it was intended — to power your radio *in place* of the battery.

NiCad Memory

Listening to local repeaters, I've become aware that there are too many users of NiCads who still do not have a full understanding of proper NiCad usage. Two of the most common bits of conversation by HT operators are, "Am I making it?" and "My batteries just went." Let me now address the bugaboo of "memory," the least understood topic.

Memory pertains to a phenomenon unique to NiCads whereby you cannot completely use the rated ampere-hour capacity (designated as C) of the battery (see Fig. 1). For example, operating your HT in the receive mode for three hours diminishes part of the capacity. Use of battery energy in this manner is defined as "shallow discharge." If you charge the unit to full capacity, then use the receiver for only another three hours, repeating this charge-and-listen procedure for many *identical* cycles, the capacity can be temporarily reduced as much as 70%. A memory level is set by many *identical* shallow discharges. Memory is not a major factor in having NiCad batteries go dead at the wrong place and time. If you do not take advantage of the total capacity built into your battery, you're not using your investment wisely. There is a lesson to be learned from this: Do not listen for hours, recharge, listen and then recharge. Do some transmitting!

Another cause for memory is long-term overcharge. Long-term, in this case, is defined as more than several months, such as when your spare battery is not being "exercised" while you are saving it for emergencies. To overcome the memory problem, put your NiCad to work!

Temperature, A Critical Parameter

The case temperature of a NiCad is a

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critical parameter. It is usually ignored in the rush to get an HT on the air. See Table 1. I suggest that you pay attention to the limitations. Note that 41° F is 5° C. Charging at a higher rate than recommended will cause increased internal temperature, which will result in premature loss of capacity. While some batteries can accommodate quick recharging, who knows if your batteries are designed to withstand many cycles of rapid charging?

NiCads, being one of the more forgiving electronic components, will take much short-term abuse, but don't overdo it. The safest and most reliable way to keep your batteries in good health is to charge them at a 0.1C rate for 14 hours between 41° F and 95° F (5° C and 35° C). Do not make the mistake of presuming that less is better. While you can use a trickle charge (0.033C) on a battery that is fully charged, it definitely is not advisable to use a rate of less than 0.1C (except as noted below) to recharge a discharged battery. Otherwise your NiCad will *lose* capacity. If waiting the necessary 14 hours is more than you can stand, buy an extra battery! It will be less expensive in the long run.

Low-temperature charging is also detrimental to the battery. If you have to charge in a cold ambient, reduce the charging current. At 32° F (0° C), instead of 0.1C, reduce the charging rate to 0.075C. This means that for a 500-mAh battery, the charge rate should be about 35 mA; for a 225-mAh battery, a 17-mA current is satisfactory. It is easy to plug these numbers into the formulas given in the original article.

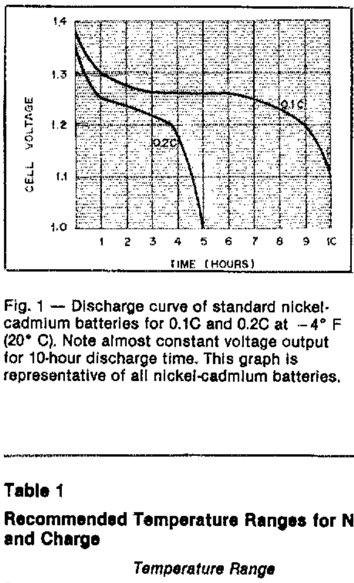

Fig. 1 — Discharge curve of standard nickel-cadmium batteries for 0.1C and 0.2C at −4° F (20° C). Note almost constant voltage output for 10-hour discharge time. This graph is representative of all nickel-cadmium batteries.

A Cause of Dead Cells

Another phenomenon associated with NiCads causes much consternation — discovering one or more dead battery cells. More often than not, dead cells are caused by "cell reversal" as opposed to an electrical short circuit. Cell reversal results from millions of individual cells being manufactured and then bundled in groups of eight or nine to form batteries, one of which is installed in your rig. The manufacturer should select a group of cells that have closely matched characteristics — particularly capacity, C. What happens in cell reversal is that, as the battery discharges, one or more cells will discharge more than the others. A point is reached where the lower capacity cell becomes the recipient of charge from the remaining cells, and its potential becomes zero volts or may reverse polarity. In a discharge mode, the cell is being charged in the reverse direction. There isn't much you can do about this when buying the rig complete with battery, except hope that the HT manufacturer didn't buy his batteries from the "lowest, lowest" bidder.

There is something you can do after you own the radio. *Take care* of the battery. You'll hear stories of some "smart" amateurs allowing the voltage of their batteries to drop to less than 1 volt per cell consistently and supposedly getting away with it. Considering the discharge characteristics required by current HTs, I consider 1 volt per cell to be the recommended minimum cutoff voltage.

Should you suspect a reverse charged cell, put the battery pack in a charger and give it a full 14-hour charge at 0.1C. If the reverse didn't exceed −0.5 volt, the chances are that no permanent damage has been done.

There is another minor annoyance associated with NiCads, but this is easily reversible. As a sealed chemical factory, NiCads exhibit a self-discharge rate of a little over 1% per day at 77° F (25° C). Again, this rate is temperature related. At 104° F (40° C) your battery will lose about 50% capacity in two weeks. This should tell you something about storing NiCads. Keep them in a refrigerator, not a freezer. Give them a full charge before you use them again.

Charging

A word must be said once more about fast-charge batteries. The cell voltage and case temperature have to be monitored carefully. Cell-case temperature should be restricted to between 59° F (15° C) and 113° F (45° C). The charge voltage per cell must be limited to 1.5 V maximum. Also be sure the batteries are of the fast-charge type. There should be some indication on the label or on the cell itself.

Clearing an Electrical Short

I'd like to comment on the matter of "clearing" an electrical short circuit in a battery cell. Several articles have appeared in our magazines outlining procedures that the authors claim are successful in resurrecting batteries. In general, the process involves charging a capacitor to a much higher voltage than the battery voltage. For example, a charging voltage could be from 20 to 50 volts for a 12-volt battery. After the capacitor is charged properly, the battery is then zapped. Understand, however, that this procedure is only a temporary expedient. The shorts are caused by "whiskers" of metal bridging the battery electrodes. Zapping clears them, temporarily. I don't think I would want to rely on a zapped battery. Something caused the whiskers to grow in the first place; they weren't designed in.

Like it nor not, the basic operation of NiCads is also time dependent. Notwithstanding the fact that your battery may have died during an important QSO, it must be used according to its rules, not yours. If you're wise, you will wait out the time required to charge the NiCad properly. You can get away with a 0.2C or 0.3C charge to a sintered cell every once in a while. But don't abuse the privilege. Charge at 0.2C for seven hours and 0.3C for four and a half hours. These times *are* cast in concrete!

NiCad users should understand what constant-current charging means. This type of charging system, properly designed, will supply a current that is unvarying, regardless of the state of charge of the battery being charged. Believe it or not, there is much confusion over this point. Scaling a charging system for 22 mA makes that system supply 22 mA. As the charge progresses in time, it still supplies 22 mA. The charge current is not reduced at or near the end of charge; neither is it higher at the beginning. The only reading that changes as the battery accumulates charge is the voltage across the battery — with the charger disconnected. At the end of 14 hours at 0.1C rate, the battery will have a potential of 1.4 volt per cell.

Checking With a Voltmeter

Is there a way to check a NiCad to find out if your rig will make it through the

Table 1

Recommended Temperature Ranges for NiCad Storage, Discharge and Charge

	Temperature Range	
Storage	−40° F to +113° F	−40° C to +45° C
Discharge	−4° F to +113° F	−20° C to +45° C
Charge (0.1C)	+41° F to +113 F	+5° C to +45° C

outing? You betcha! A voltmeter will help. There is one time when a NiCad has more than 1.2 V per cell, and that is when it's fully charged. However, that condition lasts but a short time. Note in Fig. 2 that a NiCad with diminished capacity seems much the same on the horizontal axis as a fully charged one. Putting a voltmeter across the battery can show that the potential is above the 1 V per cell cutoff, yet internally the capacity to operate your set just isn't there. Perhaps the best way to understand the concept is to accept the fact that there is a difference between voltage and capacity. In a contest, capacity wins every time.

To check capacity of a battery accurately you will have to go through at least one complete charge/discharge cycle at a standard time and current — 14 hours at 0.1C charge and 10 hours at 0.1C discharge at 77° F (25° C). At the end of the discharge part of the cycle — 10 hours — the voltage shouldn't be less than 1 V per cell; carefully note the voltage during the test and do not let it go below that or your cell may go into a reverse charge. By multiplying current by hours when the voltage reaches 1 V per cell, you will arrive at the capacity of the battery. If it's less than about 75% of its rating, start looking for a new battery.

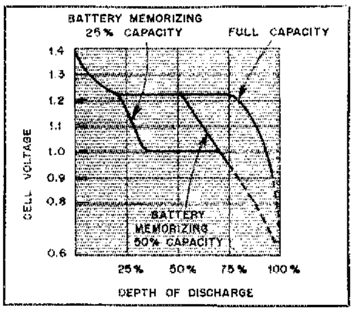

Fig. 2 — This graph shows how capacity in ampere hours is reduced when the memory phenomenon affects the battery. The horizontal axis is also time and current related, indicating that, should memory effect take place, the Ah capacity of the battery is reduced as shown. This happens rarely in Amateur Radio use because we seldom discharge to identical points on any of the curves.

Don't think you can just hang a resistor across the battery to discharge it. If you do, you will note that as the voltage drops near the end of capacity, so does the current. The law states I = E/R — always. Unless you compensate for this, your great experiment will give your incorrect results. How about using a nonlinear resistor like a small lamp? Yes, that's the way it's done.

The Definitive Treatise

The nickel-cadmium battery is a rugged, efficient source of power. If treated according to its rules, not yours, it will provide a long-term bunch of fun as a power supply for your HT. I hope that this article is *the* definitive treatise on NiCads.

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New Books

☐ *DX IS! The Best of the West Coast DX Bulletin,* edited and published by C. Allen, W5DV, and J. Allen, W6OGC, 1200 3rd Ave., Suite 1200, San Diego, CA 92101. Soft cover, 6 × 9 inches, 188 pages, $7.95 + $1.50 shipping. Foreign orders add postage for 1-lb shipping weight.

It has been over two years since the *West Coast DX Bulletin* published its final issue, leaving 3200 subscribers mourning the loss. Originally conceived in 1968 by Hugh Cassidy, WA6AUD, the *WCDXB* was to be limited to a few hundred subscriptions. Despite efforts to limit circulation, the work load became too much for Cass and his wife Virginia to handle. In July 1979, the final issue was mailed, and the labor of love had thus ended. The bulletin left behind an impressive record — over 600 issues to its credit — 11 years of continuous publication without skipping a single issue!

The reason for the *WCDXB's* popularity became obvious to all DXers who glanced at a single issue. The publication provided up-to-date information on which DX stations were active and which ones were to be expected. In addition, the *Bulletin* provided DXers with accurate propagation information and forecasting. In this respect, the *Bulletin* was not much different from others available at the time. It was the truly unique editorial style of Cass that singularly propelled the *Bulletin* to success.

Cass chose to write his editorials in short-story fashion, and included them at the end of each *Bulletin.* Most often, the stories consisted of a dialogue between himself and one of the local QRPers — individuals who worked DX but did not truly understand the art of DXing. It was through these conversations that Cass made his statements about DX issues.

The *Bulletin* left not one stone unturned. It addressed a wide variety of DX controversies including list operations, DXCC rules, bootleg stations and the "woodpecker." Although some of the issues are no longer in debate, most of Cass' editorials posessed a timeless quality, which allows them lasting significance in the world of DXing.

The editors have recognized that many of Cass' stories were DX classics and were much too good to be forgotten. Through the cooperation of Cassidy, Allen and Allen have searched through the entire 11-year run of the *Bulletin,* over 600 issues, and extracted what were thought to be the best editorials. These extractions were organized loosely into chapters, each dealing with a specific topic and *DX IS!* is the result. All of the material in the book, except for the editor's notes, preface and introduction, is presented exactly as it originally appeared in the *WCDXB.*

Veteran DXers will delight in the reminiscence that *DX IS!* will provide. Newcomers who are not familiar with Cass' writings will also benefit from their timeless nature. All readers will certainly appreciate the insight and understanding of DXing and the true-blue DXer that only Cassidy could provide. — *Dennis Lusis, W1LJ*

Build an FM-Receiver Clone

One fm receiver to receive two frequencies simultaneously? Without degradation of performance? Less than $15?

By John M. Gebuhr,* WB0CMC

As with most repeater groups, our needs often exceed our financial resources. We needed a means for linking a satellite receiver with our 2-meter repeater, but the potential expenses boggled the mind: hardline, antenna, transmitter strip, receiver strip and all manner of filtering. I conducted some initial tests by linking our 220-MHz and 2-meter repeaters. A 220-MHz transmitter served as the link between the remote receiver and the repeaters.

This was an economical approach, but the drawbacks far outweighed the savings. Then I had an inspiration: why not use the existing 220-MHz-repeater receiver to receive simultaneously the regular repeater frequency and a second closely spaced link frequency? Would it work? How much would it degrade performance?

Basic Receiver Theory

The rf and first mixer stages have about 20 to 30 dB of gain and a bandwidth of 6 to 9 MHz at 220 MHz (Fig. 1). The 10.7-MHz i-f and second mixer are not as wide, and also have 20 to 30 dB of gain. The 455-kHz i-f has a bandwidth of approximately 20 kHz, largely because of its ceramic filter.

From this it is easy to see that up to the ceramic filter any input signal on 222.34 MHz, or up to 100 kHz either side of it, should appear at the mixer output. In other words, if two or three signals fall simultaneously within the 200-kHz bandwidth they (or their resultants), should all be amplified the same amount and maintain the same frequency spacing and modulation characteristics when they appear at the second-mixer output, provided neither is strong enough to cause the amplifiers to go into limiting. That point is approximately 900 μV for the Clegg FM 76, Midland 13-509 and Cobra 200. What this means is that a signal on 222.28 MHz would produce i-fs of 10.640 MHz and 395 kHz.

It should be easy to build a 395-kHz i-f and detector with audio, squelch and COR circuits. The technical problems were not nearly as great as the logistical ones. Unfortunately, 455-kHz i-f transformers do not operate at 395 kHz without adding extra capacitance (ceramic filters for that frequency do not seem to exist).

By changing the crystal in the second LO from 10.245 MHz to 11.155 MHz, 222.34 MHz still produces 10.7 MHz, which results in 455 kHz, *but* 222.28 MHz now yields 515 kHz. All of the 455-kHz transformers I tried would tune slightly above this with no modification. (The lowest tuned to 525 kHz.)

Perhaps the most difficult thing was the method of coupling the 515-kHz signal out of the mixer. The best way was to cut the collector lead and put the primary of a (now) 515-kHz i-f transformer in series (see Fig. 2). Two i-f transformers must be used at this point to give a narrow enough bandwidth. They can be selected to give a turns ratio step-up. The two used in the amplifier should also be selected for this characteristic. They can be removed from discarded a-m transistor radios and should be the type with yellow or white

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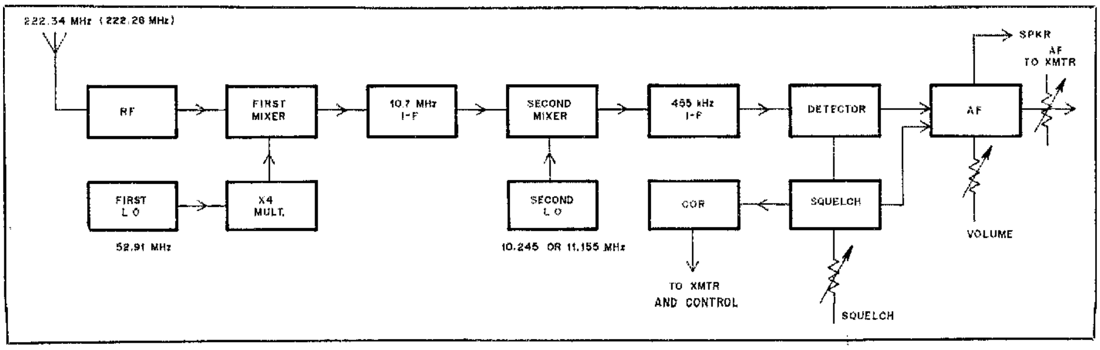


Fig. 1 — Block diagram of basic fm receiver. See text for discussion.

cores. By selecting two that give an overall step-up ratio, several decibels of noise-free gain can be had. They should both be located as close to the mixer as possible.

Next, the I-F

The heart of the i-f is an RCA or National CA3089E, which has a three-section, 90 dB i-f amplifier with agc, afc, squelch, metering and audio outputs. It is driven by a single transistor i-f amplifier which provides the additional gain necessary for the desired sensitivity (Fig. 3).

The detector on the CA3089 is a quadrature type. Board layout, particularly at this range of frequencies, is of the *utmost importance*. The one in Fig. 4 is very stable. All polarized capacitors associated with the CA3089 must be tantalum types with the shortest possible leads. This IC has about 100 dB of gain in a 3/4-inch space; therefore, short leads on all components connected to it are mandatory or severe oscillation may result. The on-board squelch seems to be a bit "squirrely" so the actual squelch voltage comes from the meter output (pin B). It is also available at the top end of a 2.7-kΩ resistor used as a test point (T.P.) for signal strength. The agc and afc outputs are not used. The agc is bypassed and terminated in a 22-kΩ resistor. If it isn't bypassed and terminated, lower gain results.

The 1-μF bypass capacitor on pin 13 (metering) may be larger if desired; it is required to keep the gain of the IC at maximum. This pin-13 voltage is also applied to the base of the dc-amplifier transistor, Q2, which controls the COR and squelch. When the voltage at pin 13 reaches 0.6 to 0.7 V, Q2 turns on, removing voltage from pin 5 (squelch) and triggering the 555, Q3 and the PTT line to unsquelch the audio. As long as Q2 is turned on, it keeps the supply for the timing capacitor low. When the metering voltage drops below 0.6 to 0.7 V, Q2 shuts off, allowing the timing capacitor to charge. Then the 555 times out, releasing the PTT line. This also drives pin 5 high,

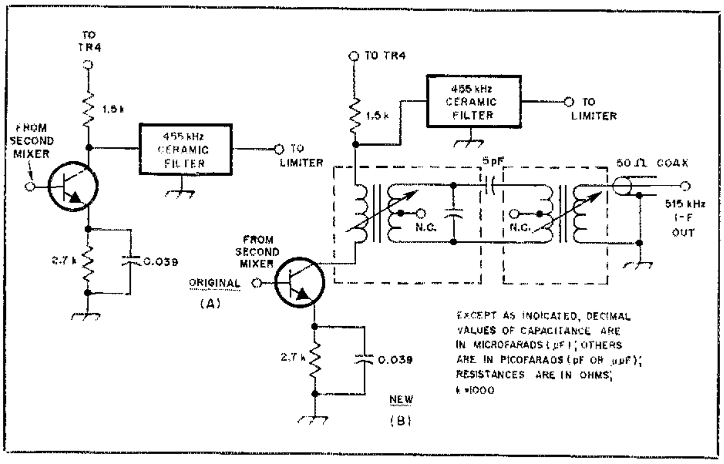


Fig. 2 — At A, the second mixer as originally configured in the repeater receiver. At B, the new version of the second mixer with outputs to both second i-fs.

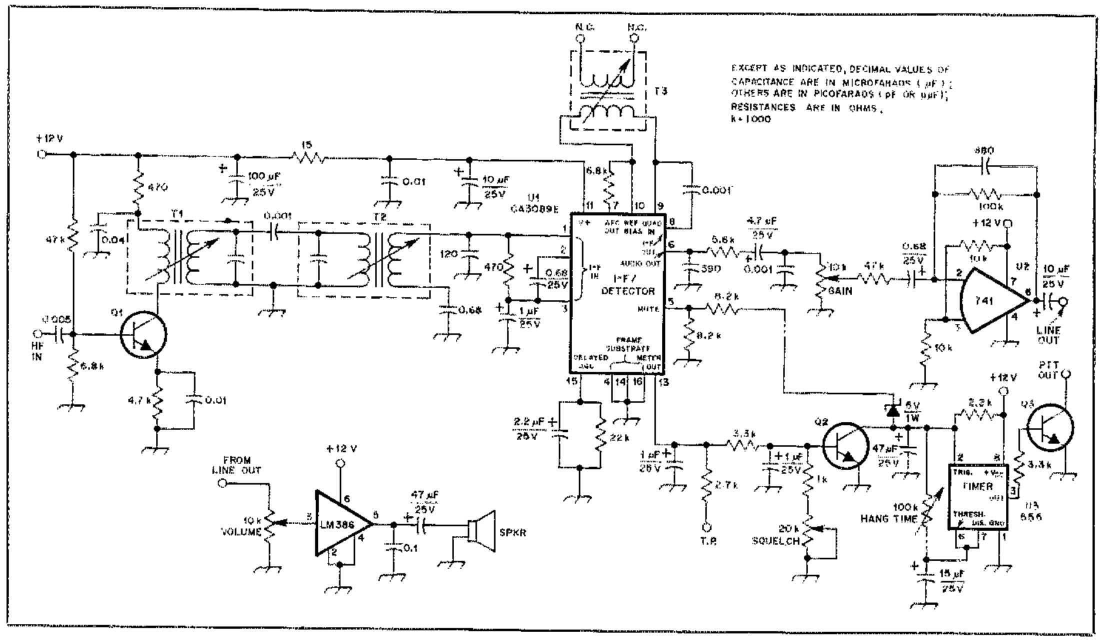


Fig. 3 — Schematic diagram of the additional second i-f and audio circuits. All capacitors are disc ceramic, except those with polarity markings, which are tantalums. Fixed-value resistors are 1/4-watt carbon composition types. Variable resistors are linear-taper composition controls.

Q1-Q3 — Silicon npn switching bipolar transistor 500 mW, 2N2222 or equiv.
T1-T3 — 455-kHz i-f transformers (see text).
U1 — Monolithic i-f/detector IC, CA3089 or equiv.
U2 — Operational amplifier IC, 500 mW, type 741 or equiv.
U3 — Timer IC, type 555 or equiv.
U4 — Low voltage audio power amplifier IC, type 386 or equiv.

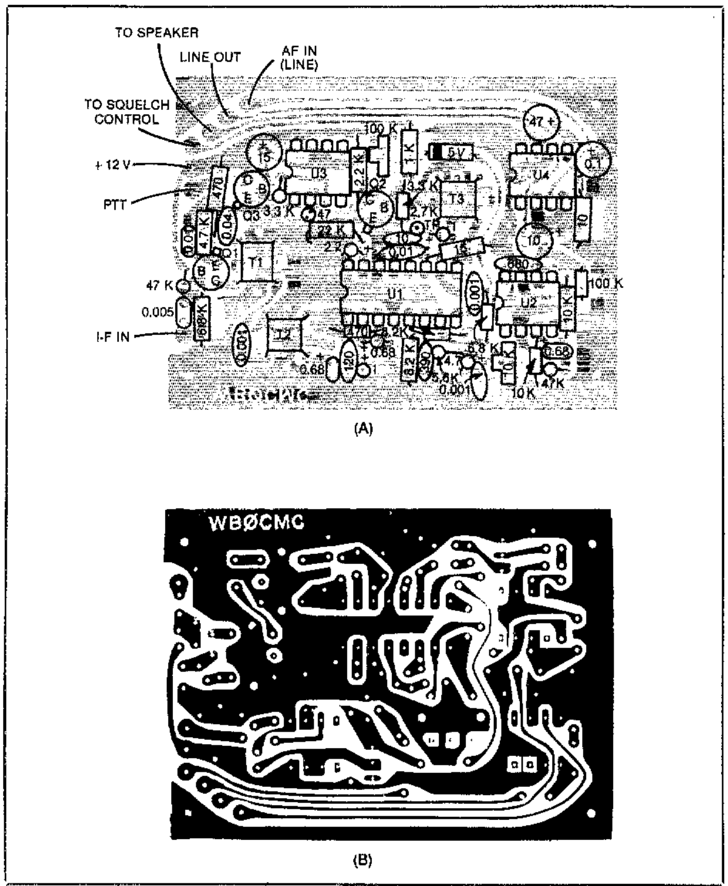


Fig. 4 — (A) Parts-placement guide for the receiver clone i-f and audio board. Components are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern. (B) Etching pattern for the receiver clone. Black represents copper; the pattern is shown at actual size from the foil side of the board.

squelching the audio. The T.P. (2.7-kΩ resistor near pin 13) may be used to tune all i-f transformers for a peak, except the one used as a quadrature coil. The RC network between pins 2 and 6 on the 555 determines the hang time for the PTT line (see Fig. 3).

The RC network from pin 6 of the CA3089 is for deemphasis and dc blocking prior to the audio gain control. The LM741 is used as a line driver and preamplifier. The 680-pF capacitor between pins 2 and 6 determines its upper frequency response. It is capable of driving the inputs of most repeaters. The LM386 is a speaker amplifier. It is nonessential to the operation of the rest of the circuit and may be deleted if desired.

Measurements taken on the overall system showed no measurable change in the original receiver: 0.25 microvolt for 20 dB of quieting, and ± 12-kHz bandwidth. Our primary receive frequency of 222.34 MHz had suffered no degradation whatsoever. Next, testing on 228.28 MHz showed 0.25 microvolt for 20 dB of quieting, but because LC filters were used the bandwidth was wider. This results in better fidelity but degraded adjacent-channel rejection. I boosted the 222.28-MHz signal to 1000 microvolts; the 222.34-MHz receiver did not suffer degradation. Again, because of the shape factor of the LC i-f, a 300-microvolt signal on 222.34 MHz begins to affect the new receiver circuit performance. The closer the carrier moves to 222.28 MHz, the lower the level required to disrupt performance: 120 μV at 222.33 MHz, 90 μV at 222.32 MHz, 50 μV at 222.31 MHz, 20 μV at 222.30 MHz and 10 μV at 222.29 MHz. I plotted a similar curve below 222.28 MHz; it was nearly a mirror image of the above measurement results. With a signal on 222.34 MHz at 0.15 μV (near squelch threshold), it takes 900 μV simultaneously on 222.28 MHz to degrade this. With 0.15 μV on 222.28 MHz it takes 900 μV on 222.34 MHz to degrade the 222.28 MHz receiver. Not bad for scavenged parts and spare time! If another pair of i-f transformers were used, the bandwidth should improve further. They were not needed for my purpose. This system allows the use of the same duplexer, feed line and antenna as the main repeater, with no tuning changes.

Alignment is Simple

Attach the probes of a voltmeter (2.5-V scale) to the test point and ground. Inject a signal into the receiver input on the desired frequency and at a level sufficient to see the meter deflect. Tune each i-f coil for maximum (except the quadrature coil). Set the af Trimpot to midrange. Remove input signal to receiver and tune the quadrature coil (T3) for maximum noise (coarse adjustment). The squelch may need to be disabled for this by grounding pin 5 on the CA3089. With a modulated signal applied to the antenna input, the quadrature coil may be adjusted for the best symmetrical sine wave at the audio output. An audio-distortion analyzer will allow fine tuning. The ear or oscilloscope is adequate as a tuning indicator in most cases. The only thing left is to set the gain where desired and the hang-time potentiometer for the desired delay.

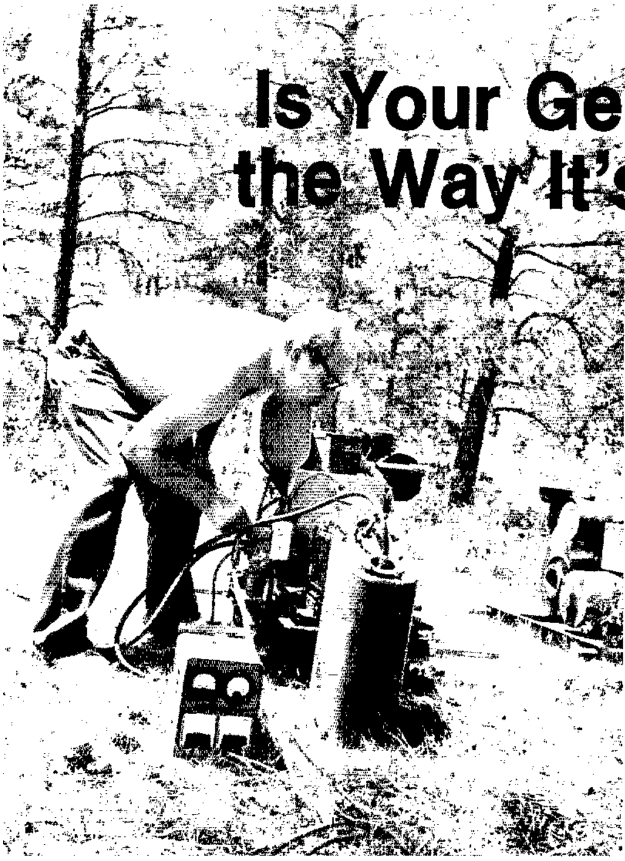
Additional Notes

If you are troubled by power-line noise, pin 13 or the T.P. may be used as a deemphasized a-m output for verification. This is useful data when you are asking the local power company for help in tracking down the noise. My total cash layout was about $10.

I have just obtained a 500-kHz ceramic filter, which greatly improves adjacent-channel and bandwidth performance. It is a TAF-01C made by Vernitron Piezoelectric Division, 232 Forbes Rd., Bedford, OH 44146. The 3-dB bandwidth is 12 kHz and the 30-dB bandwidth is 40 kHz. The skirts are ideal but the bandwidth is a bit narrow for ± 5-kHz deviation, which requires 16 to 18 kHz for good audio quality. As a result I have narrowed the deviation of the link transmitter to about 2.7 kHz (equivalent to the 12-kHz bandwidth) and changed the carrier to 222.95 MHz, retuning the four i-f transformers to 500 kHz. This results in good audio quality, the same sensitivity, but a 6 dB S/N degradation caused by the lower modulation. The overall system is still better than with only the LC transformers. Filter cost is $17.95 at the 100-lot level.

It may be true that "there ain't no free lunches," but the receiver clone would certainly qualify as a "deep discount lunch." If your needs are similar, and if the receiver frequencies are close enough, why not try this system. The performance is excellent and the cost is low. What have you to lose?

Is Your Generator "Genin" the Way It's Supposed To?



Worried about equipment damage from a malfunctioning generator on Field Day? This test circuit will lay your fears to rest.

By Wayne Stump,* WB4AHZ

On Field Day I take along a generator test box that I've had for several years. It has a voltmeter and a vibrating reed frequency meter. The frequency meter is built in a panel-meter type of case with a rectangular window through which you can see the ends of several resonant reeds. A coil surrounds the reed assembly; when ac is connected to the coil, the reed that is resonant for that frequency will vibrate. Vibrating-reed frequency meters are scarce and expensive, but there are other ways to check generator frequency.

Frequency Indicators

One safe way is to connect two 117- to 6-V transformers and a 12-V lamp, as in Fig. 1. Plug one transformer into the generator and the other into the wall socket. You now have a beat indicator with isolation between the two sources of power. If the lamp blinks twice a second there is a two-Hz difference between the generator and commercial power. This will not tell you if it is 58 or 62 Hz, so tweak the governor adjustment and see if the situation gets better or worse.

If you don't have commercial power to use as a standard, you still can check your generator. Plug an electric clock, with a large second hand, into the generator. Compare the clock second hand with that of a watch of known accuracy. If the electric clock is running fast, the generator is running fast. Slow down the engine a little and give the situation another look.

Fig. 2 is the schematic diagram of a frequency indicator that is easy to build. It isn't very expensive, and is accurate enough for Amateur Radio use. The output of U2, at pin1, is a 60-Hz square wave that turns Q1 on and off. The output of the generator goes through T1 and D1 to supply a half wave rectified voltage to DS1. When the voltages coming from U2 and D1 are in phase, DS1 will light at full brilliance; as the phase changes, DS1 will dim. When the voltages are 180° out of phase, DS1 will not light.

Adjustments

The only adjustment in this unit is the oscillator frequency. The best way is to connect the vertical input of an oscilloscope to pin 1 of U2. Turn the horizontal switch to LINE. Now turn C3 very slowly until the Lissajous figure stands still. If you don't have a scope, the best thing to do is plug the tester into a source of commercial power and adjust C3 for the longest time interval between blinks of DS1.

The tester is built in a 3 × 4 × 5-inch (75 × 100 × 125-mm) aluminum box. T1 and DS1 are mounted to the box; everything else is on a piece of perf board. Parts layout and wiring are not critical.

When working on a generator it is best to load it at one-half to three-quarters of rated output. A bank of lamps is a good load for a small generator, and heating elements are suitable for large generators. It is not wise to use your rig as a load because accidents do happen! If you were to sneeze while working on the governor adjustment, you could pull the throttle valve open and make the engine race: The generator could put out a couple hundred volts for a second or so! It's a lot easier

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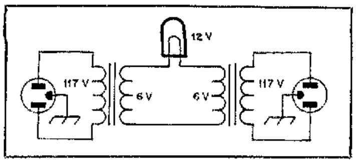

Fig. 1 — Simple circuit for checking the frequency of a generator using commercial power mains as the standard. The two transformers are small filament types, such as Radio Shack 273-1384. The lamp is a 12-V type, Radio Shack 272-1143 suitable.

and cheaper to replace a couple of 117-V lamps than to replace electronic components.

A generator operating at the right frequency provides a safe form of emergency ac power. Power sources providing frequencies other than 60 Hz can damage electronic equipment. If you want to play it safe on Field Day, check your frequency!

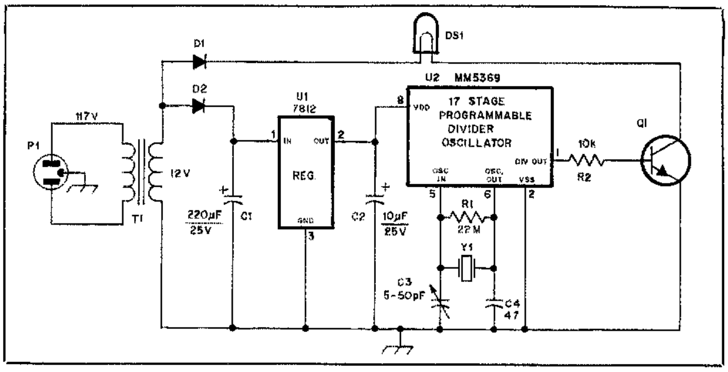

Fig. 2 — Schematic diagram of circuit for checking the frequency of a generator when commercial standards are not available for comparison.

D1, D2 — Silicon power diode, 1 A/100 PIV, type 1N4000.
DS1 — Incandescent lamp, 12 V, 250 mA, Radio Shack 272-1137 or similar.
Q1 — Silicon npn power-switching transistor, 500 mW, 2N2222 or equiv.
T1 — Power transformer, primary 117 V, secondary 12.6 V/1 A, Radio Shack 273-1505 or similar.
U1 — Monolithic three-terminal voltage-regulator IC, 5 V/ 1 A, type 7805 or equiv.
U2 — 17-stage programmable divider oscillator IC, type MM5369 or equiv.
Y1 — 3.579-MHz color-burst crystal, Radio Shack 272-1310 or equiv.

Strays

TA PROFILES

☐ We are pleased to introduce our first (and only, at this time) Canadian ARRL Technical Advisor, John S. Belrose, VE2CV. His advisory services as an antenna expert (and author of numerous *QST* articles) are appreciated.

Jack has been a licensed radio amateur for more than 30 years. Although his main interests in Amateur Radio are antennas, modeled antennas and deployment at full scale (for use on Field Days and for communication on trips), Jack is also concerned, both from Amateur Radio and work-related points of view, with practical aspects of hf, vhf and uhf communications. His particular interest is in automation (such as radio-to-telephone interconnect) to improve circuit reliability and availability. One project he is currently interested in is amplitude companded sideband (ACSB), which could provide a significant improvement in spectrum utilization in the vhf/uhf land-mobile bands. For the amateur, ACSB offers a decided decrease in battery drain and hence longer life between charges for hand-helds, as well as increased range over fm.

Residing in Aylmer, Quebec, Jack is a research scientist and director of Canada's Radio Communications Laboratory, Department of Communications, Ottawa, Ontario. He received his BASc and MASc degrees in Electrical Engineering from the University of British Columbia, and his PhD degree in Radio Physics from Cambridge University, Cambridge, UK. Jack has spent most of his research career studying low-frequency propagation, and by various techniques the media in which these radio waves propagate. His keen interest is in antennas, however, particularly electrically short antennas, vertical antennas and wire antennas of various types. His article on short center-loaded whips (*QST,* September 1953) was one of the first theoretical analyses of this antenna.

TA John Belrose, VE2CV

Most of Jack's leisure time is spent in writing antenna articles. However, he does find time to enjoy travel-camping, swimming and walking his Irish setter. — *Marian Anderson, WB1FSB*

DIRECT-BROADCAST SATELLITE TALK ON TECHNICAL NETWORK

☐ Another in the series of monthly experimental programs linking the NY-NJ-CT metropolitan area on 2-meter fm is scheduled for March 3 at 8:30 P.M. Wilbur L. Pritchard, president of Direct Broadcast Satellite Corp., of Bethesda, Maryland, will address the Long Island section meeting of IEEE from Old Westbury, New York. His talk will be broadcast simultaneously on the IEEE/LIMARC Technical Network on 147.375 MHz, thereby covering the entire New York City metropolitan area. The first net session, in November, drew more than 40 check-ins for a talk on satellite earth terminals.

For additional information, contact Ed Piller, W2KQP, net director, at 516-349-2530.

BEGINNER'S BENCH

Some Basics for Equipment Servicing

Part 4 — Knowing how to use the oscilloscope effectively as a troubleshooting tool will move you to the front of the equipment servicing class.

By Norman H. Bradshaw,* W8EEF

The two most useful instruments for troubleshooting ham gear are the VTVM (vacuum-tube voltmeter) or FET voltmeter, and the oscilloscope. Of the two, the voltmeter is probably number one, with the scope a close second. Normally, the voltmeter is used to ensure that the operating voltages are correct. If you are unable to detect a malfunctioning component from the voltage tests, the oscilloscope is used to trace a signal from the input to the output of each stage or module, thus locating the problem area.

Oscilloscope Fundamentals

Before using your oscilloscope for equipment servicing, you should be familiar with some fundamentals. A block diagram of a typical oscilloscope is shown in Fig. 1. This scope has two vertical-input channels and is commonly called a dual-trace scope. Each channel operates separately, allowing you to observe two signals at the same time. You can use channel 1 for checking the input signal of the stage under test while displaying the output signal by using channel 2. Either channel may be used as the trigger source to control the horizontal timebase. This trigger signal is used to lock the horizontal system to the vertical signal so that the trace on the screen of the cathode-ray tube (CRT) is stable.

The horizontal timebase is a calibrated sweep system that moves the electron beam across the CRT at a precise rate. This rate is selected by changing the setting of the time-base switch.

The vertical input signal is scaled by the vertical attenuator to limit the input to the preamplifier. This attenuator is necessary to keep the preamp from being overdriven and to limit the size of the trace on the CRT. A front-panel-controlled diode switch and display control section allows you to select either or both of the input channels. The vertical signal then passes through the delay line. A delay line is a very valuable feature because it allows the horizontal sweep, initiated by the vertical trigger pulse, to start before the vertical signal information arrives at the CRT. This enables you to view the leading edge of the signal. Delay lines vary in delay time from one manufacturer to another and can range from 50 or 60 nanoseconds up to 150 or 200 nanoseconds (1 nanosecond is 10^{-9} seconds). The longer the delay, the more of the signal leading edge you can observe. After passing through the delay line, the signal is amplified in the vertical deflection amplifier and then applied to the vertical deflection plates of the CRT.

Now on to the horizontal system. A triggered sweep is much more desirable than the older, recurrent system. In the recurrent, or free-running sweep, the horizontal circuit had to be adjusted to run at (or at a submultiple of) the vertical-signal frequency in order to lock the trace on the CRT. The triggered sweep system is controlled by a sample of the vertical signal, using special circuits to start the horizontal sweep in synchronization with the vertical signal. Today, most oscilloscopes use this system.

Accurate timebase calibration is

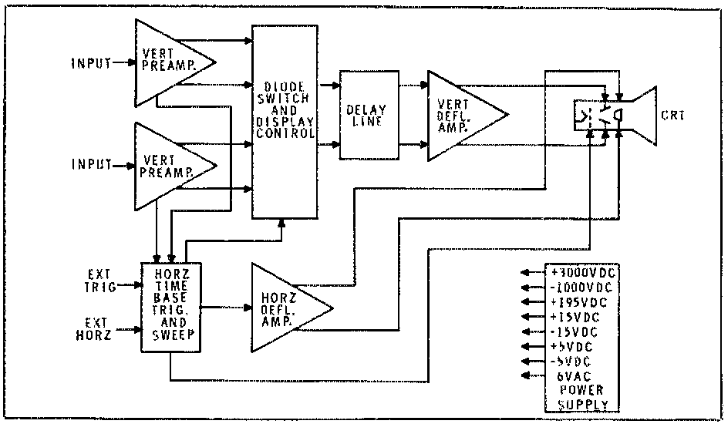

Fig. 1 — Block diagram of a dual-trace oscilloscope.

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necessary if you intend to use the scope for frequency measurements. If you have the timebase switch set for, say, 1 ms/cm, you need to be certain that the sweep is really moving at that rate. Frequency is the reciprocal of time ($f = 1/t$); if your sweep speed is 1 μs/cm and one cycle of the signal waveform occupies 1 cm on the CRT, the frequency is

$$f = 1/10^{-6}\,s = 1 \times 10^6 \text{ Hz or } 1 \text{ MHz}$$

Being able to determine the frequency of the signal you are viewing is very useful during troubleshooting.

Selecting an Oscilloscope

There are many considerations involved in the selection of a new or used oscilloscope, including:

1) Vertical sensitivity.
2) Bandwidth.
3) Single- or dual-trace capability.
4) Accuracy.

The sensitivity of the vertical amplifier determines the minimum signal amplitude that can be measured. For example, with a 1-mV/cm preamp and a 10 × probe, only a 10-mV signal is required to produce a 1-cm screen deflection. However, with a 5-mV/cm preamp, a 50-mV signal would be required.

A major consideration is the bandwidth of the oscilloscope. You should buy a scope with as wide a bandwidth as you can afford. Limited bandwidth will reduce your ability to check accurately for harmonics and spurious oscillations. An older scope with a wide bandwidth, in good condition, is a better buy than a new one with a limited response. Regardless of the type of scope you chose, a flat response from dc to the −3 dB bandwidth limit of the scope is important.

You should also consider a scope with dual-trace capability. It is more versatile than a single-trace unit because you can simultaneously view both the input and output signals of a stage to determine gain and phase shift. (See Fig. 2)

Finally, the accuracy of the oscilloscope measurements is important. The vertical attenuators in most scopes have an accuracy specification of 3%. Some are worse, but few are better than that. To meet this specification, most scopes contain some type of calibration signal. This signal is used when adjusting the preamp gain; therefore, the accuracy of your measurements will depend on the accuracy of the calibration signal.

High quality oscilloscopes can be obtained new, used or in kit form. Heath Company has a good selection ranging in bandwidth from 5 to 35 MHz. Most of the displays shown in this article were made using a Heath IO/SO 4510 scope. This is a dual-trace unit with a bandwidth of 15 MHz. It does not have a dual timebase. For comparison, the display shown in Fig. 6 was made using a Tektronix 7704 main frame with 7A26, 7B80 and 7B85 plug-ins. The Tektronix is a very high quality oscilloscope with a bandwidth of over 100 MHz.

Transceiver Troubleshooting with Your Scope

Before using the oscilloscope, be sure you have isolated the problem as much as possible by using the troubleshooting charts supplied with the service manual (a typical troubleshooting chart is shown below). Are the power supplies operating properly? Does the receiver section work? Or, are the transmitter and receiver sections both dead? If both are inoperative, check the circuits common to both

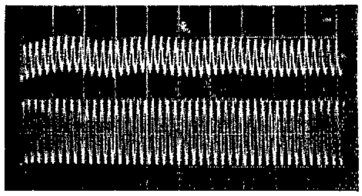


Fig. 2 — A dual-trace oscilloscope allows you to view two signals at the same time. The upper trace shown here is the i-f input signal to a receiver mixer (10 mV/div). The lower trace is the local oscillator input to the same mixer (1 V/div). With all commonly available dual-trace scopes the sweep rate is the same for both traces; in this display the sweep rate is 0.2 μs/div.

TRANSMITTER

Problem	Condition	Probable Cause(s)
(1) No power output	(a) IC OK, but no power output	* Defective L_1, L_2, L_9 * Shorted VC_1, VC_2 Defective C_{66} * Low bands only: Defective $C_5 - C_8$ * Defective RL_2
	(b) IC OK, but no output on a particular band	* Cold solder joint between band switch and tank coil * Defective band switch
	(c) No IC indication	* Defective 6146B * ACC plug not correctly wired or improperly seated * No screen voltage at 6146B because of defective L_{1804}, band switch
	(d) Idling IC OK, but no drive	* Defective 12BY7A * No screen voltage because of defective R_{1603}, C_{1009}, $R_{1007} - R_{1009}$ * Defective Q_{105}, Q_{106} or Q_{405}
(2) Poor TX	(a) No power output on LSB only	* Defective X_{502}
	(b) No power output on USB only	* Defective X_{503}
	(c) No power output on both USB/LSB	* Defective RL_{501}, Q_{502}, D_{2402} * No vox operation: defective or grounded MIC or PATCH jack * Defective Q_{503}, Q_{504} or Q_{512}
	(d) No power output on CW/TUNE	* Defective X_{504}, Q_{401}, D_{2402}
	(e) No CW keying	* Defective mode switch, Q_{1001}, and associated circuit * Defective D_{506} if carrier hangs up
	(f) No modulation on AM	* Defective $Q_{2401} - Q_{2407}$, D_{2401}, X_{2401}
(3) Abnormal meter	(a) Cannot set ALC meter	* Defective C_{1016} * Defective Q_{405}, VR_{401} * Defective meter switch or RL_1

This section of the FT-101ZD troubleshooting chart is typical of that found in the better service manuals available for amateur transceivers.

transmit and receive. The i-f system is common to both, so activate the internal crystal calibrator (or use a crystal oscillator if the transceiver is not equipped with a calibrator) and tune the receiver to a point near one of the 100-kHz or 25-kHz divisions on the dial. Usually the calibrator is inserted at, or near, the antenna input. The calibrator is designed to have an output signal rich in harmonics, so do not expect to see a pure sine wave on your oscilloscope. Fig. 3 shows the scope display of the calibrator signal in a typical amateur transceiver. Using the scope, trace the signal through the receiver rf amplifier to the mixer circuit. Then check to see if the VFO (variable-frequency oscillator) is working and a good signal is being injected into the mixer (the VFO is also common to both receive and transmit). The VFO waveform normally appears as a sine wave, as shown in Fig. 4. The output of the mixer will be at the i-f of the receiver (Fig. 5).

To prevent loading or detuning, a 10:1 scope probe is almost a *must* when signal tracing in rf and i-f circuits. This probe must be adjusted to the vertical input channel it is to be used with. A fast rise, 1 kHz square-wave signal is normally used when making this adjustment. With the square-wave signal applied, the probe is adjusted to display the best waveform (sharp corners, with no over- or undershoot). This is shown in Fig. 6. If a calibrator signal is not provided on the oscilloscope, the square-wave output of a function generator can be used for this adjustment.

After you have found the circuit where the signal goes in, but nothing comes out, use your high-impedance (10 megohm or greater) voltmeter to check the voltages on the transistor leads. There are times when voltage measurements will not prove a transistor is bad, so you may have to turn the rig off and use an in-circuit transistor tester. Under certain conditions, an in-circuit transistor tester will give an erroneous reading, perhaps showing a short when the transistor is, in fact, good. This may occur when there is a diode, a very low value resistor, or another direct-coupled transistor in the circuit. Unfortunately, the only way to be sure is to unsolder the base lead from the circuit board and recheck the transistor. The base lead is the only one that has to be disconnected, as it is the control element of the transistor. Also be sure that the polarity switch on the tester is in the correct position. Checking a pnp transistor with the tester in the npn position will show an open every time, as the transistor junctions will be reverse biased.

With equipment containing tubes, the first step after locating the defective stage is to change the tube. If this does not cure the problem, check the voltages at the tube socket. Be sure to check the voltage on the screen grid, if the tube has one. Without screen voltage, the tube will not conduct.

If the VFO and mixer circuits are operating properly, continue tracing the signal back through the unit to the i-f stages. Check crystal oscillators, mixers, buffer amplifiers and filters (ssb and cw) to be sure they are working. Remember, the malfunction almost has to be in the i-f section if both the transmitter and receiver are inoperative (assuming that the power supplies are working).

You may wish to try a troubleshooting technique that I have used for many years. When I find a circuit that is operating properly, I move back through the circuit four or more stages. If that stage is not operating, I move ahead two stages and test again. You can cut the number of tests needed in half by using this procedure.

Suppose the transmitter is working and loads up properly into your dummy load, but no sound is heard from the speaker during receive. The first item you should check is the speaker. Disconnect it from the rig and use an ohmmeter to test for continuity. If it is okay, and your S meter indicates a signal, the problem is most likely to be in the audio amplifier. Fig. 7 shows the oscilloscope display of the audio signal at the demodulator output. As there are only two or three stages in the audio section, the problem should be easy to locate. A reading on the S meter is a good indication that the circuits from the antenna through the i-f stages are operating.

Because the carrier signal is present, transmitter problems are often easiest to locate when the rig is in the cw (or tune) mode. This also eliminates the problem of having to connect an audio signal generator to the microphone input. Of course, if the rig works on cw but not on phone, the problem must be in either the VOX (voice-operated switching) or microphone amplifier, which means your search

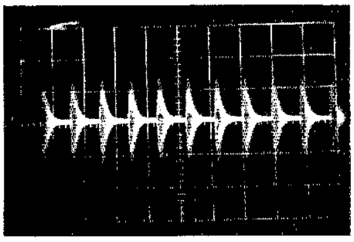


Fig. 3 — Oscilloscope display of the calibrator signal in an amateur transceiver. The calibrator signal is a useful signal source during signal tracing. Each horizontal division represents 20 μs (20 μs/div) and the vertical divisions are 100 mV (100 mV/div).

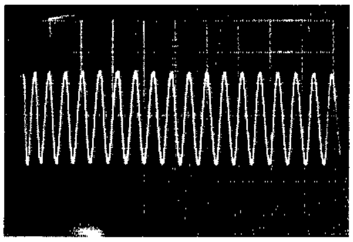


Fig. 4 — The VFO signal should appear as a sine wave. Shown here is the VFO input signal at the first mixer of an FT-101ZD. Oscilloscope sensitivity is 50 mV/div and the sweep rate is 0.1 μs/div.

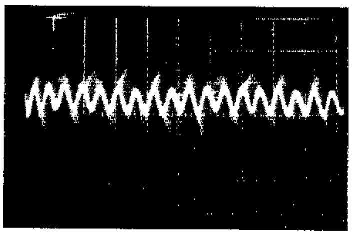


Fig. 5 — Using the calibrator as a signal source, the output of the receiver mixer appears as shown here. (10 mV/div and 0.1 μs/div). Traces of the calibrator signal can be seen "riding" on the mixer output signal. While normal for this rig, this may not occur in other equipment.

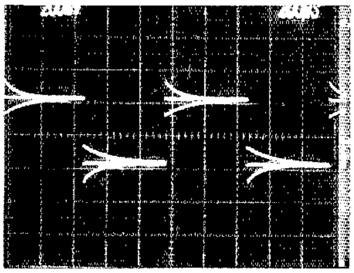


Fig. 6 — High-impedance, or 10:1, probes must be adjusted for the vertical input channel they are used with. The display shown here is a triple exposure. The upper and lower traces show over and under compensation, respectively. The center trace is the correct waveform. This display was made using the Tektronix 7704 oscilloscope.

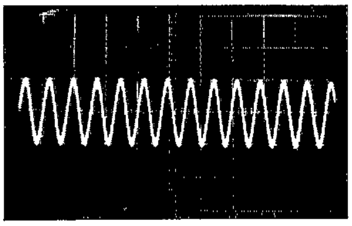


Fig. 7 — The audio output of the receiver demodulator should appear as shown here (50 mV/div and 20 ms/div).

has been narrowed to a couple of stages. Remember, the microphone could be bad! If you have a hybrid transceiver, one with vacuum tube driver and "finals," make sure that the filaments are lit. Also make sure that all voltages in these areas are correct.

Be careful — working near high voltages is dangerous! Look at the rf choke in the final amplifier plate circuit to see if it is damaged. A shorted final or loss of grid bias can overload the choke, causing an open circuit. If you are unable to detect any damage visually, shut the rig down, wait a few minutes for the power supplies to bleed off, and then check the choke with an ohmmeter. If the choke is okay, turn the rig on and check the final-stage screen voltage. Without screen voltage you will have little or no output.

Because of the high dc voltage, direct connection to the driver plate circuit could damage the probe or the oscilloscope. Placing a 10× probe *near* the driver tube plate tank circuit (or near the glass tube envelope) will give a good indication of rf on the scope if the stage is functioning properly. The display shown in Fig. 8 was obtained in this manner. Transistor drivers and final stages are current-operated devices, so you can usually probe these stages without fear of damage to the scope or probe.

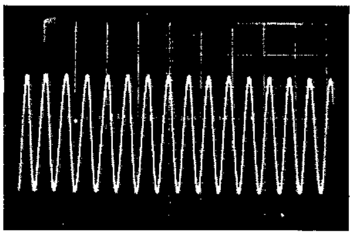


Fig. 8 — This display was obtained by placing a 10:1 probe *near* the glass envelope of a 12BY7A driver tube while the transmitter was being operated into a dummy load. The power output was adjusted to 50 W. A fairly high scope sensitivity (0.2 mV/div) was used with a sweep rate of 0.2 μs/div.

Suggestions

You will need the service manual for your rig if you are serious about doing your own repair work. Most manuals contain block diagrams showing the transmit and receive signal paths through the unit. These allow you to see the overall signal flow and are very helpful during signal tracing (see Fig. 9). The manual will also include a detailed description of each circuit, and most will provide a troubleshooting chart to help you isolate a problem in minimum time. There will be times when your particular symptom does not appear to be covered in the chart; this is when your scope and voltmeter become most valuable in tracking down the problem.

If you do not already have them, extender boards and/or cables are a good investment. With them you can get the suspected circuit out where you can work on it. It is almost impossible to troubleshoot modern transceivers with all the circuit boards in place. When inserting or removing boards, be sure the power to the rig has been turned off. You may end up with more trouble than you started with if you don't!

A very serious suggestion — if you want to realign your transceiver, be *sure* your equipment is adequate for the job. The signal generator used should be of "lab quality" frequency accuracy. It should also be "rf tight." That is, there should be no signal leakage from the box except for the signal coming from the output connector. The generator should also have an accurately calibrated attenuator. Several

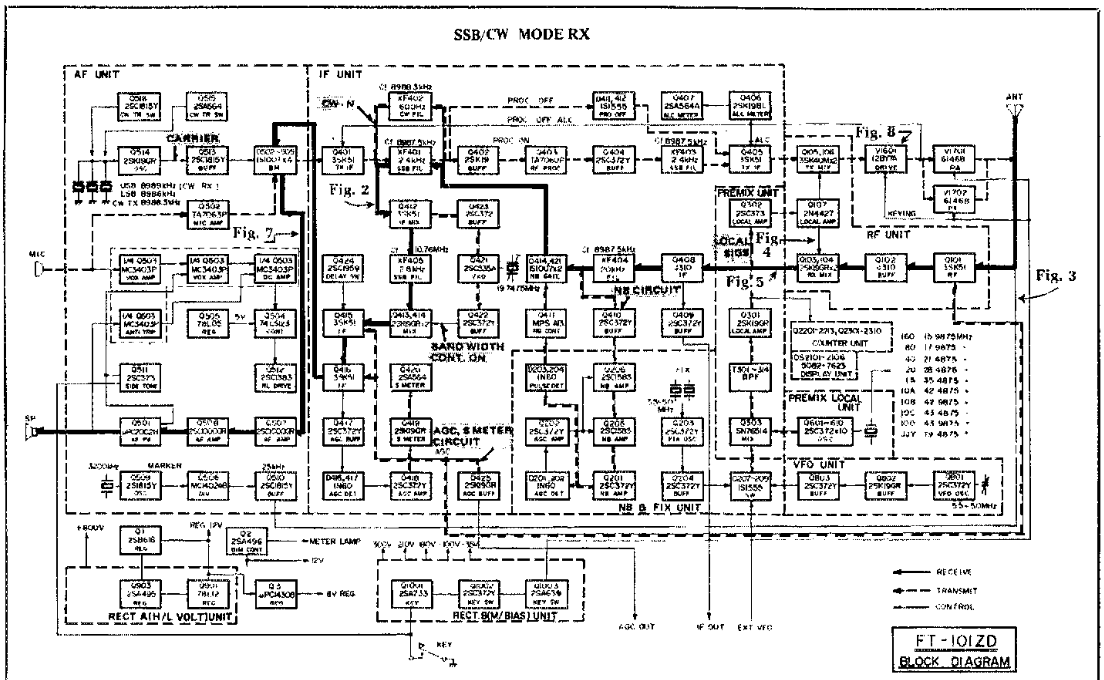


Fig. 9 — The block diagram of the FT-101ZD transceiver. It is representative of those found in most service manuals. The figure numbers shown on the diagram indicate the points at which some of the oscilloscope displays were made.

Glossary of Terms

Bandwidth — The range of signal frequencies that can be displayed with a specified accuracy. Typically, the frequency at which the scope response is 3 dB less then the response to a low-frequency signal of the same amplitude is considered to be the upper bandwidth limit. Most scopes respond to dc signals; thus, the lower bandwidth limit is dc (or 0 Hz).

Delay Line — An electrical circuit through which the passage of a signal is delayed by a fixed length of time.

Diode Switch — A circuit in which diodes are used to select a particular signal path. These electronic switches are controlled by dc voltage levels and are capable of rapid switching.

Dual-trace — The capability of simultaneously displaying two signals. Normally, two identical vertical amplifiers are provided. Electronic switching is used to select the vertical amplifier output to be displayed.

Horizontal sweep/timebase — Movement of the electron beam (and visible spot) across the cathode-ray-tube face in a uniform, horizontal motion. The horizontal timebase is the circuitry used to produce this motion.

Horizontal sweep-rate — The rate, in seconds per cm or division, at which the horizontal sweep occurs.

Probe, 10× or 10:1 — An oscilloscope probe that attenuates the signal applied to the vertical input by a factor of 10. In addition to reducing the signal amplitude, a 10× probe also provides a higher input impedance (typically 10 MΩ).

Probe compensation — 10× scope probes contain an adjustable frequency-compensating circuit to ensure a constant attenuation factor over the frequency range of the probe.

Rise time — The length of time required for a signal to increase in amplitude from a low level (10% of the maximum amplitude) to a high level (90% of maximum).

Triggered sweep — A triggered sweep system uses a trigger signal to begin the horizontal sweep, thus synchronizing the sweep and the trigger signal. The trigger signal is normally derived from the vertical input signal.

X-Y display — The display of two signals, one producing vertical deflection in the normal manner, while the second signal is applied to the horizontal-deflection input. No horizontal sweep is required for this type of display. An X-Y display allows two signals to be compared in terms of amplitude, frequency and phase.

other pieces of equipment, such as an rf voltmeter, scope, dummy load and an accurate power meter, are almost necessities if you are to do a good job. Trying to do the alignment with mediocre equipment can result in a rig so badly misadjusted that it has to be returned to the service center for calibration. So beware before you start turning adjustment screws! This also applies during troubleshooting; don't change adjustments if the rig is not working. 99.9% of the time the problem is a bad component and not incorrect adjustment.

Final Notes

A systematic approach to troubleshooting will minimize the time necessary to repair your equipment:

1) Observe the symptoms.

2) Remove the covers and use your eyes and *nose* to locate the problem area before turning the rig on.

3) Check the symptoms and probable causes in the troubleshooting charts contained in your service manual.

4) Measure the power supply voltages to be sure they are all within tolerance.

5) Follow the signal-tracing procedures outlined in this article.

6) Safety first — exercise caution whenever you must troubleshoot circuits with the power applied.

Here is to successful troubleshooting. May your rig last forever and you never need to repair it! But, if you do, I hope this article will get you started in the right direction.

Acknowledgments

I wish to express my sincere thanks to Heath Company and to Yaesu Electronics Corp. for their permission to use material from their service manuals.

Strays

MIXED-BAND DXCC WITH 2 WATTS

☐ Achievement, in whatever form, suits amateurs. That's the real "bottom line" for our interesting pastime. For some, this comes when designing equipment, earning a top score in contests or having the loudest signal in town. For others, this form of achievement is seen in QRP operation in quest of WAS, WAC or even DXCC. Although some operators of high power have been heard sending CQ CQ CQ, NO QRP STNS PSE, a stigma should not be attached to the low-power operator: He or she must work even harder to reach a specified operating goal than those with 100- or 1000-watt transmitters.

Hans Meurer, W2TO of Ridgewood, New Jersey, is but one QRP enthusiast who garnered 100 countries for a DXCC award. His rig was a Heath HW-8 transceiver (approximately 2 watts of output), which uses a direct-conversion receiver. Ordinary dipole antennas were used to confirm the first 76 countries (antenna height was 45 feet). A TA-33 tri-band Yagi served as the antenna for the remainder of his needed countries. He had 60% of his contacts on 15 meters, 35% on 20 meters and 5% on 40 meters, along with a J3 QSO on 80 meters. Hans made some of his contacts by squeezing into big DX pileups! That's where patience and skill of operating become significant for QRPers.

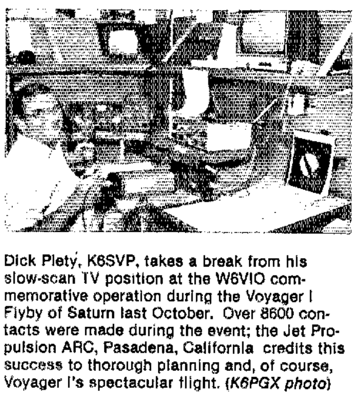
It took roughly 1-1/2 years of somewhat casual operating to collect the 100 cards for DXCC. After 47 years as a licensed amateur, Hans offers this advice: "For a truly exciting challenge, the kW boys, keyboard wizards, Honor Roll elite, OSCAR ops and 2-meter buffs should switch to QRP DXing." He may have a good point! — *Doug DeMaw, W1FB*

AMSAT SOFTWARE EXCHANGE

☐ Need a Phase III orbital prediction program? The first program offered by the AMSAT Software Exchange was written by AMSAT President Dr. Tom Clark, W3IWI. It is available for the TRS-80 disk and cassette, Apple/II diskette, Microsoft BASIC and Digital Research PL/I-80. For a complete description and ordering information, send an s.a.s.e. to AMSAT Software Exchange, Box 338, Ashmore, IL 61912. Proceeds will be donated to AMSAT in support of the Phase III satellite.

INDUCTOR STACK SHORTAGE

☐ Ed Wetherhold, W3NQN (ARRL TA), is temporarily out of 88-mH inductor stacks of the type used in the construction of the audio filter described in December 1980 *QST*. He asks that those who have already requested stacks be patient. Amateurs wishing to obtain them are requested to send a large s.a.s.e. for details and design information for cw, RTTY and speech filters to Ed Wetherhold, W3NQN, 102 Archwood Ave., Annapolis, MD 21401.



Dick Piety, K6SVP, takes a break from his slow-scan TV position at the W6VIO commemorative operation during the Voyager I Flyby of Saturn last October. Over 8600 contacts were made during the event; the Jet Propulsion ARC, Pasadena, California credits this success to thorough planning and, of course, Voyager I's spectacular flight. (*K6PGX photo*)

Product Review

Conducted By Paul K. Pagel,* N1FB

Kenwood TS-530S HF Transceiver

Have you ever wondered how equipment manufacturers choose model numbers? Is it a numerical series based on an engineering concept, or do they pull a number out of the air? Who knows, but many of us would assume that a model number like TS-530S would be an improved version of the popular '520 series. The '530 is improved, but the circuit design is also vastly different. Kenwood engineers have taken advantage of advances in technology to provide a transceiver with superior performance at a price comparable with that of its older cousin.

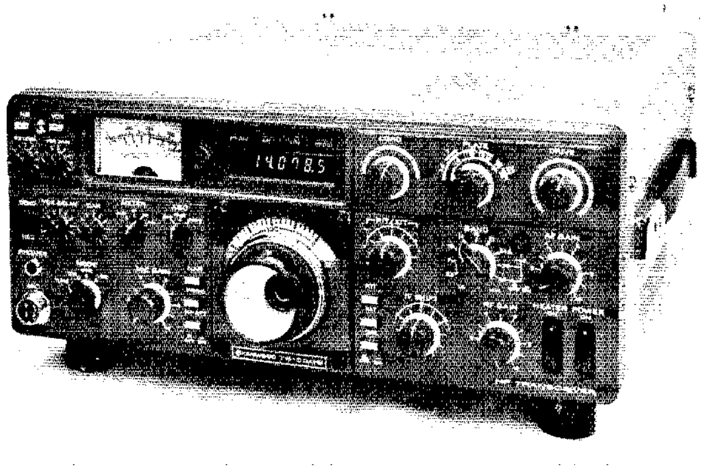
Features

Frequency coverage of the TS-530S includes all the amateur bands from 1.8 to 30 MHz, including the three WARC assignments at 10, 18 and 24 MHz. The receiver section features passband tuning, a noise blanker with an adjustable threshold level, selectable ssb and cw bandwidths (with optional filters installed), RIT and wide dynamic range. Vacuum tubes are used in the transmitter driver and final amplifier stages. There's an audio speech processor for ssb, and transmitter incremental tuning (XIT). A fluorescent blue readout displays the operating frequencies to the nearest 100 Hz.

The VOX delay and gain controls, and noise blanker threshold, require adjustment when operating conditions vary. These are located on the front panel, increasing operating ease. Other front-panel controls include switches for NARrow/wide bandwidth selection, speech PROCessor on/off, rf ATTENuator in/out, and 25 kHz CALibrator on/off, among others. The screen-grid switch, located on the rear panel, is used to defeat the final amplifier screen voltage during the neutralizing procedure or when the transceiver is used with an external transverter. The '530 has no provisions for transverter interconnection, although there are two holes punched into the cabinet, no doubt for owner addition of transverter jacks. Two DIN jacks supply a means of connection to an external power amplifier, tape recorder, and remote VFO. Also included are a 1/8-inch[1] external speaker jack, 1/4-inch key jack, a two-wire ac line cord, the fuse holder, and an SO-239 rf connector. The RF VOLT (meter control), ANTI-VOX and BIAS controls are also located on the rear panel, as these require only periodic adjustment. The final amplifier fan is the quietest I have heard on any piece of equipment!

Some Circuit Features

The '530 uses a single-conversion receiver with an 8.895 MHz i-f. A single crystal PLL synthesizer generates the HFO signals, which, along with the 5.5- to 6-MHz VFO signal, provide all the injection frequencies required by the transceiver. The I-F SHIFT control enables the operator to move the center point of the



Kenwood TS-530S HF Transceiver Serial No. 1090166

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: 1.8 to 30 MHz including 10, 18 and 24 MHz	As specified plus a minimum of 70 kHz additional at each band edge.
Modes of operation: Ssb, cw	As specified.
Frequency display: Six 0.25-inch fluorescent blue digits and analog dial.	As specified.
Resolution: Analog, 1 kHz; digital, 100 Hz.	As specified.
kHz/turn of tuning knob: Not specified.	25.
Backlash: Not specified.	Nil.
RIT range: Not specified.	± 2 kHz.
Receiver attenuator: 20 dB.	As specified.
Audio power output: 1.5 watts (8 ohms).	As specified.
Power consumption: Transmit, 295 watts; receive, 32 watts.	Not measured.
Transmitter rf power output: Not specified.	Greater than 100 watts except on 10 M — 100 W.
Spurious suppression: Better than 40 dB.	− 68 dB worst case.
Harmonic suppression: Better than 40 dB.	− 42 dB on 160 m (see photo).
Carrier suppression: Better than 40 dB.	As specified.
Transmitter third-order IMD: Not specified.	− 28 below PEP (see photo).
Frequency stability: Within 100 Hz during any 30-minute period after warm up. Within 1 kHz during the first hour after 1-minute warm-up.	130 Hz from cold start to 1 hour later
S-meter sensitivity (μV/S9): Not specified.	Ranging from 72 to 92 μV.
Receiver sensitivity: 0.25 μV for 10 dB S + N/N	Receiver dynamics measured with YK88C 500-Hz i-f filter:

	80 m	*20 m*
MDS (dBm):	− 135	− 136
Blocking DR (dB):	112	120
Two-tone third-order IMD DR (dB):	88	90

Size (HWD): 5.3 × 13.3 × 13.3 in.
Weight: 28.2 lb.
Color: Gray.

[1]in. × 25.4 = mm; lb × 0.454 = kg

*Assistant Technical Editor

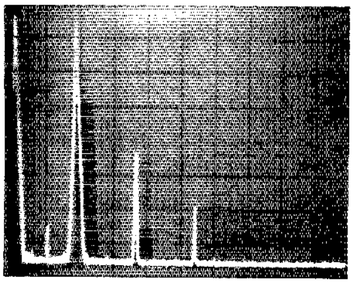


Fig. 1 — Spectral display of the Kenwood TS-530S. Vertical divisions are each 10 dB; horizontal divisions are each 1 MHz. Output power is approximately 100 watts at 160 meters. The worst-case spurious emission is approximately 42 dB down from the fundamental.

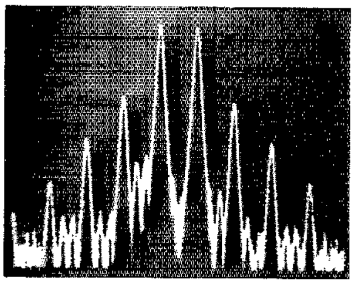


Fig. 2 — Spectral display of the TS-530S output during transmitter two-tone third-order IMD test. The third-order products are approximately 28 dB below PEP and fifth-order products are about 40 dB down. Vertical divisions are each 10 dB; horizontal divisions are each 1 kHz. The transmitter was being operated at rated input power on the 20-meter band.

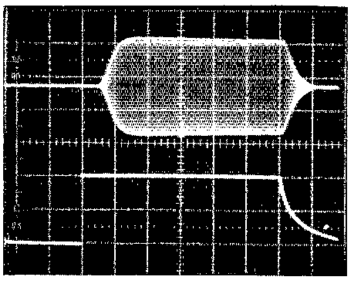


Fig. 3 — Cw keying waveform of the TS-530S. Upper trace is the rf envelope; lower trace is the actual key closure. Each horizontal division is 5 ms. The carrier level was adjusted for an alc meter reading of zero. Higher amounts of drive tend to sharpen the wavefront.

receiver passband without changing the pitch of the incoming signal. This is accomplished by "pulling" several of the internal oscillators in unison, to shift the entire i-f passband nearer to the edge of the crystal filter, helping eliminate QRM.

On-the-Air Operation

After testing the '530 in the ARRL lab, I decided to try the ultimate test — Field Day. Our operation was by no means typical, with 15 transmitters on six bands, all with kilowatt amplifiers, on a single generator! My operating assignment was 80-meter cw. We planned to have a phone and a cw transmitter on each band, 80 through 10 meters. I was skeptical of this operation, but decided to try it. As the contest began, strange noises caused by overload and cross-modulation spewed forth from the transceiver speaker. I quickly switched in the rf attenuator, and the overload effects disappeared. Sensitivity remained more than sufficient and I heard nothing from our other transmitters for the duration of the event.

My shack, located in Newington, is probably similar to that of the average apartment dweller. The wiring in the building is two-wire ac, and the shack is located on the second floor. Even without a good ground system, the transceiver did not cause TVI for my co-inhabitants! A leaky insulator on a nearby power pole provides an almost constant S7 receiver noise level, but the '530 noise blanker eliminated the problem. (The noise blanker level control must be adjusted carefully or a severe reduction in dynamic range will result). My popular "hideout" is on 40-meter cw, and the transceiver is able to handle the tremendous signals present on that band. The optional cw filter (500-Hz model provided) is quite sharp, with no excessive leakage noted. I found the ability to switch to a wide filter a great asset, especially when looking for a clear frequency.

RTTY

I recently purchased a piece of RTTY gear, and was eager to try it with the TS-530S. The '530 manual recommends that the final amplifier power input be reduced to 100 watts when using RTTY or SSTV, and at that input power the "finals" were slightly warm after transmissions. On 14 MHz, the RTTY stations seem to stick closely to 14.090 MHz, sometimes generating fierce QRM. The i-f shift control came into its own, eliminating QRM within the passband.

Observations

Any amateur in the market for a transceiver will certainly be looking for a rig that offers a good price-to-performance ratio. Does the TS-530S fit the bill? I think so. The equipment is well built, and performs well during both contest and casual operating. No flaws appeared during the review period, not even a blown fuse. For those wishing to expand the '530 station, two remote VFOs are available — the VFO-230, a 20-Hz-step digital unit, and the VFO-240, a standard L-C circuit type styled to match the transceiver. The TS-530S is available from Trio-Kenwood Communications, 1111 West Walnut, Compton, CA 90220. Price class: TS-530S, $800; VFO-230, $310; VFO-240, $170; YK88C 500-Hz filter, $63; YK88SN 1.8-kHz filter, $63. — *Gerry Hull, AK4L*

McKAY DYMEK DA100D ACTIVE ANTENNA

☐ Active antenna? What's that? An amateur phoned Hq. recently and asked, "Is an active antenna one that moves about in the wind?" Although most amateur antennas are "active" in that respect, the term "active antenna" is applied to small receiving antennas that contain, as an intergal part, an amplifier. Such is the case with the DA100D system.

Where and how might we use an active antenna? The applications are varied, but for amateur work we may find a small antenna of this variety well suited to short-wave listening when a full-size aerial can't be erected. Some apartment and motel residents might appreciate the usefulness of such a system.

Under certain propagation conditions a small active antenna is capable of enhancing reception in some of the amateur bands. This is because it responds to various angles and polarities of incoming waves more satisfactorily than might be the case during a given period when using the regular station antenna. Also, depending on the source of various forms of man-made noise, the active antenna can discriminate against the noise better than the main antenna can. Such was the case during particular periods of reception on 14 MHz at W1FB: Prior to and while the band was going out, a signal improvement of 3 to 6 dB was observed while using the DA100D, as compared to a triband Yagi at 55 feet.[1]

The Yagi was pointed toward the source of the signals (Europe) and the active antenna was mounted on a mast which placed the DA100D some 10 feet above ground. In addition to an improvement in signal strength, a marked reduction in fast QSB was noted. Some signals that could not be copied Q5 on the tribander were perfectly readable when using the active antenna.

This is not meant to suggest that an active antenna will always provide reception as good as or better than the normal station antenna. To the contrary, the improved reception is more apt to be the exception than the rule. Reception on 40 meters, for example, was inferior to that which resulted while using the half-sloper. The DA100D was more responsive to noise and generated a number of "intermod" products across the band. It is not unusual to encounter IM products when using a broadband amplifier, such as that in the DA100D. The trade-off for bandwidth (50 kHz to 30 MHz for the DA100D) is poor rejection of strong in-band and out-of-band signals, which cause IM products to be generated within the amplifier. A preselector would greatly improve the IM performance, but would restrict the antenna to a narrow band of frequencies.

DA100D Characteristics

This system comes in two pieces — a plastic-encased masthead amplifier and telescoping whip antenna, and a station control unit that contains a step attenuator and power supply. Operating voltage for the amplifier is fed through the 50-ohm coaxial cable that is supplied with the system. The DA100D can be operated from the 117-volt ac line, or from a 12-volt dc source, to permit portable or mobile

[1]m = ft × 0.3048

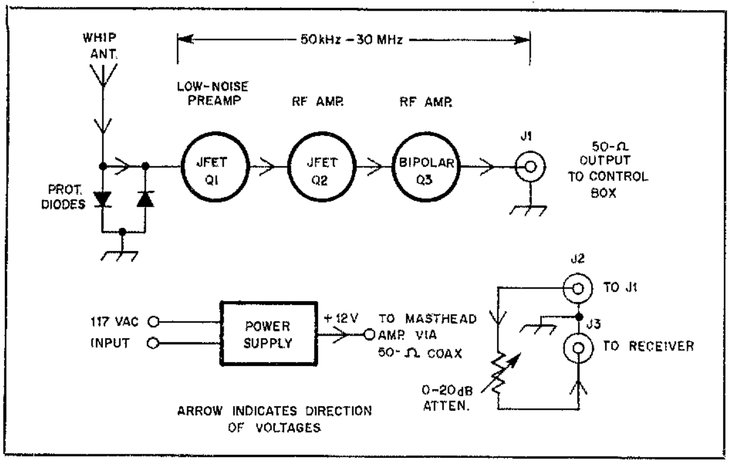


Fig. 4 — Block diagram of the DA100D broadband active antenna for 50 kHz to 30 MHz.

use. The extended length of the whip antenna is 4 feet, 8 inches. A fiberglass whip is offered as an option for those who live near salt water. A photograph of the masthead section of the DA100D can be seen in the advertisement on page 134 of September 1981 *QST*.

The manufacturer was unwilling to have the circuit published in *QST*, but we can show the general lineup in block-diagram form (Fig. 4). It can be assumed that a low-noise preamplifier is used, and that the subsequent amplifiers are employed to compensate for the normal inefficiency of a short whip antenna. Signal output from the system can be level-adjusted to suit the receiver in use.

Attenuator steps of 0, 10 and 20 dB are provided for 50-ohm operation. The control-box attenuator has positions also for interfacing the system to 100- and 500-ohm loads at 0-dB attenuation.

Burnout-protection diodes are located at the input to the masthead amplifier, but there is no strong-signal protection at either end of the coaxial cable that joins the masthead assembly to the station control box. I burned out an attenuator section and the output transistor of the amplifier module when operating 40-meter cw at the 1-kW level. Apparently the coaxial cable and overall system was resonant at or near 40 meters, and parasitic coupling to the nearby station antenna placed excessive rf energy on the system. The feed line from the station to the masthead amplifier was about 5 feet above ground during the event. Had the cable been lying on the ground or buried in the lawn, the catastrophe might not have taken place. It would be a simple matter to add protective diodes inside the control box.

Performance specifications are not listed by the manufacturer in the *QST* advertisement. Therefore, it was not feasible to perform laboratory tests to provide comparative figures. Furthermore, the high impedance (approximately 1 megohm) input of the DA100D would have made it incompatible with our laboratory test equipment. On a relative basis, however, the system performed well across the specified operating range. It should be an asset to those who travel or live where other antenna types are prohibited. It is likely that under certain adverse band conditions the active antenna would provide good reception when the regular station antenna failed to do so. This might be especially true of 80- and 160-meter operation, where noise is an almost constant threat to weak-signal reception.

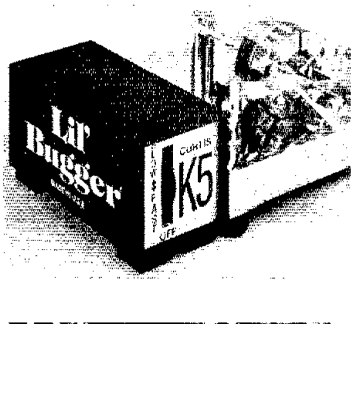
The DA100D is manufactured by McKay Dymek Company, 111 S. College Ave., P.O. Box 5000, Claremont, CA 91711, tel. 800-854-7769. Price class: $150. Unit color: satin-aluminum and black. — *Doug DeMaw, W1FB*

CURTIS ELECTRO DEVICES LIL' BUGGER

□ "Cute" is the first word that came to mind as I held the tiny keyer in my hand for the first time. But — if that's a keyer, where are the knobs, buttons and LEDs? Well, are fingertip access to keying weight, sidetone level and pitch, and message memories really needed? Message memory keyers excepted, most of the time the only keyer control many cw operators *really* need immediate access to is the SPEED control. The Lil' Bugger provides this with a front panel thumbwheel control that also acts as an ON/OFF switch. Keyer weighting, sidetone level and pitch are variable to suit your personal tastes, but are internal adjustments.

Physical Aspects

The rear panel sports a phono jack, two subminiature jacks and a rubber grommet through which key-connection wires pass. A single-conductor shielded cable with a phono plug at the keyer end is inserted into the XMTR phono jack. The other end of the key line is terminated in a plug that matches the key jack of your transmitter or transceiver. An 8-ohm dynamic earpiece, equipped with a 2.5 mm[3] plug, may be connected to the PHONE jack to monitor the keyer sidetone. Should you wish to drive an external speaker or require dc decoupling of the sidetone output, these can be accomplished by means described in the accompanying literature.



If an external supply is to power the Bugger, it should be terminated in a 2.5-mm plug with the positive lead connected to the plug tip and connected to the 9V jack. You can install a 9-V battery (alkaline type preferred for longer life) to power the unit. The keyer cover is a friction fit so it's easy to gain access to the interior. No battery holder is provided and none is needed — the battery simply rests atop the pc-board components.

A short four-wire "tail" uses three leads to connect the Bugger to the paddle dot, dash and common leads. The fourth lead is attached to the lever of a straight key that is part of a combination paddle/straight key. If a separate straight key ("hand pump") is used, you'll need a jumper wire between the paddle common and the other terminal of the pump. If you don't intend to use a straight key, you can insulate the fourth lead and tie it back. However, it could be used as a convenient means of creating a key-down condition for transmitter tuning purposes.

Inside the Lil' Bugger

What makes the Bugger tick is the Curtis 8044 keyer IC. Two transistors, six diodes and a tungsten-contact relay (along with the required resistors and capacitors) support the IC functions. The relay contacts have a voltage and current rating of 500 V and 1 A, 50 VA maximum. You don't have to worry about key jack voltage polarity with the relay.

The 8044 and 8044B ICs offer two slightly different methods of iambic (squeeze) keying in addition to single lever (non-squeeze) keying.[4] When using the 8044 IC, the dot or dash being sent when the paddles are released is completed and nothing else is sent. With the 8044B, the dot or dash being sent upon paddle release is completed and is followed automatically by an opposite element — a dot after a dash or dash after a dot. Because the IC is socketed, it is changed easily. Either IC type may be selected when ordering the keyer; specify the K5 for an 8044 IC or the K5B for the 8044B IC. A color-coded dot on the rear panel of the keyer identifies the IC type installed: green dot for the 8044, red dot for the 8044B. Non-squeeze-key operators using a single-lever paddle need not concern themselves about IC type.

Debouncing networks are included as part of the keyer circuit. These serve to compensate for any irregularities in contact closure. Both dot and dash inputs of the IC are diode protected, and an arc suppression circuit is placed across the relay contacts to help prevent contact arcing.

The maximum keyer speed is factory set at 50 wpm. An internal adjustment permits the operator to select maximum speed limits from about 10 to 100 wpm; a procedure is detailed in the accompanying instruction sheets, which are well written and complete. The printing is clear and well defined, but some OTs may have a bit of difficulty reading the small type.

[3]inches = mm ÷ 25.4

[4]L. Fay, "The Iambic Gambit," *QST*, July 1981, p. 52.

A quiescent current drain of 50 μA is drawn by the keyer. During keying, an average of 20 mA is required. If the optional mercury-wetted contact relay is substituted for the standard relay, current drain approaches 40 mA during keying.

Although the external power input jack is labeled 9v, the Lil' Bugger will operate with voltages within the 5- to 15-V range. At the low end of the range, an onboard relay current-limiting resistor must be shorted out. For operation at the 15-V level, the manufacturer cautions that the internal battery (if used) be removed first.

In Use

The Bugger is so small that it can be attached directly to the side of the paddle using the double-stick tape provided. This eliminates using long, 3- or 4-wire connections between the keyer and paddle.

Keyer operation is smooth — an accepted fact for the keyers I've had using Curtis ICs. Even if you already have a keyer, you might consider adding a Lil' Bugger to your operating position. It makes a neat package for portable or mobile operation, too. Curtis has shown that, indeed, "good things come in small packages." Price class: $40 (plus $2 shipping). Manufacturer: Curtis Electro Devices, Box 4090, Mountain View, CA 94040. — *Paul K. Pagel, N1FB*

CUSHCRAFT A743 40/30-METER ADD-ON KIT

□ When Glenn Whitehouse of Cushcraft offered to send the 40-meter adapter for the A3 Tribander,[1] I gladly accepted. Forty meters is a favorite haunt of mine and the idea of having a rotatable 40-meter dipole was alluring. The addition provides a means of having at your disposal a 4-band antenna (40 through 10 meters) that is fed by a single run of coaxial cable.

Description and Assembly

The add-on kit contains a pair of 20-meter traps, a pair of capacitance "hats," a heavy-duty driven element center insulator, aluminum tubing element extensions and a driven element support-mast assembly. Installation of the kit requires that the driven element of the A3 be disassembled at the center insulator and at points outboard of the 15-meter traps only. The addition may be configured for use on either 40 or 30 meters. On the 30-meter band, the capacitance hats are not used. All hardware is stainless steel or aluminum, and worm-gear clamps are supplied for securing the element sections.

In my opinion, the instruction sheet left something to be desired. The text does little more than refer you to the accompanying illustrations. And, while "a picture may be worth a thousand words," I felt another 100 words or so would have helped a great deal. The information is there, but close examination of the pictorials is required to avoid making a mistake. Two minor instruction sheet errors were noted. Fig. 6A has the identification of the FD and FG element sections reversed and the length of the machine screw (item 40, Fig. 5) incorrectly stated as 3/4 inch; it should be 1-3/4 inches. The manufacturer has taken steps to correct these errors.

[1]"Cushcraft A3 Triband Antenna," Product Review, *QST*, May 1981, p. 40.

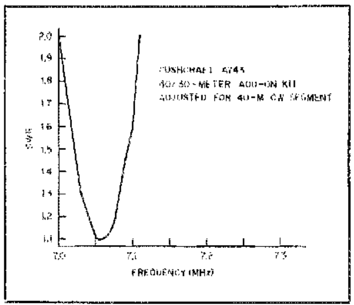


Fig. 5 — SWR curve for the Cushcraft A743 40/30-meter add-on kit for the A3 tribander.

Replacement of the center insulator is the first installation step. The new G-12 fiberglass insulator has a wall thickness of 1/4 inch (mm = inches × 25.4)) — about double that of the one supplied with the A3 originally. Additional strength is needed here because the overall length of the driven element is increased by approximately 12 feet and two traps are added that also serve to increase the weight of the element. A large portion of this additional weight is borne by the driven element support-mast assembly. This consists of a vertical tubing section (clamped to the boom) and a support line that is attached at points between the 15- and 20-meter traps. According to the manufacturer, this line is specially imported from Denmark, has more than adequate strength, and will not stretch. I have not noticed any subsequent sag in the driven element since it was installed. (In fact, to me the antenna looks even better now than it did without the adapter kit installed! I've puzzled over this for some time now and have yet to figure out *why*!)

Once the driven element has been reassembled, it is adjusted for length. Three sets of element lengths are given for the cw, center and phone segments of the band. I chose to use the cw segment lengths. I found it necessary (after initial SWR measurements were made) to trim the lengths of each side of the element by adding about an inch to the measurements given in the instruction sheet table. Fig. 5 shows the SWR curve for the antenna on 40 meters. The 1.5:1 points occur at the edges of the band segment I normally use.

Performance

Comparisons made between the A743 and my 40-meter dipole have shown a small increase in received signal strength when using the '743 (oriented in the same direction as the wire dipole), no doubt because of a slight increase in antenna height (about 10 feet). But, the primary advantage of the '743 is that it can be rotated — that does make quite a difference. Many signals that are "down in the mud" with the fixed dipole because of antenna orientation are now up to a comfortable level when the '743 is used and properly positioned. Operation on the 20- through 10-meter bands does not appear to have been affected by the addition of the A743.

If you're looking for a flexible antenna system, the A3/743 combination is one worth considering. The ability to work four bands with one antenna and one piece of coax, and to have a rotatable 40-meter dipole, might interest you. If you own a Cushcraft A4, the A744 add-on kit can be used. Price class: $80. Manufacturer: Cushcraft Corporation, 48 Perimeter Rd., P.O. Box 4680, Manchester, NH 03108. — *Paul K. Pagel, N1FB*

B & W ANTENNAS BNR 2-METER QUAD ANTENNA

□ The BNR has a distinctly home-made "flavor." The three directors, driven element and reflector are made of no. 14 copper wire strung on plastic spreaders. The spreaders are mounted on a 6-ft aluminum boom. At construction time, the builder chooses either vertical or horizontal polarization by proper positioning of the driven element.

Quad construction is straightforward. The plastic dowel spreaders are separated into five groups of two, according to length. The shortest pair is used for the third director, the next shorter pair is used for the second director, and so forth. Assembling each element consists of inserting the appropriate pair of elements into predrilled holes in the aluminum boom and stringing no. 14 solid copper wire through the holes in the spreader tips. For all elements except the driver, the wire ends are soldered to form a closed loop one wavelength long.

The instructions do not provide the loop dimensions. The builder must center the spreaders in the boom and string wire through predrilled holes, drawing it taut without bending the spreaders. Perhaps this would be adequate if each spreader locked into the boom exactly at the center: they do not. I taped them in place to keep them from sliding around. A small geometry exercise indicates that the loop perimeter varies by as much as 20%, as the intersection point of the spreaders deviates from the centers. Depending on the builder's skill, this can range from a minor inconvenience to a fatal flaw.

The kit includes an SO-239 connector for attaching 50-ohm coaxial cable. A modified gamma-match stub provides the match between the driven element and the feed line. The SWR curve (Fig. 6) indicates that the quad is a relatively broad-band antenna.

The quad performance is adequate. Informal observations indicate that it has good front-to-back and front-to-side ratios.

The structure is reasonably sound. If the builder puts it up and leaves it alone, it should be okay. I would not recommend it for someone who wished to put it up and take it down frequently. It would not tolerate that much abuse.

Price class is $45. For more information, contact Don Brooks, B & W Antennas, 2540 CR181, Clyde, OH 43410. — *Peter O'Dell, KB1N*

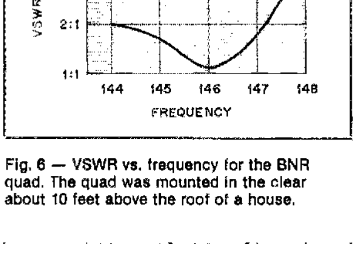


Fig. 6 — VSWR vs. frequency for the BNR quad. The quad was mounted in the clear about 10 feet above the roof of a house.

Technical Correspondence

Conducted By
Doug DeMaw,* W1FB

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FREQUENCY-STANDARD ACCURACY

☐ In the July 1981 *QST*, a reader suggested a method of frequency locking a counter time base to WWV for absolute accuracy. The editor correctly pointed out in a footnote that propagation variations limit this system to no better than a few parts in 10^7. Also recommended was the use of very narrow i-f filtering since "only carrier is wanted." This would also be a source of instability if any temperature change of the filter occurred. The center frequency of a narrow crystal filter can easily drift 5 Hz per degree C temperature change. This would impart a phase shift in the signal path, which is equivalent to a frequency drift while the temperature change is occurring.

QST readers might be interested in some of the practical problems associated with keeping an accurate house frequency standard. While a ham may not need accuracy better than one part in 10^7, going much beyond that is a whole new ball game.

My first and only entry into the now-discontinued ARRL frequency measuring contest was with a tube type of frequency synthesizer as the beat oscillator. I ran it for a week straight before the FMT, calibrating its internal standard against 5 MHz WWV. My five measurements submitted were either 1 Hz high or right on the umpire's frequency. That is about 1 part in 10^7 accuracy, which is all one can expect.

To make the change to accuracy better than 1 part in 10^{10} required the following system improvements: A solid-state, oven-controlled oscillator that could be run 24 hours a day, 365 days a year. Our oscillator, a Sulzer 5A, actually has a proportional oven inside a proportional oven inside a glass vacuum bottle! Needed next is a battery back-up system to keep the oscillator on for at least eight hours with no ac power. Before battery back-up was installed in 1979, a power outage of three hours caused the following shift in June 1978. May and June offset average 9×10^{-10} low, July average offset 129×10^{-10} low! (The very newest oscillator designs from Hewlett-Packard have made these power-outage shifts less of a problem.)

To keep track of an oscillator requires some type of phase receiver, using either TV burst, WWVB on 60 kHz, or possibly Omega or Loran C. One can make rapid measurements using TV burst, but phase jumps have to be taken into account, and live network must be readily available. In the Mountain time zone, we use WWVB out of Fort Collins, Colorado, because very little live network is aired here. Unlike TV burst at 3.58 MHz, a comparator at 60 kHz requires several hours of tracking, preferably a reading every 24 hours at high noon!

To make readings over many hours or days requires a chart recorder to keep track of the phase plot and to be sure no glitch has occurred, invalidating the data. Taking a reading once a day at the same hour minimizes variations in the ionosphere, and system changes, such as whether your receiving loop is in the sun or not. A 20-degree change in loop temperature will change the resonant frequency, shifting the phase and giving a measurement error.

After one has spent between $500 and $5000, depending on one's luck at surplus buying, the fun begins in watching your system work and trying to learn why your phase plots sometimes look like an earthquake recorder instead of a straight-line plotter. With WWVB, the farther one is from Colorado, the more problem one will have with daytime to nighttime phase shifts, plus weak signals. The closer in one is, the more apparent are the limitations of vlf transmission. In Denver, we could generally plot a nice smooth line, with the 45° phase shift every hour for five minutes as proof one was really tracking WWVB and not some buzzing light dimmer! But then at times up until December 1980, wiggly plots would almost obscure the 45° (2.08 µsec) phase shift. A call to Fort Collins revealed that the wind was blowing over 40 mph, causing their antenna to blow around, which produced a phase shift in their transmitted signal.

Throughout 1981 a phase shifter was installed at WWVB to compensate for the antenna blowing around, but at times I still saw wiggles in my plot. The more one refines the receiving system, the more one resolves the limitations in the whole loop from cesium standards at WWV to the chart recorder final output.

What kind of accuracy can you expect? Throughout December 1980 we plotted the following offsets, all times 10^{-10} parts low: 2.3, 1.5, 0.8, 0.6. All measurements were for 22 to 48 hours in duration. On March 1, 1981 it was 3.2×10^{-10} high. Thus the drift rate of this particular oscillator is about 1.5 parts in 10^{10} upward in frequency per month. That is very good, but then this oscillator is about 20 years old, and has been aging for a long time.

Frequency/time keeping is a fascinating subject, and the more experience one has, the more one sees that there is more to learn. The Bureau of Standards and Hewlett-Packard both have booklets on the subject available at no charge. Sometimes I have so much fun watching the recorder plot out, and calculating the offset, I get behind in my lab work, which is why the oscillator is run in the first place! — *Robert Sherwood, WB0JGP*

TOWER FEED WITH A GAMMA MATCH

☐ I receive a lot of questions at Hq. and while on the air. One of the more common questions concerns proper configuration of the shunt arm when exciting a tower as a vertical antenna. Amateurs ask, "How long is the shunt arm? How far should it be spaced from the tower? What is the best conductor diameter for the gamma or shunt arm? How do you match the arm to the feed line?"

If the tower and antennas atop it do not form a resonant quarter wavelength at the desired operating frequency, the dimensions for a shunt arm aren't especially critical (Fig. 1A). My best results have been obtained when running the shunt arm halfway up the tower, or even to the top. Any spacing from, say, 1 to 2 feet from the tower leg or side will provide satisfactory results. Any reasonable conductor size can be used for the shunt arm, with the larger sizes (diameter) preferred. I have had good results when using RG-59/U coaxial cable as the drop wire. The center conductor and the shield braid are joined at each end of the shunt arm (paralleled). The major penalty paid for using a nonresonant shunt-fed tower is restricted bandwidth. The matching network has to be readjusted when moving more than a few kilohertz on the lower bands (160 and 80 meters). Generally, a nonresonant shunt-fed tower is not nearly as effective as a properly matched resonant system. I have found T or L networks quite suitable for matching a 50-ohm feed line to the lower end of the shunt arm. The

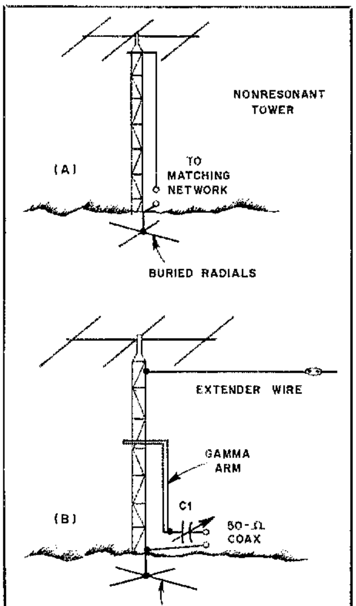

Fig. 1 — Illustration A shows a nonresonant tower vertical that uses shunt feed that extends to the top of the tower (see text). At B is a resonant tower vertical that has a gamma match for 50-ohm coaxial feed line to the station.

*Senior Technical Editor

least effective nonresonant verticals I have used were those less than 90 degrees, electrically. Some fine results were obtained with two models that were somewhat in excess of 90 degrees (quarter wavelength).

If the overall tower system can be adjusted for quarter-wave resonance by means of a top resonator (loading coil and capacitance hat) or horizontal extender wire, one can use a standard gamma match to feed it. *The ARRL Antenna Book* provides approximate starting dimensions for gamma matches (transmission line chapter). I have used them with success in shunt feeding a number of resonant towers. The easiest way to explain the procedure for gamma matching is to use an example. Assume that the tower in Fig. 1B was structured for operation at 1.825 MHz by means of an extender wire that provided an overall tower/wire length roughly 3% shorter (1830.5 kHz) than the desired resonant length (shortening necessary for gamma feed). Imagine that the tower has an outer diameter of 12 inches (mm = in. × 25.4). The gamma arm will be approximately 0.045 wavelength long (24 feet). The diameter of the gamma arm needs to be roughly 0.33 to 0.5 the tower diameter. For 1.825 MHz it will be between 4 and 6 inches. Since this is a fairly large diameter for the types of stock that are available (to say nothing of practical considerations!), a 4-inch diameter gamma arm can be fashioned from several lengths of copper antenna wire, birdcage fashion. Pieces of pc board can be used as spreaders, with the wires soldered to each spreader as they pass through it. The center-to-center spacing for the tower and arm will be on the order of 0.007 wavelength, or 3 feet, 9 inches.

The series gamma capacitor (C1 of Fig. 1B) will require about 7 pF per meter in order to provide a match between 50-ohm feed line and the gamma arm. Since 1.825 MHz is actually 164.39 meters, the required capacitance will be 1150 pF. These calculations are based on the assumption that the feed impedance of the antenna is set for approximately 25 ohms. It is assumed also that a buried radial system is attached to the base of the tower. In a practical situation it may be necessary to experiment with the length of the gamma arm and the setting of C1 to obtain a VSWR of 1:1.

Gamma feed can be used also with nonresonant towers, but the length of the gamma arm, the spacing of the arm from the tower and the value of series capacitance will probably differ greatly from those values calculated for a resonant vertical antenna. I hope this information will be helpful to those who have pondered the matter of shunt feeding towers for DX work. — *Doug DeMaw, W1FB*

PI NETWORKS FOR TRANSMATCHES

☐ I'd like to point out that the use of a pi network in antenna tuners (Transmatches) offers the capability of specifying the loaded Q (Q_L), as is done when designing pi networks for the output of transmitters. Ordinarily, the antenna-matching network is designed to accommodate the impedances involved, which results in accepting whatever Q_L results.

For example, suppose the VSWR with a 52-ohm feed system is 3:1. Limiting-impedance values producing a 3:1 VSWR are: 17.33 + j_0 (minimum resistance value), 156 + j_0 (maximum resistance value) and 86.67 + j69.33. Consider the minimum-resistance case.

Reactance Values for Pi Network in Fig. 3

Coax Z	Desired Q_L	X_1	X_2	X_3
17.33 + j_0	3	18.38 Ω	24.51 Ω	12.26 Ω
156 + j_0	3	18.38 Ω	45.80 Ω	30.59 Ω
86.67 + j69.33	3	18.38 Ω	44.41 Ω	25.12 Ω
86.67 − j69.33	3	18.38 Ω	44.41 Ω	35.02 Ω
17.33 + j_0	5	10.61 Ω	15.82 Ω	6.40 Ω
156 + j_0	5	10.61 Ω	28.08 Ω	18.13 Ω
86.67 + j69.33	5	10.61 Ω	27.25 Ω	15.78 Ω
86.67 − j69.33	5	10.61 Ω	27.25 Ω	19.19 Ω

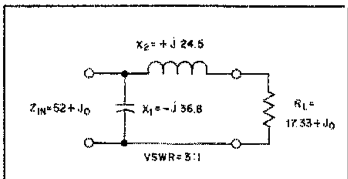

Fig. 2 — Simple L network and reactance values for correcting a VSWR of 3:1.

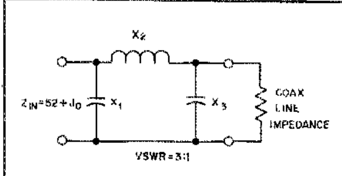

Fig. 3 — A pi network for matching two impedances. With this circuit the loaded Q can be determined in advance.

A simple L network to transform 17.33 + j_0 to 52 ohms is shown in Fig. 2. The circuit provides an excellent match, but the Q_L turns out to be only 1.7, thus ensuring relatively little harmonic attenuation.

In contrast, a pi configuration can be designed to provide the same impedance transformation with any desired Q_L, subject only to the practicality of large capacitances. The table indicates the reactance values for the pi network of Fig. 3, and is keyed to the three limiting cable input impedances that correspond to a VSWR of 3.

It should be noted that the value of X_1 depends only on Q_L. The smaller X_1 (larger capacitance) the higher the Q_L. This suggests that the optimum procedure for obtaining an impedance match with the highest Q_L is to adjust X_1 for maximum capacitance, and adjust X_2 and X_3 to obtain a VSWR of 1:1 at the tuner input.

The procedure for calculating X_1, X_2 and X_3 for a given Q_L and specifed antenna-cable impedance is similar to that for calculating pi-network elements in transmitters. A step-by-step procedure is available if you wish. A table of reactance values for various VSWRs and impedances (plus Q_L values) can be prepared readily with the use of a hand-held programmable calculator. — *K. K. Miller, W2KF*

MORE ON THE USE OF TV SWEEP TUBES

☐ DeMaw's article, "Some Thoughts About TV Sweep Tubes," in February, 1980 *QST*, provided primarily information relative to selection of sweep tubes for home-construction projects, touching only briefly on replacement of sweep tubes in existing equipment. Owner replacement of sweep tube "finals" in existing equipment has provided hours of unwanted headaches, especially when attempted with off-the-shelf tubes. The following notes may be useful.

1) If at all possible, where several tubes are operated in parallel, they should be purchased in matched sets. DeMaw mentions the need for close matching of characteristics, and that they (matched tubes) are usually available from the equipment manufacturer at higher cost than tubes purchased locally. The additional cost reflects the time involved in matching. Even so, they will still be a bargain.

2) It is best to stay with the same brand of tube originally supplied in the equipment. The subtle differences in internal construction of tubes from different manufacturers may lead to difficulty in performing the neutralization check, and possible adjustment, which should follow final-stage tube replacement. A circuit designed around a particular manufacturer's tube may not provide the range of adjustment necessary to achieve neutralization. This same problem may occur when attempting replacement with a later "improved" version, e.g., 6JB6A. Since an equipment manufacturer may have used several manufacturers' tubes, perhaps with slight modification to neutralization circuitry, it is best to mention the original tube brand and number when ordering replacements from the equipment manufacturer. If a particular brand is no longer available, the manufacturer should provide a reliable substitute, perhaps with notes on slight circuit changes necessary for its use. It would be wise to request such notes with the order.

3) Follow the equipment manufacturer's recommended neutralization procedure. It is not uncommon, on multiband transmitters, for neutralization to be somewhat a compromise. For best results it must be done on a specific band. The quick test for adequate neutralization is to observe the plate-current dip at resonance, and simultaneously the rf output on a relative or calibrated power indicator. If minimum plate (or cathode) current at resonance and maximum rf output occur simultaneously, neutralization should be adequate. Normally the manufacturer will recommend observing these two conditions while adjusting the neutralizing capacitor, should it be necessary. However, depending on the degree of compromise in circuit design, perfect neutralization may not be observed on other

bands when this same check is performed. Bear this in mind; it is not uncommon. If the plate-tuning capacitor setting varies radically between the current dip and maximum rf output on other bands, the equipment manufacturer should be contacted for assistance.

4) A bias adjustment is routine after replacing final-amplifier tubes. A more accurate bias adjustment is possible when the driver tube is first removed from the socket. Removal of the driver eliminates any possibility of carrier bleed-through from an unbalanced balanced modulator. Carrier bleed-through will result in some additional plate current, and bias adjustments made to set plate/cathode current for a specific value of resting current will be incorrect if carrier bleed-through is present. Since the proper resting current is important to final-stage linearity, remove all doubt by removing the driver tube during bias adjustments. Proper biasing should be done prior to neutralization, and removal of the driver tube may also prevent circuit instabilites caused by insufficient neutralization immediately after the tube change. Don't forget to replace the driver before proceeding with neutralization!

5) Where it is impractical or impossible to obtain matched tubes directly from the manufacturer, careful consideration of the aforementioned hints may still avoid or minimize difficulty and permit off-the-shelf tubes to be used. A friendly tube supplier may consent to let you "borrow" 10 or 12 tubes to enable you to attempt to match a pair, or perhaps several pairs. If you are that fortunate, and succeed in matching more than one pair, you may want to buy an extra pair for spares. A tube supplier really should not do this for you, so if he does, don't abuse the privilege; return any unneeded tubes immediately. To attempt to match a pair (or more), one tube socket should be selected for use by all tubes during evaluation of their transconductance characteristics (g_m). Some final circuits will have the filaments of several tubes wired in series, so it may be necessary to have tubes in all the sockets. Connect only the plate lead to the tube being evaluated. Remaining plate leads should be positioned carefully to prevent short-circuiting and operator danger. BE CAREFUL; LETHAL VOLTAGES WILL BE PRESENT DURING THESE TESTS! Turn the transmitter on and allow the tube to warm up for two minutes. Close the PTT line, and following the manufacturer's recommended bias-adjustment procedure, plus removal of the driver, quickly adjust the bias setting to the proper value for one tube. If the normal value is 100 mA for two tubes, use half that value, 50 mA for one tube, etc. Secure the transmitter power supply, allow time for filter capacitor bleed-off by bleeder resistors (one minute), and then short the plate lead with a ground strap to remove any residual power-supply voltage. Remove the tube just evaluated and return it to its carton, inserting a slip of paper under the end flap, with the resting current marked on it, then set it aside. *Without readjusting the bias,* repeat this sequence with each tube. When all tubes have been evaluated under identical conditions of bias, select those with the closest current values for retubing the final. It should be noted that often the value will differ slightly from one socket to another. It may be possible to improve the match under resting-current conditions by simply swapping the tubes into different socket positions. DeMaw, in his article, recommends grading the tubes at full power current readings, and then accepting as a compromise any mismatch that occurs in the resting currents. I see nothing wrong with this approach, and it may result in slightly improved linearity. If you have not paid for all of the tubes, this method is harder on the tube during evaluation, and this should be considered. In actuality, either method should provide a reasonable match under varying current conditions.

6) Being unable to obtain a sufficient number of tubes to attempt to match a pair, only one practical method remains. It will be necessary to attempt use of off-the-shelf tubes, and to effect a reasonable balance by providing individual bias adjustments. DeMaw's article covers balancing tube currents by this method, and, in isolating the bias supplies to the individual tubes, the article should provide the reader with some ideas on the actual circuit changes that will be necessary. It should only be necessary to make the bias individually variable to one tube, if two tubes are used. The two tubes can be evaluated per the method in paragraph 5, to determine which pulls more current. If the bias-supply circuit to only one tube socket is to be modified and made independently variable, it would be best to install the 10-kΩ series resistor between the 10-kΩ pot and ground, rather than between the pot and the bias-supply line. In this way actual bias voltage to the individually controlled socket could be varied between one-half and full bias, and that grid cannot be run at such a low negative potential during adjustment, that the tube overconducts and destroys or damages itself. It must be remembered that a decrease in bias potential produces an increase in resting current: this is sometimes overlooked. The "hotter" of the two tubes would then be installed in the unmodified socket, and the resting current adjusted with the regular bias-adjustment potentiometer to the correct value for one tube. Then, after connection of the plate cap lead to the remaining tube, resting current can be adjusted to the correct value for two tubes by adjusting the added potentiometer to provide a slightly less negative bias voltage to the "weaker" of the two tubes.

Of all the possibilities mentioned, purchase of matched tubes directly from the equipment manufacturer, whenever possible, certainly presents the best opportunity for a smooth PA tube change where parallel tubes are involved. As DeMaw points out, sweep-tube manufacturers were not concerned with transmitter applications of these tubes during their design. Neither were they concerned in parallel-tube operation, so manufacturing tolerances are not so stringent as with transmitting tubes such as the 6146. Where transmitting tubes are used in parallel operation, normally few problems of mismatch will be encountered if the precaution is taken to purchase a pair of tubes from the same production run, which should be coded either on the tubes, the cartons, or perhaps both. — *Robert G. Wheaton, W5XW/VP1XW/XE2XW*

DON'T FORGET PART 68 OF THE FCC RULES AND REGULATIONS!

☐ We at *QST* let one slip past us when we published the article, "Phone-Line Interface — Do it Solid-State Style" (*QST* for October 1981). The authors unintentionally failed to warn the readers of the FCC regulations (Part 68) concerning attachment of equipment to the phone lines. Furthermore, the editors failed to observe the omission in the article.

As a consequence, AT&T sent a written advisory about the article to FCC, and the Commission in turn called the error to our attention. We were advised that specific technical and procedural standards govern the direct electrical interconnection of all terminal equipment with the telephone network. Part 68, 47 C.F.R., gives complete details, and is available from the FCC along with Form 730 for registering equipment that will be connected to the telephone network.

Amateurs should make certain that phone-patch equipment they use complies with the standards, lest they be in violation of current laws. A special report on this subject was published in April 1981 *Telecommunications* journal. — *Doug DeMaw, W1FB*

CONCERNING POLARITY INVERTERS

☐ I read the October 1981 *QST* article "Polarity Inverter," with interest. But I can't help but believe that the device is unnecessary.

Thirty years ago I bought an MG-TD with positive ground. Fifteen years ago the dash clock became erratic because of the contact plate-over, so in an attempt to reverse the plating and to convert to a more reasonable system, I decided to change the car to a negative-ground electrical system. I was prepared for the worst.

To my surprise, nothing really had to be changed except reversing the battery, flashing the residual magnetism of the armature and firing it up. The gist of the idea is that only those things that are polarity-sensitive need be changed. These things in general contain permanent magnets or rectifiers. The only sensitive component was the zero-center ammeter, but since it works either side, I left it alone. I did reverse the primary leads of the ignition coil (a 10-minute job), but the car would actually run without the change. (Two years ago I crawled under the dash and switched the color of the red and black battery voltage test pin-jacks.)

As you can see, the conversion was made quickly and at no cost. Generators, starters, regulators, lights, horns, etc., need not be changed at all. Only those devices containing permanent magnets or diodes need be considered, and virtually all of them can be modified easily.

From time to time reports are made in auto magazines of polarity changes made at great cost. These are usually ripoffs. — *Robert Span, W3RBL, Ligonier, Pennsylvania*

Feedback

☐ Dr. Beverage points out an error in his letter in Technical Correspondence (December 1981 *QST*, p. 55). Eq. 1 should read

$$T = 0.235 \times 10^{-10} \sqrt{\frac{f}{\sigma}}$$

☐ Gary Legel, N6TO, of Fullerton, California, tells us that while he built the Hartley 210 transmitter (left photo, December 1981 *QST*, page 31), his cousin, Al Estrumse, W4KTS, of Marietta, Georgia, built the 59 Tri-Tet crystal oscillator 801 amplifier transmitter (right photo).

Conducted By Larry D. Wolfgang,* WA3VIL

LIGHTNING ARRESTOR ANTENNA-END INSULATORS

☐ The antenna-end insulator shown in Fig. 1 may provide just the protection your antenna needs. The insulator is cheap, the gap is adjustable and lockable, and leakage paths are quite long. A grounded wire is used on the end not connected to the antenna. Points are formed on the eye bolts using a bench grinder. Set screws are used to lock the eye bolts when the gap is set. It is best to use stainless steel or brass hardware. Thanks to Howard Chapman for building the unit shown in the photo. — *Frank Noble, W3MT, Bethesda, Maryland*

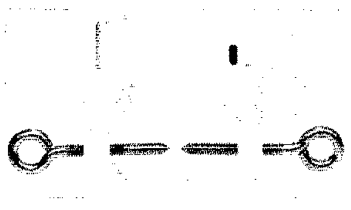

Fig. 1 — Construction details of an antenna-end insulator. The 3-1/2 inch square, 3/4-inch thick block of Lucite, with a 2-1/2 inch hole in the center, is drilled and tapped for the 1/4- × 3-inch eye bolts and 8-32 set screws (mm = inches × 25.4).

STRAIN RELIEF FOR WIRE ANTENNAS

☐ Here's an idea that has helped my temporary dipole withstand wind, snow, ice and birds in Oslo, Norway. When erecting a dipole, using trees as supports, you should provide some type of strain relief to prevent the wire from breaking as the trees sway in the wind. Tying one end to a weighted rope may not work because the rope can snag on bark or between branches of the tree. An excellent alternative is to use a few lengths of the elastic cord for tying bundles on bicycles or motorcycles. These cords have large, convenient hooks on each end, and can be purchased for a few dollars. Attach the cord between the end insulators and the support rope, and you will have an excellent strain relief for your wire antenna. — *Anthony Immorlica, LA0CT/WB6ENI, Flemington, New Jersey*

EXTRA SWITCHES WITH SWR INDICATORS

☐ Why add a switch to an SWR indicator? A switch can key the rig, turn off the amplifier, or reduce TVI or intermodulation of incoming signals. The most common use of an SWR bridge is to indicate the match of the feed line to the load. The transmitter can be keyed with a simple push-button switch on the indicator. If the switch is an NC/NO (normally closed, normally open) type, the relay line to an amplifier can be disconnected simultaneously (see Fig. 2).

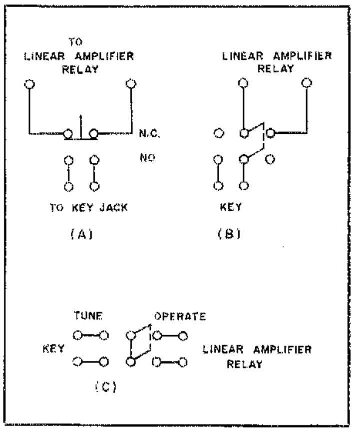

Fig. 2 — (A) A simple NC/NO push-button switch makes a convenient key on the SWR indicator. Push-button action gives a momentary on for the "tune" position. (B) and (C): A dpdt switch can perform the same function.

One particular control of a Transmatch usually has the most effect when QSYing across a single band. A dpdt center-off switch, connected to a reversing motor that is mechanically coupled to the control shaft, allows remote tuning. One field of a Honeywell (or similar) instrument motor may be reversed conveniently while you are watching the SWR indicator (Fig. 3A). In these days of 12-V dc rigs and power supplies, an inexpensive window-control motor from the automobile junkyard (Fig. 3B) is attractive, and the extra set of switch contacts may be used to key the rig.

Sometimes a load is simply beyond the adjustment range of a Transmatch, and a length of feed line (1/8 wavelength) must be inserted to permit a satisfactory adjustment. Here a dpdt or transfer relay (Fig. 4) may be located remotely and controlled by a switch. Stubs, coils or capacitors may be added similarly.

SWR-indicator unit diodes may generate weak harmonics and add intermodulation to incoming signals. Both effects can be reduced greatly by using the switch to disconnect the dc

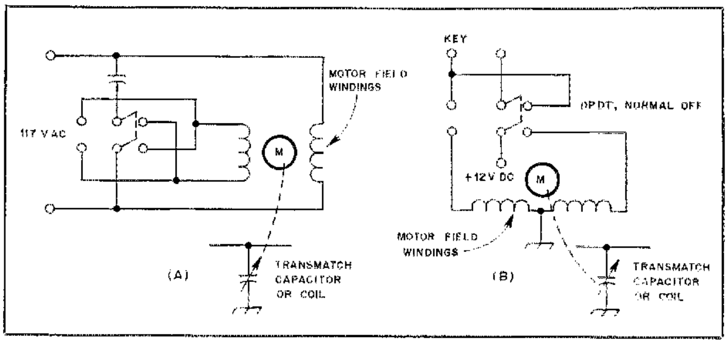

Fig. 3 — A spring-return, center off, dpdt switch allows remote, motor-driven tuning (A) with 117-V ac instrumentation servo motors, and (B) with automobile window-control motors.

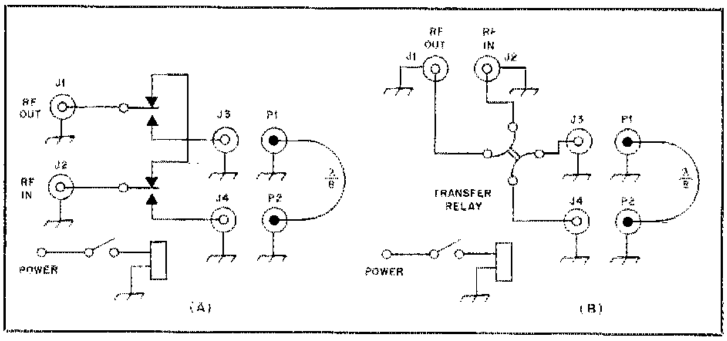

Fig. 4 — An spst switch may control a dpdt relay (A) or a transfer relay (B) to insert matching elements to extend Transmatch range. The contacts of a transfer relay rotate in 90° steps each time power is applied to the coil.

*Assistant Technical Editor

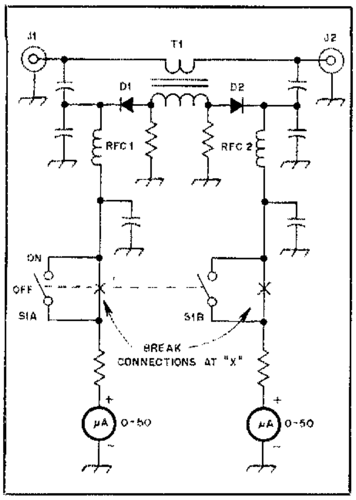

Fig. 5 — Opening the SWR-bridge detector-diode dc return will often reduce TVI and receiver intermodulation. The circuit shown is the VSWR Indicator and Power Meter from the 1981 *Radio Amateur's Handbook*. Many bridges have only a single meter, but the principle is the same.

paths from the diodes when the meter is not in use (see Fig. 5). Use one or more of these ideas to simplify your tune-up procedure. — *David Geiser, WA2ANU (ARRL TA), New Hartford, New York*

AZDEN PCS-2000 MEMORY

☐ When I looked for replacement batteries for the memory backup in my Azden 2-meter transceiver, it became clear that they were going to cost about $20 per year. Memory backup requires approximately 0.5 mA at 3 to 15 V. Almost any NiCad battery will do for this application. I recommend a 100-mAh pack such as stock no. 49F941 from the Newark Electronics Catalog, Chicago, Illinois, costing $7.06. This is a three-cell pack (3.6 V), and is a good size for the available room. Fig. 6A shows the circuit used.

Install the NiCad pack as follows: First remove the control head from the main cabinet. Next remove the top and bottom covers on the control head (two screws for each cover) and the back plate (four screws on back and one on the top pc board). Assemble the battery, resistor and diode as shown in Fig. 6B. Cover the battery with two layers of electrical tape (top, bottom and sides), and cover the resistor and diode with spaghetti or heat-shrink tubing. Solder the wire from the positive side of the battery to the pc-board connection for the positive side of the battery holder, and solder the wire from the negative side to the pc-board connection for the negative side of the battery holder. Slide the battery assembly into the opening under the battery holder, between pc boards. Now locate the + 13.5-V input on the lower pc board at the ON/OFF switch. Solder the diode to either side of the switch. Your choice will depend on how power is supplied to the rig. If power is on only when the ignition is on, then wire the diode to the power side. If power is always applied to the rig, wire it to the radio side. Then, of course, the battery will

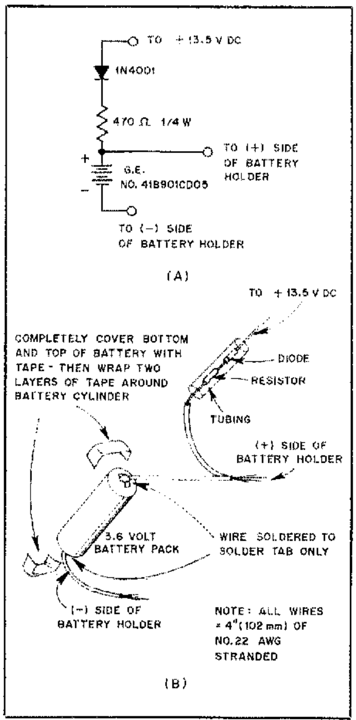

Fig. 6 — At A, a schematic diagram of a NiCad-battery memory backup for the Azden PCS-2000. The battery can be a GE no. 41B901CD05 or similar 3.6-V pack. The assembly details of the battery-charging circuit are shown at B.

only recharge when the rig is turned on. Reinstall the back plate and top and bottom covers. Most NiCad batteries are shipped in an uncharged state. The battery can be charged before installation by a direct connection to an automotive battery overnight, but only in the assembly with series resistor and diode.

If larger-capacity cells are used, the value of the series current-limiting resistor will have to be reduced. With a 470-ohm resistor, approximately 12 mA of charge current is available, just about right for the 100-mAh cells. If 150-mAh cells are used, the series resistor should be 390 ohms, and for 225-mAh cells the proper value is 330 ohms. — *Tom Burnet, W9KTB, Conyers, Georgia*

☐ After owning my Azden PCS-2000 for four months, the silver-oxide cells that power the memory function failed. A quick check of each 1.5-volt cell showed one at 1 volt, one at 0.9 volt, and one at minus 0.1 volt. After a dash to the store for new batteries, it became obvious that my old friend Murphy had been around. No memory function would work! Could the memory chip have been damaged by the reversed polarity of that battery?

Later that evening Gerd Henjes, W2ISB, mentioned experiencing a similar problem with another rig. He suggested removing all power from the rig, waiting a few minutes to bleed it off and then removing the memory batteries. Finally, he told me to short the plus and minus tabs of the battery holder for a minute or two. I followed his instructions carefully, and after replacing the batteries and turning the rig on, the memory worked!

The list price for the silver-oxide cells is $3 each or $9 for a set. I found 1.4-volt cells in the same size case that cost $2.39 for a pack of six. Knowing that the memory chip is CMOS, which will accept a 3- to 15-V supply, these should work fine. — *Clay Holland, KJ2W, Liverpool, New York*

JUNKBOX — A BETTER WAY

☐ One of the best type of storage containers for small electronics parts can be made from 35-mm film containers. For larger items or larger quantities, baby-food jars are very useful. The main drawback of these is that they break easily, but you can see what's inside. If you don't use 35-mm film yourself, the film cans may be obtained from commercial retail film developers for postage and an explanation of the intended use. If there are a few people in a club who want these, join together and use the club name. This may aid in getting the cooperation of the supervisor.

Once the containers are obtained, you have the question of how to mark the items for ease of identification. File dots work very well on both type of containers. These come in a variety of colors and sizes. The 1/2-inch dot size is easy to write on. To ease identification among capacitors, resistors, ICs and other items, use a different color for each of the categories. To break the categories down further use the 1/8-inch color dots to distinguish between Mylar, disc and tantalum capacitors, or between different wattage resistors. With this system you can quickly check a parts list to see what is on hand.

A good way to store the containers is in a chest of drawers. Use of 4-inch wide finger jointed and grooved drawer-siding material will ease construction of the drawers. This material is 3/8- to 1/2-inch thick with a 3/16-inch groove on one side and a 1/4-inch groove on the other side to make it easier to insert a bottom for the drawer. See Fig. 7 for construction details. — *Robert Hicks, KA5BLB, Brenham, Texas*

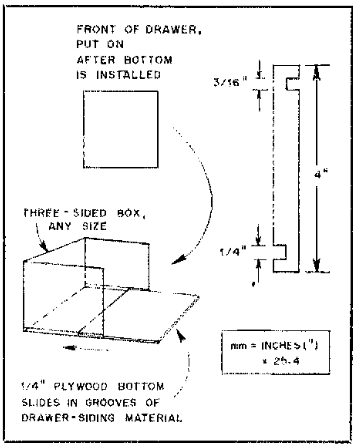

Fig. 7 — Construction of junkbox drawers using finger jointed and grooved drawer-siding material. Dimensions of the drawer should suit the builder.

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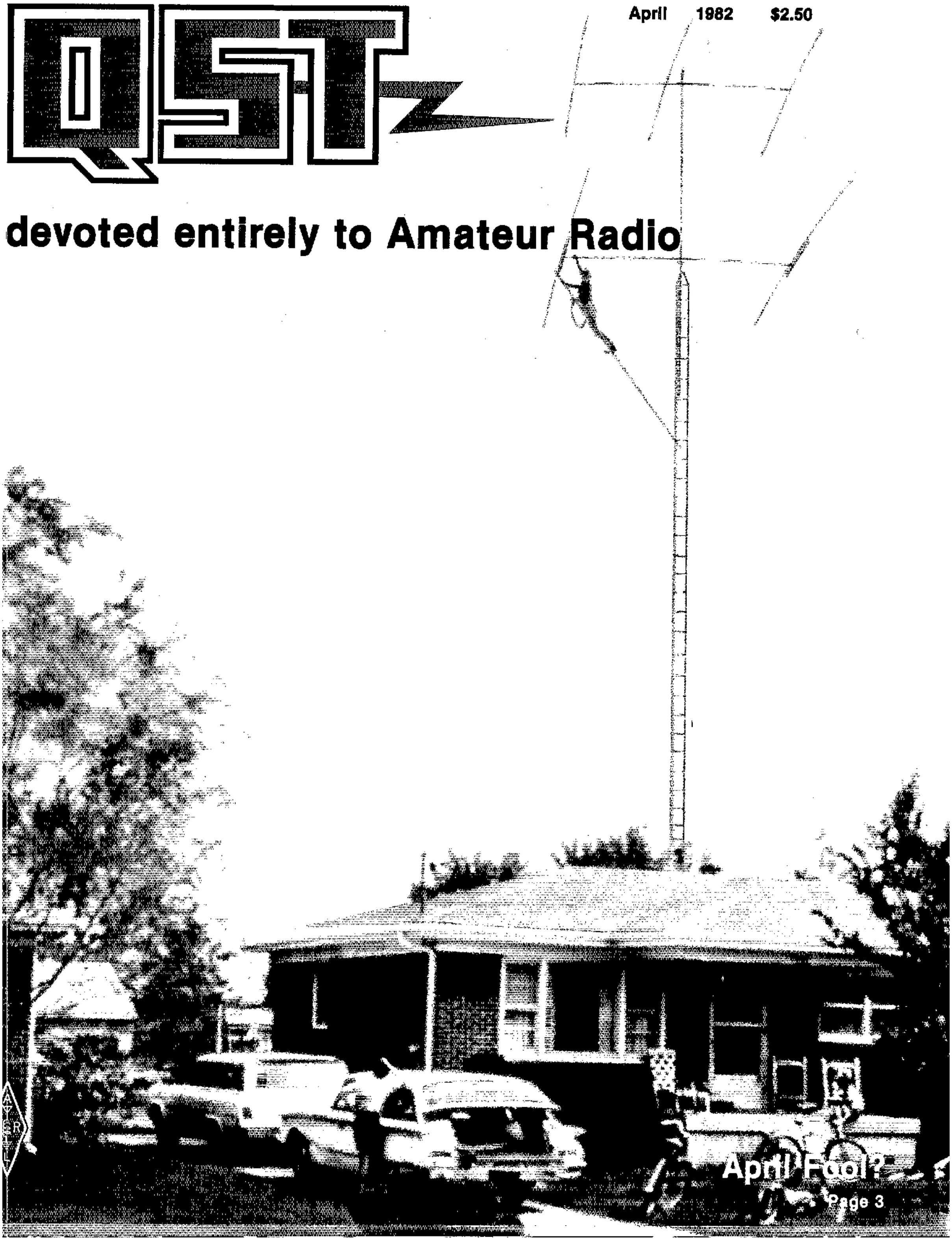

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THE COVER

Are we kidding? No, this is our safety lesson for this month. . . this is the way *not* to do it.
(Photo courtesy of N4XM/W4BCV)

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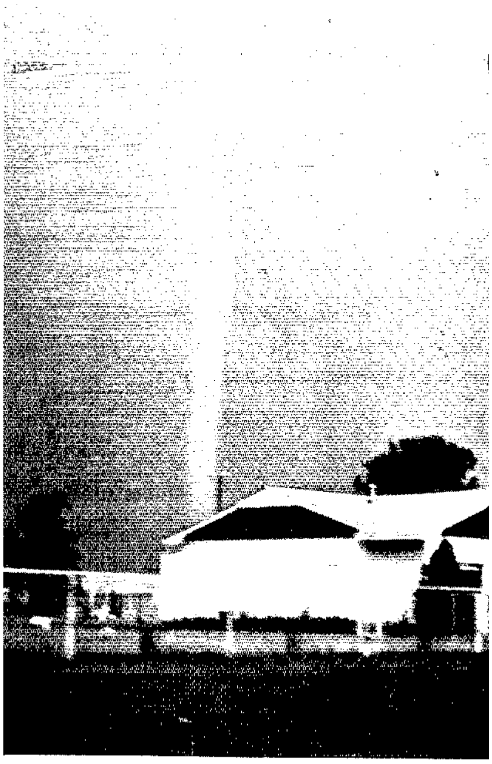


A funnel cloud approaches Union City, Oklahoma. Amateur Radio operators trained as storm spotters often warn the National Weather Service of an oncoming storm before it shows up on radar. (*photo by Alan Moller, NWS*)

Next time your home is threatened by severe weather, you'll be thankful for the hams who volunteer for the NWS. Why not join them?

By Larry E. Mooney,* WB5PWY

CENTRAL TEXAS HILL COUNTRY (Early August 1978) — Tropical Storm "Amelia" dumps 30 inches of rain in one night 50 miles northwest of San Antonio. With normal communications out, Amateur Radio operators work their way into the flood-stricken area to collect river-stage and rainfall readings, which the National Weather Service needs desperately to calculate the volume of water heading toward downstream cities. Members of the San Antonio Repeater Organization man the SKYWARN net control station at the NWS Forecast Office for 36 hours as mobile amateurs remain in their cars overnight to watch river stages and observe rainfall.

WICHITA FALLS, TEXAS (April 10, 1979) — Just before 6 P.M., NWS radar indicates a possible tornado southwest of the city. An Amateur Radio storm spotter reports a tornado just to the southwest of Memorial Stadium. This report is received by the amateur station at the NWS office, and a warning goes out. Although nearly 18,000 people are in or near the tornado's path, fewer than 50 people are killed.

FORT WORTH, TEXAS (May 8, 1981) — A huge, severe thunderstorm produces winds of 120 to 130 miles an hour in western Tarrant County. In eastern Fort Worth, softball-size hail penetrates some roofs and causes what is called the worst hailstorm in U.S. history. While the county is hit with $110 million in damage, only a few injuries occur — largely due to the advance warning based on reports from RACES spotters who speed information to amateur stations at the NWS office, civil defense and a major TV station.

These examples show graphically how trained Amateur Radio operators have saved lives and untold misery. More such volunteers are needed, anyplace there is a National Weather Service office.

A number of *QST* articles have described the activities of various amateur groups that provide assistance to the National Weather Service (NWS). While these articles have been extremely worthwhile, they've described this important public service from the viewpoint of the provider rather than that of the recipient of the aid. While most amateurs may be aware of the importance of their contributions to their local NWS office, few are in a position to appreciate the scope of this assistance on a national basis. In fact, the value of amateur assistance to the NWS is so extensive and significant that it is probably impossible to do justice to the subject in a single article. Nevertheless, the need exists to document some of the major contributions of the amateur community from the NWS perspective.

The Storm Spotter Program

While radar is a valuable tool, trained spotters are the backbone of an effective severe weather warning system. Traditionally, spotter networks have consisted of private citizens in rural areas who report by telephone. Such "networks" are supplemented by involving emergency service agencies such as police, fire and civil defense personnel. While this approach can sometimes be adequate, additional assistance is usually required where there is much severe weather. What is needed is a well-organized and highly-motivated group with reliable fixed and mobile communications.

Amateur assistance to the NWS is not new. In some areas, amateurs have participated in the spotter program for several decades. Only recently, however, has this effort been expanded nationwide.

*Regional Preparedness Meteorologist, National Weather Service, Southern Region, 819 Taylor St., Fort Worth, TX 76102

To a large degree, this was the fault of the NWS, as we sometimes failed to recognize the advantages that amateur assistance offered. In some cases, NWS station managers even turned down offers of help because they confused Amateur Radio with less effective organizations. Fortunately for the NWS, a few managers in key positions recognized the importance of amateur involvement and began a program to educate NWS personnel about the advantages of amateur assistance.

The real credit for the expansion of amateur participation belongs almost exclusively to the amateur community, however. Many of the more successful networks have developed through the sponsorship of local Amateur Radio clubs. Others were established through the RACES structure. RACES nets have proven especially effective in major metropolitan areas, where a more formal structure may be needed. ARES groups have also proven to be very effective. Unlike RACES, ARES does not depend on the existence of an organized civil defense group for sponsorship. Furthermore, ARES has the necessary organizational structure to conduct a coordinated program. In some locations, amateur spotters are civil defense volunteers with no other affiliation.

Two basic principles are fundamental to the amateur spotter program. First, the operation and management of the networks must remain in the hands of the amateurs. NWS involvement should be limited to support functions, such as providing training. Beyond activities such as requesting activation and soliciting reports, the NWS should have no operational role in actual network management. Equally important, the network should be organized to provide information and assistance to all interested parties. The NWS encourages all emergency-service agencies and the news media to support and participate in the amateur networks. The ideal situation is to have amateurs located at all key emergency operating centers and news media outlets in addition to the NWS office.

Amateurs' Spotter Abilities

In addition to the obvious communication capabilities, amateurs have demonstrated some special attributes that have made them the elite among storm spotters:

1) *Reportability* — Reports must be received in a timely and efficient manner. Amateur Radio has the excellent "airways discipline" that is essential for ensuring that significant reports are not delayed or missed because of idle chatter on the frequencies. This has been a major liability with some of the other volunteer organizations.

2) *Mobility* — Flexibility in positioning spotters is a key element of a successful network. Not only does mobility increase the likelihood of a spotter being in the best possible position to observe storm features, but it also reduces the number of spotters needed to cover a storm. Unlike many police and fire units, amateurs are not restricted to jurisdictional boundaries.

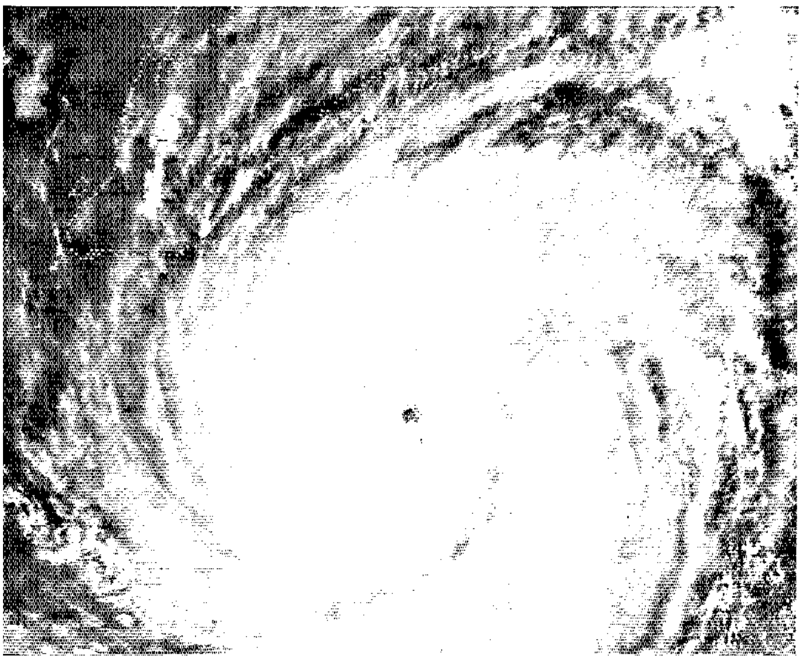
3) *Availability* — Spotters must be available for assistance with very little notice. Likewise, NWS forecasters must be able to activate their procedures as rapidly as possible. Activation of a multicounty amateur network is often possible with only one phone call by the NWS forecaster. In contrast, dozens of calls might be needed to alert all the emergency service agencies in the same area.

4) *Reliability* — In addition to being available on a 24-hour basis, spotters must be able and willing to perform their services for extended periods. It is not unusual for amateurs to leave their jobs or to get up at all times of the night to provide spotter assistance. Once activated, they may stay involved in a net for hours at a time, or even days at a time during hurricane threats.

5) *Capability* — This is probably the most significant attribute of the amateur community. An effective spotter must not only know the cloud patterns associated with severe weather, but must also understand the physical processes involved. This is necessary to interpret properly what is actually occurring, as this will not always fit the classic models taught in the classroom. Furthermore, the spotter must be able to learn and retain information quickly, as the time for training is often limited. Because of the amateur's technical background and learning skills, it is much easier for the NWS to provide the detailed training required for quality reports. Experience has shown that frequent, repetitive training is needed for most spotters, both as a refresher and to impart new knowledge about storm structure and reporting procedures. More than any other group amateurs have shown the willingness to devote the necessary time to such a training effort.

Amateurs in the NWS Office

Where severe weather and hurricane are a frequent problem, many of our offices have made arrangements to have amatuer stations operate right in the NWS office. Forecasters are often required to make what may turn out to be a life-or-death decision with very limited or conflicting information available. As a result, tension is often high, with heavy demands on the entire staff. Meshing amateurs into our operations under these conditions requires considerable tact and judgement on the part of both the amateurs and the NWS staff. In many ways, the demands on the amateurs in our offices are greater than those on the spotter in the field. The NWS has been fortunate to have high-caliber volunteers operate amateur stations in our offices. Their willingness to contribute time and equipment has provided signifi-



A spectacular portrait of a killer storm, Hurricane Allen, as it gathered strength in the Gulf of Mexico before hitting the Texas coast in August 1980. *(photo courtesy National Weather Service)* cant benefits to the NWS and the public.

We receive reports faster and with greater detail if Amateur Radio is a part of our operation. The importance of speed is illustrated by events such as the Wichita Falls, Texas, tornado of 1979, where the timeliness of amateur reports meant the difference between life and death for many people. At times, negative reports are also extremely important. For example, when a forecaster receives a public report of a tornado in a populated area, he or she has to react quickly and has little time to verify the report. The result is that such reports, from the untrained public, contribute significantly to overwarning. By having amateurs in the NWS office, the forecaster is in a better position to verify or discredit such reports quickly. I reviewed the severe weather logs of our Fort Worth Forecast Office for a three-year period and could not find a single public report that had not either been reported previously or discredited quickly by members of the RACES groups in Tarrant and Dallas Counties.

Closer working relationships develop by by having the amateurs in the NWS office. It enables the amateurs to understand both how we operate, and our capabilities and limitations. This places the amateurs in a better position to identify areas where amateur assistance can be of help. Furthermore, the forecasters gain a better understanding of network capabilities and more confidence in the reports.

Through amateur networks, the NWS has been able to increase the dissemination of warning and radar information to emergency service agencies. In many communities, emergency operating centers lack a reliable means of receiving such vital information except via Amateur Radio. In addition, this same critical information can be passed or relayed to distant spotter groups. By having amateurs at the NWS office and at television stations with radar, it is possible to compare and exchange valuable radar data.

The NWS warning system depends almost totally on telephone lines for communications. While line failures are not common, they do seem to occur more frequently during adverse weather. Even if NWS communications remain operational, failures at key media outlets or emergency operating centers can seriously degrade the warning process.

The value of backup communications assistance is well illustrated by an event that occurred during a severe weather day at Oklahoma City. With a large portion of the city without telephone service, all but one television station was knocked off the air. During this brief but critical period, ARES operators were able to maintain the flow of information between the NWS office and the one operational television station.

In addition to providing backup communications to the media and other agencies, amateurs are assisting with internal backup communications between NWS offices. During Hurricane Allen, amateurs at the Brownsville, Texas, NWS office demonstrated the potential value of this type of aid by establishing a link with amateurs at the National Hurricane Center at Miami.

Additional Amateur Assistance

While I have highlighted the severe-local-storm-spotter program, it is by no means the only NWS program benefiting from amateur assistance. Indeed, nearly all NWS warning and forecast programs receive amateur help in one form or another. Perhaps the oldest form of assistance is in the area of data collection. Temperatures, precipitation and other meteorological data are collected daily by regional, statewide and local weather nets. Such information helps to fill in the gaps between official surface reporting stations. While this data may appear to be of local interest, some of it receives nationwide distribution. For example, reports from the Colorado Amateur Radio Weather Net are used throughout the U.S. to brief travelers to Colorado ski areas. At times, such supplemental data can be very helpful in locating the position of fronts or other weather features that are located between official reporting stations. The additional "resolution" can often mean the difference between a correct forecast or a total bust.

Moreover, the collection of supplemental data is extremely helpful during significant weather events such as winter storms and hurricanes. Reports from amateurs throughout the Caribbean and along the U.S. coasts have become a traditional part of the hurricane program. While winter storms often cover large areas, their effect on any particular community may be localized. Supplemental reports are essential under these circumstances.

In recent years, flooding has become the number one weather hazard in many parts of the U.S. Regardless of the type of flooding, a key element of a successful flood warning system is timely rainfall reports from critical locations. Often, these key locations are in remote areas where telephone service is subject to failure. The amateur community is again helping with this problem. For example, amateurs in South Texas routinely report rainfall totals to an amateur station in San Antonio. These reports are formatted on a home computer and sent via radioteletype to a printer in the NWS San Antonio Forecast Office. All the equipment is furnished and maintained by the amateurs. As a result of this effort, critical rainfall reports are available even when normal communications are disrupted.

Amateur assistance has not been limited to strictly operational problems. Post-storm documentation of severe weather events and public awareness projects have also been facilitated because of amateur involvement. Amateurs have played an important role in the NOAA (National Oceanographic and Atmospheric Administration) Weather Radio (NWR) program. At several locations, amateurs have actually built and maintained the NWR transmitter. This initiative made the service available in their communities sooner than it would have been otherwise. The NWR transmitter at Orlando, Florida, is still owned and maintained by local amateurs. Because of their technical and public service backgrounds, amateurs have been much quicker than the average citizen to recognize the importance of the NWR system. As a result, many amateurs have played lead roles in promoting and even purchasing NWR receivers for their places of business and schools.

Getting Involved

The scope and type of assistance needed varies among NWS offices. Local factors, such as frequency and types of weather hazards, the existing communications system and the capabilities of local warning systems, must be taken into consideration. At a number of locations, informal letters of cooperation have been used to define specific areas of cooperation between the amateurs and the NWS. Suggestions for organizing a weather net or spotter group appear in an article by Brian Peters, WD4EPR, in April 1977 *QST*, page 53.

Future Cooperation

While the amateur community is well known for its post-disaster communication assistance, contributions of equal or greater magnitude are being made in the area of pre-disaster communications. The increase of amateur participation in the severe-storm spotter program has been called the most significant improvement in the nation's natural disaster warning system since the addition of weather radar. In some ways, amateur assistance has been of more importance to the NWS than many technological advances. Since World War II, the NWS has continued to shrink in size while providing more and more services. Because this trend is likely to continue and even accelerate, the continuation and expansion of amateur assistance will be essential if the NWS is going to meet its obligations to the public. At the same time, the continuation of support to the NWS offers the amateur community a significant opportunity to demonstrate the importance of the Amateur Radio Service to the public welfare. Furthermore, it serves as a means of increasing amateur expertise and experience in the important function of emergency communications. Of course, the true beneficiary of continued cooperation is the public.

The future holds many opportunities for additional cooperation. The NWS is in the process of developing a highly advanced weather radar system that is far more sophisticated than any radar now available. As important as this system will be to the warning system, its maximum benefit will not be obtained without the development of highly mobile and well-trained spotters. It is obvious to many of us in the NWS that Amateur Radio operators are well on their way to fulfilling this requirement for a new breed of storm spotters. We are faced with serious problems in the hurricane program. For some coastal communities, the amount of advance warning we can provide is less time than is required to complete an orderly evacuation. As the urbanization process continues, and homes are built on flood plains, the devastation from floods is sure to increase.

It is obvious that we must solidify and expand our current levels of cooperation. While the various forms of assistance that I have discussed are not applicable to all locations, there are certainly other opportunities for cooperation. If your amateur organization does not presently participate in any of these efforts, I encourage you to contact your nearest NWS office to explore the need for assistance.

New Books

☐ *Intuitive IC Electronics*, by Thomas M. Frederiksen, First Edition. Published by McGraw-Hill Book Co., Suite 26-1, 1221 Avenue of Americas, New York, NY 10020. Hardcover, 6-1/4 × 9-1/4 inches, 182 pages, $18.50. (Orders may be placed directly with McGraw-Hill by giving book number ISBNO-07-021923-0. You will be billed later.)

Amateurs will be happy to discover a new book that introduces and explains all the significant semiconductor devices in a manner that anyone can comprehend. Assuming that readers have no prior knowledge of semiconductors, the author begins with basic electrical concepts and then applies them in building the PN junction diode, which in turn becomes the key building block toward understanding all other modern semiconductor devices, including MOS.

As the explanations are intended to be informative, not rigorous, the treatment keeps mathematics to an absolute minimum, stressing the basic physical mechanisms. Many illustrations are used to illuminate important semiconductor principles and mechanisms. Coverage includes all types of forward and reverse breakdown diodes, bipolar transistors, optoelectronic devices, JFETs, MOSFETs and many more. With emphasis on IC electronics, these devices are then used to describe the menagerie of process technologies including, but not limited to, bipolar, super beta, I^2L, CMOS, Bi-FET, PMOS, NMOS, DMOS and VMOS. How these technologies spawn product families such as ROMs, RAMs and EPROMs is disclosed by explaining important circuit blocks and process advantages. The book is balanced in the treatment of analog and digital areas, while also revealing why MOS technology is the backbone of digital products and has important ramifications in traditional analog areas as well.

The author, Tom Frederiksen, is well known in the IC field as circuit designer, innovator and lecturer. His intuitive explanations of sophisticated and complex subject matter may well be the best reason to own this book. Whether grounded in calculus or arithmetic, the reader will attain a deeper understanding and appreciation of IC electronics. The author's numerous anecdotes from his inside experience in the field, and his generally friendly and communicative writing style, make for enjoyable reading. I heartily recommend this book as both a reference (the index is excellent) and a text for any ham who is curious about semiconductor technology and who wishes to achieve a working understanding of the new silicon world. — *Dennis Monticelli, AE6C*

☐ *ZAP — Impedance and Power Potential*, by Charles F. Ryan, VE7BFT. Published by RYCO Enterprises Ltd., 764 Lilly Ave., Victoria, BC V8X 3R6. Softcover, 60 pages, $6.95 ($6.80 in Canada).

In the cover letter attached to the review copy, author Ryan states that the purpose of the booklet is "to present an overview of good radio station grounding . . . along with a progressive outlook towards radio station safety." On the other hand, the preface states: "Chas. Ryan has gathered practical ideas and hints and kinks which will have direct benefit to you and your station." Before opening to the body of the book I was confused about the content.

After reading through it, I feel that neither of the stated objectives had been effectively completed. The organization of material is difficult to follow. The first chapter is on antenna radiation resistance, followed by chapters on ground systems, transmission lines, more on antennas, and then a section on interference. Much of the book is cluttered with useless or incorrect information. To point out a few examples: In the section on grounding systems the author provides detailed physical properties of aluminum, which are of no interest to the average ham installing a ground system! In the section on antennas, author Ryan has a chart on "Isolated resonant antennas" (?) giving the radiation resistance and gain over a half-wave dipole. The first entry in the chart states that a length of wire one-half wave long will have a gain of 1 dB over a half-wave dipole! These are just a few of many errors found in the text. In one area only did the book reflect a superb job — the subject of grounding antennas and lowering soil resistance. This information is of practical value to the active hf operator.

What the author has compiled, instead of a useful booklet on antenna grounding systems and safety, is a mixed bag of hints and kinks related to antennas and ground systems. There are good sections in the book, but the reader must dig through the "pile-up" of useless material to find it. — *Gerry Hull, VE1CER*

☐ *Simple, Low Cost WIRE ANTENNAS For Radio Amateurs*, By William I. Orr, W6SAI, and Stuart D. Cowan, W2LX. Published by Radio Publications, Inc., Wilton, Connecticut. Second edition, 1972. Softcover, 5-1/2 × 8 inches, 181 pages, $6.95.

When preparing antenna articles for publication, most authors and editors assume the reader has a basic understanding of simple antenna principles. Unfortunately, that may not be the case for newcomers and inactive amateurs. *WIRE ANTENNAS* provides an introduction to antenna basics. Because it contains detailed information on hidden and disguise antennas, amateurs living in apartments and condominiums may also find it useful. The second edition has been revised to include data for constructing antennas for the WARC bands.

The title of the first chapter, "Sugar-Coated Antenna Fundamentals," provides a strong clue to the tone of the volume. Antenna theory and design concepts are presented in a lively, light-hearted style that makes for easy reading. Jokes and gags are judiciously sprinkled throughout.

Practical construction information is provided for dipole, random-length wire, vertical and wire beam antennas. Several antenna-matching networks are detailed also. A chapter is devoted to the plight of the apartment dweller; it covers the grounding problem as well as antenna construction. Another chapter covers SWR meters and how to use them, while one provides detailed instructions for installing coaxial connectors.

If you are new to Amateur Radio, or if you find yourself confused by most antenna articles, *WIRE ANTENNAS* may be for you. If you have some antenna experience under your belt, you may find *WIRE ANTENNAS* too elementary. — *Peter O'Dell, KB1N*

Strays

MOVING? UPGRADING?

☐ When you change your address or call sign, be sure to notify the Circulation Department at ARRL Hq. Enclose a recent address label from a *QST* wrapper if at all possible. Address your letter to Circulation Department, ARRL, 225 Main St., Newington, CT 06111. Please allow six weeks for the change to take effect. Once we have the information, we'll make sure your records are kept up-to-date so you'll be sure to receive *QST* without interruption. If you're writing to Hq. about something else, please use a separate piece of paper for each request.

SCHOLARSHIPS OFFERED

☐ Are you a licensed Amateur Radio operator and a graduating high school senior who is entering an accredited college or university in the fall of 1982? If so, you may qualify for one of three $500 scholarships to be awarded this year by the Atlanta Radio Club. You better hurry, though. Entries must be postmarked no later than July 1, 1982. For details and an application form, write Phil Latta, W4GTS, Sec'y., Atlanta Radio Club Scholarship Committee, 259 Weatherstone Pkwy., Marietta, GA 30067.

ANTENNA ATOP RABBIT BRINGS LIGHT SENTENCE

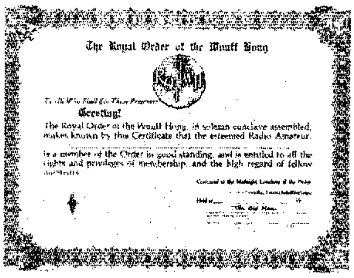
☐ When Eric Scace, K3NA, of Frederick, Maryland, was stopped by a traffic cop there late last year, he was told that he was violating a state law by carrying an amateur antenna that extended about a foot and a half beyond the frame of his VW Rabbit. As readers of the Washington *Post* learned, Scace was found guilty and sentenced to two months of probation, and to find 25 licensed drivers and tell each of them about the obscure law (which makes it illegal to carry anything on the roof of a car that extends beyond the car's frame on the driver's side). The judge added his own name to the list, as he apparently hadn't heard of the law either! — *information courtesy Al Brogdon, K3KMO*

WOUFF HONG INITIATION

☐ You have read about the Wouff Hong and its origin in the editorial of the January 1982 issue of *QST* and the brief mention therein of the Royal Order of the Wouff Hong, the amateur secret society of ARRL convention.

Now, you have some questions: What is this secret society? When does it meet? How can I join?

The Royal Order is a secret brotherhood of radio amateurs who are members of the ARRL. The first meeting of this Order was held at the Second Annual Michigan ARRL Convention at Flint, at midnight on February 11, 1923. The Order of the Wouff Hong can be conferred only at a National, Division, State or Section Convention of the ARRL. Each candidate, upon induction, receives a certificate of membership to be displayed prominently in his or her shack.


The Royal Order of the Wouff Hong

Greeting!

The Royal Order of the Wouff Hong, in solemn conclave assembled, makes known by this Certificate that the esteemed Radio Amateur

is a member of the Order in good standing, and is entitled to all the rights and privileges of membership, and the high regard of fellow amateurs.

The ceremony is not conducted at every League convention, so you'll have to watch the convention writeups in *QST* or publicity mailings to determine whether it is one of the scheduled events at a convention in your area. Then, with proof of League membership in hand, register to be one of the inductees into the great secret fraternity of Amateur Radio, the Royal Order of the Wouff Hong. — *Marge Tenney, WB1FSN*

CARSONOMICS

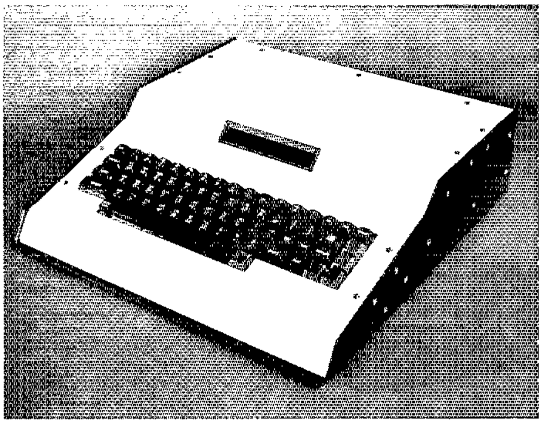
☐ As its contribution to the fight against inflation, the Cranford Amateur Radio Society of Cranford, New Jersey, has decided not to require its members to pay any dues for 1982. Also, there will be no entry fees or admission charge to the CARS's public exhibit, "Vintage Wireless to Modern Radio Equipment," which is to be shown in the Community Room of the Cranford Municipal Building on May 13. — *Kenneth McGrath, W2CMK*

MORE VACUUM TUBE ATTRITION

☐ Tubes are being unseated (or unsocketed) steadily by semiconductors. This has compounded the woes of many amateurs who, when they could locate replacement tubes, had to pay sky-high prices to obtain spares. Well, the supply-and-demand syndrome has created still more vacuum-tube casualties. *Electronic Buyers News* for February 15, 1982 stated that RCA will discontinue the manufacture of the following glass tubes: 2E26, 5563A, 828, 813 (ouch!), 7094 and 810. Also listed were the 2X2A (rare DX call?), 3E29, 811A (ouch again!), 829B, 6293 and, note this — 807!

For some hams, this constitutes a "read 'em and weep" item. Even this writer must take a nostalgic backward glance, for nearly all of the foregoing "valves" found service in his early-day, homemade amateur gear. Weren't those the days? When we proudly displayed our 6-foot racks of transmitting gear to our peers and relatives? Oh well, maybe they'll be just as impressed with our homemade solid-state gear that fits in the palm of one's hand! But there was always a warm feeling that accompanied the glow of orange filaments. Guess we'll have to settle for the touch of a warm heat sink. — *Doug DeMaw, W1FB*

A Microprocessor-Controlled Contest Accessory



What's your desire — RTTY, ASCII, cw? With the aid of this unit, you have them all, including a built-in display and dupe-checking capabilities.

By Brian Wood,* WØDZ

The potential of a computer for contest use as a "dupe" (duplication) checker and cw keyboard with stored message exchanges is obvious. However, computers can be awkward things to lug around on Field Day, and floppy disks do not adapt well to dusty, mosquito-infested environments. Clearly, there is a need for small, portable, rugged units dedicated to amateur use. The HAL CT2100, MicrologATR-6800 and Robot 800 are such devices. They do, however, lack dupe-checking capability as standard features. Here is a description of a microprocessor-controlled unit you can build that will perform dupe checking, will transmit and receive cw and RTTY, and has other features as well.

General Description

Physical: The chassis of the unit shown in the photographs is professionally made, and has a black anodized bottom and a painted top. A commercially available power supply is used and a line filter has been added to reduce conducted interference. The main controller is attached to the chassis bottom with threaded standoffs. All analog circuits are constructed on plug-in boards that connect them to the controller. This is desirable from the standpoint of serviceability and future expansion. A standard ASCII-encoded keyboard is used.

The Processor: An 8085 microprocessor (μP) was chosen for the controller because it has extensive interrupt capability, requires a single voltage source and is low in cost. In addition, support ICs are readily available. Many home computers use a Z-80 μP, for which the 8080 and 8085 are software-compatible. This allows the use of a cross-assembler running on a home computer to generate the program, which can be dumped into PROMs. Fig. 1 is a block diagram of the system. For a good description of the operation of the 8085, see the article "Designing a Microprocessor-based RTTY Speed and Code Converter" in the January and February 1982 issues of *QST.*

To handle RTTY transmission and reception, two 8251A USARTs are used. The processor can easily program these devices for ASCII or Baudot codes. One USART allows switching (for afsk) and another provides an RS-232C level port, permitting interconnection of printers, modems, etc.

To provide a clock for the USARTs, an 8253 counter/timer is used. The 8253 has three different divide-by-N counters in it. Two provide the transmit and receive clock pulses for the two USARTs. The third counter serves as a Real Time Clock for the μP. This pulse occurs every 5 ms, causing the processor to stop what it is doing and go do something else. In this case, the "something else" is updating the date and time, seeing if a Morse or RTTY character needs outputting from the buffer (into which characters have been entered from the keyboard), and so on.

Read-Out: A video interface can occasionally be more of a hindrance than a help. A TV monitor consumes a fair amount of power, takes up a lot of space, and is one more thing to carry around. For these reasons, and because of the ease of interfacing it to the 8085, a single-line display consisting of 16 alphanumeric characters was chosen. The display uses an 8279 programmable keyboard/display interface IC. As shown in Fig. 2, the ASCII subset coming out of the 8279 drives an 18-segment decoder/driver that provides segment data to all 16 display characters. Meanwhile, four lines of the 8279 are used to select one of the 16 characters. The scanning rate is set high enough that the eye perceives no flicker. The 8279 also detects the presence of an ASCII character from the keyboard. It then provides an interrupt to the microprocessor that reads the ASCII and does any necessary conversion (e.g., to Baudot or cw) by means of a lookup table.

Memory: The program is permanently stored in three 2732 EPROMs. Although the program occupies only about 10k bytes (about 6000 lines of program code), 16k bytes were allowed for. Some read/write memory (RAM) is also needed. Since a transmit buffer of 512 characters and eight general-purpose buffers of 64 characters each were desired, 1k bytes of RAM are required. To allow room for variables and stack, 2k bytes were chosen during design. Dupe checking also requires RAM, but it must be nonvolatile — memory that "remembers" even when the power is turned off. A lot of RAM is required because a single amateur call sign can use as many as 6 bytes (not including suffixes used to indicate portable operation). CMOS RAM was chosen because of low power requirements, permitting

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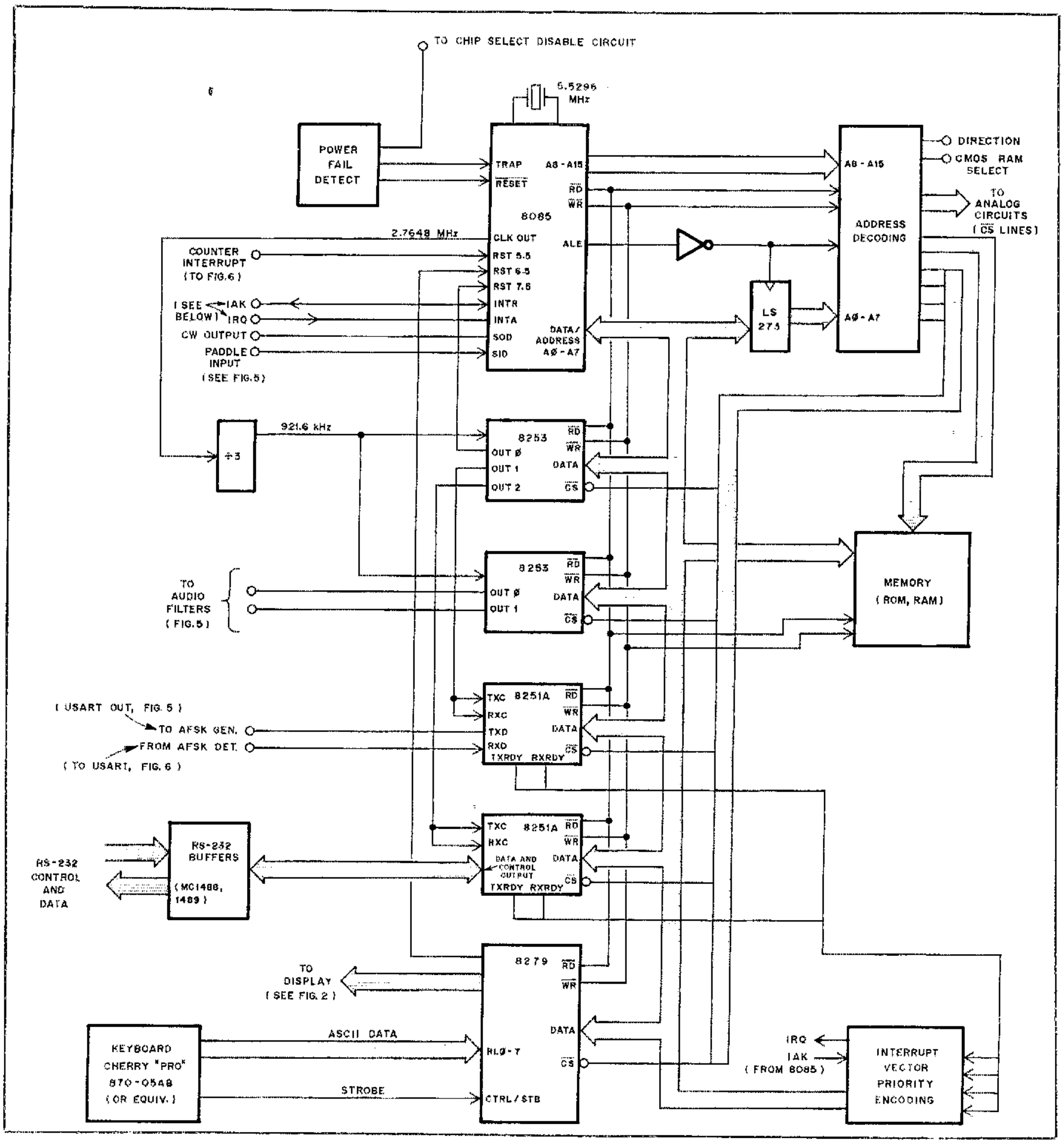
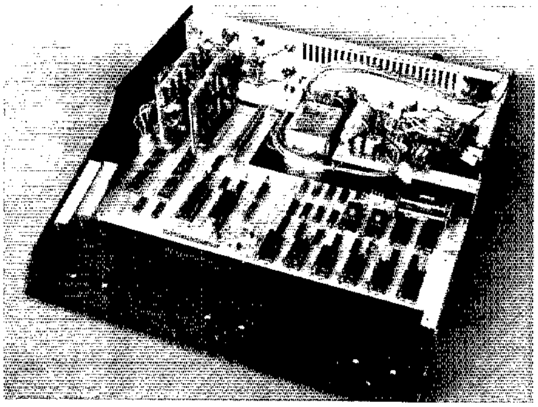


Fig. 1 — Block diagram of the Microprocessor-Controlled Contest Accessory.

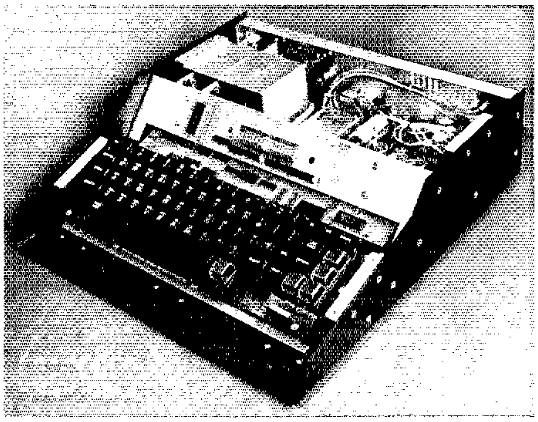
battery operation. The Hitachi 6116LP (2k × 8 static RAM) is used, since it can retain data with a potential as low as 2 volts applied. By using six of these ICs, a storage capacity of 12k bytes is obtained. This offers the capability of storing up to 1500 calls of six letters each, more than enough for many contests.

Fig. 3 diagrams the CMOS RAM interface to the μP and battery backup. NiCad batteries were chosen because of long life, rechargeability and terminal voltage. When the normal supply goes down, the diodes provide a smooth transition to the battery, and vice versa, when the power comes back on. The 2.7 volts supplied by the NiCads is reduced to about 2.3 volts after the diode. It takes about 40 hours for the battery backup to drop to 2 volts, at which point the memory starts "forgetting" data. For the 6116LP to retain data without drawing normal operating current (12 mA), V_{CC} must be greater than 2 volts, and all address, data and control lines at greater than V_{CC} − 0.2 volts or less than 0.2 volt above ground. This is accomplished easily by pulling all those lines up to V_{CC} with resistors. The resistor values must be large enough that the resultant current does not overload the stage connected to the RAM when the lines are low, but low enough that the signal rise time is not lengthened appreciably. For the data bus, 4.7-kΩ resistors are okay, but the address bus needs 1-kΩ resistors because of the high output capacitance of the 74LS05 drivers.

Note that the 74LS05 is an inverter, not a buffer. It may not be immediately obvious why the address lines can be inverted. The answer is that the memory is totally random access, and it is not used



Front view of the chassis with the top cover, keyboard and display removed. All the logic is located on the main controller board, which is fastened to the case bottom. The two vertically mounted boards to the left contain all the audio circuits.



Front view of the unit with the top cover removed. The display and keyboard assemblies are now in place. A retaining bracket (left rear of the chassis) secures the plug-in audio boards.

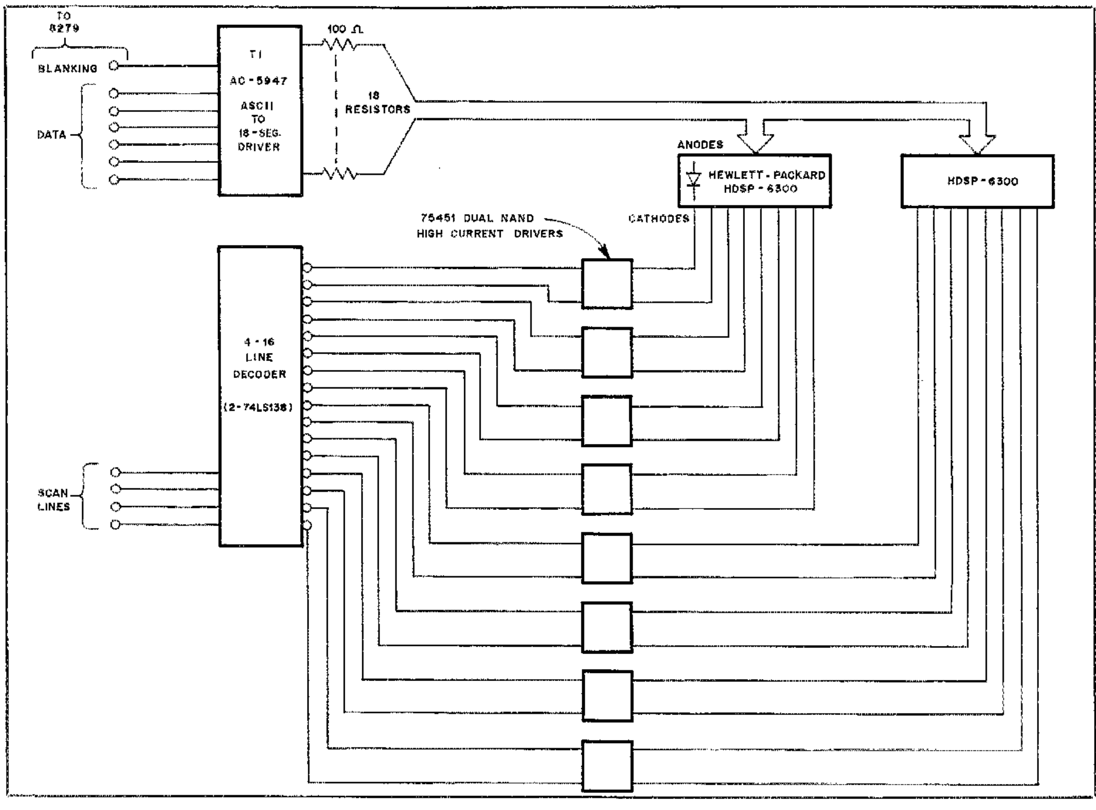


Fig. 2 — Block diagram of the display drivers.

for program storage. Thus, the data need not be stored in any particular address locations. Since it is desirable to isolate these lines from the TTL and NMOS circuit parts, devices with open-collector outputs are an obvious choice. This allows the lines to be pulled up to the V_{BB} battery-backup voltage, which is a requirement for data retention when the power supply is off, and avoids latch-up when power is applied or removed.

Fig. 3 also shows transistors being used to drive the chip enable ($\overline{CE}$), output enable ($\overline{OE}$), and read/write ($\overline{WR}$) lines. This was done to isolate these critical lines from the TTL and NMOS ICs in the circuit. In the case of the chip enable, it was also done to allow a power fail detection circuit to disable the memory as the power is applied or removed. Not any transistor can be used here. A good quality, high-speed switching transistor is an absolute must. The timing of the chip select and read/write pulses is on the order of 1 microsecond, and transistor storage times greater than about 60 nanoseconds cannot be tolerated or timing problems will develop between the data and the write signals. The transistor of choice for this application is the 2N3646, which has a storage time specification of about 35 nanoseconds.

Power-Failure Detection

A novel power-failure detection circuit is shown in Fig. 4. The LM10 is an ultra-low power op-amp that operates from a supply as low as 1 volt, while drawing only 270 μA! This means that it can be powered from the battery. It also contains a 0.2-V reference, which is multiplied by 7.81 to provide the other op-amp in the LM10 with a reference voltage of 1.56 volts. This second op-amp is run open loop as a comparator, getting some hysteresis from the 1-MΩ feedback resistor. The inverting input to the comparator is set to one-third of the power supply voltage, nominally 1.67 volts. This situation causes the output to remain low until the power supply potential drops to about 4.9 volts. At this point, the comparator trips, causing a Power-Failure (PF) interrupt to be signaled to the μP, which can then cleanly stop whatever it was doing. A delay circuit then causes point PF to go high about 2 ms later, disabling the CMOS RAM before the supply goes below 4.75 volts, the minimum voltage at which the processor circuit is specified to operate. The same delay circuit provides an output to the processor reset line so that when power is restored, the reset line will be activated about 30 or 40 ms after the supply has reached 4.75 volts. (The 8085 requires that reset be activated at least 10 ms after the supply has reached 4.75 volts and the clock is running.) This circuit assumes that the power-supply voltage decreases exponentially with a time constant of about 150 ms.

Analog Circuitry

Okay, so we have a μP capable of doing all sorts of wonderful things. How do you get from the digital world to the analog world? It's really pretty easy. The microprocessor provides signals that can be used to latch data from an 8-bit data bus into many flip-flops. These can be used to turn relays on and off, operate CMOS switches, enable sidetone amplifiers, and so on. The same signals allow data to be fed onto the data bus by means of tri-state buffers so that they can be read by the μP.

Greg McIntire showed how square-wave signals can be converted to sine waves by simply passing them through a

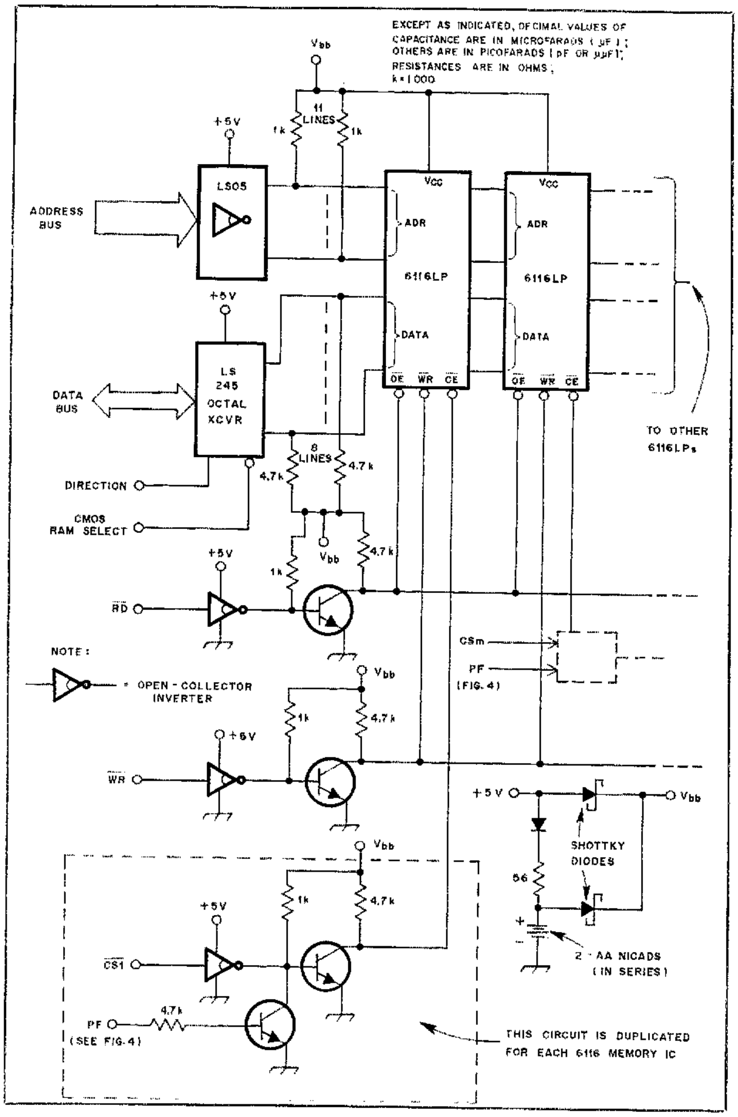
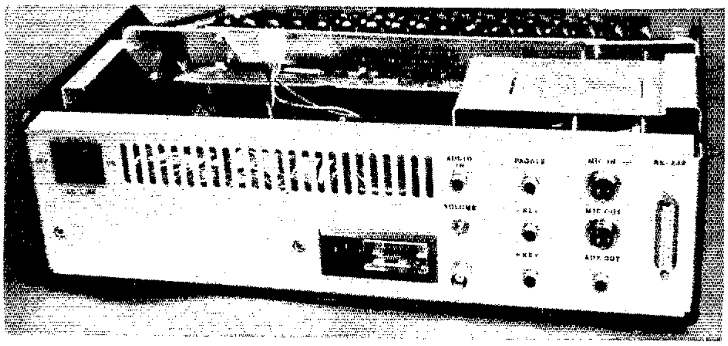


Fig. 3 — CMOS memory interface and battery-charging circuit diagrams.



Rear view of the unit. Ventilation holes are above the power supply.

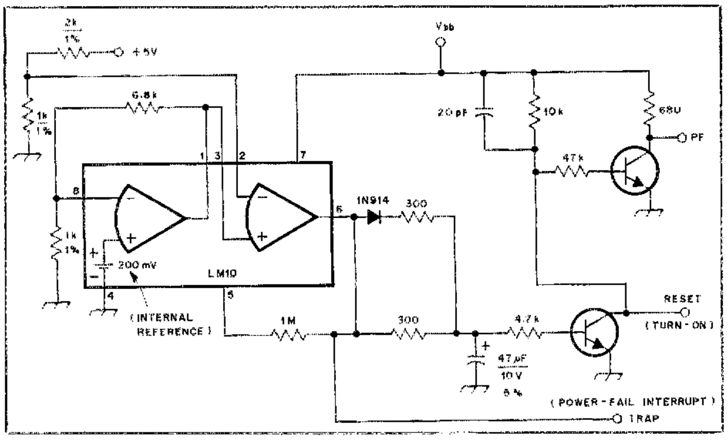


Fig. 4 — Schematic diagram of the power-on reset and power-fail detection circuits.

multipole low-pass filter.[1] I've carried the concept to a logical conclusion (see Fig. 5) by adding switchable breakpoints (by means of CMOS switching) and deriving the inputs from the programmable counter outputs, thereby achieving the ability to generate any combination of tones from about 500 to 3000 Hz. By allowing two tones to be on at once, Touch-Tone frequencies can also be created.

The output of the final filter stage is passed through CD4053 CMOS switches, which can be turned on and off independently by the μP programming, or they can be enabled alternately by the USART output, thus providing mark and space tones. These signals, along with the switched output of a microphone preamplifier, are then fed into an audio

[1]Notes appear on page 21.

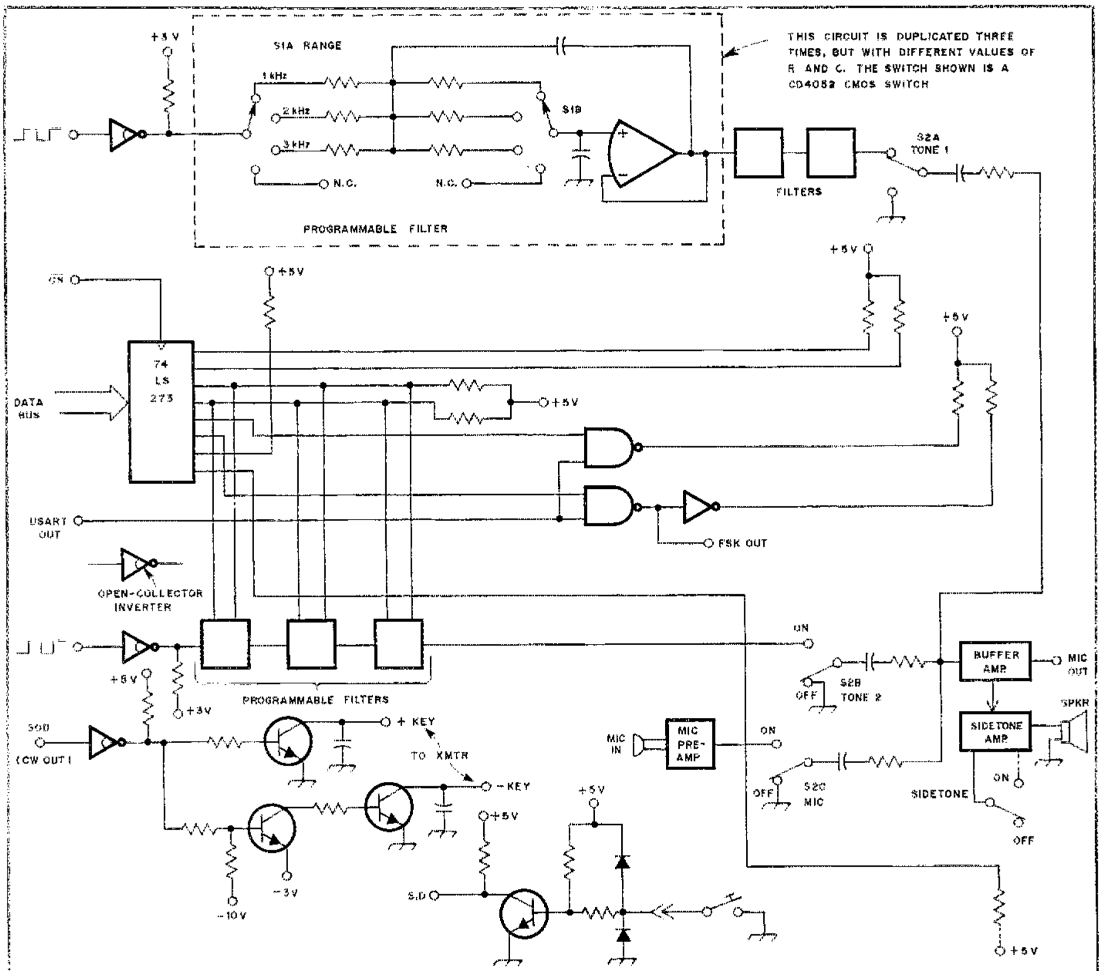


Fig. 5 — Block diagram of the tone output, sidetone, microphone, positive and negative keying lines and paddle-input circuits. S1 and S2 are CMOS switches. The programmable filter shown at the upper left of the diagram is duplicated three times in each channel.

mixer amplifier. This permits the microphone to be switched in when the tones are not used, and vice versa. The sidetone amplifier is driven from the mixer output so that cw, RTTY and Touch-Tones can be monitored. A small fringe benefit is that if the sidetone amplifier is turned on and the microphone enabled, a crude P.A. system evolves!

Cw output is produced easily by taking the SOD (Serial Output Data) line from the 8085 and driving a keying transistor directly; both plus and minus keying line polarities are accommodated. The software then turns that bit on and off, performing all the timing based on the 5 ms Real Time Clock interrupts.

Input Circuits

Receiving cw and RTTY requires more effort on the part of the programmer than does transmitting. The signal, once decoded, must be read by the μP, placed in a buffer and displayed in a timely fashion. For cw, the character must also be decoded in software, while RTTY characters can be decoded by the USART. There is much literature concerning which hardware techniques work best. A recent *QST* article contains a good circuit based on the use of an XR-2211 PLL.[2] Some experimenting showed that two '2211s could be used even more effectively, one being used for the mark frequency and another for the space frequency, with only one being used for cw. See Fig. 6. By setting the capture range to about 100 Hz, and then tying the Q output of one decoder to the $\overline{Q}$ output of the other, the PLLs work together, acting as an audio filter TU having very high values of Q.

In order to program the desired frequency, μP-controlled DACs (Digital-to-Analog Converters) are used. To compensate for drift, the PLL outputs can be fed into a counter and the counter set to cause an interrupt every 16 counts. In this manner, the center frequency of the PLLs can be computed, then corrected if in error. The PLLs have to be connected in a certain way to do this. CMOS switches allow the PLL reference to be fed back to the input, causing the lock-detect output to oscillate at the center frequency. Another switch allows one and then the other PLL output to be fed into the frequency counter for measurement.

For cw reception the output of one of the PLLs is fed directly to an input port. The Real Time Clock interrupt samples the bit every 5 ms and creates a count of marks and spaces. These counts represent the length of time that a tone was present or absent. The last 16 numbers are then averaged. Since the numbers include dots and dashes, and spaces between dots and dashes (a space being the same length as a dot between parts of a character or a dash length for spaces between characters), this average conveniently falls about halfway between a dot and dash length. This can be used as a criterion for determining what is a dot or dash in future incoming characters. This means the algorithm is constantly adjusting itself to the speed of the data being received.

Another feature of the algorithm is that once a space has been received, the current character (or space between words) can be displayed. It has always annoyed me that many algorithms wait for a character to start before displaying the last one received.

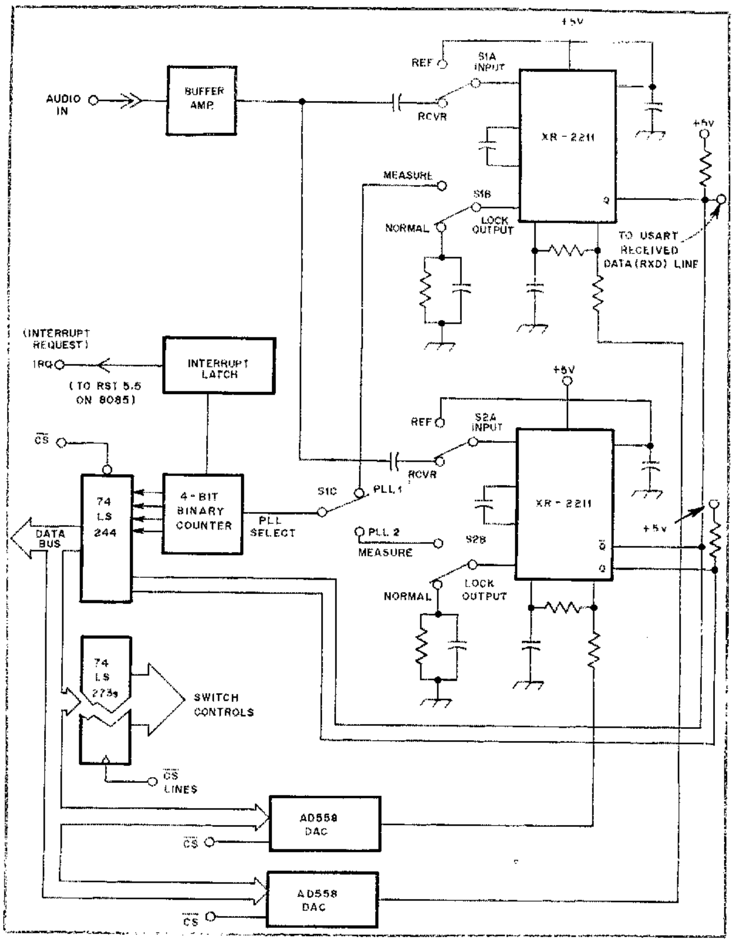


Fig. 6 — Separate PLLs are used for demodulating the mark and space signals. The action of this circuit is like that of an audio filter terminal unit having high Q values.

Software and Summary

One of the biggest hurdles in developing a device such as the one described here is writing the software to control it. I used a Heath H89 computer connected through an RS-232C link to a commercially available PROM programmer. It is impractical for me to provide listings of the program, since it is so long. However, individuals constructing this unit are welcome to contact me for programming advice.

It should be possible to buy all the necessary parts for this project (not including the chassis, keyboard, power supply or empty pc boards) for about $600. Space restrictions preclude presenting the entire schematic here, but a complete set of schematics is available from the author for $10. A set of empty, double-sided boards with plated-through holes, soldermask and silk-screened component designators (with schematics) is available for $250. The chassis shown in the photographs is priced at $175. A complete set of programmed ROMS is $100. Other parts and additional information are available from the author.[3]

Notes

[1] G. McIntire, "A Crystal-Controlled AFSK Generator," *QST*, December 1980, p. 27.
[2] M. Di Julio, "A State-of-the-Art Terminal Unit for RTTY," *QST*, December 1980, p. 20.
[3] The ARRL and *QST* in no way warrant these offers.

A 432-MHz Yagi for $9

This 22-element Yagi was designed with OSCAR Phase III in mind. Use of readily available materials makes it an attractive project.

By David O. Guimont, Jr.,* WB6LLO

Access to inexpensive but efficient equipment is a *must* if new technology is to remain within reach of the average amateur. Without returning to the oatmeal box and "cat's whisker," there are ways to keep our hobby an affordable one. This antenna is a step in that direction.

If all new material must be purchased, the cost of building this 22-element antenna should be about $9. (A complete list of necessary materials is presented in Table 1.) It is simple to build, weighs only 21 ounces,[1] and rolls into a compact package for storage or transport. A simple and inexpensive means may be employed to change polarization. The estimated antenna gain is 14.5 dB.

Construction

Refer to Figs. 1 and 2 and the photographs. Antenna element lengths and spacings given in Table 2 were selected from information in the 1982 *Handbook.*[2] Gamma matching is used for easy adjustment. The gamma-matching capacitor I used is a tubular ceramic type that is easy to weatherproof with a silicone sealant after matching adjustments are completed. Using copper wire for the driven element and gamma rod allows the use of solder during assembly.

All directors are made from no. 9 aluminum wire and are slightly flattened at a point 2-1/2 inches each side of center. Holes are drilled through the elements at these points to pass the 50-lb nylon fishing line that is used as a boom.

Cut the element spacers to provide the proper spacing as given in Table 2. Two scrap plastic spreaders are cut to a length of about 7 inches and drilled to pass the nylon line. One spreader is used at each end of the antenna. The insulated spacers and antenna elements are placed on the nylon boom as you would beads on a string.

The PVC pipe and T are assembled as shown in Fig. 1. This boom supports the copper wire driven element and single reflector, the latter of which is made of no. 9 aluminum wire. The assembly is fastened behind the first director as

Table 1
Materials List

- 19 ft — no. 9 aluminum wire (clothesline wire).
- 13 in. — no. 8 copper wire.
- 6 in. — no. 14 copper wire.
- 28 ft — insulating spacers (insulation stripped from no. 14 wire or equivalent).
- 21 in. — 1/2-in. schedule 40 PVC pipe.
- 1 — 1/2-in. schedule 40 PVC T.
- 40 ft — 50-lb-test monofilament nylon fishing line.
- 2 — snap swivels.
- 1 — SO-239 chassis connector.
- 2 — plastic spreaders, 6 × 3/8 × 3/16 in.

Table 2
Antenna Element Lengths

Element	*Length*
Reflector	13-3/32 in.
Driven	12-23/32 in.
1st director	11-27/32 in.
2nd director	11-5/8 in.
3rd director	11-1/4 in.
4th director	11 in.
5th director	10-29/32 in.
6th director	10-13/16 in.
7th to 20th director	10-11/16 in.

Note: The reflector to driven element spacing is 5-1/2 in. Spacing between all directors is 8-7/16 in.

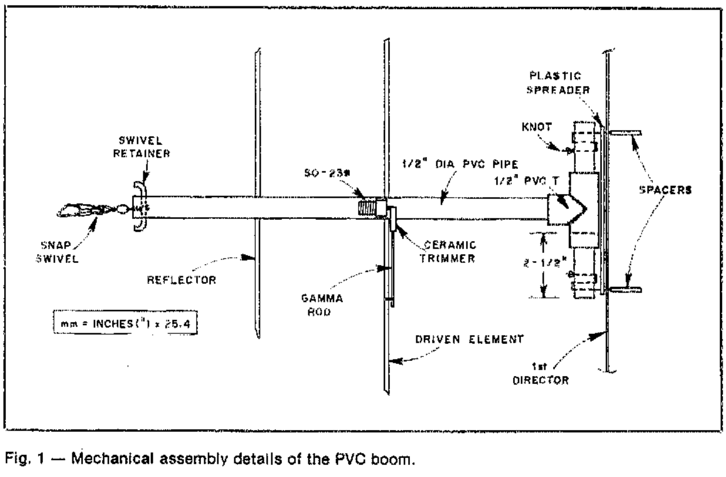
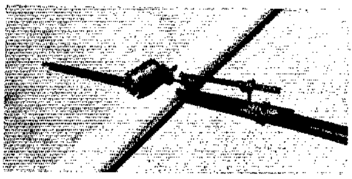
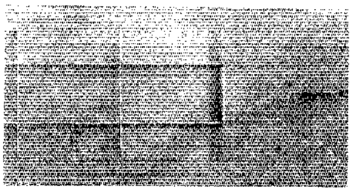


Fig. 1 — Mechanical assembly details of the PVC boom.

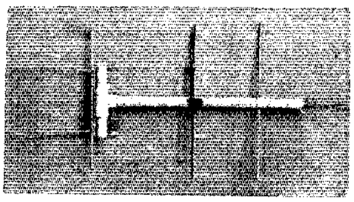
[1]Notes appear on page 23.
*5030 July St., San Diego, CA 92110



Close-up view of the gamma matching section and driven element. Use of copper wire makes the assembly easy.



This shows the arrangement of the last three directors on the nylon fishing-line boom. The elements are separated by spacers fashioned from pieces of insulation removed from lengths of no. 14 wire. One of the plastic spreaders is next to the last director.



A short PVC boom supports the reflector and driven element. The PVC T at the left provides a means of attachment to the rest of the antenna.

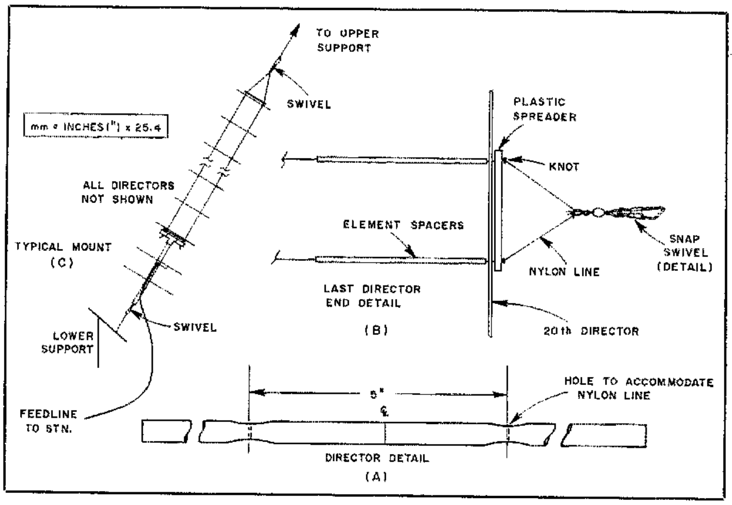


Fig. 2 — At A, the method used to fashion the director elements. A detail of the assembly at the 20th director is shown at B, while a typical method of installation is depicted at C.

shown. An S turn of nylon line at each attachment point is used for tension adjustments. Snap swivels at the antenna ends permit it to be rotated easily to change polarization. The lower end of the antenna can be positioned to adjust antenna elevation and azimuth.

Results

All antenna testing was done using Mode J (2-meter uplink and 70-cm downlink) receive. In every case, the home-made antenna outperformed an 11-element Yagi with a preamplifier mounted on the boom. (Without the preamplifier, the 11-element Yagi produced signals that were barely discernible. Use of the preamplifier provided readable signals.) For both horizontal and vertical polarization of the antenna, the indicated beamwidths are 30°.

Now that you've got a simple and inexpensive way to build a gain antenna, why wait any longer? Let's hear you through OSCAR!

Notes

[1]g = oz × 28.35; mm = in × 25.4; kg = lb × 0.454.
[2]Element lengths were derived from Table 4, p. 21-5 and element spacings from Fig. 4, p. 21-4.

Strays

MARCONI ANNIVERSARY DEMONSTRATION A SUCCESS

☐ With Guglielmo Marconi's daughter among the 500 at Columbia University in New York City waiting patiently, the crackling sound came through loud and clear: a long tone, followed by three short ones. The group, which had just heard Mrs. Gioia Marconi Braga finish an address, was commemorating the 80th anniversary of the first transatlantic radio communication.

The re-creation of the Morse code signals that originated from Cornwall, England, was organized by G3ZPW in England, VO1HP in Newfoundland and a group of amateurs in New York. The New York hams linked a local hf station with a Metroplex 2-meter repeater to broadcast the signals to the audience at Columbia. — *John Smale, K2IZ, SCM NY-LI*

Following the successful demonstration of how Marconi heard the first transatlantic radio communication, members of a group that arranged to broadcast the signals to an audience commemorating the event were all smiles. From the left: WA2LVY, KH6IQD, Mrs. Braga, K2IZ and WA2OVG.

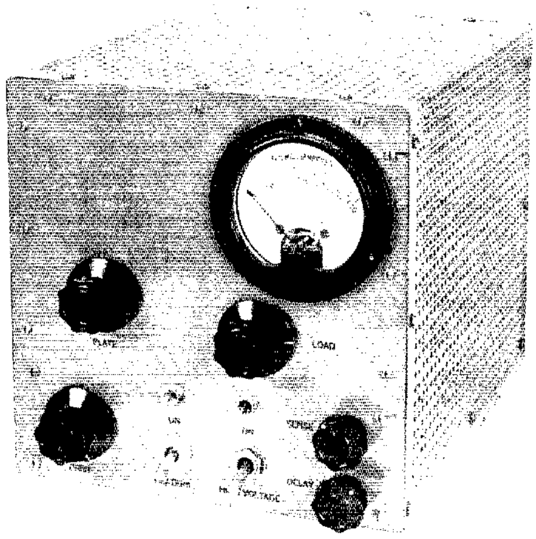
ROANOKE DIVISION PLANS PLANNING SESSION

☐ This year's Roanoke Division League Planning Meeting will cover all phases of Amateur Radio. Under the joint sponsorship of the Raleigh and Cary (North Carolina) ARCs, it will be held May 22 and 23 at the Crabtree Sheraton Motor Inn, Raleigh. Information and pre-registration information is available from Sherman Starnes, W4TZU, Rte. 1, Box 99, Franklinton, NC 27525. — *Gay Milius, W4UG, and Chuck Littlewood, K4HF*

I would like to get in touch with . . .

☐ other Vibroplex key owners who can provide information on the relationship between serial number and date of manufacture. Richard W. Randall, K6ARE, 1263 Lakehurst Rd., Livermore, CA 94550.

Build A 6-Meter "Mini-Lini"



Tired of being a QRP station? Boost your low-level signal with a pair of sweep tubes.

By Wilson Hoag,* WA5OLT

Is low power enough for equality on 6 meters? Perhaps, but it has long been my contention that some stations are more equal than others! One of the great features of 6 meters is the ability to make contacts with just a few watts when the band is open. As solar activity begins to decline, band openings will be shorter and less frequent. This amplifier will add punch to your QRP signal.

The current offerings of solid-state 6-meter transceivers and transverters provide operating ease and good signal quality, but at the expense of rf power output. This, coupled with the paucity of linear amplifiers, resulting from the infamous amplifier ban, has caused an overall reduction in the average power output on 6 meters.

When I acquired my first solid-state rig (an IC-551) some time back, my tendency was to use its scan feature to locate a signal and then work the station with a 240-watt tube-type rig. A minor panic occurred when the tube rig "rolled over and died" midway through the '79-'80 F2 season. The Mini-Lini resulted from that panic.

Design Approach

The amplifier was designed to be compatible with common power supplies, use a readily available tube, provide push-to-talk operation with the IC-551 and have approximately the same rf output as most tube-type transceivers. Fortunately, a design incorporating most of these features had been developed by Ed White, WA5RIA.[1] The major changes I made were in the methods of switching and bias adjustment. The tube used is the 6JB6, which is inexpensive, available and "happy" at 50 MHz. The biasing arrangement, an idea borrowed from Doug DeMaw,[2,3] allows the tubes to be matched for safe parallel operation. This amplifier provides about 50 watts of output when driven by a 10-watt exciter. More than one year of almost daily use has been trouble free and productive (42 states, including KH6 and KL7, plus JA and several Europeans).

Circuit Details

The circuit is conventional and typical of many low-band amplifiers. The original design used a capacitive input, but I thought that the parallel-tuned input method shown in Fig. 1 would provide more output when used with other QRP drivers. This was proven in practice: The amplifier delivers about 20 watts of output when driven by an IC-502. The potential problem of operating unmatched tubes in parallel has been avoided by biasing each tube individually. Component values shown will allow coverage of the entire 6-meter band.

The output network will not reject harmonic energy, and the second harmonic, as measured in the ARRL lab, was less than 40 dB below the fundamental (Fig. 2). This works out to a healthy 5 mW at 100 MHz. Most fm receivers in the neighborhood will detect this easily. FCC requirements for a commercial amplifier at this frequency are to have all spurious radiation at least 60 dB below the fundamental.

To meet this requirement (and to prevent a lot of RFI complaints) a 7-pole Chebyshev low-pass filter was built from data given in the 1982 *Radio Amateur's Handbook*, pages 6-11 and -12. Details of a filter with 0.01-dB of ripple and a 60-MHz cutoff frequency are given in Fig. 3. The coils can be wound on toroids, or be air-core types. Amidon T44-10 (or larger) cores should be adequate. The number of turns required will depend on core size or coil diameter, and can be calculated from data given on pages 2-12 and 2-30 of the *Handbook*. This filter reduced the second harmonic output to more than 65 dB below the fundamental (completely gone for all practical purposes). See Fig. 4.

Construction

It should be possible to duplicate this amplifier for $40 or less, depending on the status of your junkbox. Oddly enough, the tube sockets proved to be the most difficult component to locate, since they are not a common catalog item. The 6JB6 uses a 9-pin NOVAR socket, and the best source turned out to be a shop that specialized in TV replacement parts. Tuning capacitor C4 is a junkbox item of questionable parentage. Any spacing greater than about 0.060 inch (mm = inches × 25.4) should be okay. RADIOKIT of Greenville, New Hampshire would be a good source for all of the variable capacitors.

My amplifier is constructed on an 8 × 10 × 2-1/2 inch chassis (BUD AC-1418) for a base, with 8 × 8-inch end panels. The panels were flanged with 1/2 × 1/2-inch aluminum channel for attachment of a cane-metal cover for safety and TVI protection. Component placement is not critical, but all component leads should be as short as possible. The

[1]Notes appear on page 26.

*1704 Venetian Circle, Arlington, TX 76013

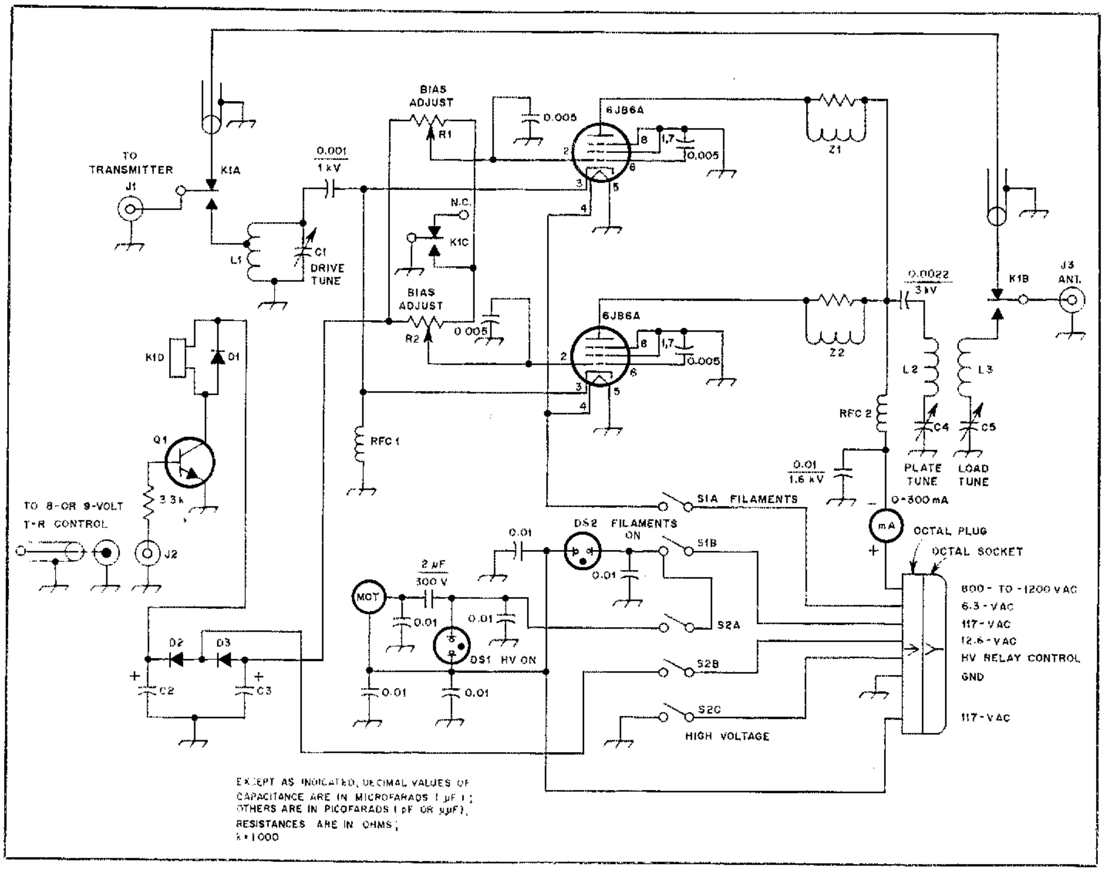


Fig. 1 — Schematic diagram of the 6-meter linear amplifier. The tube filaments can be wired in series, eliminating the need for a separate 6.3-V supply.

C1 — 50-pF miniature air variable, Cardwell 148-4 or equiv.
C2, C3 — 220-µF electrolytic, 50 V.
C4 — 25-pf air-variable, wide-spaced Hammarlund HF30X or equiv.
C5 — 100-pF air variable, Johnson 149-5 or equiv.
D1 — 1N914.
D2, D3 — 1 A, 50 V.
J1, J3 — SO-239.
J2 — Phono jack.
K1 — 3pdt 12-V dc coil, rf type preferred, or KRP14DG.
L1 — 6 turns no. 14 enameled wire, 1/2-inch ID × 1-inch long, tapped at approximately 1-1/2 turns.
L2 — 5 turns no. 12 enameled wire, 1-1/2 inch ID × 2-1/2 inches long.
L3 — 2 turns no. 12 enameled wire, 1-1/2 inch ID × 1/2-inch long.
mA — 0-300 mA dc meter.
MOT — 117-V fan motor.
P1 — Chassis-mount octal plug.
Q1 — NPN power transistor, TIP31 or equivalent, (RS no. 276-2017).
R1, R2 — 10-kΩ, 2-W potentiometer.
RFC1 — 300-µH choke with ferrite bead on the ground lead.
RFC2 — 83 turns no. 28 enameled wire on a 1/2-inch diameter ceramic form. The coil is 2 inches long.
Z1, Z2 — 1 turn no. 16 enameled wire on 47-Ω, 2-W resistor.

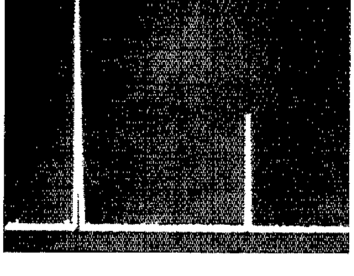


Fig. 2 — Spectral display of the amplifier output. Vertical divisions are each 10 dB, and horizontal divisions are each 10 MHz.

resulting layout was determined largely by some mid-project design changes aimed at making the unit compatible with a newly acquired IC-502. Visible on the lower-right front panel are potentiometers that were reserved for control of a planned rf-operated T-R relay.[4]

The tube sockets are modified slightly to ground the necessary tube elements. Copper washers, cut from flashing copper, fit inside the pins on the underside of the sockets. Pins 1, 4, 7, 8 and 9 are bent over and soldered to the washer. The washers are grounded to the chassis with short pieces of no. 14 wire on opposite sides of the socket. Pins 2 and 6 of both tubes are bypassed to ground by connecting 0.005-µF disc-ceramic capacitors from these pins to the copper washers (Fig. 5). The control grids are raised above dc ground while providing a path for rf return. It also permits us to apply a dc bias to the control grid. This will establish the class of operation and cut the tubes off during receive, if desired.

Coils L1, L2 and L3 are wound with solid TW-insulated house wire from the local hardware store. I stripped the insulation from the wire before winding L1 and L2, but left it on L3 to prevent accidental contact with L2. The inside diameters shown are more the result of

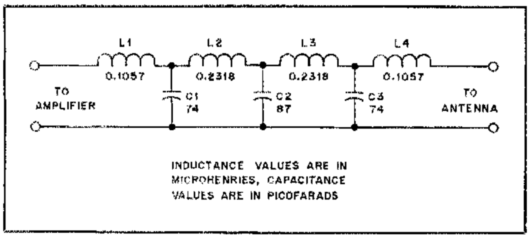


Fig. 3 — Schematic diagram of a 7-pole Chebyshev low-pass filter. Capacitors are silver-mica units, combined in parallel or series to obtain the design values. The text has information about winding the inductors.

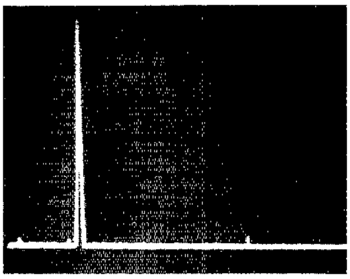


Fig. 4 — Spectral display of the amplifier output with a 7-pole Chebyshev filter. Vertical divisions are each 10 dB, and horizontal divisions are each 10 MHz.

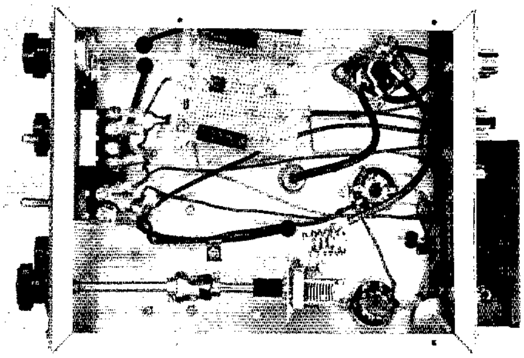


Fig. 5 — Bottom view of the amplifier chassis. Note the washers on the tube sockets, used to provide a ground connection for the appropriate pins.

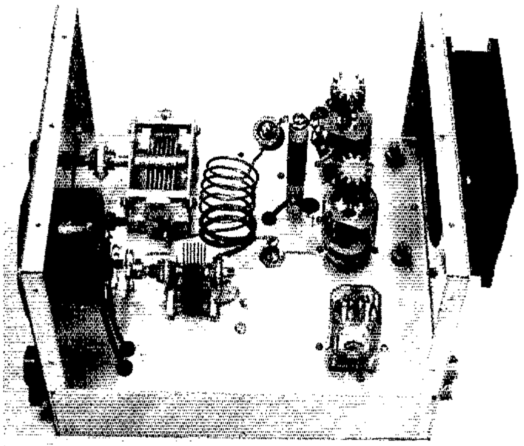


Fig. 6 — Top view of the Mini-Lini chassis. Large heat-dissipating plate caps and a fan help maintain cool operation of the tubes.

available cylindrical shapes than any electrical calculation. Coil spacing was adjusted, with the tubes in place, using a dip meter to ensure resonance at the proper frequency.

Heat-dissipating plate caps and a small fan provide cooling for the tubes. See Fig. 6. No thermal distress has been evident under any operating condition. The fan can be wired through S1 or S2, depending on whether cooling is desired during standby operation. Power connections to the fan should be isolated from the chassis.

A possible modification, shown on the schematic diagram, involves the use of a 3pdt relay for K1. The ground legs of R1 and R2 can be wired through one of the normally open contacts. This lifts the potentiometers above ground in the receive mode, applying full bias voltage and cutting off the tubes.

The bias voltage source and relay driver are "hard wired" on a small piece of perf board. The signal for T-R switching is applied to J2. This +8-V signal is obtained from pin 6 of the IC-551 accessory socket. For use with other rigs, a 9-V battery, wired through a foot switch, works well. Current drain on this battery is low. An rf-operated T-R relay could be used in place of the directly keyed one described in this article. S2 disables the relay driver by removing the 12.6-V ac source in the standby position to permit straight-through operation.

Tune-Up and Operation

Initial tune-up is simple and ordinary. Connect a dummy load and the power supply to the appropriate jacks. Any high-voltage power supply that has an output of 750- to 1200-V dc should be satisfactory. Turn on S1 and allow the heaters to warm up for a minute or more. Switch S2 to turn on the other voltages. Actuate K1 to ground the bias resistors, R1 and R2. Adjust R1 and R2 to obtain 15 mA of idling current for each tube (30 mA total).

Connect the exciter to the amplifier through an SWR indicator. Actuate K1 and apply a small amount of drive. Adjust the position of the tap on L1 for minimum SWR. Be sure to remove all voltages each time you move the tap position!

Next, apply drive to the amplifier and adjust C1, C4 and C5 for maximum power output. For those lacking a wattmeter, an SWR indicator set in the FORWARD position can be used in the line between the amplifer and the dummy load.

Conclusion

The Mini-Lini should be ideal for those looking for more output from their solid-state rigs. Typical operating parameters are 50 watts out for 10 watts of drive, with 1050-V dc on the plates. Reports of signal quality have been complimentary. Enhance your "equality" and come join the fun on 6! I would be happy to answer any questions about the amplifier — enclose an s.a.s.e., please.

Notes

[1]The design was taken from personal correspondence with Ed White, WA5RIA.
[2]D. DeMaw, "Some Ground Rules for Sweep-Tube Linear-Amplifier Design," *QST*, July 1968, p. 30.
[3]D. DeMaw, "Some Thoughts About TV Sweep Tubes," *QST*, Feb. 1980, p. 11.
[4]D. DeMaw and J. Rusgrove, "An RF-Sensed Antenna Change-over Relay," *QST*, Aug. 1976, p. 21.

Noise-Mode Communications

Noise has always been considered the enemy of DX (weak-signal) communication. But not now — not when it can work *for* you!

By A. R. Eskay,* W6WQC

In 1948 Claude Shannon, the brilliant Bell Labs scientist, published his famous treatise, "A Mathematical Theory of Communications," in which he showed that communications is corrupted by noise. Notwithstanding the profound and far-reaching impact this had in academic circles, it is hardly the sort of statement that excites the amateur fraternity.

As hams, we are doomed to live in a world of perpetual and insufferable noise. This causes us to go to extraordinary pains to lessen the devastating effect noise interference imposes on our efforts to communicate with each other. Consider that the more resourceful and enterprising in our ranks expend a great deal of time, money and effort to reduce noise interference. We seek a quiet location, erect enormous and elaborate antenna arrays, and invest in sophisticated and expensive receiving equipment. Moreover, most of us devote a substantial amount of time developing the ability to copy through noise.

Not long ago, while struggling to fathom the subtle intricacies of Shannon's abstractions, I began to think about ways hams deal with the noise problem in order to make the best of a bad situation. I recalled a statement made by Professor G. Garson Darby, inventor of the correlated vertical phase filter, in one of his lectures: "Do not attempt to eliminate system anomalies until you are sure that they can't be made to work for you." It's a fact that noise is always louder by several orders of magnitude than the signal we wish to copy, and it occurred to me that if we can *use* noise, we are better off with it than without it. Subsequent investigations, based on the feasibility of using noise to convey intelligence, proved to be theoretically sound. I realized that everything we have been doing for the past 70 years was all wrong.

*30 Sonorous La., Van Noyes, CA 91444

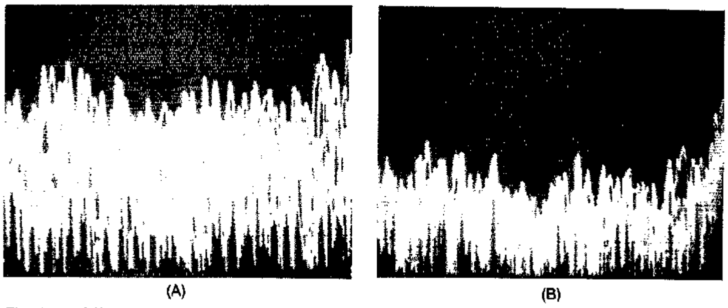


Fig. 1 — "Off-the-air (spectrogram) of noise under varying conditions. Scale: 1 cm = 0.01 sec., BW = 2.45 kHz. (A) Typical sample when noise level isn't important. (B) Normal 20-dB degradation of S/N during important communication. Compare with A and note difficulty of copy. (Experimental noise-mode communication photos courtesy NMC Corporation.)

On strictly logical principles nothing compels us to reject noise as being inherently incapable of serving a useful purpose. In the beginning we made a choice to use generated carriers — we simply made the wrong choice and have been stuck with it ever since. Of course this is contrary to the traditionally accepted way of viewing the phenomena of electrical communication, and it takes a little getting used to.

In engineering terminology the word "noise" does not necessarily refer to static. "Noise" is any unwanted disturbance within the useful frequency band. It is also defined as anything that interferes with transmission or that does not carry relevant information. From these definitions it follows that we can regard carrier signals as the unwanted component, and static as the desired component, in the transmission circuit. I have named this new concept "Noise Mode Communication" (which demonstrates that creativity in one area can lead to lack of imagination in another).

In cw we key our transmitters on and off. On the other hand, Noise Mode Communication requires that we key our transmitters off and on, so that intelligence is conveyed during the key-down, transmitter-off intervals. In its practical application, this requirement is ridiculously simple. All that is required is a single inverter in the keying lead. If you are using a keyer with relay output, you need only reverse the interface with the transmitter key input. This modification results in maximum noise during key-down transmitter-off conditions.

Wishing to verify the practicability of the idea, I conducted a series of classical A-B type comparisons. First, I would contact a weak DX station and ask for a signal report. Invariably and after several repeats the answer was always UR DOWN IN THE NOISE OM, PSE RPT. I would then ask the DX op to convert to noise keying and QRS to 3 wpm. The reason to QRS will be explained shortly. When this was accomplished I was copying noise at 40 dB over S9! (The ambient noise level at my QTH is +40 dB.) This was a mind-boggling experience, to say the least.

Then I would switch over to noise keying and ask the DX op to concentrate on the noise. He (or she) experienced equally astounding results. Ample documentation to this exists in the form of hundreds of QSLs with noisy reports on my walls.

Those who take pride in their ability to copy conventional code at elevated speeds are in for a surprise when attempting to copy noise code. When I first tried it I was shocked to discover that my code speed had dropped from 45 wpm down to 2 or 3 wpm. After several weeks my speed was up to 13 wpm, where I languished a while at the 13-wpm plateau. However, diligent practice and perseverance resulted in a gradual and steady increase, until now I am up to about 20 wpm comfortable copy. This interesting and unforeseen turn of events appears to involve psychophysiological considerations that I have not yet had time to investigate. I suspect that it is more psycho than physio, because we have to retrain ourselves to copy noise while disregarding carrier signals. This is compounded by the fact that sending remains conventional. I must warn you that the mental effort to do this is formidable, but it can be done. In this respect things are opposite to that which we are accustomed. For example, CQ sounds like a noisy dididit dididit.

After further reflection on the matter, I began to suspect that there should be no need for carrier signals at all because they are now the disturbing influence. Theoretically, carriers could be eliminated entirely, just as with conventional signaling, where we desire to eliminate noise static altogether. To put this theory to the test, I devised a series of experiments to verify the hypothesis. One evening I snagged a weak ZS on the low end of 40 meters. He was QRP with 2 watts. I asked him to reduce his power gradually and, as he did so, I was able to copy more and more of the noise until finally, at maximum noise, I asked what his power input was. To this he replied that his transmitter was turned *off*!!! Before I could recover my wits and continue the experiment, a W5 plopped down on the frequency, began calling CQ and completely obliterated the QSO. I suspect the experience completely unhinged the ZS, since he has not made a reappearance on the band.

Those of us who are already blessed with high ambient noise levels are ideally situated to take advantage of noise mode communications, but there are several things the rest of you can do to enhance the receiving environment. First, move into a noisy location. A location near or adjacent to high-tension lines is perfect. Second, erect a simple nondirectional antenna, preferably a vertical with no ground system. Third, discard your expensive receiver and procure a broadband job. Almost anything will do. The idea is to pick up as much noise as possible. Remember — *the noise is the signal.*

It is interesting to note that all future would-be hams have an enormous advantage over the rest of us. They can start copying noise right off. Furthermore, they are not likely to have foolishly invested in low-noise receiving setups or to have squandered their budgets on directional gain antennas.

Telephony

Now a word to you ssb phone adherents. As you are no doubt aware, new but yet-to-be-realized 'phone communication schemes utilize digitally synthesized voice techniques. In a sense, this is nothing more than an imaginative form or adaptation of cw, which uses only the dits and not the dahs. Begin to see the picture? Practical experiments along those lines have not yet been implemented, however, and this topic will have to await a future report.

If you are to take full advantage of the fantastic results noise-mode communications has to offer, it is absolutely essential that you understand the basic concepts. A few well-meaning but misinformed critics insist that the key-up transmitter carrier must not only still exist but must necessarily be of sufficient strength to break up the noise into discernible dots and dashes. This is utter nonsense. It is just as preposterous as saying that noise static is required to separate conventional signaling into recognizable dots and dashes. This, of course, is absurd.

Other experimenters who have likewise failed to grasp the essence of noise-mode communication have attempted to modulate their rigs with noise generators. I'm sure you have heard these intrepid souls many times in DX pile-ups. Again, this will not work because it is primarily the ambient noise at the receiving end that is heard by the receptee. In fact, to maximize the noise at the receiving end we must radiate the least amount of power necessary to maintain the contact. This point is one which has been stressed repeatedly in the ham literature for as long as any of us can remember.

Proof

For engineer types, mathematically rigorous proof can be demonstrated by the following process. Let the "goodness of copy" (defined as the Readability Quotient, RQ) be equal and directly proportional to the signal-to-noise ratio. Thus,

$$RQ = \frac{S}{N} \qquad \text{(Eq. 1)}$$

where

RQ = readability quotient
S = signal (noise)
N = noise (carriers)

Clearing fractions,

$$NRQ = S \qquad \text{(Eq. 2)}$$

Finally, transposing terms but maintaining the identity,

$$S = QRN \qquad \text{(Eq. 3)}$$

Since QRN is the Q code for noise, this proves our basic premise.[1]

The only drawback to noise-mode communication is that it doesn't sound good. No, it does not. But that is the price we have to pay for vastly increased communications efficiency. If this proves to be an insurmountable obstacle there are a few things you can try. After all, onions are not everybody's cup of tea. You can add a narrow flat-topped, steep-skirted filter to the receiver to cut out most of the noise. Fortunately, noise information content is not band limited, owing to its non-recurrent nature. Next, install a multielement directive antenna high up and in the clear. The noise-to-signal ratio will be drastically reduced immediately. As a last resort, convert to carrier signaling. Lo and behold, you will find the signal-to-noise ratio has increased dramatically. A random sampling of hams using these techniques revealed a unanimous consensus that the higher the signal-to-noise ratio the better the sound. If this sounds too easy, be forewarned that you must now relearn the code. For example, CQ will now sound like dahdidahdit-dahdahdidah! Finally, you must make a conscious effort to disregard the noise.

There you have it. All the information you need to make the best choice between two possible worlds. See you on the low end.

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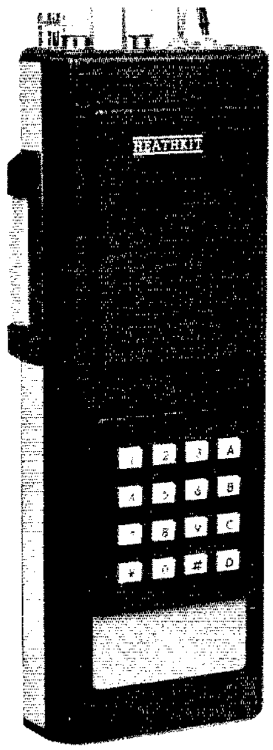
[1] An alternative derivation has been developed by my friend Gideon Fanshaw using the Method of Least Squares. It lacks the elegant simplicity of the proof presented here.



A Modern Synthesizer for Portable VHF Transceivers

Build this synthesizer and you'll never be "rockbound" again!

By Al Helfrick,* K2BLA

It wasn't too many years ago that the synthesized amateur transceiver was regarded as a modern triumph that allowed extreme versatility of vhf operation. Today, the ultimate in vhf fm equipment is the synthesized hand-held transceiver, which provides the same versatility in a pocket-sized package. Generally, the synthesizers used in these hand-held units are well-packaged versions of those used in mobile transceivers. Most portable synthesizers use a crystal offset oscillator to lower the frequency from the VCO to a range suitable for the programmable divider. Use of an offset oscillator not only lowers the VCO frequency from the vhf range but also allows some frequency manipulation. The major disadvantages of the offset oscillator, aside from the required additional hardware, is the possibility of generating spurious signals and the need to accurately control the offset oscillator frequency.

A synthesizer design, superior in many areas, is the dual-modulus programmable divider in a single loop. This design has the advantage that only one IC need operate at the vhf range, while the majority of the digital logic operates at a much lower speed. For a complete discussion of the dual-modulus programmable divider as applied to vhf synthesis see Ref. 1 and 2.

The vhf dual-modulus programmable divider requires one ECL integrated circuit. Unfortunately, ECL ICs are notorious for high supply currents and most ECL dual-modulus prescalers are not suited for portable equipment. Recently, some manufacturers have been developing lower-power ECL dual-modulus prescalers for use in portable communications equipment. An advantage of the dual-modulus synthesizer is that it is completely digital and therefore can be compressed to fit into small equipment.

Another recent development, making possible the use of the all-digital synthesizer in portable equipment, is the development of CMOS LSI synthesizer chips made especially for the dual-modulus prescaler. There have been, for several years, LSI synthesizer chips that were developed for citizens band transceivers, entertainment receivers and other applications. Synthesizers using these chips required an offset oscillator to reduce the VCO frequency and suffered other disadvantages with programming. A dual-modulus prescaler used with a CMOS LSI logic chip is the basis for the synthesizer described here.

Unfortunately, even the CMOS chip has a disadvantage. The programming for the LSI chip is in the form of pure binary. Even worse, the data is fed into the chip in a serial format. This is done to reduce the number of pins required on the IC. If the programming data were fed into the IC in parallel form, the IC would be in a 28-pin package and would, therefore, be much larger. The synthesizer chip is intended to be used with a microcomputer where the proper serial data can be generated within the computer. The microcomputer in portable equipment poses a serious problem. Most microcomputer chips are made with either PMOS or NMOS technologies and require more power than can be safely provided by a battery supply. Although CMOS microcomputers exist, programmable ROMs are not generally available in CMOS. Therefore, in this design the binary serial data is generated with conventional CMOS logic circuits from a keyboard entry. Although quite a few ICs are required, the total power requirement is only a few microwatts.

The synthesizer is designed to operate with transceivers that require only one crystal per channel. This eliminates the requirement to rechannel the synthesizer between transmit and receive, and eliminates the need to tailor the synthesizer for a specific i-f. There are several transceivers using a single crystal, including the Heath VF-2031, which I chose for modification.

The synthesizer (Fig. 1), excluding the programming logic, is extremely simple.

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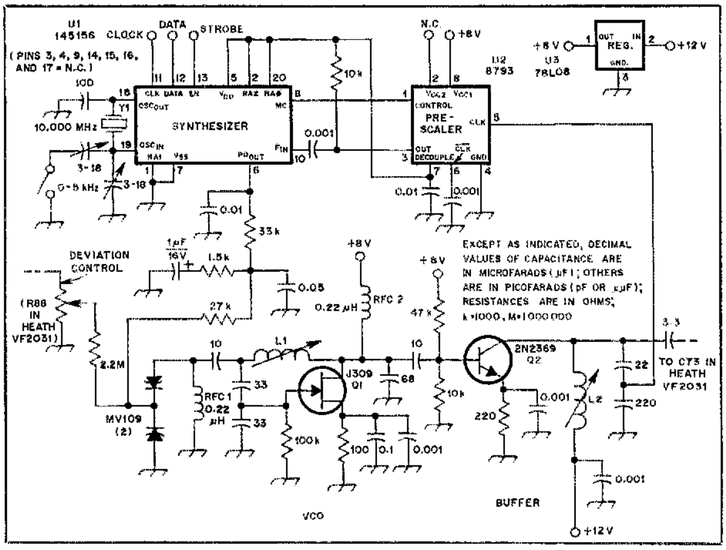


Fig. 1 — Schematic diagram of the frequency synthesizer. All resistors are 1/4-W, 5% carbon-film or composition types.

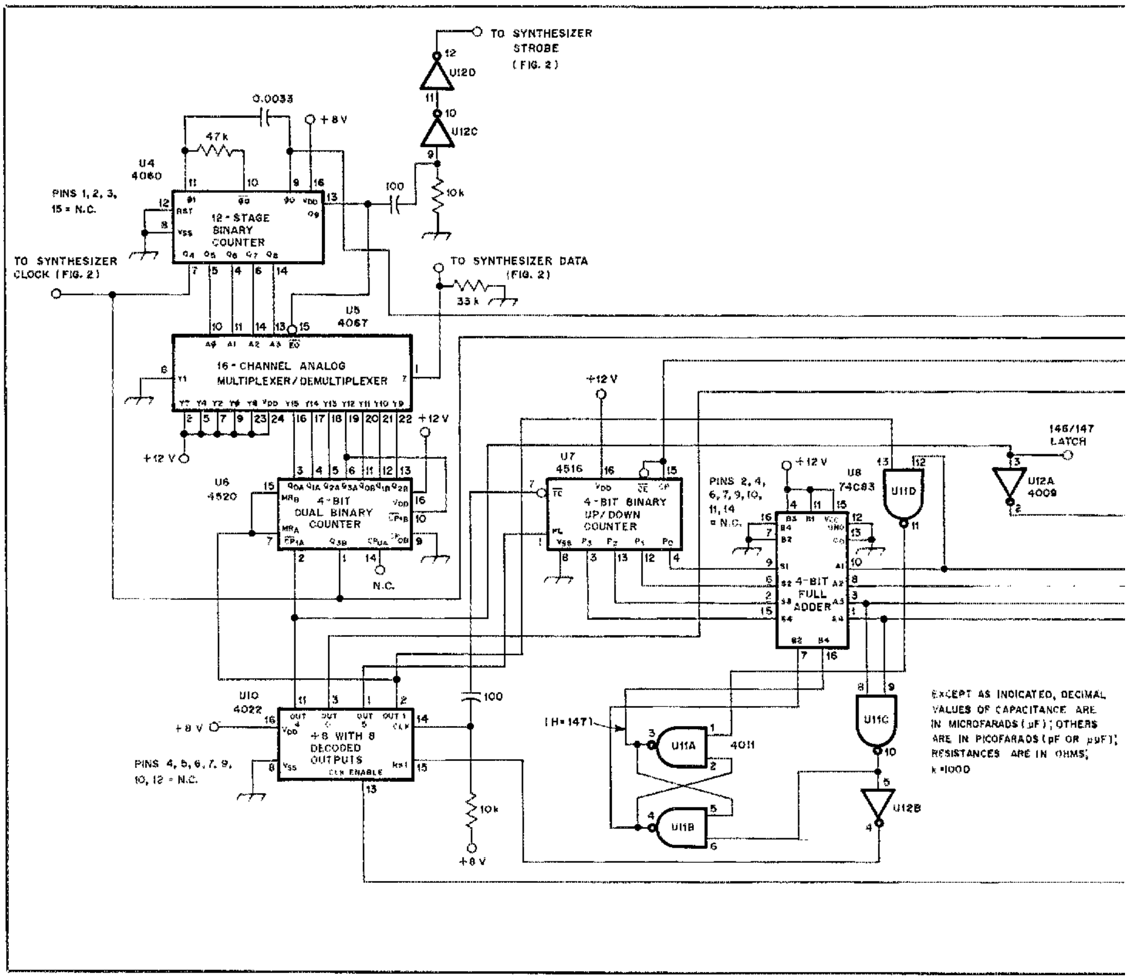
L1, L2 — 3 turns of no. 26 enamel wire on a 1/4-inch (6.4-mm) slug-tuned form (brass core).

U1 — Motorola MC145156 CMOS serial-input frequency synthesizer.

U2 — Plessey SP8793 200-MHz low-power, two-modulus prescaler (divide by 40/41).

The VCO is followed by a single buffer stage, which drives the dual-modulus prescaler and external circuits. The remainder of the circuit is the LSI synthesizer chip, which contains the reference oscillator and dividers, the programmable divider and the phase detector. No loop amplifier is used, and a simple loop filter closes the loop.

The programming circuits (Fig. 2) consist of 10 CMOS ICs. These are mounted on a separate board located behind the front-panel keyboard. The 5-kHz offset is programmed with a toggle switch



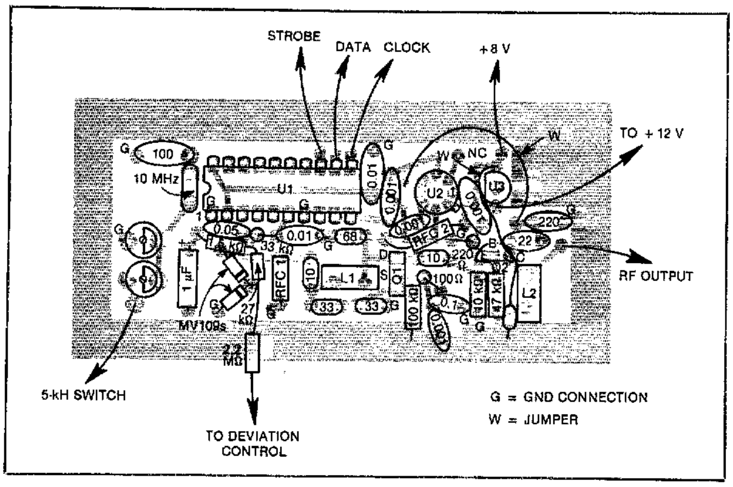
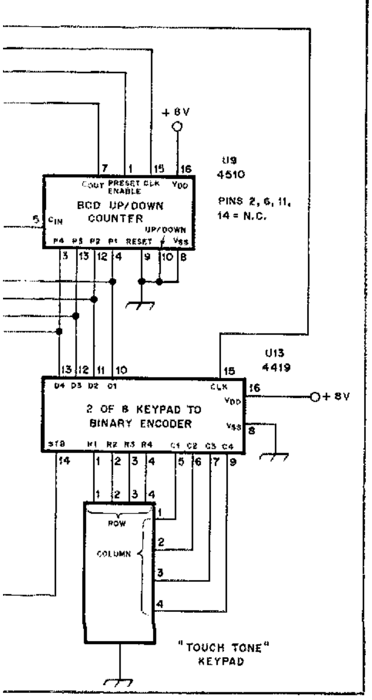


Fig. 3 — Parts-placement diagram for the frequency synthesizer circuit board.

Fig. 2 — Schematic diagram of the frequency synthesizer programming circuits. All resistors are 1/4-W, 5% carbon-film or composition types.



mounted near the synthesizer board.

Synthesizer Construction

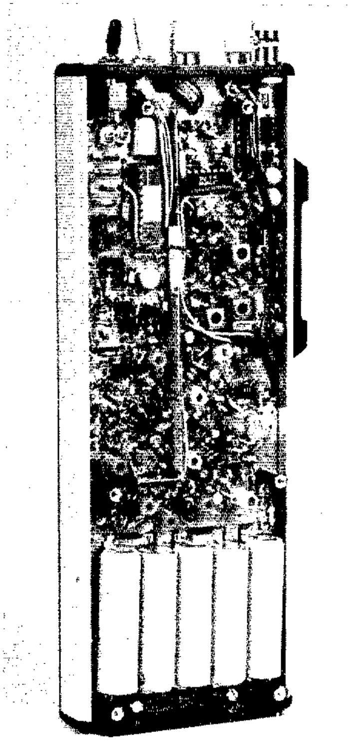
If the synthesizer is to be installed within a piece of existing equipment, the intended location of the synthesizer should be studied to determine what area is suitable for the pc board (see Fig. 3). Usually, the area normally occupied by the crystals can be used, as they are not required after installation of the synthesizer. If additional space is required, the frequency multipliers following the crystal oscillator can also be removed.

The Heath hand-held was purchased with the intention of installing the synthesizer, so the crystals, oscillator and frequency multipliers were not installed during construction. Often, the last multiplier supplies the local oscillator signal to the mixer. This stage can be left intact and used as a buffer amplifier between the synthesizer and the mixer. This was done in the Heath unit.

Finding room to house the programming circuits offers somewhat more of a challenge. The area normally occupied by the tone-signaling circuits was used to house the synthesizer programming circuits. According to the manufacturer's data sheet, it is possible to parallel the keyboard encoder chip and the tone generator. It may be possible to add the tone signaling at a later date either externally or internally.

The supply drain is about 8 mA, which is not as low as some synthesizers but is sufficiently low for portable use. Most of the power is supplied to the ECL prescaler.

Modulation is supplied from the speech processing circuits within the unit. Because the modulation is applied directly to the loop, the result is direct fm. If the transceiver contains a phase modulator, pre-emphasis is applied before the speech processing, and then de-emphasis is applied before the audio is applied to the modulator. For use with the synthesizer, both the pre-emphasis and de-emphasis should be removed. This usually involves no more than removing the de-emphasis capacitor and increasing the value of the pre-emphasis capacitor. If the transceiver used true fm, such as a crystal oscillator modulated with a varactor diode, the modulation normally applied to the varactor diode may be applied directly to the synthesizer.



The synthesizer circuit board is difficult to see after installation in the Heath VF-2031. It is located in the upper left-hand corner in the area normally occupied by the crystals. The programming logic is mounted immediately behind the front-panel keyboard.

The amount of modulation required for the synthesizer is about 500 mV rms for 15-kHz peak deviation. This can vary from one synthesizer to another and the actual deviation should be checked with a modulation meter.

Using the Synthesizer

The operating frequency range of the synthesizer is 146.3 to 147.575 MHz. Only the receive frequency is entered into the synthesizer. By use of the OFFSET switch on the transceiver, the total transmit frequency range is 145.7 to 147.995 MHz. By

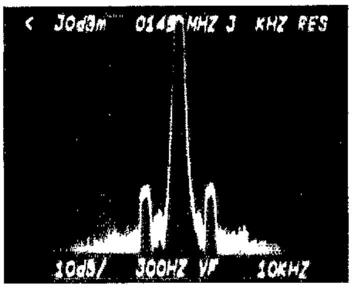


Fig. 4 — Close-in spectrum showing the 10-kHz reference sidebands approximately 54 dB below the carrier.

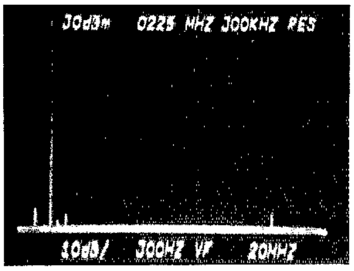


Fig. 5 — Wideband spectral display of the synthesized transceiver output. Harmonics and other spurious signals are all less than −60 dB relative to the carrier.

using the +600 kHz offset and entering frequencies above 147.395 MHz, out-of-band operation will result. This could be desirable for MARS operators, but those not authorized should take precautions against illegal operation.

To enter frequencies into the synthesizer, first clear the synthesizer by pressing the "A" button, usually located at the upper-right-hand corner of the keyboard, then press the MHz, 100s kHz, 10s kHz and the zero or 5 kHz digits of the receive frequency. As an example, to enter a receive frequency of 146.985 MHz you press "A" (clear), 6, 9, 8, 5. Pressing the last digit, either a zero or five, does not actually enter that number into the synthesizer. The last digit is more of an "enter" function. It is easier to punch 6, 9, 8, 5, and set the offset switch, than to punch 6, 9, 8, "enter," and then set the offset switch.

There is no indication of the operating frequency once the data has been entered from the keyboard. Therefore, if there is any doubt about the frequency of the synthesizer, re-enter the desired frequency, rather than take a chance of operating on an unauthorized frequency.

Spectral Purity

Every effort was taken to keep the synthesizer as small as possible so that it could be installed in a hand-held transceiver. Therefore, the minimum of buffer amplifiers are used between the VCO and the dual-modulus prescaler. The minimum buffering allows the generation of reference sidebands. The sidebands, which are present to some extent in every PLL synthesizer, are between 50 and 60 dB below the carrier, depending on the frequency of the synthesizer. For amateur use, a spurious signal is defined by the FCC as a signal outside of the amateur band in use. A reference sideband will be outside of the 2-meter amateur band, and will thus be a spurious signal, when the synthesizer is operating at 147.990 MHz or higher. To check the level of the reference sideband at this frequency, the rf output was measured during transmit with a spectrum analyzer. The result is shown in Fig. 4. The reference sideband is 54 dB down compared to the carrier. The requirement for vhf transmitters of less than 25 watts output is 40 dB down with a maximum of 25 microwatts. The legal limit would not be exceeded until the transmitter power were raised above 6.4 watts. Other spurious signals, such as harmonics and the local oscillator feed-through, are more than 65 dB down as shown in Fig. 5. Of course this is a function of the transceiver and not the synthesizer. Therefore, the power output of the unit can be amplified to any power level and used on any frequency except 147.990 MHz and above. If the output is amplified to 6.4 watts or less, any frequency can be used.

Other Applications

This basic synthesizer can be used in practically any communications system application by simply changing the VCO range, the reference frequency and the programming information. If the application is not a portable system, the CMOS logic circuits could be replaced with a microcomputer.

This synthesizer, without any modifications, may be used in transceivers other than portable equipment. It is especially suited for application in a remote mounted mobile transceiver. The programming circuits may be mounted at the control location and the data sent serially to the transceiver.

The development work on this synthesizer took place before the repeater sub-band was expanded. There are no inherent limitations of the synthesizer that would prevent operation below 146.3 MHz. In order to lower the frequency of the synthesizer, the number entered into the main counter will have to be lowered.

References

[1]A. Helfrick, "A High-Performance Synthesized 2-Meter Transmitter," *QST*, Sept. 1980, pp. 17-22.
[2]A. Helfrick, *Amateur Radio Equipment Fundamentals* (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1982).

Strays

FIRST TRANSCONTINENTAL PACKET-RADIO QSO

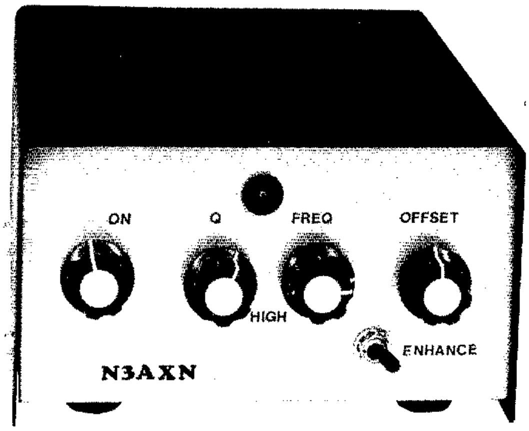
On February 7, 1982, Howard Nurse, W6LLO, in Palo Alto, California, and Ed Kalin, K1RT, in West Hartford, Connecticut, completed what is believed to be the first transcontinental hf packet-radio QSO. Hams are using packet-radio techniques experimentally to provide computer-to-computer communication over amateur frequencies (see "The Making of an Amateur Packet-Radio Network" by Borden and Rinaldo, October 1981 *QST*, page 28). The QSO took place in the 20-meter band using RTTY-standard 170-Hz shift fsk signals with a data rate of 75 bits per second (bps).

The objective of the QSO was to demonstrate the feasibility of using hf to link together geographically dispersed vhf local area packet-radio networks. Band conditions at the time limited the exchange to call signs, short control signals, and tests of the ability of one station's equipment to contact the other station automatically. Future tests will help to determine optimal packet lengths and signaling speeds in the presence of QRM, QRN and multipath propagation typically encountered in hf work.

The equipment in use by K1RT included a Terminal Node Controller (TNC) designed by the Vancouver Amateur Digital Communications Group (VADCG). The TNC was built by members of AMRAD, who donated it to ARRL for use by W1AW in such experiments. The Connecticut end of the QSO was conducted from the station of WA1GDX in nearby West Hartford to prevent the possibility of interference from the W1AW bulletin and code practice transmissions. The other equipment used by K1RT included a TRS-80 microcomputer, HAL ST-6 RTTY demodulator, Collins KWM-380 transceiver, ETO Alpha 76 amplifier, and a Telrex TB-6EM antenna at 60 feet. Equipment in use at W6LLO was similar — a Vancouver TNC, HAL ST-6000 demodulator, KWM-380, a computer terminal and a low, 20-meter dipole. — *Ed Kalin, K1RT*

CALL FOR VHF CONFERENCE PAPERS

☐ Papers are solicited for the Western Michigan University 28th annual VHF Conference, to be held October 23 at WMU, Kalamazoo. Paper synopses are due for selection by June 30, and final papers are due October 1. The conference is designed for vhf radio amateurs interested in design, construction and testing. — *Glade Wilcox, W9UHF, Kalamazoo, Michigan*



Concept and Construction of a CW Filter and Enhancer

Do QRM and QRN "bug" you? This circuit can help kill those problems dead.

By Tom Cook,* N3AXN

The active audio filter has been around for several years. It is relatively simple to design and build, is inexpensive, and requires little effort to install. It is normally inserted between the receiver audio output and the headphones. With careful design and choice of parts, very high Q is possible and the center frequency can be made adjustable. That makes this type of filter a versatile addition to the ham shack.

The only serious drawbacks to active audio filters are increased noise level at high Q and their limited ability to handle interference. A marginally weak signal received with heavy QRN is difficult to filter. High Q tends to make noise and signal sound alike, since a bandwidth of less than about 100 Hz will not give the ear enough frequency spectrum to evaluate the sound it is receiving. In addition, the recent influx of ssb onto frequencies previously reserved for cw has created new QRM problems that even high-Q audio filters are ill equipped to handle. Voice frequency signals can bounce in and out of the filter passband, making noises that sound suspiciously like cw.

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Any attempt to improve the active audio filter must deal with two problems: noise and non-cw QRM. Most noise and some types of interference are broadband. Their energy is, for the most part, equally distributed both inside and outside the filter passband. That fact suggests one method of improving filter performance. If the energy outside the passband could be subtracted from the energy inside the passband, it would leave only the desired signal unattenuated. That would help alleviate copy problems caused by noise and interference.

Theory of Operation

Fig. 1 is a block diagram of a filter enhancing system that uses this approach. Audio signals from the band-pass filter input and output are fed to the rectifier circuits, where their energy content is translated into dc levels. These levels are applied to the input of the differential amplifier (diff. amp.). A greater energy

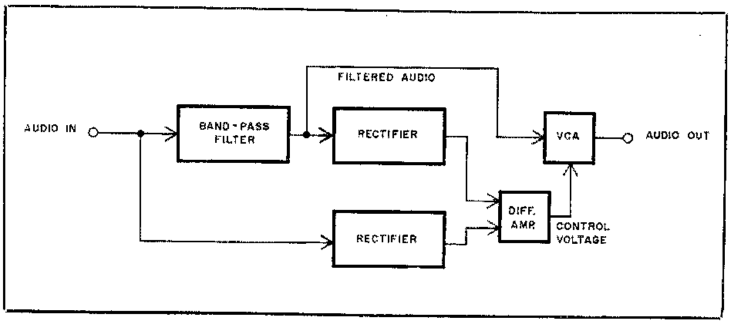
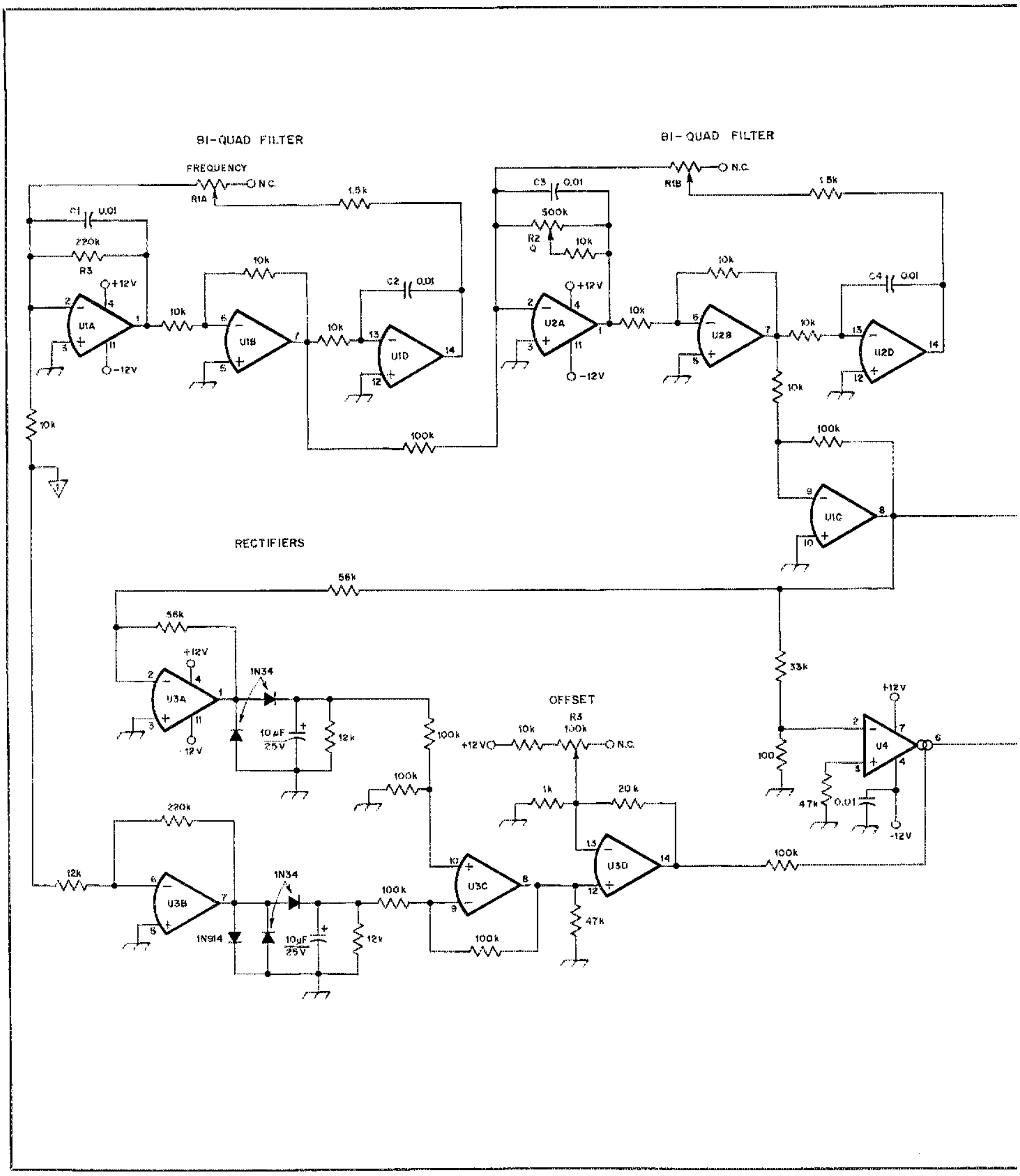


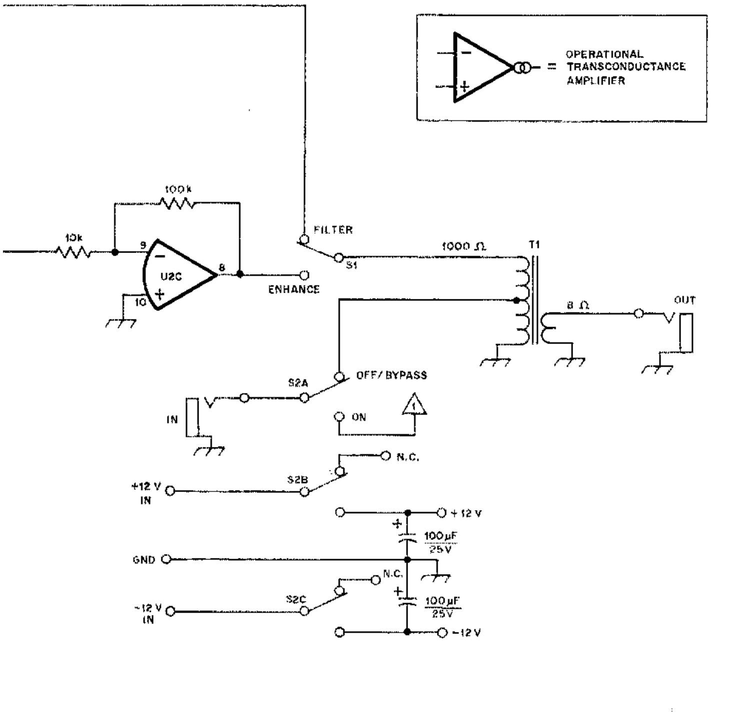
Fig. 1 — In the enhancer, filtered and nonfiltered audio is rectified and fed to a differential amplifier. The difference signal controls the gain of a voltage controlled amplifier (VCA), thus cancelling noise and broadband interference.



level at the filter output causes the diff. amp. output to go positive. The diff. amp. controls the gain of the voltage controlled amplifier (VCA). A positive control voltage increases gain in the VCA. When the audio input is only noise, the outputs of the rectifier circuits will balance. The diff. amp. output will therefore be zero. This causes the VCA to shut off. When a cw signal is centered in the filter passband it upsets this balance and the control voltage goes positive. This increases the gain in the VCA and the desired cw signal is heard clearly at the output.

This design concept was implemented according to the schematic diagram in Fig. 2. The band-pass filter consists of two bi-quad filters cascaded for high Q without ringing. There is considerable gain at resonance in this filter design. That means that the filter will not only attenuate signals outside the passband but also amplify signals within the passband. This

Fig. 2 — Schematic diagram of the cw filter and enhancer. An external ± 12 volt power supply is required. Capacitance values are in microfarads (µF). Resistances are in ohms, k = 1000. Fixed-value resistors are 5%, 1/4-watt metal film.
C1-C4, incl. — 0.01 µF close tolerance.
R1 — Dual potentiometer, audio taper.
T1 — Audio transformer, 1000 Ω ct/8 Ω.
U1, U2 — TL084 quad bi-fet op amp.
U3 — LM324 quad op amp.
U4 — CA3080 operational transconductance amplifier.



gain is affected by the Q control. R1 is a dual 100-kΩ audio taper potentiometer. It controls the center frequency and is reverse wired so that maximum frequency is at the extreme counterclockwise position. C1 through C4 determine the center frequency and should be close tolerance types. R2 controls the Q and gain of the second stage (the Q of the first stage is set by R3).

Full-wave rectifiers provide a varying dc voltage that matches the envelope of the incoming ac signals. One rectifier responds to the filter output, while the other responds to the original nonfiltered audio signal. The 1N914 diode assures that excessively strong unwanted signals will not shut down the VCA completely. Filter capacitor and bleeder resistor values were chosen to give best response to the steep slopes of cw envelopes. U3D amplifies the varying dc voltage from the diff. amp. The offset potentiometer, R4, acts as a gain control for the VCA. When a strong signal is being enhanced this control may be rotated toward the + 12 volt side to more fully attenuate background noise. Weaker signals will not permit as much offset so the unit enhances the signal of interest without completely attenuating unwanted noise.

The VCA is built around an RCA CA3080 operational transconductance amplifier (OTA). This device has the ability to increase or decrease amplification of a signal in response to a voltage applied via a current-limiting resistor to pin 5. By properly applying the output of the diff. amp. to the VCA, I was able to vary the audio output of the filter. What I heard was a series of dots and dashes louder than the noise, even when using the highest Q settings and under the heaviest QRN and QRM conditions.

An output transformer allows the use of low-impedance headphones. The output devices, U1C and U2C, should not be used with a load of less than about 2 kΩ. I chose a transformer that would match my 8-Ω headphones to either the filter, enhancer or the 500-Ω output of my Heath transceiver. You may wish to use a different configuration. Input impedance matching is noncritical.

Construction and Use

The components of this unit are inexpensive and tolerant of abuse, and this particular circuit is not the only possible implementation of the design concept. Therefore, experimentation is encouraged. Changes in a few component values, particularly in the rectification circuits, will drastically alter the performance characteristics of the enhancer. Enhancer action can be tailored easily to suit individual preference. The only component that should not be changed is R5; decreasing this value will lead to overheating and possible destruction of the CA3080.

Construction of the unit is straightforward. I tried several printed-circuit-board arrangements with equally good results.[1] Fig. 3 is a photo of the unit currently in use at N3AXN. All parts are available from Radio Shack except the CA3080; it is available from Jameco Electronics[2] and other distributors.

Optimum use of the enhancer involves proper adjustment of three parameters: the amount of signal and noise entering the system (controlled by the transceiver gain control), the amount of filtered signal (controlled by the Q control) and

[1]Notes appear on page 36.

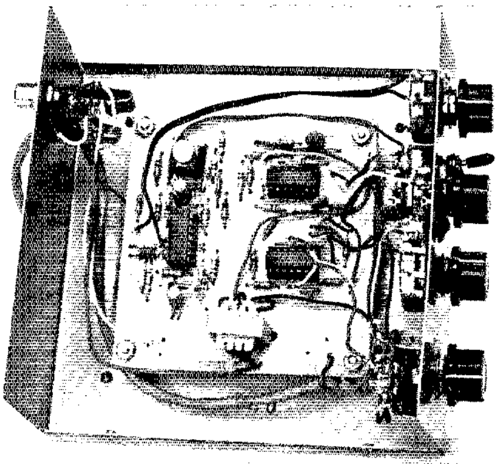


Fig. 3 — An inside view of the cw filter and enhancer. Close-tolerance capacitors have replaced those in the bi-quad filter sections, and additional decoupling has been added, since the photo was taken.

the minimum amplifier level (adjusted by the OFFSET control). The following sequence is recommended for those who are unfamiliar with the controls. Start with the unit switched off, Q at minimum, OFFSET at maximum (full clockwise), and S1 switched to FILTER. Adjust the receiver for comfortable listening and turn the unit on. Adjust the filter center frequency until it matches the signal of interest, then advance the Q control toward maximum. (Be careful; strong signals will be very loud. Decrease the receiver gain if necessary.) Next switch S1 to ENHANCE and decrease the offset until the background noise is minimized.

I've used the cw filter and enhancer system successfully under a variety of conditions: (1) the "insanity" of the 40-meter Novice band, (2) while sorting cw signals out of foreign ssb on the low end of 40 m, (3) during summer static conditions on 80 m, (4) while experiencing severe QSB on 15 m, and (5) during an attack of the "woodpecker." It is not a cure for all problems, but it has saved a lot of QSOs from oblivion. I find those QSOs that don't need saving more relaxed because of the reduction in noise.

Notes

[1]Circuit boards, negatives and parts kits are availablefrom Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002.
[2]Jameco Electronics, 1355 Shoreway Rd., Belmont,CA 94002.

Strays

QRPer LIKES "UGLY" CONSTRUCTION

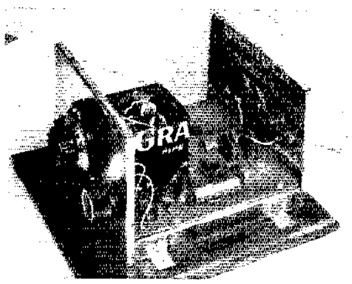
Projects need not be exact duplicates of those shown in *QST*. Parts substitutions (made with care!) and alternative construction techniques open the door to innovation and cost shaving when building homemade gear. Wes and Roger Hayward (W7ZOI and KA7EXM) illustrated in their 1981 *QST* article, "The Ugly Weekender," how an amateur can avoid the implied (however subtle) rule that the builder duplicate exactly the magazine project of his or her interest.

One amateur who believes in doing things his way is John Billones, WD6GGC. The accompanying photographs show his versions of the *QST* "YY Special" beginner's receiver and the "Universal QRP Transmitter" from September 1981 *QST*. Neither project resembles the original, but John reports excellent performance for both circuits. It is worth noting that his cw key is also homemade.

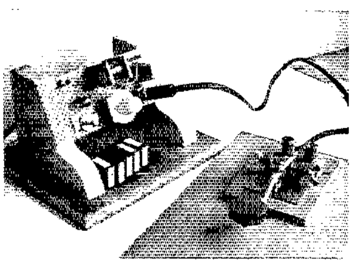
Parts substitutions include a coil form made from a rolled 3 × 5-inch file card in place of the toroid core, a miniature bc-band type of variable capacitor instead of a standard trimmer capacitor, and a toothpaste cap for the tuning knob. John also used resistors in parallel or in series to obtain the specified resistance values in the circuit. A wooden base was built for the transmitter, and pipe-tobacco cans were cut and formed to provide a VFO shield and end panels for the receiver. It was then affixed to a wooden base plate, as shown.

John claims no DX records with his "fly power", but says he has no trouble working stations over a 200-mile radius during the day on 40 meters. Reports range from RST 224 to 599. He goes on to say that he doesn't do much better under those conditions with his commercial 100-watt transceiver. The antenna is less than ideal — a random-length wire, matched to the rig by means of a homemade QRP Transmatch. John says the station works very well, but feels "power mad" when he uses his Heath HW-8 for QRP work!

The WD6GGC philosophy is, "With regard to home brewing (others may or may not agree), I believe that the equipment should look homemade — not sloppy, but showing at least a modicum of craftsmanship. To me, working cw with home-brew equipment is still the nitty-gritty of Amateur Radio." — *Doug DeMaw, W1FB*



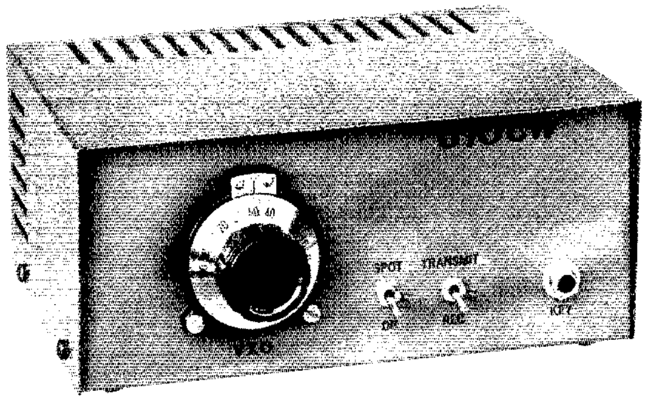
The WD6GGC version of the "YY Special" receiver from the popular *QST* article of the same title.



A wooden base and perf board serve as the main frame for the WD6GGC "Universal QRP Transmitter" (a W7ZOI design). A homemade straight key is in the foreground.

BEGINNER'S BENCH

Getting Started on VHF: A 6-Meter Transmitter You Can Build



Part 1: Constructing simple vhf gear will give you hours of workshop and operating enjoyment.

By George Collins,* KC1V

Getting started at vhf (very high frequency) need not be difficult or expensive. Building this 6-meter transmitter is a good low-cost way for the newcomer (and some old timers, too!) to begin enjoying the uncrowded world above 50 MHz. For many reasons the 6-meter, or 50-MHz, band is the best place to begin our vhf activities. Relatively simple equipment can be used with good results: The techniques and components required are similar to those used at lower frequencies.

This transmitter includes several features that will make your operating hours more pleasurable. It has variable-frequency control and an output power of 10 W. Under favorable conditions you should be able to work stations hundreds of miles away, using only a simple homemade antenna.

Circuit Highlights

A VXO (variable crystal oscillator) is used to provide variable frequency control. This circuit (Fig. 1) differs from a normal fixed-frequency crystal oscillator in that an LC (inductance/capacitance) circuit is placed in series with the crystal. By varying the series capacitance (C1), the oscillator frequency can be changed, or pulled, approximately 12 kHz. If the crystal frequency is pulled too far, unstable operation can result, so a limit-set capacitor (C2) has been included in the circuit. Following the oscillator is a buffer amplifier, Q2. It isolates the oscillator and provides the signal level necessary to drive the frequency-multiplier chain.

As the VXO operates in the 12.5-MHz range, the frequency must be multiplied by four to reach the 50-MHz band. This is done by using two diode-frequency doublers. Each doubler contains a pair of diodes fed from a trifilar transformer. This balanced configuration reduces the level of undesired signals (such as three times the input frequency) at the doubler output. By keeping the undesired frequencies at a low level to start with, much less filtering is needed to ensure a clean output signal. To further reduce spurious signal levels, each doubler is followed by a tuned circuit. The inductors for these LC circuits are wound on powdered-iron toroids. Links, wound over the main winding, are used to couple to the tuned circuit. A stage of amplification is used after each doubler to provide the correct signal level to the following stages. The 50-MHz signal from the frequency-multiplier chain is passed through a two-pole band-pass filter and amplified before leaving the driver board.

The circuit of the final-amplifier board,

*Assistant Technical Editor

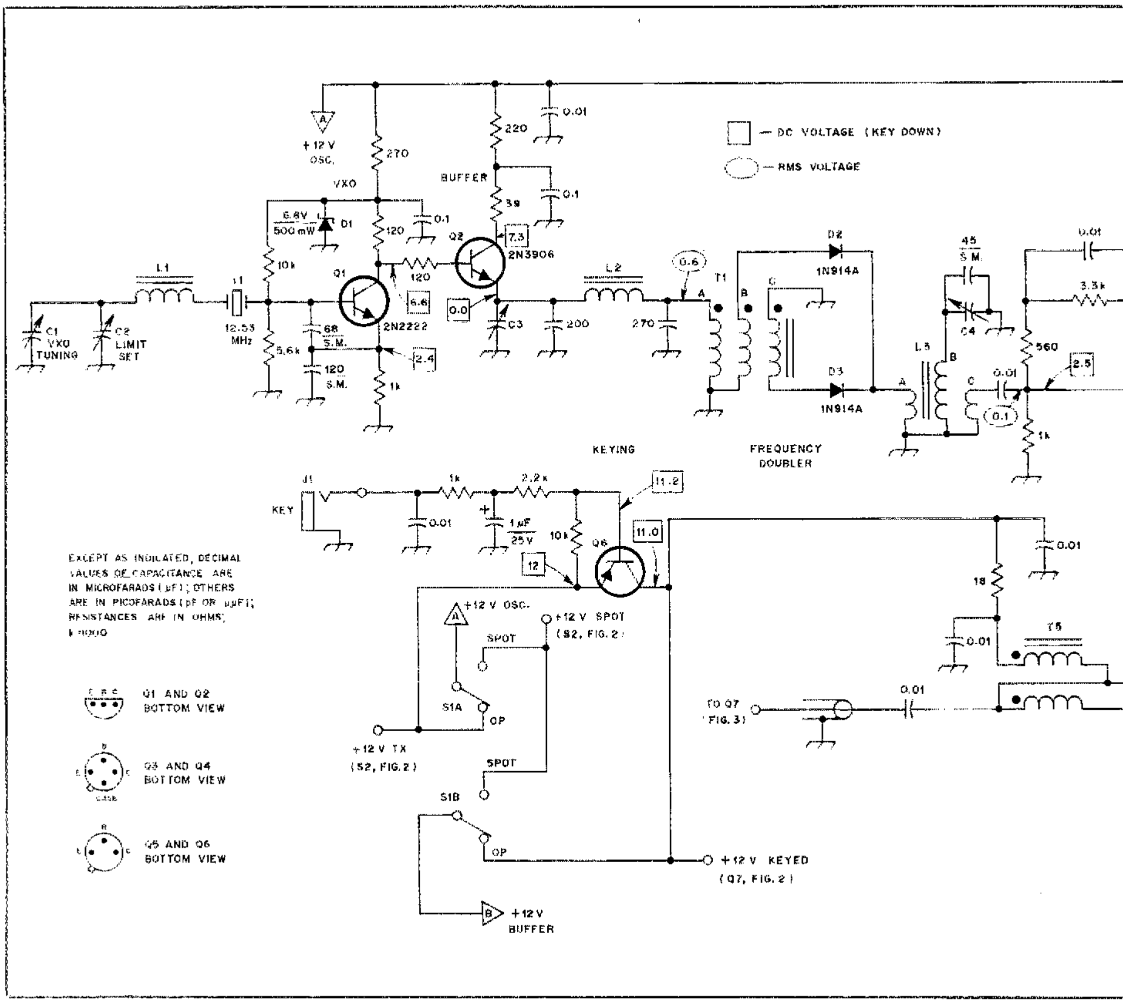


Fig. 1 — Schematic diagram of the low-level, or driver, stages of the 6-meter transmitter. The letters A, B and C above T1 and T3 are keyed to the parts-placement diagram (Fig. 5A). All resistors are 1/4-W, 5% carbon types. Unless specified otherwise, capacitors are disc ceramic.

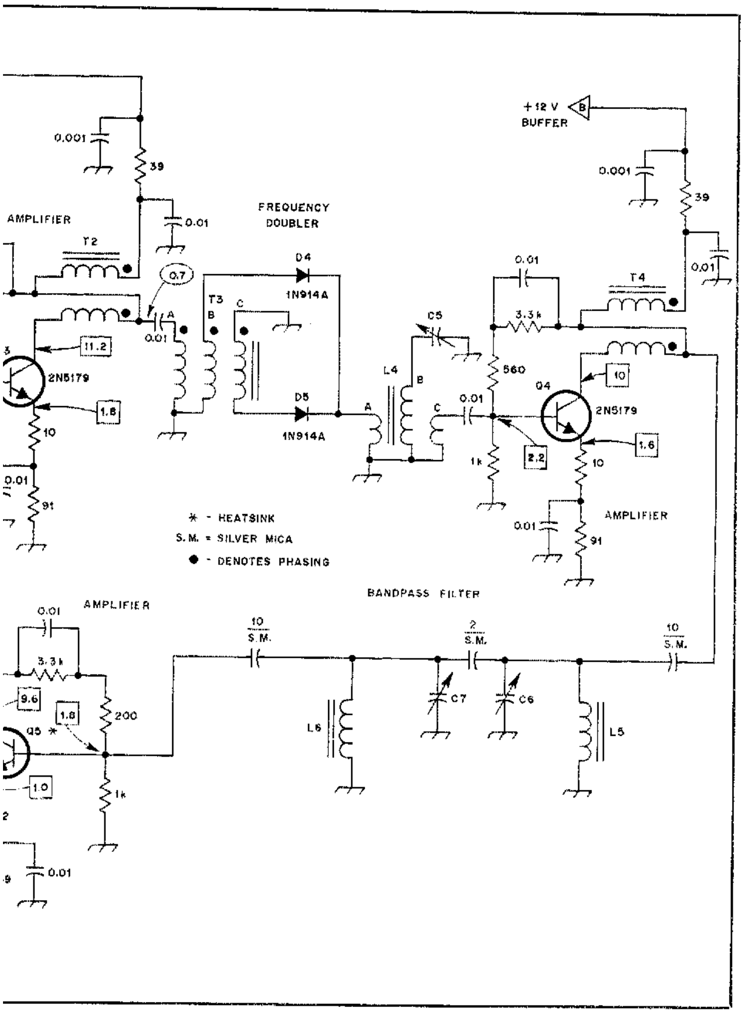
C1 — Air variable capacitor, 75- to 100-pF maximum capacitance.
C2-C7, incl. — 3- to 68-pF miniature trimmer.
D1 — 6.8-V, 1/2-W Zener diode.
D2-D5 — 1N914A silicon switching diode.
J1 — 1/4-inch phone jack.
L1 — 35 ts. of no. 28 enameled wire on an Amidon or Palomar T50-2 (red) toroidal core.
L2 — 15 ts. of no. 26 enameled wire on a T37-6 (yellow) toroidal core.
L3 — 11 ts. of no. 26 enameled wire on a T37-6 (yellow) toroidal core. Input and output links are each 3 ts. of no. 28 enameled wire wound over the ground end (low-impedance end) of L3.
L4 — 11 ts. of no. 26 enameled wire on a T37-12 (green and white) toroidal core. Input and output links are each 3 ts. of no. 28 enameled wire wound over ground end of L4.
L5, L6 — 8 ts. of no. 28 enameled wire on a T37-6 (yellow) toroidal core.
S1 — Two pole, two-position toggle switch. Radio Shack 275-663 or equiv.
T1, T3 — 6 trifilar ts. of no. 28 enameled wire on an FT37-43 toroidal core. See text and Fig. 4.
T2, T4, T5 — 6 bifilar ts. of no. 28 enameled wire on an FT37-43 toroidal core. See text and Fig. 4.

shown in Fig. 2, contains two stages. In the first, a 2N4427 (Q7) is used to provide approximately 0.7 W of drive to the output stage. Q7 is operated with a small amount of forward bias; this improves the keying characteristics and increases the stage gain slightly. The output stage is a Class C MRF479. A seven-pole low-pass filter is used to provide the necessary harmonic suppression. A spectrum analyzer display of the transmitter output is shown in Fig. 3.

Construction and Testing

There are two sections to the transmitter circuit, with the components of each section mounted on separate printed-circuit boards.[1] Each board measures 2-1/4 × 5-1/2 inches.[2] The driver board contains the VXO, doublers, amplifiers and band-pass filter. This board is double-sided (copper clad on both sides), with the unetched component side serving as a ground plane. The driver stage (Q7), final amplifier and low-pass filter are mounted on the second board. A single-sided board is used here, with all components soldered to large pads on the foil

[1]Notes appear on page 42



side of the board. A notch is cut in the board so that Q8 can be fastened to the heat sink.

Wherever possible, driver board component leads that connect to ground are soldered to both sides of the board. This helps ensure effective rf grounds — an important consideration when working at vhf. Soldering component leads to the ground plane requires two things: Your soldering iron must provide sufficient heat to do the job, and you must be able to reach the lead with the iron tip! An iron rated at 27 to 30 W, with a 1/8-inch cone-shaped tip, is recommended for all the soldering in this project. Lower wattage irons will not heat the ground-plane foil rapidly enough to avoid overheating the component. Make sure you keep the iron tip clean and well tinned with solder. Cleaning the surface of the board with fine steel wool, followed by washing with soap and hot water, will help make your soldering easier.

If you are to be able to reach the component lead with the iron, you must place the parts on the board in the correct order. Start with the grounded components that are located near the center of the board, then work toward the edges. After all the grounded components are mounted, the remaining parts can be soldered to the board in any order you wish.

The transmitter should be assembled and tested one stage at a time. In this way, any problems that may arise can be located and corrected more easily. Begin construction with the VXO and buffer stage (Q1 and Q2). Solder all the components ahead of T1 to the board. Connect a 47-Ω resistor across the 270-pF capacitor following L2. This resistor will serve as a temporary load for the buffer. Be sure to remove it after testing the stage! It is not necessary to connect the tuning capacitor (C1) during initial testing; for now, just set C2 at maximum capacitance (plates fully meshed). With Y1 in the crystal socket, apply 12 V to the circuit. Check all of the dc voltages shown in Fig. 1 with a high-impedance voltmeter (VTVM or FET VOM). The rf voltage across the load resistor can be checked with an rf probe. Remember, the voltage readings you obtain can differ by 10 or 15% from those shown.

With the VXO functioning correctly, we are ready to wire the first frequency doubler and tuned circuit. Transformers T1 and T3 are trifilar wound. To construct this type of transformer, three identical lengths of enameled wire are twisted together until there are about 10 "twists" per inch. This bundle of three wires is then used to wind the toroidal core with the required number of turns. The number of turns specified is the number in *each* of the three windings that are formed. Using wires of three different colors (paint each a separate color, if desired) will make wiring the transformer to the circuit board easier. If wires of the same color are used, you will need to identify the windings with an ohmmeter. T2, T4 and T5 are wound in a similar manner, but are bifilar (only two wires twisted together). Fig. 4 shows how these transformers are wound and identifies the leads. Wire these transformers carefully; it is easier to avoid winding errors than to correct them later!

Wind the tuned-circuit inductors, L3 and L4, in a conventional manner. Place the large winding on the core first. Space the turns evenly around the core, leaving a gap of 1/8 inch between the first and last turns. Then wind the input and output links over the grounded end of the main winding. Test the doubler by connecting the 47-Ω temporary load resistor from the output link of L3 to ground. Apply 12 V to the circuit and adjust C4 for maximum rf voltage across the load resistor. C4 should peak near the center of the capacitance range.

The first amplifier (Q3) is assembled next. Be sure to install the 0.01-μF blocking capacitor at the amplifier output. Connect the 47-Ω load resistor between the blocking capacitor and ground. The capacitor prevents dc from flowing through the load resistor. Using your rf probe, measure the rf voltage across the load resistor and readjust C3 and C4 for maximum output.

Install the remaining stages in the same step-by-step manner, testing each stage as you proceed. Adjust all tuned circuits for maximum rf voltage across the temporary load connected to the stage output. When testing the last two driver board stages, supply 12 V to the circuits with jumper wires. The last section of the driver board

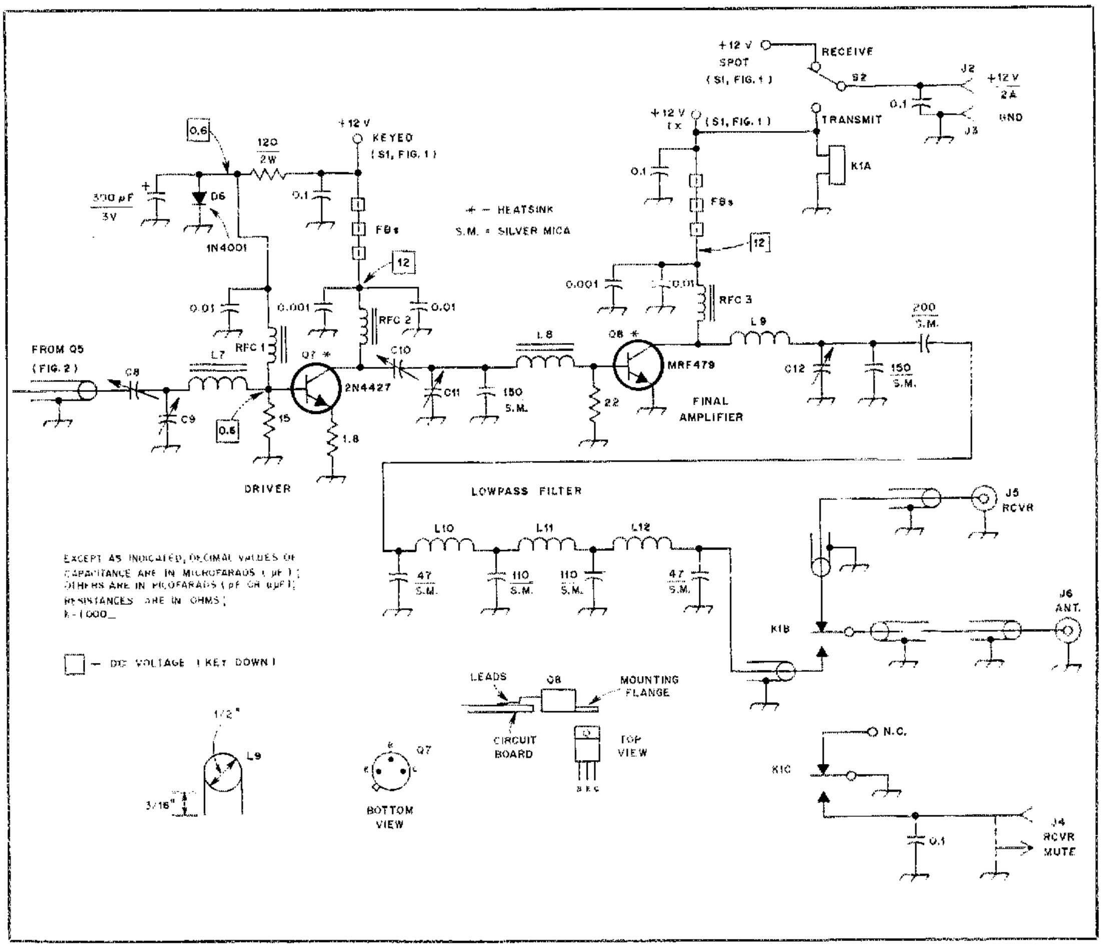


Fig. 2 — Schematic diagram of the final-amplifier board. Unless specified otherwise, resistors are 1/4-W, 5% carbon types and capacitors are disc ceramic.

C8-C12 — 3- to 68-pF miniature trimmer.
D6 — 1-A, 50-V silicon diode, 1N4001 or equiv.
FB — Ferrite bead, Amidon FB101-43 or equiv.
J2, J3 — Binding post. Radio Shack 274-661 or equiv.
J4 — RCA style phono jack. Radio Shack 274-346 or equiv.
J5, J6 — Coaxial connector to match those used in station. SO-239 type suitable. Radio Shack 278-201 or equiv.
K1 — Two-pole, two-position relay with 12-V coil. Radio Shack 275-221 or equiv.
L7 — 6 ts. of no. 26 enameled wire on a T37-6 (yellow) toroidal core.
L8 — 4 ts. of no. 26 enameled wire on a T37-12 (green and white) toroidal core.
L9 — 1-1/2 ts. of no. 16 enameled wire, 1/2-inch ID, spaced one wire diameter with 3/16-inch leads. See text.
L10, L12 — 8 ts. of no. 24 enameled wire, 5/16-inch ID, 7/16-inch long. See text.
L11 — 8 ts. of no. 24 enameled wire, 5/16-inch ID, 1/2-inch long. See text.
RFC1 — 16 ts. of no. 28 enameled wire on an FT23-43 toroidal core.
RFC2 — 11 ts. of no. 26 enameled wire on an FT23-43 toroidal core.
RFC3 — 5 ts. of no. 24 enameled wire on an FT37-43 toroidal core.
S2 — Single-pole, two-position toggle switch. Radio Shack 275-662 or equiv.

to be assembled is the keying circuit, Q6.

Final-Amplifier Board Assembly

Construction of the final-amplifier board is straightforward. Simply place the component leads on the circuit board and solder. Wire and test the driver (Q7) and the final amplifier (Q8) as a unit.

Mount Q8 on the board first. Bend the transistor leads so that they contact the circuit board along the full length of the narrow part of the lead (see Fig. 2). Be careful not to allow the emitter or collector lead to contact the ground foil just in front of the transistor body. Bend the leads of Q7 so the bottom of the transistor case is no more than 1/8 inch above the board. Attach the heat sink to Q7 before you solder it to the circuit board.

You will find it helpful to tin the related foil area before attaching the lead. Use the parts-placement diagrams (Fig. 5) to determine component orientation. Keep all lead lengths to a minimum.

The final amplifier circuit has four air-wound inductors. The shape of these coils is shown in Fig. 2. The easiest way to make L10, L11 and L12 is to use a 3/8 × 16 machine bolt as a winding form. If the wire is wound tightly in the threads, when the bolt is unscrewed from the winding, the coil will have the correct diameter and turns spacing.

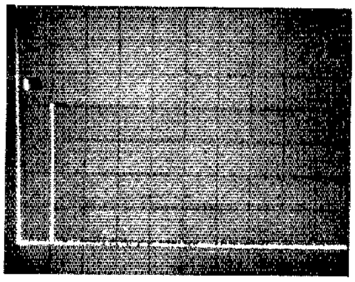


Fig. 3 — Spectral display of the transmitter output. Each horizontal division represents 50 MHz. The large pip at the left of the display is the zero frequency reference generated by the spectrum analyzer. Each vertical division represents 10 dB. In this display, the carrier has been attenuated by means of a notch filter to prevent overloading the analyzer. Effectively, the carrier is at full height. All harmonic and spurious signals are 60 dB or more below the carrier power, thereby complying with FCC regulations for commercial gear.

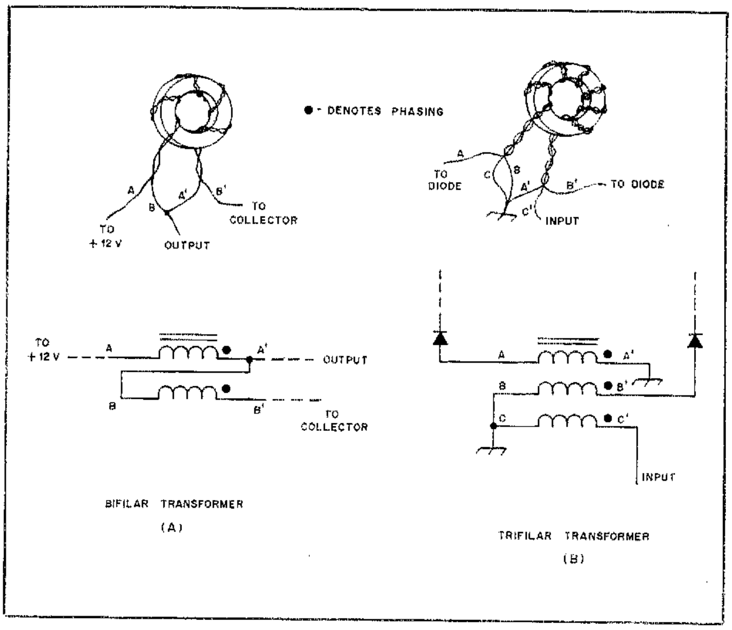


Fig. 4 — Several bifilar and trifilar transformers are used in this transmitter. The bifilar type is wound as shown at A, while the trifilar type is shown at B.

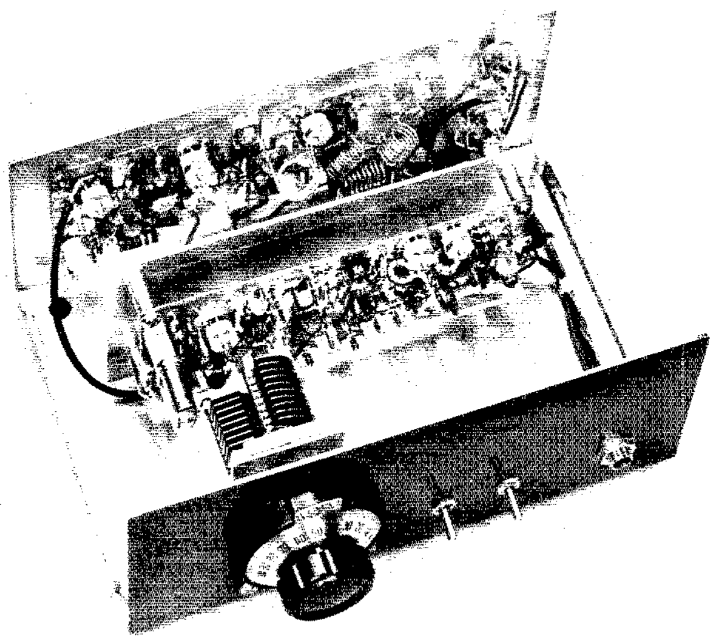
Complete the construction by mounting the circuit boards in the cabinet. Then wire the control switches and antenna relay. Check the TRANSMIT/RECEIVE (S1) and SPOT (S2) switch wiring carefully. With the crystal removed, measure the dc voltages under key-up, key-down and spot conditions. The correct values at various points in the circuit are shown in Table 1.

Turn off the dc power, replace the crystal and connect J6 to a 50-Ω dummy load. If a wattmeter or other power indicator is available, place it in the transmission line between J6 and the dummy load. Set capacitors C8 through C12 to the middle of the capacitance range. Apply power and, with S1 in the transmit position, close the key. With your rf probe at the base of Q8, adjust C8 through C11 for maximum output voltage. Now move the probe to J6 and adjust C12 for maximum output. Because the adjustments interact somewhat, you should repeat the alignment. Always tune for maximum output power. At the 10-W output level, the total supply current will be approximately 1.5 A.

To complete the alignment, adjust the tuning-limit capacitor (C2). Set the VXO tuning capacitor (C1) at minimum capacitance and adjust C2 for maximum capacitance. While monitoring the output power, adjust C2 toward minimum capacitance. The output should remain fairly constant until a point is reached at which it falls off rapidly. Increase C2 until normal output is obtained.

Operation

As on any band, the better your antenna the better your results will be. This does not mean that you need a 6-element beam at 70 feet to get good results. A 2- or



The transmitter is housed in a 3-1/2 × 7-7/8 × 5-11/16 inch metal cabinet. Any metal enclosure large enough to contain the two circuit boards and the relay can be used. Small aluminum brackets are used to mount the tuning capacitor and relay. Be sure to ground the shield braids at both ends of each coaxial cable used to connect the transmitter, relay and jacks.

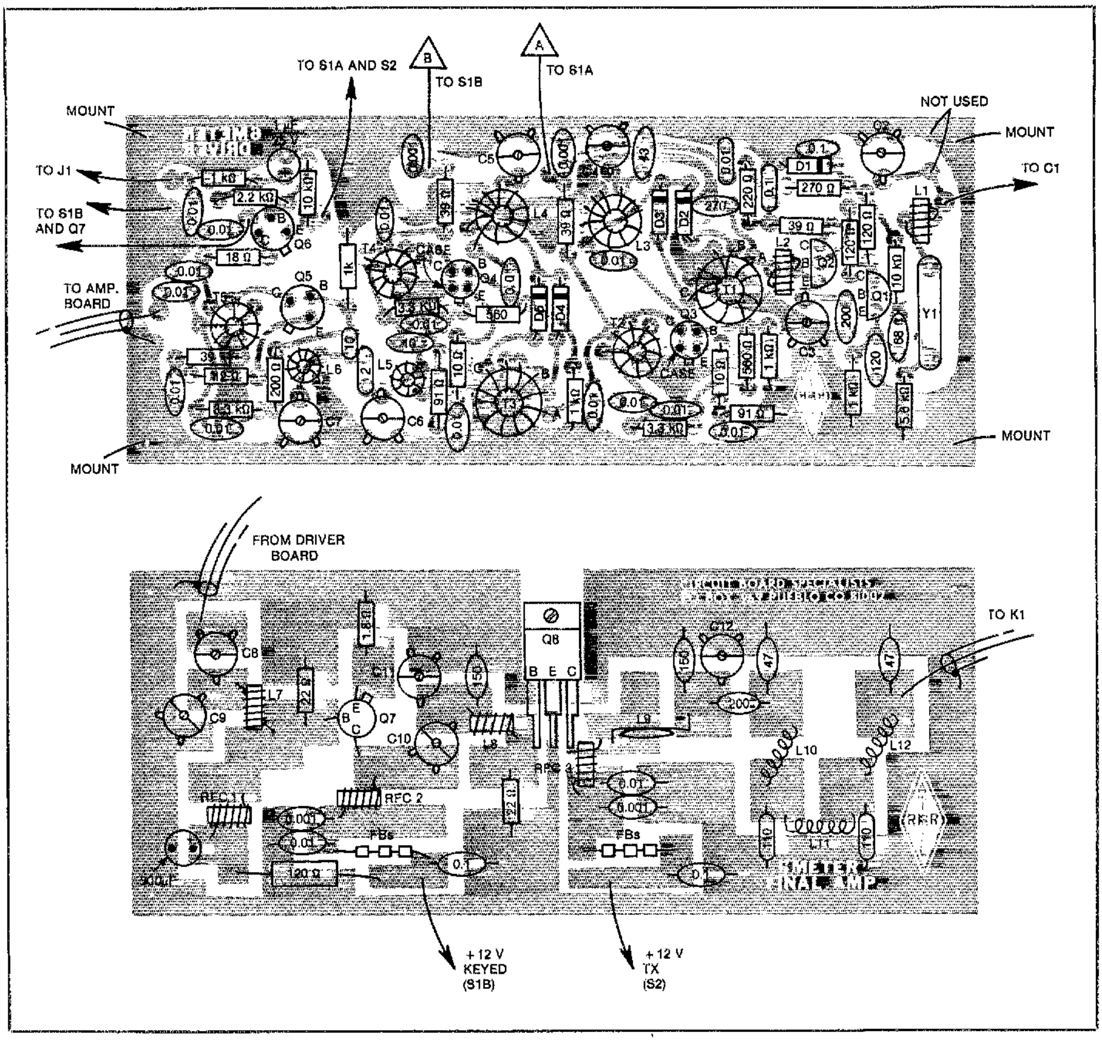


Fig. 5 — Shown here are the parts-placement diagrams for the driver board (A) and final-amplifier board (B). Views are from the component side of the boards, with gray areas representing unetched copper.

Table 1
Control Voltages

Position			*Voltage at Points Labeled*				
S1	S2	KEY	+12 OSC.	+12 BUFFER	+12 KEYED	+12 SPOT	+12 TX
REC	OP	UP OR DOWN	0	0	0	12	0
REC	SPOT	UP OR DOWN	12	12	0	12	0
TRAN	OP	UP	12	0	0	0	12
TRAN	OP	DOWN	12	12	12	0	12
TRAN	SPOT	UP	0	0	0	0	12
TRAN	SPOT	DOWN	0	0	12	0	12

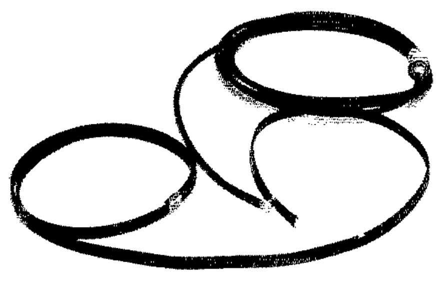
3-element Yagi will do very well, even if it is only at roof top level. Information on the construction of 6-meter antennas can be found in *The ARRL Antenna Book* and *The Radio Amateur's Handbook*, both available from ARRL. While this transmitter is very tolerant of feed line mismatch (high SWR), it is best to limit the SWR to 2:1 or less during operation. See you on 6 meters!

Notes

[1]Circuit-board layout work was done by Bob Shriner, WAØUZO. Circuit boards, negatives and parts kits for this project are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002.

[2]mm = in. × 25.4.

The 300-Ohm Ribbon J Antenna for 2 Meters: A Critical Analysis



Whip your rubber duck with a 3/4-λ ribbon. This aerial will provide up to 20 dB of gain over a flex antenna.

By John S. Belrose,* VE2CV

The vertical J antenna is an end-fed half-wave radiator. It is fed and matched by means of a quarter-wave line. Vertical half-wave antennas are particularly suitable for portable application since no ground plane is needed, and the radiation pattern is a maximum on the horizon.

A current-fed antenna, such as a 1/4-λ or 5/8-λ radiator, requires a ground plane. Such antennas, when operated over ground planes of finite size, frequently have radiation patterns that are tilted up.[1] These antennas *can* be designed to provide a maximum radiation on the horizon, but the patterns vary markedly with element length changes and the degree to which radiating currents may be kept off the outside of the coaxial-cable braid.[2] Fig. 1 shows how a quarter-wave coaxial choke, open at the top, can be used for this purpose. The 1/4-λ radials also act somewhat like a choke to feed-line currents. Compared with the performance of a half-wave radiator, the gain of such a ground-plane antenna is − 1.55 dB. The input impedance is also low, less than half the impedance of a center-fed dipole. This is an advantage, however, since for the same power the current is higher. With proper design, the gound-plane antenna can be matched to a 50-ohm feed line. For example, if the antenna is resonant, the feed point can be moved up the vertical element until a matched condition is reached, without affecting the pattern.

Some insight can be gained concerning the differences between a half-wave radiator and a ground-plane antenna by considering the current distributions (Fig. 2). The 1/2-λ radiator carries a symmetrical, in-phase current over its length, with maximum current at the center of the radiator. Hence, the radiation pattern will be a maximum on the horizon. On the other hand, the current distribution on the ground-plane antenna is certainly not symmetrical, and current on the rods contributes to the pattern.

A quarter-wave antenna with no ground rods will exhibit a null on the horizon, even if feed-line currents are choked off. A 1/4-λ or rubber-flex antenna on a hand-held tranceiver is not the same as a monopole with no ground plane, because the chassis will act in part like the lower half of the antenna. There may not be a *null* on the horizon, but the radiation pattern is probably far from ideal. Besides, the radiation efficiency of a rubber-flex antenna is poor (the gain is said to be − 6 dBd).

Vertical J antennas employing sectionalized or telescopic elements have been designed for portable application.[3] This article concerns a roll-up and put-in-your-pocket J, which is rather convenient for portable applications. It is made from 300-ohm twin-lead.

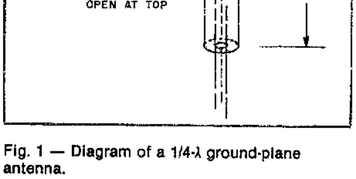


Fig. 1 — Diagram of a 1/4-λ ground-plane antenna.

Theory of Operation

A 300-ohm ribbon J antenna is illustrated in Fig. 3. The quarter-wave matching stub and half-wave radiator are constructed from 300-ohm twin-lead. The stub length will be a free-space quarter wavelength times the twin-lead velocity factor (0.83). Currents on each half of the stub are 180° out-of-phase, and approximately equal in amplitude; hence, stub radiation is kept to a minimum. For the 1/2-λ radiator the floating wire is closely coupled to the driven wire and carries in-phase current. The velocity factor for the ribbon is unimportant, but the antenna is shortened by the usual antenna factor (0.965). Find the free-space wavelength by using the equation

$$\lambda = \frac{300}{f(\text{MHz})}\ (\text{m}) \text{ or } \lambda = \frac{11{,}811}{f(\text{MHz})}\ (\text{in.}) \qquad \text{(Eq. 1)}$$

The 50-ohm coaxial cable is tapped onto the line at an appropriate point to provide the required match. For portable use the antenna will operate satisfactorily without choking off current flow on the outside of the feed line, but if a long feed line is employed, as for example if the J antenna were used as a base-station antenna, a quarter-wave coaxial choke should be placed over the outside sheath of the cable. The 1/4-λ choke will be open at the top and closed (connected to the cable sheath) at the bottom. For portable use, the electrical length of the feed cable should be an integral multiple of a half wavelength, so that if the J antenna is

[1]Notes appear on page 45.

*3 Tadoussac Dr., Aylmer, PQ J9J 1G1

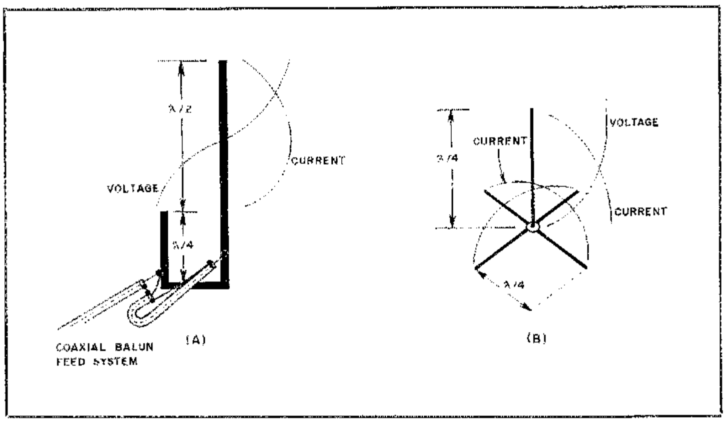


Fig. 2 — The voltage and current distribution on a J antenna is shown at A. The distribution on a ground-plane antenna is shown at B for comparison.

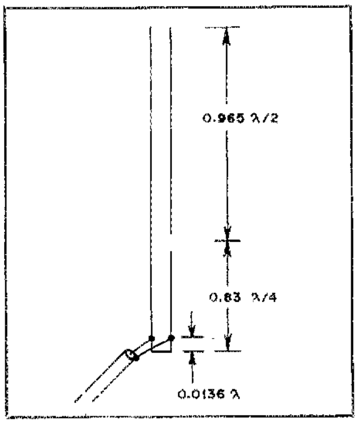


Fig. 3 — The construction details of a J antenna.

detuned because of its close proximity to metal objects, the feed line will not add additional reactance to the radiating system.

Design of the Ribbon-J Antenna

In my initial design, I used a velocity factor of 0.8 in calculating the length of the 1/4-λ stub. Belden 8230 ribbon was used. This resulted in an antenna that was resonant *above* the design frequency. An antenna cut for 147 MHz resonated at 152 MHz. While the antenna impedance could be changed by varying the length of the half-wave radiator, the resonant frequency of the coupled system, comprised of the radiator, the quarter-wave stub and the balun (or 1/4-λ choke) could not be decreased to 147 MHz. The length of the stub exhibited a dominating influence over the resonant frequency of the antenna. The only frequency for which exact resonance could be achieved was 152 MHz. Clearly the stub length was too short.

By employing an effective velocity factor of 0.83, the antenna could be resonated at the design frequency. The impedance was measured with a Hewlett-Packard rf impedance analyzer, Model 4191A, and the impedance (Z) and phase angle (θ) were machine plotted (Fig. 4). Note that at resonance (f = 147 MHz), the input impedance is approximately 50 ohms, and that the impedance is higher and lower than this value for frequencies below and above resonance. The reactance is inductive on both sides of resonance (positive phase angle), and near 0° at resonance.

This variation of reactance is typical for a J antenna. For a conventional 1/2-λ end-fed radiator, the antenna will exhibit an inductive reactance below and a capacitive reactance above resonance.

Dimensions for a design frequency of 147 MHz are given in Table 1. The tap point, measured from the shorted end of the 1/4-λ stub, corresponds to 0.0136 λ (or 5 electrical degrees).

The graph of Fig. 4 also shows the voltage-reflection coefficient $|\Gamma|$, which is near zero at resonance. Since

$$SWR = \frac{1 + |\Gamma|}{1 - |\Gamma|} \qquad \text{(Eq. 2)}$$

the bandwidth defined by an SWR < 2 can be read from the graph. For $|\Gamma| < 1/3$, this bandwidth is 4 MHz (± 1.4%). For the design dimensions given in Table 1 the SWR will be less than 1.5 ($|\Gamma|$ <0.2) from 146 to 148 MHz.

Performance

For 2-meter operation this antenna will significantly increase

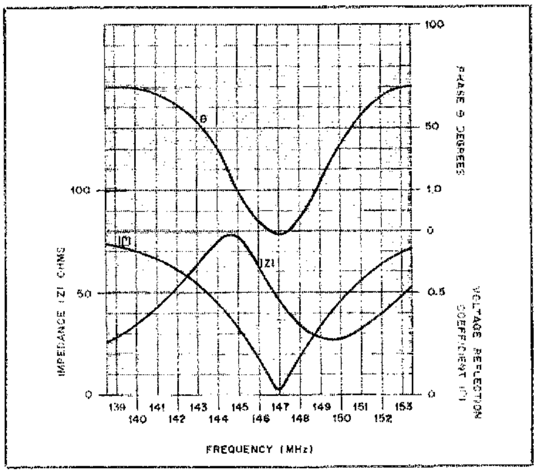


Fig. 4 — A graph of phase angle (θ), impedance (Z) and voltage-reflection coefficient ($|\Gamma|$) vs. frequency from a J antenna designed for 147 MHz.

Table 1

Design Dimensions of a 300-Ohm Ribbon-J Antenna for 2 Meters

Design Frequency (MHz)	*Length of 1/4-λ stub (inches)*	*Length of radiator (inches)*	*Tap Distance (inches)*	*Gap Distance (inches)*
147	16-39/64	38-25/32	1-3/32	15/64

mm = inches × 25.4

the range of your portable rig. A half-wave antenna is the type most suitable for use with a hand-held transceiver where there is no ground plane. In the forest, the antenna can be hung from the branch of a tree, providing an effective gain of up to 20 dB over a rubber flex antenna at ground level. For the hiker, it can be supported by a lightweight bamboo rod attached to your pack board. In this application, the J antenna will provide a gain of 6 dB or more over a rubber flex antenna. Indoors you might hang the J antenna from the drapery rod in front of a window — but beware. The aluminum frame surrounding some windows can be resonant at about 2 meters, and this resonance will detune your antenna and alter the pattern.

Some amateurs have constructed ribbon-J antennas for use in a base-station application. In such a situation the antenna could be installed inside a PVC-plastic tube. The 300-ohm ribbon will fit nicely inside a 5/8-inch white plastic water pipe, and an end cap can be fitted to provide a waterproof radome. If you construct such an antenna, the freespace dimensions should be reduced (multiply by 0.95), since the dielectric constant of the tube reduces the resonant frequency of the antenna. The J antenna should not be used without a balun for base-station application, where the feed line is long. A quarter-wave choke could also be used to minimize feed-line currents.

While a J antenna can be operated without a ground plane, this is not to say that it cannot be used with advantage above a large flat conducting surface, such as a car roof. The half-wave radiator and its image in the ground plane are separated by one wavelength (center to center) when the shorted stub is placed flush to the roof. This is the optimum separation for collinear 1/2-λ elements, and the theoretical maximum gain is 3.27 dBd. Try tying your ribbon-J antenna to a bamboo rod lashed to the luggage rack on the roof of your vehicle.

Notes

[1]O. R. Foster and T. Miller, "Radiation Patterns of a Quarter-Wave Monopole over a Finite Ground Plane," IEE Conference Pub. No. 195, 1981, *Antennas and Propagation,* Pt. 1, Antennas, pp. 451-455.

[2]W. V. Tilston and A. H. Secord, "The Radiation Patterns of Ground Rod Antennas," *Electronics and Communications,* August 1967, pp. 27-30.

[3]J. S. Belrose, "Vertical J Antenna for 2 Metres," *TCA,* July/August 1979, pp. 23-26.

New Books

☐ *Morse Code, Baudot and ASCII Radioteletype Programming for the TRS-80 Models I and Models III,* by Bob Richardson, W4UCH. Published by Richcraft Engineering Ltd., No. 1 Wahmeda Industrial Park, Chautauqua, NY 14722. First edition, 1981, spiral-bound, 8-1/2 × 11 inches, 276 pages, $18 plus $2 shipping.

Here is a book written for the radio amateur or computer hobbyist that will "turn the hair white" of those firms that have been selling Morse code and radioteletype assembly language programs in the $149 and up (mostly up) category. At a bookstore price of $18, here is what you will receive:

Chapter 1 — 8-800 (wpm) transmit programs; chapter 2 — Adding type ahead capabilities; chapter 3 — Morse receive decoding program; chapter 4 — Merging above programs - 12 prepared messages; chapter 5 — Baudot transmit program 60, 66, 65 and 100 wpm; chapter 6 — Baudot receive program (for above speeds); chapter 7 — Merging above programs - 22 prepared messages; chapter 8 — ASCII transmit program 110 baud (300 optional); chapter 9 — ASCII receive decoding program; chapter 10 — Merging above programs - 22 prepared messages; appendix 1 — LPRINT 64 characters/line using the EDTASM; appendix 2 — Model I to Model III I/O interface adaptor; appendix 3 — RTTY frequency diversity — the SELCOMP system; appendix 4 — Begin LPRINT assembled object code at any line; appendix 5 — Software generation of 2125/2295 audio tones; appendix 6 — RTTY speed tester — 60, 66, 75, 100, 110, 300; appendix 7 — Modifying the Flesher TU-170 for 300-baud ASCII.

As a modestly experienced assembly language programmer, I found the expanded commentary in each chapter and the full-printed-out OBJECT CODE and SOURCE CODE with comments for each program extremely helpful in understanding the program logic and flow. These programs are definitely *not* for the beginning assembly language programmer, who must at least learn the difference between a JR and JP instruction.

The author has simplified the program flow by using only the minimum JUMPS necessary. Programs have been designed so that once loaded from cassette/disk, the radio amateur unfamiliar with the TRS-80 can master their operation with minimal practice.

Chapters 1-4 describe how to generate perfectly timed Morse code. For transmit speed, one simply inputs the words per minute desired. For receive speed, the operator is asked to input *two* numbers that correspond to dot length and typical space length.

Chapters 5-7 are worth five times the price of the entire book. Having been a radioteletype buff for many years, I've finally "found a home." Gone are the whirring and clanking machines of times past. All the operator need do is tell the program the equivalent Baudot speed desired, and most everything else is automatic. The CLEAR key on the keyboard is the T-R switch.

Chapters 8-10 are similar to chapters 5-7 *except* for 110 baud, 8-bit, ASCII code instead of 5-bit Baudot code. If you study and ENTER the programs in chapters 1-10, you will have mastered a number of very difficult subjects. None of the programs in the volume requires the RS-232C interface unit to be installed in the Model I or the Model III because they generate their own UART in software (serial-to-parallel and parallel-to-serial conversion). And, for the programs in chapters 5-10, a digital port interface (such as the Design Solution AN-511, Telesis VAR/80 or Alpha Product Interfacer 2) is required. All will work with or without the expansion interface on the Model I, and *all* work with the adapter on the Model III. Appendices 1-7 cover:

1) *EDTASM* grabs most all MEM available. This program details an interesting approach to writing a mini-program in low MEM. Your line printer prints out 64 characters and/or spaces per line.

2) Covers an adaptor to allow the use of most any Model I ancillary-port-operated device (40-pin connector) with the Model III TRS-80 (50-pin connector).

3) Is a modification of the unique SELCOMP (selective compensation) RTTY decoder that allows selective fading of either the MARK or SPACE signal *without* losing received data.

4) Ever wish you could start LPRINTing an EDTASM program being assembled at any line *without* starting at the beginning? This simple 39-cent modification may be installed in about 10 minutes.

5) This demonstration program allows you to generate the 2125-Hz radioteletype MARK tones and 2295-Hz SPACE tones with software rather than a terminal unit (TU).

6) Here is a short program that prints out the speed in equivalent wpm of any Baudot radioteletype signal being received — 60, 66, 75 or 100 speed. It also tests for 110- or 300-baud ASCII RTTY.

All programs are divided into individual TRANSMIT, RECEIVE and COMBINED chapters to allow the reader the opportunity to assimilate the concepts being presented in reasonably sized bites. The programs may be used as is, by inserting only your call sign, name and address in the appropriate prepared message locations with the Radio Shack Editor/Assembler.

All three transmit/receive programs are available on two 35-track disks, though this book is also required for operating instructions. On special order, Richcraft will insert your call, name and address in the proper locations of all three transmit/receive programs for Morse, Baudot and ASCII RTTY.

The appendices are extremely useful. Volume 4 deserves an excellent rating and should be invaluable to any microcomputerist who wishes to understand the concepts of code conversion and use the versatile TRS-80 in the expanding field of modern telecommunicatiions. — *William M. Laird, W2CIX/3*

Technical Correspondence

Conducted By
Peter O'Dell,* KB1N

The publishers of QST assume no responsibility for statements made herein by correspondents.

TIPS ON THE F6CER I-F STRIP

☐ I'd like to make a number of comments regarding the August 1981 *QST* article, "A Universal MOSFET I-F Amplifier." One comment is on the adjustment of I_{dss} for the three MOSFET devices. This appears to be either a typographical error, on a translation error, since I_{dss} is a characteristic of a particular MOSFET and not something to be adjusted. What was meant was I_D, drain current, should be adjusted. I strongly disagree with the current levels of 10 mA to 12 mA stated in the article. The RCA data on the 40673 shows a typical I_{dss} of 15 mA. For maximum dynamic range the amplifiers should be biased at a little less than half I_{dss}. A convenient operating point for the 40673 is a drain current of 5 mA with a gate 1-to-source voltage of −0.7 V dc. In the i-f amplifiers this could be accomplished by changing the 47-kΩ resistors in the gate-1 circuits to 20 kΩ. Lowering the quiescent drain currents also will help if the MOSFETs used are not "typical" and have I_{dss} values lower than 15 mA. The only drawbacks of rebiasing the amplifiers in this way is that the lower drain current will decrease g_m from 12 mS to 10 mS, and the signal load will decrease. Both will cause the gain of the i-f strip to decrease slightly.

The agc-bus circuit could be simplified by eliminating networks. These serve no purpose, since gate 2 of each MOSFET has a 2.2 kΩ/0.01-μF decoupling network, which should be entirely adequate. Adding a small 100-pF capacitor to the three gate 2s should be done to provide a good bypass in the upper vhf and lower uhf ranges. At these frequencies the 0.01-μF capacitors are beyond their self-resonance, and with the MOSFETs having a gain beyond 400 MHz, a good bypass to ground is needed. The smaller-value capacitor in parallel with the larger 0.01-μF unit will provide the stability needed. Other methods mentioned in *Solid State Design for the Radio Amateur* include putting a ferrite bead on the gate-2 lead of the MOSFET to prevent instability in the vhf or uhf regions. Eliminating the 100 Ω/0.01 μF decoupling network on the output of U2 eliminates the possibility of the capacitance causing the operational amplifier to oscillate. The 100-Ω resistor will help isolate the capacitive load from the amplifier output, but it may not be enough for all 741s.

Some typographical errors should also be noted. The resistor used to provide the source voltage of Q1 in conjunction with D1 should be 2.2 kΩ, not 220 Ω. The description of the agc operation was reversed. The output of U2 will be 0 V at full receiver input level, and 8 V with no signal input, and not the reverse as stated in the article. The adjustment of the agc characteristics can be done by adjusting R3 and R5, not R3 and R4 as stated in the alignment section.

The last comment about the article would be that it did not emphasize how critical the shielding is to proper operation, and the filter feedthrough capacitors shown in the photographs. With the circuit having a gain of 110 dB, the shielding between input and output should be at least 120 dB. The construction and integrity of the shielding and grounding must be very good to obtain this figure when all the gain is on one relatively small printed-wiring board. While the box is shielded, three signals pass through. The two S-meter lines and the 12-V supply are brought through the enclosure shield via filter feedthrough capacitors. These components have built-in ceramic capacitors that provide excellent bypassing of signals up through the microwave range. With all the gain in the i-f amplifiers, this bypassing of input and output leads is absolutely necessary. Imagine how little BFO signal energy would be needed on the power bus to cause the i-f amplifier to go into agc! The feedthrough capacitor performance could be improved by using inductors in the three signal lines to provide decoupling action rather than just bypassing. Another technique would be to run the BFO on a different supply than the i-f strip. This would help prevent leakage from getting in through the power bus.

Going over the foregoing comments caused me to read Wes Hayward's original description of "A Competition Grade CW Receiver" in the March and April 1974 issues of *QST*. Two more comments are in order. The first is to provide a signal return for the drain load of Q4. A 0.1-μF capacitor from the supply side of the 470-Ω resistor should be satisfactory. The second is that Q5 in combination with U2 *do not* form the familiar control circuit used by W7ZOI and W1FB. The circuit in the high-performance receivers uses the FET source follower as a unity-gain buffer to the noninverting input of the operational amplifier. The inverting input is used to set the amplifier gain and provide a manual i-f gain control. The F6CER circuit uses the noninverting operational amplifier input to set the i-f output signal level. The output impedance of the source follower sets the gain of U2, which makes the gain dependent on the g_m of the FET. These differences should be considered when integrating the i-f strip into a receiver.

The comments should help make the construction, testing and operation of the i-f strip easier for those getting into hardware building. — *Mal Crawford, K1MC, Lexington, Massachusetts*

DECOUPLE VHF VERTICALS

☐ Improper decoupling of transmission lines from vertical antennas mounted above ground can destroy the predicted radiation patterns. I built W1FB's 5/8-wave antenna (June 1979 *QST*) for 2-meter fm service and erected it a few feet above my roof. The performance did not meet my expectations — it was scarcely better than a quarter-wave ground-plane.[1]

After researching the subject, I concluded that current was flowing on the outer conductor of the coaxial feed line. This current produced fields that interacted with the antenna fields, resulting in an upward deflection of the radiation lobe, which meant degraded performance.

I built the decoupling network shown in Fig. 1 and added it to the original antenna. Now the feed line goes through the TV mast and attaches to the bottom of the antenna. It is essential that a good mechanical and electrical connection be made between the braid (antenna ground) and mast top. Instead of attaching the radials to the loading coil base, I mounted them on the mast with a hose clamp at a point 5/8-wavelength below the loading coil. In a similar fashion, I affixed a second set 1/4-wavelength below the first.

Although I expected some improvement in performance, I was pleasantly surprised at the difference in received signal strength. A station located approximately 10 miles (16 km) away acts as a control for a MARS net on 143.99 MHz (simplex). Before adding the decoupling circuit, I could barely copy him. After the addition, his signal consistently fully quiets the receiver and pins the S meter on my Heath VF-7401. He reports a similar improvement in my transmitted signal strength.

In the present configuration, the antenna would be described as an extended double Zepp. The name is not important, but improved performance is. Because the fields pro-

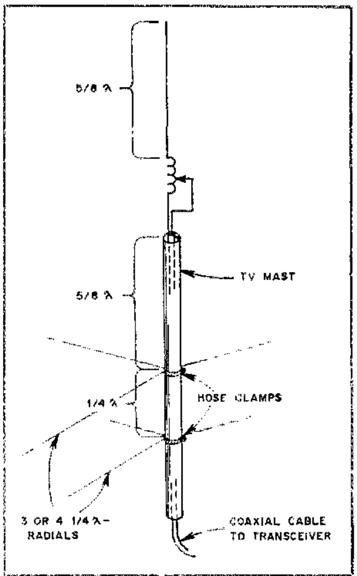


Fig. 1 — The supporting mast becomes part of the decoupling network.

[1]The W1FB design was developed for mobile use, which provided a ground plane by virtue of the car body. The feed line was therefore contained within the ground system.

*Assistant Technical Editor

duced by feed-line radiation vary from one installation to another, the amount of improvement after decoupling will also vary. If you are not getting the performance from your vhf vertical that you expect, you may want to add a decoupling system. The improvement may surprise you. — *Peter O'Dell, KB1N*

THOUGHTS ABOUT THE WA2ANU SWR INDICATOR

☐ Dave Geiser's "Human Engineering the SWR Indicator" (Technical Correspondence, *QST*, June 1981, page 38) covered some interesting approaches to reading convenience. However, there is a 1-meter circuit which is not only more economical than the 2-meter version, but which makes tune-up virtually error-free for maximum power transfer and minimum SWR.

The circuit, for which I claim no originality, is shown in Fig. 2. As compared with the conventional SWR meter, it requires only two additional resistors and a three-position, instead of a two-position, switch. When the switch is in either the FWD or REFL position, the meter will provide the conventional indication of forward or reflected power, respectively, proportional to the voltage drop across R1 or R2. When the switch is set to DIFF (differential), the meter reading is proportional to the differential voltage across R1 and R2 in series.

If an infinite SWR is assumed, along with matched diodes in the SWR bridge, and matched resistors (R1 and R2), the reflected power will be equal to the forward power. Therefore, the voltage drops across R1 and R2 will be equal, resulting in zero meter current. If the SWR is unity, there will be no reflected power, so that the voltage drop across R2 will be zero and the meter reading will be proportional to the forward power. At any SWR between unity and infinity, the meter reading will be proportional to the forward power minus the reflected power.

Even if the diodes and/or resistors are not perfectly matched (resulting in some error), adjustment of an antenna or matching unit is simplified to a procedure that yields maximum meter current when the switch is set to the DIFF position. Maximum power transfer into the load is also indicated by maximum meter current. — *Robert S. Stein, W6NBI*

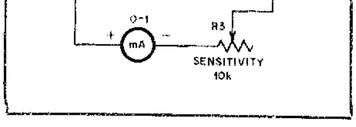


Fig. 2 — Schematic diagram of the SWR indicator.

POWER VERSUS ENERGY

☐ The letter in December 1980 *QST*, page 56, from Mr. J. T. Kroenert, responding to "The Imperfect Antenna System and How it Works," takes issue with the author's statement, "In reality, power does not travel down the line." I feel that Mr. Kroenert and the article author are using different definitions for the word "power," and each is correct in his respective understanding of the word.

In everyday conversation we use the word "power" in statements like: "A power plant generates power and supplies it to the power line. My transmitter supplies power to the transmission line. The power travels down the line to my antenna."

In each of these statements the speaker is talking about something he calls "power" being generated, transferred, traveling and being used. The listener, upon hearing these statements, visualizes something being generated, transferred, traveling and being used, and this is as it should be, because the speaker intended him to visualize this. From the physics-book standpoint, however, the word "power" should not have been used in these statements. More correctly the speaker should have said: "A power plant generates electrical energy. My transmitter supplies electrical energy to the transmission line. The electrical energy travels down the line to my antenna."

The physics book defines "power" as the *rate of doing work*. In electricity and electronics, this work is done when a transition of electrical energy takes place. When electrical energy is being translated into heat energy in a resistor, tube or transistor, "work" is being done, and the rate at which it is being done can be expressed as so many watts of power. Thus, power is not something that can move around, but is just a statement of how fast something (the electrical energy) is changing.

Since the word "power" expresses a rate of transition of energy, it would seem quite appropriate to refer to the rate of movement of energy down a transmission line as power. Thus we could say that "the electrical energy is flowing down my transmission line at the rate of 50 watts. It is being radiated by my antenna at the rate of 40 watts," or whatever. When we say that the forward power and the reflected power are so much, we are actually talking about the rate of flow of the forward and reflected electrical energy; however if, in our everyday conversation, we visualize the "power" as being the electrical energy, we are using our everyday definition of the word "power."

To say that "50 watts is moving down my transmission line" is like saying that "50 miles per hour is moving down the highway." Actually it is my automobile that is moving down the highway at the rate of 50 miles per hour!

I see nothing wrong with using the word "power" to mean electrical energy, as long as we understand it that way and recognize the difference when someone uses it according to the physics book, as did Mr. Gibilisco in his article. — *Charles W. Simonds, W5NEN, Norman, Oklahoma*

NOTES ON TOWER-ERECTION PHYSICS

☐ In July 1981 *QST*, Peter O'Dell, KB1N, in his article "The Ups and Downs of Towers," states that "walking up" hinged towers should

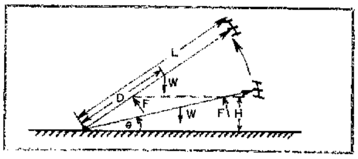


Fig. 3 — Pertinent factors related to "walking up" a hinged tower.

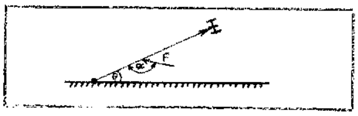


Fig. 4 — Illustration of the application of factor F in tower erection.

be avoided unless one has a good grasp of the physics involved. I would like to support this statement by presenting a simple derivation of the forces involved in walking up a hinged tower. Consider a hinged tower of length L and weight W and whose center of gravity is located a distance (D) from the base, as shown in Fig. 3.

Suppose that a force (F) is applied perpendicular to the length of the tower at a constant distance (H) from the ground, which would be the case in walking up a tower from a horizontal to a vertical position. Let θ be the angle the tower makes with the horizontal. Applying the concept of torque for any angle θ we have:

$WD \cos \theta = FH/\sin \theta$, which may be written

$$F = WD \sin 2\theta/2H$$

Therefore, for any angle θ between arc sin (H/L) and 90° the force required is given by

$$F = WD \sin 2\theta/2H$$

This equation clearly shows the difficulty in walking up a hinged tower, because the force becomes a maximum at an angle of 45°. For example, if a 50-foot tower, weighing 200 lb and having its center of gravity located 27 feet from the base, is pushed up from a point 6 feet above the ground, then at 45° the force required will be 450 lb, which is more than twice the weight of the tower! The horizontal and vertical components of the force that the hinge exerts on the tower are given by $F \sin \theta$ and $W - F \cos \theta$, respectively. The total force that the hinge bolts have to exert is given by

$$\sqrt{F^2 + W^2 - 2FW \cos \theta}$$

If F is applied to the tower at any angle α, as shown in the Fig. 4, the equation for the required force becomes

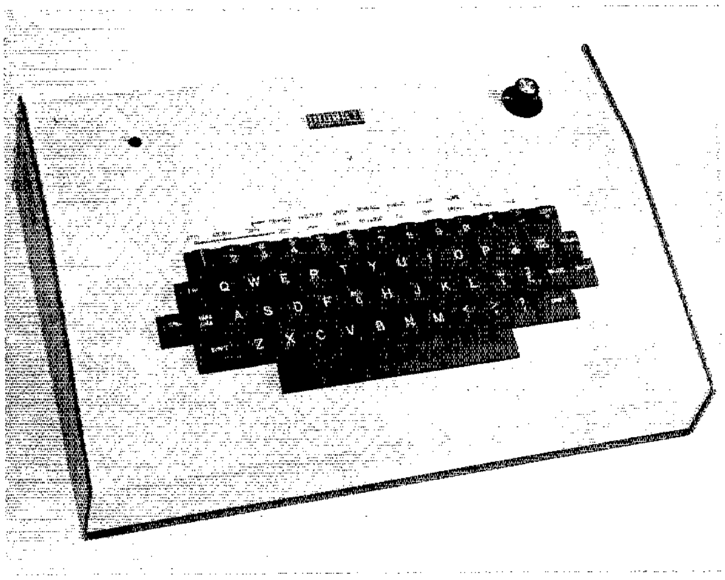
$$F = WD \sin 2\theta/2H \sin \alpha$$

which shows that, at an angle of 90° or normal to the tower, the force is most effective in producing rotation about the hinge. However, walking up a tower in practice usually means that angle cannot normally be held at 90°, which compounds the difficulty. For a given tower the force (F) can be minimized only by increasing H, the distance from the ground to the point of application of the force. Therefore, from the physics of the problem, I can only reiterate Mr. O'Dell's words of caution before erecting a hinged tower. — *Robert Larson, KAØGQV, Fenton, Missouri*

Product Review

Conducted By Paul K. Pagel,* N1FB

Robot 800 Specialty Mode Terminal



"Silent RTTY" is well entrenched and growing every day. If you've never experienced this exciting mode of communication, you're missing a lot of fun. With a unit such as the Robot 800 and a video monitor, you can open a new range of communications experiences to yourself. RTTY (Baudot), ASCII, cw and SSTV character generation are at your fingertips.

The Robot 800 is designed to send and receive 850- and 170-Hz shift RTTY at speeds of 60, 66, 75, 100 and 132 wpm, Morse at 1 to 99 wpm, and ASCII at 110 baud. It also acts as a character generator for SSTV, but a unit such as the Robot 400 is required for complete SSTV operation. A video monitor (not available from Robot) is required to complete the system.

Physical Sketch

The 4 × 15.5 × 10.25-inch[1] (HWD) unit weighs 10 pounds. A rugged, two-piece, two-toned (dark gray and white) sloping keyboard cabinet houses the Robot 800 electronics, which are mounted on a neatly arranged, double-sided, glass-epoxy circuit board. The unit certainly appears to have been built to last, providing years of trouble-free service.

Interface between man and machine is by means of a rear-panel mounted ON/OFF switch, SIDETONE and afsk OUTPUT level controls, a top-mounted input level control, and the 55-key keyboard. All control functions, alphanumeric and special character generation are implemented from the keyboard, which has a touch I found quite comfortable.

Machine-to-machine connections are made from the rear panel. Each Robot 800 is supplied with four cable assemblies to permit quick and easy equipment interconnection. Two three-circuit jacks provide CW KEYing and TO XMTR (afsk) outputs to the transmitter. Phono jacks are used for fsk output keying (TTY LOOP), receiver audio input (FROM RCVR), and SCOPE MARK and SPACE outputs that may be connected to a scope used as a tuning indicator. A female BNC (TO MONITOR) connector links a video monitor to the '800. The AUX OUT jack is used with the Robot 400 SSTV scan converter. A ground terminal, ac line cord and fuse holder are also located at the rear of the unit.

Electronics

The Robot 800 is a "dedicated computer"; a microcomputer that is designed for a specific application. For those "into computers," the '800 uses an 8085A µP, supported by 6144 bytes of ROM and 2560 bytes of RAM. An 8251 USART is used for serial I/O and 8155s for parallel I/O and keyboard interfacing.

The built-in TU (terminal unit) employs active filters. These are constructed using low-cost 1458 dual op amps. Following the input level control is a high-pass/low-pass filter combination. Only the high-pass filter section is used during 850-Hz shift RTTY reception. A limiter, separate mark/space discriminators for 850- and 170-Hz shift, full-wave rectifiers, tuning indicator, low-pass filter, ATC (Automatic Threshold Computer) and slicer sections follow. A sidetone oscillator for monitoring and certain signaling applications and a sine-wave synthesizer for afsk generation are also included.

In Operation

As is typical of many Amateur Radio stations today, a transceiver is used at N1FB. Baudot (using afsk and fsk), cw and ASCII were employed, Baudot quickly becoming a favorite mode.

CW

I haven't used a machine yet that could match the human ear/brain combination for copying cw under all operating conditions. The Robot 800 was no exception. When copying machine-sent cw with good reception conditions, the '800 performed well, but for the most part, I relied on "head copy" while using the keyboard for transmitting.

The RTTY mark channel filter (1275 Hz) is used by the Robot 800 when copying cw, and though the passband is narrow (about 70 Hz), the transceiver must be operated with the MODE switch in the LSB or USB position. Because the ssb filter must be in the i-f chain in order to pass the 1275-Hz tone required by the '800, it compromises the station operation in a couple of ways. First, while the narrow passband of the mark channel audio filter can protect the '800 from unwanted audio frequencies, the bandwidth of the ssb filter is about four times as great as that of the cw filter (500-Hz cw filter being used). This allows unwanted signals to get to the i-f stages of the receiver section and degrade overall receiver performance. Second, some transceivers automatically insert the cw filter when the transceiver MODE switch is in the cw position; there is no narrow/wide selection switch. This means that the operator must continually switch between the CW and USB MODE switch positions when going between transmit and receive because the transmitter cw keying circuit is deactivated in the SSB mode.

Another anomaly noted was the extended word spacing that occurs when an end of line is reached. A carriage return/line feed is automatically generated by the microcomputer, and this causes a slightly exaggerated word space at that point. But the CR/LF is a necessity for machine-to-machine copy and shouldn't unduly upset an operator copying by ear.

ASCII

Few ASCII stations were noted on the air. Some that were heard couldn't be copied because their transmission speed exceeded the 110 baud rate of the '800. Copying ASCII is fun — the characters stream from left to right

[1]mm = in. × 25.4; kg = lb × 0.454

*Assistant Technical Editor

across the screen quickly and smoothly. It's another story when it comes to transmitting, however! Unless you're a terrific typist, the 511-character transmit buffer will empty before you know it and you're back to transmitting at whatever speed your typing skill permits. For me, that's about 50 wpm. And since I had no specific reason to use ASCII, I "QSYd" to RTTY, where the predominantly used speed of 60 wpm more closely matched my typing speed.

RTTY

Some transceiver models permit switching between fsk and afsk transmission with a flick of the mode switch. I set my unit up that way, preferring to use afsk because of the MONITOR feature my transceiver employs. This enables me to keep a constant check of the output tone quality while monitoring the transmitted waveform on an SB-610 scope. The FSK position of the transceiver was used only when QRM was rough and the narrower passband of the cw filter was desired.

I felt (as did some other Robot owners to whom I spoke) that a transmit buffer capacity of double that available (511 characters) would be most welcome. However, there is also a tie-in with the video display, which will show only 11 lines of transmit text, no matter how full the buffer is. The same memory is used for the screen display and transmit buffer. If the screen is called to present all received text, any information that may have been stored in the transmit buffer is erased.

Another instance in which the buffer is erased is when any transition is made from receive to transmit and back to receive again *without transmitting the text* (two ESCape key depressions). The '800 is fooled into thinking that the transmit buffer has been called to empty, when in actuality nothing has been transmitted.

Tuning in an RTTY signal is simple. You merely adjust the receiver/transceiver tuning control for maximum deflection of a bar in the upper left-hand corner of the screen. No external tuning scope is required although mark and space channel outputs are provided for that purpose on the rear panel.

I never ceased to be amazed at the ability of the Robot TU to copy RTTY signals that I could hardly discern by ear! Rapid QSB was the greatest enemy of perfect reception, otherwise it appeared as though little could deter the Robot from the assigned task of copying a desired incoming signal. On many occasions, very strong adjacent signals would literally "bury" the desired signal, but the Robot kept on printing to the screen as if nothing had changed.

Two 64-character message memories make a convenient place to store short, oft-repeated messages such as your call sign, name and location for inclusion in a CQ. A separate i-d message memory can be called to identify the station, but the transmission speed of the cw i-d during RTTY operation cannot be altered; it is fixed at about 16 wpm.

General

The instruction manual that accompanies the Robot 800 is a vinyl-clad loose-leaf three-ring binder. It is well written and includes schematic diagrams of the unit. Some resistor values used in the TU were not noted on the diagram, perhaps because they are used for trimming the discriminators. Parts lists, a quick reference guide for the keystrokes required to make the '800 perform (too many to list here), and an addendum that notes the parts value differences between the low-tone model 800 and high-tone model 800H are included. Block diagrams and a complete technical description of the terminal unit aid the owner in understanding the operation of the Robot 800.

The low-tone model 800 uses 1275-Hz mark and 1445-Hz space tones for 170-Hz shift, and a 2125-Hz space tone for 850-Hz shift on RTTY. An 800H high-tone pair model is available that uses tone frequencies of 2125 Hz for mark and 2295 Hz for space with 170-Hz shift, with a 2975-Hz space frequency for 850-Hz shift.

There are more features to list than space allows, but some of these are: A Morse trainer that sends random 5-letter groups at selected speeds from 1 to 99 wpm, keyboard-operated transmitter control (KOX), on-screen status and tuning indicators, unshift on space, automatic carriage return/line feed, "RY" and "Quick Brown Fox" test messages, and 8-character programmable WRU (Who aRe yoU) and SELCAL (SELective CALling) codes. Using the continuous line or word transmit modes and the editing feature can make your transmissions smooth and errorless.

Each display line contains 72 characters, with 11 lines devoted to received text and 11 lines to transmit text when using the split-screen mode. In the full-screen mode (deleting the status indicator and divider lines), 24 lines of text are presented. Word wrap-around prevents the awkward splitting of words at the end of a line.

Early models of the Robot 800 did not have the split-screen feature. If you own one of those units, you'll be pleased to know that it may be retrofitted at the factory for $40 plus shipping charges.

Summary

If you've never used a terminal like the Robot 800 or have never operated RTTY or ASCII, I'd recommend a little off-the-air practice beforehand — if not for your sake, for the other guy's! Try to eliminate as much of the "cockpit error" as you can before generating any rf energy. The quick-reference keystroke guide can be removed from the instruction manual and placed conveniently nearby to help you.

I thoroughly enjoyed using the '800. It provided me with hours of trouble-free enjoyment. Not once did it glitch, even when an unenclosed 1-kW amplifier was being used. If you want more information, contact Robot Research Inc., 7591 Convoy Ct., San Diego, CA 92111. Price class: $800. — *Paul K. Pagel, N1FB*

WILSON SYSTEMS, INC. SYSTEM 40 TRIBANDER

☐ Within the past few years, several antenna manufacturers have introduced large tribanders. The Wilson System 40, with 10 elements, the longest of which is 36 ft,[1] certainly ranks as one of the most imposing! The antenna arrived packed in two long, heavyweight shipping cartons, and ideas of "instant Yagi" were speedily revised! Twenty-three hours later, after following the instructions in Wilson's thorough assembly manual, the System 40 was ready to go aloft at AC1Y. It is worth noting that much of that time was spent in inventorying the hundreds of bolts, nuts and washers that hold the antenna clamps together. The extra effort was worthwhile, permitting smooth assembly.

Mechanical and Electrical Details

The System 40 is not a typical tribander. Rather it may be described as two antennas interlaced on a common boom. The first antenna is a full-sized, 4-element, 20-meter monobander; the second antenna is a 6-element trap duobander for 15 and 10 meters. There are four active elements on 15 and five on 10. The feed system is formed by a beta match driving the 20-meter and 15/10-meter driven elements in parallel. An rf choke, supplied by Wilson, is a coil of RG-8/X coaxial cable encased in a heavy plastic tube.

The antenna element sections have slots for ease of assembly, and sturdy compression clamps secure the telescoped sections. Polypropylene rope supplied in the kit is not for use with a gin pole! Appropriate lengths of the rope are cut for each untrapped element half and inserted therein during assembly. The rope within the elements serves to damp wind-induced vibration, and helps to prevent premature weakening and structural breakdown of the aluminum. A large plastic envelope containing conductive grease was supplied with the antenna to facilitate assembly and to ensure future electrical continuity. This compound is very often missing from antenna kits; it definitely prolongs the useful life of the antenna.

Wilson rates the System 40 at 12.1 sq. ft of surface area with a finished weight of approximately 75 lb. Power handling capability is 2 kW PEP input. A Yagi of this size requires both a secure tower installation and a hefty rotator. I have utilized a CDE Ham III and an Alliance HD-73 with excellent results. However, it is worth noting that I provided for adequate torque stress relief in the rotor system by mounting the rotor approximately 8 ft below the tower thrust bearing.

The System 40 did not, at first test, yield VSWR curves on 10 and 15 meters within the range suggested by the manufacturer. Two factors were found responsible: My tower installation included uninsulated guys as well as a number of wire antennas suspended within several feet of the System 40. In addition, during discussion of the VSWR problem with the factory, I learned that the design was prototyped atop a 60-ft freestanding tower with no adjustment provided for problems with resonant guy wires. Wilson agreed that their design parameters might not be electrically compatible with some individual installations. The manufacturer advised me that they were sending new traps to those System 40 owners experiencing VSWR problems. (These traps lower the resonant frequency of the antenna on 10 and 15 meters.) The new traps arrived soon afterward, at which time I proceeded to insert insulators in the top set of guys. The new traps were installed, and new VSWR curves were taken; these are shown in Fig. 1. They represent the broadband nature of the System 40 design, which should present a reasonable match for modern solid-state transceivers. Experience shows that VSWR curves are representative in an antenna manufacturer's literature, and will likely vary between individual installations.

In well over a year of operation at AC1Y, the System 40 has given good front-to-back and

[1] m = feet × 3.28; $m^2 = ft^2 \times 0.0929$; kg = lb × 0.454.

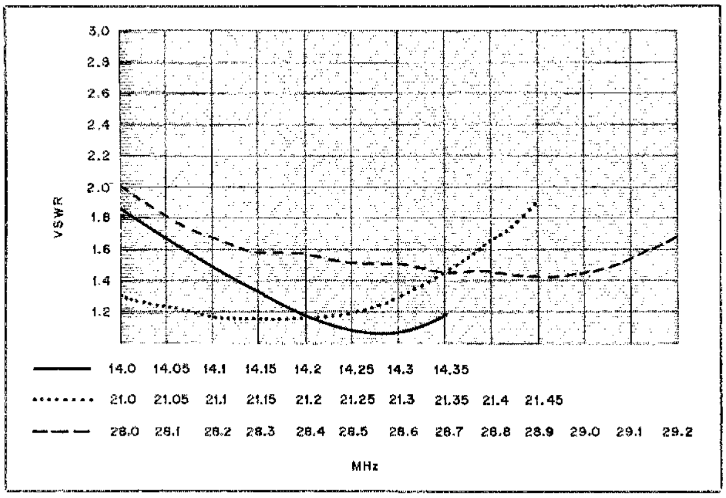


Fig. 1 — SWR curve of the Wilson SY-40 tribander.

front-to-side ratios; performance on all three bands yield consistent results in this category. Forward gain, too, appears to be excellent, judging from signal reports received. Overall, the System 40 has performed very well mechanically, having withstood some nasty Connecticut winter weather this past year, including two ice storms! Recent inspection of the antenna shows it to be in fine shape.

The System 40 is well designed. Although it has a great many small parts in the bolt and nut category, everything together makes for a sound Yagi. The amount of assembly time required is worthwhile, considering the durability the antenna provides. The aluminum and associated hardware is of excellent quality, and the instructions are thorough. The System 40 is manufactured by Wilson Systems, Inc., 4286 S. Polaris Ave., Las Vegas NV 89103. Price class is $395. — *Sandy Gerli, AC1Y*

FOX-TANGO YF-90H1.8 CRYSTAL FILTER

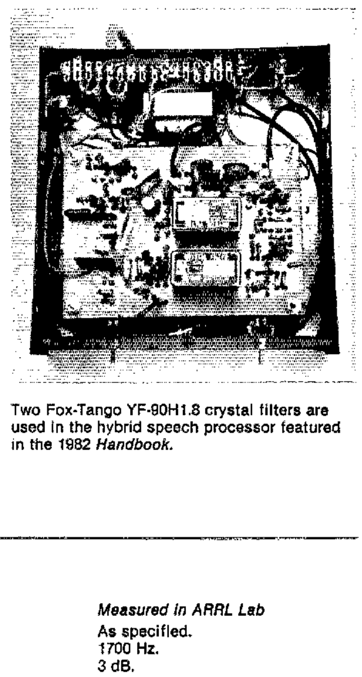
☐ An essential trait of a communications receiver is good adjacent-channel selectivity. In a modern superheterodyne receiver, this quality is determined by the i-f filter and associated circuit. In a filter type ssb voice transmitter, the filter defines the audio fidelity and establishes adequate opposite sideband (and sometimes carrier) suppression. Transceive applications require filters having all of these characteristics; in short, the i-f filter is the heart of a superheterodyne communications transceiver.

When the i-f is in the hf range, quartz crystals are usually employed in the filter. *QST* has offered articles on home construction of crystal filters, but the process can be tedious, and the design is not easy. Today most builders design their radio circuits around commercially manufactured filters of known performance. I opted for this "systems engineering" approach when roughing out the design for the hybrid speech processor featured in the 1982 *Handbook*. Milt Lowens, N4ML of Fox-Tango Corporation, recommended the YF-90H1.8 crystal filter for my application and supplied a pair of these units for evaluation. The YF-90H1.8 is a 1.8-kHz bandwidth, eight-pole[1] filter designed for plug-in replacement service in the Yaesu FT-301 and FT-7B transceivers. The Fox-Tango literature gives complete specifications for the filter, but because they were destined for unusual service, some tests and measurements were necessary before I could finalize my design.

The specifications are summarized in the table, but as with most measurements, there's a story behind the numbers. A 2500-3000 Hz bandwidth is accepted as standard for a voice channel, so if you think a bandwidth of 1800 Hz is a bit sharp, you're right. The 3000-Hz requirement is for intelligibility and recognizability. With only 1800 Hz to work with, we have to be satisfied with intelligibility. But to get that intelligibility, we must select the *proper* 1800-Hz bandwidth. The optimum slice will vary from voice to voice, but it's safe to say that 0-1800 Hz is not optimum. Many voice devices have an upper frequency 3-dB rolloff of 2500 Hz. When the upper −3 dB response of the YF-90H1.8 is set at 2500 Hz, the specified −6 dB response is at 2950 Hz. The corresponding lower −3 dB and −6 dB responses fall at 1350 Hz and 1150 Hz, respectively. The half-power bandwidth of the YF-90H1.8, then, is 1600 Hz. For voice modulation or demodulation, the carrier oscillator should be set to 8.99795 MHz or 9.00205 MHz to center the filter passband on the 1350-2500 Hz range. This is the second formant of the speech spectrum. The articulation is contained in this formant.

In the *Handbook* speech processor, the second-formant signal is heterodyned up to 9 MHz, where it is filtered, clipped, filtered again and finally demodulated as recovered audio. A single carrier oscillator serves for both the modulation and demodulation processes, so the output frequency is the same as the input frequency. The carrier oscillator frequency is important, but only in selecting the proper audio passband. In a receiver or transmitter, however, the carrier oscillator frequency is critical, not only for passband selection, but also for accurate demodulation. With "normal" communications bandwidths of 2400 Hz, the receiver can be mistuned a couple of hundred hertz, and an experienced operator can still understand the "gravelly" or "Donald

[1]The term "pole" is often tossed about by amateurs without thorough understanding. When pressed for an explanation, most hams (including this one) are inclined to stutter. The concepts of "poles" and "zeros" are based on some fairly sophisticated mathematics, including root locus and complex variables. At the risk of oversimplification, a pole is a parallel-resonant circuit, and a zero is a series-resonant circuit. Unless it's necessary to discuss the fine details of filter design theory, perhaps it's safer (and more useful) to describe the product being reviewed as an "eight-crystal filter," "eight-resonator filter" or "eight-element filter."



Two Fox-Tango YF-90H1.8 crystal filters are used in the hybrid speech processor featured in the 1982 *Handbook.*

Fox-Tango YF-90H1.8 Crystal Filter

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Center frequency: 9.000 MHz.	As specified.
6-dB bandwidth: 1800 (± 100) Hz.	1700 Hz.
Insertion loss: 6 dB.	3 dB.
Terminating impedance: 500 ohms, resistive.	
Case dimensions: (HWD) 18 × 18 × 50 mm.	As specified.

Duck-y" speech. Not so with the narrow bandwidth offered by the YF-90H1.8 — because there is less information for the ear/brain combination to process, the frequency accuracy must be significantly greater. This imposes tighter stability and backlash constraints on "conventional" receivers and requires synthesized receivers to have finer resolution.

Don't use a YF-90H1.8 for i-f tail ending — the combined passband will be too narrow for effective voice work. Instead, use a 2.4-kHz-bandwidth unit for the post i-f filter. So how did I get away with using a pair of YF-90H1.8s in the *Handbook* speech processor? First, a clipping stage follows the first filter. The amplitude vs. frequency characteristic of the clipper output is flat for all signals above the clipping threshold. If the stage is adjusted for 10 dB of clipping, the output is uniform over the 10-dB bandwidth of the filter. This is just over 1800 Hz for the unit measured, so the ultimate selectivity is defined by the post-clipper filter. Second, audio fidelity is further enhanced by injecting the separately processed first-formant (300-600 Hz) audio in the output stage.

The manufacturer's specifications and the measured response curve (Fig. 2) show the YF-90H1.8 to be a high-performance filter. In the ARRL laboratory, we tracked the skirt response down to the −90 dB point, the dynamic range limit of our test set-up (Fig. 3). From the −6 dB and −60 dB bandwidth figures, we can compute a claimed maximum shape factor of skirt ratio of 1.82. Our measurement was even better: 1.53. Some designers attach more significance to the 3-dB and 30-dB bandwidths. The skirt ratio using these figures measured 1.41. Particularly impressive are the passband smoothness and skirt symmetry.

A logical question might be, "Can I duplicate the laboratory results with my transceiver?" The answer is a qualified yes — if the circuit layout is clean and the terminal impedances are correct. The test fixture diagrammed in Fig. 3 has the filter mounted in a double-sided pc board with a shield partition between the terminals and the unit completely enclosed. BNC fittings couple the fixture to the test set-up. The impedance-matching resistors are mounted on short leads between the filter and connectors. Padding the system with these resistors ensures that the signal generator and spectrum analyzer "see" 50-ohm resistive terminations, and that the filter "sees" 500-ohm resistive terminations. Swamping the system this way sacrifices some dynamic measurement range, but the frequency independence gained enhances the accuracy over the dynamic range that remains. In practice, the filter would most likely be terminated in tuned circuits. At 9 MHz, such circuits are usually broad enough not to influence the passband or near-stopband performance. While testing the YF-90H1.8, we swished the signal generator 1 MHz either side of the center frequency without detecting any spurious stopband responses.

Filter effectiveness is degraded if signals can leak around it. Close proximity of input and output traces and long ground leads contribute to leakage. Where several filters are used, the switching system can encourage leakage. If you're installing a YF-90H1.8 in an attempt to upgrade a commercial transceiver, you may be stuck with a poor layout unless you're willing to perform some surgery (or butchery, depending on your outlook and craftsmanship). In home-built gear you can extract maximum i-f system performance by switching i-f *strips* rather than filters. The parts cost is insignificant compared with that of the filters, and you can tailor the gains for the various bandwidths.

One more point should be made: If you can afford only one filter and you operate both ssb and cw, the best i-f bandwidth to use within the constraints discussed earlier may be 1800 Hz. The reduction of ssb "monkey chatter" is truly remarkable, and you can eliminate one channel of cw QRM that would pass through a 2400-Hz bandwidth filter. The YF-90H1.8 and other filters are marketed by Fox-Tango Corporation, P.O. Box 15944, West Palm Beach, FL 33406. Price of the YF-90H1.8 is $55. — *George Woodward, W1RN*

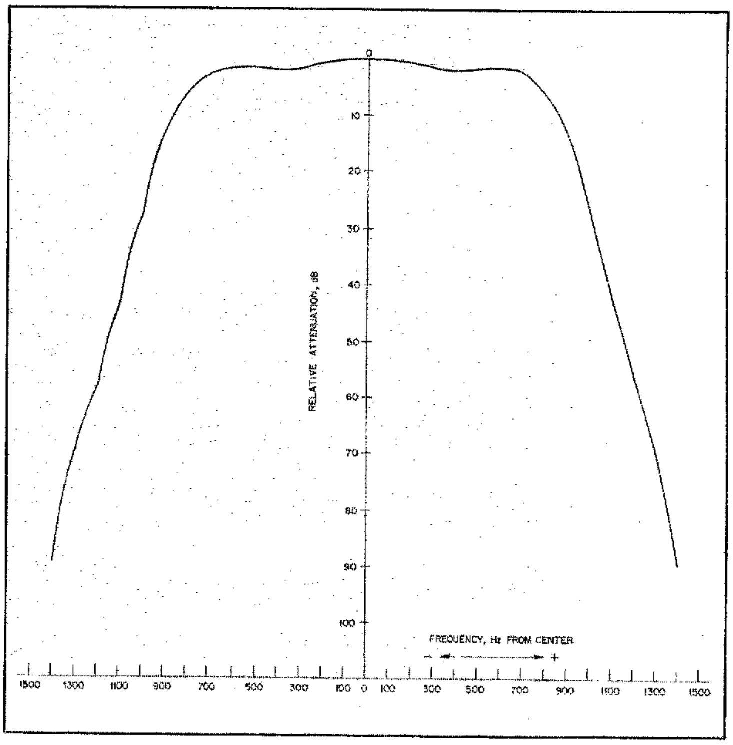


Fig. 2 — Frequency vs. amplitude characteristic of YF-90H1.8 filter, serial no. 059, as plotted in the ARRL laboratory. The center frequency is 9 MHz.

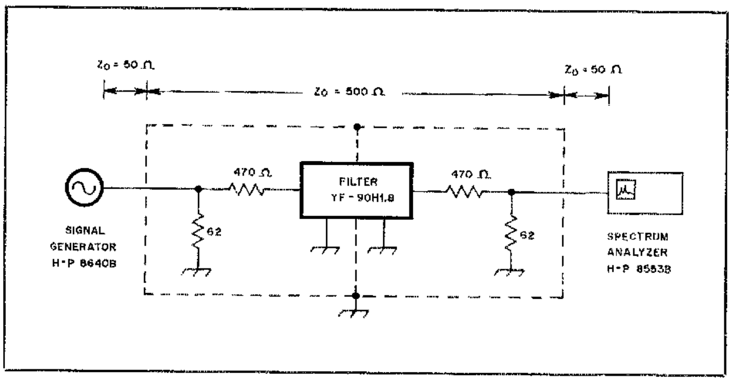


Fig. 3 — Test set-up used to plot the curve shown in Fig. 2. To measure the center-frequency insertion loss, a reference level is recorded with the filter in place. Then, the filter is removed and replaced with a wire jumper. The difference between the two levels is the insertion loss.

Hints and Kinks

Conducted By Larry D. Wolfgang,* WA3VIL

BRAKE PROTECTION FOR THE CDE HAM IV ROTATOR

☐ The Ham-series rotators have been used in directional antenna systems for years. They have a potential problem, common to all CDE rotators having a brake wedge that is disengaged by the application of an ac voltage from the control box. (CDE TV- and CB-type rotators do not have this feature.) The problem occurs if your finger slips off the BRAKE RELEASE switch while the rotator is turning. The antenna inertia can cause severe torsional stress to the supporting structure, damage to the brake assembly or possibly jamming of the rotator mechanism. The manufacturer's instructions caution users always to let the motor coast to a stop before permitting the brake solenoid to release the wedge, engaging the brake.

The suggestion given here will positively prevent brake engagement until 2 to 3 seconds after removing power to the motor. This provides ample time for the rotator to coast to a stop. An additional advantage is that the BRAKE RELEASE switch can be released immediately after the motor starts, without any danger to the structure.

All modifications are done on the underside of the chassis, in the control box. You may have the required parts in your junk box. I cemented the relay to the underside of the chassis with epoxy glue and wired the other parts point to point (Fig. 1).

When the cw or ccw switch is operated after BRAKE RELEASE is pressed, D1 or D2 will charge C1 through R1. The relay will prevent the brake from being engaged until C1 discharges sufficiently to permit K1 to drop. It would be wise to check the release time of the relay and change the value of C1 to ensure a lag of 2 to 3 seconds. — *John Reinke, AB6I, Casselberry, Florida*

*Assistant Technical Editor

CABLE ENTRANCE FOR THE SHACK

☐ Getting the coaxial cable and rotator control leads into my new ham "shack" was a job that I dreaded. How could I make a hole in the house that would be weatherproof and would not be ugly? The answer was simple.

I bought an aluminum clothers-dryer vent and installed it on the side of the house. The feed lines and control cables enter through the vent. A piece of fiberglass insulation is used to weatherproof the vent. (I filled the inside and wrapped the outside of the vent with insulation to keep the cold air and critters out.)

Wire-reinforced plastic dryer-vent hose can be used to keep the cables out of sight from the vent to the operating position. Connect one end of a length of hose to the cable-entrance vent, and place the other end near the rig. — *C. L. "Chuck" Hutchinson, K8CH, ARRL Hq.*

ENCLOSING CABLES IN CLOTHES-DRYER TUBING STOPS TVI

☐ I have found that by using flexible duct tubing made for clothes-dryer exhausts, I have been able to contain rf fields associated with my transmission lines, which had been responsible for TVI. The cables are placed inside the tubing, a type made with a spiral wire from one end to the other. This coil is grounded at the transmitter end. Because my equipment is in the basement, the transmission lines extend upward from the operating position. By enclosing the cables in the duct, the station appearance is improved. After installing the tubing, I no longer have TVI affecting my inexpensive TV set, less than 15 feet away. — *Earl P. Anderson, WD9DID, Milwaukee, Wisconsin*

REMOTE TUNING WITH A VARACTOR

☐ I was using an old WW 2 radio that was too big and bulky to place near my desk. I needed some method of remote tuning, so I used the varactor-diode circuit shown in Fig. 2.

A varactor will act as a variable capacitor if reverse bias is applied. The control voltage can be positive, as shown, or it can be negative if the diode is reversed.

I used an RCA SK3327, which has a minimum capacitance of 3.2 pF and a maximum capacitance of 33 pF. If this pulls your crystal or VFO too much you can reduce the swing by changing the value of C1. A 33-pF fixed-value capacitor will yield a total of half the varactor value, about 16.5 pF. If you need the full change in capacitance, use a larger value at C1, about 0.001 µF.

The variable resistor should be one with a smooth resistance change. I used an Allen/Bradley potentiometer, which has a thick coating of resistance material. It might be a good idea to apply some graphite (mixed with a light grade of oil) on the control shaft to en-

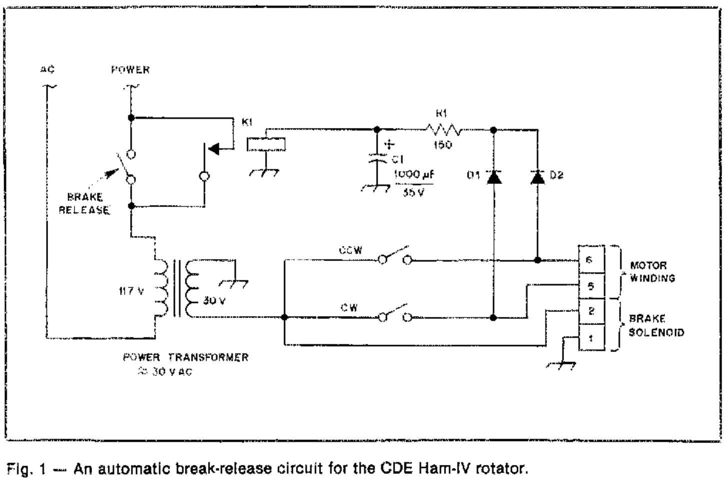


Fig. 1 — An automatic break-release circuit for the CDE Ham-IV rotator.

K1 — Relay, 24-V dc, 600-ohm coil (P&B KHP-17D).
D1, D2 — Diodes, 750 mA, 600 V (1N4001).
R1 — 150 ohm, 1/2 W.
C1 — 1000 µF, 35 V electrolytic capacitor.

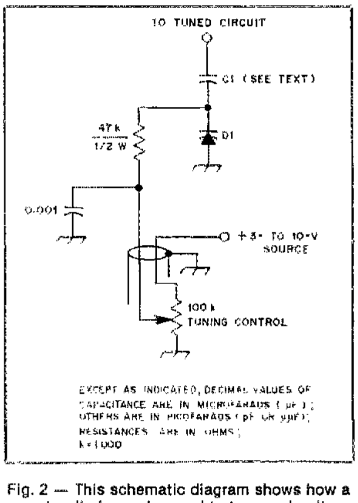


Fig. 2 — This schematic diagram shows how a varactor diode can be used to tune a circuit remotely.

sure a smoother action. You can use a vernier knob if you want better control.

By adjusting the values of C1 and the variable resistor, the frequency swing can be tailored to suit your needs. The leads should be shielded to prevent rf from getting into the diode. An rf choke of about 750 μH can be substituted for the 47-kΩ resistor. There is no current through this resistor because the diode is reverse biased, so no voltage drop exists.

This method can be used for a VFO, BFO, crystal oscillator or other circuits where you want to vary a frequency without using mechanical means. — *Joe Rice, W4RHZ, Covington, Kentucky*

RFI AND THE MAGIC GARAGE DOOR

☐ After having a Genie garage-door opener installed I found that the door would open occasionally when I was operating on 40 meters while using my amplifier (about 600 watts output). I tried shielding, ground straps and bypass capacitors, all to no avail.

One day I noticed the twisted pair of wires coming from the wall switch to the receiver on the door opener. My suspicion was aroused and I grabbed a tape measure. The wires were 32 feet long,[1] almost a perfect quarter wavelength on 40 meters!

I rerouted the wire and was able to shorten the twisted pair to 24 feet. This solved the problem completely: My XYL no longer plays Russian roulette when she drives under the garage door while I am operating the radio.

[For the successful solution to another garage-door opener problem see January 1981 *QST*, p. 49. — Ed.] — *Wayne Mitchell, K6VPN, San Bruno, California*

ELECTRONIC BIAS SWITCHING CIRCUIT

☐ I have been interested in articles on electronic bias switching. I use a variation of the circuit given by Hank Garretson, W6SX, in March 1981 *QST*, p. 52. My amplifier is homemade. It contains 572B tubes. The cathode circuit is keyed with the electronic bias circuit shown in Fig. 3. The transistor switch shorts out the 50-kΩ cathode resistor. This eliminates the need for a separate bias supply, but cuts off the plate current during key-up intervals. This circuit should work well with any amplifier that uses a cathode resistor for tube cutoff: It eliminates the relay contacts needed to short out the resistor. — *Dick Barnes, W6IPL, Fortuna, California*

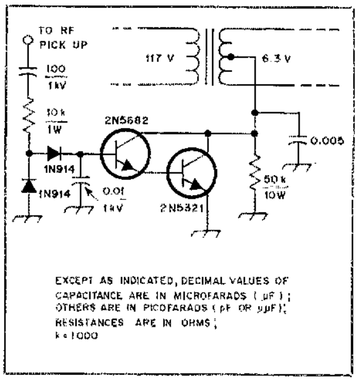


Fig. 3 — Schematic diagram of the electronic bias switching circuit used at W6IPL.

[1]m = feet × 0.3048

VARIABLE-BANDWIDTH CONTROL FOR THE HW-8

☐ I replaced the two-position selectivity switch on my HW-8 with a variable resistor, as shown in Fig. 4. This provides a variable-bandwidth control, with any degree of selectivity between the original WIDE and NARROW positions. — *Bill Ames, KA1EXB, Sandy Hook, Connecticut*

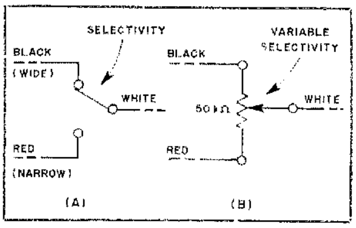


Fig. 4 — At A, the original selectivity switch in the HW-8. At B, the switch is replaced with a variable resistor.

PC-BOARD PATTERNS THE EASY WAY

☐ Paul Pagel's (N1FB) product review of the GC Electronics Lift-It Transfer Sheets in September 1981 *QST* (page 49) reminded me of a trick I learned in my instructional media class in college. Transparent self-adhesive plastic (such as Con-Tact,® manufactured by United Merchants and Manufacturers, Inc.) can be used to make a positive from a printed pc-board pattern. Cut out the pattern, place a similar-size piece of the plastic (backing removed) on it and rub the plastic side with a blunt object to ensure complete adhesion. Place the pattern in warm, soapy water for 15 to 20 minutes, and rub the paper off with your fingers. Be sure to remove all of the paper. You don't have to put the adhesive backing on a piece of Mylar,® but doing so will prevent dirt from collecting on the sticky surface (if you plan to save the pattern).

I found that a photocopy produced a much darker positive than an actual *QST* page could. This saves cutting precious magazines. It should also be possible to draw your own pattern, photocopy it and produce a positive or negative for exposing a board. Some photocopy machines may not produce a print that works as well as the one I used, however.

You should be able to find transparent self-adhesive plastic at a local department store. I found some that was 18 inches[2] wide and cost about 80 cents for 3 feet. — *Larry Wolfgang, WA3VIL, ARRL Hq.*

FADING AUDIO FROM THE HEATH MICODER II

☐ When I began receiving reports of fading audio on the repeaters, I replaced the 9-volt battery in my Heath Micoder II. This solved the problem temporarily, but after about a month the problem returned. This time I monitored the voltage of the new battery, with the mike keyed, and found that after about 30 to 40 seconds the voltage began to sag toward 8 volts. The culprit was isolated to a leaking 1-μF tantalum capacitor (C103). This was replaced with a capacitor of a higher voltage rating, and the Micoder has been okay since. — *Saul Dinman, K1PDX, Wayland, Massachusetts*

[2]mm = inches × 25.4

CHECKING RECEIVER SENSITIVITY

☐ Here is an idea that will help to determine whether the sensitivity of your receiver or transceiver is as good as it has been in the past. This method is entirely independent of the antenna or band conditions, and will be most effective if the calibrator signal in your receiver is injected at the antenna input.

I made a table of frequencies at a certain point in each band, for example, at 3.7 MHz, 7.2 MHz, etc. I record the S-meter reading from the crystal calibrator at each frequency (antenna disconnected). At a later date, if reception seems poor, I compare the present S-meter reading from the calibrator for that band. If the readings are the same the receiver is doing as well as before, and the poor reception is caused by something other than the receiver.

My original measurements were made in November 1978. Recently the 15- and 20-meter bands seemed very quiet. When I compared S-meter readings on these bands I found that they were less than half the original values. My receiver was not as sensitive as it had been. I traced the problem to dirty contacts in the band switch. After a good cleaning, the bands opened up again! — *Robert E. Troy, Jr., W4AHP, Montgomery, Alabama*

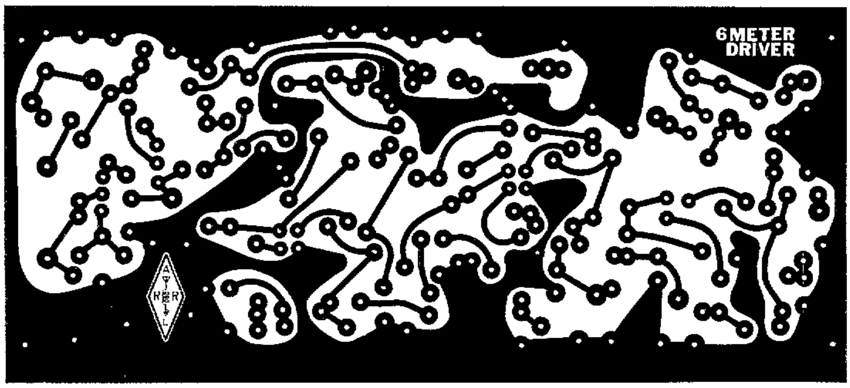
OLD TIMERS NOTEBOOK

Emergency Solder

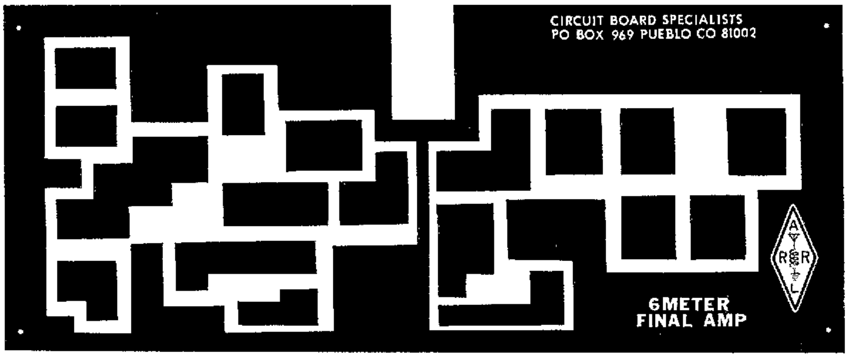
☐ Before setting out on Field Day or a long trip in the mobile station, prepare a few pieces of emergency solder. Melt some solder on a soldering iron and then flick the iron to throw the solder off. Catch the melted solder on a flat surface, such as a sheet of aluminum, and then peel it off. The resulting solder is extremely thin and will easily flow under the flame of a match. To solder a joint in an emergency where no iron is available, apply flux, wrap the thin solder around the joint and then heat with a match or lighter. The result is a good electrical connection made without benefit of a soldering iron. — *Bill Phillips, K8EJL, March 1961 QST*

De-Soldering Tip

☐ The melted solder that accumulates when you are unsoldering connections may be quickly and easily removed by brushing with a paint brush. Use a small 1/2- to 3/4-inch natural bristle brush. If it is made from synthetic fibers, small balls will form on the end of each bristle because of the heat, but this will not affect the effectiveness of the brush. It is an easy job to remove excess solder from the holes in soldering lugs, tube pins, etc. The brushing may produce small quantities of splattered solder but these can usually be removed without much difficulty. — *George P. Firmin, July 1961 QST*



(A)



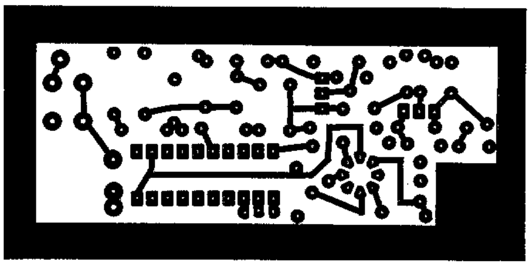
(B)

Etching patterns for the driver board (A) and the final amplifier board (B) used in the 6-meter transmitter. Black areas represent unetched copper, viewed from the etched side of the board. Parts-placement diagrams appear on p. 42.

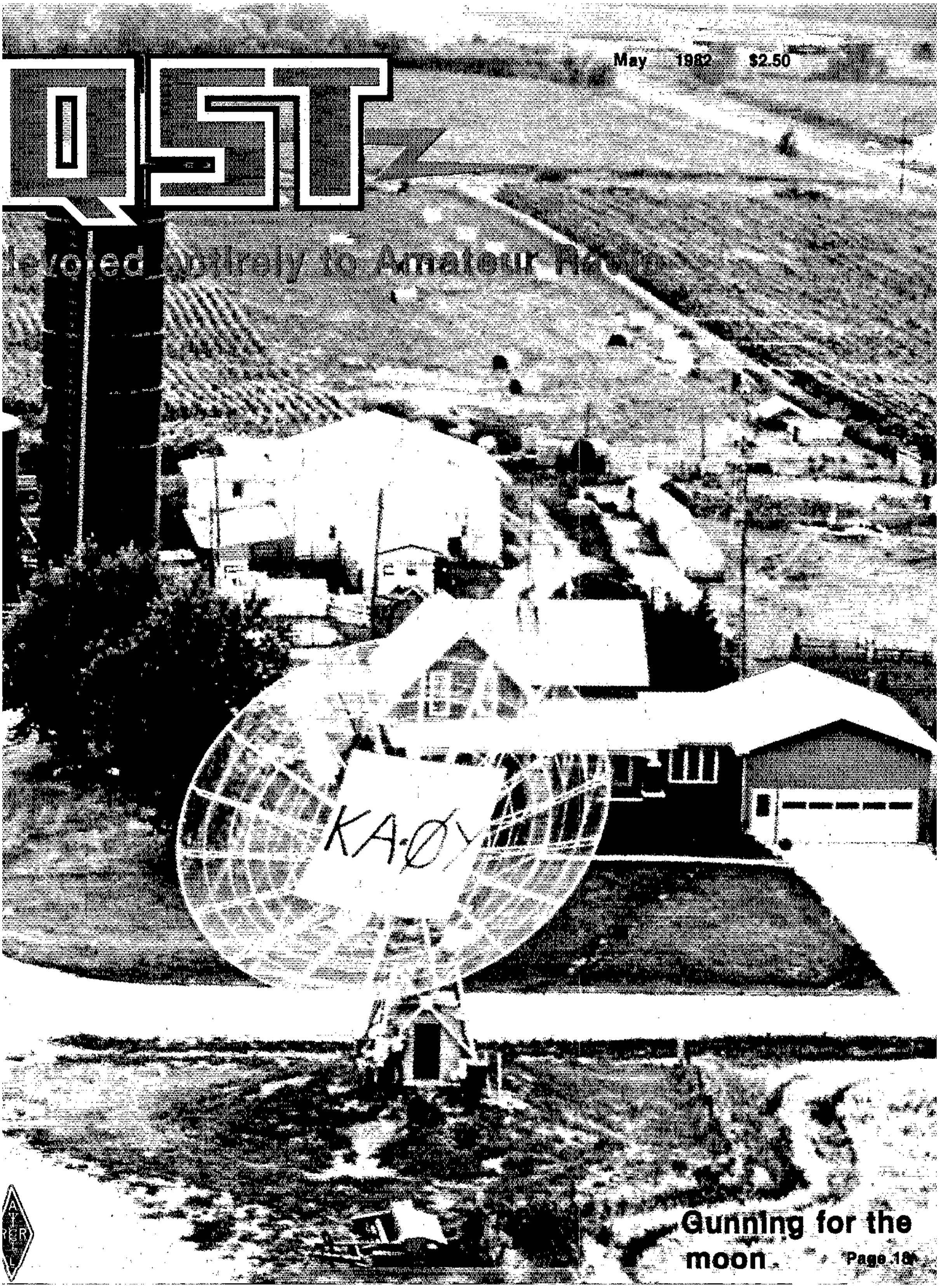
Feedback

☐ The FCC has asked that we correct a misstatement in March Technical Correspondence concerning Part 68 of the Commission's rules. Title 47, Code of Federal Regulations (parts 20-69), is not available from the FCC. Rather, it may be obtained from the U.S. Government Printing Office, Washington, DC 20402, at $8.50 per copy. Phone 202-783-3238 for information on Vol. 10 of these regulations. Or visit any law library that has material on communications.

☐ In Fig. 10B of "A Progressive Communications Receiver," November 1981 *QST*, C25 should be shown as a variable capacitor. Revised template sheets are available from the ARRL for an s.a.s.e.



Etching pattern for the vhf synthesizer circuit board. Black areas represent unetched copper viewed from the etched side of the board. Parts-placement diagram appears on p. 31.


QST
May 1982 $2.50
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KAØY
Gunning for the moon
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May 1982 *Volume LXVI Number 5*

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THE COVER

Take 1300 sq. ft of 1-in. aluminum. Add 14,000 POP rivets. Plant a 10-ton gun mount. Hire a crane. The result: instant EME antenna! *(photo courtesy KAØY)*

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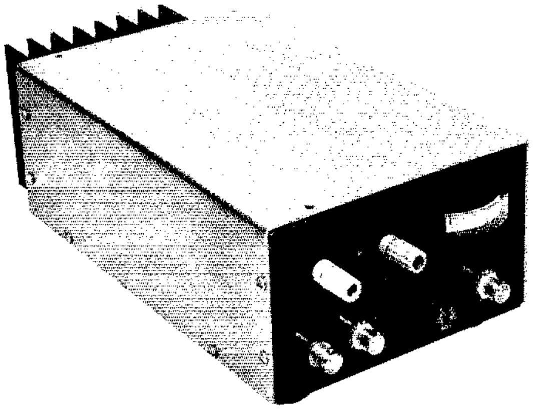


A Solid-State 6-Meter Linear Amplifier You Can Build

Does your 6-meter signal need a little more punch? This amplifier will solve your problem — without breaking the bank!

By T. Tammaru,* WB2TMD

The new breed of 8- to 10-W, solid-state vhf transceivers offer compactness and relative freedom from TVI. However, there are times when 10 W will not do the job. This amplifier can correct that situation. I used it during the September vhf QSO party and was able to work every station I heard, except one.

The transistor used in the amplifier is a Motorola MRF-492, which is designed for use as an fm amplifier in the "vhf low" public-service band. In this service, the nominal output is rated at 75 W with a 12.5-V collector supply. The manufacturer's data sheet shows a maximum output of 120 W at 16 V. Hence, in ssb service, I felt it would be safe to operate at the 100-W PEP level from a 13.5-V supply. Although no numbers are given, the MRF492 is claimed to have "load mismatch capability at high line and rf overdrive."[1]

Circuit Description

The amplifier schematic diagram is shown in Fig. 1. Since I do not believe in "reinventing the wheel," the output matching network was taken directly from the Motorola data sheet. This network, incorporating L2 and L3 in the signal path, should provide excellent harmonic rejection. The network transforms the 50-Ω load impedance to the optimum transistor load of 0.6 + j1.0 Ω. Note that this unit, like most rf amplifiers, does not have a 50-Ω output impedance. We simply adjust the output network to obtain the rated power into a 50-Ω load. Fig. 2A is an amplifier output spectral display. While the harmonic suppression is good, additional filtering is required before using the unit on the air. A simple, 5-pole, low-pass filter was placed at the amplifier output, and the resulting spectrum is shown in Fig. 2B. The low-pass filter circuit is given in Fig. 3.

Because the data sheet does not give values for input impedance in Class B service, the input circuit was derived basically by trial and error (the second version worked). The T matching network transforms the highly capacitive input impedance of approximately 1 Ω to a 50-Ω nonreactive load for the exciter.

In a Class B amplifier it is necessary to forward bias the base-emitter junction. There are basically two ways of doing this: the shunt diode method, and the emitter-follower method. The latter method undoubtedly results in lower intermodulation products, but I have destroyed too many transistors using that method to try it with a $20 device. Forward bias is achieved by using the shunt regulator diode D1. This diode must be connected to the same heat sink as the MRF492, Q1. The voltage across D1 is adjusted to give a Q1 collector current of 100 mA with no drive applied. Do not attempt to set the bias point by measuring the base voltage of Q1 — use a milliammeter in the collector supply lead. I used an unmarked, surplus, 15-A rectifier diode for D1. Almost any diode will work, including power Zeners. I prefer a stud-mounted diode because it is easy to place in contact with the heat sink. Just be sure the polarity is such that the cathode is connected to the case. Several Motorola application notes specify a 1N4997 for this application. Unfortunately, this is a press-fit device. In any case, the heat sink must be grounded.

Parts Procurement

All parts, with the possible exception of an adequate heat sink, are readily available. The MRF492 has recently been advertised by Westcom[2] and Semiconductor Surplus.[3] RFC1 is a Nytronics shielded ferrite choke, designed to reduce coupling between the base and collector circuit. The J. W. Miller 9250-682 should be as good. A toroidal inductor of 1 to 10 μH would also be suitable, since it is across an impedance of 1 Ω. Arco trimmers should be available from your local jobber. I used a surplus heat sink, measuring 3-1/2 × 4-1/2 × 1-3/4 inches, which is quite adequate for ssb.[4] Anything much smaller will require a fan. Remember, it must be flat on one side. A replacement heat sink for any of the 80- to 100-W 2-meter amplifiers would be ideal.

The Circuit Board

All the components shown in Fig. 1

[1]Notes appear on page 14.
*58 Fish Hawk Dr., Middletown, NJ 07748

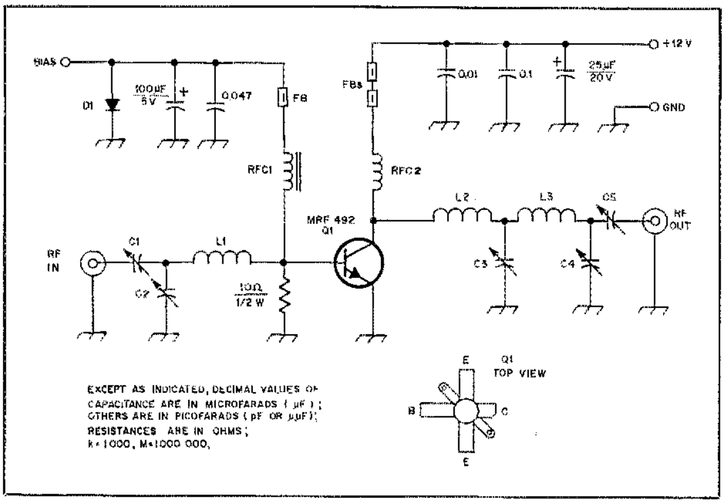


Fig. 1 — The schematic diagram of the amplifier circuit board. Decimal value capacitors are disc ceramic and polarized capacitors are electrolytic. Resistors are 10% carbon type.

C1 — 9- to 180-pF mica compression trimmer, Arco 463 or equiv.
C2, C4, C5 — 50- to 380-pF mica compression trimmer, Arco 465 or equiv.
C3 — 80- to 480-pF mica compression trimmer, Arco 466 or equiv.
D1 — 15-A, 50-V rectifier diode (see text).
Fb — Ferrite bead, Radio Shack 273-1571 assortment or equiv.
L1 — 2 t. of no. 14 bare copper wire, 13/32-inch ID, 3/16-inch long.
L2 — Half loop of no. 14 bare copper wire, 19/32 inch high, 13/32 inch long (see photograph).
L3 — 2 t. of no. 14 bare copper wire, 13/32-inch ID, 1/4-inch long.
Q1 — Motorola rf power transistor, MRF492.
RFC1 — 6.8 µH, Nytronics SWD 6.8 or equiv. (see text).
RFC2 — No. 16 enameled wire, close wound over full length of a 330-Ω, 2-W carbon resistor.

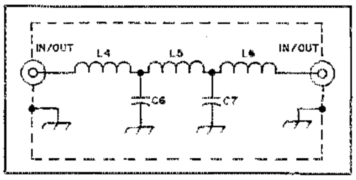
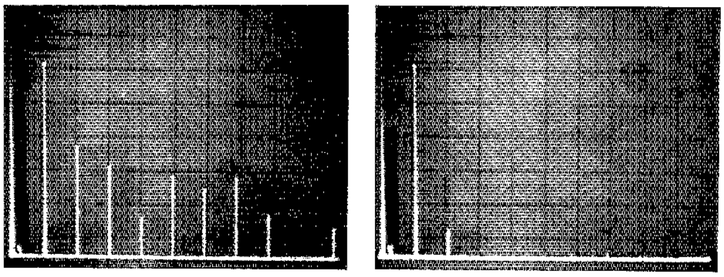


Fig. 3 — A simple low-pass filter for use with the 6-meter amplifier. The design information for this filter was taken from the 1982 ARRL *Radio Amateur's Handbook*. If the filter is mounted outside the amplifier cabinet, it should be enclosed in a metal box for shielding.

C6, C7 — 82-pF, 1000-V silver-mica capacitor.
L4, L6 — 4 t. of no. 14 enameled wire. 3/8-inch ID, 3/4-inch long with 1/8-inch leads (approximately 0.1 µH).
L5 — 6 t. of no. 14 enameled wire, 3/8-inch ID, 1/2-inch long with 1/8-inch leads (approximately 0.2 µH).



(A) (B)

Fig. 2 — The amplifier output matching network provides some harmonic suppression (A). To further reduce harmonics, a simple low-pass filter should be used (B). With the filter, all harmonics and spurious signals are more than 60 dB below the carrier, thus meeting current FCC spurious emission requirements for commercial equipment. In these displays, the carrier level has been reduced by means of a notch filter to avoid analyzer overload. Vertical divisions are each 10 dB and the horizontal divisions are each 50 MHz. These measurements were made in the ARRL lab.

mount on, or through, the circuit board (Fig. 4). Use double-sided glass epoxy board and cut away narrow channels to separate the various land (foil) areas. To form the channels, use a steel ruler and a sharp utility knife to cut through the foil. Next, pull a hot soldering iron along the strip of foil to be removed. You should see it curl up and away from the board. Start at one end, and pry up with the knife if it gets stuck. You will have to drill two holes, slightly more than 1/2 inch in diameter, through the board to provide clearance for Q1 and D1. Use a small round file to make the two clearance areas for the flanges of Q1. Connect the ground foils on the top and bottom of the board together by placing short lengths of wire through holes drilled in the board. Place the wires close to the transistor emitter tabs and near each corner of the board. Use pieces of the same type of wire you used to make the inductors, and drill the holes just large enough to pass the wire. Solder the wire on both sides.

Assembly

Make sure you have all the parts on hand before you solder anything to the board. This will ensure that everything fits properly. To keep the inductors in place, I drilled holes through the board and stuck the ends of the wire into the holes. You will have to remove the foil from around these holes on the bottom of the board to keep from shorting the inductors to ground. A large drill bit works fine for this. Center the board on the heat sink, and drill the mounting holes for Q1 and D1. Although you may be able to use screws and nuts to attach Q1 and D1 (depending on the heat sink design), a better method is to tap the holes for the desired screw thread. Mount the board to the heat sink near the corners, shimming it with washers to the same depth as the Q1 mounting flange. Drop Q1 in from the top of the board. The tabs of Q1 should rest just above the top of the board when the flange is in contact with the heat sink. Do not put any upward pressure on the transistor tabs. Never cut or file an rf power transistor body — they contain berillium oxide. It is highly toxic in powdered form and could be inhaled or absorbed through the skin.

Fasten Q1 to the heat sink before soldering it in place. Use thermal grease when mounting Q1 and D1. Be sure to solder the full length of the tabs to the board, right up to the body of the transistor. This is especially important for the emitter tabs, because nanohenrys of inductance here translate to decibels of gain loss.

Break off the little tabs on the sides of the mica compression trimmers. Bend the ends of the mounting terminals with pliers to aid in soldering the trimmers to the board. In doing this, be sure the adjusting screw will not touch the board when it is all the way down. C2, C3 and C4 should be oriented so that the screw is connected

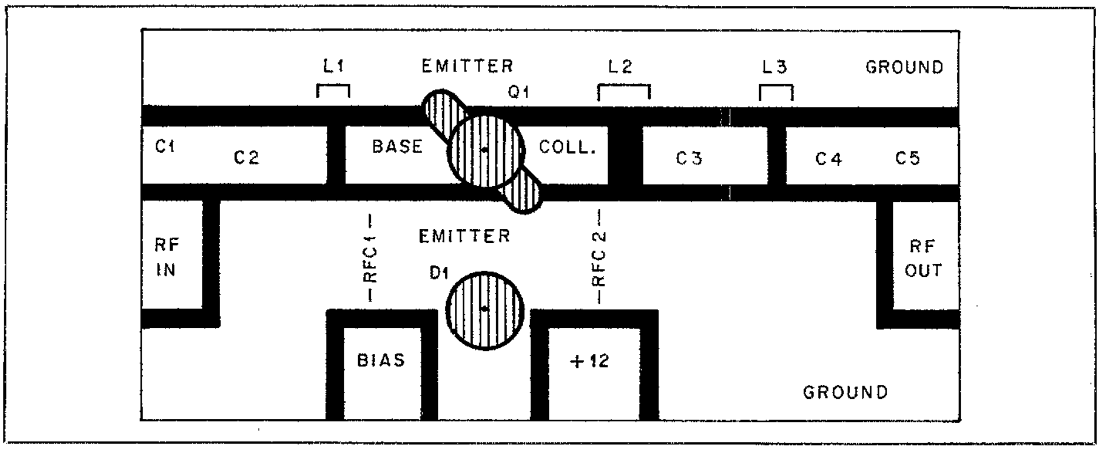


Fig. 4 — Full-scale circuit-board pattern and parts-placement guide for the 6-meter amplifier. Black represents those areas where copper has been removed by cutting or etching. The 10-ohm base resistor is connected between the base and ground foils, and is positioned next to RFC1.

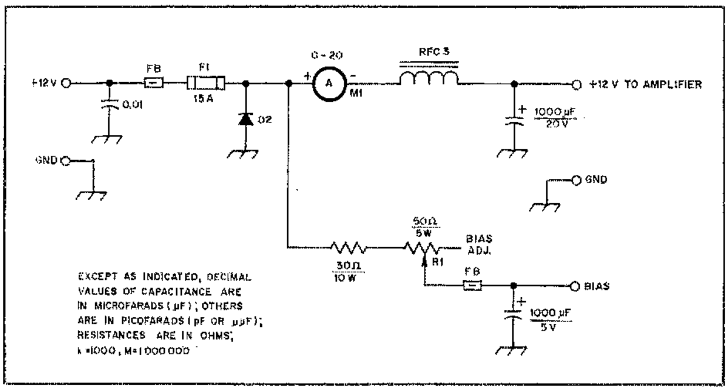


Fig. 5 — Schematic diagram of the bias-adjust circuit and other components not mounted on the circuit board. Decimal-value capacitors are disc ceramic, and polarized units are electrolytic type. Resistors are wire-wound type.

D2 — 20-A, 50-V rectifier diode.
RFC3 — One turn of wire through a TV balun core (part of Radio Shack 273-1571 assortment or equiv.).

to the ground end of the capacitor. For C1 and C5 let the screw end be the 50-Ω side.

Putting It All Together

I installed the circuit board and heat sink on the back wall of a 3-1/2 × 6 × 10-inch Minibox. This is much larger than necessary, but does provide room for relays and a receiving preamp for an eventual remote installation. I usually discard the top (plain U-shaped) half of these boxes and bend up a new piece that fits over the other half, instead of sliding into it.

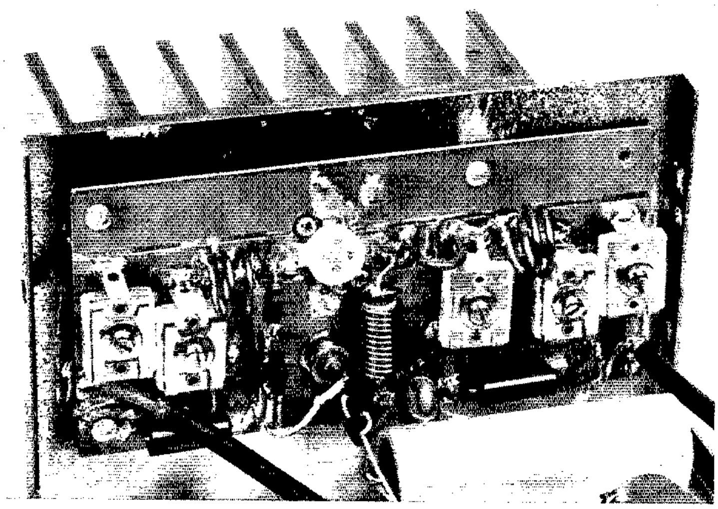
Fig. 5 shows the biasing circuit and other chassis mounted parts. Control schemes for use with a transceiver are described by Kapplin[3] and Ridpath[4] (also see the ARRL *Radio Amateur's Handbook).* D2 does not have to be heat sinked. It only has to last long enough to blow the fuse in case the wrong supply polarity is inadvertently applied. On the other hand, the 50-Ω bias adjust control (R1) gets quite warm, and should be mounted to the enclosure. In wiring the bias circuit, attach one wire from R1 to D1 and another wire from D1 to the bias point on the circuit board; all other connections are made to the circuit board. If R1 were connected to the circuit board, with a strap going to D1, you would almost certainly damage the transistor if the strap to D1 broke.

Alignment

It is necessary to set the bias before aligning the rf circuits. For an initial check, disconnect the wire between D1 and the circuit board (R1 is connected to D1). Apply power and measure the voltage across D1. It should be possible to lower it to 0.65 V, or less, by varying R1. Set R1 for the lowest voltage and connect the wire from D1 to the circuit board. Now reduce the resistance of R1 until the collector current is 100 mA. Be sure you are measuring collector current and not total supply current (you have about 300 mA flowing into D1).

For aligning the trimmers you will need, at least, an SWR indicator and a 50-Ω dummy load. You will, of course, not know how much power you are getting unless you also have a wattmeter. Connect the amplifier output to a dummy load and apply about 1 W of drive to the input through the SWR indicator. Adjust C1 and C2 for an SWR of 1:1. With C5 snug, but not tight, adjust C3 and C4 for minimum collector current. With the SWR indicator or wattmeter connected between the output and the dummy load, adjust all the trimmers for maximum output. If more than one setting gives the same power, pick the one that corresponds to the lowest collector current. Slowly bring up the drive and keep readjusting all the trimmers. With 8 W of drive you should get an output of 100 W. The collector current will be approximately 15 A. Readjust the input for a 1:1 SWR at full power. This may, or may not coincide with maximum gain and you may have to compromise.

During testing you might consider using a harmonica to generate a multitone signal to reduce the average power dissipation (keep the speech processor off). If at any time the heat sink gets so hot you cannot hold your hand on it for five seconds, let it cool off. As a rough indication of power output, I found that at 100 W, a Drake



Interior view of the 6-meter amplifier showing the parts arrangement used by the author. The input matching network is at the right of the photo.

DL 300 dummy load become too hot to hold after two minutes of key-down operation. To prevent rf burns, do not touch the dummy load while rf power is applied.

To maintain linearity, adjust the output circuits for 100 W, even if you are going to operate at 75 or 80 W. I evaluated the amplifier linearity by making two-tone IMD measurements with a spectrum analyzer. At a PEP output of 100 W, the third-order products were 25 dB below the PEP. At 80-W PEP they were down 30 dB. In over 100 contacts, I have not received any adverse comments on the signal quality.

Notes

[1]Motorola Inc., *Motorola Rf Data Manual*, 2nd ed. (Phoenix, AZ: Motorola Inc., 1980), p. 6-15.
[2]Westcom, 1320 Grand Ave., San Marcos, CA 92069.
[3]Semiconductor Surplus, 2822 N. 32nd St., No. 1, Phoenix, AZ 85008.
[4]mm = inches × 25.4.
[5]S. Kapplin, "Boots for QRP Rigs," *QST*, July 1981, pp. 15-20.
[6]I. Ridpath, "T-R Switching with PIN Diodes," *QST*, March 1981, pp. 19-21.

New Books

☐ *Apple II User's Guide*, by Lon Poole with Martin McNiff and Steven Cook. Published by OSBORNE/McGraw-Hill, Berkeley, California. Soft cover, 6 × 9 inches, 321 pages plus appendices and index, $7.95.

Anyone familiar with the Apple II computer knows about the outstanding documentation supplied with the machine at purchase. Unfortunately, this information is scattered throughout three books, with still another necessary if a Disk II floppy disk drive is used. The writers of this book have compiled the best of the information from these books and put it in one place. This book is the one reference that contains the information needed to get the most from the Apple II computer.

Chapter 1, entitled "Presenting the Apple II, " contains an entry-level explanation of how information enters and leaves the Apple II. Pictures as well as brief explanations of the many available external device controller cards are used to introduce the reader to the various peripherals available for use.

Chapter 2, "How to Operate the Apple II," introduces the prompt character, which tells the user which BASIC (the Apple has two) the machine is using. The computer keyboard is also presented as a means of communication with the machine, with all nonstandard typewriter keys and their special uses explained in an easy-to-understand format. Use of the cassette interface to load a program into memory is discussed, along with the operation of the Disk II floppy disk drive. Disk Operating System (DOS) topics include initialization of diskettes and transferring DOS commands from the diskette to the computer memory, sometimes called "booting" a diskette.

The "meat" of the text begins in Chapter 3, "Programming in BASIC." The available programming modes of the Apple II are introduced, and the reader is instructed in performing simple calculations on the computer. Since every programmer makes mistakes at one time or another, error message codes are also listed along with their meanings. Program execution and editing techniques are discussed, giving the reader an understanding of how the machine will act upon the commands it is given.

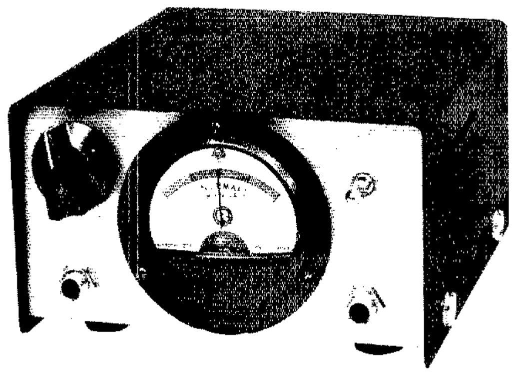
Once several BASIC commands and statements are introduced, the reader is well on the way to writing simple software. Commands and functions are added one at a time in appropriate places to build one's self-confidence in programming skills. By this time, the reader will be prepared for Chapter 4, appropriately labelled "Advanced BASIC Programming."

As the text continues through the remainder of its eight chapters, the user becomes intimately familiar with the DOS, graphics and sound, and the use of the Apple machine language monitor, which enables the user to communicate directly with the 6502 microprocessor used in the Apple II.

Chapter 8 is a "Compendium of BASIC Statements and Functions." All Apple II statements and commands are listed with their operations *and* proper usage (syntax). This chapter is an excellent reference to use while programming.

The 12 appendices occupy the final 65 pages of the book, with charts and other very useful information (such as derived functions and memory maps, among others). It should be noted that while this information *is* available in the documentation supplied with the machine, the reviewer has never seen it presented previously in one book. The appendices alone make this book a worthwhile investment for the experienced programmer and the casual operator who would just like to learn more about the machine. — *Michael B. Kaczynski, W1OD*

Updating the Double-Ducky Direction Finder



Add these simple modifications to your DDDF and you'll be hard to beat on the next fox or turkey hunt.

By David T. Geiser,* WA2ANU

The Double Ducky Direction Finder (DDDF)[1] has drawn considerable mail asking where you can get the PIN diodes, how the proper null is chosen, what is suggested for the right-left indicator, and what's the easiest way to combat jamming attempts? Here are some answers to those questions.

Diode Supply

Rogers[2] pointed out that if you were not planning to transmit through the array you can use 1N914 or 1N4148 computer diodes instead of the PIN diodes. This also works with the DDDF. These computer diodes sell for approximately 10/$1 or less.

Hewlett-Packard does have a group of authorized distributors for the PIN diodes, and Microwave Associates is presently setting one up.[3] There is no reason other brands of PIN diodes having about a 100 nanosecond carrier lifetime and approximately 1 Ω of forward resistance won't work.

Sense Modification to the DDDF

All the information needed to tell which is the proper null is available from the DDDF. The oscilloscope photographs[4] tell whether the right or left antenna is nearer to the hidden transmitter, but oscilloscopes are expensive and awkward to use.

While a synthetic third antenna may be made with a delay line, it is hard to duplicate. I added a third antenna in my final design (Fig. 1). First, I get a null with antennas 1 and 2, and then switch to antenna 3 instead of antenna 2. If antenna 3 (as sketched) is now closer to the transmitter, I have a left error indication, and if antenna 3 is farther away, there is a right error indication. I located the third antenna halfway between the existing antennas and 3 inches (76 mm) off of the center line joining them. This gives about a 30° error indication. If some audio from either pins 5 or 8 of the 567 IC (depending on your receiver) is subtracted from the receiver audio, the result will be different for the front and rear nulls. (I haven't tried this, preferring to use the right/left indicators described later.)

As long as I was modifying the DDDF switcher, I decided to add switching at both ends of the coaxial cable, eliminating frequency sensitivity from the half-wave lines. This is done with diodes D4 through D7, the 1-kΩ resistors, and the separate equal-length lines going to the switcher. Switching S2 to the right connects antennas 1 and 2, and to the left connects antennas 1 and 3. At the same time I added another phono jack for the 0° audio from the 567 IC pin 8 to accommodate the W9MKV right/left indicator.

Note that since the sense antenna (no. 3) has a fixed relation to the position and null of antennas 1 and 2, the receiver tone from antennas 1 and 3 will always be a fixed magnitude if the ground plane is kept in the position of the antennas 1 and 2 null. This keeps the audio or meter sense indication constant and easier to repeat.

Antenna Position and Transmit Mode

It is important to hold the ground plane level and the whips or "duckies" vertical to suppress spurious horizontal reflections that may confuse the true null direction. Always paying attention to the vertical null saves much hunting.

The DDDF phase-modulates any signal on the channel, whether it be a-m, fm, ssb, steady carrier, cw or noise. With an fm or phase detector you can DF on any of them.

Right-Left Indicator

The right/left indicator (R/L) is made up of two identical af amplifiers, a phase-shifter (which may or may not be needed) and a synchronous detector. The audio amplifiers each use one LM386 IC, two capacitors, a resistor and a gain control. The phase shifter uses a center-tapped audio transformer, a capacitor and a potentiometer. The ring-modulator synchronous detector uses two more of the same transformers and four 1N914 or 1N4148 diodes feeding a zero-center microammeter.

The receiver headphone output is fed into the phase shifter input (Fig. 2), and the "90° Audio" from the switcher unit is fed into the lower amplifier. Balanced modulators work best when one of the input levels is much greater than the other. As the "90° Audio" is constant, I adjust the gain of the lower amplifier into clipping, giving a square wave input to the synchronous detector. This is done most easily with the power switch on BAL and monitoring one end of the lower transformer output to ground with an oscilloscope. (It helps to have the pitch of the switcher high because lower frequencies have more trouble with RC time con-

[1]Notes appear on page 16.

*ARRL TA, RD 2, Box 787, Snowden Hill Rd., New Hartford, NY 13413

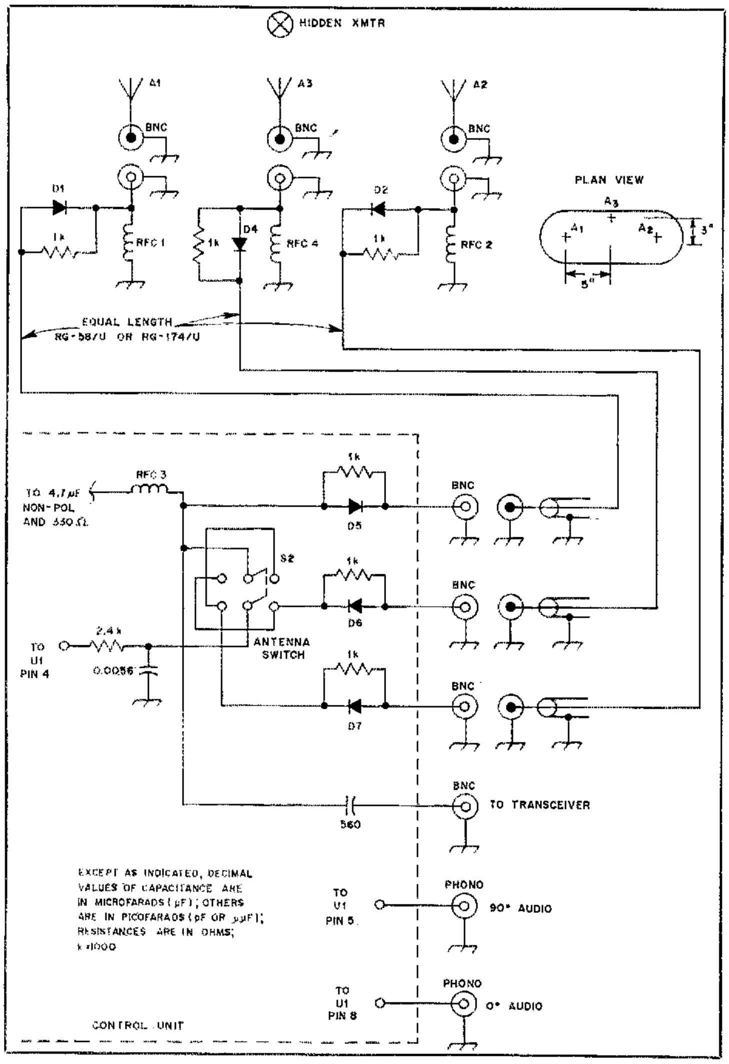


Fig. 1 — Modification of the DDDF to make sensing the proper null easier and to minimize frequency effect. D4-D7, inclusive, are the same type as D1 and D2. See text and original article (Note 1) for discussion of diodes, rf chokes and antennas. S2 is a dpdt slide switch (Radio Shack 275-403 or equiv.).

stants and transformers.) Balance the 1-kΩ potentiometer for zero meter reading.

With the power switch ON, adjust the upper amplifier gain control for the desired meter sensitivity. (The receiver audio can be monitored through phones or an external speaker plugged into the external speaker jack on the R/L.)

Using a 100-0-100 microammeter, I get sensitivity adjustment ranging from 10° half-scale to 90° half-scale without any difficulty. I see no reason why almost as good results shouldn't be possible with even the more rugged 500-0-500 microammeters.

The phasing control is used only to adjust for equal angular sensitivity on each side of the antenna null position. Phasing may not be needed with some transceivers.

I used two batteries to avoid coupling from one amplifier to the other by way of the power supply. (My early designs used lab power supplies.) Use of voltage regulators should minimize this problem. The LM386 amplifiers should be more reliable with a 6-V dc supply.

Sensing with the R/L

The R/L allows the meter to indicate the true null when the sense direction changes. "Forward" will kick the meter in one direction, while a true null position behind will drive the indication in the other direction.

A Transformerless Phase Detector

When I built the DDDF, my local Radio Shack store didn't have all the parts I needed. I designed a transformerless version of the phase detector. It is sensitive and, except for the meter, costs less than $5 for parts. Another advantage is it uses only one battery.

Opposite switches in the CD4066 (Fig. 3) make and break simultaneously, acting like four diodes in a ring modulator. Signals at the switching frequency are rectified, giving a steady positive (or negative) meter indication for the antennas aimed to the right of null, and opposite for left indication. All other audio is bypassed by C1.

The sensitivity depends on the receiver audio output, and possibly could be increased with an additional external audio-amplifier stage; I did not find it necessary.
— *Frank Reid, W9MKV*

Anti-Jam and Easy Nulling

The first thing a user will notice with the R/L is that nulling is much easier. On high-sensitivity settings the null will occupy less than a degree of antenna rotation with a tone practically unnoticeable by ear. Second-harmonic and jamming tones have very little effect on the null. The transmitter operator may be screaming or wailing into the microphone without causing much meter disturbance.

The R/L reacts only to its own chopping frequency or tones so close (1 or 2 Hz) that the meter can respond. (Bandwidth can be narrowed further by shunting the meter with nonpolarized electrolytic capacitors.) Most accidentally successful jamming can be eliminated by slight adjustment of the switcher pitch. The jack is provided so an external meter or even an antenna rotator can be operated from the R/L.

Other Bands

The system may be used on any band for which an fm receiver is available. Clegg, for instance, makes an up-converter that translates 10 Hz-30 MHz to 144-148 MHz, allowing the use of a 2-meter receiver. Of course, other antennas or diodes may be needed.

Other modifications could enhance the performance of the DDDF. Of course, some of you may have questions still unanswered. I will be happy to correspond with anyone about this project if they include an s.a.s.e. Good Hunting!

Notes

[1]D. Geiser, "The Double-Ducky Direction Finder" *QST*, July 1981, p. 11.
[2]T. Rogers, "A DoppleScant," *QST*, May 1978, p. 24.
[3]The closest geographical listings the author has will be supplied for an s.a.s.e.
[4]See Note 1.

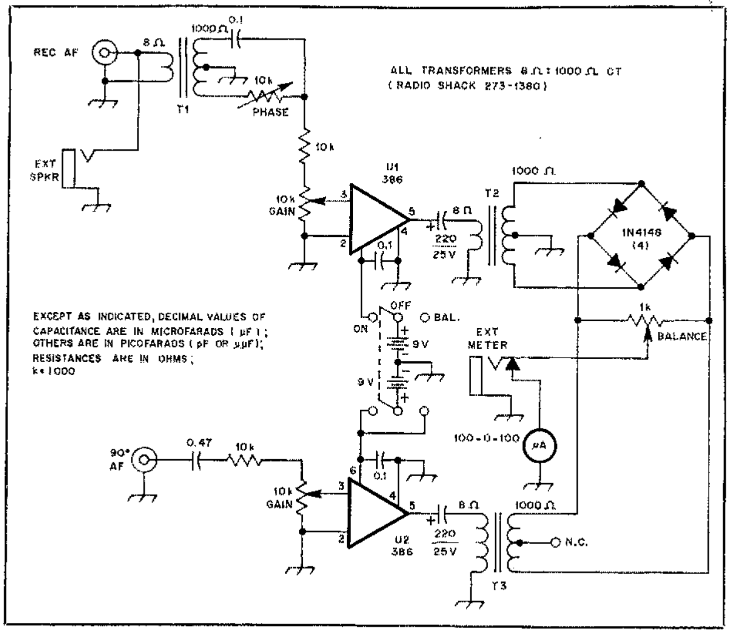


Fig. 2 — The simple circuit of the Right/Left Indicator. Neither the transceiver nor the DDDF have to be modified. Two batteries are used to minimize coupling problems. See text for alignment. Capacitors are disc ceramic except for those with polarity markings, which are electrolytic. Fixed-value resistors are 1/4-watt, carbon-composition types. Potentiometers are 1/4-watt, circuit-board types. See text for discussion of the microammeter.

T1-T3 — Small audio-output transformer, primary 1000 Ω ct, secondary 8 Ω, Radio Shack 273-1380 or equiv.

U1, U2 — Low voltage audio power amplifier IC, 250 mW, type LM386 or equiv.

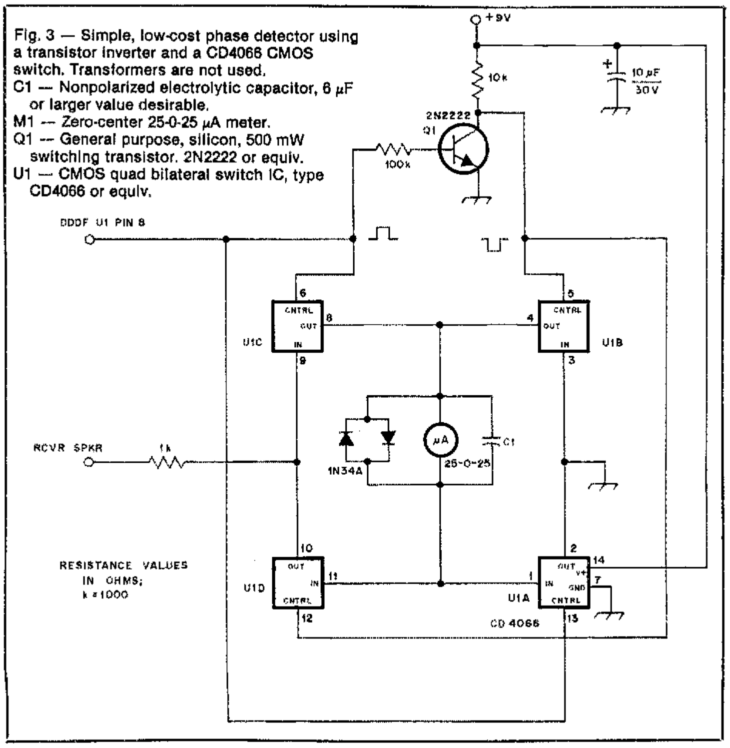
Fig. 3 — Simple, low-cost phase detector using a transistor inverter and a CD4066 CMOS switch. Transformers are not used.

C1 — Nonpolarized electrolytic capacitor, 6 µF or larger value desirable.

M1 — Zero-center 25-0-25 µA meter.

Q1 — General purpose, silicon, 500 mW switching transistor. 2N2222 or equiv.

U1 — CMOS quad bilateral switch IC, type CD4066 or equiv.



Strays

TIS DO'S AND DON'TS

☐ The ARRL Technical Information Service is offered free to members. Although we are eager to help newly licensed amateurs and others with technical problems, in fairness to members we cannot respond to continuing requests for assistance from those who choose not to join the League.

For us to respond promptly to your inquiries we must have:

(1) your name

(2) your amateur call and license class (tell us if you're not licensed)

(3) your membership expiration date

(4) a stamped, *business-size* envelope bearing your mailing address for our reply (IRCs acceptable from outside the U.S.).

When writing, we ask that you observe the following guidelines so we may provide the best possible service to the greatest number.

1) Before writing for technical assistance, search your files of *QST* and other ARRL publications. The answer you need may be there, available immediately. Consult the annual index of articles in each December issue.

2) Please do not ask for comparisons among commercial products. Choice of equipment is largely a matter of personal preference. Consult Product Review information in *QST;* compare manufacturers' specifications in their brochures.

Do not ask for information on articles published in other magazines. Write to the editor or author of that article.

Do not request custom designs for amateur gear.

Do not ask advice on nonamateur matters. We cannot respond to questions about CB, marine radio, hi-fi, etc. (unless they concern interference caused by amateur gear).

3) Use a typewriter when possible; otherwise, write or print *clearly.* Please be reasonable in the number of questions you ask; try to limit your questions to three per letter.

4) When writing, please come right to the point, and be sure to share with us whatever experience you have had with the problem in question. This will avoid our reply covering ground you've already been over.

5) Address all technical questions to: Technical Information Service, American Radio Relay League, 225 Main St., Newington, CT 06111. — *Mike Kaczynski, W1OD*

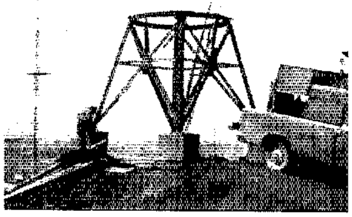
I would like to get in touch with . . .

☐ collectors of antique radios. Ed Best, AK4W, 2004 University Dr., Durham, NC 27707.

EME — Iowa Style

How to be a "Big Gun."

By Rod Blocksome,* KØDAS



(D)

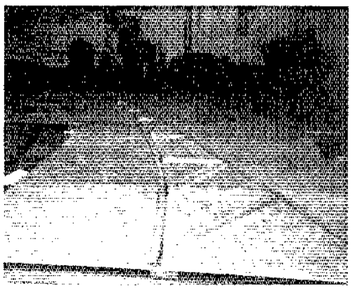
It is well known that large antennas are required for EME or "moonbounce" QSOs. My friend, Ken Kucera, KAØY, has accomplished the dream of many vhf DXers. He constructed a fully steerable, 42-foot, parabolic dish antenna. The major construction steps are briefly outlined here. Specific details may be obtained by sending an s.a.s.e. to Ken.[1]

Ken used a plywood fixture (photograph A) to shape each of the 18 ribs to a parabolic curve. Rib construction required 1300 feet[2] of 1-in. square extruded aluminum, 14 drill bits and 14,000 POP rivets. Each rib is fastened to a hub (photograph B) to form the dish. The dish is lined with 1-in. poultry netting (photograph C). Aluminum sheet covers the center. This supports Ken when he works on the feed system.

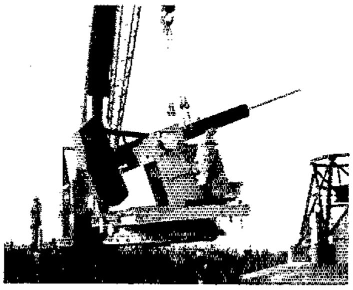
A 10-ft support tower, constructed of 5- × 1/4-in. angle iron, was built on a large mound of earth. It is anchored in 14 cubic yards of steel-reinforced concrete (photograph D). A surplus 5-in. naval gun mount, weighing 20,000 lb (that's right, 10 tons), is used to steer the dish. The gun mount is modified to accept a piece of 12-in. OD, 1/2-in. wall steel pipe and a 3500-lb counterweight. A large crane lifts the behemoth to the tower top (photograph E). The completed tower and gun-mount assembly (photograph F) was given a coat of white paint. At this point, many a passerby inquired about Ken's intentions with his "big gun."

A 150-foot crane (hired) was used to mount the dish to the "gun barrel" (photograph G). The project was completed by adding the feed antenna and polarization rotator to the small pipe. Photograph H shows the completed antenna in the "stowed" position. The building under the tower contains motor controls, power supplies, preamps, and T-R relays. Finally, 1-5/8 in. pressurized coaxial line and control cables were buried between the ham shack and the antenna.

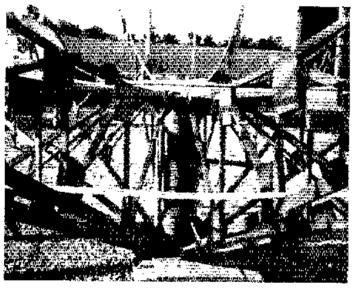
Since May 1980 when the antenna became operational, Ken has logged 121 QSOs on 432-MHz EME (10 were on ssb). Recent operation on 220-MHz EME has netted 6 QSOs, one of which was the first ever ssb EME QSO on 220 MHz when Ken worked Louis Anciaux, WB6NMT. Using sun-noise measurements, the approximate antenna gain is judged to be 24.5 dB on 220 MHz and 31 dB on 432 MHz, relative to a dipole.



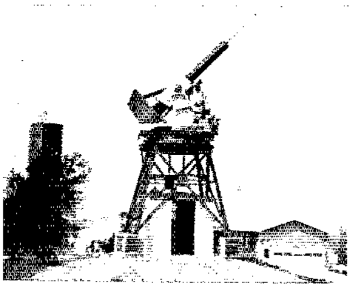
(A)



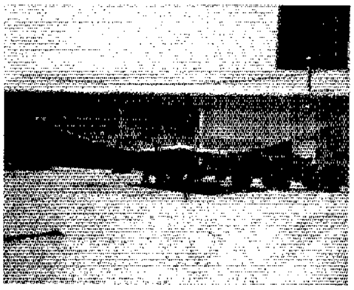
(E)



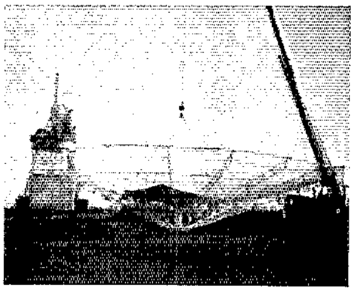
(B)



(F)



(C)



(G)

(H)

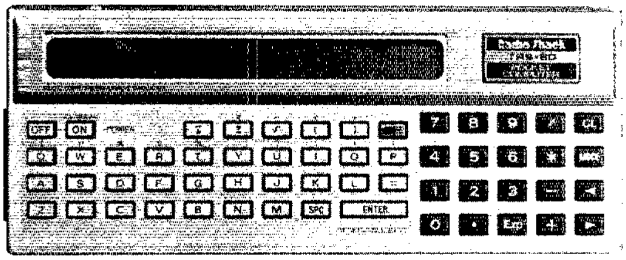
*690 Eastview Dr., Robins, IA 52328

Notes

[1]Ken Kucera, KAØY, Rte. 2, Box 52A, Riverside, IA 52327.

[2]m = ft × 0.3048, mm = in. × 25.4, m³ = yd³ × 0.7641, kg = lb × 0.4536.

Pocket Directory



Got a short memory for names and call signs? Let the TRS-80® Pocket Computer do the work for you!

By Robert L. Martin,* WB2KTG

Anyone who has attempted to write while driving a car (a dangerous practice) can attest to the fact that only hieroglyphics are more resistant to later interpretation! The problem of keeping track of the local repeater users' names was quite a chore for me until the Radio Shack TRS-80® Pocket Computer came to the rescue. With the computer, the programs presented here provide complete editing and memory management functions, enabling you to keep track of 65 sets of call signs and names simultaneously.

Some Pocket Computer Basics

Four modes of operation may be selected: user DEFinable, RUN, PROgram and RESERVE. The capitalized letters correspond to the legends shown on the LCD panel. These modes are set by pressing the MODE key and are defined as follows:

User DEFinable: A program or program segment called is defined by the placement of a label (a letter) as the first character of that program or program segment. Pressing the SHIFT and appropriate letter keys causes the computer to perform an implied GOTO and EXECUTE with only two keystrokes. For example, SHIFT A begins program execution at line 10, SHIFT D at line 30, etc. (See Table 1.)

RUN mode: Manual calculations may be performed or previously entered programs run in this mode.

PROgram: Programs are written, edited and listed.

RESERVE: Short program blocks or other data may be entered and recalled in either the PROgram or RUN modes. This feature can save many keystrokes when entering repetitive data or commands.

All the programs are written to be used in either the normal RUN mode or the powerful DEF (user defined function) mode. In the RUN mode, each program is run by typing R.NN where NN is the line number of the first statement of the program. In the DEF mode, each program is run by pressing SHIFT A, D, G, J or L, corresponding to the appropriate user-defined key. (Recall these letters as being the first entry in each program after the line number.) These keys were chosen to minimize potential error in a mobile environment.

Table 1

Program Listing for The Pocket Directory

```
10:"A"INPUT "INPUT CALLSIGN:";A$
12:INPUT "NAME:";B$:F=0
14:FOR E=8TO (C-2)STEP 2
16:IF A$=A$(E)F=1
18:IF F=1PRINT "DUPLICATE:";A$:GOTO 10
20:NEXT E
22:A$(C)=A$:A$(C+1)=B$:C=C+2
24:GOTO 10
30:"D"INPUT "FIND NAME?";A$:F=0
32:FOR E=8TO (C-2)STEP 2
34:IF A$=A$(E)F=1
36:IF F=1PRINT A$,A$(E+1):GOTO 30
38:NEXT E
40:PRINT "NOT FOUND:",A$:GOTO 30
50:"G"FOR E=8TO (C-2)STEP 2:F=E+1
52:PAUSE E;" ";A$(E);" ";A$(F)
54:NEXT E
56:END
60:"J"INPUT "DELETE:";A$:F=0
62:FOR E=8TO (C-2)STEP 2
64:IF A$=A$(E)F=1
66:IF F=1LET A$(E)=A$(E+2):A$(E+1)=A$(E+3)
68:NEXT E
70:IF F=1LET C=C-2
72:IF F=0PRINT "NOT FOUND:",A$:GOTO 60
74:GOTO 60
80:"L"INPUT "CLEAR ALL? (ENTER YES)";A$
82:IF A$="YES" GOTO 86
84:GOTO 94
86:FOR E=8TO C
88:A$(E)=" "
90:NEXT E
92:C=8
94:END
```

Program Descriptions

The first program (lines 10 through 24) provides for DATA ENTRY AND DUPLICATE CHECKING of call sign/name combinations. The computer prompts with INPUT CALLSIGN. You respond by keying in the call sign and press ENTER. The next prompt is NAME. You enter the amateur's name. The computer then checks the entered call sign against all others stored in memory and either puts the information in memory or returns with DUPLICATE if the call sign has already been stored in memory. If you wish to enter more data after DUPLICATE has been displayed, press the ENTER key; that will return the prompt INPUT CALLSIGN. To terminate this mode, press BREAK or SHIFT (letter) to execute another program.

Lines 30 through 40 comprise a NAME AND CALL SIGN SEARCH routine. This program returns the name corresponding to the call sign that is entered. When a name is not found or a duplicate exists, the call sign and NOT FOUND or DUPLICATE is displayed.

The INVENTORY program (lines 50 through 56) will scan all data, displaying each call sign/name combination for approximately 0.85 seconds. A number (N) will also be displayed. This number corresponds to the array element A$(N) containing the call sign. The storage location of the corresponding name is in array element A$(N + 1).

A SINGLE ENTRY DELETE program (lines 60 through 74) allows you to delete call sign/name entries one at a time by entering the appropriate call sign. In addition, this program shifts all higher address

*45 Salem La., Little Silver, NJ 07739

data downward to prevent wasting memory space.

Lines 80 through 94 will CLEAR ALL DATA from memory. To the prompt CLEAR ALL? a YES must be entered. Any other entry will cause program termination and a return to the USER mode. This feature makes accidental data loss all but impossible.

Other Applications

Each entry, name or call sign, is stored as a string variable, A$(N). The string variable length limitation is seven characters. Telephone numbers, by coincidence, also have a seven character length if the area code is ignored. Three program lines (see Table 2) modify the original program to turn it into a Micro-Phone Directory. Before running the directory program for the first time, it is necessary to set C = 8, as with the call letter program. The variable "C" is a memory pointer. It points to the next location available for call sign storage. Location "C + 1" is the next available for corresponding name storage.

Table 2

Program Listing for The Micro-Phone Directory

```
10:"A"INPUT "IN
   PUT NAME:";A
   $
20:INPUT "PHONE
    #:";B$:F=0
30:"D"INPUT "FI
   ND PHONE# ?"
   ;A$:F=0
```

At initial program start, it is necessary to set C = 8 to allow room for the variables used during program execution. This allows variables A(1) to A(7) (A through G) to be used by the main program for housekeeping, etc. If the command is given to CLEAR ALL, the program automatically sets C = 8. During program data modifications, the value of C is adjusted automatically. It is possible to modify the program to take care of all "C" manipulations, but this method minimizes program length.

These programs can access any seven-character string by entering any other seven-character string. The examples shown are merely representative of many applications handled easily by the versatile TRS-80® Pocket Computer.

Conclusion

During the many months in which these programs have been in use, no problems have arisen. The only obvious improvement would be to speed up the search routine using a less primitive technique. For the intended purpose, these programs are quite satisfactory and a pleasure to use. I hope you will find them useful, too.

Strays

TA PROFILES

We amateurs are fortunate to have the professional advice offered by ARRL Technical Advisor Brian Wood, WØDZ. The ARRL extends its thanks! His areas of expertise are RTTY, microprocessor control, digital design, plus software and firmware for computers.

In 1966, while attending Saguaro High School in Scottsdale, Arizona, Brian received his first Amateur Radio license. The same year, he became acquainted with Rick Olsen, N6NR (now an ARRL TA for microwave circuits). During his high school years Brian was active in the TWN net and in the local radio club, participating in many public-service activities. He was a member of the Arizona Mountain Moguls (a prestigious Field Day group), which was often in the race for first place in the four-transmitter class.

One of Brian's most memorable experiences with Amateur Radio occurred at the 1968 ARRL Convention in Phoenix, where he was involved in the induction of Barry Goldwater, K7UGA, into the Royal Order of the Wouff Hong. Cw, DXing, RTTY and microwave circuits are his main interests in Amateur Radio.

Brian earned his BSEE degree at the University of Arizona. He now resides in Loveland, Colorado, and is employed by Hewlett-Packard, Inc., where he designed a hefty amount of the digital logic in the HP 3060A Board Test System. Other hobbies Brian enjoys are skiing and handball.
— *Marian Anderson, WB1FSB*

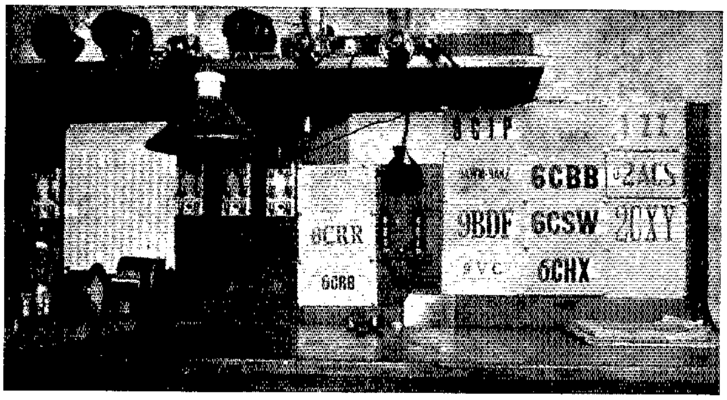
TA WØDZ at his favorite spot, the ham shack.

PARTS SALES ON DECLINE

☐ Resistors, capacitors and other so-called passive electronics parts accounted for only 10% of all electronics parts sold last year, according to Arthur D. Little, Inc., a Massachusetts consulting firm. This figure, down 6% from four years before, will probably continue to drop, the company said, as more and more of these separate parts are replaced by integrated circuits.

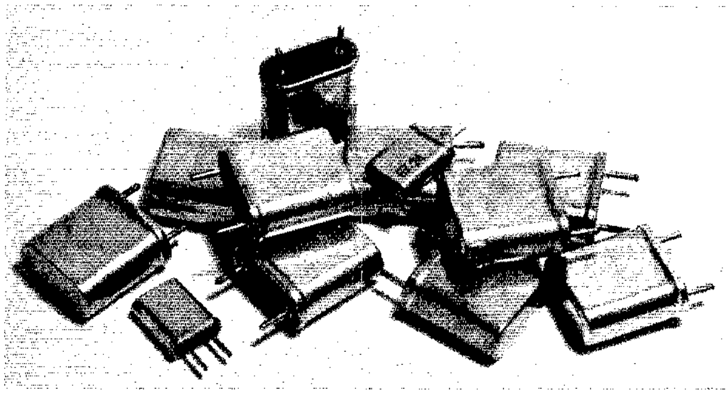
I would like to get in touch with . . .

☐ other ZX81 computer owners. Respond NTS. Terry Isenhour, WA4OPO, Rte. 2, Box 653, Lincolntown, NC 28092.



This 1925 photo shows 6CPW's (now W6CPW, Darrell Teachout, of Burlingame, California) transmitter on the left side of the table and three-tube receiver on the shelf above. The transmitter-tube dc came from slop-jar rectifiers with a power transformer, choke coil and filter condensers. The receiver filaments were powered with 6 volts of an 8-volt submarine battery, while the plates used "B" dry cells. *(photo by W6CPW)*

A Unified Approach to the Design of Crystal Ladder Filters



Have you turned away from a construction project because of high-cost crystal filters? Why not build your own?

By Wes Hayward,* W7ZOI

The design of crystal ladder filters has been treated in the professional literature[1] and amateur journals.[2] However, the design methods are specific — they treat crystal filters as a special field with isolated methods. Actually, the same design methods for L-C bandpass filters may be applied directly to crystal filters. Such a unified design method should be more pleasing to the designer, and will allow more flexibility in the resulting filters.

The amateur's interest is primarily one of economics. Crystal ladder filters are easily designed and built with readily available components, yielding great savings for the builder. Television color-burst crystals are attractive for ladder filters. These are at 3.579 MHz in the U.S., while European crystals are at 4.433 MHz. The latter are popular with the many builders in the G-QRP-Club.

This paper addresses a number of goals. Simple methods are presented for the crystal evaluation and measurements needed for the design of filters. The accuracy is adequate for most amateur filter designs. Also, a simple set of design equations is given, which allows the measured data to be used in the design of filters. Tables are presented for Butterworth and 0.1-dB ripple Chebyshev filters.

Finally, some design subtleties are presented to aid in the construction and tuning of rather precise filters. These details may be ignored for many simple amateur-built filters, but should be of interest to the exacting designer. The results of the more exact methods are compared with the simplified ones.

All of the design may be done with a hand-held scientific calculator. Detailed analysis of filter frequency response may be done with sophisticated programmable calculators, such as those offered by Hewlett-Packard or Texas Instruments. All of the analysis reported by the writer was done with an HP-41CV calculator.

Some Filter Fundamentals

Fig. 1A shows a traditional LC-coupled resonator filter. This circuit uses two coupled, parallel-tuned circuits. Many more resonators (tuned circuits) may be used to obtain a steeper skirt response. Filter bandwidth and response shape are determined by the loading caused by the end terminations (the source and load resistances) and by the coupling between resonators.

There is no reason to restrict the filters to those using parallel resonators. Series-tuned circuits are just as viable. This type of L-C filter is shown in Fig. 1B, the exact duplicate of that using parallel resonators. Design of multielement filters of both types is covered in the literature.[3]

A detail that is not generally appreciated is the relative freedom available to the filter designer. For example, a 5-MHz L-C filter with a 100-kHz bandwidth could be designed with inductors of less than 1 μH, with inductors greater than 10 μH, or with anything in-between. Some values might be more practical, but this is not a fundamental restriction. Once an inductor is chosen, the rest of the filter components are determined. This applies to both filters of Fig. 1.

Another overlooked detail can be the termination of the filters. Any filter *must* be terminated at both ends in the resistance for which it was designed. The filters of Fig. 1 are doubly terminated with equal resistances at each end. This is common, but not mandatory. It is not proper, however, to design a filter for a given load at each end, such as 50 ohms, and then to expect the same response from that filter with other terminations.

Fig. 2A shows the equivalent circuit for a quartz crystal. This is a model — a circuit that shows the same response as a real crystal. The components of the model may not be practical, but this is of no significance for design work. For example, a 5-MHz crystal used in some filters built by the writer had a motional inductance of L_m = 0.098 and a motional capacitance of C_m = 0.0103 pF. The loss resistance was R_s = 13.4 ohms, and the parallel capacitance was C_p = 5 pF.

The parallel capacitance, C_p of Fig. 2A,

[1]Notes appear on page 27.

*7700 S.W. Danielle, Beaverton, OR 97005

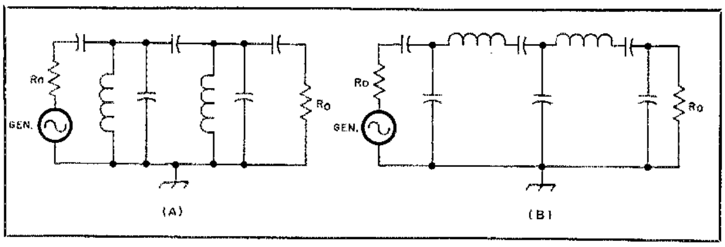


Fig. 1 — Double-tuned circuits with equal termination at each end. Parallel resonators are used at A; series-tuned circuits are used at B.

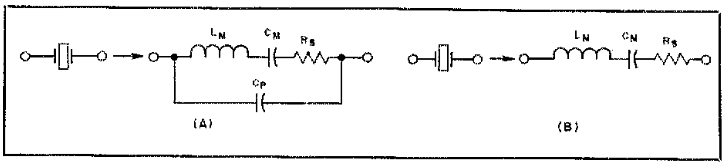


Fig. 2 — Equivalent circuit for a quartz crystal. L_m and C_m are "motional" components. Parallel capacitance, C_p, is included at A while it is ignored at B.

is rarely more than a few picofarads and may often be ignored for a design. This leaves the equivalent circuit of Fig. 2B. This is nothing more than the series-tuned circuit, exactly like that used in the L-C filter of Fig. 1B. Realizing this, the same methods may be used for the design of an L-C or crystal filter — one is no more complicated than the other.

Crystal Measurements

If the methods of LC-filter design are transferred to the design of crystal filters, it is mandatory that the vital inductance and capacitance values in the crystal, L_m and C_m, be known. It is not reasonable to substitute an arbitrary crystal of "proper" frequency into an existing design and expect it always to work. This will be illustrated later.

The crystal parameters are measured indirectly, but easily, with lab-quality instrumentation. A suitable measurement may also be done with equipment available to most amateur experimenters, and with a special test set constructed from ordinary components.

The nature of the measurements is understood with reference to the simplified crystal equivalent circuit of Fig. 2B. The crystal is placed between a source of known characteristic impedance and a detector, also of well-defined impedance. The generator is adjusted until a peak response is found. Then, the reactances of L_m and C_m cancel, leaving the result dominated by R_s. This is evaluated easily by replacing the crystal with a small-value variable resistor that is adjusted for the same response in the detector. The potentiometer is then measured with an ohmmeter, providing a value for R_s.

Next, the crystal is reinserted in the signal path and the generator is tuned to both sides of center frequency. The two frequencies where the response is down by 3 dB are noted. The difference is the loaded bandwidth in the test circuit. This is used to calculate a loaded-Q value. But, this is directly related to L_m. Using the condition for resonance, C_m is then calculated. C_p may be measured, but is not vital to the design of the filters described in this paper. Instead, we have assumed that $C_p = 5$ pF for all examples.

Fig. 3 shows the test set that is used to perform the measurements. The first element is a signal generator. It should have an adjustable output level (up to about −10 dBm or more) and should have excellent stability and good bandspread. Remember that we may be measuring frequency differences of only 100 Hz or so. A suitable generator is described in Chapter 7 of *Solid State Design.*[4] The output of the signal source is applied to a frequency counter and to the test set. The counter should have a 1-Hz resolution.

The generator output is attenuated with a 20-dB pad and then applied to the crystal. The high attenuation ensures that low power is delivered to the crystal and provides a 50-ohm termination for the crystal. Output from the crystal under test drives an amplifier with a 50-ohm input resistance. The signal is amplified by four gain stages and then applied to a diode detector, D1. The dc output drives a high-impedance voltmeter. The test set should be operated with output voltages of 2 or less to prevent overdrive of the amplifiers. Q4, the related components, and the detector may be eliminated, if desired. Then, the output from Q3 is routed to an oscilloscope with a 50-ohm terminator.

Amplifier gain is switchable with S1. With S1 open, the net gain is somewhere around 40 dB. Closing S1 changes the emitter degeneration in Q2, causing the net gain to increase by 3 dB.

A batch of crystals may be evaluated easily for filter applications with this test set. A crystal is inserted and the generator is tuned for a peak response in the voltmeter. That response is carefully noted. The crystal is then removed and replaced with the potentiometer. This is adjusted to obtain the same voltmeter response as was obtained with the crystal. The "pot" is then removed from the circuit and measured, providing a value for R_s.

The crystal is now reinserted in the circuit, with S1 open. The generator is tuned again for a peak response. Both the series-resonant frequency, F_o, and the meter response are carefully noted. S1 is then closed to produce an increase in output. The generator is tuned to the two sides (above and below F_o) until the meter reads the same as it did earlier. The two frequencies are noted and the difference is recorded as Δf, a parameter used for later calculations. Note that there is no need for amplitude calibration anywhere in this system.

This procedure is repeated for a reasonable sampling of the crystals on hand. The work that the writer has done would suggest that the values for F_o, R_s and Δf may be averaged for later calculation as long as the spread is not excessive. One batch of 20 surplus TV color-burst crystals showed an average R_s value of 20.78 ohms, with a standard deviation of 7.2 ohms. The average series-resonant frequency was 3577.257, with a standard deviation of only 67 Hz.

The designs which follow are based on having all crystals in a filter at the same frequency. Hence, frequency matching is required. A rule of thumb is that the deviations should be less than about 30% of the bandwidth of the filter. The center frequency measured in the test set will be the series-resonant value. This is not necessarily the value that would come from an oscillator. A simple oscillator is shown in Fig. 4. It may be used for matching the crystals. This circuit operates at a frequency slightly higher than the series-resonance. It is still suitable for frequency matching. It will serve also for BFO applications. The operating frequency may be increased further by insertion of a variable capacitor in series with the crystal.

Simplified Filter Design

Now that data is available on existing crystals, filter design may commence. See Fig. 5. A few approximate equations may be used. They require additional data and normalized filter parameters. These are presented in Tables 1 and 2, respectively,

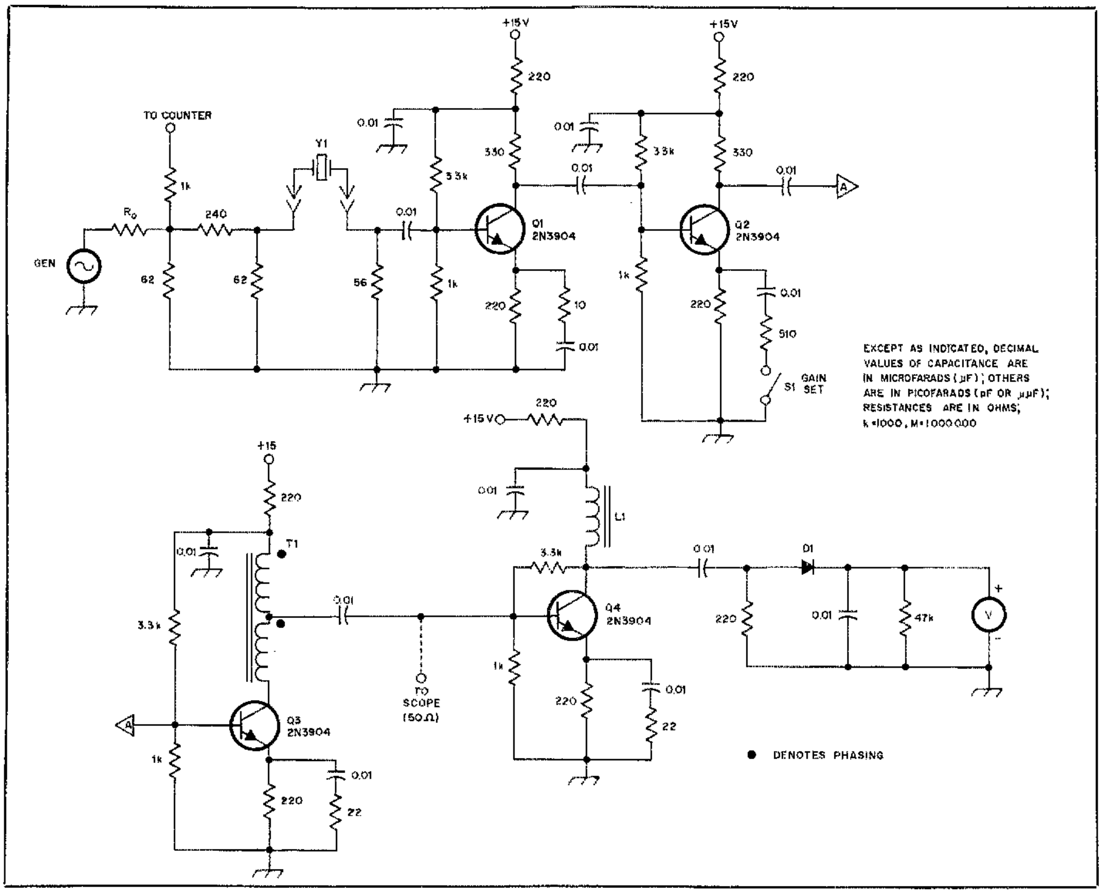


Fig. 3 — A simple test set for the evaluation of crystals to be used in filters. Construction is not critical.

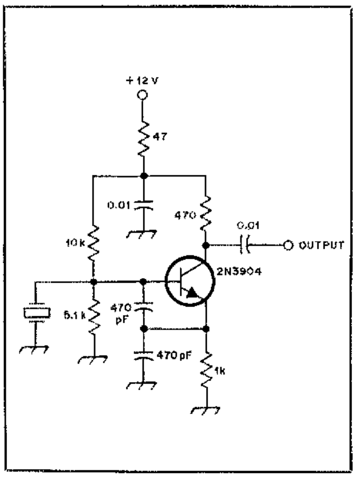


Fig. 4 — A simple crystal oscillator that may be used for crystal frequency matching. The 470-pF capacitors may be ceramic, mica or polystyrene. This circuit will function with crystals from 1.8 MHz to over 10 MHz.

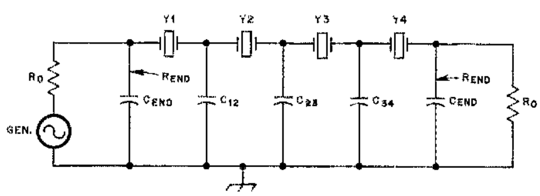


Fig. 5 — A four-pole crystal ladder filter used for illustration. The circuit may be designed for an arbitrary number of crystals.

Table 1

Normalized k and q Values for a Butterworth Response Without Predistortion

N	*q*	k_{12}	k_{23}	k_{34}	k_{45}
2	1.414	0.7071			
3	1	0.7071	0.7071		
4	0.7654	0.8409	0.4512	0.8409	
5	0.6180	1	0.5559	0.5559	1

Table 2

Normalized k and q Values for a 0.1-dB-Ripple Chebyshev Filter Without Predistortion

N	*q*	k_{12}	k_{23}	k_{34}	k_{45}
2	1.6382	0.7106			
3	1.4328	0.6618	0.6618		
4	1.3451	0.685	0.5421	0.685	
5	1.3013	0.7028	0.5355	0.5355	0.7028

for the Butterworth and the 0.1-dB ripple Chebyshev filters. More exacting designs may be done with the exhaustive tables presented by Zverev.[5] His work considers the effects of response-shape distortion, a consequence of loss in filter elements. The Zverev tables are termed "predistorted."

The motional crystal components, L_m and C_m, have been factored into the equations and need not be calculated. Equations are given for them, though. An equation is also given for the unloaded crystal Q (Q_u). This parameter is not needed directly for filter design, but should be evaluated, nonetheless. The Q_u value should exceed the filter Q by a factor of 10 or more to allow simple filters to be built. Filter Q is defined by F_{center} ÷ bandwidth, where both are in hertz. Some surplus crystals may have a Q_u value that is too low for filter applications. The parameters are defined with respect to Fig. 5 as:

Δf = bandwidth measured in test fixture (Hz)
B = filter bandwidth in Hz
R_o = end termination to be used (must be greater than R_{end})
R_{end} = end resistance required to terminate the filter without matching capacitors
C_{end} = matching end capacitor (pF)
C_m = crystal motional capacitance (F)
L_m = crystal motional inductance (H)
F_o = crystal center frequency (MHz)
R_s = crystal series-loss resistance as measured in test set
C_{jk} = coupling capacitor (pF)
C_p = crystal parallel capacitance (assumed to be 5 pF in all equations)
k_{jk} = normalized coupling coefficient, given in Tables 1 and 2
q = normalized end-section Q, given in Tables 1 and 2
N = number of crystals to be used in the filter

The simplified design equations are

$$C_{jk} = 1326 \left[\frac{\Delta f}{B\, k_{jk} F_o}\right] - 10 \text{ (pF)} \quad \text{(Eq. 1)}$$

$$R_{end} = \left[\frac{120\ B}{q \Delta f}\right] - R_s \text{ (ohms)} \quad \text{(Eq. 2)}$$

$$C_{end} = \left[\frac{1.59 \times 10^5}{R_o F_o}\right] \times \sqrt{\frac{R_o}{R_{end}} - 1} - 5 \text{ (pF)} \quad \text{(Eq. 3)}$$

Additional equations not mandatory for simple designs are

$$Q_u = \frac{1.2 \times 10^8\ F}{\Delta f\ R_s} \quad \text{(Eq. 4)}$$

$$C_m = 1.326 \times 10^{-15} \left[\frac{\Delta f}{F_o^2}\right] \text{ (farad)} \quad \text{(Eq. 5)}$$

$$L_m = \frac{19.1}{\Delta f} \text{ (henrys)} \quad \text{(Eq. 6)}$$

The design process will be illustrated with an example. Note that the equations use the units given in the list of parameters. Assume that a small group of crystals is frequency matched and found to have the average parameters f = 294 Hz, ΔF_o = 3.577 MHz and R_s = 23 ohms. This data is typical of inexpensive TV color-burst crystals. These crystals will be used to design a 3-pole Butterworth crystal filter with a 250-Hz bandwidth. We eventually would like to terminate the filter in 50 ohms, but will not pick a termination, R_o, just yet.

The normalized coupling and loading values are found in Table 1 with N = 3. We see that $k_{12} = k_{23}$. Hence the coupling capacitors (Fig. 5) will be equal. The capacitor value is evaluated with Eq. 1.

$$C_{12} = C_{23} = 1326 \times \left[\frac{294}{250 \times 0.7071 \times 3.577}\right] - 10 = 606.5 \text{ pF} \quad \text{(Eq. 7)}$$

The end resistance needed to terminate the filter is given by Eq. 2.

$$R_{end} = \left[\frac{120 \times 250}{1 \times 294}\right] - 23 = 79 \text{ ohms} \quad \text{(Eq. 8)}$$

A value for R_o may now be picked. It may be any resistance greater than 79 ohms. A value of 200 ohms is chosen, and an end-

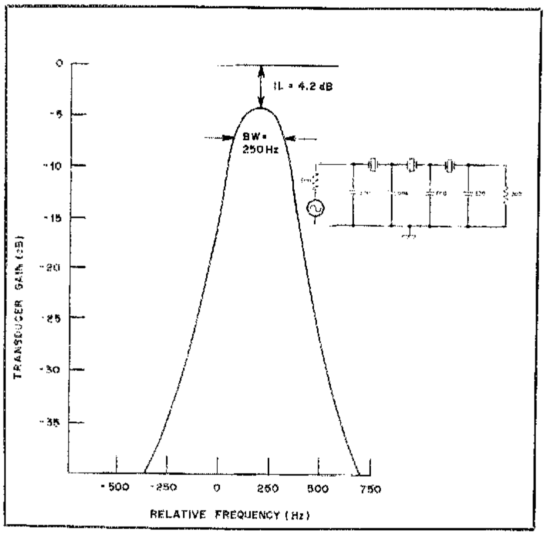


Fig. 6 — Circuit and calculated response for a 3-pole crystal filter at 3.577 MHz with a 250-Hz bandwidth. The design is based on measurements on surplus TV color-burst crystals.

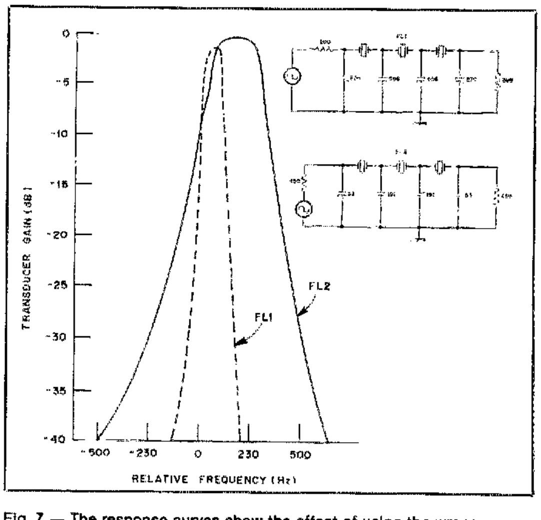


Fig. 7 — The response curves show the effect of using the wrong crystals in a design. The narrow response uses the circuit of Fig. 6 (FL1) with high-quality crystals. The wider response uses the circuit shown (FL2), designed on the basis of measurements on the crystals. Crystal data: F_o = 3.579 MHz, R_s = 6.2 and Q_u = 721,000.

matching capacitor is calculated from Eq. 3.

$$C_{end} = \left[\frac{1.59 \times 10^5}{200 \times 3.577} \right] \times \sqrt{\frac{200}{79} - 1} - 5 = 270 \text{ pF} \quad \text{(Eq. 9)}$$

The final circuit is shown in Fig. 6. The calculated response is also shown. These calculations were done using the Ladder Method,[4] and accounted for the 5-pF C_p value.

The 200-ohm resistance levels may be transformed to 50 ohms with ferrite transformers. This may not be needed in a circuit application, but is certainly useful for measurements.

Note that the filter has an insertion loss of 4.2 dB. This results from the crystal loss with a relatively low crystal Q (Q_u = 63,000), evaluated with Eq. 4. The bandwidth is very close to the desired 250-Hz value, but the peak shape is much more rounded than would be expected from a Butterworth filter. This is also a result of crystal loss.

Consider now the effect of using the circuit of Fig. 6 with other crystals. A group of high-quality 3.579-MHz crystals were measured in the test set. The results were very different than those found with the surplus crystals. The Δf was 96 Hz, and R_s was only 6.2 ohms. The calculated Q_u was 721,000 — over 10 times that of the surplus crystals. L_m was also much different.

The filter of Fig. 6, designed for the low-Q surplus crystals, was evaluated with the parameters of the high-Q crystals. The result is shown in the narrow response of Fig. 7. The bandwidth is much narrower than the desired 250-Hz value, and would be nearly useless in a cw receiver, owing to excessive ringing.

A filter was then designed around the measured crystal parameters. This response is also shown in Fig. 7, as is the circuit, FL2. This filter has a low insertion loss of only 0.4 dB and a shape like that expected of a Butterworth design. A comparison of Fig. 6 and Fig. 7 illustrates the effects of shape distortion.

The data in Figs. 6 and 7 are calculated. An obvious question regarding any experimental pursuit is how well do calculated curves compare with measured data? This comparison is presented in Fig. 8 for a 5-MHz, 250-Hz bandwidth filter. The three-pole circuit is also shown in the figure. The comparison between calculation and measurement is very good. The offset in center frequency is of no significance — it resulted from using 4.999 MHz for F_0 during the calculation, rather than a more accurate value. The measurements were done with the writer's receiver synthesizer as a signal generator, followed by a step attenuator and then the filter. This was followed by a broadband amplifier and a 50-ohm-terminated oscilloscope. Similar results have been obtained with filters at 3.579 MHz.

The experimental curve of Fig. 8 is marked with a BFO frequency. This would be the proper frequency to provide a 700-Hz beat note and to ensure good suppression of the opposite sideband. This filter would be very practical in a simple superhet receiver for cw application, especially if it were supplemented with an R-C active low-pass audio filter. This scheme has been used very successfully by the writer in a portable Field Day transceiver.[7]

A simple three-pole filter is also practical for some ssb applications. Such a filter at 5 MHz is shown in Fig. 9. Measured and calculated frequency-response curves are also shown. Note that the filter shape is lacking in symmetry. Indeed, this is an illustration of why this type of circuit is termed a "lower sideband ladder." This also justifies the position of the BFO in Fig. 8. In spite of the poor attenuation slope on the low-frequency side, the filter of Fig. 9 would be practical for a simple ssb exciter. This passband ripple may be eliminated by tuning, a detail shown in the figure and covered in the following section.

Filter Tuning

The method presented so far has assumed that all crystals are exactly at the same frequency. This simplification is sufficient for many applications, especially with narrow-bandwidth filters. It is not adequate for critical designs. Additional tuning is required if we want to design filters with an exactly predicted bandwidth, achieve a desired shape more accurately, or build wide-bandwidth filters with more than 3 or 4 crystals.

Modern filter theory has been used to calculate coupling and end-matching capacitors. The detail that we have ignored is that the individual crystals have

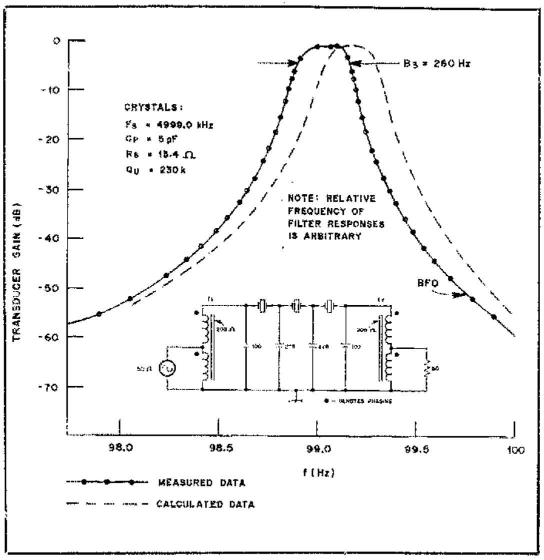


Fig. 8 — Comparison of calculated and measured results on a 5-MHz cw filter. The crystals had F_0 = 4.999 MHz, C_p = 5 pF, R_s = 13.4 ohm and Q_u = 230,000. A proper BFO frequency is marked. See text for discussion.

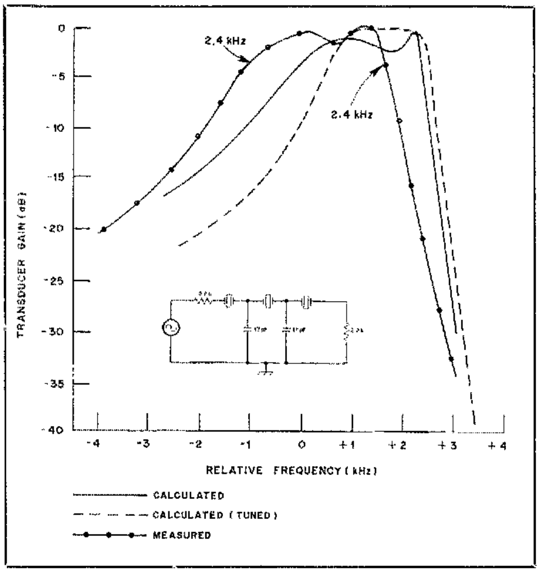


Fig. 9 — Measured and calculated (with and without tuning) results for a wider bandwidth filter for use in a simple ssb exciter. Crystals are the same as used for the filter of Fig. 8.

been detuned by the shunt capacitors. The detuning may be "fixed" through proper choice of crystal frequencies or with the insertion of additional capacitors in the circuit.

Fig. 10A shows one end of a crystal filter. The crystals have been replaced with the simplified equivalent circuit without loss resistance. All crystals are assumed to be at the same frequency, which implies that all L_m and C_m values are the same throughout the filter.

Filter theory states that each loop in this circuit should be resonant at the same frequency when that loop is considered alone. Adjacent loops are open-circuited during this evaluation. Consider the interior loop shown in Fig. 10B. The crystal resonance is determined by L_m and C_m. However, the resonant frequency of this loop is determined by L_m and the series equivalent of the three capacitors, C_{12}, C_{23} and C_m. The loop will resonate slightly higher than the crystal frequency. The actual frequency is easily calculated with standard formulas and a hand calculator.

Analysis of end-section resonance is slightly more complicated. The end resistance and the related parallel capacitance must be resolved into a series equivalent, shown in Fig. 10C. The series capacitance is given by

$$C_s = \frac{\frac{1}{R_o^2} + \omega^2 C_{end}^2}{\omega^2 C_{end}} \qquad \text{(Eq. 10)}$$

where $W = 2\pi F_o \times 10^6$.

The resonant frequency of the end loop is then calculated from L_m and the series combination of C_s, C_m and C_{12}.

Consider an example, a 4-pole ssb filter. This circuit, shown in Fig. 11, was designed for a 0.1 dB Chebyshev response using the k and q values from Table 2 and crystals with $F_o = 3.577$ MHz, $R_s = 23$ ohms and $Q_u = 63{,}000$. Assume for the present that the two 96-pF capacitors are shorted. The filter is symmetrical, so only two frequency calculations must be done — one for the ends and one for the interior loops. The end loops are resonant 1220 Hz above F_o, while the inner two loops resonate 1790 Hz above F_o.

Two methods may be used to tune this filter, to force all loops to resonate at the same frequency. One method requires that the F_o of the crystals in the end sections be increased 570 Hz over that of the inner loops (570 = 1790-1220). This difference is small compared with the filter bandwidth, so we would not expect a dramatic difference in response shape.

The other method places capacitors in series with crystals in those loops requiring a frequency increase — the end sections of Fig. 11. This is the circuit shown in the figure. A value of 96 pF was found to be necessary for the 570-Hz shift. The addition of series capacitors allows more design flexibility, especially when working with surplus crystals. On the other hand, it may be convenient to use stagger-tuned crystals if the batch on hand has the proper frequency spreads. It is, of course, possible to use a combination of the two methods.

The frequency response of the four-pole filter is shown in Fig. 11 for the cases with and without tuning. The center frequency is raised with tuning, and pass-band ripple is reduced to near the desired 0.1-dB level. Either filter would be practical for amateur applications.

The bandwidth of the ssb filter of Fig. 11 was 2.2 kHz. It was designed for a 2.5-kHz bandwidth. The difference results from simplifying assumptions used to derive the critical equations and using the k and q values from Table 2, where the effect of filter loss is ignored during design. Improved accuracy is obtained with the Zverev tables to supply the k and q values. Suitable amateur filters may be designed by increasing the design bandwidth slightly over the desired one, while using the Table 1 or 2 data.

The effects of shape distortion are more dramatic with narrow-bandwidth cw filters, for the losses are higher with decreased bandwidth. The Butterworth data of Table 1 provide a good starting point for design. As losses increase, the shape of a narrow-bandwidth filter evolves toward one with a more rounded peak shape, approaching something like a Gaussian response. This rounded shape is desired for narrow-band application, for it offers an improved time-domain characteristic with less filter ringing. Chebyshev filters should not be used for cw applications.

The effects of filter tuning were examined experimentally in the filter of Fig. 12. This was a 250-Hz wide design using the 5-MHz crystals applied in other filter experiments. A 5-pole design was chosen. The measured responses with and without tuning are also shown with the circuit. Without tuning, the attenuation slope on the high-frequency side of the response was poor. Tuning the filter improved the shape and reduced the insertion loss. The shape was still not the Butterworth response predicted. This was traced to variations in the crystal frequencies that had not been taken into account during the design. This filter is destined for use in a multiband portable transceiver.

Conclusions and Applications

Home construction of crystal filters is very practical, especially for the experimentally inclined amateur with the usual amount of instrumentation. Laboratory-grade equipment is definitely not needed. It is important, however, that the filters be carefully designed, and that the designs be based on the crystals to be used. Measurements are performed easily in the home lab to obtain the needed crystal parameters. None of the filter circuits presented in this paper is suitable for exact duplication.[4]

Filter tuning may or may not be required, depending on the filter to be built. An interesting filter that would never require tuning is a two-pole circuit. This results from symmetry. Any detuning would be the same in both crystals. Improved stopband attenuation may then be obtained with a cascade of several filters with isolating stages of gain between them.

Another interesting special case is the three-pole filter with all crystals at the same frequency. The terminating resistance, R_o, may be set equal to the calculated R_{end}. There will then be no shunt capacitors at the ends. This filter may be tuned by placing series capacitors

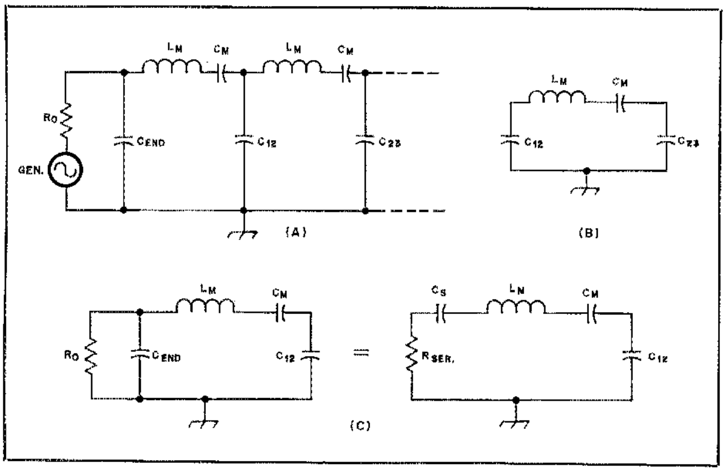


Fig. 10 — Partial filter circuits used in evaluation of tuning of individual loops. See text for details.

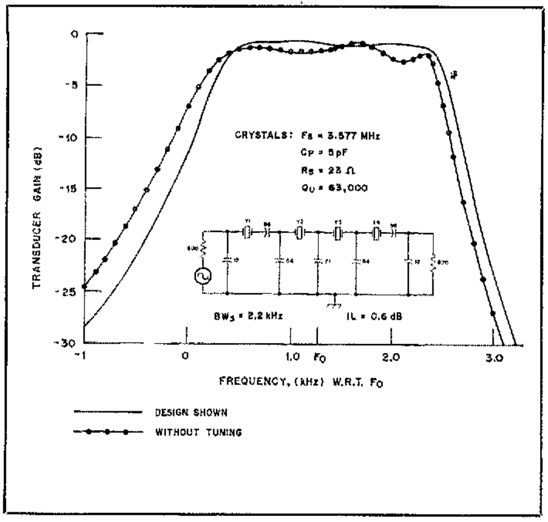


Fig. 11 — Calculated response for the 4-pole ssb filter shown. Surplus color-burst crystals were used for the design. The two response curves show the effects of filter tuning.

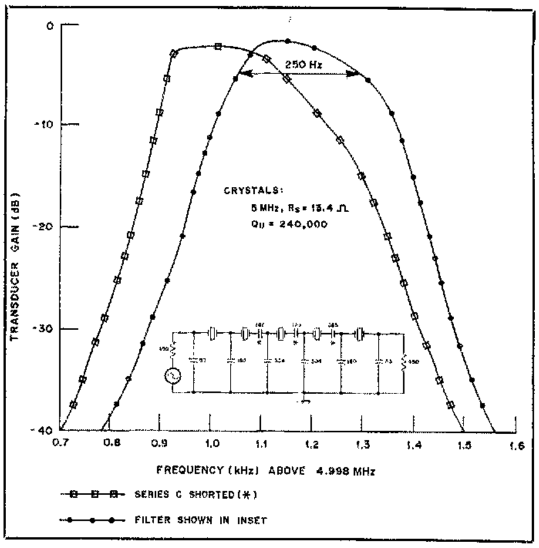


Fig. 12 — Measured response curves for a 5-pole, 5-MHz cw filter. The two curves show the effects of tuning a filter with series capacitors.

in the end loops, which have a value equal to the coupling capacitors. An example of this is the ssb filter shown earlier in Fig. 9. The tuning was realized with the addition of 17-pF capacitors in series with the two outside crystals. Variable capacitors may be used, of course, in any of the circuits shown. Instrumentation must then be built for alignment.

The 3.58-MHz TV color-burst crystals offer an attractive possibility for a simple cw receiver. A single local oscillator could be built at approximately 10.5 MHz. This will then allow both the 40- and 20-meter cw bands to be received with no band switching in the LO. This scheme is not well suited to an ssb receiver, for harmonics of the BFO appear at 7.16 and 14.32 MHz. This harmonic relationship could also lead to spurious responses in a two-band cw transceiver.

Examination of the design procedure reveals some interesting subtleties. Careful choice of termination, R_0, could lead to filters requiring no tuning. Useful filters *can* be built from poorly matched crystals, although the design may get messy. Excessive tuning with series capacitors will increase the loss of the filter. Finally, careful choice of termination resistance will allow the construction of filters with a switched bandwidth.

Notes

[1]A. I. Zverev, *Handbook of Filter Synthesis* (New York: John Wiley and Sons, 1967), Chapter 8.

[2]J. A. Hardcastle, "Ladder Crystal Filter Design," *QST*, Nov. 1980, pp. 20-23.

[3]W. Hayward, *Introduction to Radio Frequency Design* (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1982). Both filter types are covered in detail in Chapter 3.

[4]W. Hayward and D. DeMaw, *Solid-State Design for the Radio Amateur* (Newington: ARRL, 1977), p. 171.

[5]See note 1, pp. 341-379.

[6]See note 3.

[7]See note 4, p. 214.

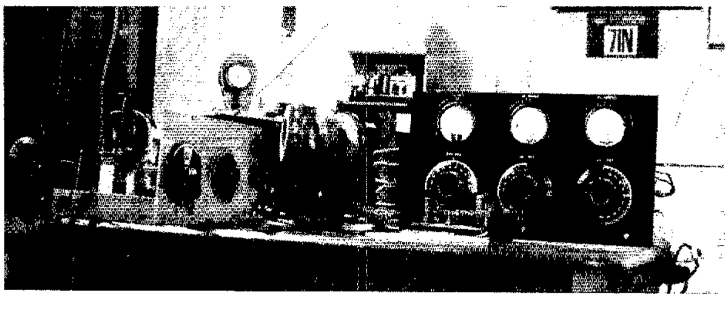
[8]The author has made arrangements to supply crystals at a variety of frequencies that have been characterized for filter applications. Interested readers should send an s.a.s.e. for a data sheet.

Strays

***QST* congratulates . . .**

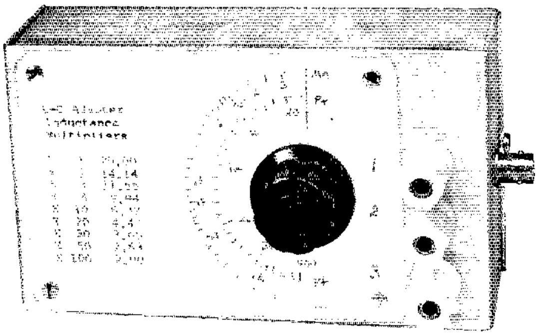
☐ Retired Army Colonel Fred J. Elser, KH6CZ, of Honolulu, on receiving a PhD in American Studies from the University of Hawaii. His doctoral thesis was entitled "Amateur Radio — An American Phenomenon."

☐ Ira Bechtold, W6NCP, on receiving the Los Distinuidos Award from the La Habra Heights (California) Improvement Association for 10 years of outstanding service to his community.



Bill Staiger, W7IN, of Portland, Oregon, came across this photo while going through an old box buried in his attic. The honeycomb coil receiver (left) was used for arc reception around 15,000 meters and also for i-f reception on 600 meters (500 kHz) with different plug-in coils. The transmitter (right) was a TPTG back-to-back circuit fed with a 60-Hz power supply with a 120-Hz note. The breadboard receiver seemed to work, Bill notes, if he didn't get too close to the coupling unit and disturb the body-capacity effect while tuning. *(photo courtesy W7IN)*

Measuring Inductance and Capacitance With a Reflection-Coefficient Bridge



Need an inexpensive means of accurately measuring unknown L and C values? A few well-spent weekend hours and that capability is yours!

By Jack Priedigkeit,* W6ZGN

When constructing tuning coils for a receiver, inductors for an rf filter, or coils and transformers for impedance-matching purposes, it is convenient to have a means of directly and accurately measuring inductance. A reflection-coefficient bridge, useful for measuring an impedance match in terms of reflection coefficient, return loss, or VSWR on a transmission line,[1] can be adapted to measure inductance.

Described here is the construction and calibration of a simple LC adapter that can be used with a reflection-coefficient bridge to measure inductance values from 0.2 μH to 200 μH, and capacitance values from 5 pF to 400 pF. Depending on the care taken during calibration, the resulting accuracy can be comparable to that of an expensive Q meter.

Circuit Theory and Operation

Fig. 1 shows the LC adapter as a simple series circuit consisting of a calibrated capacitor, C1, the unknown inductance, L_X, and a 51-ohm resistor, R1. At resonance, the capacitive reactance of C1 cancels the inductive reactance of L_X, leaving R1 to terminate the coaxial cable connecting the LC adapter to the reflection coefficient bridge. Thus, a sharp dip is seen on the bridge receiver S meter as C1 is tuned through resonance.

The value of L_X at resonance is calculated easily, as both the frequency and the value of C1 are known.

$$L_X = \frac{10^6}{(2\pi f)^2 C1} \qquad \text{(Eq. 1)}$$

where f is in MHz and C1 is in pF.

Mathematical calculations are not required if a dial is attached to the shaft of the variable capacitor and calibrated in terms of capacitance and inductance values for a specific operating frequency, f_o. The capacitor calibration is independent of frequency. So, multipliers for the inductance scale can be realized by selecting different operating frequencies according to the relation:

$$f_m = \frac{f_o}{\sqrt{M}} \qquad \text{(Eq. 2)}$$

where

f_o is the calibration frequency for the ×1 multiplier

f_m is the new operating frequency

M is the inductance scale multiplier (×2, ×5, etc.).

For example, the inductance scale is multiplied by a factor of 5 when the operating frequency is reduced by a factor of $\sqrt{5}$.

Table 1 shows some multiplier factors that can be had when a general-coverage receiver is used with the bridge. Table 2 provides multipliers for use with a ham-bands only receiver. An operating (or ×1) frequency above 20 MHz is not recommended because of possible resonances within the LC adapter.

Construction

An adapter constructed by the author is shown in Fig. 2. This one is mounted in an LMB model 138 box which measures 3-1/2 × 6-1/4 × 2-1/8 inches (mm = inches × 25.4). To minimize lead length and internal inductance, the location of the binding posts (J1 through J3) and the BNC connector (J4) relative to the terminals of the variable capacitor is important. The adapter shown is self-resonant at 32 MHz with the inductance terminals shorted and C1 set to maximum capacity. This indicates an equivalent internal inductance of 0.06 μH, which limits the minimum inductance that can be measured.

C1 is the most important component of

[1]Notes appear on page 29.

*441 Sherwood Way, Menlo Park, CA 94025

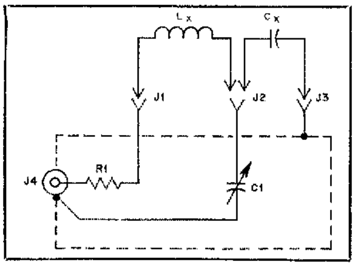


Fig. 1 — Schematic diagram of the LC measuring adapter. Short interconnecting leads should be used.

C1 — 465 pF variable (see text).
CX — Capacitor to be measured.
J1-J3, incl. — Binding post, Voltex 35N844 or equiv.
J4 — Female BNC chassis connector.
LX — Inductor to be measured.
R1 — 51 Ω, 1/2-watt, 5% carbon composition.

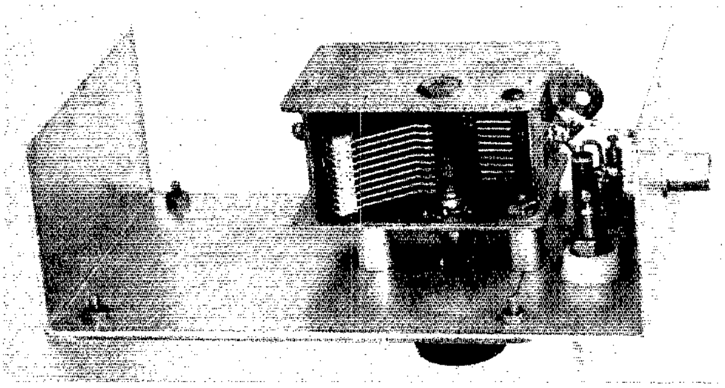


Fig. 2 — An inside view of the LC adapter constructed by the author. Short, heavy leads connect the capacitor to the binding post (J2) and to a grounding lug secured beneath the BNC connector (J4) mounting nut.

Table 1
General-Coverage Receiver Multipliers

Multiplier	Operating Frequency (MHz)
X1	20.00
X2	14.14
X3	11.55
X5	8.94
X10	6.32
X20	4.47
X30	3.65
X50	2.83
X100	2.00

Table 2
Ham-Band Receiver Multipliers

Multiplier	Operating Frequency (MHz)
X1	14.140
X4	7.070
X16	3.535
X50	1.999

the adapter; the capacitor chosen for C1 should be one of good quality. A mechanically sound capacitor ensures smooth operation and reliable calibration. An ideal capacitor would be a single-section, 465-pF, straight-line frequency type with ceramic or glass insulation. Such capacitors were frequently found as World War 2 surplus items, and a few may be still resting quietly at the bottom of some junk boxes.

One section of a dual, 465-pF-per-section capacitor of the type used in early four-tube TRF and superheterodyne bc radios is a good second choice. These capacitors have phenolic insulation and are equipped with a small padder capacitor. The padder should be removed, as it will limit the minimum capacitance setting and could change the dial calibration if the adjusting screw were to move. A single-section capacitor of this type was used to construct the adapter shown in Fig. 2. Miniature tuning capacitors salvaged from transistor radios are of questionable value because of their low capacitance range and poor mechanical quality.

Calibration

Access to a reliable low-frequency capacitance bridge or a Q meter that has a resolution of a few picofarads[2,3] is required to calibrate the LC adapter. A calibration frequency of less than 100 kHz should be used to minimize the effects of the inductance of the test leads connecting the adapter to the capacitance bridge. Be sure, however, to compensate for the capacitance between these test leads, as it will be on the order of 10 to 20 pF and will result in appreciable error it is if not taken into account.

First, calibrate the capacitance scale. Then select the operating frequency for the × 1 multiplier, and calculate the location of the inductance values relative to the calibrated capacitance scale. For example, to locate the 1-μH calibration mark when f_o is chosen as 20 MHz, the value of the resonating capacitance is:

$$C = \frac{10^6}{(2\pi f_o)^2\ L} = \frac{10^6}{(2\pi \times 20)^2 \times 1}$$

$$= 63.3\ \text{pF} \qquad \text{(Eq. 3)}$$

The 1-μH calibration mark should be located opposite 63.3 pF on the calibrated capacitance scale. If f_o were chosen to be 14.14 MHz, the 1-μH mark would be opposite 127 pF on the capacitance scale.

Repeat the foregoing procedure for the other values to be located on the inductance scale. Remember — the accuracy of the LC adapter depends on the accuracy of calibration.

Measuring Inductance and Capacitance

To measure inductance, select an operating frequency for the desired inductance-scale multiplier, and tune the signal generator and bridge receiver to this frequency. Connect the inductance to be measured to terminals 1 and 2 of the LC adapter, and adjust C1 for resonance, as indicated by a dip in the S-meter reading of the bridge receiver. Read the value of inductance from the calibrated scale.

For capacitance measurements, select an inductance and operating frequency such that the coil can be resonated with C1 near mid-range. Connect the coil to terminals 1 and 2, and note the capacitance value of C1 at resonance. Now connect the capacitor to be measured to terminals 2 and 3 of the adapter, and adjust C1 again for resonance. The unknown capacitance value is the difference between the initial and final readings on the capacitance scale.

Remember that the calibration of the capacitance scale is independent of frequency. Thus, for unknown capacitance values that may approach 400 pF, the operating frequency during measurement should be lowered so that the initial value of C1 is near maximum capacitance.

Spend a couple of hours assembling this inexpensive adapter. It will provide you with a means of making accurate measurements of unknown L and C values — a worthwhile addition to your workbench.

Notes

[1]J. Priedigkeit, "A Reflection Coefficient Bridge — Impedance Matching Measurement the Easy Way," *QST*, October 1981, p. 18.
[2]Hewlett-Packard model 4260A CRL Bridge or equivalent.
[3]Hewlett-Packard model 4342A Q Meter or equivalent.

Calibrate Your 2-Meter Synthesizer With Only a General-Coverage Receiver

Short on test equipment and money? Need to align your 2-meter synthesizer? Be innovative! Do it with a general-coverage receiver!

By L. H. Cantwell,* WA9KKR

Are radio amateurs always inventive? Usually, but there are gaps where just a little additional innovation would yield surprising results. The tuning of frequency synthesizers (common in 2-meter fm equipment) is one of these areas. Does your synthesizer need tuning?

One popular method of tuning a synthesizer relies on a frequency counter. A less popular method requires a general-coverage receiver. The principle of this (my) approach is "zero beating." The results of the two methods are the same; but I didn't have to buy a frequency counter with my technique!

Historical Perspective

This procedure has roots in the history of ham radio. Until the advent of ssb transceivers, zero beating was used almost universally to match the transmitter frequency with the receiver frequency. If there are two carriers within the passband of an i-f amplifier, they produce a beat note that is equal in frequency to the difference of the two carriers. In the "good old days," if one of these carriers came from a station we wished to talk with, and if the other was leakage from our VFO, we simply adjusted the VFO in a manner that would reduce the frequency of the beat note to zero.

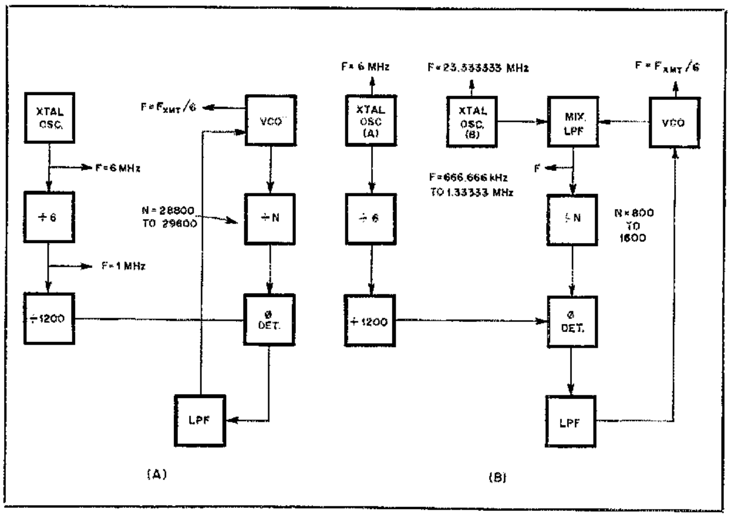


Fig. 1 — At A, simplified block diagram of a basic synthesizer. At B, a block diagram of a more complex synthesizer that employs an offset oscillator.

Before the beat-note frequency reached zero, it would be too low to be readily audible. Fortunately, at that point, a visual fluttering would appear on the receiver S meter. We adjusted the VFO to make the meter flutter slower and slower until the movement stopped. At this point, the two carriers were equal in frequency.

Basic Synthesizer

This technique still has value for calibrating crystal oscillators, and it is the method I use to check my 2-meter syn-

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thesizer. Let's look at the basic divide-by-N synthesizer (Fig. 1A). It has the advantage of using only one crystal oscillator. Once this oscillator is properly calibrated, the synthesizer is on frequency for any setting. This scheme is not without drawbacks; a divide-by-N counter must be capable of high-speed operation (on the order of tens of MHz). This can generate objectionable spurious frequencies. A complex switching scheme is required to translate the dial setting to the proper N during reception and offset transmission. Nonetheless, practical circuits have been developed using this method.

Referring again to the technique of zero beating, we must have two carriers within the audio passband of a general-coverage receiver. The standard frequency we select will be one of the transmit frequencies of WWV. Most likely, it will be either 5, 10 or 15 MHz. Our other carrier will be related to the synthesizer reference oscillator. It can not be the reference-oscillator frequency, because 6 MHz is not harmonically related to any WWV frequency.

We look to the reference oscillator divider chain to see if a useful frequency is produced. After the divide-by-six counter, the output frequency is 1 MHz. Harmonics of this frequency are equal to our WWV choices. All synthesizers do not employ this scheme. Some dividers are binary, making it more difficult to uncover a portion of the circuit having a harmonic relationship to WWV. You might find frequencies as low as 10 kHz useful, if you reference them to the 5-MHz WWV transmission. If you are referencing to the higher WWV frequencies, you should not use a carrier frequency lower than 100 kHz.

Connect a capacitor (between 10 and 100 pF) to the output of the divide-by-six counter. Attach the other end of this capacitor to a wire that is placed near the terminals of a communications receiver. Tuning the receiver to WWV, you should hear a beat note. Adjust the frequency of the crystal oscillator to zero beat with WWV. This completes the calibration of the reference oscillator.

Offset Synthesizers

Offset synthesizers are more complex (Fig. 1B). Our representative circuit has a second offset oscillator, which must be properly adjusted, in addition to the first oscillator. Instead of the divide-by-N circuit counting the VCO frequency, it counts the difference frequency of the VCO and a second oscillator known as the offset oscillator (Table 1). This results in a VCO frequency that is the sum of the divide-by-N-counter and the offset oscillator frequencies. Many disadvantages to the simple synthesizer are overcome, but at the expense of a loss of simplicity as well as some sacrifice of frequency stability. Two oscillators, rather than one, are now controlling the VCO frequency. Should they drift in the same direction, both will add to the VCO frequency error.

Our adjustment of the offset oscillator is not as simple as that of the reference oscillator. The offset crystal frequency is 23.333333 MHz. I assure you that looking for some harmonic relationship to a standard frequency is pointless. We can take a "back-door approach" to adjusting this oscillator with great success. Let's assume this oscillator is on frequency and the synthesizer is operating properly. Examining the VCO frequency, we find it to be one-sixth the operating frequency, or 24.000000 to 24.666667 MHz for a transmitting frequency of 144.000 to 148.000 MHz, respectively.

Although 24 MHz is not harmonically related to any WWV frequency, we are not out of luck. Remember, the divide-by-six counter produces an output of 1 MHz from our 6-MHz oscillator. Since it is a square wave it will be rich in harmonics. Because we have calibrated this oscillator to WWV — just as we did with the simple synthesizer — it will become our new standard for adjusting the VCO frequency. Setting the synthesizer dials to 144.000 MHz, and placing the transceiver in the transmit (simplex) mode, causes the VCO to operate at 24 MHz.

For this stage of the alignment we use the test set-up depicted in Fig. 2. Attach the wire from the 100-pF capacitor to the receiver antenna terminal, and then tune the receiver to 24 MHz. (Note: If the 100-pF capacitor seems to load down the output of the divide-by-six counter, reduce the value to one that does not, e.g. 10 pF or so.) Connect a second wire to the receiver terminal and route the other end near the VCO. Enough rf energy from the VCO and the 24th harmonic of the 1-MHz output should be present at the antenna terminals of the receiver to produce an audio beat note. If the offset oscillator is exactly on frequency, the VCO will be exactly 24 MHz and no beat note will be heard. Adjusting the offset oscillator while following the zero-beat procedure will bring the offset oscillator on frequency.

We now have adjusted the offset frequency for simplex operation only. We can adjust the − 600-kHz offset by setting the synthesizer to the − 600 mode and the transceiver to receive 144.60 MHz. This puts the VCO frequency at 24 MHz during transmission. Repeat the zero-beat procedure for this offset oscillator. We can align the + 600-kHz offset oscillator in the same manner, except we set the transceiver frequency to 143.400 MHz. [Editor's Note: Some circuits will require extensive modification to enable coverage of this frequency.]

Adjusting the receiver offset is a bit more tedious. First of all, the frequency range of the VCO must be determined. My transceiver uses a 10.7-MHz i-f, resulting in a VCO frequency of 22.216667 to 22.883333 MHz for reception of 144.000 to 148.000 MHz, respectively. Several multiples of 100 kHz occur in this range, offering one method of alignment. With my radio I can take a simpler approach. I set the transceiver frequency for 142.700 or 148.700 MHz to provide a VCO frequency of 22.000 or 23.000 MHz, respectively. Tune the communications receiver to 22 or 23 MHz, corresponding to the transceiver setting, and zero beat. This completes the zero-beat method of alignment.

Although I used a specific synthesizer as an example, the technique is general. After spending some time with a calculator and the block diagrams of most of the common schemes, I determined that variations of this approach would work with any of them. Are you inventive? What other gaps can you fill?

Table 1

Transmit and Receive Frequency Formulas for Offset Synthesizers

VCO Transmit Frequency

$$\frac{F_d + F_o}{M} = F_{vco}$$

where
F_d = synthesizer dial frequency
F_o = transmit offset frequency (simplex, ±600 kHz, etc.)
F_{vco} = VCO frequency
M = transmitter multiplication factor (M = 6 in text)

VCO Receive Frequency

$$\frac{F_d + F_{i\text{-}f}}{M} = F_{vco}$$

where
F_d = synthesizer dial frequency
M = transmitter multiplication factor
$F_{i\text{-}f}$ = frequency of first i-f amplifier (treat as a positive number if high-side injection is used, and as a negative number if low-side injection is used)

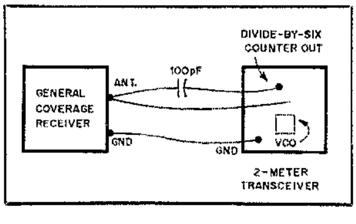
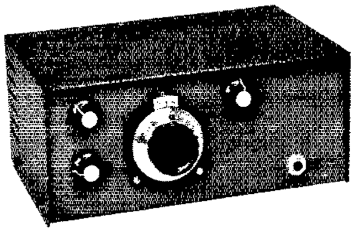


Fig. 2 — Hook-up diagram for aligning an offset synthesizer that uses only a communications receiver.

Beginner's Bench



Getting Started on VHF: A Tunable I-F for VHF Converters

Part 2: This project provides a solid foundation for your 6-meter receiving setup.

By George Collins,* KC1V

Does successful vhf operation demand an adequate receiving system? Yes, and fortunately the vhf newcomer can put together a satisfactory receiving setup without having to forego a second car or the children's education! One of the simplest options available is also one that can provide high performance at low cost — a crystal-controlled converter followed by a tunable i-f (intermediate-frequency) unit.

Most commonly, the i-f unit is the regular station receiver operating at 10 meters. A 6-meter converter, for example could be used to convert signals between 50 and 52 MHz to the 28- to 30-MHz range. Any 10-meter receiver or transceiver could then be used as the tunable i-f. The 10-meter band is often chosen as the i-f because of the wide frequency coverage (28 to 30 MHz) provided on most receivers. If your interest is in only a small part of the vhf band, other hf bands can be used as the i-f.

This type of system has several advantages. First, if you have a suitable receiver available for use as the i-f unit, the cost of this approach can be very low. You need only buy or build the converter portion of the system. In addition, the overall system selectivity and stability are nearly the same as that of the tunable i-f receiver. The major disadvantage of using your hf receiver or transceiver as the i-f unit is that you must disconnect the converter when using the hf bands and reconnect everything before you can listen to the vhf band. The experienced vhf operator knows that he will be doing a lot of listening. A separate vhf receiver is far more convenient and allows you to monitor the vhf calling frequencies while using your hf equipment for normal operating. It should be noted that some current transceivers have provisions for the use of vhf transverters (a combination receiving and transmitting converter). These transceivers make convenient i-f units.

A 10-MHz Tunable I-F

The receiver described here serves well as a tunable i-f unit and, as a "plus," you can use it to listen to the new 10-MHz band! A 6-meter receiving converter, using 10 MHz as the output frequency, is being developed for use with this receiver. It will appear in an upcoming Beginner's Bench installment.

This receiver, originally called the Mini-Miser's Dream, was designed by Doug DeMaw, W1FB, as a portable 40-meter receiver.[1] It is a superheterodyne design using a crystal filter to provide good selectivity. Integrated circuits (ICs) have been used in the mixer, i-f amplifier and audio amplifier stages to reduce the number of components. As an aid to simplicity, agc (automatic gain control) has not been included. A front-panel potentiometer serves as a manual i-f gain control.

To change the receiver tuning range from 40 meters to 10 MHz, only two circuits require modification. The mixer (U1) input circuit is tuned to 10 MHz by changing the number of turns on T1 and retuning C1. To cover the 10.0- to 10.3-MHz range, the VFO (variable-frequency oscillator) must tune from approximately 6.7 to 7.0 MHz. This is accomplished by changing the oscillator tank circuit components (L2 and the associated capacitors). The buffer amplifier (Q3) output filter is also changed to the new frequency.

To make the receiver more compatible with the 6-meter VXO transmitter,[2] a muting circuit, audio-frequency gain control and sidetone input have been added to the original circuit. All of these modifications have been incorporated in Fig. 1.

Circuit Highlights

Mixer U1 converts the incoming 10-MHz signals to the i-f of 3.3 MHz. L1 and C2 tune the mixer output to the i-f, where FL1, a single-crystal filter, provides the selectivity. A phasing capacitor, C3 is used during alignment to adjust the filter for best selectivity. Following the filter is an IC i-f amplifier, U2. The amplifier output is tuned by T2 and C4 to the i-f. T2 also provided the necessary impedance match between the mixer and the two-diode product detector. Beat-frequency oscillator (BFO) injection voltage is provided by means of a crystal-controlled oscillator (Q1). After detection, the audio signal is amplified in U3. Approximately 300 mW of audio is available to drive headphones or an 8-Ω speaker.

The VFO section contains two transistors. A JFET (junction field effect transistor) is used as the oscillator. The circuit configuration used here is known as a series-tuned Colpitts. A buffer amplifier (Q3) is used to isolate the VFO from the mixer. Voltage regulation for the oscillator is provided by U4, a three-terminal regulator.

Construction Notes

Receiver assembly is simplified by using an etched-circuit board.[3] All components except the panel-mounted potentiometers and switches are contained on the single board. Component placement is shown in Fig. 2.

The VFO section is enclosed in a compartment made from double-sided circuit-board material. The compartment measures (HWD) 1-3/8 × 1-5/8 × 2-3/4 inches.[4] To form the enclosure, first cut the sections of board to size. Then carefully tack solder the pieces together, using a small drop of solder at each inside corner of the box. Make sure the box is square, then tack solder the outside seams. Now flow a bead of solder along each seam. With care, this can be done with a 27-W soldering iron, but a 40-W iron will make the job easier.

Place the finished shield compartment on the circuit board, using the component

*Assistant Technical Editor

[1]Notes appear on page 34.

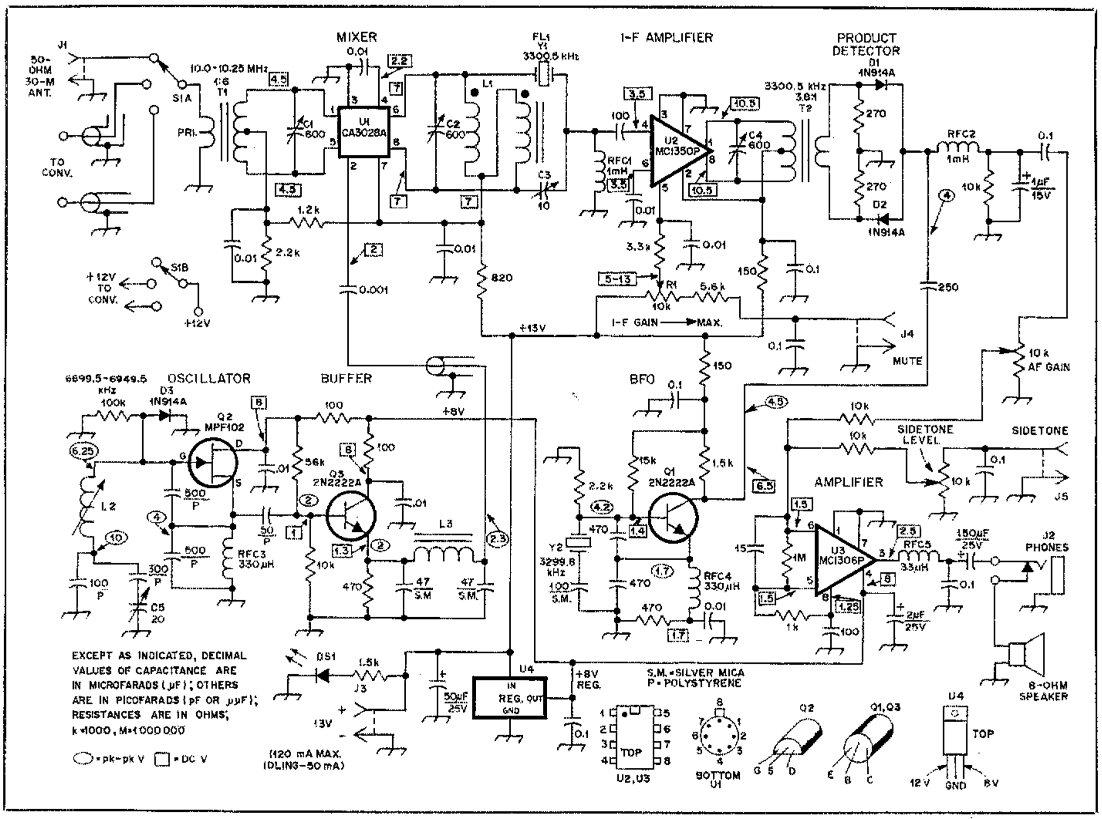


Fig. 1 — Schematic diagram of the Mini-Miser's Dream, modified to operate at 10 MHz.

C1, C2, C4 — 170- to 600-pF mica trimmer (ARCO 4213).
C3 — 10-pF miniature trimmer. Ceramic or pc-mount air variable suitable.
C5 — Miniature air variable, 2 to 20 pF.
D1-D3, incl. — High-speed silicon switching diodes, 1N914 or equiv.
J1, J3-J5, incl. — Single-hole-mount phono jack.
J2 — Closed-circuit phone jack.
L1 — 8 bifilar turns of no. 28 enameled wire wound on an Amidon FT37-61 ferrite core (L = 5.8 μH).
L2 — Slug-tuned inductor, 5-μH nominal inductance. Miller 42A686CBI (3.6 to 8.5 μH) or equiv.
L3 — 12 turns of no. 26 enameled wire wound on an Amidon FT50-61 ferrite core.
R1 — 10-kΩ panel-mount control, linear taper.
R2 — 100-kΩ panel-mount control, audio taper.
R3 — 10-kΩ pc-mount control.
RFC1, RFC2 — Miniature 1-mH rf choke (Millen J302-1000 or equiv.).
RFC3, RFC4 — Miniature 330-μH rf choke (Millen J302-330 or equiv.).
RFC5 — Miniature 33-μH rf choke (Millen J302-33 or equiv.).
S1 — 2-pole, 3-position rotary switch.
T1 — Toroidal transformer. Primary has 2 turns of no. 24 enameled wire. Secondary has 12 turns of no. 24 enameled wire on an Amidon, Palomar or RadioKit T50-2 core.
T2 — Toroidal transformer. Primary has 9 turns of no. 26 enameled wire (center-tapped). Secondary has 3 turns of no. 26 enameled wire on an Amidon FT37-61 ferrite core.
U1 — RCA IC. Bend pins to fit 8-pin dual-in-line IC socket.
U2, U3 — Motorola IC.
U4 — Three-terminal 8-V regulator IC.
Y1, Y2 — Surplus crystal in HC-6/U holder or International Crystal Co. type 433115. Specify exact frequency when ordering crystals. International Crystal Manufacturing Co., 10 North Lee, Oklahoma City, OK 73102.

mounting holes in the VFO area as a guide. Be sure the front of the box is parallel to the edge of the circuit board. Tack solder the compartment to the board, check the alignment and then flow solder along the seam between the compartment and the circuit board. Make a similar shield, 1/4-inch high, and attach it to the bottom side of the board, opposite the top partition. Finish the shielding by making a U-shaped metal cover for the compartment. The shielding will keep the VFO energy from straying into circuits where it doesn't belong.

Polystyrene capacitors are recommended for use in the VFO tank circuit. After the receiver has been assembled and tested, secure these capacitors to the circuit board with a small drop of hobby cement. This will prevent frequency shifts caused by capacitor movement. Be sure to use small-diameter coaxial cable, such as RG-174/U, when wiring S1 to the receiver board, antenna jack and converter (when it is added).

The receiver shown in the photographs is housed in a metal cabinet measuring approximately 3-1/2 × 8 × 6 inches. This is larger than necessary for the receiver, but the extra space can be used for mounting the vhf converter and other accessories. The circuit board is fastened to the cabinet bottom by using 1/2-inch spacers. If you don't have suitable spacers available, 3/4-inch long screws and nuts can be used to hold the board at the proper height. To prevent the board from flexing (causing backlash) when C5 is rotated, you should use six mounting screws. Four are located at the board corners and one is placed at the center of the front and rear edges of the board.

Alignment and Operation

Before you begin aligning the receiver, check the dc and rf voltages shown in Fig. 1. This will give you a good indication as to whether or not all stages are functioning correctly. The audio stage can be checked by applying a sidetone signal to J5. Sidetone volume should not be affected by the AF GAIN control, but you should be able to use the SIDETONE LEVEL control to set the sidetone volume at a comfortable level.

The first step in aligning the receiver is to adjust the VFO tuning range. This is most easily done with a frequency counter or general-coverage receiver. The frequency counter is connected to pin 2 of U1. If you use a general-coverage receiver, a short wire connected to the antenna terminal and placed near the VFO should produce a strong signal when the receiver and VFO are tuned to the same frequency. With C5 set for maximum capacitance, adjust L2 for a VFO frequency of 6.699 MHz. Tuning C5 to minimum capacitance should produce a frequency of approximately 6.949 MHz. The exact tuning range will depend on the actual values of the tank circuit components. You can change the VFO tuning range by using a different value of fixed capacitor in series with C5. A larger value will produce a wider tuning range.

To adjust the mixer and i-f stages, connect an antenna and tune the receiver to a weak signal near the center of the tuning range. Adjust C1, C2 and C4 for maximum response. C3 is adjusted for minimum response on the unwanted side of zero beat. To make this adjustment, tune in a fairly strong signal. You should be able to hear the signal on both sides of zero beat. Zero beat is the point at which the tone of the received signal becomes very low. On one side, the signal should be weaker. This is the unwanted response. Adjust C3 for minimum signal at this point. Because the selectivity is affected by the setting of both C2 and C3, you will have to experiment with these adjustments to obtain optimum performance. Always adjust C3 for minimum unwanted response.

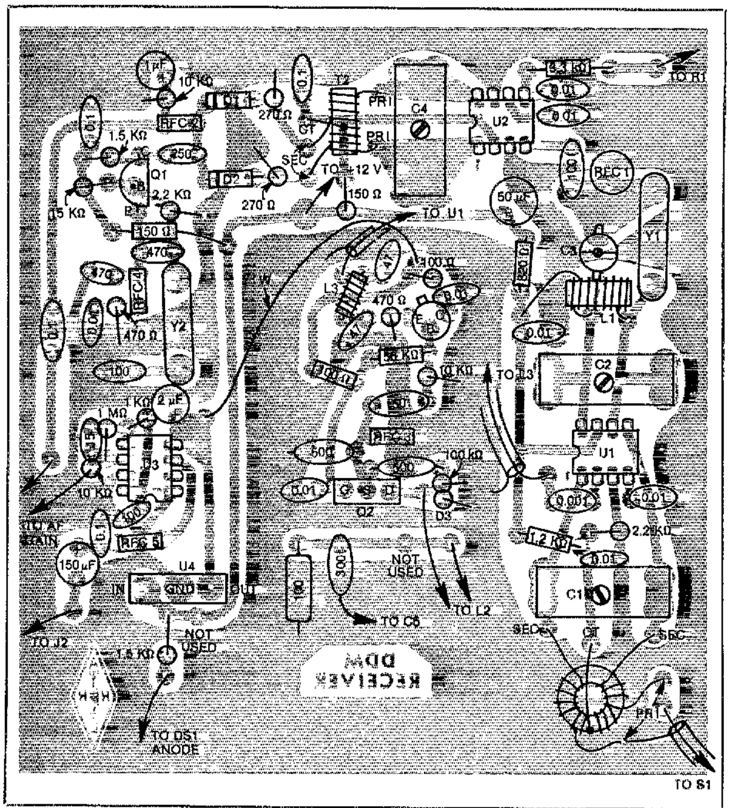
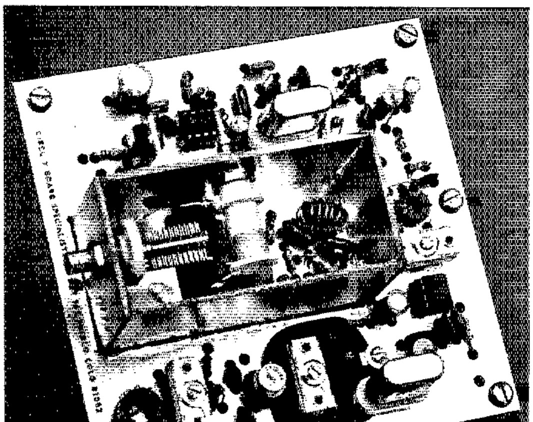


Fig. 2 — Parts-placement diagram for the 10-MHz receiver. The circuit board is shown from the component side with gray areas representing unetched copper. The etching pattern appears in Hints and Kinks, page 37.

During operation, the MUTE jack (J4) must be shorted to ground while you are receiving; it must be open during transmit. The optimum setting of the i-f gain control will depend on the strength of the signal you are listening to; the stronger the signal, the less i-f gain required. If you find that you have the audio gain set near maximum, you very likely have the i-f gain set too low.

With the alignment and testing complete, you are ready to put your receiver "in service." One of the first signals you are likely to hear is WWV transmitting at 10 MHz. This standard-frequency station, operated by the National Bureau of Standards, provides a handy reference point for checking your dial calibration (the adjustment of L2). WWV also transmits time and propagation information useful to amateurs. While the newly allocated 10.1- to 10.15-MHz band is not available for use by U.S. amateurs, several other countries have begun 30-meter amateur operation. The coming months should provide increased amateur activity for you to listen in on while you are finishing up your 6-meter station.



The modified Mini-Miser's Dream before installation in the cabinet. The top-side ground foil has been removed from the VFO and crystal filter areas to reduce stray capacitance.

Notes

[1]D. DeMaw, "The Mini-Miser's Dream Receiver," *QST*, Sept. 1976, pp. 20-23.

[2]G. Collins, "Getting Started on VHF: A 6-Meter Transmitter You Can Build," *QST*, April 1982, pp. 37-42.

[3]Circuit Boards, negatives and parts kits for this project are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002.

[4]mm = in. × 25.4.

Hints and Kinks

Conducted By Larry D. Wolfgang,* WA3VIL

PORTABLE OR MOBILE REMOTE MICROPHONE

☐ Soon after I acquired an IC-2AT 2-meter, hand-held transceiver, I was in the market for a remote microphone for mobile use. ICOM offers a remote speaker/microphone combination, but this did not suit my particular need — occasionally operating mobile from a motorcycle, where I desired to listen through a small earphone worn inside the helmet. This would not be possible with the speaker/mike combination.

I happened to have a "retired" dynamic microphone, complete with a dpdt push-to-talk switch. The microphone output was of high impedance, and the level was relatively low — not compatible with the low-impedance input of the hand-held.

A friend suggested I look into the electret microphone elements that are available at Radio Shack stores — a very good suggestion, since the IC-2 has a built-in electret condenser microphone. Radio Shack presently offers two different electret elements, one with omnidirectional and the other with unidirectional characteristics. I purchased the unidirectional element, to obtain better rejection of wind and motor noise while biking. This element requires a supply potential of from 2 to 10 volts at approximately 0.5 mA, and has a 600-Ω output impedance. At home, with some temporary connections, I determined that the output level and the impedance were indeed quite compatible with the IC-2. I'm sure that ideas from my microphone conversion can also be applied to rigs other than the IC-2.

The microphone originally used three conductors in a heavy coil cord: the PTT line, audio line and common. The IC-2, and perhaps other hand-held rigs, require only a two-wire connection: audio and common. A dc closure on the audio line (20 kΩ to 30 kΩ) keys the transmitter. I replaced the original coil cord with another of about half its diameter, taken from a surplus telephone. After affixing the subminiature plug at the end, I reinforced the mechanical connection with a 1-1/2 inch length of heat-shrink tubing over the plug and cable (mm = inches × 25.4). This can be seen in Fig. 1. The shrink tubing is somewhat flexible, and is by far the best approach I've found to providing a maintenance-free connection for these tiny plugs.

*Assistant Technical Editor

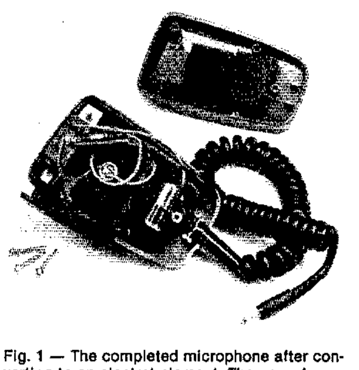


Fig. 1 — The completed microphone after converting to an electret element. The new element is the small, circular object in the approximate center of the case. R1 is enclosed in spaghetti tubing and runs parallel to C1 from the switch lug. Foam insulating material holds everything in place when the case is assembled.

The original dynamic element was large, approximately 1-3/4 inches in diameter. In addition, the microphone case contained a small impedance transformer. With these removed, there was far more room than required to house the electret element (approximately 3/8-inch diameter by 1/2-inch long) and a small 6-V battery. The electret element was taped in place, and the extra space was taken up with several pieces of adhesive-backed foam. These pieces were cut to fit from a strip, sold in hardware and department stores as insulating material. This may also be seen in Fig. 1.

The diagram I used in wiring the electret element is shown in Fig. 2. I retained the original PTT switch, S1. All other parts shown in the diagram were added. R1 provides the dc closure for keying the rig. Instructions with the electret element call for 10 μF at C1, but I found such a large value to be unsatisfactory. If left connected in series with P1, i.e., unswitched, its leakage current was sufficient to key the transmitter continuously. If wired as shown and switched, it introduced audio distortion for several seconds after I keyed the mike, while charging to the 5-V potential present on the audio line. I determined experimentally that 2.2 μF was about the optimum value for avoiding these problems without noticeable loss of audio quality or level. I elected to include the battery in the microphone case, rather than to attempt to draw from the voltage present on the audio line. Prolonged battery life for the hand-held and higher audio output from the remote mike were my considerations.

I've been using the converted microphone for several months now, and am well pleased with its operation. The audio level is not quite that of the built-in microphone, but is quite satisfactory. The battery and mike element cost approximately $7, and I had all other parts on hand. I consider it money well spent. — *Jerry Hall, K1TD, ARRL Hq.*

EXTERNAL MICROPHONE FOR A HAND-HELD TRANSCEIVER

☐ I wanted to use an external microphone with my ICOM IC-2AT, but did not want to buy the speaker microphone for the radio. Two important reasons are that the electret microphone has a very high frequency response and a high sensitivity. These characteristics are poor for mobile use because of the high ambient noise level in the car.

My decision was to use a dynamic microphone with high impedance (50 kΩ) and a frequency response in the normal "communications" range. The next problem was to interface the mike with the IC-2AT.

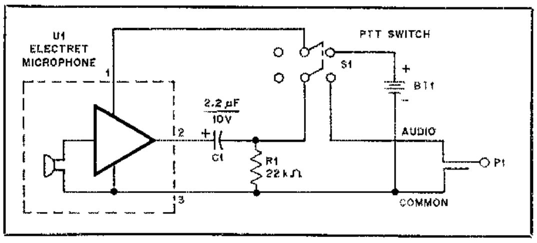


Fig. 2 — Diagram for wiring the electret element. Components not listed below are identified for text reference.

BT1 — 6-V photo battery, A544 or similar.
C1 — 2.2-μF, 10-V electrolytic.
P1 — Subminiature phone plug.
U1 — Unidirectional electret microphone element, Archer 270-091.

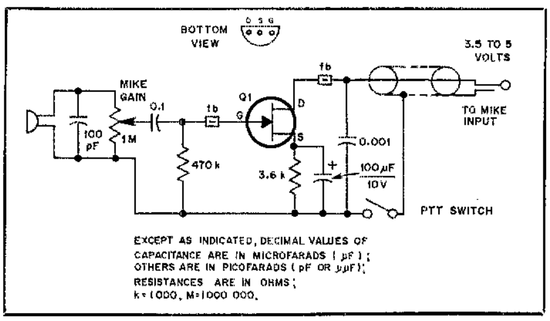


Fig. 3 — Schematic diagram of an external-microphone circuit that allows the use of a high-impedance microphone with an IC-2AT. Q1 is an MPF102 transistor.

Measurements indicated a voltage of 4.97 V at the mike jack in the receive mode and 2.78 V during transmit. This voltage is used to provide power to the circuit shown in Fig. 3. The dynamic microphone and preamplifier provide a flat audio response and 17 dB of gain. This arrangement simulates the load conditions of the internal electret microphone.

Required parts can be built into the case of a hand-held microphone. The PTT switch is used to key the transmitter by completing the ground side of the external audio circuit.

A 33-kΩ resistor is wired in parallel with the internal mike element. The purpose of this resistor is to ensure that the transmitter remains keyed during peak audio swings. I did not have this problem with the external mike, but if you do, a 33-kΩ resistor can be added in parallel with the 0.001-μF capacitor. This would also require changing the source resistor on Q1 to 5.6 kΩ to maintain the 2.78 V on the Q1 drain. — *Thomas Nolan, KO2G, Wrightstown, New Jersey*

EASY CURE FOR FREQUENCY DRIFT

☐ My Drake TR-7 drifted as much as 1.8 kHz over an operating period of several hours. It drifted at least 1 kHz during the first hour from a cold start. While this is within factory specifications, I found it to be quite annoying. A Drake representative blamed the problem on humidity, but had no specific suggestions for a remedy.

A check with my dealer and other TR-7 users indicated the problem was widespread. Some were placing a small dial lamp or a resistor inside the cabinet near the VFO enclosure. This would raise the temperature and lower the humidity. I tried this solution and found that it did decrease the drift by about half, still not satisfactory to me.

I placed four heat strips on the outside bottom of the cabinet. I purchased these strips from Herbach & Rademan[1] at a cost of four for $10. These are very thin strips with a self-adhesive backing and are rated at 12 watts, 117 V ac. I wired the four in series/parallel, so the total draw is 12 W. Electrofilm, Inc.[2] also has a catalog with many kinds of heat strips.

Maximum frequency drift from a cold start is now 200 Hz, which makes operating during the first hour a pleasure. Electric power is applied to the strips continuously. The lower humidity in the cabinet may also have a beneficial effect in preventing component corrosion. I estimate the cost to be about 50 cents per month at my power rates. — *Hal Price, KR4R, Satellite Beach, Florida*

KEYBOARD-KEYER VARIABLE-CHARACTER SPACING

☐ I built the Al Helfrick, K2BLA, unbuffered keyboard.[3] It has served well both on the air and in the classroom. For classroom use, I wanted to be able to vary the time between characters independent of keyer speed. This will allow a slow overall word speed, while the character speed is maintained at about 15 wpm (Farnsworth method). A gated oscillator and flip-flop (Fig. 4) perform this function.

The heart of this keyer is the counter, U8, which is clocked by the oscillator U3A/B. When a character and the space following is completed, the line from U5 pin 3 to U3 pin 6 goes high. This enables the oscillator and starts the counter for the next character. The circuit of Fig. 4, inserted in this line, controls the rise of U3 pin 6 by using the rising edge of U5 pin 3 as a trigger.

When pin 3 of U5 goes low at the start of a character, the character-space oscillator, U15A/B, is stopped. Flip-flop U16 is reset, driving and holding U3 pin 6 low to stop the counter oscillator. When U5 pin 3 rises at the end of a character, U15A/B is started with a low output condition. The rising edge of the first timed pulse clocks the flip-flop, driving and holding U3 pin 6 high to start the counter oscillator. Fig. 5 shows a logic timing diagram.

The values shown for R1 and C1 give a slow speed of about 2.5 wpm and a fast speed sufficient that the U3C/D oscillator assumes control of both character and word speed again.

I added an LED to U3 pin 6 to indicate a "keyboard ready" condition. It pulses momentarily during normal word transmission and stays on if the operator pauses.

I also connected the space bar between pins A7 and B6. This gives about a two-character space between words, which I judged to be about right for a standard word space. — *David McClune, WB0ZID, Boulder, Colorado*

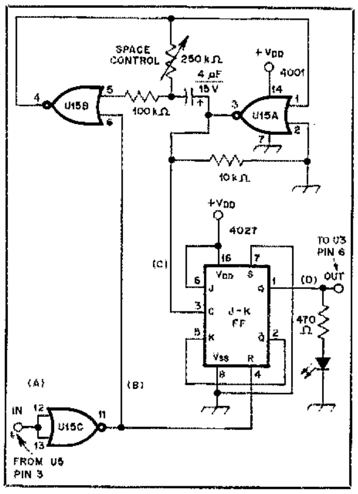


Fig. 4 — Schematic diagram of a circuit to add variable character spacing to the K2BLA keyboard. The letters A, B, C and D refer to the timing diagram traces of Fig. 5.

ADDING MEMORY TO THE K2BLA BUFFERED KEYBOARD

☐ The buffered Morse keyboard that appears in the 1981 and 1982 editions of *The Radio Amateur's Handbook* has no provision for a storage memory. A *QST* article[4] describes an add-on memory for the unbuffered keyboard.[5] It turns out that no circuit changes are required to adapt this modification for use with the buffered keyboard design.

Only two connections are required to interface the units. Pin 12 of U2D on the memory board connects to pin 6 of U15 on the keyboard, and pin 1 of U3A on the memory board connects to pin 4 of U18 on the keyboard. Remember that the 2102 memory chips require a 5-V supply. — *Gerry Hull, AK4L, ARRL Hq.*

LOW-COST ACTIVE AUDIO FILTER

☐ This active audio filter can be built in a few hours, and parts should be available at the local Radio Shack store. The filter is unique in that the center frequency may be varied approximately 10% by adjusting R2 (Fig. 6). Changing R1 will not disturb any of the other filter parameters. With R2 at mid resistance,

[4]A. Helfrick, K2BLA, "A Memory for the K2BLA CMOS Keyboard," *QST*, Dec. 1980, p. 33.
[5]See note 3.

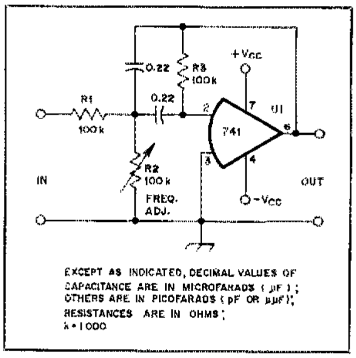


Fig. 6 — Circuit diagram of the active audio filter. R1 and R3 are 5%, 1/4-watt types. U1 is a 741 op amp.

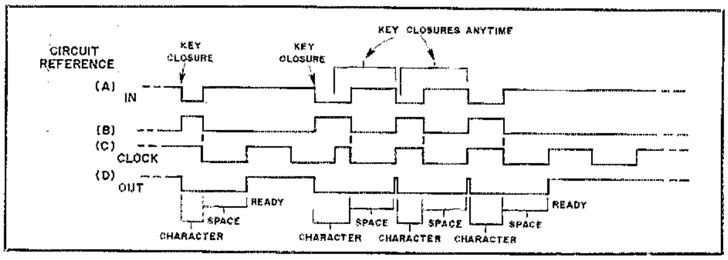


Fig. 5 — Logic timing diagram for the variable character-space circuit.

[1]Herbach & Rademan, 401 E. Erie Ave., Philadelphia, PA 19134, part no. TM21K837.
[2]Electrofilm, Inc., 7116 Laurel Canyon Blvd., North Hollywood, CA 91605.
[3]A. Helfrick, K2BLA, "An Inexpensive Morse Keyboard," *QST*, Jan. 1978, p. 24.

the center frequency was found to be approximately 400 Hz.

This filter will provide a worthwhile improvement in cw selectivity. For better performance, two filters can be cascaded.

With the indicated values, the voltage gain is 1, the Q is 20 and the passband center frequency is 400 Hz. Power for the unit is provided by two 9-V transistor-radio batteries. — *Howard Weinberg, WA6JCH, Montebello, California*

QSK WITH VOX CIRCUITS

□ For several years I had operated a cw station with full break-in capabilities. When I moved up to a "state-of-the-art" transceiver I never felt comfortable using the VOX circuit for cw. The VOX delay had to be set long enough to keep the transmitter from dropping out between words, but this caused me to miss the beginning of the next transmission.

I decided to short the R-C network capacitor in the VOX circuit at the end of my transmission. This capacitor can be found by tracing the wiring from the VOX delay control. The control is wired across the R-C capacitor. I used a "spare" jack on the rear panel of my transceiver, connecting the R-C capacitor across the jack. I connected 0.01-μF disc capacitors across the lines to bypass stray rf to ground. Then I cemented a Micro Switch to my keyer paddle, connecting it to the jack with a piece of RG-58/U coaxial cable.

When I become impatient with the VOX delay, I simply depress the Micro Switch, putting my transceiver into the receive mode immediately. — *John Werner III, WB8IPG, Warren, Michigan*

TRANSMITTER-KEYING INTERFACE

□ Radio amateurs have an interesting and enjoyable variety of ways to generate Morse code. Keyboards and computers share air time with straight keys and bugs. But interfacing the newest equipment with a transmitter may not be an easy task. Many of these new code generators are not specifically designed for transmitter keying.

The circuit shown in Fig. 7 can be used between any code generator that produces an audio signal and virtually all transmitters. New parts will cost about $10. This unit was originally built for the N4DR 10-MHz beacon, and it interfaces a tape-recorded cw message with the beacon transmitter.

U1A is a conditioning amplifier, which sets the level of the incoming signal. C1, C2, R4 and R5 allow the interface to operate from a single-polarity power supply. D1, D2, C3 and R6 form a rectifier circuit that changes the ac voltage into a dc voltage that varies with the envelope of the incoming ac voltage. U1B is wired as a Schmitt trigger. Voltage from the rectifier will cause the trigger output to go from low to high, lighting the LED and closing the reed relay.

Construction is straightforward. Use the maximum level setting that will allow the LED to flicker with the cw signal. It should be decreased only if the background noise level falsely triggers the interface.

An additional use of the interface is to key a transmitter that does not have a sidetone. Simply use a code-practice oscillator to drive the interface circuit. — *Tom Cook, N3AXN, Pittsburgh, Pennsylvania*

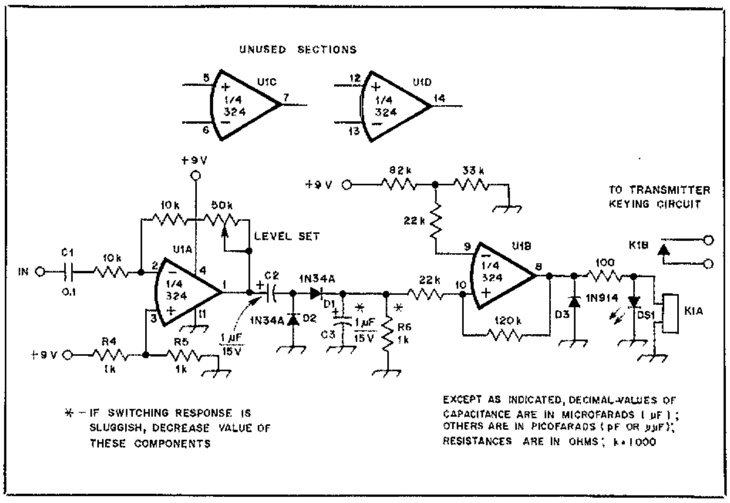
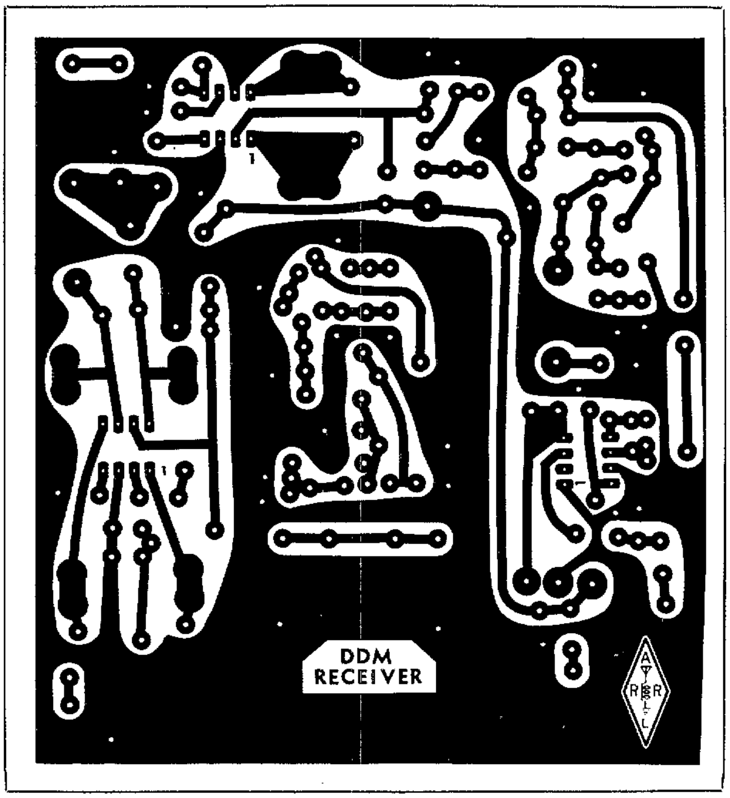


Fig. 7 — The schematic diagram of a simple transmitter-keying interface.
K1 — Reed relay (RS 275-229). **U1 — 324 quad op-amp.**



Etching pattern for the 10-MHz Mini-Miser's Dream. The black areas represent unetched copper viewed from the foil side of the board. Parts-placement guide appears on page 34.

Product Review

Conducted By Paul K. Pagel,* N1FB

Kenwood TR-7730 2-Meter FM Transceiver

☐ I don't "do" fm these days, having sworn off during the era of political mayhem and repeater wars some years ago. But when N1FB said he needed a reviewer for the TR-7730, I volunteered. It seemed worthwhile to acquaint myself with the features of modern fm equipment: The earlier experience was with surplus land-mobile gear and new-to-the-market American 2-meter fm equipment. The TR-7730 offers features and performance that were only dreamed of a few years ago. Furthermore, it is compact and delivers 25 watts of power output. The countless features available in the transceiver should answer the needs of most 2-meter fm operators.

Some Features

The unit contains 15 ICs, 46 transistors, 7 FETs and 91 diodes. It has a frequency synthesizer, a five-channel memory, scanning circuit and digital readout for frequency. The size? Well, the entire works are contained in a 5-3/4 × 2 × 7-3/4 inch (WHD) cabinet. Synthesizer resolution is selectable at 5 or 10 kHz from the front panel. A high-low power switch permits the operator to use 5 or 25 watts of rf output.

The memory (for frequency-pair storage) will retain the data programmed into it as long as the transceiver remains connected to a +13.8-V power source. The operator can add the optional TK-1 battery back-up unit externally (rear-panel connector) if he or she does not want the memories to be erased when the transceiver is disconnected from the primary power source (such as when taking the rig out of the car).

Front-Panel Controls

A memory-selector switch (M. CH) provides for selection of five stored channels. Position 5 allows the storage of odd frequencies (splits), whereas channels 1 through 4 can be used only for standard repeater pairings (600 kHz).

Push-button switch M is used to program the memories in accordance with the frequency displayed on the digital readout. The MR switch is depressed when the operator wishes to recall the frequencies stored in the memories. When MR is not depressed, the transceiver operates on the frequency indicated on the digital display, which is chosen by means of the main tuning knob.

A BUSY indicator lamp will light when the receiver squelch is open, thereby indicating that a channel is in use. This feature is useful when the scan circuit is actuated, and when the receiver audio is turned off. There is also an on-the-air light, as well as lamps that indicate the transmitter-offset state (plus or minus the receive frequency).

The transmitter offset switch (– S +) places the transmit frequency 600 kHz below the receive frequency when set in the minus (–) position. In the plus (+) position the offset is 600 kHz above the receive frequency. Simplex operation can be carried out when the switch is set on S.

Memory scan is initiated when the M.S. switch is depressed. Scanning of the entire range from 144.0 to 148.0 MHz takes place when the SCAN button is pushed in. Adjacent to this button is the HOLD button, which when pressed, stops the scanning action. The microphone push-to-talk (PTT) switch can be depressed to stop scanning action, also. I found the scanning from 144 to 145 MHz an annoyance, since there is no repeater activity in that part of the band for this area. It lengthens the total scan time by an appreciable amount, which is not desirable. The HI-LOW power switch and 5-kHz/10-kHz resolution button are also on the front panel for easy access. Two other controls are on the front panel of the unit. They are the on-off/volume (POWER/VOL) and SQUELCH controls.

A sequential LED bar indicator is used to monitor relative power output and received signal strength. It is located to the right of the digital-display block.

Main tuning is accomplished by means of a rotary click-type control. Frequency coverage in 5- or 10-kHz increments is continuous from 144.0 to 148.0 MHz. A TONE switch is included for those who wish to add the Kenwood tone generator for use with repeaters that require tone access.

Other Comments

The instruction book appears to be complete, and I found it easy to comprehend when learning how to operate the transceiver. Complete instructions for mobile and fixed-station installation are given in pictorial form. An adjustable mobile-mounting bracket is supplied with the TR-7730, as is the standard push-to-talk mike. Those wishing to use the rig with autopatch facilities can obtain the MC-46 accessory mike, which has a TT pad built into it.

*Assistant Technical Editor

Kenwood TR-7730 2-Meter FM Transceiver, Serial No. 2011236

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: 144.0 to 147.995 MHz.	143.900 to 148.990 MHz.
Readout: Digital	As specified; four 1/2-inch LED blocks.
S-meter sensitivity: Not specified	LED sequential bar type. S1 = 0.9 µV; S5 = 2.1 µV; S9 = 4.5 µV.
Receiver sensitivity: Better than 0.5 µV for 30 dB S/N.	For 20-dB quieting, 0.38 µV.
Squelch threshold: 0.16 µV	0.8 µV
Spurious response: Better than −60 dB from peak power output.	See Fig. 1
Receiver spurious (birdies): Not specified.	None observed.
Receiver audio output: More than 2 W at 10% distortion (8 ohms).	1.2 W maximum (8 ohms).
Transmitter output power: 5 W (adjustable) and 25 W (minimum).	5 W and 30 W.
Current drain: Receive, 0.4 A; transmit (low), 3 A; transmit (HI) 5.5 A.	Approx. as specified.
Operating voltage: + 13.8 V dc.	As specified.
kHz per turn of main tuning knob: Not specified.	50 or 25 kHz, at 5-kHz and 10-kHz resolution, respectively.
Size (HWD): 2 × 5-3/4 × 7-3/4 inches.†	
Weight: 3.3 pounds.	
Color: Black.	

†mm = inches × 25.4; kg = pounds × 0.454

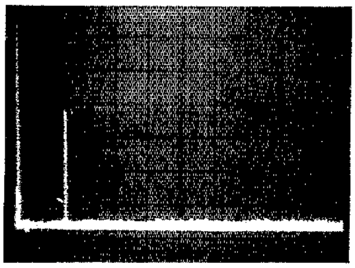


Fig. 1 — Spectral display of the Kenwood TR-7730. Vertical divisions are each 10 dB; horizontal divisions are each 100 MHz. Output power is approximately 30 watts at a frequency of 146.52 MHz. The fundamental has been reduced in amplitude approximately 33 dB by means of notch cavities; this prevents analyzer overload. The TR-7730 complies with current FCC specifications for spectral purity.

The mike also has up-down switching for changing the transceiver frequency — a definite advantage while driving the automobile.

Performance in my car over a two-month period (hot and cold weather conditions) was without mishap. If I were to criticize the transceiver, I would mention that the frequency display is useless in bright daylight. How nice it would be if one could read the digital displays of mobile equipment in bright-day periods! Most rigs fail in this regard.

Another problem I encountered was inadequate undistorted receiver audio level when the ambient noise in the car was high. This is a common malady with many mobile transceivers, owing to the speaker pointing toward the floor instead of outward toward the operator. A quick and satisfactory fix resulted when I added the Kenwood SP-40 external speaker. I attached it to the ash tray in the center of the dashboard (mag-mount), pointed it toward my face, and eliminated the poor audio quantity and quality I first experienced. I highly recommend this speaker to anyone who operates mobile. It is small, but it has a big voice! Distributed in the USA by Trio-Kenwood Communications, 1111 West Walnut St., Compton, CA 90220. Price class: TR-7730 and MC-46 Touch-Tone microphone, $349; SP-40 speaker, $25.95. — *Doug DeMaw, W1FB*

HEATH VL-1180 2-METER AMPLIFIER

☐ If you're looking to put a little more "punch" into your mobile 2-meter signal, this little box of watts may be the answer. Of course it isn't limited to mobile-only use; it's at home at the base station, too. The VL-1180 and VL-2280 are basically similar, but the VL-2280 has been designed specifically for base station use and has a built-in power supply and metering circuit.

The '1180 is an "all-mode" (fm, cw or ssb) amplifier designed for use with any transmitter or transceiver capable of providing 1 to 10 watts of driving power. With about 10 watts of drive, the power output of the '1180 is rated at a nominal 75 watts.

Automatic T-R switching is accomplished by a built-in relay and rf sensing circuit. The drop-out delay is selected by means of a jumper wire on the circuit board. When the jumper is grounded, the amplifier relay will remain energized for approximately one second. This prevents relay chatter when ssb VOX operation is being used.

Construction and Circuit Description

It took me almost seven hours to construct the '1180. No problems were encountered during assembly. There are two circuit boards in the amplifier: an antenna transfer circuit board and the amplifier circuit board. The antenna-transfer board contains the T-R relay switching components and a low-pass output filter. A Darlington amplifier transistor is used to operate the dpdt relay when the amplifier is in use. When the amplifier is switched off, the relay is prevented from being energized, and the exciter rf energy is fed through the normally-closed relay contacts and the low-pass filter to the antenna.

The amplifier board uses strip-line construction, but also employs four air-wound inductors, three of which are adjusted during tune-up. Assembly of the board requires the insertion of 47 rivets to ensure proper bonding between the ground foils on opposite sides of the board. The amplifier transistor and biasing diode are thermally bonded to the heat sink through holes in the board. This arrangement provides bias voltage tracking, ensuring linear operation at all operating temperatures.

Heath supplies small-diameter Teflon coaxial cable for making the required internal connections and for use as a 1/4-wave transmission-line section. The latter acts as a

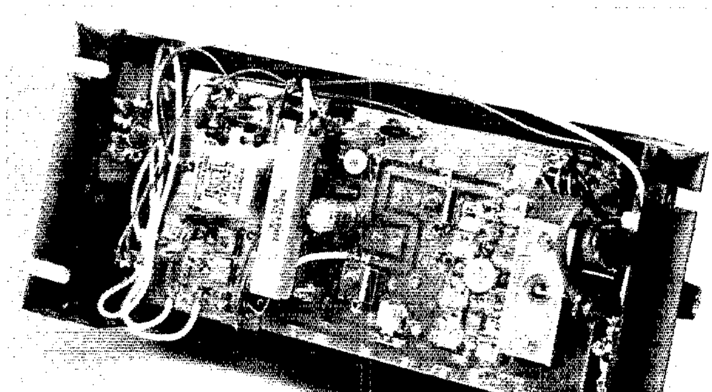


Fig. 2 — An inside view of the VL-1180. The bias diode is immediately to the right of the output transistor, supported by the metal bracket.

Heath VL-1180 2-Meter Amplifier

Manufacturer's Specifications	*Measured in ARRL Lab*
Frequency range: 144 to 148 MHz.	As specified.
Power output: 75 W (nominal) at 13.6 V dc with 10 W drive.	82 W, 144 to 147 MHz; 80 W, 147 to 148 MHz.
Input VSWR: 2:1 maximum	Less than 1.2:1.
Spurious and harmonic output: −60 dB or better.	−64 dB (see Fig. 3).
Third-order distortion: −30 dB referenced to cw power.	Limited by test equipment capability.
Size: 2-3/4 × 4-3/4 × 10-3/4 in. (HWD).†	
Weight: 3-1/4 lb.	

†mm = inches × 25.4; kg = lb × 0.454

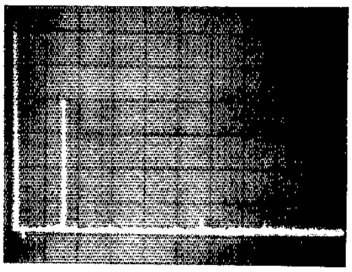


Fig. 3 — Spectral display of the Heath VL-1180. Vertical divisions are each 10 dB; horizontal divisions are each 100 MHz. Output power is approximately 82 watts at a frequency of 146 MHz. The fourth harmonic is just visible at approximately 64 dB below peak fundamental output. The fundamental has been reduced in amplitude approximately 30 dB by means of notch cavities; this prevents analyzer overload. The VL-1180 complies with current FCC specifications for spectral purity.

half-wave stub at the second harmonic of the desired output frequency, thereby providing harmonic energy attenuation. With the lead lengths involved, the Teflon properties of the cable are welcome. If a standard type of cable were used, you'd probably wind up with a melted dielectric and/or shorted cables. Caution should be observed when cutting the transmission-line trap to ensure the proper length is maintained. Otherwise, a deterioration of the second-harmonic suppression will occur.

Good quality components are used throughout. The power-amplifier transistor is an MRF247 — a rugged device. If you can remember what a tube is (those things that look like bottles that glow), you'll marvel at that little piece of silicon being able to generate over 75 watts of *output* power at 2 meters! You'll find no VSWR protection circuit in the amplifier; the MRF247 doesn't need it. It is rated to withstand an SWR of 30:1 at full power input at all phase angles! That should make it just about "klutz proof."

Tune-Up

Initial tune-up and testing can be accomplished in a matter of minutes. Although a voltmeter can be used as an output indicator during the tune-up procedure, to be sure a minimum SWR exists between the exciter and the amplifier, a wattmeter or VSWR indicator should be employed. A dummy load capable of dissipating the amplifier power output and an exciter capable of providing 1 to 10 watts of output power are also needed.

For me, all went well until the power output was measured. Lo, only 72 watts. Because the power output level was below that specified by Heath, the factory was contacted and the problem explained. Another MRF247 was shipped, installed (that took a bit of doing!), and when the output power was measured again, the wattmeter showed 82 watts being delivered from 144 to 147 MHz and 80 watts at 148 MHz, well above that specified by Heath.

Spectral purity and third-order IMD tests were run in the ARRL lab. Because of the limits imposed by the test equipment used, the third-order IMD figures specified by Heath could not verified.

Summary

During construction of the antenna-transfer circuit board, you are asked to decide whether or not ssb operation is intended. If so, the jumper wire mentioned previously is connected to the ground foil. This adds a capacitor to the relay driver circuit, which then acts to delay T-R relay drop out during ssb VOX operation. It would be a simple matter to mount an spst switch on one amplifier end panel to allow external switching of the jumper. This would eliminate having to make an internal change should you wish to use the amplifier for all-mode operation.

If you have a base station power supply capable of supplying 13.6-V dc at 12A, you can turn the VL-1180 all-mode amplifier into an all-purpose amplifier as well. This little black box of watts may be just what you need to make your presence known on the 2-meter band. For further information, contact Heath Company, Benton Harbor, MI 49022. Price class: $138. — *Paul K. Pagel, N1FB*

THE HY-GAIN V-2 2-METER ANTENNA

☐ It is possible to improve the old tried and true 2-meter vertical, you ask? You bet it is, and Hy-Gain has done just that! The model V-2 antenna solves a problem not considered until recently — that of radiation-pattern distortion.

Back in the "good ol' days" we simply put up a 1/4 λ or collinear vertical for 2-meter fm work and accepted the performance. Just how could you improve the omnidirectional vertical, anyway? Eliminate the pattern skewing, for one! Fact is, the typical 2-meter vertical suffers from a less than ideal radiation pattern. If the coaxial feed line and supporting mast are not properly isolated from the antenna, interaction results. This may cause a number of problems, including unwanted lobes of high-angle radiation, along with a horizontally polarized component. Keep in mind that for the majority of 2-meter fm and repeater work the ideal antenna would provide only vertically polarized radiation, and aim it entirely at the horizon. After all, the horizon is where distant repeaters and mobile stations are lurking, not up in space somewhere!

The Hy-Gain V-2 is an omnidirectional collinear antenna consisting of two 5/8-λ vertical sections in phase, as can be seen in Fig. 4. It utilizes two sets of 1/4-λ radials to decouple the lower 5/8-λ radiating section from the mast and feed line. According to the manufacturer, the resulting isolation allows the V-2 to provide a clean radiation pattern, and concentrate the power along the horizon where it is needed most.

Construction

The V-2 comes supplied as an easy-to-assemble kit. All components are precut, drilled and made of the highest quality materials. The aluminum used is of the 6063-T832 variety, and all hardware is rust-proof, plated steel. A screwdriver, adjustable wrench and pliers are the only tools necessary for construction, which took approximately one hour. The instructions supplied are complete and easy to understand. A chart is provided so that the antenna length may be adjusted to the desired frequency. An interesting feature is the feed arrangement, where the coaxial cable is positioned *inside* the bottom

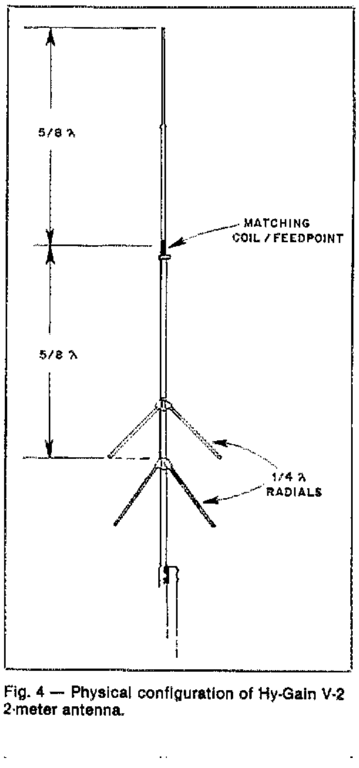


Fig. 4 — Physical configuration of Hy-Gain V-2 2-meter antenna.

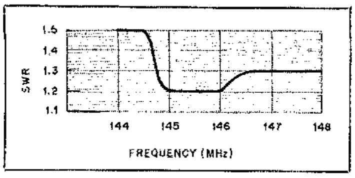


Fig. 5 — SWR curve for Hy-Gain V-2 antenna. Resonance was adjusted to 146 MHz.

half of the antenna to mate with a centrally located, 200-watt matching coil. The feed system places the entire antenna at dc ground, providing a degree of lightning protection. This arrangement also provides excellent weatherproofing for the coaxial connectors and feed point. Total antenna height is 122 inches,[3] and wind loading is a mere 0.67 square feet.

Performance

Although the V-2 may be fine-tuned for any frequency between 138 MHz and 174 MHz, I learned quickly that the exact choice of frequency is not critical. The manufacturer specifies a 2:1 VSWR bandwidth of at least 7 MHz! Our antenna was set for 146 MHz, and checked for SWR. The results can be seen in Fig. 5. As specified, the V-2 was found to provide an extremely broadband match. It was time to try out the antenna.

Perched 50 feet high on top of the Hq. building, the V-2 has provided very good performance. Using only 10 watts output at W1INF, the Hq. Operator's Club station, literally dozens of repeaters in southern New England and New York state were accessed within an hour. Signal reports were always good — including full quieting through the Mount Greylock, Massachusetts, repeater — located a mere 85 miles to the north! Need more be said?

The Hy-Gain V-2 is an excellent choice for the operator who wishes to catch those distant repeaters and still retain omnidirectional coverage. Price class — $39.95. For more information contact the Hy-Gain division of Telex Communications, Inc., 9600 Aldrich Ave. So., Minneapolis, MN 55420 — *Dennis J. Lusis, W1LJ*

HEATHKIT μMATIC MEMORY KEYER, MODEL SA-5010

☐ Microprocessors are "taking over the world." It seems that almost every major piece of electronic equipment being introduced these days has a microprocessor in it. Sometimes the design is defective or the internal programming is inadequate, resulting in a piece of equipment that just doesn't meet the potential. I am happy to report that such is not the case for the Heathkit μMatic Memory Keyer.

One of my co-workers points out that the Heath designer was smart enough to use "big computer" techniques on a "little computer." What does that mean? Let's take a look at the features of the SA-5010.

Characteristics

The SA-5010 uses a custom 3870 microprocessor IC to perform all the main functions of the keyer. Such an approach should provide the user with tremendous flexibility — and it does! Most of the operating parameters are set with the 20-key pad located on the top of μMatic. The user can choose any speed between 1 and 99 wpm. If the operator desires, the spacing between characters may be increased to provide a "fast code" effect, which can be useful when building code speed. Weighting is also variable (five light, five heavy settings and normal, i.e., a dash is three times as long as a dot).

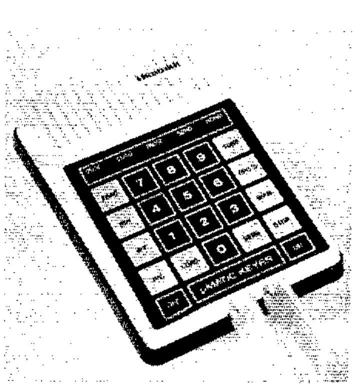
Heath has provided 10 memory buffers in the SA-5010. A total of 240 character spaces are available for the memory. The user can load as many or as few characters into any memory (soft partitioning) as desired. Command strings can also be stored in the memory buffers. When room for 20 or fewer characters remains in memory, the sidetone pitch drops noticeably as a warning. A pause may be programmed into any memory (e.g., for inserting an RST report). The memory automatically repeats up to nine times.

A left-handed user may reverse the paddles by making the appropriate entry. A battery (three "watch" cells) retains the memory when the μMatic is not connected to a power source. Each time the keyer is turned on, the microprocessor initiates a diagnostic program to ensure all is well. If the test fails, all the LEDs light and the sidetone sounds constantly. While turned off, the SA-5010 retains the last entered speed and other operating parameters.

Heath has given consideration to the operator who wants to practice copying code. The user selects alphabetic characters, alphanumeric characters, alphanumeric character and common punctuation, or alphanumeric characters and all punctuation. The keyer has over 6000 different practice sequences available. As with normal keyer operation, the user can vary the speed, spacing and weight. Also, the code practice keys the output stage.

The μMatic output is solid state. Two jacks, located on the rear panel, provide for positive (250 V at 100 mA) or negative keying (−200 V at 40 mA). The user has access to the sidetone volume and pitch controls through two holes in the case bottom.

Heath has included built-in paddles. Unlike the more common mechanical variety, these paddles operate on a proximity principle instead of a switch closure. When the user presses a finger against the metal paddle, his body capacitance is added to that of the circuit. This causes a transistor to conduct. Sensitivity controls for the paddles are located on the circuit board and are accessible through two holes in the case bottom.



I've been using mechanical paddles for years and found it difficult to adjust the paddle sensitivity to accommodate my fist. This probably would not be a problem for most operators — particularly those not already accustomed to mechanical paddles. The user can attach external mechanical paddles through a rear panel jack. If you have paddles that you are comfortable with, use them; if not, you may not need to spend $20 to $50 or more for paddles!

Using the Memories

Probably the most revolutionary concept in the SA-5010 is the ability to handle command strings. What is a command string? Suppose MEMORY 1 has "CQ" programmed in it. MEMORY 2 has "DE" and MEMORY 3 has "KB1N." MEMORY 0 can then be programmed to repeat MEMORY 1 nine times at 20 wpm with normal spacing and weight. The program continues with MEMORY 2 sent once, and concludes by sending MEMORY 3 twice at 18 wpm, heavy weighting and 15-wpm spacing. Sending MEMORY 0 causes the keyer to produce 10 CQs followed by one DE (all at 20 wpm with normal spacing and weighting) followed by three KB1Ns. However, the KB1Ns will sound different because the dots, dashes and intra-character spacing will be generated at a 15-wpm rate. Additionally, the weighting will be different. MEMORY 0 is an example (albeit, somewhat contrived) of a command string.

Creative operators could store a complete QSO (Novice style) in the memory and still have a couple of buffers and several characters left over. All they would have to do is load the other station call sign into a buffer at the beginning of the QSO and push buttons. Users can make operation as simple or as complex as they choose. That's what my co-worker meant about the designer being smart enough to use "big computer" techniques on a "little computer."

Construction

The SA-5010 is a moderately easy-to-assemble kit. Heath describes it as a two-evening kit. I clocked about six hours of actual construction time. The instructions are clear, precise and easy to follow — just what I expect from Heath! Other kit manufacturers would do well to mimic the Heath style. I found only one problem in the instruction manual. Pictorial 2-6 details the installation of a single-in-line-package socket. The builder positions the socket by locating the side with the slot and orienting to one side of the circuit board. The pictorial reminds me of optical illusion drawings that I've seen in puzzle books. I installed the socket — backwards! When I tried to plug the ribbon from the keyboard into the socket, I discovered my mistake. Because I destroyed the socket removing it from the board, I had to wait a few days for a replacement. If you are building the SA-5010 and are confused by Pictorial 2-6, flip ahead in the construction manual and assure yourself that the socket is oriented properly.

The keyer has performed flawlessly on the air while keying a TS-130S transceiver driving a kilowatt amplifier. I am delighted with it! Oh, yes, the SA-5010 even turns itself off if the operator forgets to do so!

Price class for the μMatic and matching ac power supply is $110. More information may be obtained from Heath Company, Benton Harbor, MI 49022. — *Peter O'Dell, KB1N*

[3]mm = in. × 25.4; m^2 = ft^2 × 0.0929.

Technical Correspondence

Conducted By Dennis J. Lusis,* W1LJ

The publishers of QST assume no responsibility for statements made herein by correspondents.

NOTES ON PATH-LOSS ANALYSIS

☐ Some readers of the excellent article by Brown in December *QST*[1] may have been a bit skeptical of his claims of 3000-mile DX on 50 MHz while running 100 mW to an attic-mounted dipole. However, a quick analysis of the loss in an ideal single-hop, F2-layer propagation path shows that solid contacts could be made with much less power. Now that amateurs are familiar with the idea of receiver sensitivity being expressed in terms of noise floor,[2] such an analysis should be within the capabilities of anyone who understands the concept of the decibel. Path-loss analysis is common in moonbounce and microwave[3] work, but a great deal can be learned from its application to other forms of propagation.

The unit of power measurement which is best suited to path-loss analysis is the decibel relative to 1 milliwatt, or dBm. That is, 1 mW = 0 dBm. Thus, the 50-MHz transmitter at W6HPH delivers an rf output of +20 dBm. Here's what happens to that rf as it wends its way across the continent to a receiver 4000 km away in New England:

Transmitter output	+20 dBm	(100 mW)
Feed-line loss	0 dB	(If transverter is mounted at the antenna)
Antenna gain, relative to isotropic	−5 dB	(Loss assumption based on poor performance of low dipole at low radiation angles)
Free-space loss over 4000-km path at 50 MHz	−139 dB	(Assuming perfect reflection from F2 layer)
Receiving antenna gain relative to isotropic	+12 dB	(Typical installation)
Feed-line loss	−2 dB	(Typical installation)
Signal at receiver antenna terminals	−114 dBm	

Taking ambient noise into consideration, the usable noise floor of an ssb receiver on 50 MHz during a band opening is probably on the order of −135 dBm. Thus, assuming that the propagation is via a single-hop F2 path, with no absorption and with perfect reflection, our 100-mW signal will be 21 dB above the noise at a receiver 4000 km away. In reality of course, we don't see perfect reflections from the ionosphere; the F2 layer is in a constant state of flux, which introduces fading and losses not accounted for here. However, when the maximum usable frequency is at or slightly above the operating frequency, those losses may be considerably less than 21 dB. This is shown by the fact that the experiences of W6HPH are not unique; reports can be found in the pages of *QST* of instances where even lower transmitter powers were used successfully.[4,5]

The important lesson isn't that DX can be worked with very low power; hams have been doing that for many years (with the help of good operators, and good receivers, at the other end!). The significant point is that we now have all the information we need to make our *own* path-loss measurements for virtually all propagation paths. We can measure transmitter output power and feed-line loss; we can determine with reasonable accuracy the gain of an antenna at a given radiation angle; we can express receiver sensitivity in terms of dBm. All that's lacking is the self-discipline to make ***accurate measurements and reports*** of incoming signal strengths, or to adjust transmitter output power to determine the point at which the signal disappears into the noise.[6] If we're willing to take that single extra step, we can teach ourselves a great deal about what happens to our signals once they leave the transmitting antenna. — *David Sumner, K1ZZ, ARRL Hq.*

THEORY FOR LONG-RANGE PROPAGATION

☐ I wish to present a theory for long-range radio-wave propagation that is different from all others I have seen. Conventional propagation theory states that the radio wave leaves the antenna and travels beyond the horizon to the downward curving, spherical shell of the ionospheric F layer, which is situated approximately 200 miles above the earth. The wave is then reflected back to the ground, toward the horizon, ahead of this reflection point, or area. It is then said to bounce off the earth and back up to the ionosphere, where the cycle is repeated as often as required to reach the reception point — several thousand miles away. By laying out the earth and its ionosphere on a scale drawing, it is found that to reach the other side of the earth, the energy would have to reflect off the earth's surface several times. (See Fig. 1.)

After doing some experimentation on 20-meter cw with low power (0.1-watt output), I feel that there would be too much attenuation of the rf energy during the bounces to allow the signal to be detected. Thus, I believe there is another mechanism that readily explains the long-range radio-wave propagation observed by hams for so many years. It can be described as follows.

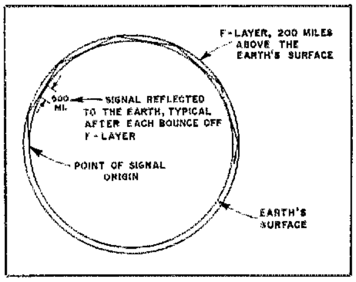


Fig. 1 — Illustration of how radio waves propagate according to conventional ionospheric theory.

RF energy is radiated from the antenna and travels to the ionospheric F layer, where it is reflected downward toward the horizon ahead. The wave passes above that horizon where it continues on toward the F layer, where it reflects toward the horizon again. The process is repeated several times without the earth's surface coming into play to attenuate the signal. In addition to this mode, a smaller part of the rf energy is reflected toward the ground and arrives as a signal to be received. This component would be produced with each reflection off the F layer. This theory explains a propagation mode that offers much less attenuation to a long range path. — *S. B. Mackenzie, K8IRY, Rootstown, Ohio*

MORE ON THE W2EA COLLINEAR ARRAY

☐ Except for the directors, the antenna described by Schmidt in December *QST*, page 32, is essentially the design of the late Oliver Wright, W6GD. This antenna has been used extensively here in W6 land on all vhf bands for many years, and has consistently provided excellent performance. A large-scale version often wins the West Coast antenna-measuring contests.

When W6GD designed this antenna in the late 1940s, he did a great deal of experimenting to optimize the performance. One important finding was that directors of any length would lower the gain. This result might be contrary to theory, but it has been confirmed many times by other researchers, including myself. If the W2EA antenna is built without the directors, it will yield a higher gain, and lower wind resistance as well. — *Fred Brown, W6HPH, Lake San Marcos, California*

DTMF DECODER ALTERNATIVES

☐ I enjoyed the DTMF decoder article in the

[1] F. Brown, "An Introduction to the Bilateral Transverter," *QST*, December 1981, pp. 34-38.
[2] *The Radio Amateur's Handbook*, ARRL, 1982 edition, p. 16-40.
[3] "The New Frontier," *QST*, December 1980, p. 74.

*Assistant Technical Editor

[4] In "The World Above 50 MHz," January 1980 *QST*, p. 84, W3IP reported working a W6 while running 20 milliwatts to a dipole.
[5] In "The World Above 50 MHz," February 1980 *QST*, p. 90, W4ATC reported working K6PXT while running 50 ***microwatts*** to an unspecified antenna.
[6] For example, see Troster, et al., "The WB6ZNL Beacon," *QST*, January 1980, pp. 57-58.

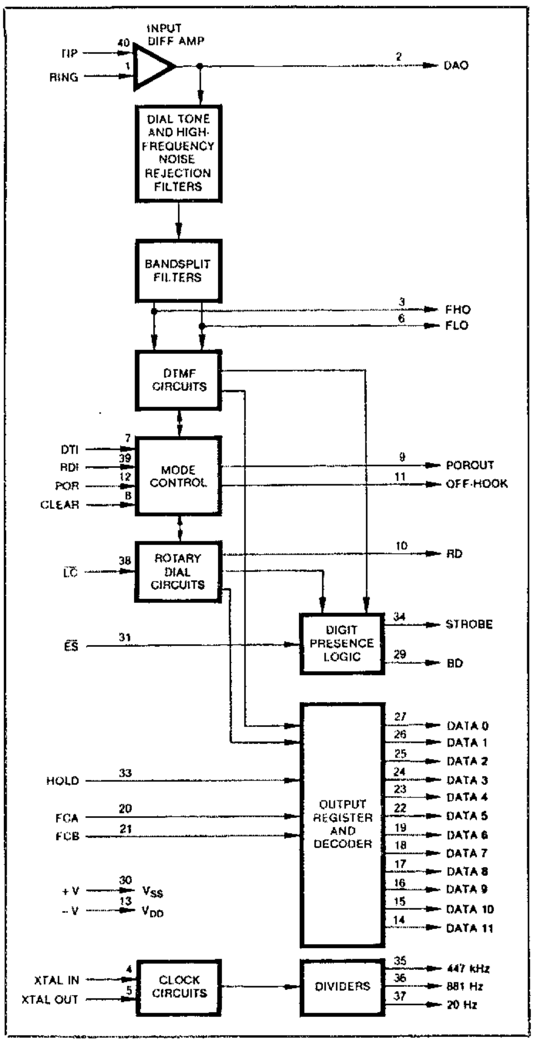


Fig. 2 — Block diagram of the Teltone M-927 DTMF receiver.

January 1982 issue of *QST*, and strongly agree with the author's statements concerning the limited capabilities of a 567 PLL based decoder. An alternative, however, is a decoder manufactured by the Teltone Corporation.[1]

The M-917 decoder is a small module (approx. 2.5 × 3.5 inches) that contains all necessary circuitry including the band-split filters. This decoder is of central-office quality and has performed well in our local repeater for over a year.

Teltone has recently introduced an even smaller decoder, the M-927, which is housed in a standard 40-pin DIP package. (See Fig. 2.) It also includes band-split filters, but requires the use of an external 3.579-MHz crystal. The single-quantity price of the M-927 is $75. — *Bob Witte, KBØCY, Loveland, Colorado*

AID FOR THE DIGITAL CAPACITANCE METER

☐ In reference to the article "A Digital Capacitance Meter" in the December 1981 *QST*, I feel that the project described is a bit out of date and impractical. The inability of the meter to measure capacitance in the picofarad range makes it useless for values most often used in rf circuits. Capacitors in the nanofarad range generally have a broad tolerance and do not require accuracy in their application.

A large number of articles have appeared describing meters that will measure in the picofarad range. The adapter unit described in August 1977 *QST* will operate in the less than 10-pF range by subtracting the residual reading from the indicated value. The addition of a simple counter such as the 74C925 or the MC14553-14543 combination will make a complete meter with minimal power consumption. There are many refinements applicable to the circuit. A CMOS version of the 555 (7555) will provide a higher input impedance, resulting in higher accuracy at low capacitance values. A constant current source to supply the charging current is helpful; an LM334 can be used, or a JFET and one resistor will suffice.

Suppressing the residual component requires some additional circuitry. If the counter is presetable, a value equal to the residual reading can be set in. If counters such as the 7490, 74LS90 and 74C90 are used, they can be preset to nine instead of zero. For example, in a four-digit readout, the two most significant digits can be reset to nine — resulting in a reading of 9900. This will suppress up to 100 pF of stray capacitance. A small air-variable capacitor across the input can then be used to set the reading to zero. An adjustable one-shot circuit and gate can do the same task.

David Dage described an auto-ranging meter in *Popular Electronics* for February 1978. I duplicated his boards and built this unit some years back. It is stable and the residual capacitance can be suppressed. *Radio-Electronics* published a design in September/October 1978 of a meter that will measure capacitance from 1 pF to 9999 μF.

I have built a number of meters of this sort, both digital and analog. One word of caution — it is essential that the unit be completely shielded. All ICs should be bypassed and a low-ripple power supply used. As the voltage on the capacitor rises to the trigger voltage, a very small transient in the measuring circuit can cause premature triggering with a resultant loss of accuracy. — *Warren H. Clark, W6COK, Balboa, California*

[1]P.O. Box 657, 10801 120th Ave. N.E., Kirkland, WA 98033

Feedback

☐ In Fig. 1 of "Refining the SB-104," March 1982 *QST*, a ground symbol should be added to the junction of the base and emitter resistors and emitter bypass capacitor of Q702. Also, the 0.1-μF bypass at the collector end of R721 should be moved to the opposite (dotted line) side. (Thanks to Ulrich Rohde, DJ2LR.)

☐ The i-f of the Kenwood TS-530S was incorrectly stated to be 8.895 MHz in the March 1982 *QST* Product Review. The correct frequency is 8.83 MHz.

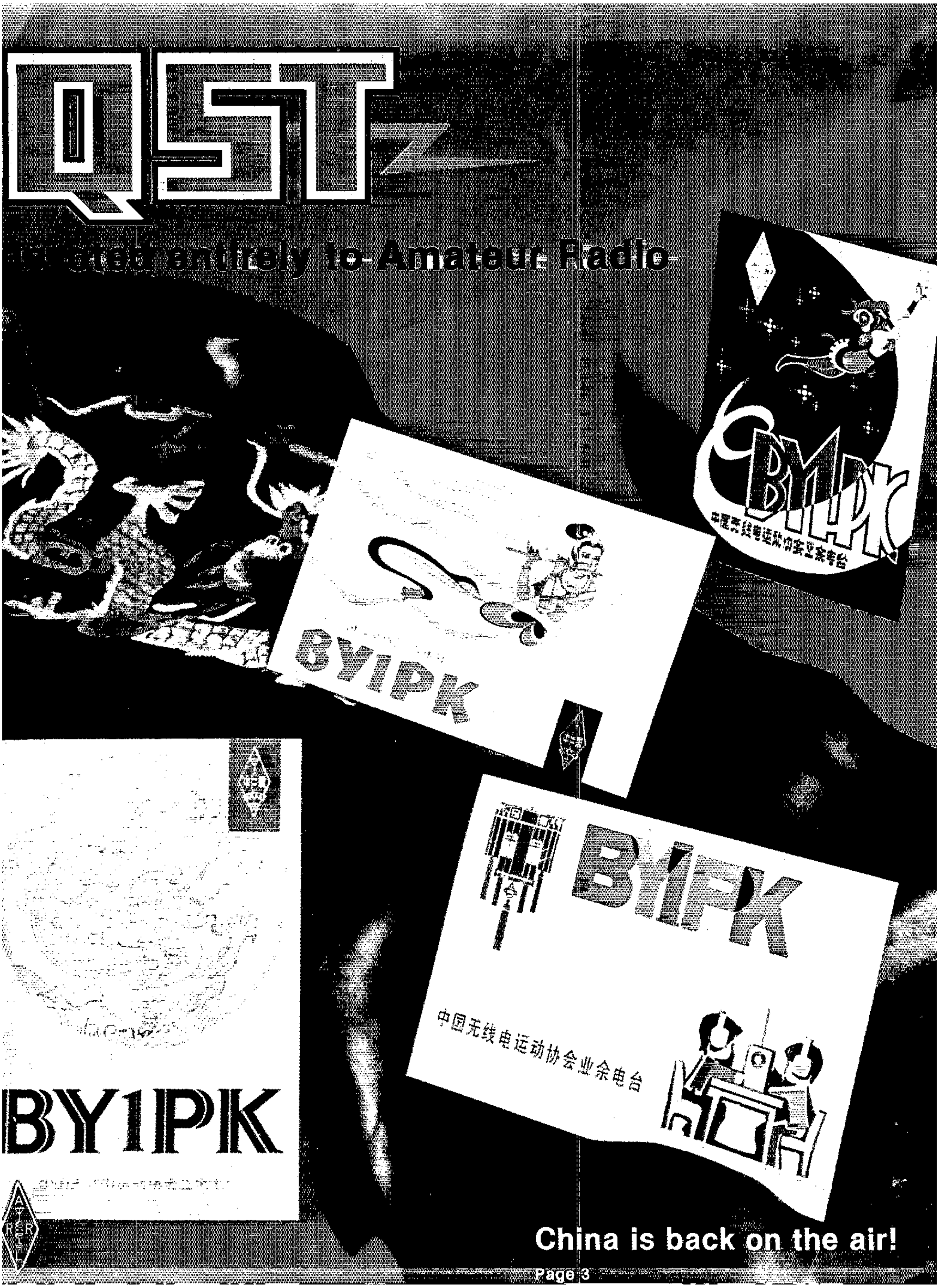
☐ Greg McIntire, author of "Designing a Microprocessor-Based RTTY Speed and Code Converter" (January 1982 *QST*, p. 18), advises that he has incorrectly shown S1 as a 3-position switch in Fig. 1. S1 should have 4 positions. The additional position should be open on both sections to select mode 3 (110-baud ASCII). Q3 was also omitted from Fig. 3. It can be located near Q1 and Q2 in the lower corner of the board.

☐ Two resistor values are reversed on the parts-placement diagram of the af/rf signal injector (Fig. 6B, February 1982, p. 44). The 2.2-kΩ, Q2 collector resistor is shown as 22 kΩ, and the 22-kΩ, Q3 collector resistor is shown as 2.2 kΩ on the placement diagram. Thanks go to Dick Abeles, W2LMR, for pointing out the switch.

☐ David Abramson, General Electric Marketing Specialist, informs us that GE is not able to sell transient voltage-suppression devices directly from the factory, as indicated in the February 1982 *QST* article, "Protect Your Equipment from Damaging Power-Line Transients." Readers interested in purchasing the GE devices should contact any authorized GE electronic distributor.

An additional source of these units is Cramer Electronics, 85 Wells Ave., Newton, MA 02159.

☐ John Christopher's call sign (Stray, March *QST*, page 77) is (this time we're positive!) KE6CB.


QST
entirely to Amateur Radio
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BY1PK
China is back on the air!
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QST

June 1982 *Volume LXVI Number 6*

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THE COVER

VE3CJ got these samples of the attractive BY1PK QSL cards during an April visit to the station in Beijing. Want one? Look for BY1PK on 14 and 21 MHz cw!

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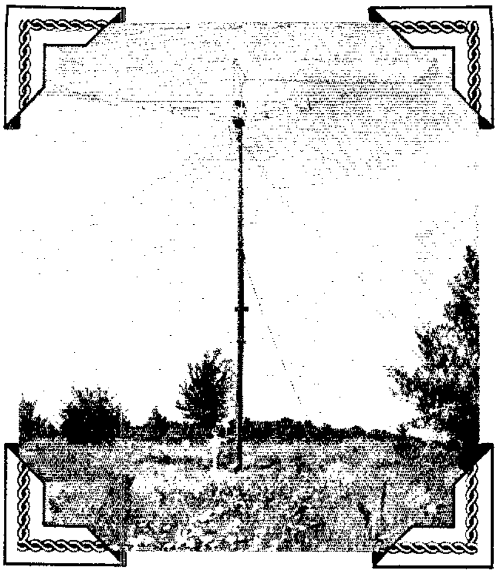
The W8JK Antenna: Recap and Update



John Kraus with the first rotary W8JK antenna in August 1937. The barely visible horizontal wires spanning 60 feet are supported by a gondola-like structure of bamboo.

The famous and effective "8JK" DX antenna remains a favorite with many amateurs. For those who haven't tried it, here's the design rundown.

By John Kraus,* W8JK

Less than 100 years ago, in 1888, Heinrich Hertz built the first radio transmitter and receiver. His transmitting antenna was a half-wavelength dipole and his receiving antenna a one-turn loop. Operating at 5 meters, he was able to demonstrate radio transmission over a distance of a few paces.

Hertz's experiments remained a laboratory curiosity until Guglielmo Marconi repeated and extended them. He added tuning, large antenna and ground systems and, at longer wavelengths, was able to communicate across the Atlantic in 1901. He also demonstrated radio communication with ships. Prior to radio, or "wireless" as it was then called, complete isolation enshrouded a ship at sea. Disaster could strike without anyone on the shore or aboard nearby ships being aware that anything had happened. Marconi changed all that.

Commercial radio focused on wavelengths of 1000s of meters, especially for long-distance communication. Following World War I, with continuous-wave tube transmitters replacing "King Spark," amateurs pioneered in demonstrating that wavelengths of less than 100 meters were useful for long distances. At these shorter wavelengths, dipoles could be conveniently arrayed to produce directional antennas. A simple directional antenna then consisted of a half-wavelength dipole, with a similar dipole placed parallel to and one-quarter wavelength from it as a reflector. One-quarter wavelength spacing was regarded appropriate until George H. Brown of RCA showed in his classic January 1937 paper in the *Proceedings of the Institute of Radio Engineers* that smaller spacings might be better. The key to Brown's discovery was that instead of considering antenna current to be constant, he calculated the antenna gain for a *constant power input.*

When Brown's paper appeared I was intrigued with some of the possibilities it suggested and, in spite of freezing temperatures, lost no time in designing and erecting the first W8JK beam antenna with two parallel dipoles driven in opposite phase and separated by the unprecedentedly small spacing of one-eighth wavelength. It was the first practical, popular antenna to use such closely spaced elements.

As I relate in my book, *Big Ear,* I was elated to find that the antenna provided the gain Brown had predicted mathematically. I wrote a series of articles on the antenna for *RADIO,* starting in the March 1937 issue and, subsequently, articles for *QST, Short-Wave World,* the *Proceedings of the IRE,* and a section for my book, *Antennas* (McGraw-Hill, 1950). Then, in July 1970, I published another article on the antenna in *QST.*

Now, in this article, I wish to introduce some new thoughts, while describing in some detail a rotary beam (W8JK) of the simplest, most versatile type. Some of its characteristics are that:

1) It can operate at any wavelength over a continuous frequency range of more than 3 to 1,

2) It needs no traps or loading coils in the antenna,

3) No antenna dimensions are critical, since the antenna and feed system is resonated,

4) It can be operated horizontally or vertically to obtain optimum elevation angle of radiation (or reception),

5) It is ideal for finding open round-the-world communication paths,

6) It has theoretically zero radiation off the ends of the elements and perpendicular to the plane of the elements,

7) It can be fed with low-loss, inexpensive twin-line,

8) It is compact, a 6-band (20, 17, 15, 12, 10 and 6-meter) design being only 7.3 m[1] long.

The Basic Arrangement

In simplest terms, the W8JK consists of two parallel linear conductors or elements with equal oppositely phased currents, as

*The Ohio State University Radio Observatory, 1854 Home Rd., Delaware, OH 43015

[1]Notes appear on page 14.

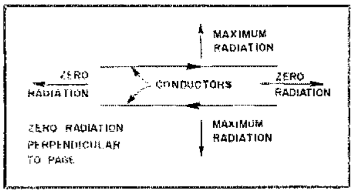


Fig. 1 — Basic W8JK antenna. The conductors carry equal out-of-phase currents.

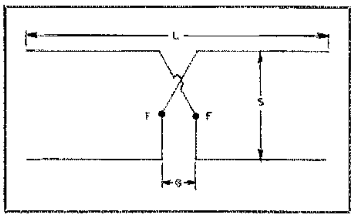


Fig. 2 — Center-fed W8JK antenna. Two-wire feed line connects at FF.

suggested in Fig. 1. The elements may be center fed or end fed. The center-fed arrangement is shown in Fig. 2. Typically, the spacing (S) is about one-eighth wavelength on the lowest frequency used. The length (L) can range from less than one half wavelength to more than three half wavelengths.

If L is somewhat less than one-half wavelength for the 20-meter band, the same antenna can be used also on 6 meters and on all wavelengths in between, including the amateur 17, 15, 12 and 10-meter bands. The center cross-over gap (G) can be any convenient value, such as 250 mm.

Feeding and Matching

The antenna elements can be fed with a resonant twin-line connected to points FF, with tuning done at the station end by means of a balance-to-unbalance, inductor-capacitor tuner. This has the disadvantage that high-voltage points on the twin-line are brought into the station.

An alternative is to short the twin-line at a current maximum and couple a coaxial line at that point. To do this, I have used a section of open twin-line made of aluminum tubing, with a sliding section, or "trombone," as illustrated in Fig. 3. For a given tap distance (T), the trombone is moved up or down to resonate the antenna transmission-line combination and to give a minimum VSWR on the coaxial line to the transmitter. The tap distance can then be adjusted to reduce the VSWR further if necessary. Since the twin-lines above the shorting strap constitute a resonant system with the antenna, it is not necessary that all twin-line sections be of the same impedance. Thus, I have used an aluminum-tubing section with about 300 ohms impedance, while the flexible twin-line between it and the antenna was anywhere between 200 and 400 ohms impedance.

The distance (D) from the antenna feed points (FF) to the shorting strap on the trombone will vary, depending on the frequency band being used. As an example, for operation on 20 and 6 meters and all bands in between, the overall element length (L), including the center gap (G), can be 7.3 m, with the spacing S equal to 2.6 m, as shown in Fig. 4. For these dimensions, the distance (D) to the shorting strap on the trombone unit will be approximately as indicated in Table 1.[2] Note that, in addition to the closest short

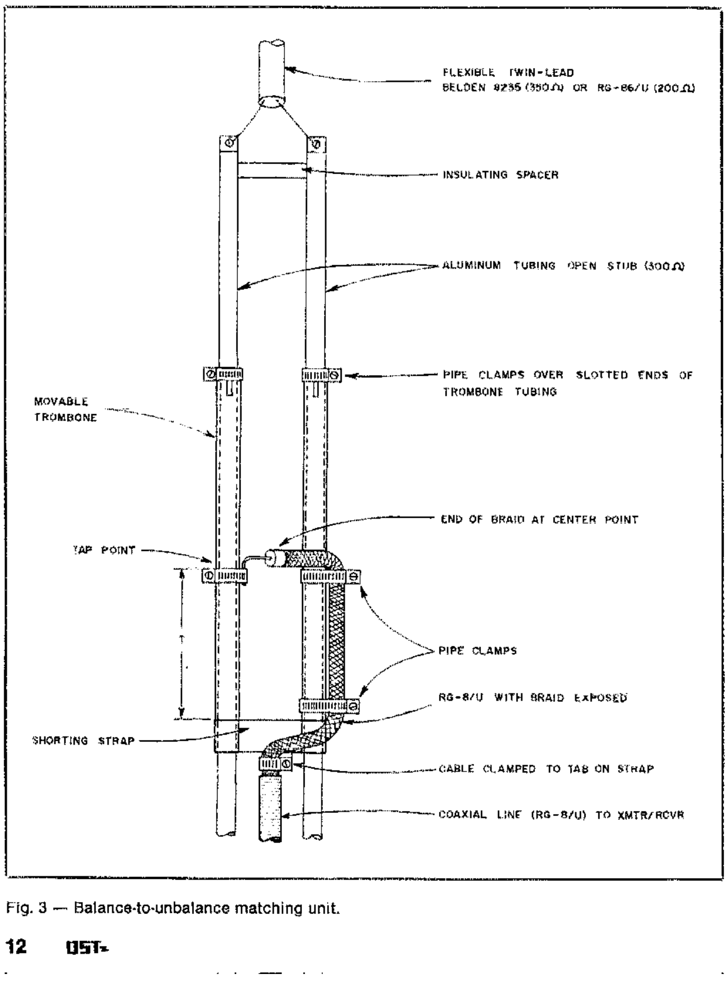


Fig. 3 — Balance-to-unbalance matching unit.

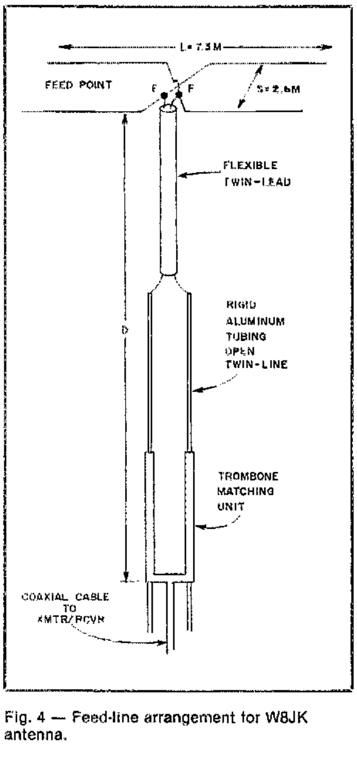


Fig. 4 — Feed-line arrangement for W8JK antenna.

position indicated in the second column, the short can also be a half wavelength farther, as indicated in the third column. In fact, the short can be at any multiple of one-half wavelength.

The distances in Table 1 assume all open conductor twin-line between the antenna and the short, with wave velocity equal to or nearly that in free space. Since the velocity on flexible twin-line is less than this (typically 80%), D will be less by an amount depending on the length of flexible twin-line. For example, at this velocity value (80%), a 4-m section of flexible twin-line will be equivalent to a 5-m length of open line.

Gain and Beamwidths

The gain in dBi of the antenna over an isotropic radiator, and the half-power beamwidths, are given in Table 1. Although the antenna could be operated at wavelengths longer than 20 meters, the gain tends to decrease and the matching adjustments tend to become more critical. At wavelengths shorter than 6 meters, the gain drops sharply and the side-lobes become larger.

The Antenna Environment

Any antenna performance is highly dependent on its environment; that is, its siting and surroundings. What I wish to say in this section about environment applies to all antennas, including the W8JK.

There are two extreme cases. One is with the antenna all alone in free space, a never-realized ideal, even on a satellite. The other is with the antenna situated above a flat, perfectly conducting ground. The latter case is of particular interest because it permits a ground reflection, which at best can double the field strength, giving the equivalent of a fourfold increase in power (6dB gain). At the worst, it can result in a complete cancellation of the signal. Ordinarily, the ground is not flat or perfectly conducting, and there may be trees and buildings, which absorb or scatter the radiation. Nevertheless, let us consider some of the implications of the ideal ground reflection case.

Vertical Angle Control

Consider an antenna at a height (H) above a perfectly conducting flat ground, as in Fig. 5. If the distance (R-D) is an odd number of half wavelengths (1, 3, 5 . . .), then the direct and reflected waves will reinforce for a horizontally polarized antenna, but will cancel for a vertically polarized antenna. However, if (R-D) is an even number of half wavelengths (0, 2, 4 . . .), the reverse is true.

Although such an ideal situation is rarely realized in practice, it is noteworthy that a transmitted (or received) signal might be quadrupled in power, or reduced to zero, depending on the height (H) of the antenna, the wavelength and the vertical or elevation angle (θ). If there is imperfect ground reflection, there will be only partial reinforcement and cancellation, resulting in less than a 6-dB reflection gain and significant radiation at the zero radiation angles of the ideal case.

The ideal situation is shown graphically in Fig. 6. With the antenna one wavelength above ground, there is a maximum signal at an elevation angle of 15° if the antenna is horizontally polarized (point P), but zero signal if it is vertically polarized. At this same height, a vertically polarized antenna will have maximum radiation at a 30° elevation angle, while a horizontally polarized antenna has zero radiation at this angle (point Q). To produce maximum radiation at 30°, the horizontally polarized antenna can be lowered in height to one-half wavelength, or the antenna could be flipped to vertical polarization.

Owing to Faraday rotation of the polarization, a horizontally polarized wave transmitted via the ionosphere may arrive at any polarization, and the polarization may fluctuate continuously. Thus, if 15° is the optimum elevation angle for the transmission path in use, it does not mean that a horizontally polarized antenna one wavelength above ground will be effective at all times. But the polarization and height are at least necessary conditions, because a vertically polarized antenna at that height will have a null at 15°.

Table 1

Characteristics for W8JK Antenna

	Distance D (approx.)		*Gain*	*Half-power beamwidth*	
Band	*1st short*	*2nd short*	*dBi*	*Horiz.*	*Vert.*
20m	10.8m	21.2m	5.7	62°	90°
15	5.5	12.6	6.7	60	93
10	2.8	8.1	7.7	56	96
6	9.0	12.0	8.2	30	105

L = 7.3 m and S = 2.6 m, as in Fig. 4.
Values for the new 12- and 17-meter bands can be interpolated.

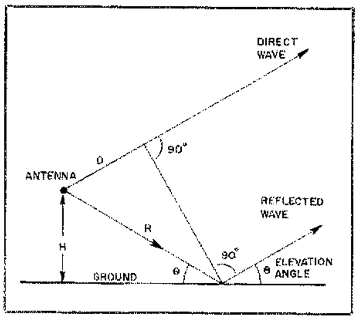


Fig. 5 — Effect of ground reflection.

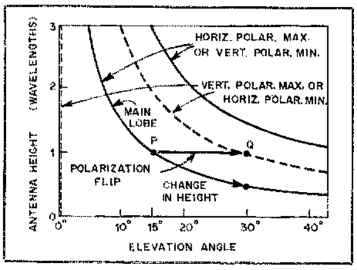


Fig. 6 — Elevation angles of maximum and minimum radiation from horizontally and vertically polarized antennas over a perfectly conducting flat gound.

The curves of Fig. 6 were calculated for an isotropic radiator, so they do not correspond exactly to those for directional antennas. But at the lower elevation angles shown, the differences are small.

To flip a W8JK antenna between horizontal and vertical polarization, the central boom can be constructed as suggested in Fig. 7. The W8JK antenna is small and light enough to make this polarization change practical. Alternatively, a vertical W8JK antenna, identical to the horizontal one, could be mounted on the same boom and a relay used to switch either antenna to the twin-line. Vertical-angle control can be just as important as the horizontal-angle control afforded by an antenna rotator.

Round-the-World Paths

A bi-directional antenna, such as the W8JK, is ideal for finding open round-the-world communication paths. A simple technique I have used is to tap out an occasional dot while slowly rotating the antenna. When I hear an echo, it means that my signal has found an open path around the world. The time delay is about one-seventh of a second, and most receivers recover from a transmitted signal in less time than this. In my experience, 15 meters was the most productive of open round-the-world paths. Once I found one, I listened for a while or sent a "CQ," and was frequently rewarded by DX contacts all along the path. The question of long

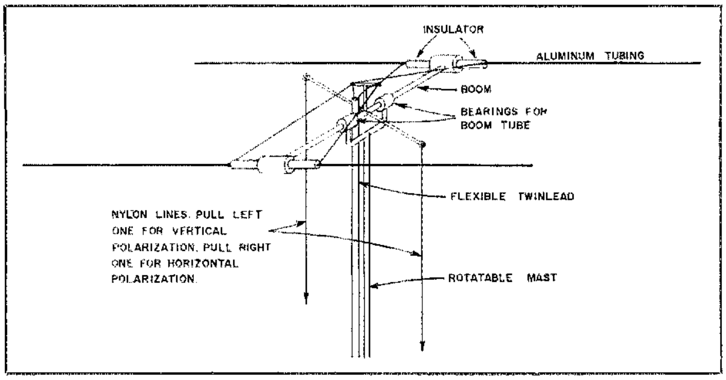


Fig. 7 — Central boom construction for flipping between horizontal and vertical polarizations.

path versus short path does not arise.

Summary

The characteristics of W8JK antennas are reviewed, and a simple 6-band (20, 17, 15, 12, 10, 6-meter) version is described in some detail. Feeding, siting, polarization and vertical-angle control are discussed. I hope the information will make the advantages of the W8JK better understood, and may even encourage some enterprising amateurs to build one.

John Kraus, W8JK, is McDougal Professor Emeritus of Electrical Engineering and Astronomy at the Ohio State University, where he has been on the faculty since 1946. He is also Director of the Ohio State-Ohio Wesleyan Radio Observatory and is visiting Stocker Chair Professor at Ohio University. He received his PhD degree in physics from the University of Michigan in 1933. He is author of hundreds of technical articles and of the books Antennas *(McGraw-Hill, 1950),* Electromagnetics *(McGraw-Hill, 1953),* Radio Astronomy *(McGraw-Hill, 1966),* Electromagnetics *2nd edition with K. R. Carver (1973),* Big Ear *(Cygnus-Quasar, 1976), and* Our Cosmic Universe *(Cygnus-Quasar, 1980). Dr. Kraus is the inventor of the helical beam antenna, the corner reflector antenna, the backward-angle-fire grid antenna, the W8JK and other close-spaced arrays, multi-wire doublets and additional antenna types. Dr. Kraus is a Fellow of the IEEE and a Member of the National Academy of Engineering. He has been a licensed amateur since 1926.*

Notes

[1]inches = mm × 0.03937; feet = meters × 3.281.
[2]When properly adjusted, a given T and D usually provides less than a 2:1 VSWR over all or most of any amateur band. The tap distance (T) is typically 0.5 m.

New Books

☐ *Interference Handbook* by W. R. Nelson, WA6FQG. Published by Radio Publications, Inc., Box 149, Wilton, CT 06897. Soft cover, 5-3/8 × 8-1/8 inches, 241 pages plus index, $8.95.

William Nelson worked 33 years for the Southern California Edison Company. He spent two years as a groundsman and then moved up to lineman. After five years as a lineman he was promoted to estimator. His work included distribution design, power facilities and load management. In 1964 he was appointed Amateur Radio Representative and RFI Investigator for the company. He held that position until his retirement in 1980. As an investigator, Nelson was both RFI sleuth and speaker at club meetings and conventions. He helped change construction practices in the electrical utilities. These changes have reduced the potential for RFI.

Nelson is past chairman of the Los Angeles Council of Radio Clubs TVI Committee. Today he is a consultant to power utilities on RFI problems, including investigation and training.

RFI is a growing problem, the kind of problem that finds the Amateur Radio operator the victim more often than the culprit. Most of us need help in developing the art and understanding the science of RFI identification and elimination. This book should help you toward that end.

Interference Handbook contains 13 chapters and 173 illustrations. Chapter 1 consists of introductory material. In Chapter 2, spark discharge interference and noise suppression are discussed. Other items covered in this interesting and useful chapter include: the means by which RFI can be transmitted, and some helpful hints on tracking down interference. Did you know that RFI carries farther on lower frequencies? By listening to the highest frequency that the interference can be heard on and moving higher as you "zero" in on it, an RFI source can be tracked down. Nelson describes how to use your car radio, hf mobile rig and a vhf receiver to track down troublesome RFI sources.

Electrostatic discharge is the subject of Chapter 3. This is a potential troublemaker that most of us don't think about very often. When you get through reading this one you'll want to go out and check your station grounding, or, perhaps, install a better ground system.

Chapters 4 through 6 cover the RFI investigator and power company practices. We may not be able to climb the power pole to correct a fault, but most of us will find power line construction and how it can generate RFI fascinating. Every power utility employee in the country should be required to read Chapters 5 and 6.

Noise-reducing bridges for your receiver is the subject of Chapter 7. Chapters 8 through 10 cover nonlinear devices, transmitters, TV sets and audio equipment. Chapter 11 is on grounds and grounding; it concludes: "A combination of multiple ground rods and bypass plugs will be a great help in difficult cases of RFI when transmitter and receiver are located in the same building."

Vehicle noise suppression is the topic of Chapter 12. Mobile Amateur Radio operators, and even more so, RFI investigators, dislike those annoying noises that are sometimes generated by vehicular electric systems. Nelson gives some good pointers on locating and reducing noise sources in your car, truck or boat.

The book concludes with an RFI roundup. This includes a variety of miscellaneous items that did not fit handily into any of the earlier chapters. The final item is the *Consumer Products RFI Assistance List* compiled by Harold Richman, W4CIZ, of the ARRL RFI Task Group.

The easy-to-read style and the many anecdotes found throughout make this book fun to read and easy to understand. The perspective and insights into power utility practices are of interest to any ham who has had a noise or powerline interference problem. — *Chuck Hutchinson, K8CH*

A Compatible Slow-Scan Color-Television System

New techniques, plus SSTV technology, equals color pictures for the radio amateur.

By Don C. Miller,* W9NTP

The SSTV system described here will permit the transmission of color images in the same bandwidth and transmission time as that being currently used for sending black-and-white images. It is patterned after U.S. and Canadian color television (NTSC) standards.

To understand the system, let us consider the image storage and transmission method that is used. A digital memory, limited in resolution by 128 × 128 × 4 MOS memory elements, is utilized. There are 128 pixels in each horizontal line (a pixel is a sampling point) and 128 lines in each field. The gray-scale (luminance) resolution is 4 binary bits and, therefore, is capable of representing 16 shades of gray.

The required bandwidth for this video system can be determined easily by calculating the amount of data that is necessary to be transmitted in a given period of time. Eq. 1 is used universally to give an estimate of required bandwidth. (Since the image will be sent using Amateur Radio equipment, the maximum bandwidth that may be used is less than 3 kHz.)

$$\text{Bandwidth (Hz)} = (\text{pixels/line} \div 2) \times \text{lines/field} \times \text{fields/sec} \quad \text{(Eq. 1)}$$

By entering the resolution data for our system into Eq. 1, we find that the bandwidth and field rate are related by:

$$\text{Bandwidth (Hz)} = 8192 \times \text{fields/sec} \quad \text{(Eq. 2)}$$

Most Amateur Radio transmitters cannot handle subaudible frequencies. This means that if low-frequency field rates are to be employed, it will be necessary to place the video information on a subcarrier so that it will pass through the transmitter as medium-frequency audio signals. Many years ago, it was agreed that the SSTV system should operate as an fm system. (The noise immunity properties of fm made it preferable to a-m.) Standards for the fm system are shown in Table 1.

Base video bandwidth chosen is 960 Hz. Entering this value into Eq. 2 to determine the time required to transmit a single picture, we get:

$$960 \text{ Hz} = 8192 \times \text{fields/sec}$$
$$\text{fields/sec} = 960 \div 8192 = 0.1172$$
$$\text{sec/field} = 8.53$$

The frequency spectrum of a typical SSTV signal is shown in Fig. 1. Most of the signal is above 1200 Hz. Spectrum analysis and observation prove that there is little energy in the low end of the audio range.

Compatible color television is possible, in part, because less resolution is required by the eye for color pictures than for black and white. The NTSC and other color TV systems utilize overlapping frequency spectrums. The same techniques may be used to modify the standards of slow-scan television to permit the transmission and recording of a color SSTV image in the same bandwidth and transmission time as required for a black-and-white image.

Three color signals, Y (luminance), R − Y (red minus Y) and B − Y (blue minus Y) are recovered from a color camera, TV monitor or a specially built decoder (see Fig. 2). It will be necessary to bandwidth-limit all three signals before they are converted to digital information and stored in memory. The bandwidth of the two color-difference signals should be half that of the luminance signal; i.e., 500 Hz. The three video signals, after bandwidth filtering, are fed to separate analog-to-digital (A/D) converters. The digital signals are then stored in memory. Since the color-difference signals are handled as narrow-bandwidth signals, it is possible to use much less memory for them than would otherwise be required.

Once the three signals are placed in memory, they can be read out simultaneously at the same rate as that used for normal black-and-white SSTV pictures. The output of each memory is fed through a digital-to-analog (D/A) converter, producing three analog SSTV signals.

The Y signal is connected to an fm oscillator, as in the present system, and

Table 1
SSTV Standards

Sync subcarrier frequency	1200 Hz
Black video frequency	1500 Hz
White video frequency	2300 Hz
Sync pulse width	5 ms (horizontal), 66 ms (vertical)
Line frequency	15 Hz (U.S. standard)

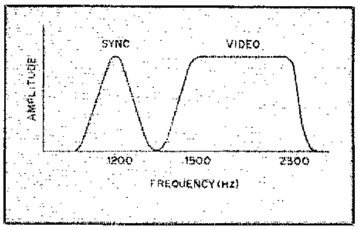


Fig. 1 — Frequency spectrum of a typical black-and-white SSTV signal. Black level is 1500 Hz; white is 2300 Hz.

*Box 95, RR 1, Waldron, IN 46182

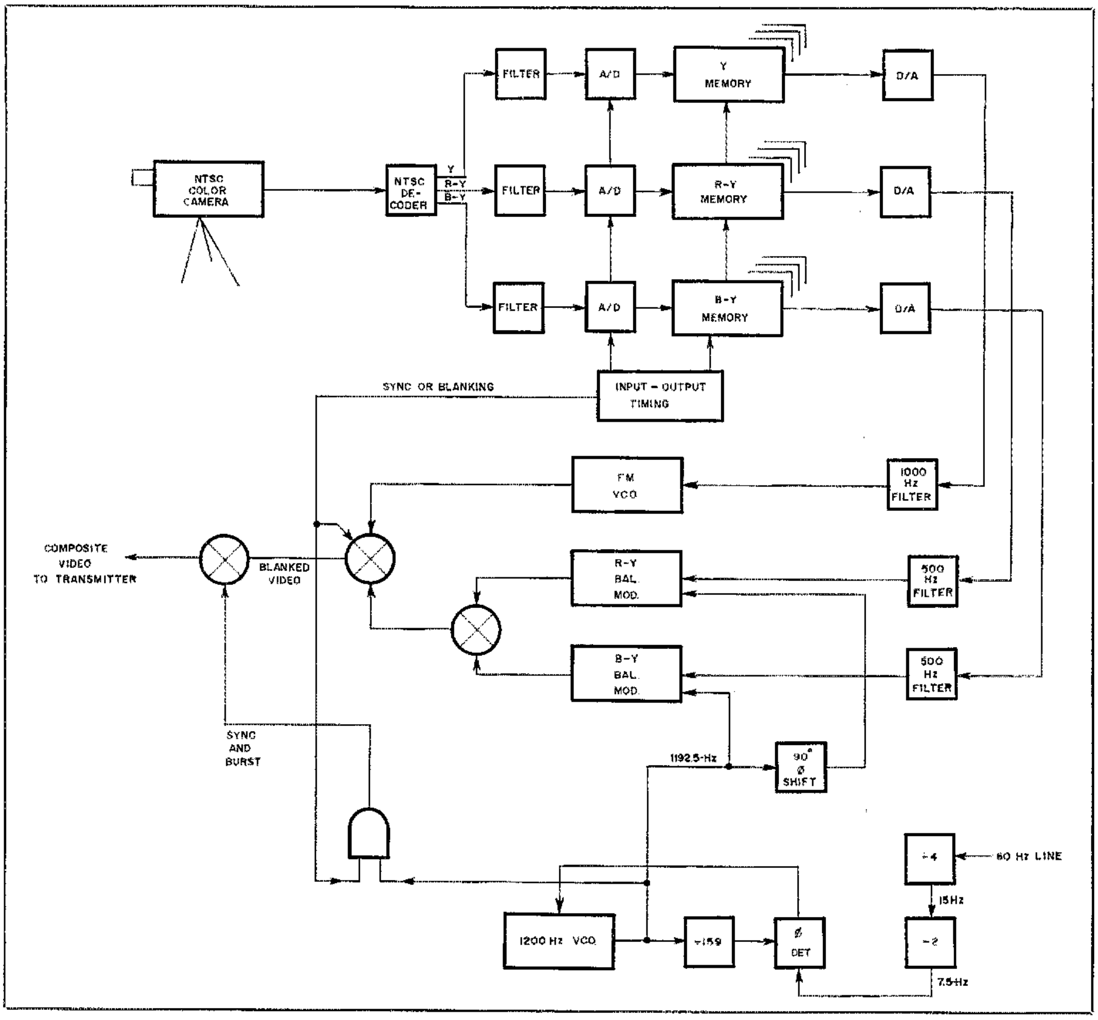


Fig. 2 — Color SSTV transmitting system.

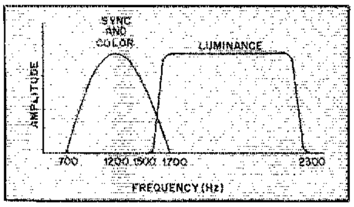


Fig. 3 — Spectrum of a typical color SSTV signal.

swings the frequency between 1500 and 2300 Hz. The sync signal (1200 Hz) is not produced in the normal way. It is generated by making it an odd multiple of one half the 15-Hz horizontal line rate. Horizontal sync is usually derived from the 60-Hz power line. The sync subcarrier (1192.5 Hz) is gated by the normal SSTV sync signal and appears at the output as before.

As in the case of NTSC color TV, the 1192.5-Hz carrier is 90 degree phase-shifted and, together with the zero-degree signal, is fed to a pair of balanced modulators. Each of the two color-difference signals will also feed the respective balanced modulators. This produces a pair of dsb spectrums, centered on the 1200-Hz signal; they occupy approximately 700 Hz to 1700 Hz. This also produces a slight overlap with the luminance spectrum between 1500 Hz and 1700 Hz (see Fig. 3). It is important that the dsb spectrums have symmetrical sidebands. Some sideband filters in Amateur Radio transceivers may give trouble with low-frequency roll off. In that case, equalization must take place before the three color signals are detected.

It may not be necessary to make the sync frequency an odd multiple of one half the horizontal line frequency. Under normal operation, it is very probable that the overlapping energy will not cause much picture degradation.

Fig. 4 is a block diagram of the receiving system. It functions in much the same manner as the transmitting system, only in reverse. Of course, further refinements to the receiving system are possible. Recently developed comb filters could be used to completely remove the crosstalk between the luminance and color-information channels.

This system produces completely compatible color-TV signals. It can be used with the popular multiple-memory, color-scan converters. Transmission time and bandwidth is the same as for black-and-white transmissions.

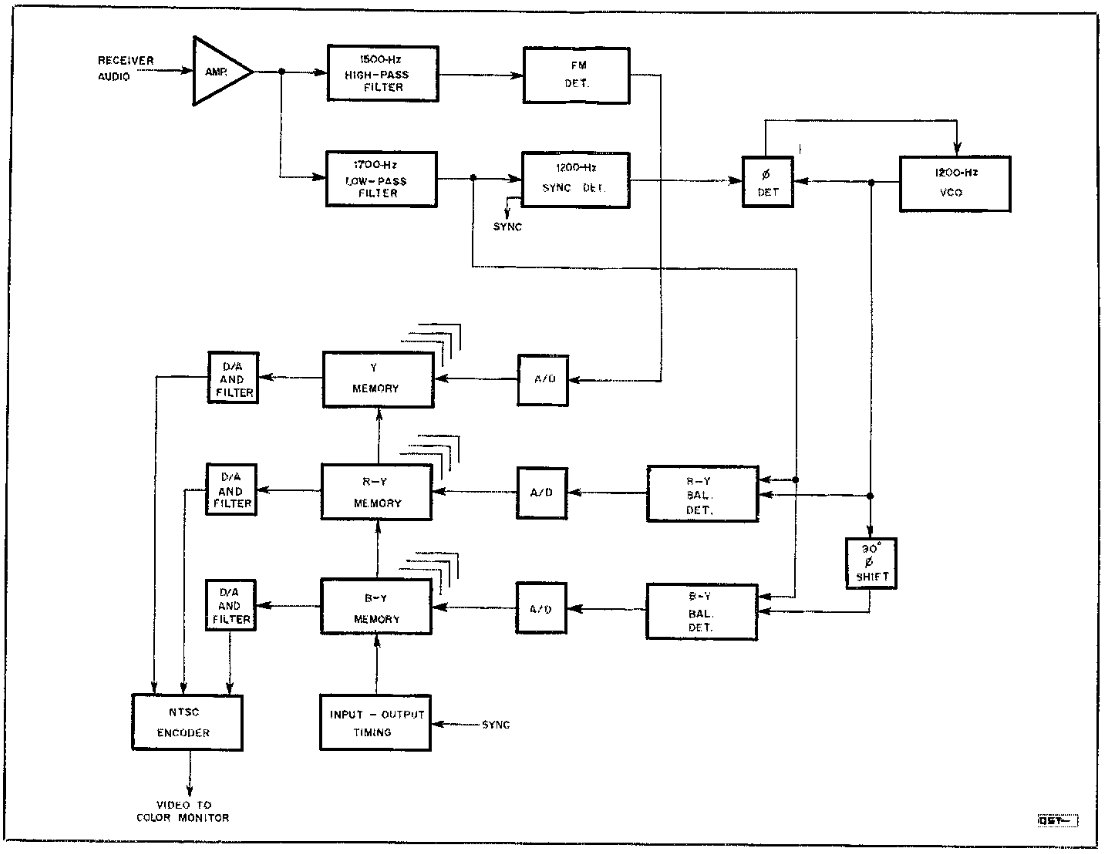


Fig. 4 — Color SSTV receiving system.

Strays

JOHN DiBLASI, W2FX, CO-FOUNDER OF QCWA

On January 13, 1982, John DiBlasi, W2FX, of Great Neck, New York, became a Silent Key. First licensed way back in 1912 or 1914, W2FX spent his entire life in electronics, both as a business and as a hobby. He remained active on the air until about eight years ago, when he was left paralyzed and bedridden by a stroke.

John was one of the founders of the Quarter Century Wireless Association in 1947, and was QCWA's first president, a position he held for 17 years. A member of ARRL and an avid collector of *QST*, W2FX was especially active on 20-meter ssb in his later years. He maintained regular schedules with many hams, including a group in Italy, which he called the "spaghetti net."

W2FX is survived by his wife, Anna, two sons and a daughter, and numerous grandchildren. — *John Facella, K9FJ/G5CYM, Bracknell, Berks, England*

CALL FOR PAPERS ON VEHICULAR TECHNOLOGY

☐ Papers are invited for the 1983 IEEE International Conference on Vehicular Technology to be held in Toronto, Ontario, on May 25-27, 1983. Topics in vehicular communication include trunking, cellular systems, ssb and packet switching. Abstracts of 500 words should be submitted by September 15, 1982 to N. J. Haslett, Telecom & Electronics Unit, Metropolitan Toronto Police, 2050 Jane St., Weston, ON M9N 2V3, Canada.

ARRL Foundation President Robert York Chapman, W1QV (right) presents a Satellite Booster plaque to ARRL President Vic Clark, W4KFC, in recognition of Vic's outstanding support of the Foundation's Twentieth Anniversary Satellite Fund Drive. The presentation was made in March at the Board of Directors meeting at Hartford, Connecticut.

Try the "TJ"

Whether TJ makes you think of Cameroon or Tokyo, Japan, the "DXpertise" of this antenna could help you snag the rare ones.

By R. R. Schellenbach,* W1JF

City dwellers and small-lot owners frequently complain, "No room for a good DX antenna." Can you work DX on 160, 80 and 40 meters from that restricted bit of real estate? The answer is yes. Let me tell you about a compact antenna that is useful for working DX.

The TJ is a five-band, vertically polarized antenna system. In the 160-meter band the TJ is essentially a 1/4-wavelength (λ) T (see Fig. 1). It becomes a 1/2-λ T on 80 meters and a 5/8-λ T on 40 meters. For 20 and 15 the configuration becomes a 1/2-λ inverted J. It is from this combination of T and J that the antenna gets its name.

High performance is realized with the TJ on 80 through 15 meters because the maximum current point is elevated above ground. On 160 meters, the performance approaches that of a full-size, 1/4-λ vertical antenna. The horizontal section of the TJ does not radiate appreciably. The current on each side is of equal magnitude and opposite phase, thus canceling radiation.

The three lower frequency bands employ a combination of top-loading techniques to physically shorten the antenna. The end sections act as capacitance hats on 80 and 160 meters. On those two bands there is an almost 2/3 size reduction in the TJ. Because top loading is employed, bandwidth is not reduced as drastically as it would be if other methods were used. On 160 meters, top loading means a more desirable current distribution and a more favorable feed point impedance (30 to 40 Ω compared with 8 to 10 Ω for a base-loaded vertical). If the ground system has a resistance of 5 Ω, the TJ should be about 85% efficient on 160 meters. A base-loaded vertical would exhibit only half that efficiency. Better efficiency means more effective radiated power — exactly what we all want.

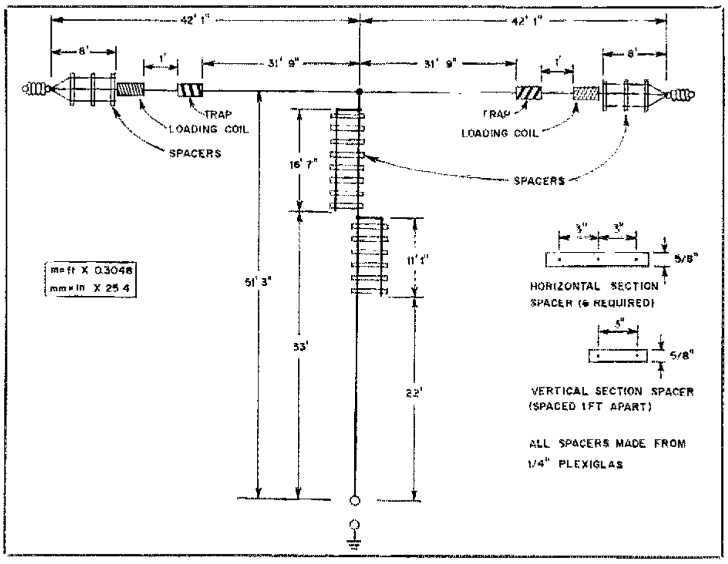


Fig. 1 — The TJ antenna.

Construction Details

The loading coils are wound on 8-inch lengths of 1-1/2 in. PVC tubing.[1] Use 120 turns of close-wound, no. 14 enam. copper wire. I installed a pair of egg insulators inside each coil for support.

The 40-meter traps employ the same type of tubing and support scheme. They were constructed after a *QST* article by Johns.[2] I used RG-59/U coaxial cable and found resonance at 7.05 MHz, using 11 turns.

The dimensions shown in Fig. 1 were derived empirically. You can copy the measurements or modify them for operation in your favorite parts of the bands. I find resonance in my antenna at 1.815, 3.6, 7.05, 14.1 and 21.1 MHz.

Install the TJ in the clear, as far from surrounding objects as is possible. High quality glass or ceramic insulators should be used at the antenna ends. Nylon rope can be used to support the antenna. The feed point should be no more than 2 feet above the ground.

A good ground is required for efficient operation on 160 and 40 meters. My ground system covers 2 acres and employs a buried network of over 5000 feet of solid copper ribbon. You may not want to duplicate that, but you should install an effective ground system. Stanley described several possible configurations in *QST*.[3]

Tuning the TJ

An antenna-matching network is essential to proper operation of the TJ. The network should be installed at the antenna feed point, using the shortest leads possible. Adjustments can be set for the

*12 Whitehall La., Reading, MA 01867

¹Notes appear on page 19.

Table 1
Antenna Feed-Point Impedance

Band	*Impedance (approx.)*
160	35 Ω
80	>1000 Ω
40	100 Ω
20	>1000 Ω
15	>1000 Ω

favorite band of operation, or you can do it by remote control.[4, 5, 6]

Feed-point impedances are given in Table 1. These impedances can be matched with the three configurations shown in Fig. 2. The exact values for these networks should be determined experimentally for each installation. Components for the matching networks should be mounted in a weatherproof housing.

Start with a quarter wavelength of coaxial cable for the 40-meter matching stub. To find the length in feet, divide 234 by the frequency in megahertz and multiply by the velocity factor of the cable. (Velocity factor is 0.66 for polyethelyene dielectric and approximately 0.80 for foam.) Short the free end of the stub and observe the SWR. Now shorten the stub, short the end and check SWR. Continue this process until a satisfactory match is found. The stub can now be rolled into a coil and the end taped.

One nice feature of stub matching is bandwidth. As you move away from resonance, the reactance of the antenna and stub move in opposite directions. The reactances tend to cancel, thus providing greater bandwidth.

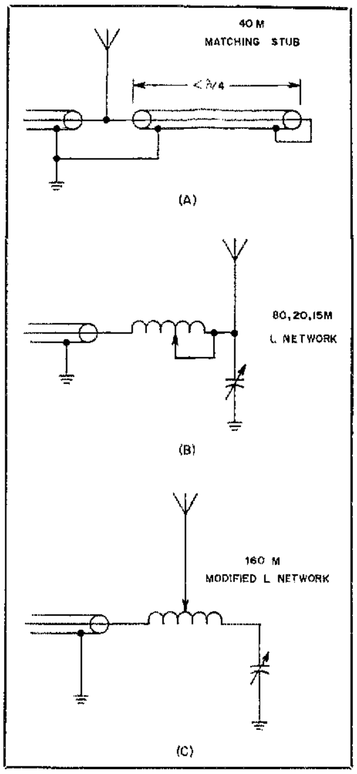


Fig. 2 — Matching networks for the TJ. Capacitance and inductance values should be determined experimentally for each band.

The matching circuit for 80, 20 and 15 meters is a simple L network. On 160 meters I employ a modified L network. I found that the best match and highest antenna current was obtained with the tap a little more than half way toward the variable capacitor. The TJ covers the entire cw portion of any of the five bands, with one setting of the antenna-matching unit.

Performance

Short-skip performance is not as effective as it is with a low horizontal antenna. Lack of high-angle radiation explains that characteristic. Ground-wave coverage is very good, thanks to vertical polarization and a low angle of radiation. Best of all, that low angle accounts for the excellent DX results I have obtained while using the TJ.

I found it satisfying and a lot of fun to build my own antenna. You would, too. Why not construct your own TJ? Good luck and good DX!

Notes

[1]mm = in. × 25.4, m = ft × 0.3048.
[2]R. H. Johns, "Coaxial Cable Antenna Traps," *QST*, May 1981, p. 15.
[3]J. O. Stanley, "Optimum Ground Systems for Vertical Antennas," *QST*, December 1976, p. 13.
[4]H. Drake, Jr., "A Remotely Controlled Antenna Matching Network," *QST*, January 1980, p. 32.
[5]B. K. Imamura, "A T-Network Semi-Automatic Antenna Tuner," *QST*, April 1980, p. 26.
[6]W. H. Sanford, Jr., "A Modest 45-Foot DX Vertical for 160, 80, 40 and 30 Meters," *QST*, September 1981, p. 27.

Strays

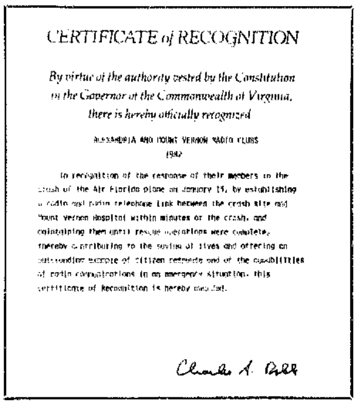
Last December, four members of the Sam Houston Amateur Radio Klub went to jail — just for a day — as part of the club's Christmas Project on behalf of the inmates at the Huntsville (Texas) State Prison. Using stations operating on 2-meter fm and ssb, the amateurs braved bone-chilling temperatures to relay seasons greetings to the families of more than 450 inmates. Seated, l-r, are N5CDN, WA4AOG, KA5DQP and KA5FPV. Two inmates look on. *(photo by Jim Bacon)*

FIELD DAY SATELLITE INFORMATION

☐ Field Day rules in May *QST* allow 100 points for a satellite QSO. This year, with the addition of the Soviet Amateur Radio satellites, operating activity can be spread out to make your operation more enjoyable. AMSAT-OSCAR 8 will remain in the mode listed in the operating schedule (page 93) for June 26 and 27, UTC. The Soviet RADIO satellites will operate Mode A, and a QSO with one of them will count for the 100 points; just list the QSO number (for the ROBOT), date and time. See the schedule for operating times and frequencies. — *Bernie Glassmeyer, W9KDR, OSCAR Program Manager, ARRL*

I would like to get in touch with . . .

☐ amateurs who are interested in volunteering two hours a week to record textbooks for blind and handicapped students. Dorothy Dorben, Reading for the Blind, Inc., 5022 Hollywood Blvd., Los Angeles, CA 90027.



CERTIFICATE of RECOGNITION

By virtue of the authority vested by the Constitution in the Governor of the Commonwealth of Virginia, there is hereby officially recognized

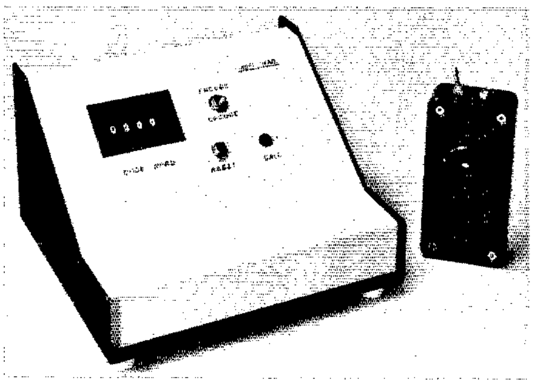
ALEXANDRIA AND MOUNT VERNON RADIO CLUBS
1982

In recognition of the response of their members to the crash of the Air Florida plane on January 13, by establishing a radio and radio telephone link between the crash site and Mount Vernon Hospital within minutes of the crash, and maintaining them until rescue operations were complete, thereby contributing to the saving of lives and offering an outstanding example of citizen response and of the capabilities of radio communications in an emergency situation, this Certificate of Recognition is hereby awarded.

Charles S. Robb

In the wake of the crash of an Air Florida jetliner in Washington, DC, on January 13, 1982, Virginia Governor Charles Robb issued this proclamation, commending the members of the Alexandria and Mount Vernon ARCs for establishing and maintaining a communications link between the crash site and a local hospital until rescue operations were complete.

Not just Another Decoder



Do you monitor the local repeater "just in case" someone might call you? Would you like a 2-meter paging system for your club? NAD will keep your receiver quiet until there's a message for you!

By Paul Newland,* AD7I

This is a description of NAD, Not just Another Decoder. Ideally suited for fm operation, NAD provides selective calling of other NAD-equipped amateurs. NAD is simple to build, low cost, and easy to operate. It is battery powered and features standby current so low that no on/off switch is needed. All parts may be purchased at Radio Shack, except the MM53200 and the MM74C14 integrated circuits.

The heart of this circuit is the National Semiconductor MM53200, a digital-code encoder/decoder IC. The chip was designed as a garage-door-opener device, but we will use it as a pager transceiver.

The 1980 MOS Data Book by National outlines the MM53200 features. It comes in an 18-pin dual-in-line package, contains its own oscillator circuit for internal timing, and has all the necessary circuitry to generate or decode digital code words. The MM53200 has two modes of operation: The ENCODER mode is used for generating 12-bit code words and the DECODER mode is used for detecting 12-bit code words. In either mode the code word is selected by setting the Data Select Leads (DSLs) to either logic one or zero.

Fig. 1 is a representation of the digital signal that is generated by the encoder. The MM53200 first sends the synchronization signal (12 bit times of logic low), followed by the code word (12 bit times of data 1 or 0, depending on the level of the DSLs). This pattern is repeated as long as the chip is in the ENCODER mode.

If this encoder signal is applied to the input of an MM53200 in the DECODER mode, and the clock frequency of the encoder and decoder are within a factor of 2 of each other, the output of the decoder will go low when it detects four repetitions of the code word, provided both are set to the same code. If the words don't match, the decoder output is inactive.

Extending the MM53200 to Radio

Some form of modulation is needed since the digital signals generated by the MM53200 cannot be sent directly over the radio channel. The encoder amplitude modulates a 1900-Hz audio pilot tone; logic 1 turns the tone off, logic 0 turns it on. The tone is fed into the transmitter microphone jack for encoder operation; audio from the earphone jack is connected to NAD for decoder operation. This method is simple and easy to implement. It suffers from poor noise immunity, but providing better noise immunity would complicate the circuit.

Circuit Description

A schematic diagram of NAD is given in Fig. 2. I have defined, for the Data Select Leads only, that logic 1 will be a connection to ground; logic 0 will be a floating DSL. This corresponds to the closing and opening of the switch that connects each DSL to ground.

ENCODER Mode

In the ENCODER mode, switch S1 is set to the ENCODE position, causing U2A to go low and U1 MODE to go high (U1 MODE is the mode input — high is encode). With U2A low, both D2 and D3 are conducting; The input to U1 is low and to U2B is high, turning Q1 on. Q1 controls the power down function. In the ENCODER mode, NAD is always fully powered because Q1 is always on. R3 and C2 control the timing parameters for the internal clock. The code word is placed on the DSLs by switch S2. While in the ENCODER mode, the U1 output sends the digital data pattern that is shown in Fig. 1. Q2 amplitude modulates, or on/off keys U3 — a 1900-Hz LM555 oscillator that is coupled to the bidirectional audio jack via C7, R9, and T1. This modulated pilot tone may be observed by listening to the audio output of the piezo element,[1] Y1.

DECODER Mode

In the DECODER mode, S1 is set to DECODE; U2A is high and Q1 is off, placing NAD in the power-down condition. (When Q1 is off, there is no ground connection for U1). In this condition, the current drain should be less than several microamperes. You can measure this current by inserting a 100-kΩ resistor in series with the 9-volt battery. Place a high-impedance voltmeter across the resistor, then short out the resistor and voltmeter for about two seconds. Remove the short and measure the voltage across the resistor. Every volt indicates 10 microamperes of current through the resistor; you should read less than several

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[1]Notes appear on page 23.

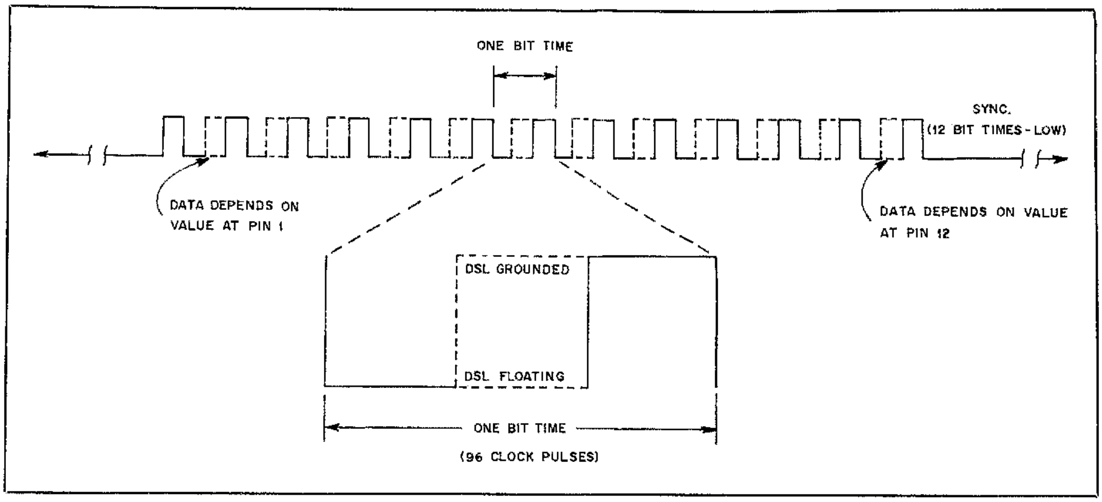


Fig. 1 — Diagram of the encoder/decoder-data waveform.

hundred millivolts. If your reading is greater than this, make sure any unused inputs on U2 are connected to either ground or +9 volts.

Received audio is applied to T1, which steps up the audio voltage, biasing U2A on and off in step with the negative audio peaks. When U2A goes low, both D2 and D3 conduct. R4 and C3 form a retriggerable, one-shot timer with a time constant of about one second. The output of this timer controls Q1 and the power-down feature. Thus, NAD stays powered up for about one second following the last audio signal. When the tones are received, the longest tone-off period is about 15 ms, much less than the one-second time.

R2 and C1 form an integrator to demodulate the original digital data from the amplitude envelope of the received audio. This digital data is "squared-up" within U1 by a Schmitt-trigger input. The desired code word is programmed into U1 via the DSLs. When the signal from the radio matches this code word, the U1 output goes low. When this happens, Q2 will conduct, causing U3 to oscillate. The piezo-electric element, Y1, will emit an alerting signal that can easily be heard. Additionally, D4 and D5 will conduct. U2C, a 25-second, one-shot timer will energize K1, the speaker-control relay, allowing the operator to monitor the channel for 25 seconds following a decode. D5 conducting causes the flip-flop formed by U2D and U2E to set with U2E low. This enables U2F, a low duty cycle, 1-Hz oscillator that flashes D9 until the reset button is pressed.

Construction Techniques

Simple low-frequency circuits can be constructed in many ways. Some may find either pc boards or point-to-point wiring with perforated board (perf board) most suitable; I happen to like wire-wrap. When many circuit changes are likely (such as during circuit development), wire-wrap proves to be flexible; changes are quick and simple to make. The result is a circuit that is sturdy and reliable, with no need to transfer the bread-board circuit to another form. You should use whatever method is most comfortable for you.

I used wire-wrap IC sockets for the chips and Vector T44 pins for the discrete components. IC sockets were held to the board with the wires wrapped to their posts. The shoulders of the T44 pins were forced into the board by placing a soldering iron on top of the pin and pushing downward to melt the plastic perf board, seating the pins. The discrete components were then soldered to the T44 pins. All interconnections were made using no. 30 wire-wrap wire (Fig. 3).

Adjustments

Before you can use NAD, the clock circuit needs to be trimmed to frequency. Either of two methods can be used: One requires an ear and a stopwatch; the other requires a scope or frequency counter.

Ear Method

Temporarily connect a 47-kΩ resistor for RV3 (the code word setting is not important), and set NAD to ENCODE. You should now hear tones coming from the piezo element. If you listen closely, you should hear a distinct cadence or rhythm with about two beats per second (or 20 beats per 10 seconds). The value of RV3 needs to be adjusted to provide 18 to 22 beats per 10 seconds. Standard-value resistors should provide enough resolution to meet the 18- to 22-beats requirements.

Scope Method

Connect a scope or frequency counter to TP1 with a high-impedance probe, and connect the probe ground clip to a convenient signal ground point. Set NAD to ENCODE (the code word is unimportant), and adjust the value of RV3 (starting with 47-kΩ) using standard values to provide a 4600-Hz frequency. Don't get carried away with accuracy; standard values should provide enough resolution to get the clock to within 10% of 4600 Hz.

Operation

To transmit, set the code-word switches to the desired values and connect the audio signal from NAD to a low-impedance point in the transmitter microphone circuit. Set the NAD mode switch to ENCODE then key the transmitter for several seconds. This will cause any NAD decoders monitoring the channel to generate the alerting signal when they hear the matching code word.

To receive, set the code-word switches to provide the desired code word on the DSLs. Adjust the audio for a loud but comfortable listening level. It may take some experimentation to determine the proper audio setting for your radio. Connect the speaker audio (the external earphone or external speaker jack is ideal) to NAD audio input (be sure the radio has a capacitor in its audio-output circuit). Set the mode switch to DECODE (when not transmitting NAD codes, NAD should always be in the DECODE mode). Your NAD will sound its alerting signal whenever any NAD signal is received

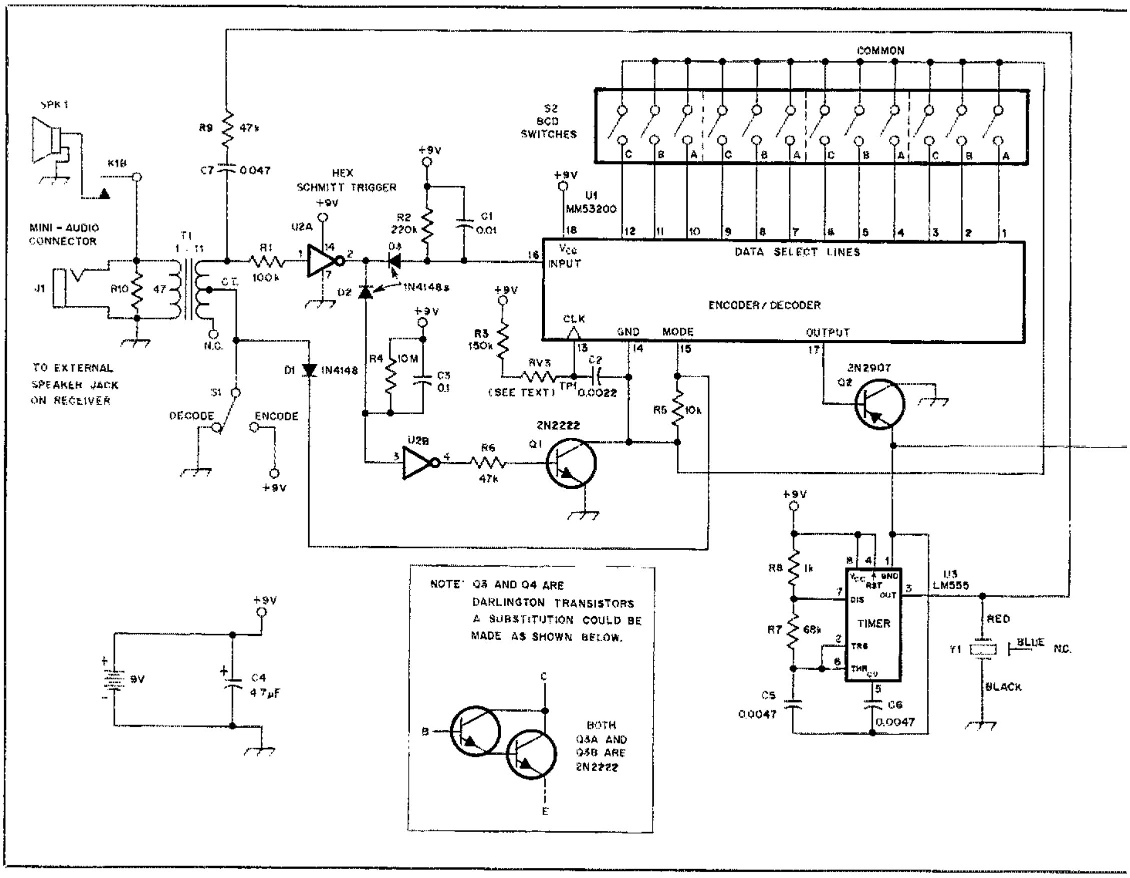


Fig. 2 — Schematic diagram of the NAD circuit. All resistors are 1/4-watt, 10% carbon-composition types.

C1 — 0.01-µF Mylar capacitor, 12 V.
C2 — 0.0022-µF Mylar capacitor, 12 V.
C3 — 0.10-µF disc capacitor.
C4 — 4.7-µF electrolytic or tantalum capacitor, 12 V.
C5 — 0.0047-µF Mylar capacitor, 12 V.
C6 — 0.0047-µF disc capacitor.
C7 — 0.047-µF disc capacitor.
C8 — 2.2-µF electrolytic or tantalum capacitor, 12 V.
C9 — 0.22-µF disc capacitor.
D1-D7 — 1N4148.
D8 — 1N4002.
DS1 — General-purpose LED.
K1 — 9-V spst relay (RS275-004).
Q1 — 2N2222 or equiv.
Q2 — 2N2907 or equiv.
Q3, Q4 — 2N6725 Darlington transistor or equiv.
R1, R12, R13 — 100 kΩ.
R2, R14 — 220 kΩ.
R3 — 150 kΩ.
R4, R11, R15 — 10 MΩ.
R5 — 10 kΩ.

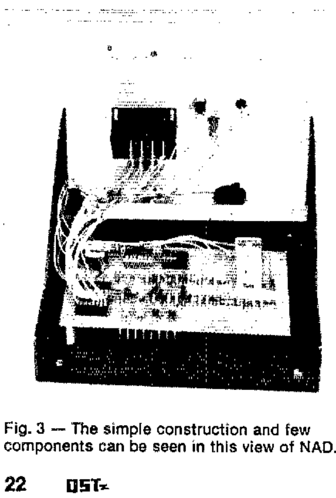


Fig. 3 — The simple construction and few components can be seen in this view of NAD.

using the code word to which your decoder is set.

Conclusion

This article describes how to build a pager transceiver based on the MM53200 IC. I hope that this information proves useful for those interested in the convenience that NAD can provide. I will be glad to answer any questions that readers may have, but please include an s.a.s.e.

If there is enough interest, I will offer a design of a unit that could be used at a repeater to convert the BCD (Binary Coded Decimal) data from a Touch-Tone[2] decoder to NAD signals so that only one NAD encoder would be needed for a repeater system. I would like to thank Philip Thompson, WB2EWB, for his help in reviewing and correcting this manuscript.

APPENDIX

Description of Code Words

Let the code word be partitioned into four groups of three bits each. Now the code word can easily be described as a four-digit octal number. The Most Significant Digit (MSD) would be composed of DSLs 10, 11 and 12, with DSL12 being the Most Significant Bit (MSB).

For example, assume the following code word:

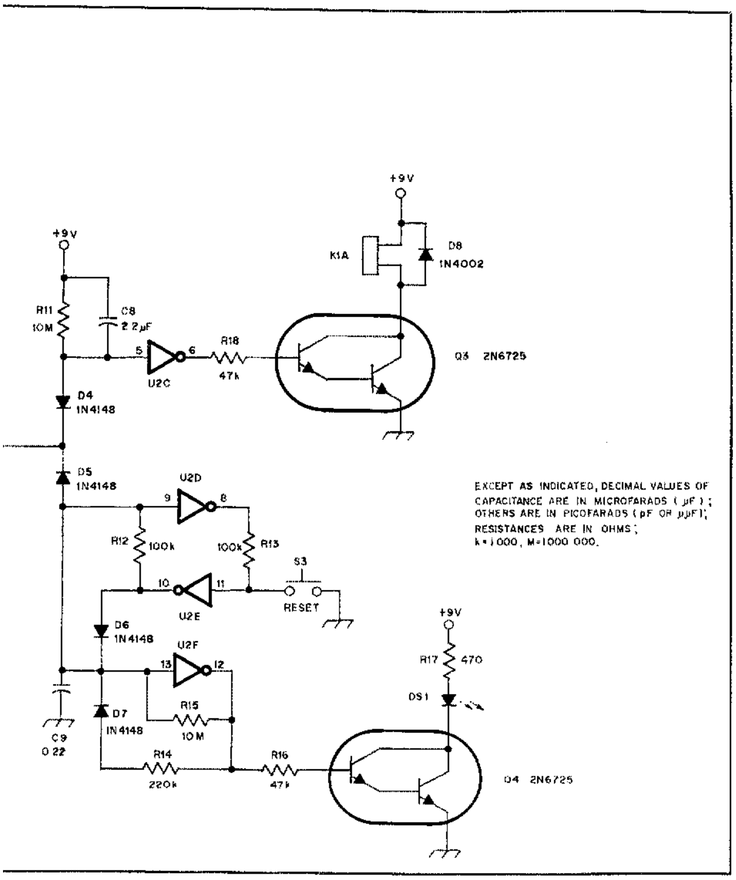
0 1 1 1 1 1 1 1 0 1 0 1 bits
12 11 10 9 8 7 6 5 4 3 2 1 DSLs

where, in the first row, 1 means DSL grounded and 0 means DSL floating.

To convert this to octal, partition the bits into groups of three. For example,

011 111 110 101

Within each group, assign the left bit the weight value, 4, the middle bit, 2, and the right bit, 1. Within a group, wherever a 1 occurs, add the corresponding weights together to



R6, R9, R16, R18 — 47 kΩ.
R7 — 68 kΩ.
R8 — 1 kΩ.
R10 — 47 Ω.
R17 — 470 Ω.
RV3 — 47 kΩ to start.
S1 — Spdt toggle switch.
S2 — 4-digit BCD switch, such as Jameco® SF21, (4) SF-EP (1 pair).
SPK1 — General-purpose speaker.
T1 — Transformer, 8-ohm primary, 1000-ohm ct secondary (RS 273-1380).
U1 — MM53200, National Semiconductor.
U2 — MM74C14, National Semiconductor.
U3 — LM555 timer.
Y1 — Piezo element (RS 273-064).

determine the value of that group. For example,

011	111	110	101
2+1=3	4+2+1=7	4+2=6	4+1=5

octal number is 3765

Selecting a Code Word

To determine which code word to use as your own, the following method is offered. Those who don't like this method are certainly free to select arbitrary code words.

To select an octal code word for your own call sign, you will need a calculator, but not necessarily a fancy one. Simply follow this procedure:

1) Write out your call as it appears on your license (no /7 or /RPT stuff!). Assign a position number above each character (increasing from left to right) and a value number below each character. Position starts with 1 and increments with each movement to the right. For values use 1-26 for A-Z and 30-39 for 0-9. For example,

position:	1	2	3	4
call sign:	A	D	7	I
value:	1	4	37	9

2) Multiply the value number by the position digit appended with the next three counting digits. Following these multiplications, underline only the *last* four digits of each calculation. For example,

character	*value*		*position*		*result*
A	1	×	1234	=	1234
D	2	×	2345	=	9380
7	37	×	3456	=	127872
I	9	×	4567	=	41103

3) Add each of these underlined values to create a new number. Again, underline the *last* four digits. For example,

1234 + 9380 + 7872 + 1103 = 19589

4) If the underlined part of the result is greater than 4031 (that includes 4032), subtract 4032 and continue doing so until the result is less than 4032 (zero is perfectly acceptable). This result is a code word, but it is expressed in base 10, not base 8 (octal). For example,

9589 − 4032 = 5557
5557 − 4032 = 1525

5) To convert to octal, divide the result by 512 and note (write down) the digit to the left of the decimal point. Next, subtract that digit from the displayed value, then multiply by 8. Again, note the digit to the left of the decimal point and subtract that digit from the display. Then multiply by 8. Note the digit, subtract and multiply by 8. The remaining number on the display should be rounded to the nearest whole number, and be written down. This sequence of four digits is the octal representation of the code word. For example, to convert 1525 to octal,

1525/512 = 2.9785156
−2.
0.9785156
×8.
7.8281248
−7.
0.8281248
×8.
6.6249984
−6.
0.6249984
×8.
4.9999872

Therefore, 2765 base 8 is equal to 1525 base 10. The octal code word is 2765. This is the number to be entered on the BCD thumb-wheel switches to set your code word.

An alternative to the BCD switches would be to use 12 spst switches (such as DIP switches). In this case the code word would have to be converted to the binary system, and the code entered by closing the appropriate switches.

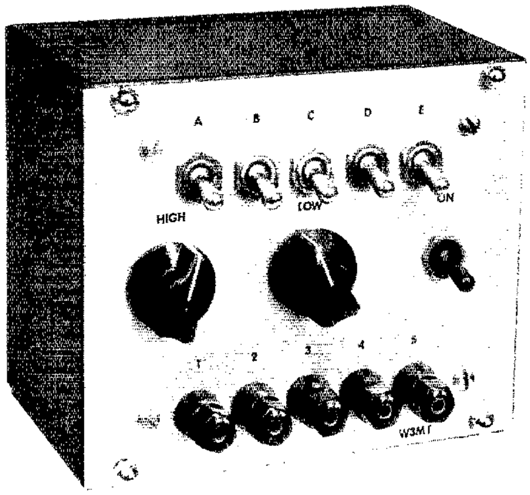
There are many call signs that will be mapped to the same code word. This is unavoidable. If you find that a code word is overused in your area, just pick another. This method of mapping call signs to code words only allocates those codes between octal 0 and octal 7677. Octal 7700 to octal 7777 are unused. This was done intentionally. The unassigned code words are available for repeater-system managers to assign as group calling functions. Some examples of these functions might be to call a regular net to session (some people are forgetful), or to begin an announcement of a serious weather alert, and so on.

A decoder that will respond to either of two (or more) code words can be constructed by paralleling the $+V_{cc}$, ground, input, output, and mode leads of another MM53200 to the present one. A second R-C network will be needed for the clock. Separate switches are required for the DSLs.

Notes

[1]Piezo element is the name Radio Shack gives to their piezo-electric transducer. NAD uses it to convert the electrical signals from U3 to an audio signal that the operator can hear.
[2]Touch-Tone is a trademark of American Telephone and Telegraph Co.

Construct a Simple L-C Audio Oscillator



"Turned off" by the high prices of test equipment? Spend an afternoon and a few dollars on parts, and build this oscillator. Make it the tone of your life!

By Frank Noble,* W3MT

For most amateur work an audio oscillator should have good waveform, a number of known and stable frequencies between 500 and 3000 Hz, low output impedance and continuously variable output voltage. Other desirable features are ground-isolated output, push-pull output, small size, battery operation, simplicity and low cost. It sounds like a lot to ask of a simple circuit, doesn't it?

The Circuit

This oscillator (Fig. 1) produces 32 frequencies by switching five capacitors across a 44-mH telephone toroid. Largely because of the coil quality, the waveform and stability are superb. The circuit has a grounded single-ended output of 9 V pk-pk or more, with a source impedance of less than 20 kΩ, and a ground-isolated push-pull output of at least 400 mV pk-pk per side, with a source impedance of less than 135 Ω per side. Both outputs are continuously variable, and the low impedance output uses a dual potentiometer to maintain balance-to-common in the push-pull mode. The circuit uses one JFET that draws less than 3 mA from two 9-V transistor batteries contained within the case.

The circuit, a modified Hartley oscillator, is self-biased by the dc restorer action of D1 and the coupling capacitor. Although the effects of D1 in reducing distortion and capacitance variation are probably not important here, it also reduces power consumption, and that *is* important! I included the 1-kΩ resistor in series with the gate as a precaution. It slows down the transistor so that high-frequency resonances in the long connecting wires will not see enough gain to cause trouble. The gate return is to the source, making the initial transconductance large, ensuring dependable starting. Should oscillation fail for any reason, the transistor dissipation at zero bias is within rating. Experimentally, I found that a resistor in the coil center-tap-to-source circuit improves the waveform. It also tends to maximize the output voltage, but I did not pursue the reasons for it functioning in this manner.

Since the impedance of the resonant circuit increases with the product of the frequency and the Q, and since the Q increases with frequency in this range, the impedance tends to increase with the square of the frequency, roughly, from 4 kΩ to about 200 kΩ. Our transistor would react to this by making the output increase markedly with frequency. Substituting a 5-kΩ potentiometer for the 50-kΩ unit will reduce the level variation, but the output voltage will be lower and the waveform at high frequencies will suffer.

The low-impedance output could be made even lower by substituting a dual, 100-Ω potentiometer, if available. Should the oscillator fail to start, increase the value of the 50-kΩ potentiometer a bit. Or, you can try reducing the 150-Ω resistor in the coil center-tap circuit.

The Functions

Thirty-two frequencies are available. Table I gives the switch settings and the corresponding frequencies produced. Although I used toggle switches, you can use the less expensive slide switches without degrading performance.

The 44-mH toroid acts as a step-down transformer to produce the balanced, low-impedance output. From Wetherhold's data[1] I deduced that the coil has a total of 536 turns. If we wish to obtain a line-to-line impedance 125 times less than the main coil impedance, we must wind 48 turns on the secondary, tapped in the center. I used no. 30 double-cotton insulated wire. Any small-gauge, insulated wire should work equally well. If care is taken while winding, the toroid will accept two uniform windings of 24 turns, one on each half-torus.

Start with 6 feet of wire, weight the far end with a solder loop, stand on a chair and guide the wire through the hole, keeping the turns closely spaced at the inside of the hole and as near radial as possible. (In theory, it does not matter how messy the winding is, but it is mechanically easier to handle a neat coil.) Be sure to continue the second winding in the same direction, so the adjacent ends may be joined to form

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[1]Notes appear on page 25.

the common output. Cement hose washers to the finished coil with 5-minute epoxy; this provides a stable pad so the coil may be mounted between a pair of washers by means of a bolt with an insulating sleeve. Alternatively, you can use double-sided tape to affix the coil.

The enclosure I used is steel, measuring 4 × 5 × 6 inches[2] (Bud CU-729 BR). A metal cabinet is desirable only for mechanical protection, since the toroid is self-shielding and the impedances are low. I used superior posts, because they were on hand. You can use an ordinary screw-terminal strip, which will work as well, even though it will be less convenient.

I mounted all parts (including the batteries) either on the panel or on a circuit board spaced off the panel. Using a pair of homemade aluminum brackets, I secured the batteries on opposite sides of the circuit board. Although I used Vector board with push-in, 0.042-inch round terminals, you can employ any convenient construction technique. Attach the capacitors to the circuit board by passing the leads through appropriate holes and bending them over. Pass connecting wires beneath these leads and solder. Make the panel easily removable by tapping the four holes in the box with 8-32 threads. Drive 3/8-inch screws in from the back. Slip the panel onto these studs and secure with knurled nuts. I replaced the steel panel with 1/16-inch aluminum, performed the metal work, labeled the panel with rub-on transfers, and spray-lacquered the labels down before assembling parts to the panel.

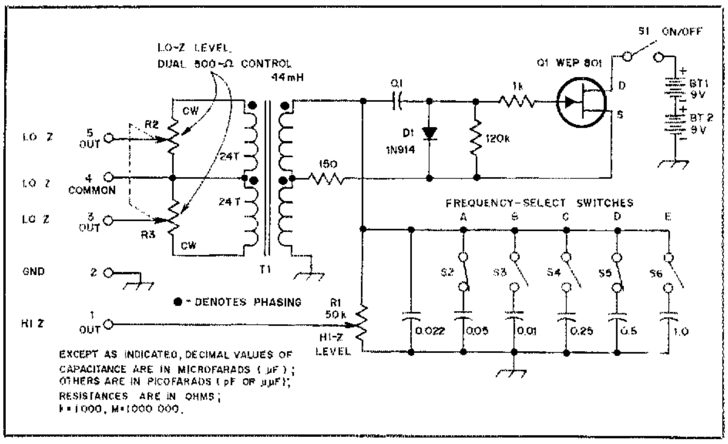


Fig. 1 — Schematic diagram of the tone oscillator. All capacitors can be any nonpolarized type, such as paper or Mylar.

BT1, BT2 — 9-V transistor battery.
D1 — Silicon, small signal, 10 mA, 75 PIV, 1N914 or equiv.
Q1 — JFET, small-signal vhf mixer and amplifier, 330 mW. WEP-801, 2N3821 or equiv.
R1 — Potentiometer, 50-kΩ (see text).
R2, R3 — Potentiometer, dual section, ganged, 500 Ω per section (see text).
T1 — Primary 44-mH toroid, secondary 48 turns, center-tapped, wound over primary (see text).

I glued a chart containing output connections and frequency vs switch-position information to the back panel. You can cut out Table 1 and use it. If any frequency less than 5.117 kHz is desired and not available by switching the internal capacitors, you may obtain it anyway. Set the high-impedance potentiometer full up and shunt the high output terminals with capacitance, such that the sum of the capacitors shunting the coil satisfies the relation

$$C = \frac{0.5761}{f^2} \quad \text{(Eq.1)}$$

where C is in μF and f is in kHz.

If adjustable phase is needed, the phase shifter[3] of Fig. 2 may be made from two parts. It shifts phase continuously throughout the shaded regions on the vector diagram, leaving two blank regions of about 5 degrees each. For frequencies other than 759 Hz, select C to satisfy the relation

$$C = \frac{0.759}{f} \quad \text{(Eq. 2)}$$

where C is in μF and f is in kHz.

If you need a two-tone signal, the ground-isolated output of this oscillator allows it to be series-connected with another signal source. This provides the simplest possible arrangement for combining the tones.

All this performance from such a simple circuit may be a lot to ask. This oscillator meets all requirements — and more! Can you afford to be without it?

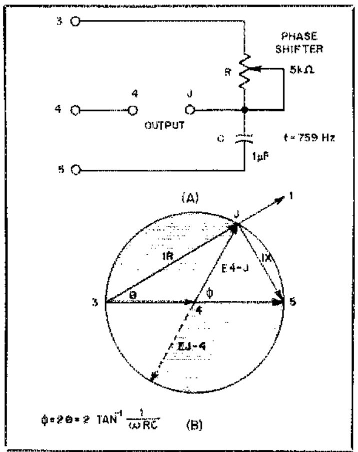


Fig. 2 — At A, schematic diagram of phase shifter. The 5-kΩ potentiometer can be any convenient style. The capacitor is any nonpolarized type (see text for value). The numbers refer to output terminals of the oscillator. At B, vector diagram of the phase shifter (see text for discussion).

Table 1

Switch Setting vs Output Frequency

Freq.	Switches On	C (μF)	Freq.	Switches On	C (μF)
547	ABCDE	1.922	790	ABCD	0.922
555	BCDE	1.872	813	BCD	0.872
562	ACDE	1.822	837	ACD	0.822
570	CDE	1.772	864	CD	0.772
587	ABDE	1.672	926	ABD	0.672
596	BDE	1.622	962	BD	0.622
605	ADE	1.572	1004	AD	0.572
615	DE	1.522	1051	D	0.522
636	ABCE	1.422	1168	ABC	0.422
648	BCE	1.372	1244	BC	0.372
660	ACE	1.322	1338	AC	0.322
673	CE	1.272	1455	C	0.272
701	ABE	1.172	1830	AB	0.172
717	BE	1.122	2173	B	0.122
733	AE	1.072	2829	A	0.072
751	E	1.022	5117	—	0.022

1 HI Z
2 GND
3 LO Z Line 1
4 LO Z Common
5 LO Z Line 2

$$f = \frac{759}{\sqrt{C}}$$

f is in Hz;
C is in μF

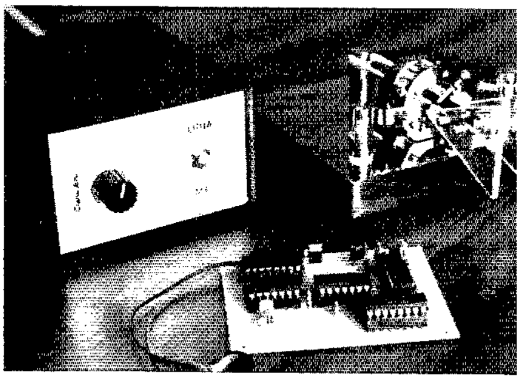
Notes

[1] E. Wetherhold, "Inductance and Q of Modified Surplus Toroidal Inductors," *QST*, September 1968, p. 36. The extrapolation assumes that the inductance of a toroid is proportional to the square of the number of turns. Within the range of Wetherhold's data, this assumption is borne out. Also, the voltage transformation of this oscillator provides further confirmation.

[2] mm = inches × 25.4.

[3] Chance, et al. *Waveforms* (MIT Radio Lab. Series: McGraw-Hill, 1949), p. 137.

A Digital CMOS Iambic Keyer



After reading the theory on this keyer circuit you may exclaim, "Why didn't *I* think of that!" Simple CMOS circuitry provides expensive performance at low cost.

By Ted Theroux,* N9BQ

This CMOS keyer contains only five ICs and still has features such as iambic and electronic bug operation, dot and dash memories, perfect weighting, 9-volt battery operation, solid-state positive and negative output keying, no ON/OFF switch and low cost. It can be built in one evening.

Theory of Operation

The heart of this keyer is a two-bit binary counter. This counter has four possible output values or states: 0, 1, 2 and 3. The state of the counter is decoded to determine if the transmitter is to be on or off. During state 0, the transmitter will be off. When sending a dot, the counter will go to state 1 and then return to state 0; during a dash it will go through states 1, 2 and 3 before returning to state 0 (see Fig. 1). These state loops establish a perfect dot/dash/space ratio of 1:3:1. Each state is entered for one time unit, and the length of the time unit is determined by the setting of the SPEED control.

To make the following explanation easier to follow, the keyer has been broken down into 10 sections (see Fig. 2). The input filter consists of bypass capacitors C1 and C2, and pull-up resistors R1 and R2. An iambic paddle is connected to it at points labeled INDOT and INDASH. Paddle closure will pull these inputs to ground.

Dot and dash memories are made up of U1, a quad dual-input NAND gate. These gates make two flip-flops, whose outputs are DOTM for the dot memory and DASHM for the dash memory. Grounding inputs INDOT or INDASH will set the dot and dash flip-flops, respectively. Each memory will be cleared by the memory-clear gate after its respective cycle is completed.

U2B is the sequence control flip-flop. This flip-flop is clocked on the transition from state 0 to state 1. The J and K inputs are connected to DOTM and DASHM, the dot/dash memory outputs. The output SEQ will be clocked high if DOTM is active, low if DASHM is active, and alternate high and low if both are active. The sequence control flip-flop will determine if a dot or dash cycle will be entered. If SEQ is high, a dot cycle will be made — if low, a dash cycle. Outputs SEQ and $\overline{\text{SEQ}}$ enable memory-clear gates U3A and U3D, respectively.

The memory-clear gates, U3A and U3D, will gate the memory-clear pulses (CLP) from U2A pin 1 to clear the dot and dash memories. If SEQ is high, the dot memory will be cleared; if $\overline{\text{SEQ}}$ is high, the dash memory will be cleared.

U4A is the clock-control gate. The input pins are connected to the output of the dot and dash memories. If either input DOTM or DASHM is high, the output will go low, removing the STOP signal from the clock and the counter.

The clock circuit consists of U4B and U4C, capacitor C3, resistor R3 and potentiometer R7. The clock output is forced low when the STOP signal is high.

Memory-clear pulses are generated by U2A and U3C. Pulses will only be generated when the keyer is in state 0 and the clock is on its rising edge. During state 0, $\overline{\text{S0}}$ will be low, causing U3C pin 10 to go high. With U2A pin 6 high, the rising edge of the clock at U2A pin 3 will cause pin 1 of U2A to go high. Since pin 1 is connected to the clear input of U2A, the flip-flop will clear itself once it is set. Therefore, CLP will be a very short positive pulse.

The state counter consists of U5 and U4D. Pin 1 of U5A carries the most significant bit (MSB) of the two-bit binary counter, and pin 15 of U5B carries the least significant bit (LSB) of the counter. These signals are labeled M and L, respectively. The state of the counter will change on the rising edge of the clock. The counter state is determined by the input to U4D pin 13. If this input is high, the count will be 1, 0; if it is low, the count will be 1, 2, 3, 0.

An output decoder, U3B, decodes the value of the counter. Its output is low during state 0 and high during state 1, 2 and 3. The output driver is used to convert the CMOS logic level of the state decoder to an output capable of switching a positive or negative voltage to ground.

An Example

Operation of the keyer will be explained by using the letter "A" as an example. Use the schematic diagram in Fig. 3 and the timing diagram in Fig. 4 as references. A "1" will indicate a high logic level, and a "0" will indicate a low level.

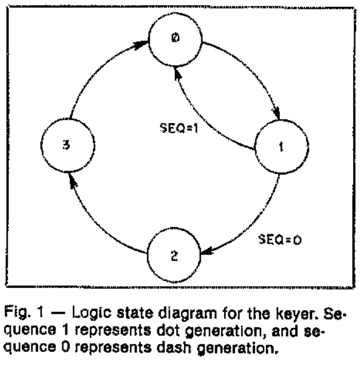


Fig. 1 — Logic state diagram for the keyer. Sequence 1 represents dot generation, and sequence 0 represents dash generation.

*26148 W. Mary Anne Rd., Antioch, IL 60002

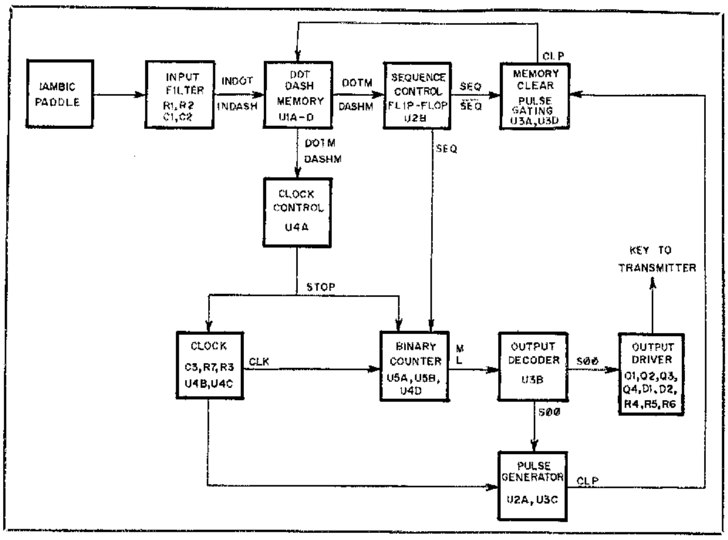


Fig. 2 — A binary counter forms the "heart" of the keyer design. See text for details.

When the keyer is in the idle state, it will be in state 0, with M = 0 and L = 0. The STOP signal is high since both the outputs of the dot and dash memories are low. The STOP signal forces the clock to a low level and enables the clear inputs to the counter — U5 pins 4 and 12.

For the letter "A," the dot paddle is activated, followed by the dash paddle, and then both are released. Let's begin by examining the operation of the keyer from the moment the dot paddle is initially depressed. The paddle pulls the INDOT signal low, which causes the dot memory to be set. DOTM will go high. With DOTM high, STOP will go low and the CLK will go high. The first rising edge of the clock will increment the counter to a count of one; therefore, L = 1 and $\overline{L}$ = 0. With U3B pin 6 low, S00 will go high, turning on the output driver and keying the transmitter. The U2B clock input is clocked on the low to high transition of the S00 signal. With DOTM = 1 and DASHM = 0, SEQ will go high, thus enabling the next clear pulse to be gated to the dot memory through U3D.

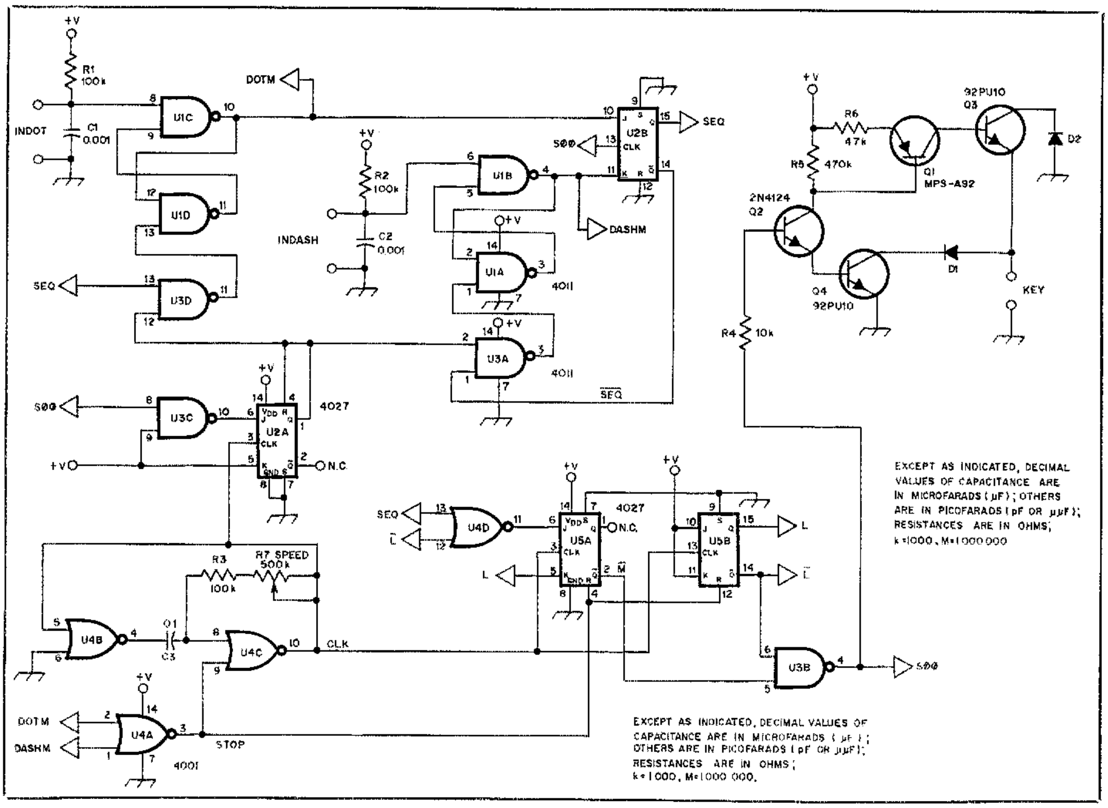


Fig. 3 — Digital CMOS keyer schematic diagram. All resistors are 1/4-watt, carbon-composition types. Capacitors are disc-ceramic 50-volt units, unless otherwise specified.

C1, C2 — 0.001 µF.
C3 — 0.1 µF.
D1, D2 — 1N4004 silicon diode.
Q1 — MPSA92.
Q2 — 2N4124.
Q3, Q4 — 92PU10 npn silicon medium-power. V_{ceo} = 300 V, IC = 30 mA and V_{cb} = 300 V.
U1, 3 — 4011 CMOS quad two-input NAND gate.
U2, 5 — 4027 CMOS dual J-K flip-flop.
U4 — 4001 CMOS quad two-input NOR gate.

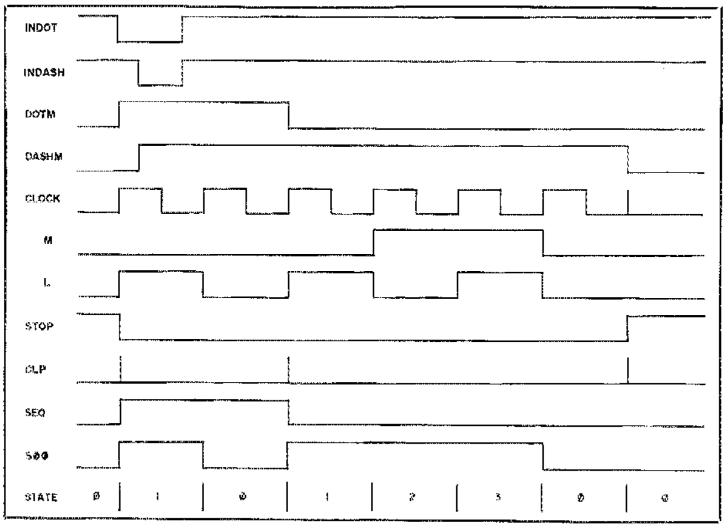


Fig. 4 — Timing diagram for the letter A. See text for details.

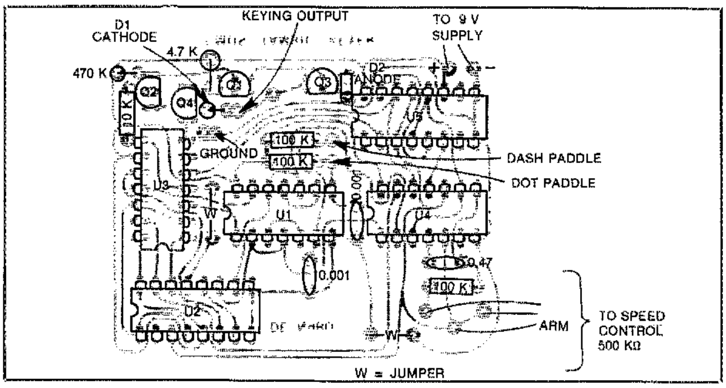


Fig. 5 — Parts-placement guide for the CMOS keyer. Parts are located on the nonfoil side of the board. The shaded area represents an X-ray view of the copper pattern.

With SEQ = 1, the J input to U5A pin 6 will be low. Therefore, on the second clock pulse, the counter will return to state 0 and the transmitter will be "unkeyed." Since the dash paddle was also depressed, DASHM = 1, which continues to disable the STOP signal and keeps the clock running. On the third clock pulse, a clear pulse generated by U2A (pin 1) is gated by U3D to clear the dot memory. The third clock pulse will also increment the counter to state 1, and again the transmitter will be keyed. On this second transition from state 0 to state 1, U2B will be clocked once again at pin 13. This time, since DOTM = 0 and DASHM = 1, the flip-flop will be reset and SEQ = 0. Now that SEQ = 0, the state counter will be enabled to go to state 2 on the fourth clock pulse, state 3 on the fifth clock pulse, and back to state 0 on the sixth clock pulse. Since the seventh clock pulse occurs during state 0, another clear pulse will be generated and, since S̄EQ = 1, the dash memory will be cleared through U3A. Now that DOTM = 0 and DASHM = 0, the STOP signal is enabled, the clock will be disabled, and the clear inputs to the state counter will be enabled.

Construction

All parts are mounted on a single printed-circuit board.[1] Other construction techniques such as point to point or wire wrapping can also be used. The keyer can be installed inside a small chassis box, or you may want to install it inside your rig. Power is supplied by a 9-volt battery or any dc source from + 7 to + 15 volts. The current drain in the key-down position is 2.5 mA at 9 volts. The output of the keyer is capable of switching voltages of + 300 V to − 300 V to ground with a maximum current of 55 mA.

For electronic bug operation, connect the dash side of the iambic paddle to the output of the keyer instead of to the DASHIN input. Do not connect the dash side of the paddle to both the DASHIN input and the output of the keyer at the same time. A switch could be added so you can select between iambic or bug operation. No rf shielding was used on the prototype, and no RFI problems have been encountered in the shack or in the field.

[1]Etched and drilled printed-circuit boards and complete parts kits are available for $12 and $25.95, respectively, postage paid from the author. The ARRL and *QST* do not warrant this offer in any way.

Strays

PALDEN THONDUP NAMGYAL, AC3PT

Palden Thondup Namgyal, AC3PT, the deposed King of Sikkim, died in New York in February 1982, following a prolonged illness. He was 58. The last Chogyal (maharaja) of Sikkim, Namgyal ruled that mountain kingdom on the southern slopes of the eastern Himalayas from 1964 to 1975, when he was forced to relinquish power and his kingdom was annexed by India.

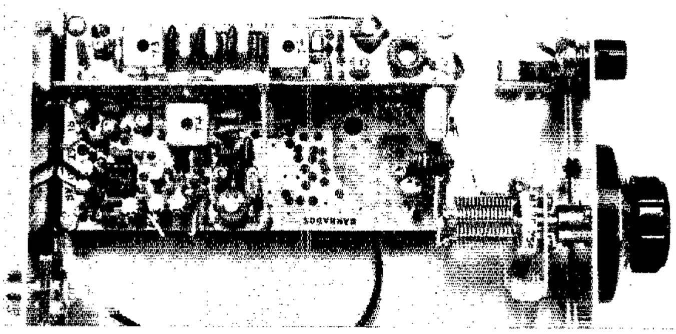
SILENT SIDE OF MAXIM

☐ There is an interesting article about H. P. Maxim in the February issue of *The American Rifleman.* Although Maxim's Amateur Radio pursuits are largely ignored, the article describes his work in developing the Maxim Silencer. There are lots of photos of Hiram and his son, H. H. Maxim, who played an important role in the early days of ARRL and Amateur Radio.

I would like to get in touch with . . .

☐ someone who can provide a schematic for a Code-A-Phone model 1400 phone recorder. Lee Allen, WB4DOR, P.O. Box 444, Madison, TN 37115.

Build a Bare-Bones CW "Superhet"



Low cost, minimum stage count and excellent cw selectivity are yours for 20-meter portable or QRP operation with the simple receiver in this article. Eliminate the frills and save $!

By Doug DeMaw,* W1FB

Tired of working with D-C (direct conversion) receivers because they do not provide single-signal reception? Because they are prone to common-mode hum? And how about problems with microphonics? If these are familiar laments, perhaps it's time to consider building a *superheterodyne* cw receiver for use in your portable setup. The foregoing maladies will no longer confront you with the circuit described here. It can be used on 40, 15 or 10 meters by changing the local-oscillator frequency and modifying the mixer input tuned circuit. No other changes are required. If the bare-bones format doesn't appeal to you, consider the circuit as a foundation to which you may add all manner of goodies, such as a speaker amplifier, rf amplifier, tunable L-C local oscillator or even agc.

Design Rationale

My objective at the drawing board was to develop a simple circuit that contained the minimum number of stages to yield acceptable performance in terms of sensitivity, dynamic range and overall gain for use with headphones. Other goals were good oscillator stability, easy availability of components and low current drain. These aims were realized with the circuit of Fig. 1. Cw selectivity is 260 Hz at the −6 dB points on the response curve, current drain is only 12 mA when using a 12-volt dc supply and there are but seven stages in the receiver. Overall gain is approximately 100 dB — more than ample for good headphone volume, even when copying weak signals. Finally, I wanted the receiver module to be relatively small. Bob Shriner, WAØUZO, made this possible with his pc-board layout, which was developed from my circuit diagram. He even included extra holes to accommodate an L-C type of local oscillator in place of the specified VXO.

Circuit Information

There is no rf preamplifier in the circuit of Fig. 1. If the receiver is to be used on 15 meters, I recommend adding the rf amplifier of Fig. 2 to improve the noise figure. This amplifier is not necessary for 40- or 20-meter operation, although some builders may want to include it for 20-meter reception if they operate in very quiet locations (low levels of man-made and atmospheric noise).

Signals from the antenna are fed directly to the mixer, Q1, through a simple front-end resonator (T1 and C1). The Q of the circuit is high enough to provide good selectivity, but not so high as to limit the desired response within any 50-kHz tuning range of 14 or 21 MHz. The trimmer (C1) is set for peak signal response in the center of the desired tuning range. A panel-mounted miniature air variable capacitor can be substituted at C1 for 40-meter operation. This is suggested because of the greater tuning range of the receiver with the L-C oscillator (200 kHz), and because the bandwidth of the input circuit will be half of that for 20-meter operation (assuming an identical value of Q for the resonator in each case).

The mixer and product-detector stages were chosen to provide gain; hence passive devices were not used at Q1 and Q3 of Fig. 1. This aids in minimizing the number of stages required for good overall gain.

A VXO (variable crystal oscillator) was my choice for the local oscillator in order to simplify the circuit and ensure high stability. Q4 of Fig. 1 operates as a series-tuned Colpitts oscillator, which provides a tuning range of roughly 30 kHz when using 17-MHz fundamental crystals.

*QST Senior Technical Editor

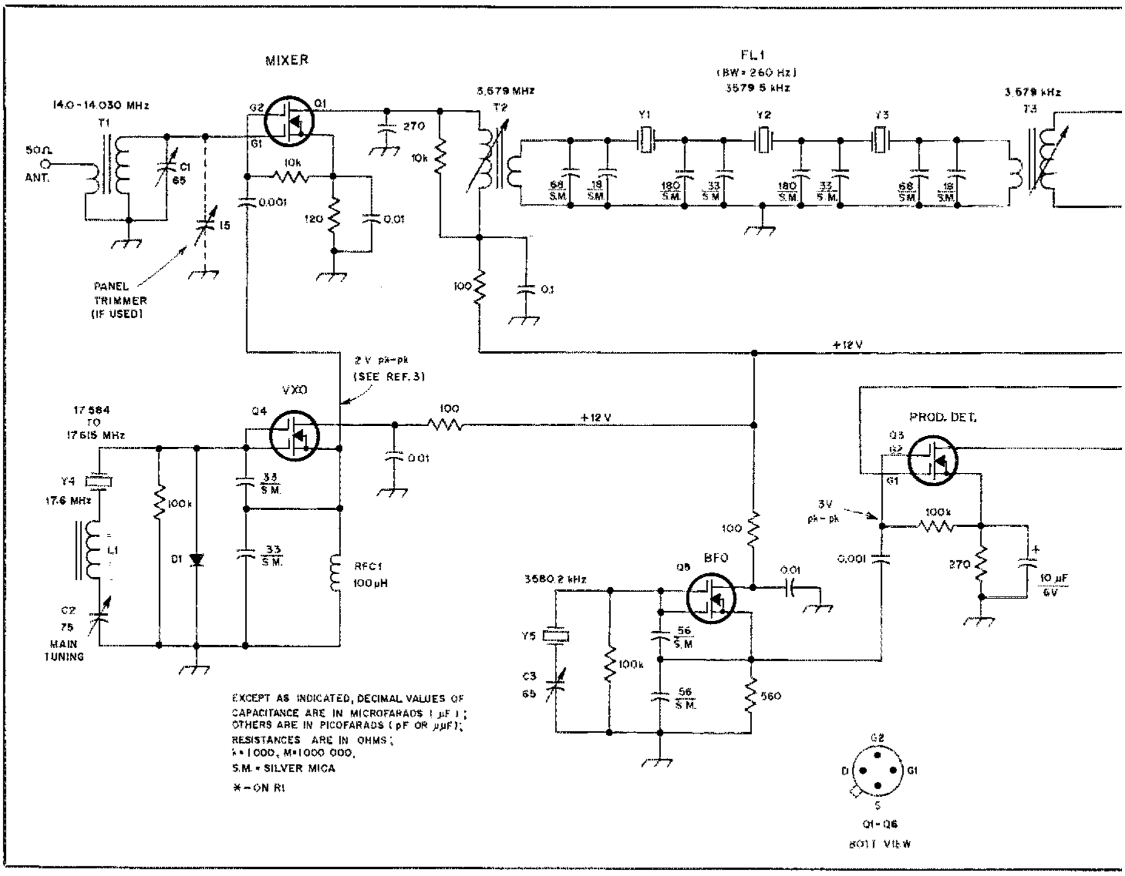
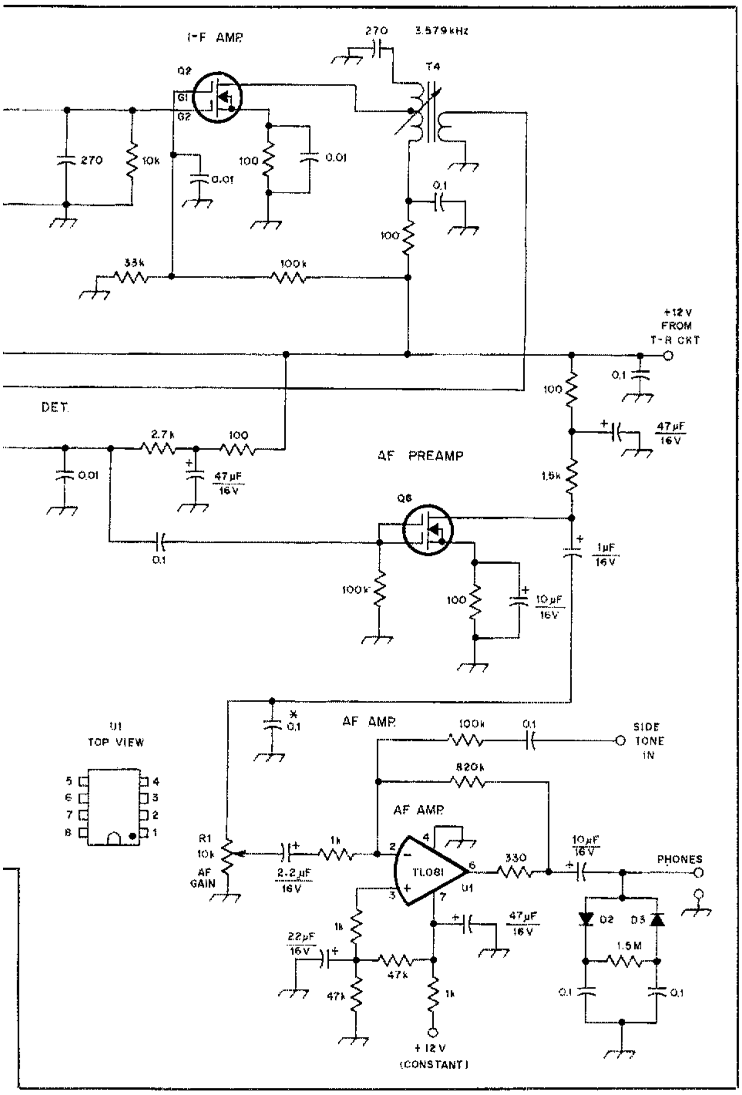


Fig. 1 — Schematic diagram of the simple superheterodyne receiver. Fixed-value capacitors are disc ceramic. Polarized capacitors are electrolytic or tantalum. Fixed-value resistors are 1/4- or 1/2-watt composition. S.M. indicates silver mica. NPO ceramic or polystyrene capacitors may be substituted for those with S.M. indicated.

C1 — PC-mount trimmer, except for 40 meters. Use panel-mounted air variable for 40 meters.
C2 — Miniature 75-pF air variable. Main tuning, use vernier drive.
C3 — Same as C1 for all bands.
D1 — Silicon diode, 1N914 or equivalent.
D2, D3 — Radio Shack Schottky diode, or equivalent.
FL1 — Ladder filter, 260-Hz bandwidth (see text).
L1 — 6-µH toroidal inductor. 36 turns no. 26 enam. wire on Amidon T50-6 toroid core. A_L = 47, powdered iron.
Q1-Q6, incl. — Dual-gate MOSFET, 40673 or 3N211. MPF102 or 2N4416 suitable for Q4, Q5 and Q6.
R1 — 10-kΩ, audio-taper, composition control.
RFC1 — Miniature rf choke, 100 µH. Value not critical.
T1 — Input transformer, toroidal. For 15 meters, 1.9 µH (20 turns no. 26 enam. wire over entire T50-6 core, link = 2 turns). For 20 meters, 3.2 µH (26 turns no. 26 enam. wire on T50-6 core, link has 2 turns). For 40 meters, 13 µH (51 turns no. 28 enam. wire on T50-2 core, link 5 turns).
T2, T3 — Miniature transformer, 4.7:1 turns ratio, 6.5 µH. (27 turns no. 28 enam. wire on bobbin of an Amidon [Micrometals] L57-2 transformer assembly. Use 6 turns for the link.)
T4 — Same as T2 and T3, but with the primary center tapped.
U1 — Op amp, 741 or Radio Shack TL081.
Y1, Y2, Y3, Y5 — Radio Shack TV color-burst crystal, 3.5795 MHz. Do not substitute without redesigning FL1 in accordance with Note 2.
Y4 — Fundamental crystal in HC-6/U-style holder. Same general range for 20 and 15 meters. Select for portion of the bands to be tuned. International Crystal Co. type 434110, 30 pF load capacitance, recommended (10 N. Lee St., Oklahoma City, OK 73102).

Overtone crystals (52.8 or 88 MHz) that have fundamental frequencies on or near 17.6 MHz can be used, but they will yield less tuning range. Also, they will commence oscillation somewhat lower in frequency than will the fundamental types. A 30-pF load capacitance should be specified when ordering Y4, and it should be in an HC-6/U style of holder. The tuning characteristic for C2 is nonlinear. That is, the rate of frequency change is much faster near the minimum-capacitance setting of C2, and the rate decreases as maximum capacitance is achieved.

The VXO can be used for 40-meter operation if the builder is willing to accept a limited tuning range — generally 5 to 10 kHz maximum. The amount of frequency shift varies with the crystal used, and is unpredictable, even when seemingly identical crystals are supplied by a given manufacturer. Large frequency spreads are possible by increasing the inductance of L1 (Fig. 1), but the circuit no longer functions as a true VXO. The oscillator degenerates to a conventional L-C type of device, and the frequency stability declines accordingly. You may want to experiment along these lines when building a 40-meter version of the unit. If ambient temperature changes aren't too severe, stability may be entirely acceptable. I did



not investigate this matter while testing the circuit.

I-F Filter

A major expense when building a narrow-bandwidth receiver is the i-f filter (FL1 of Fig. 1). In order to indulge my miserly ways, I chose a 3-pole ladder filter, designed for a 250-Hz bandwidth. Color-TV burst crystals are easy to obtain and are inexpensive, so I used them as filter elements. This provides an i-f of 3.5795 MHz, which of course rules out operation of the receiver on 80 meters. With the help of my colleague, Wes Hayward, W7ZOI, the four Radio Shack crystals (Y1, Y2, Y3 and Y5) I purchased were checked for unloaded Q and series resistance. These parameters must be known before calculating the values of the end and center capacitors in the filter. The correct terminal impedance is also derived from that information. W7ZOI has developed a computer program that "whistles" out the answers when the Q and series resistance of the crystal are known.[1] His program provided the values specified in this article. The Q of the Radio Shack crystals is 105-kΩ, and the series resistance is 38.6 ohms. To ensure minimum band-pass ripple, it is important to provide the computed terminal resistance for FL1 — 450 ohms. The end and center capacitors are nonstandard values. This requires using standard values in parallel at each point in the filter, thereby achieving the desired end result (85 and 212 pF). The primary of T2 and the secondary of T3 are bridged by 10-kΩ resistors to force a 450-ohm termination at each end of FL1. The required transformer turns ratio is 4.7:1, but a 5:1 ratio is acceptable from a practical point of view. FL1 should be in the $12 to $15 price range at current market rates.

[1]Notes appear on page 33.

Ladder filters yield an asymmetrical response, with the steepest skirt occuring on the high-frequency side of the curve. Best cw results will be had when the BFO is placed on the *high* side of center frequency — at 3580.2 kHz in this example, for a 700-Hz offset.

Y1, Y2 and Y3 should be very close in frequency to prevent excessive bandwidth and unwanted band-pass ripple (dips and peaks). My set of crystals were within 50 Hz of one another, which turned out to be acceptable. A simple crystal oscillator and a frequency counter can be used to check the crystal frequencies beforehand.

I-F Amplifier and Product Detector

A single i-f stage (Q2) is used. It has no agc applied, and operates at full gain all of the time. To aid stability of the amplifier, the drain is tapped down on the primary of T4. Output from T4 is coupled to an active detector, Q3.

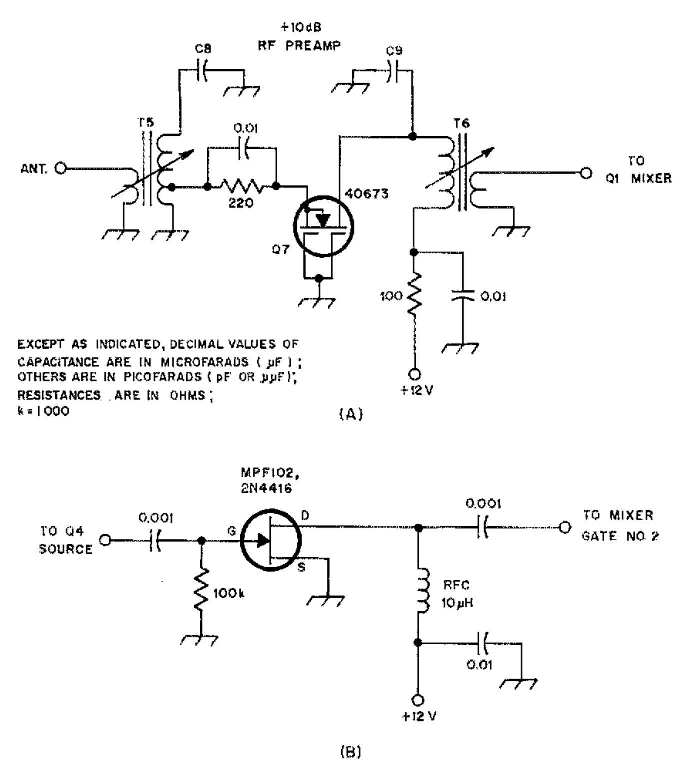
The fourth color-burst crystal, Y5, is used in the BFO (Q5). C3 was included to permit "rubbering" the crystal to 3580.2 MHz, thereby ensuring the 700-Hz offset discussed earlier. Tune C3 for a 700-Hz audio note peak.

Audio-Amplifier Section

A dual-gate MOSFET is used as the af preamplifier (Q6) to help establish a low noise figure in that part of the circuit. A 0.1-µF bypass capacitor at the high side of control R1 is used to roll off some of the high-frequency hiss in the receiver. This aids the overall noise figure of the receiver. Larger values of capacitance will further reduce the noise, but will cause some attenuation of the output signal.

A 40-dB-gain op amp (U1) serves as the headphone amplifier. A 1-kΩ resistor has been placed between R1 and pin 2 of the amplifier to prevent self-oscillation when R1 is at the extreme ends of its range. Oscillation will otherwise occur when using low-impedance phones with the receiver (8-ohm hi-fi phones in particular). The resistor prevents significant changes in the op-amp feedback when R1 is set for maximum or minimum audio gain. The 330-ohm resistor at pin 6 of U1 also aids the stability.

A self-adjusting audio limiter (D2, D3) helps to prevent very loud signals from "shattering" one's ears while tuning the



	C8	C9	T5	T6	Link
20 M	47 S.M.	47 S.M.	L-43-6 (2.6 μH) 18TS, tap 6 ts from gnd	L-43-6 (2.6 μH) 18 ts	2 ts
15 M	33 S.M.	33 S.M.	L-43-6 (1.7 μH) 15 TS, tap 5 ts from gnd	L-43-6 (1.7 μH) 15 ts	2 ts

Fig. 2 — Schematic diagram of the 15/20-meter optional preamplifier (A). See Note 3 for performance details of Circuit B. Capacitors are disc ceramic if not numbered. See table for other types. Resistors are 1/4- or 1/2-watt composition. S. M. indicates silver mica.

C4, C5 — See inset table.
Q7 — Dual-gate MOSFET, 40673 or 3N211. JFET may be substituted.
T5 — See table. Transformer assembly is an Amidon (Micrometals) L56-6 (yellow core). Use no. 26 enam. wire for the windings. Ground shield cans to pc-board ground.

receiver. Schottky diodes should be used to take advantage of the low barrier voltage (0.3 V). These can be purchased at Radio Shack stores. Silicon diodes, such as the 1N914 type, start to clip at 0.7 volt, which is too high for listening comfort. The limiter circuit can be regarded as poor man's agc. However, large signals will cause considerable audio distortion in U1 unless the gain control, R1, is used to reduce the gain to normal headphone level. This is the major trade-off for not including agc in the receiver circuit.

Construction

Circuit boards and complete parts kits for the receiver of Fig. 1 are available.[2] A scale pc-board pattern appears in the Hints and Kinks section of this issue of *QST*.

My version of the receiver will eventually become part of a 10-watt, 20-meter trans-receiver for portable use and camping. To that end I included an input line to pin 2 of U1 (Fig. 1), intended for introducing sidetone for cw monitoring. Also, the 12-volt line to U1 is separate from that which feeds the remainder of the receiver. This allows U1 to remain operational at all times (necessary for sidetone monitoring). The main 12-volt line can then be turned on and off via a T-R (transmit-receive) switching circuit in the mating transmitter. The antenna will be switched in a like manner.

Packaging can be tailored to your needs. If the lead from the antenna jack to T1 is more than 2 or 3 inches long, use miniature coaxial cable for the connection and ground the shield braid at both ends of the line.

Performance

This receiver is not intended as a high-performance or state-of-the-art example. Rather, the design was done to meet the objectives of simplicity, low cost and small size. The dynamic range is approximately what one would expect at 20 meters when a dual-gate MOSFET is used as a mixer (single-ended) and is not preceded by a low-noise rf amplifier. The MDS (noise floor) measured − 117 dBm. Blocking commenced at 96 dB, and the IMD number was 67 dB — not spectacular, but entirely adequate for the intended application.[3] This is still as good as or better than the numbers obtained when testing some pieces of commercial receiving gear in the ARRL lab.

Various segments of the band of interest can be tuned by changing crystals at Y4. In my case, I'm interested primarily in the range from 14,000 to 14,030 kHz. One crystal provides that coverage. The crystals will oscillate (C2 unmeshed) approximately 12 to 15 kHz higher than the marked value. This must be taken into account when ordering your crystal. This may not be true if other VXO circuits are used. Make certain that the rotor lug on C2 has a short lead between it and the ground foil of the pc board. If not, the VXO may perform poorly, and the tuning range may be restricted. The rotor should be grounded also to the receiver case or chassis.

Operation on 15 meters can be realized by using a crystal (Y4) in the same general range as for 20 meters. However, the receiver tuning will be backward from that on 20 meters.

A parts-placement guide is shown in Fig. 3. Information is given for a VFO that is suggested for 40-meter operation. The VFO circuit is presented in Fig. 4.

Although 10-meter operation is possible with all but the VXO, the limiting factor is the unavailability of fundamental crystals for the local-oscillator at the required 24,450 kHz frequency. The alternative would be to use a VXO crystal at half that frequency, then route the output through a doubler (push-push type preferred).

The receiver could be set up for 160 meters by changing the input tuned circuit and using a VFO in the 5.5 MHz range. By selecting the proper VXO crystal frequency and modifying T1, it would be practical also to employ the receiver on the WARC bands (10, 18 or 24 MHz).

Whatever your preference, the simple superhet can serve your portable needs in

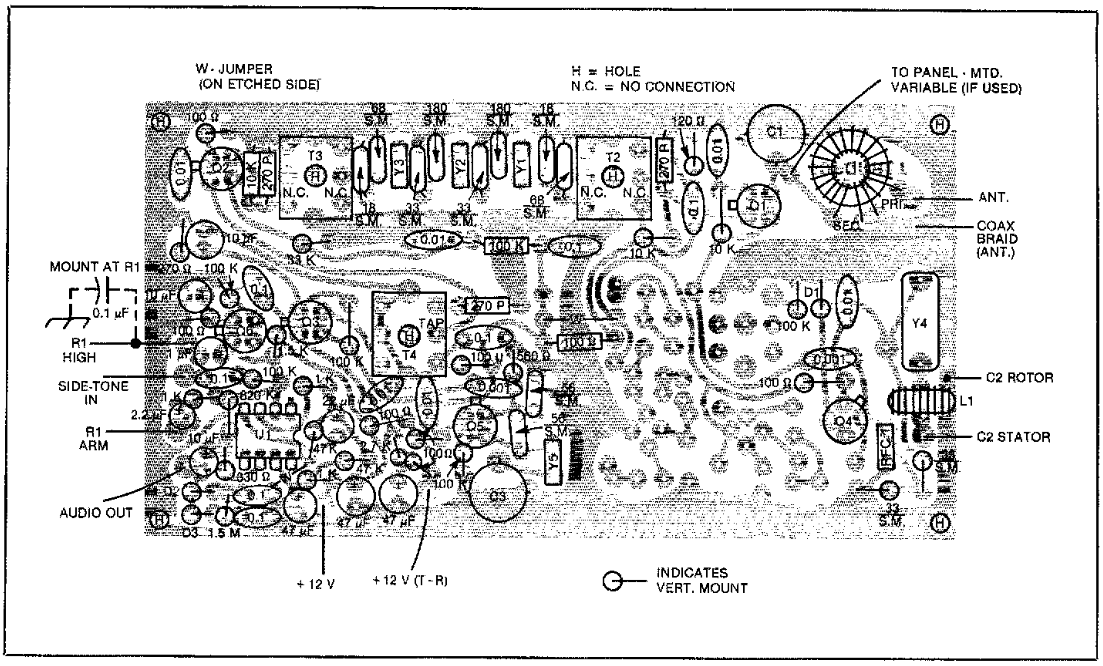


Fig. 3 — Parts-placement guide for the simple receiver. View is from component side of board. The LO section will accommodate the VXO of Fig. 1 or the suggested VFO of Fig. 4.

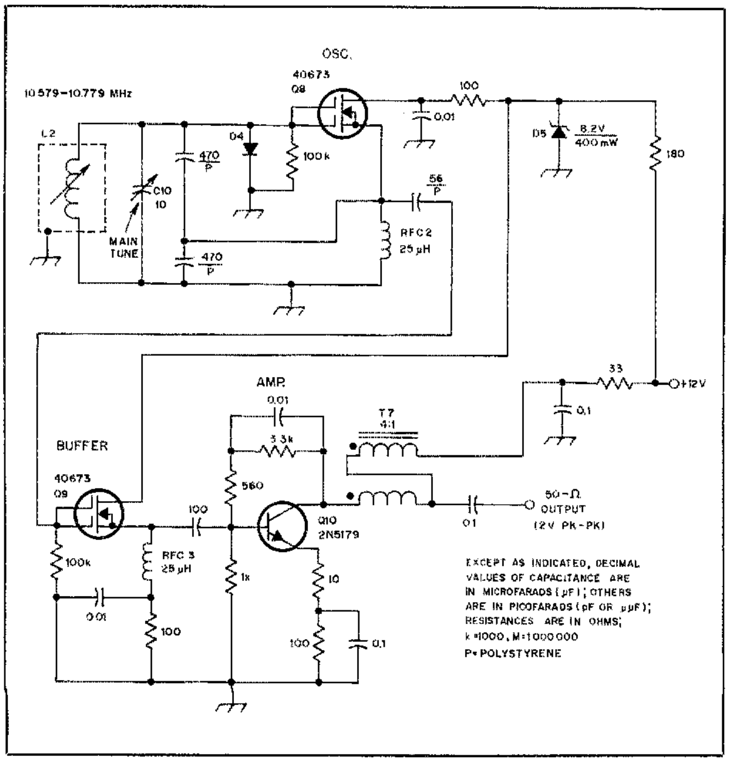


Fig. 4 — VFO circuit for use on 40 meters. With specified tuning range of Q8, coverage on 40 meters will be 7.0 to 7.2 MHz. Fixed-value capacitors are disc ceramic unless otherwise noted. Resistors are 1/4- or 1/2-watt composition.

C10 — Miniature 10-pF air variable, double-bearing type recommended for best mechanical stability.
D4 — Silicon diode, type 1N914.
D5 — Zener diode.
L2 — Inductor, 0.9 µH. Use 10 turns no. 24 enam. wire on bobbin of an Amidon L57-6 transformer assembly.
Q8, Q9 — Dual-gate MOSFET or 2N4416-family JFET.
RFC2, RFC3 — Miniature rf choke, approximately 27 µH.
T1 — Broadband, bifilar transformer, 4:1 impedance ratio. Use 10 bifilar turns of no. 24 enam. wire on Amidon (Fair-Rite) FT50-61 ferrite toroid core. Observe phasing dots when connecting to circuit.

fine style. Not only that, it provides a simple short-term workshop project for those who enjoy building homemade equipment.

Notes

[1]W. Hayward, "A Unified Approach to the Design of Crystal Ladder Filters," *QST*, May 1982, pp. 21-27.

[2]Negatives, pc boards and parts kits for this receiver are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002.

[3]The dynamic range can be improved by increasing the LO injection of the mixer from 2 volts pk-pk to 5 volts pk-pk. The latter is the prescribed level for optimum performance of the 40673 mixer. See Fig. 2B for circuit details.

An End-Fed Extended Double Zepp for 2 Meters

Add a bit of "Zepp" to your 2-meter signal. Build this inexpensive gain antenna that'll provide the coverage you need.

By Jim McDonald,* WBØJQH

The Zepp, double Zepp and extended double Zepp have been a part of the amateur's antenna repertoire for many years. The extended double Zepp offers some advantages over other antennas of simple construction, such as the dipole or ground plane vertical. It has approximately 3 dB of gain over a half-wavelength dipole[1,2] when center or stub fed,[3] is easy to feed with common transmission lines and is fairly broadband. An extended double Zepp is composed of two approximate 5/8 wavelength elements driven (usually) through a phasing section. The antenna exhibits gain over a half-wavelength dipole because of the addition of another element and the greater current-lobe spacing than would occur in a one-wavelength dipole (Fig. 1). In practical use, the conventional construction method has some disadvantages: no dc ground, and transmission line interaction with the lower radiating element, when the antenna is polarized vertically.

The end-fed version described here eliminates these problems. This feed method (Fig. 2) lends itself nicely to vertical operation. The transmission line is tapped along a shorted quarter wavelength matching section, or J-feed. This permits antenna and transmission line impedance matching and removes the feed line from the radiating plane. It also provides a dc grounding point for lightning protection.

The "Why"

This antenna was designed for accessing 2-meter repeaters in a 60-mile[4] radius, and occasionally a distant one about 100 miles away. These repeaters are scattered along the Front Range of the Rocky Mountains from above the Wyoming/Colorado border to south of Colorado Springs. No coverage to the east, the open plains, was needed. To obtain this pattern, I decided to ensure a little gain by properly spacing the antenna alongside the tower, using the tower as a reflector.

Construction

Assembling an antenna of this type is simple and inexpensive. Construction details are provided in Figs. 3, 4 and 5. Aluminum tubing or EMT (electrical metallic tubing) can be used. Check your local building supply store or junkyard for economical antenna materials.

A PVC center insulator is satisfactory with transmitter power inputs of up to 100 watts. If high power operation is anticipated, a better insulating material, such as Plexiglas, Lucite or ceramic should be substituted.

The completed antenna is spaced 16.25 inches (about 0.2 wavelength) from the

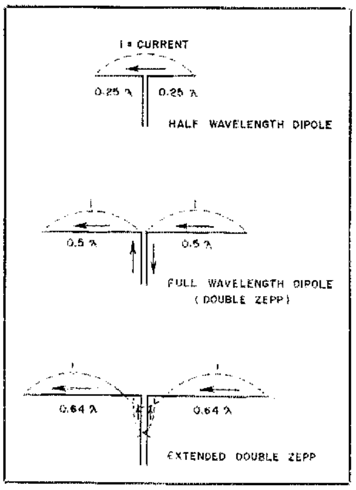


Fig. 1 — Current distribution for the various antennas discussed in the text.

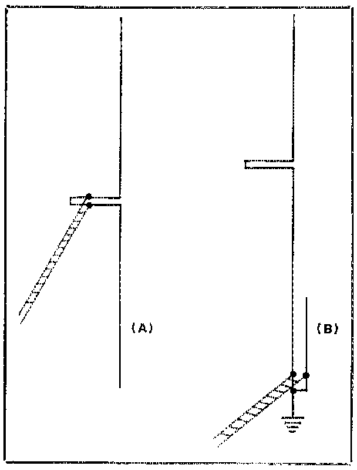


Fig. 2 — At A, the conventional arrangement for feeding the extended double Zepp. The end-fed or J-fed method is shown at B.

[1]Notes appear on page 35.
*P.O. Box 251, East Derry, NH 03041

tower on two brackets. These brackets are made of the same materials used for the antenna. The upper bracket has PVC tubing as an insulating sleeve and attaches to the upper element about 20 inches above the center. The lower bracket has no insulator and provides the dc ground through contact with the tower leg. Mounting details are shown in Fig. 6.

Feed Methods

I have used two methods of coupling the coaxial feed line to the quarter wavelength matching section: direct, unbalanced, coaxial feed, and balanced input using a bazooka or 1:1 coaxial balun.[5] There seems to be little difference in the performance of the antenna with either feed method, although the balanced input seems to "feel good" to me. Another amateur in the area has reported success using a 4:1 coaxial balun.

An SWR indicator is inserted in the feed line and observed while the transmission line is moved along the matching section rods. When the best match is obtained, the line is permanently attached to the rods with sheet-metal screws or compression clamps. In my installation these points are between 4 and 4.5 inches above the shorting strap at the end of the section. If the 4:1 balun is used, these dimensions will probably vary.

How Well Does It Work?

Now that the antenna is up, how does it fare against the competition? A wire version of this antenna was built and compared to a vertically polarized half-wave dipole. The antennas were connected to an antenna switch through equal lengths of RG-58/U coaxial cable. An rf step attenuator, similar to those described in *The Radio Amateur's Handbook,*[6] was inserted in the transmission line from the extended double Zepp. Signals were monitored using a 2-meter transceiver while I switched between the antennas. The attenuator was adjusted until the extended double Zepp showed the same S-meter reading as the dipole. With the Zepp in the clear (using no reflector) it showed approximately 3 dB gain over the dipole. This would correspond roughly to 4.5 dB over a ground plane. A slight reduction from the 3-dB figure was expected because of the end-fed system causing slight differences in the magnitude of the currents in the two radiating elements, but none was detected with the equipment used. When mounted on a mast and spaced 0.2 wavelength from it, the wire antenna showed the expected cardioid pattern and an additional 1 to 1.5 dB forward gain.

This antenna has proven to be quite effective. The desired repeaters can be accessed and good signal reports are received. Simplex operation is improved dramatically compared with similar operations using a J-pole antenna at the same height. Try the extended double Zepp. An antenna design that is almost as old as Amateur Radio itself, it's inexpensive and performs well.

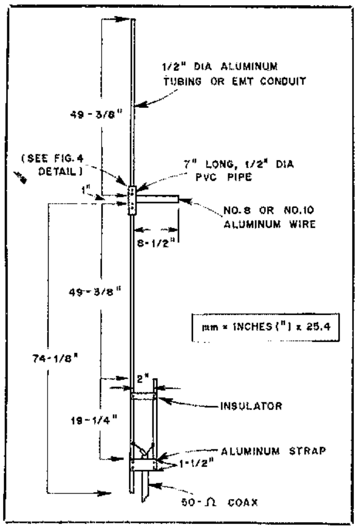


Fig. 3 — Construction of the end-fed extended double Zepp for 2 meters.

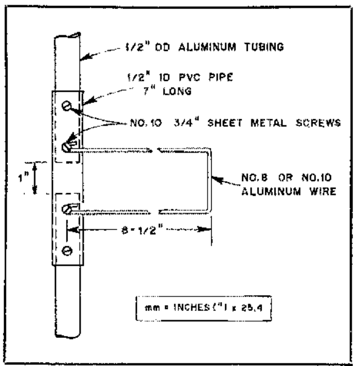


Fig. 4 — Center phasing section construction details.

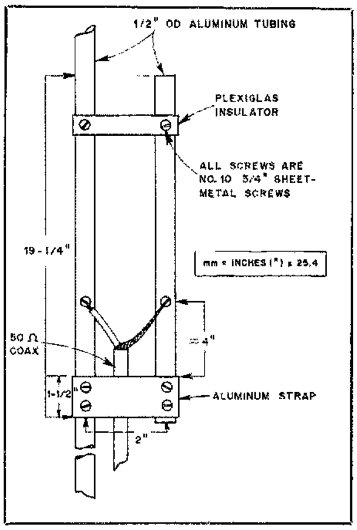


Fig. 5 — Quarter-wave matching section details.

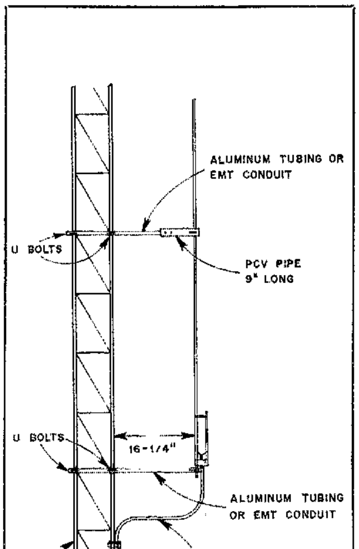


Fig. 6 — The method used in securing the extended double Zepp to the side of a tower. A section of PVC pipe is used to insulate the upper support from the antenna proper. The lower support provides a dc ground for the antenna (through the tower).

Notes

[1] *The ARRL Antenna Book,* twelfth edition (Newington: American Radio Relay League, 1970), p. 141.

[2] W. Orr, *The Radio Handbook,* twenty-first edition (Indianapolis: Editors and Engineers, 1978), p. 28.11.

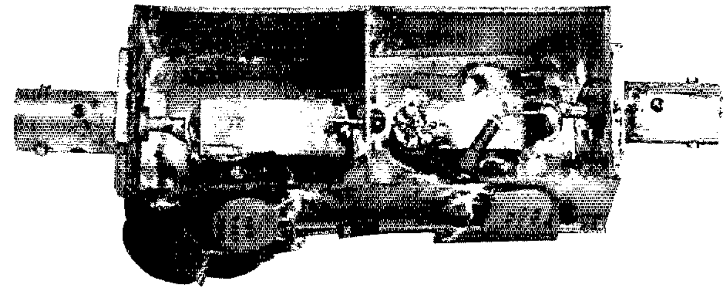
[3] *The Radio Amateur's VHF Manual* (Newington: American Radio Relay League, 1965), p. 173.

[4] km = mi. x 1.609, mm = in. x 25.4

[5] See note 1.

[6] *The Radio Amateur's Handbook,* fifty-eighth edition (Newington: American Radio Relay League, 1981), p. 16-38.

Low-Noise Preamplifiers for 1296 MHz



Plagued by poor "hearing"? Having trouble making the cost/performance trade-off? Here are some answers for 1296-MHz ops.

By Geoffrey H. Krauss,* WA2GFP

In many areas of the world, *all* the amateur bands below 1 GHz are relatively crowded. Many amateurs, seeking a new band to explore, are turning to the 23-cm band (1215 to 1300 MHz). Becoming active on this band is now fairly easy; antennas, transmitting equipment and receiving converters can all be purchased commercially. Equipment for the weak-signal portion of the band, centered around 1296 MHz, is particularly plentiful. One problem that has impeded the growth of activity on this band is the higher-than-desirable noise figures (poor "sensitivity") of the commonly available receiving converters. This can be a serious handicap because, as is often stated, "If you can't hear them, you can't work them!"

Most receiving converters fall into one of two types: the mixer-only converters, having a mixer and an i-f amplifier (possibly preceded by an image-rejection filter); and the single-rf-amplifier type of converter, having one preamplifier stage preceding the mixer. This type may have a post-mixer i-f amplifier, and often may not have an image-rejection filter between the preamplifier and the mixer. The mixer-only converters typically have noise figures of 6 to 15 dB, while single-amplifier types rarely have less than 3 dB noise figures. Therefore, the effective noise temperatures,[1] T_e, of such converters range between approximately 290 K and 9000 K. Generally, this is considerably greater than the external noise temperatures available at these frequencies. Only in the last few years, as relatively inexpensive devices for low-noise preamplifiers have become available, have noise figures below even 6 dB been obtainable at this frequency. An easy-to-build, low-noise preamplifier is often the most needed item in a 1296-MHz station.

[1]Notes appear on page 39.

*16 Riviera Dr., Latham, NY 12110

Required Preamplifier Characteristics

The total noise figure of a receiving system (Fig. 1), looking into the input of the added preamplifier, is given by

$$NF_s = 10 \log F_s \qquad \text{(Eq. 1)}$$

F_s, the system noise *factor*, is given by

$$F_s = F_p + \frac{(F_c - 1)}{G_p} \qquad \text{(Eq. 2)}$$

where F_p is the preamplifier noise factor, F_c is the converter noise factor and G_p is the numerical gain of the preamplifier.

Since gain is typically measured in decibels, and noise figure is always measured in decibels, the appropriate conversion formulas are

$$F_p = \log^{-1}(NF_p/10) \qquad \text{(Eq. 3)}$$

$$F_c = \log^{-1}(NF_c/10) \qquad \text{(Eq. 4)}$$

$$G_p = \log^{-1}(G_a/10) \qquad \text{(Eq. 5)}$$

Table 1 shows the system noise figure (NF_s) that results when a preamplifier with a gain of G_a and a stage noise figure of NF_p is used in front of a converter having an NF_c of 8 dB.

In addition to having a relatively low stage noise figure (no greater than 3 dB) and a high stage gain (typically, 10 dB plus the converter noise figure), the 1296-MHz preamplifier should also be easy to build. Other electrical characteristics, such as resistance to overload and IMD, need not be nearly as stringent as they are, for instance, on the 2-meter band. A relatively small bandwidth is often desirable, however, so that no additional filtering is needed prior to the preamplifier. Any insertion loss in front of the preamplifier, such as that of a band-pass filter (or feed line), will add directly to the system noise figure (and effective noise temperature). It is extremely desirable to mount the preamplifier, along with the T-R and receiver-protection relays, as close to the antenna as possible.

Results

Over a period of three years, I have built 47 individual 1296-MHz preamplifiers, using 25 different devices or combinations of devices. The results obtained with both microstrip and π-network preamplifiers are listed in Table 2, while the noise figure versus gain characteristics for the various devices and device combinations are plotted in Fig. 2.

The device column of Table 2 lists the

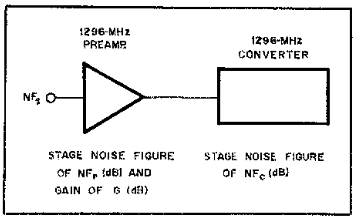


Fig. 1 — Receiving system block diagram.

Table 1

Total System Noise Figures

Preamp. Noise Figure, NF_p (dB)	*Preamp. Gain, G_a (dB)*	*System Noise Figure, NF_s (dB)*
3	12	4.2
2	12	3.5
1	12	2.8
3	15	3.6
2	15	2.8
1	15	2.0
3	18	3.3
2	18	2.4
1	18	1.5

manufacturer's full device designation; where a pair of devices was used, the input device is listed first. The next two columns list the approximate cost, as best as could be ascertained, and the manufacturer of the particular device, or combination of devices. Almost all of the tested devices, with the exception of the BFR series, are types unique to a single manufacturer.

The preamp noise figures (NF_p) have been calculated from the measured system noise figures (NF_s), using Eqs. 1 and 2. Noise-figure measurement accuracy is believed to be $-0.1/+0.3$ dB for the particular test setup used. The associated gain, G_a, is the gain measured (with an accuracy of ± 0.2 dB) after the stage had been tuned for best noise figure (as listed in the previous column). Tuning a particular preamplifier for maximum gain will typically provide from 1 to 6 dB of additional gain, but at the expense of a deterioration in noise figure. The reverse gain, G_r, is the gain from preamplifier output to input, when tuned for best noise figure. This parameter is occasionally important when a preamplifier is inserted in front of a mixer-only type of converter, as it is used in determining the attenuation of local oscillator feed-through from the local-oscillator chain to the station antenna. G_r is also used to calculate the gain margin,[3] G_m, which is a measure of preamplifier stability, and should be as large as possible. The preamplifier noise measure, M, is an indication of the lowest system noise figure that is obtainable with several identical preamplifiers connected in series. As the lowest noise-figure preamplifier is almost always used as the first stage, noise measure M yields a lowest practical noise figure for a system having that particular preamplifier as the first stage.

The cost factor (X) is the product of the preamplifier noise measure (M) and the cost (C) of the device and may be used as a guide to device selection. For example, both the MGF1400 and the NE24483 have approximately the same stage noise figure (NF) and noise measure (M) but have different cost factors (X) due to the lower price of the MGF1400. The cost factor (X) and the associated forward gain (G_a) are approximately the same for a single MGF1400 stage and a dual NE02135 stage, yet the latter has a noise figure over 2 dB higher. The bandwidth (BW) for the

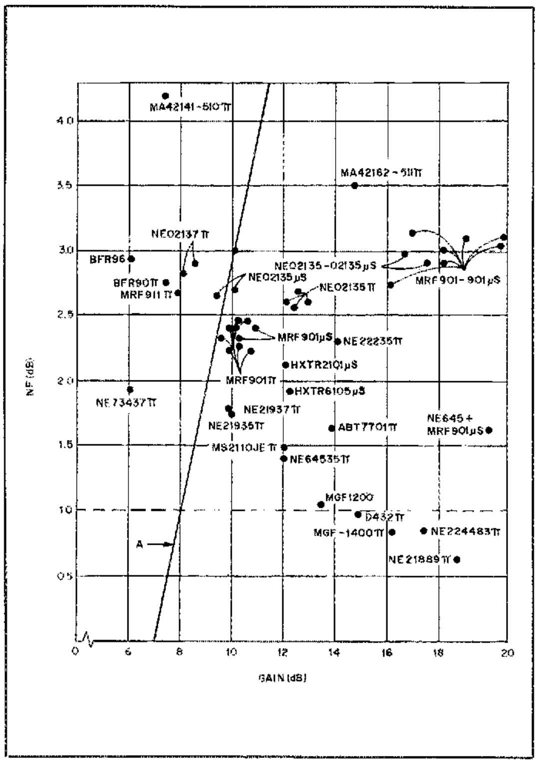


Fig. 2 — Graph of noise figure versus forward associated gain of each device tested. Line A establishes the minimum gain, at each noise figure, required to overcome the effect of a subsequent stage with a 6-dB input noise figure.

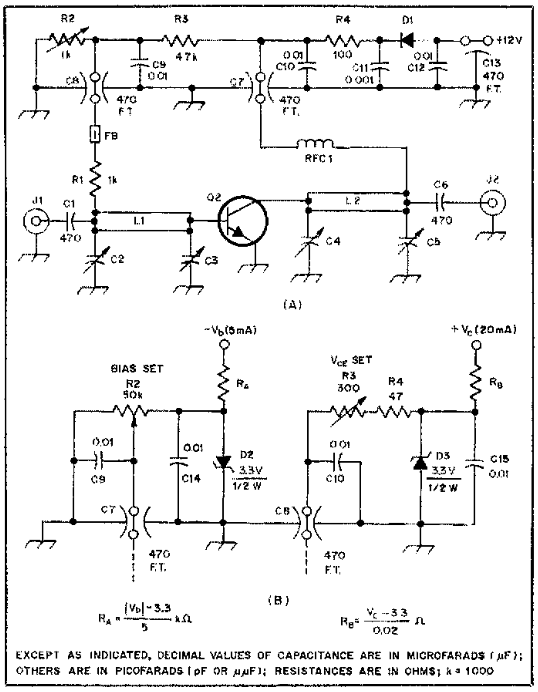


Fig. 3 — Schematic diagram of the Universal 1296-MHz Preamplifier. This circuit can be used with any of the devices discussed in this article. The bias circuit for bipolar transistors is shown at A, while the circuit for use with GaAs FETs is shown at B. All resistors are 1/4-W, 5%-tolerance carbon types.

C1, C6 — Chip or leadless disc type (see text).
C2-C5, incl. — 0.8- to 10-pF microwave-type piston trimmers.
RFC — 8t. no. 28 enameled wire, 0.1-inch ID.

Table 2
1296-Preamplifier Data

Device(s)	Cost ($)	Mfr.†	NF (dB)	G_a (dB)	$-G_r$ (dB)	G_m (dB)	M (dB)	X (M × C)	BW (MHz)	Ckt.	Remarks
NE21889	75.00	NEC	0.62	18.7	27.0	8.3	0.63	47.09	40	pi	GaAs FET
MGF1400	23.50	MIT	0.82	16.2	23.0	6.8	0.84	19.74	45	pi	GaAs FET
NE24483	35.00	NEC	0.83	17.4	27.0	9.6	0.84	29.40	50	pi	GaAS FET
D432	25.00	DXL	0.97	14.9	22.0	7.1	1.00	24.97	90	pi	GaAs FET
MGF1200	13.00	MIT	1.03	13.6	21.0	7.4	1.07	13.91	60	pi	GaAs FET
NE64535	7.50	NEC	1.40	12.0	16.0	4.0	1.48	11.10	60	pi	Cer., 2 emit.
MS2110JE	15.00	TI	1.49	12.0	18.0	6.0	1.57	23.55	140	pi	Cer., 2 emit.
NE64535 + MRF901	10.05	NEC – MOT	1.61	19.9	37.0	11.1	1.62	16.28	160	μS	WA2AAU design
ABT7701	25.00	A	1.63	13.8	27.0	13.2	1.69	42.65	120	pi	Cer., 2 emit. (NLA)
NE21935††	4.50	NEC	1.74	9.9	19.2	9.3	1.90	8.55	180	pi	Cer., 2 emit.
NE21937††	4.00	NEC	1.79	9.8	13.0	3.2	1.96	7.84	100	pi	Pl., 2 emit.
HXTR-6105	28.00	HP	1.81	12.2	24.0	11.8	1.96	53.20	50	μS	Cer., 2 emit., note 3
NE73437	3.30	NEC	1.92	6.0	12.0	6.0	2.41	7.95	>200	pi	Pl., 2 emit.
HXTR-2101	18.00	HP	2.11	12.0	21.0	9.0	2.39	43.02	50	μS	Cer., 2 emit., note 3
MRF901	1.55	MOT	2.23 – 2.47	9.5 – 10.7	16.3 – 16.8	5.6 – 6.8	2.49 – 2.59	3.94 – 3.98	120 – 130	pi	Pl., 2 emit., 8 samples
MRF901	1.55	MOT	2.32- 2.40	10.2- 10.8	16.8- 16.5	6.6- 5.5	2.51- 2.56	3.88 – 3.97	>200	μS	Pl., 2 emit., 2 samples, note 7
NE22235	11.00	NEC	2.30	14.0	26.0	12.0	2.37	20.07	115	pi	Cer., 2 emit. (NLA)
BFR-91	3.00	AMP	2.49	7.6	14.0	6.4	2.87	8.61	100	pi	Pl., 1 emit.
NE02135††	3.50	NEC	2.56 – 2.68	12.1 – 12.9	20.0 – 24.0	7.9 – 12.2	2.72 – 2.76	9.52 – 9.66	100 – 130	pi	Cer., 2 emit., 5 samples
NE02135	3.50	NEC	2.65 – 2.70	9.3 – 10.0	19.5 – 22.0	10.2 – 12.0	2.91 – 2.92	10.17 – 10.21	>200	μS	Cer., 2 emit., 2 samples, note 8
MRF911	2.00	MOT	2.67	7.8	17.4	9.6	3.05	6.10	150	pi	Pl., 2 emit.
BFR-90	2.70	AMP	2.75	7.3	17.3	10.0	3.19	8.62	100	pi	Pl., 1 emit.
MRF901 + MRF901	3.10	MOT	2.72 – 3.10	16.0 – 20.5	32.0 – 40.0	14.9 – 23.2	2.77 – 3.22	8.59- 9.98	>200	μS	WA2AAU design, 7 samples
NE02137††	3.00	NEC	2.82 – 2.89	8.0 – 8.5	12.5 – 12.9	4.5 – 4.4	3.19 – 3.22	9.58 – 9.67	100 – 105	pi	Pl., 2 emit., 2 samples
NE02135 + NE02135	7.00	NEC	2.97	16.6	40.0	23.4	3.02	21.14	>200	μS	note 8
BFR-96	4.30	AMP	2.93	6.0	16.5	10.5	3.60	13.44	120	pi	Pl., 1 emit.
MA42162-511	18.00	MA	3.50	14.7	18.0	3.30	3.60	64.50	140	pi	Cer., 2 emit.
MA42141-510	15.00	MA	4.22	7.3	14.0	6.70	4.8	71.96	140	pi	Cer., 2 emit.

†Device manufacturers are:

A — Aertech Industries, 825 Stewart Dr., Sunnyvale, CA 94085.
AMP — Amperex Electronic Corp., Slatersville Div., Slatersville, RI 02876.
DXL — Dexcel, Inc., 2285-C Martin Ave., Santa Clara, CA 95050.
HP — Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, CA 94304.
MOT — Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, AZ 85036.
MA — Microwave Associates, Inc., Bldg. 4, South Ave., N.W. Industrial Park, Burlington, MA 01803.
MIT — Mitsubishi. Small quantity orders to Applied Invention, RD 2, Rte. 21, Hillsdale, NY 12529.
NEC — NEC, c/o California Eastern Labs, 3005 Democracy Way, Santa Clara, CA 95050.
TI — Texas Instruments, Microwave Semiconductors, P.O. Box 5012, Dallas, TX 75222.

††NE21935 and NE21937 are the same device in different packages. The same is true of NE02135 and NE02137.

particular stage is also listed, as is the type of design used (π-network or a microstrip). Note that most, but not all, microstrip designs yield a much greater bandwidth. The microstrip design for the HXTR-6105 and HXTR-2101, a Micro-comm Amplifilter,[3] utilizes a two-pole band-pass filter in the preamplifier output circuit to obtain the relatively narrow bandwidth listed.

Finally, a remarks column indicates which are GaAs FET devices, whether the package is ceramic or plastic (for the bipolar units), the number of emitter electrodes and some additional information. Two of the devices, available when this program began, have been superseded by better and less costly semiconductors and are no longer available (NLA). Where appropriate, references to the microstrip circuits appearing in other articles, and used for particular preamps, are indicated.

Some Notes About Device and Circuit Selection

The better microwave devices generally have a ceramic package; units having identical transistor chips in different packages (ceramic and plastic) are indicated in Table 2 for comparison. In general, the use of the π-network design will provide slightly lower noise figure than a microstrip design, because of lower insertion loss in the air-dielectric π-input circuit.

The use of a transistor having a pair of emitter (or source) leads is desirable at this frequency; all of the GaAs FET units have dual, opposed source leads. A recent article[4] describes a 1300-MHz preamplifier, using an NE138 GaAs FET device (in the $130 price class) that achieves a less than 0.5-dB noise figure (and about 0.2 dB noise figure when cryogenically cooled) by using additional source lead inductance to help obtain noise match. It is relatively difficult in home-built preamplifiers to solder the source/emitter leads of any transistor to ground without lead inductance at this frequency. Because of this, all the preamplifiers shown here have some small source/emitter inductance present. No attempt was made to optimize this inductance.

A "Universal" Preamplifier

The initial preamplifiers were built using microstrip techniques for input noise matching, output gain-matching and bias circuitry. However, it became apparent to me that modern transistors, particularly the GaAs FET devices, did not benefit from the additional loss in the input noise-matching circuit. This is a result of the dissipation in the microstrip dielectric. A "universal" preamplifier structure, utilizing input and output π networks, was designed, fabricated and used for most of the preamplifiers built during the last year of my program. A schematic diagram of the preamplifier is shown in Fig. 3, while Figs. 4 and 5 illustrate the construction of this preamplifier.

Similar dual π-network designs have been utilized by others.[5] It is used here because of the relative ease of construction and also because every unit tested could be optimally noise- (and power-)

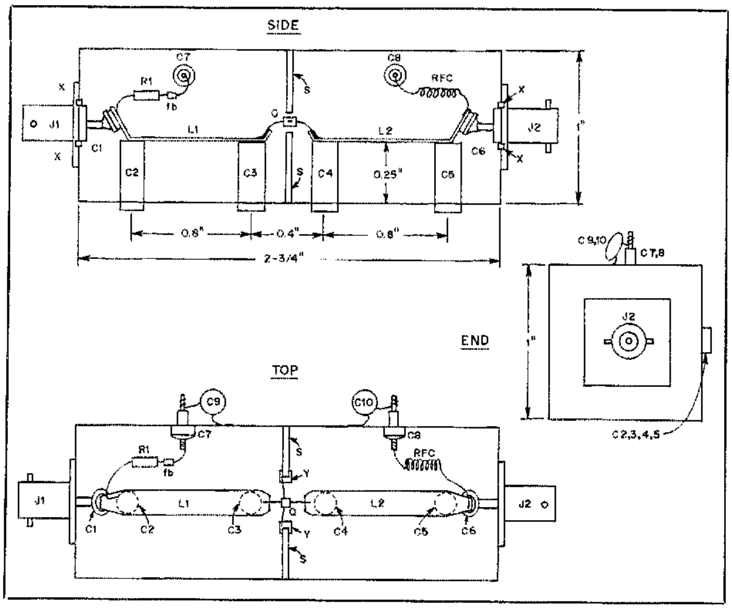


Fig. 4 — Physical layout of the preamplifer. mm = inches (") × 25.4.

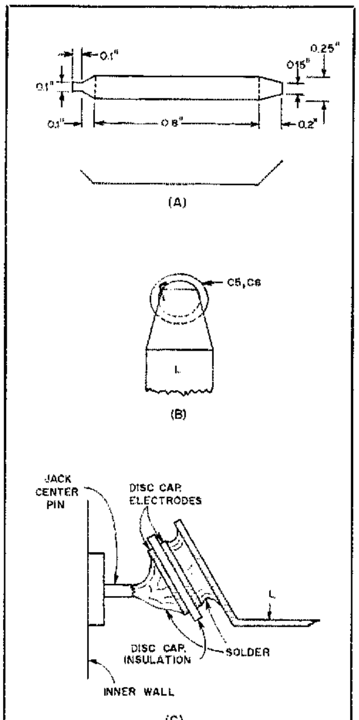


Fig. 5 — The strip-line inductors are formed as shown at A. The attachment of the inductors to the leadless disc capacitors is shown at B (end view) and C (side view). mm = inches (") × 25.4.

matched with the component values shown. It should be noted that, if capacitors C2 and C5 were increased to a maximum value of about 20 pF, a 50-Ω source/load impedance match to almost any real transistor input/output impedance can be obtained. The use of an additional 10-pF chip capacitor (shunting C2 or C5) was not, however, found necessary in any preamplifier tested thus far.

Construction Procedure and Hints

A five-sided box was initially built of double-sided pc board. Holes were formed in the end pieces for the connectors, J1 and J2; in one side piece for the feed-through capacitors, C7 and C8; and in the bottom piece for mounting the π-network capacitors, C2 through C5. A number of copper-foil strips were passed through the connector openings (X in Fig. 4) and soldered to the inside and outside copper to maintain ground continuity. The connectors were soldered to the outside copper cladding of the box and the π-network capacitors were then placed in position and soldered to the inside and outside ground planes. The shield, S, is fitted to the inside of the box, and the location for a hole is marked between capacitors C3 and C4, at a height such that the transistor, having its collector lead passing through the hole, will lie slightly above the free ends of the trimmer capacitors. A pair of copper-foil strips (Y in Fig. 4) are passed through the hole and soldered on both sides. Of course, if you make your shield of copper sheet the foil strips are not necessary. The shield is soldered in place, midway between capacitors C3 and C4. The feed-through capacitors, C7 and C8, are then soldered to both the inner and outer ground planes. All of this soldering requires a relatively high-wattage (greater than 100-watt) iron, and some softening of the solder seals on the trimmer capacitors may occur. It would be preferable to enlarge the box so that the width is about 2 inches, while the 1-inch height and 2-3/4-inch length remain the same. The added width would allow more room to maneuver a high-wattage soldering iron without destroying expensive piston capacitors. The effect of the wider wall spacing upon inductances L1 and L2 is minimal; the dimensions of the inductance strips and the 1/4-inch height above the ground plane are much more critical.

Strip inductors L1 and L2 are formed as shown in Fig. 4 and then soldered to the top of the associated piston capacitors. The strips can be silverplated, although I did not do so. The input and output coupling capacitors, C1 and C6, *must* be microwave types. I used 470-pF leadless discs, because I had a large stock of them on hand. Microwave chip capacitors of at least 100 pF would be preferable, particularly for the input coupling capacitor, C1.

Always install the transistor last, with the source/emitter leads soldered to the input-compartment side of the shield. Tune-up of the preamplifiers is done in the normal manner.[6] Best results appear to be obtained by initially adjusting the capacitors for minimum capacitance, then repeatedly tuning first the output, and then the input capacitors. This is necessary because of interaction between the circuits.

Conclusion

Low-noise preamplifiers for 1296 MHz, having characteristics hitherto unobtainable, can be built with relative ease by amateur operators. I would like to thank all of the manufacturers who have made samples available for this program. I particularly want to thank Dick Frey, WA2AAU, for providing several microstrip designs and invaluable help during this construction/test effort, including a contest operation at W2SZ/1. I would be happy to discuss with readers any information relating to this article, if an s.a.s.e. is provided for my reply. QST

Notes

[1]Effective noise temperature; $T_e = 290\,(F - 1)$ K.
[2]Gain margin; $G_m = -(G_a + G_t)$.
[3]Amplifilter RF-1200, Microcomm, 14098 Sandy La., San Jose, CA 95098. (P. Shuch, N6TX; be sure to include an s.a.s.e. with all inquiries.)

[4]A. Katz, ed., *432 And Up EME News*, Jan. 1981.
[5]B. Atkins, ed., "The New Frontier," *QST*, Jan. 1981, p. 12. This is a design by WB5LUA.
[6]G. H. Krauss, "VHF Preamplifiers," *Ham Radio*, Dec. 1979, pp. 50-60.
[7]P. Shuch, "Low-Cost 1296-MHz Preamplifier," *Ham Radio*, Oct. 1975, pp. 42-46.
[8]P. Shuch, "Microstripline Preamplifiers for 1296 MHz," *Ham Radio*, April 1975, pp. 12-27.

A 40-Meter Quad, the EZ Way†

Are you a "little pistol" on 40? Hankering to compete with the "big guns"? This quad may be the answer. Build it for less than $20!

By Anthony W. (Tony) DePrato,* WA4JQS

When I decided to try my hand at 40-meter DXing, I soon found that the inverted-V antenna just did not compete. Using a kilowatt amplifier, I could do a fair job of holding my own, until I found myself in a pile-up with the "big guns."

Enter the Quad

What I needed was an antenna with gain and directivity, but it had to be inexpensive and present low wind loading. A standard Yagi beam was out of the question! I decided on a fixed-direction quad. Since I have two towers, on the east and west end of my lot, I chose to string the quad between these supports.

My first try was a driven element only. In addition to improving the signal to the north and south, it decreased the QRM from European broadcast stations. Even though I was impressed with the results, I wanted something better. I wanted to add a reflector element, but I had trouble imagining how to do it, since I had only two supports.

Then I had an inspiration! Since the 1/8-wavelength element spacing of a 40-meter quad is approximately 17 feet,[1] why not use horizontally mounted lengths of wood two-by-fours? Shortly thereafter, I made a trip to the lumber yard and procured two 20-ft-long two-by-fours.

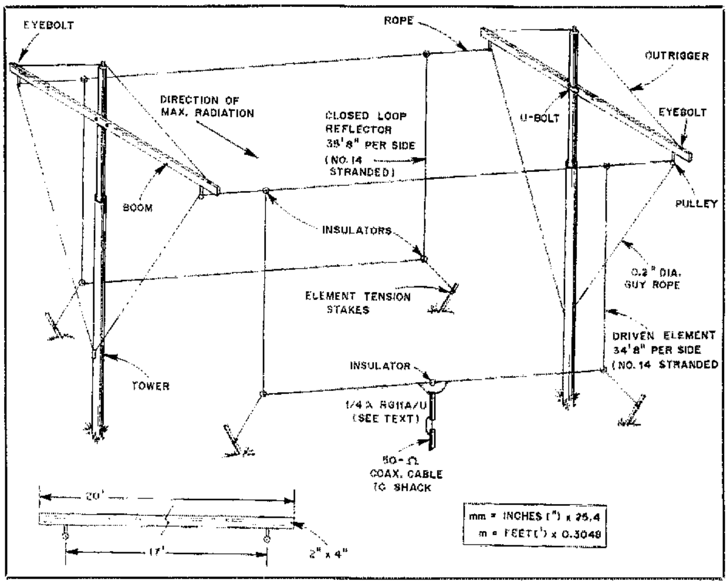


Fig. 1 — Construction details for the 40-meter quad. The quad could be erected in a diamond configuration, but this would require some structural alterations.

Construction

My design is shown in Fig. 1. The length of the driven element can be found with the formula

$$L = \frac{1005}{f} \qquad \text{(Eq. 1)}$$

where L is the length in feet, and f is the frequency in MHz. The reflector should be cut approximately 5% longer. For resonance at 7.2 MHz, the length of the driven element is 139 feet, 5 inches, or 34 feet, 8 inches, per side.

After cutting the wire for the driven element and reflector, I installed four insulators on the reflector so that each side was of equal length (35 feet, 8 inches). I used five insulators on the driven element — one at each corner and a fifth one at the feed point.

[1]m = feet × 0.3048; mm = inches × 25.4.

†Adapted from an article of the same title appearing in September 1981 *Radio ZS* (South African Radio League).

*205 Cherokee Tr., Somerset, KY 42501

Before mounting the two-by-fours to the tower with U bolts, I drilled holes 17 feet apart in each. After installing eye bolts with pulleys in each hole, I weatherproofed the wood with spar varnish. With an adequate supply of rope in each pulley, I hoisted the two-by-fours to the tops of the towers and attached them with U bolts. The outrigger system, which had been attached previously to the wood with eye bolts, was then secured and pulled taut. Finally, I raised the elements into place and tied off the bottom insulators with rope to stakes.

The feed-point impedance of a 2-element quad will vary somewhat with element spacing, but will usually be in the vicinity of 100 ohms, so the mismatch to 75-ohm coaxial cable should not be prohibitive. The impedance can be matched more closely by means of a gamma-matching section or, more simply, by using a quarter-wavelength transformer. For a feed-line impedance of 50 ohms, this transformer may consist of a section of RG-11/U (75 ohms) cut to the formula

$$L = \frac{246\ V}{f} \qquad \text{(Eq. 2)}$$

where
L = length in feet of the matching section,
V = velocity factor of the cable used as the transformer, and
f = frequency in MHz

Using coaxial cable with a velocity factor of 0.66, the length of the matching section for my quad is 22 feet, 5-1/2 inches.

After I had installed the antenna and pruned it while using a noise bridge, I conducted SWR and bandwidth checks. Running full legal amateur power, I had 1 watt of reflected power at 7.200 MHz and less than 3-watts reflected at the band edges. Nice! On-the-air tests have proven that the antenna performs excellently. The quad is fixed to the south-southwest; my reports from VK and ZL stations have consistently been S9 plus. I've received S9-plus-40-dB reports from Antarctica and S9 from Japan (long path). Can you beat that for less than $20?

References

Hall, J., ed., *The ARRL Antenna Book,* 13th ed. (Newington, CT: ARRL, 1978).

Orr, W., *Radio Handbook,* 21st ed. (Indianapolis, IN: Editors and Engineers, 1978), p. 29-12.

Orr, W. and S. Cowan, *All About Cubical Quad Antennas,* seventh printing (Wilton, CT: Radio Publications, Inc.).

New Books

☐ *Secrets of Ham Radio DXing,* by Dave Ingram, K4TWJ. Published by TAB Books Inc., Blue Ridge Summit, PA 17214. Softbound, 8-1/4 inches, 176 pages (including title pages and index), $7.95.

The DXer, whether he or she is one country from the coveted DXCC Honor Roll or having just made that first transatlantic QSO, is one who is willing to take the time to study the "science" of DXing and learn all that can be learned in order to snag that next elusive country. It's on that premise that author Dave Ingram has chosen to pass on his *Secrets of Ham Radio DXing.*

Ingram does his best to make interesting reading from what could be "dull, instructional text." Once you've read the book, you'll have to admit that he carries out his task with enthusiasm and style. The writing is clear and concise — easy to read and to enjoy.

After the obligatory definition of terms and goals, the reader is treated to a dandy, if all too short, six-page history of DXing from 1915 through the present. Shades of jumping sparks and scents of ozone!

Although specialty and exotic modes such as uhf/vhf, SSTV, and satellite DXing are briefly touched upon, the main thrust of the book is aimed at the low-band (160- through 10-meter) DXer. There are excellent sections on strategy for working DX and on setting up your station, as well as ways of dealing with such distractions as line noise and rf feedback — FB! The reader will also find useful parts of the book that offer "tips" on antennas and propagation, QSLing, DXC contesting as a way to run up the old country totals, DX aids, and descriptions of several of the major awards of interest to DXers.

Because of the ever-changing world situation — new countries emerging from old, new call-sign allocations, etc., the prefix/country/beam-heading charts in this book are a little out of date. DXers would be well advised to check the latest ARRL DXCC Countries List before turning their beams to work a 7G1 in the Republic of Guinea (now 3X) or waiting to work a KZ5, Canal Zone (now a "deleted country") as their last country on 40 meters for the 5 Band DXCC Award.

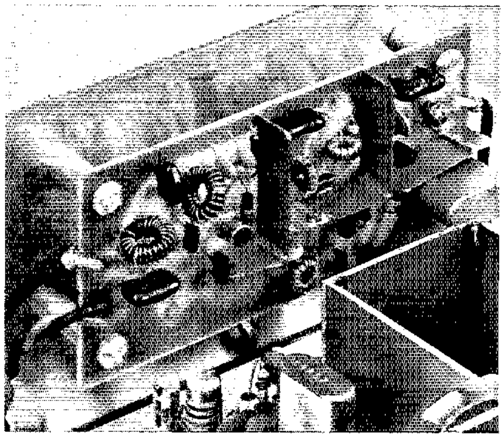
As icing on the cake, there is an entire chapter on DXpeditioning. Ingram presents some thoughts on the absolute basics of planning a simple DXpediton and a short discussion of some effective operating techniques. This chapter really comes in to its own with brief descriptions of a couple of major DXpeditions and DXpeditioneers of the past. What amateur who claims to be a DXer could not imagine being halfway around the world mashing giant cockroaches and working the pile-ups with Gus Browning, W4BPD? What DXer does not share that twinge of excitement of taking hostile gunfire with K1MM and the gang of 1S1DX while looking for an operating spot in the Spratly Island Group?

The only disappointment with *Secrets* comes not with the editorial content, but with the graphics in the book. Photograpic quality throughout the book is generally poor, while the figures (drawings) are unlabelled and practically worthless. Most of the photos are reproduced in such a way that they are dark, "grainy" and not pleasant to look at. Antenna diagrams have arrows and markings on the major components, but no labels. Photo captions are generally well done and explain the photos better than the photos themselves. (Perhaps one picture is *not* worth a thousand words, but rather one picture is worthless without a thousand words.) Hopefully, this situation will be corrected in subsequent printings of this otherwise useful book.

If you've got an extra $7.95 in the kitty and an evening of free time, *Secrets of Ham Radio DXing* might prove an entertaining diversion as well as providing a little help for your trip up the DXCC standings. — *Bill Jennings, K1WJ*

BEGINNER'S BENCH

Getting Started on VHF: A 6-Meter Receiving Converter



Part 3: Building this simple converter will complete your 6-meter station and let you join the fun on 50 MHz.

By George Collins,* KC1V

Last month, Beginner's Bench presented the foundation for a vhf receiving system — a tunable 10-MHz i-f receiver.[1] This installment completes the 6-meter station with an easy-to-build receiving converter. Containing only three transistors, on an etched-circuit board measuring just 3-3/4 × 1-3/4 inches,[2] this converter is a great candidate for your next weekend project.

In order to take advantage of a readily available circuit board, the design chosen for this converter is a modification of the Rochester VHF Group converter.[3] Originally, the circuit was designed to operate at an i-f of 28 to 30 MHz. For use with our 10-MHz i-f unit, the local-oscillator (LO) and mixer-output circuits have been modified. The same circuit board can be used at either i-f.

How It Works

The heart of any receiving converter is the mixer. In this circuit (see Fig. 1), that function is served by Q2, a dual-gate MOSFET (metal-oxide semiconductor field-effect transistor). By combining the 50-MHz input and the 40-MHz LO signals in Q2, output signals are produced at frequencies equal to the sum and the difference of the two input frequencies

50 MHz + 40 MHz = 90 MHz (Eq. 1)
50 MHz − 40 MHz = 10 MHz (Eq. 2)

In this case, the desired output, at 10 MHz, is the difference between the two inputs. The sum, 90 MHz, is rejected by the circuits following the mixer and by the i-f receiver.

Any signal present at the mixer input (even at frequencies other than 50 MHz) will combine with the LO signal, forming sum and difference output signals. Most of these signals are rejected easily by the i-f receiver, but there is a special case of which we must be aware. If a 30-MHz signal is applied to the mixer input, the output signals will be

40 MHz + 30 MHz = 70 MHz (Eq. 3)
40 MHz − 30 MHz = 10 MHz (Eq. 4)

The sum at 70 MHz is rejected by the i-f receiver, but the difference is exactly the same as our desired output! This unwanted response to 30-MHz signals is called the *image* response. It can be avoided only by preventing the image signals from reaching the mixer. Fortunately, the 30-MHz image is sufficiently removed from the 6-meter band to allow it to be suppressed relatively easily.

Q2 is followed by a band-pass filter. This helps reject signals outside the 10- to 10.25-MHz tuning range. By tapping the output down on L5, the mixer output impedance is matched to the i-f receiver input (50 Ω).

Local oscillator injection to the mixer is provided by means of a crystal-controlled JFET (junction field-effect transistor) oscillator, Q3. Output from the oscillator is taken from a tap on the tank-circuit inductor, L6. The tap position and the value of coupling capacitor C7 are selected to provide the correct LO voltage at the mixer.

A JFET (Q1), in the common-gate configuration, is used as the rf amplifier stage. The 50-MHz input signals are fed to the source of Q1 from a tuned circuit comprised of L1 and C1. This circuit provides front-end selectivity and impedance matching between the antenna and the amplifier. Additional rf selectivity is provided by a band-pass filter between the amplifier output and the mixer stage. This selectivity is important for two reasons: First, without adequate selectivity, strong out-of-band signals may overload the rf amplifier or the mixer. This can cause cross modulation and a loss of sensitivity. Second, the image response is determined by the degree of selectivity ahead of the mixer.

[1]Notes appear on page 44.
*Assistant Technical Editor

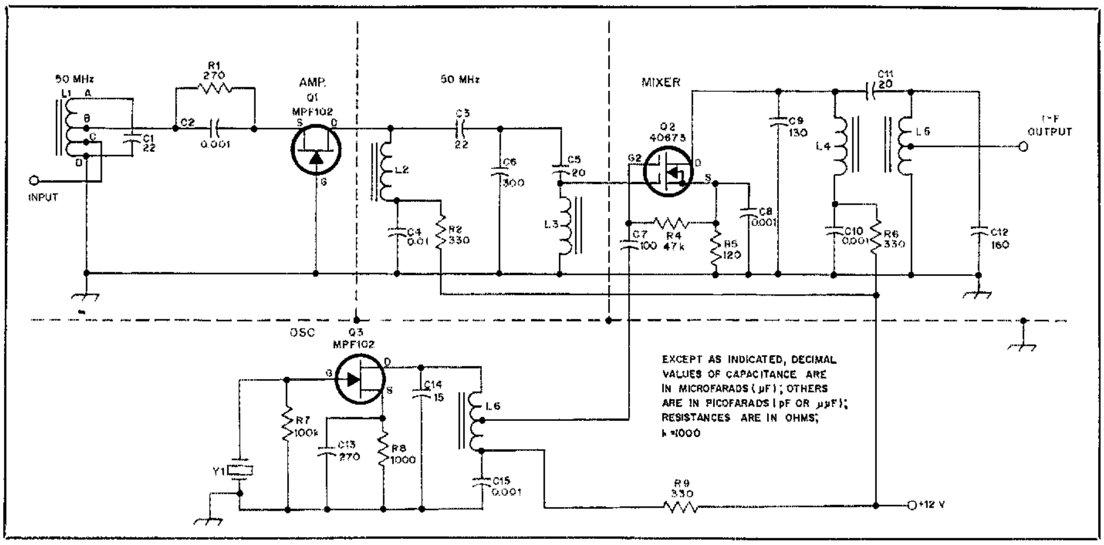


Fig. 1 — Schematic diagram of the 6-meter converter. The dashed line represents the shield used to isolate the stages. All resistors are 1/4-W, 5% carbon types. Decimal-value capacitors are 16-V disc ceramic types; others are 5% silver-mica units. All inductors are wound with no. 28 enameled wire.

L1 — 14 t., tapped at 4 turns (point C) and 6 turns (point B) from ground, on a T25-6 core.[7]
L2 — 13 t. on a T25-6 core.
L3 — 12 t. on a T25-6 core.
L4, L5 — 21 t. on a T37-6 core. L5 is tapped at 5 turns from ground.
L6 — 18 t., tapped at 4 turns from ground, on a T25-6 core.
Y1 — 40.000-MHz crystal. ICM[8] type 471150 (specify frequency when ordering).

Resistor R1 determines the gate-to-source bias voltage for Q1. This sets the bias current at the correct value. To provide a low impedance path for the rf signal, R1 is bypassed with a 0.001-μF capacitor (C2).

Construction

Asembling the converter is simply a matter of placing the components in the proper locations (see Fig. 2) on the circuit board.[4] The most difficult step in the construction (and it isn't really difficult) is winding the tapped inductors. One way to make the taps is to remove approximately 2 inches of insulation from the center section of a length of enameled wire. Now fold the wire at the center of the stripped portion. Twist the stripped portion, forming a single lead; this will be the tap lead. Place the wire on the core and wind the required number of turns, first on one side and then on the other side of the tap.

When winding L1 (which has two taps), use this method to form the tap closest to the center of the winding. After placing all the turns on the core, scrape the insulation from the wire at the point of connection for the second tap. Use a length of the same wire used to wind the coil for making connection to this point. Be sure to wind the coils carefully, spacing the turns evenly around the toroid. Leave a gap of approximately 30° between the first and last turns. Pay attention to the location of the taps on L1, L5 and L6; it is important that they are placed correctly.

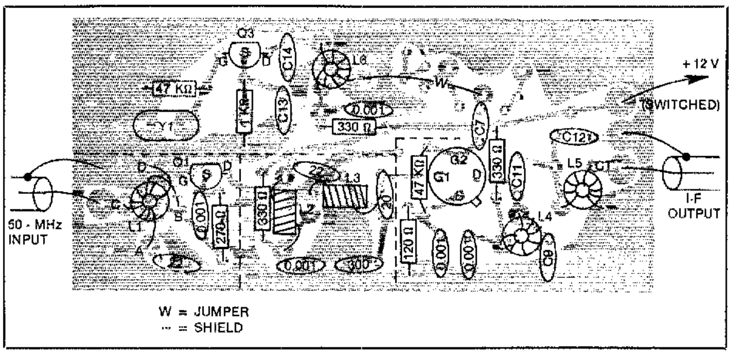


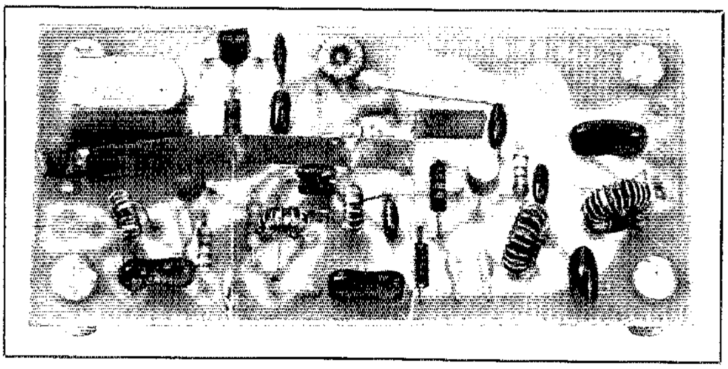
Fig. 2 — Parts-placement diagram for the 6-meter converter. The board is shown from the component side, with gray areas representing an X-ray view of the unetched copper. This board was designed for use on several bands, and a number of holes are not used for the 6-meter version.

A 3/8-inch high shield, made from thin flashing copper or brass shim stock, is used to separate the various converter stages. The shield is held in place by soldering it to 1/2-inch lengths of no. 16 bus wire placed through holes in the circuit board and soldered to the ground foil. After the shield is in place, trim the bus wire on both sides of the board. Install the shield after all the components have been soldered in place.

Provisions have been made on the circuit board for the use of two sizes of crystal holders. An HC-32/U-style crystal is recommended, but the larger HC-6/U style can be used if one is on hand.

Alignment

To reduce the cost of the converter, variable capacitors have not been used in the tuned circuits. Peaking of these circuits is done by compressing or spreading the turns of wire on the inductors. Pushing the turns together will increase the coil inductance. The range of adjustment using this method is limited, but it is sufficient if the correct value of



As shown here, the coils in the band-pass filters should be positioned at approximately 90° to each other. Use of an HC-6/U-style crystal in this unit required that the shield partition be bent slightly to provide clearance. The input circuit is at the left, while the mixer stage is at the right of the photo.

capacitance is used. For this reason, 5%-tolerance mica capacitors are recommended.

The input circuit (L1 and C1) is relatively broadbanded, making adjustment of this stage noncritical. Simply peak L1 for maximum response to a signal in the center of the tuning range. The interstage network, between the rf amplifier and the mixer, and the mixer output network should be stagger-tuned for uniform response across the tuning range. Do this by first applying a signal at the low end of the band (near 50.01 MHz, for example). Adjust L2 and L4 for maximum response at that frequency. Now inject a signal near the high end of the band and adjust L3 and L5 for maximum response.

If you are using a crystal- or VXO- (variable crystal oscillator) controlled transmitter as an alignment-signal source, you may not be able to obtain signals at both ends of the tuning range. In that case, you can make the adjustments using whatever frequency spread is available. Any loss in sensitivity at the band edges will be be reasonably small.

During operation, the converter should be enclosed in a metal case to prevent 10-MHz signals from "leaking" into the i-f receiver. Placing the converter in the receiver case will provide adequate shielding, in most cases. If you are going to use this converter with the transmitter and i-f receiver described in Parts 1 and 2 of this series,[5,6] you will need to change the transmitter relay wiring. All that is necessary is to move the wire between the RCVR MUTE jack (J4) and K1C from the normally open relay contact to the normally closed position. This will mute the receiver during transmit. With this converter completing your 6-meter station, you are ready to begin enjoying the interesting world at 50 MHz.

Notes

[1]G. Collins, "Getting Started on VHF: A Tunable I-F for VHF Converters," Part 2, *QST*, May 1982, pp. 33-35.

[2]mm = inches × 25.4.

[3]G. Woodward and G. Collins, eds., *The Radio Amateur's Handbook*, 59th ed. (Newington, CT: ARRL, Inc., 1982), pp. 9-18 to 9-21.

[4]Circuit boards, negatives and parts kits for this project are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002. Circuit boards are also available from Dynaclad Industries, P.O. Box 296, Meadow Lands, PA 15347.

[5]G. Collins, "Getting Started on VHF: A 6-Meter Transmitter You can Build," Part 1, *QST*, April 1982, pp. 37-42.

[6]See note 1.

[7]Toroidal cores are available from Amidon Associates, Inc., 12033 Otsego St., North Hollywood, CA 91607 and Palomar Engineers, 1924-F W. Mission Rd., Escondido, CA 92025.

[8]International Crystal Manufacturing Co., Inc., 10 North Lee, Oklahoma City, OK 73102.

Strays

When hams provide a public service, they often do it in other ways than through the airwaves. Bill Welsh, W6DDB (r), recently presented fellow ham (and fellow long-time blood donor) Arthur Godfrey, K4LIB, with an award at the Los Angeles Chapter of the American Red Cross. The occasion was the 40th anniversary of the first pint of blood collected by the Red Cross in Los Angeles.

When John, W2AAF, ran into Harry, W2HD, while they both were on jury duty, John invited Harry to visit the electronics shop at Ward Melville High School, where W2AAF is an instructor. While there, then ARRL President Dannals (without the beard) spoke to a junior high school science class via the school 2-meter repeater and 10-meter remote base. John tells us he will provide demonstrations at the school, in Setauket, New York, for anyone interested. *(photo by Chuck Muether)*

FAST-SCAN TV NET

☐ Attention Midwestern video experimenters: A net to discuss fast-scan television topics meets Saturdays at 1700Z on 7.290 MHz. This net is followed at 1800Z by a new facsimile group, conducted by Robert Roehrig, K9EUI. If you're interested, tune in!

***QST* congratulates . . .**

☐ Ann Harrison (daughter of Duke, K2MZ) and Todd Wolin (son of Sid, K2LJH), winners of the First Annual Helen Reed, K2AIU, Memorial Scholarship Fund Awards. Sponsored by LIMARC, the Long Island (New York) Mobile ARC, the Fund was created in memory of K2AIU, who served her family and her community via Amateur Radio despite an incurable illness.

I would like to get in touch with . . .

☐ other club presidents who are interested in establishing a net to discuss club activities and exchange ideas. Ronald D. Brooks, KA1AFN, 213 E. Pearl St., Torrington, CT 06790.

Conducted By Larry D. Wolfgang,* WA3VIL

CHECKING 117-V GROUNDED POWER OUTLETS

☐ Grounded outlets are sometimes wired incorrectly. With the ground terminal at the top, the neutral wire should be on the right and the hot wire on the left.

Fig. 1A shows a device that will indicate whether the outlet is wired properly. I make no claims to originality, but offer this to help those who have never seen such a device. Only lamps 1 and 2 should light if everything is okay. If lamps 1 and 3 light, you will know that the white and black wires are reversed, and if 2 and 3 light, the black and green wires are reversed. When lamp 1 lights by itself, green is open, and if only lamp 2 lights, then white is open. If all lamps light, you may be connected to a 3-wire, 234-V system. If no lamps light, black may be open, or the outlet is turned off at the fuse box. Note that no indication is given about white and green being reversed.

This device can be wired inside of a large grounding plug, with the bulbs visible through the top, or the circuit can be built in a small box. If the bulbs are mounted on one panel of the box, the markings shown at Fig 1B can be used for quick reference. — *Dave Geiser, WA2ANU, New Hartford, New York*

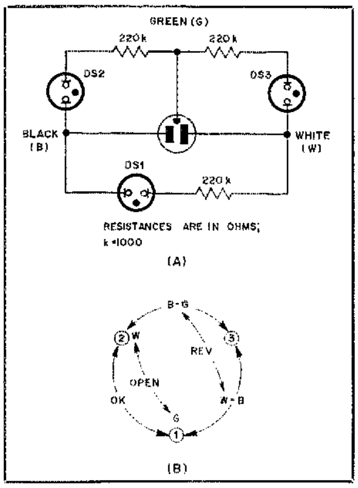


Fig. 1 — Circuit diagram for a grounded-outlet checker is shown at A. Neon bulbs are type NE-2. Resistors are 1/8 W or more. At B, a panel marking for quick reference to the condition of the outlet under test.

MEASURING IN-CIRCUIT BATTERY CURRENT

☐ Sometimes it is desirable to measure the battery current to a piece of equipment. Here is a simple idea I use to break the circuit and insert my ammeter. Two strips of aluminum foil are taped to either side of a piece of note paper. The note paper should be slightly larger than the foil to insulate the strips.

The test strip is inserted between the batteries, or between the battery and holder, and alligator clips on the meter leads connect to each strip of foil. The device is quick and easy to build, is disposable, and makes good electrical connection because the strip is thin enough for the positive battery cap to force the other side against the negative end of the battery. — *James W. Milburn, WB5BYK, Hollywood, California*

MEASURING AC CURRENT

☐ Most inexpensive VOMs have an ac-voltage scale. They do not have an ac-current scale, however. Here is a method to make an approximate measurement of the ac current.

I insert a 1-ohm, 50-watt resistor in series with the source and load. Using the ac-voltage scales, I measure the voltage across the resistor. The scale is read directly in amperes. A suggested test circuit is shown at Fig. 2. Tip jacks mounted on the electrical box will make connection to the VOM easy.

Low-value, high-wattage resistors are common at flea markets. Other resistance values will work, if you would like to do some Ohm's law calculations. — *Edwin Walker, WA4OFS, Mountain City, Tennessee*

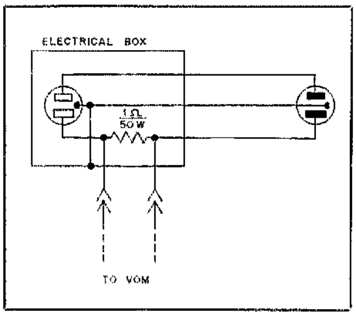


Fig. 2 — Test circuit for measuring ac current. The device can be plugged into the test circuit, the plug connected to an outlet, and the meter connected. Ac current is read directly from the appropriate ac-voltage scale.

TS-830 RIT/XIT MODIFICATION

☐ Ed Sanders, W4XC, sends this welcome change to the Kenwood TS-830. Extending the RIT/XIT control tuning range to approximately ± 8 kHz may be done easily. Two 1/4-watt, carbon-composition resistors are needed. A 160-Ω resistor is placed in parallel with R17 (6.8 kΩ), which is located at the rear of the RIT/XIT control potentiometer. R87 (10 kΩ) is paralleled with a 2.7-kΩ resistor. This can be done without removing the af board by connecting the resistor between the right side of VR2 and the terminal marked TPG. Recalibration of the RIT control is accomplished by centering the control knob and noting the frequency displayed on the readout. Turn the RIT on and adjust VR2 until the frequency noted previously is displayed. That's it!

Ed also mentioned that the addition of a 0.001-μF capacitor in series with the hot lead of both his MC-50 and Shure 444 microphones decreased the bass response markedly. This results in increased intelligibility, especially when DXing. Use the MONITOR function of the '830 to select the capacitor value that suits your needs. — *Paul K. Pagel, N1FB, ARRL Hq.*

DIRT IN METER MOVEMENTS

☐ The magnet in a meter movement can pick up tiny bits of iron filings. These filings can work their way into the gap between the magnet and the armature, interfering with the meter coil movement. It is best to use care to prevent such contamination, but when it does occur the meter is ruined unless the dirt can be cleaned out.

I have successfully repaired meters by carefully removing the armature from the magnet. Any particles that cling to the armature can be brushed away. Next, direct a narrow flame from a propane torch through the gap in the magnet. The tiny bits of iron are heated to incandescence, and are blown away as tiny sparks long before the magnet itself is heated enough to cause damage. A temperature of 200° to 300° F should not harm the magnet, but you could hold it in a wet rag to keep it cool.

Carefully reassemble the meter in a place *free* of iron chips. The movement should be free, and the meter will be as good as new. — *I. Dean Elkins, K4ADJ, Henderson, Kentucky*

TRY AN HOUR METER

☐ Most ham shacks are equipped with a variety of electrical meters, but few include an hour meter. This accessory is useful in evaluating equipment performance and planning purchases of replacement tubes and lamps. It also creates an interesting record of station activity.

An hour meter is an elapsed-time recorder. Good sources of these meters would be hamfests and any company that deals in surplus electronics equipment, such as Fair Radio Sales[1] or Herbach and Rademan, Inc.[2] A surplus meter costs just a few dollars and can be built attractively into a small cabinet with a pilot light, fuse and power cord.

My meter is wired to the station main-power switch. I keep a meter log with readings taken at the following times: (1) On the first of each month, (2) when a tube or other component is replaced, (3) when new equipment is added or an old piece is returned to service, and (4) when a piece of equipment fails or is otherwise removed from service. — *Neil Friedman, N3DF, Washington, DC*

[1]Fair Radio Sales, Box 1105, Lima, OH 45802.
[2]Herbach and Rademan, Inc., 401 Erie Ave., Philadelphia, PA 19134.

*Assistant Techical Editor

RTTY AND THE APPLE II COMPUTER

☐ A few months after my son purchased an Apple II computer, I wanted to try it on SSTV and RTTY. After making inquiries at the local computer shops, the answer began to look expensive and complicated. Al Mierau, VE5WZ, a local computer and RTTY enthusiast, showed me how he interfaced his Apple computer with his Drake equipment. By adapting his circuit to my TS-180S, I began receiving RTTY on the Apple computer, using the Galfo program — but it was upside down! (Mark and space tones reversed.)

I tried using an opto-isolator in the local loop circuit for transmit, but that didn't work. There just isn't enough current available at the Apple Game I/O to drive the isolator. Glen Waldner, a co-worker, suggested that I try a hex inverter. This worked! The 7404 provided the necessary current for the opto-isolator. I used a couple of the inverters to get the transmitted signal right side up and to cure the receiving problem.

Fig. 3 shows a schematic diagram of the circuit, and Fig. 4 gives a pc-board pattern and parts overlay. The received signal is picked up from the base of the keying transistor on my Flesher DM-170. Operating RTTY using a computer is turning out to be another fascinating branch of Amateur Radio. — *Bruce Rattray, VE5RC, Saskatoon, Saskatchewan*

TS-180S POWER CONNECTOR

☐ I recently discovered that it is possible to insert the power plug for the TS-180S into the chassis connector in a misaligned position. The result is 117-V ac applied to the 12-V dc line on the transceiver. Even with the power switch off, the final transistors can be destroyed. At $40 apiece for new transistors, this can be a disastrous mistake.

The plug appears to be nonreversible, and most owners probably have that impression. This led me to a false sense of security, as I reached over my station shelf to insert the power plug. Careful inspection of the plug and connector will show that if the plug is inverted and misaligned on the vertical axis, pins 6 and 4 from the plug will mate with pins 4 and 6. Pin 6 carries 117-V ac for switching. This is an unfused line, and it can be hot or neutral, depending on the orientation of the wall plug.

If the line is hot, the ac is applied directly to the final-amplifier collectors. If it is neutral, no damage will occur until the transceiver power switch is turned on. Then the ac voltage is applied to the 12-V dc line throughout the rig.

One remedy is to glue a strip of plastic about 1/8-inch thick along the bottom edge of the chassis connector. I used Super Glue for this, and now the connector really *is* foolproof. My thanks to Lou Potter, K6VT, for suggesting this simple cure. I believe this same problem exists for the TS-120. — *Bob Foreman, AG6M, Sacramento, California.*

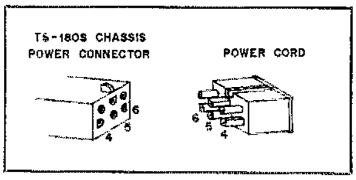


Fig. 5 — Drawing of the shape and orientation of the power-connector pins for the TS-180S. Note that by inverting the power-cord connector, the top three pins will mate with the bottom three pins on the chassis connector.

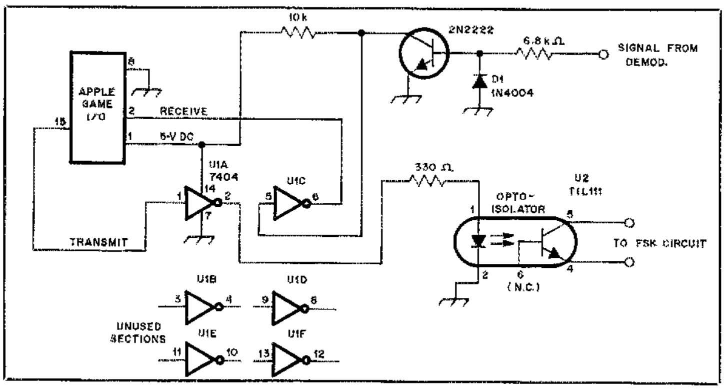


Fig. 3 — Schematic diagram of a computer/transceiver interface for RTTY operation.

ANOTHER USE FOR THE SWR INDICATOR

☐ An SWR indicator can be made to double as a field-strength meter simply by disconnecting it from the transmission line and plugging a length of wire into the TRANSMITTER input. Relative field strength can be read with the meter set in the forward position.

I used mine to tune a 2-meter mobile amplifier for maximum output. With a 19-inch piece of stiff wire in the coaxial jack, and the meter sitting on the car hood, I was able to adjust the amplifier quickly and easily. — *Jesse "Bill" Tillett, K5CVK, Slidell, Louisiana.*

AZDEN PCS-2000 UPDATE

☐ Two articles in the March 1982 Hints and Kinks column prompted several readers to write with their suggestions for solving the memory back-up battery problem. Various

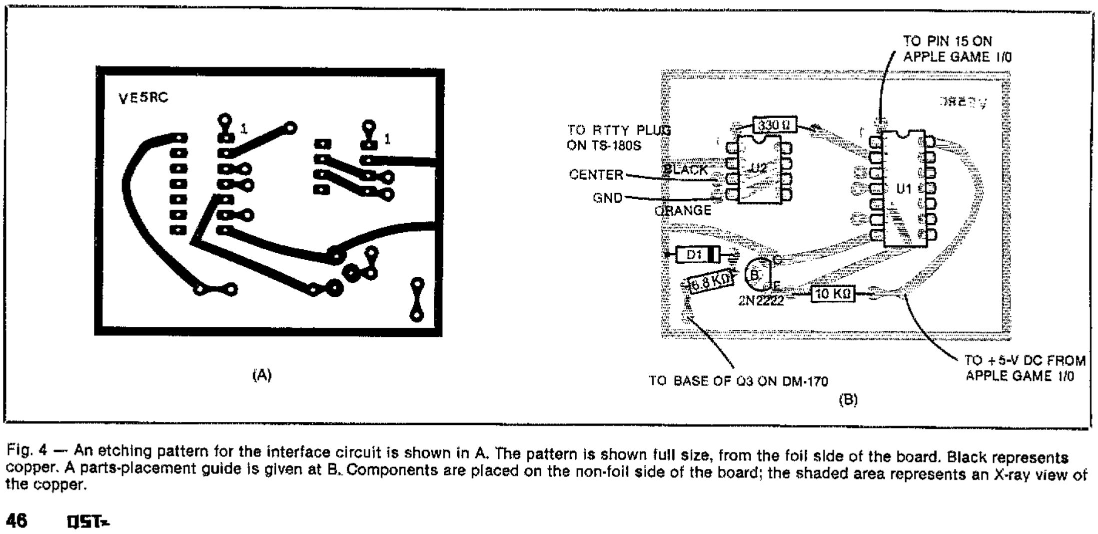


Fig. 4 — An etching pattern for the interface circuit is shown in A. The pattern is shown full size, from the foil side of the board. Black represents copper. A parts-placement guide is given at B. Components are placed on the non-foil side of the board; the shaded area represents an X-ray view of the copper.

battery types and mounting methods have been suggested.

One alternative worth mentioning is the battery pack used for the Azden PCS-3000. This 4.8-V nickel-cadmium battery will fit conveniently in the control head. It is available from Amateur-Wholesale Electronics.[1] — *Larry Wolfgang, WA3VIL, ARRL Hq.*

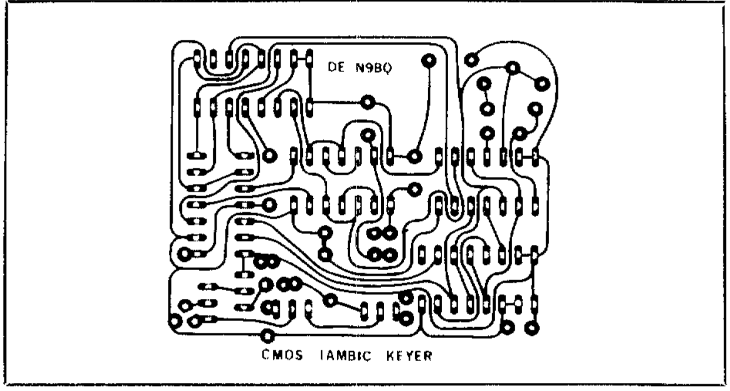
ICOM IC-730 CW FILTERS

☐ When I purchased an ICOM-IC-730, I also ordered the IC-EX203 cw audio filter. After installing the filter, according to the manufacturer's instructions, I was disappointed to find that the filter was actuated in both the cw and CW-N positions. I find that having a 150-Hz filter in the circuit at all times during cw operation is inconvenient. With minor circuit modifications, my audio filter is now active only when the MODE switch is in the CW-N position.

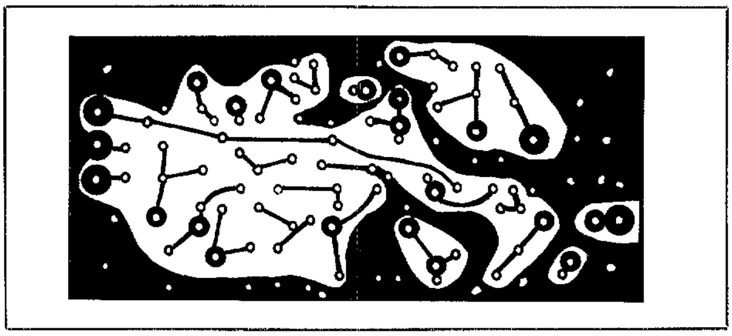
The first step is to fabricate a 5-inch length of wire with a flat pin on each end. The pins I used were removed from an IC socket found in my junkbox. Remove the green wire and the connector from P1, which plugs into J3 on the detector board. This wire goes to pin 1. Now install the filter board. One end of the wire fabricated earlier is plugged into the connector on the green wire removed from P1. The other end of this wire is soldered to the point on P6 that goes to J4 pin 2. I used a piece of plastic electrical tape to insulate these connections.

With the mode switch in the CW-N position, 8-V dc is supplied to the audio filter, turning it on. Now I have two bandwidth choices on cw, and operating is much easier. — *Robert Putnam, K7ACP, Roseburg, Oregon* QST

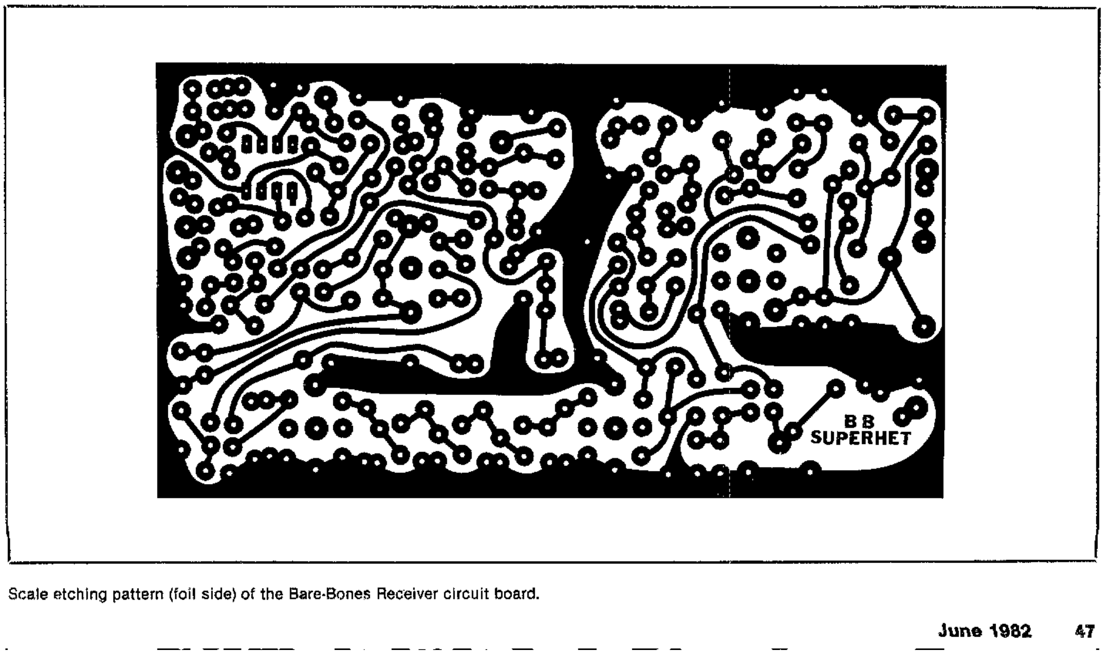
[1]Amateur-Wholesale Electronics, 8817 S.W. 129th Terr., Miami, FL 33176. The cost is $5.70, plus shipping. AWE will also supply a modification sheet, with details of how to install this battery, on request.



Circuit-board etching pattern for the CMOS keyer. Pattern is shown at actual size from the foil side of the board, with black representing copper. Copper is on one side only. The parts-placement diagram appears on page 28.



Etching pattern for the 6-meter receiving converter. Black areas represent unetched copper, viewed from the etched side of the board. Parts-placement diagram appears on page 43.



Scale etching pattern (foil side) of the Bare-Bones Receiver circuit board.

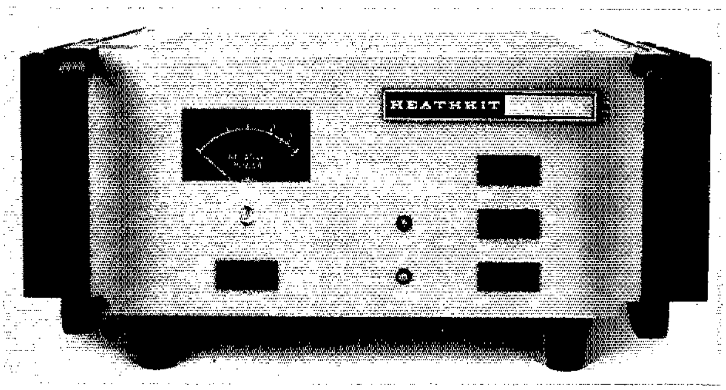
Product Review

Conducted By Paul K. Pagel,* N1FB

Heathkit Model VL-2280 2-Meter Base Station Amplifier

Have you ever tried to operate your 2-meter mobile rig from home, using an external power amplifier and associated heavy-duty power supply? Unless you do this often, what results from such a setup is a disastrous mess of coaxial cable and power cables. Heathkit has provided a solution to this problem, and in the process has designed a fine base station amplifier — the VL-2280, a 75-watt linear amplifier and a heavy-duty, regulated supply in one cabinet.

The front panel of the '2280 is simple, yet functional. A back-lighted panel meter reads switch-selected relative power or supply voltage. Three other switches select amplifier bypass (EXC/AMP), transmit-receive delay (SSB/FM), and ac POWER. Two green LEDs indicate when the dc supply is on, and when the amplifier is on. The rear panel has connections for rf in and out, fuses for primary power and supply output, the ac line cord and an accessory socket with connections for T-R control. There is provision for a 13.8-V, 4-A output for powering external equipment.



Heathkit VL-2280 2-Meter Amplifier

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency range: 144-148 MHz.	As specified.
Power output: 75 W nominal with 10 W drive.	80 W at 10 W drive.
Spurious and harmonics: 60 dB down.	Greater than 70 dB.
Third-order distortion: −30 dB below PEP.	Exceeds −24 dB measurement ability of test equipment.
Power requirements: 120 V ac at 4 A, 240 V ac at 2 A or 12 V dc at 11 A.	
Modes of operation: Ssb, cw, RTTY and fm.	As specified.
Duty Cycle: 50%; 10 min on, 10 min off.	Not measured.
Size (HWD): 5-1/2 × 13-1/2 × 12-3/4 in.†	
Color: Gray and Black.	
Net Weight: 27 lb .	

†mm = in. × 25.4.; g = oz × 28.35; kg = lb × 0.454.

Construction and Circuit Details

Because the VL-1180 mobile amplifier and the VL-2280 are basically the same, the information will not be repeated here. The reader is requested to refer to the earlier review.[1] Construction time did vary; it took 13 hours to complete the VL-2280.

Testing and Operation

During the initial testing of the amplifier, the MRF247 failed — cause unknown. Heath promptly supplied a replacement device, and it has provided trouble-free service ever since.

Because of some constructional errors caused by yours truly (the over-anxious builder), the '2280 failed to meet the manufacturer's published specifications. Once the errors were corrected, the '2280 passed with flying colors.

The VL-2280 was used during a mountain-topping contest effort, on a very hot day. During 24 hours of operation, the power output remained constant. Two anomalies appeared during the contest. Rf energy from other transmitters in the area caused the T-R relay to chatter, and the T-R switching delay on ssb was much too long for rapid-fire communications. Each of these problems was corrected, the former by placing the amplifier in the bypass mode when not in use, and the latter by using T-R control from the exciter.

I'm very happy with the amplifier. Operating my mobile rig from inside the house is a simple task, and the amplifier delivers an outstanding signal. Since I enjoy operating linear modes, I'm glad Heath made the '2280 a linear amplifier — not one just for fm (Class C)! Price class for the VL-2280 is $275. For more information, contact Heath Company, Benton Harbor, MI 49022 — *Gerry Hull, AK4L*

[1]Product Review, *QST*, May 1982.

*Assistant Technical Editor

MACROTRONICS TERMINALL

☐ I've used a number of RTTY/cw "interfaces" with my TRS-80® (Model I) computer and, in my opinion, the Macrotronics Terminall is the best. It is easy to install and use. Also, there are many options that make it versatile.

Installation

All radio connections are made by means of a 24-pin edge connector on the rear panel. Three cables, two with standard quarter-inch phone connectors, are already soldered to the edge connector. These are used to interconnect the terminal to the transmitter cw key jack and the receiver headphone jack. The third cable is wired to the transmitter microphone connector.

A small interface board mounts directly on the expansion port of the TRS-80® keyboard or expansion interface. A 2-foot long ribbon cable connects this interface to the main unit. The final connection is to an ac power source (117 or 234 volts, selectable).

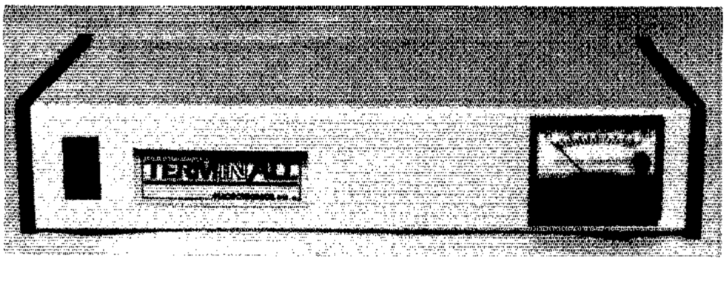
Software

Terminall software is provided in cassette and diskette formats. Cassette software requires 16k of RAM and Level II or Model III BASIC; the diskette software calls for 32k of RAM and a disk system.

The most-wanted cw and RTTY operating options are included in the software. You can create and save preprogrammed messages, such as equipment description, name, location, etc. These messages may be mixed with control functions that permit automatic station identification, time announcements, mode changes, etc., during message transmission. For RTTY, you can choose fast, slow or no "diddle," UT4-type delay, wide or narrow shift (170 or 850 Hz), automatic cw identification, ignore carriage returns/line feeds, and automatic unshift-on-space. WRU functions are also provided.

In the cw mode you can transmit and receive at speeds from 1 to 135 wpm (the Terminall automatically adapts to whatever cw speed is received). In the RTTY mode, the standard Baudot speeds are included (60, 66, 75 and 100 wpm). ASCII at 75 and 110 baud, with 6- 7- or 8-bit word lengths and odd, even or no parity, is also provided.

Once you set up the software options to your liking, you can save that option configuration



on cassette or diskette for loading at future operating sessions. You can save as many configurations as you need: one for cw contests, another for RTTY traffic handling, for example.

Hardware

Terminall hardware consists of a complete RTTY/cw terminal unit. The RTTY demodulator, employing active filters, is quite sensitive and selective. Signals that are barely audible are printed perfectly, and, unless another signal zero-beats the one being received, QRM is no problem. A front panel tuning meter is used during RTTY reception.

The cw demodulator uses band-pass filtering tuned for an overall bandwidth of 100 Hz centered at 1 kHz. Sensitivity and selectivity are comparable to that of the RTTY demodulator. The algorithm used to decode cw is as successful with sloppy fists as it is with good fists. A front panel LED is used when zeroing in on the desired cw signal.

The hardware also includes a crystal-controlled afsk generator, a loop keyer and receiver, RS-232-C input/output, a sidetone generator and a "real-time (time of day) clock." This clock is used for transmitting real-time information on the air, and is the source of the time continually displayed on the video screen during operation. It is independent of the computer; therefore, disk I/O operations do not disrupt the clock function.

A separate interface board is used to latch the control signals from the computer and to buffer input into the computer. It also limits the radiation of rf from the address and data bus to reduce interference to radio equipment.

Evaluation

All Terminall software and hardware performed faultlessly.

After an hour or so on the air, one should become an expert with the major operating controls. The Terminall is available for either the TRS-80® Model I or the Model III from Macrotronics, Inc., 1125 N. Golden State Blvd., Turlock, CA 95380. Price class: $500. — *Stan Horzepa, WA1LOU*

EGBERT RTTY PROGRAM

☐ I remember RTTY — that's the mode that uses those noisy mechanical nightmares . . . Gladys almost divorced me the last time I tried RTTY . . . I'd *love* to try RTTY, but I can't justify the expense of the required equipment.

If the thought of RTTY brings one of the above lines to mind, the Egbert RTTY Program could be for you. Noisy mechanical teleprinters and most of the expensive interfacing hardware are no longer necessary to get started in RTTY operation.

This program is designed for use with the Apple II Plus® personal computer, or an Apple II® with an Applesoft BASIC language card. With either system, 48k of Random Access Memory (RAM) and one disk drive are required. The diskette will work with either of the Apple II® Disk Operating Systems (DOS), so there is no need to run a "loader" or "format" program ahead of this one. This makes the program compatible with all Apple II® computers, old and new alike.

Features

Egbert RTTY has several capabilities that make it a pleasure to use: (1) Transmission and reception of 170-Hz shift Baudot at 60, 67, 75 and 100 wpm and 110-baud ASCII make the package compatible with almost every station on the RTTY airwaves. (2) Receiver tuning is accomplished via the Apple® high-resolution graphics mode. (3) End-of line indication is provided to alert the operator when a carriage return must be inserted. (4) This program has provisions for sending any one of the nine operator-stored "canned" messages with two keystrokes. This is a handy feature for station description or traffic handling. (5) The program features an "n-key rollover," which allows the user to type ahead of the transmitted text. This system allows formulation of a reply *even while receiving*. (6) Cw identification is generated automatically at the end of each transmission.

The most outstanding feature of this package is that no terminal unit (TU) or frequency-shift keyer (fsk) is necessary for initial operation — the Apple II® decodes the incoming signal and generates the afsk tones internally. The only connections that need be made are between the receiver audio output and the Apple® CASSETTE IN jack (for reception), and between the CASSETTE OUT jack of the Apple® to the MIC INPUT connector of the ssb transmitter. After setting the audio levels (instructions included), you're on the air.

How well does the system work? For a bare-bones system, results are very gratifying. After several months of use, with no additional filtering than that offered by my transceiver, I worked 25 states and the same number of countries. For the casual operator, the system will "play" well as is. For the serious RTTYer, I'd recommend using an audio filtering device or terminal unit.

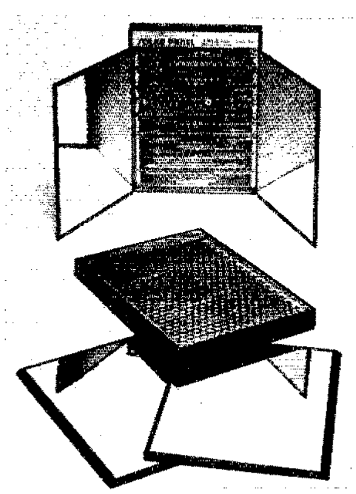
All factors considered, the Egbert RTTY Program is a great way for the Apple II® owner to get involved in RTTY with a modest initial investment. The package is available through the W. H. Nail Co., 275 Lodgeview Dr., Oroville, CA 95965. Price class: $25. — *Michael B. Kaczynski, W1OD*

EDMUND SCIENTIFIC MINI SOLAR PANELS

☐ Edmund Scientific is selling two small, lightweight, low-voltage, low-current solar panels that are ideal for use with QRP equipment. Both panels produce approximately 50 mA at the rated voltage when exposed to bright sunlight. One panel is designed for 12-V output, while the other has taps for 3, 6 or 9 volts. Output is through subminiature phone jacks. Each panel is equipped with a set of folding mirrors that reflect extra light onto the 24 crescent-shaped solar cells.

Tests conducted at ARRL Hq. indicated that the panels are useful for recharging battery packs. On a slightly overcast winter day, I was able to achieve a charge rate of 35 mA into two nickel-cadmium cells while using the 6-V tap. The charge rate dropped to approximately 18 mA from the 3-V tap. We can extrapolate that the 12-V panel will provide a moderate charge rate into 7- to 9-V battery packs.

Each panel measures 5-3/4 × 4-1/4 × 1/2 inches (HWD) (without the mirrors) and weighs approximately 4 ounces. Price class is $20 for the multivoltage version and $15 for the 12-V version. For more information contact Edmund Scientific Co., 101 East Gloucester Pike, Barrington, NJ 08007 — *Peter O'Dell, KB1N*



AEA ISOPOLE-220 220-MHz VERTICAL GAIN ANTENNAS

☐ The IsoPole-220 is similar in construction and design to the IsoPole-144.[1] It is a 5/8-λ antenna designed with decoupling in mind. What effect does decoupling have on the performance of a vertical radiator? Plenty! Decoupling keeps current from flowing on the outside of the coaxial cable that feeds the antenna. If current is permitted to flow it generates additional fields that interact with the antenna radiation field. This results in a distortion of the radiation pattern. The distortion will vary with the particulars of each antenna and installation. In some cases, a quarter-wavelength ground-plane radiator may outperform a *gain* antenna, because the combined fields of the antenna and the transmis-

[1]L. Aurick, Product Review, *QST*, April 1980, p. 51.

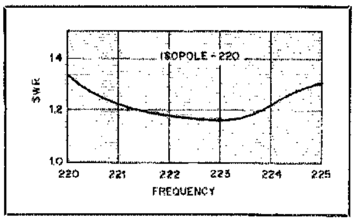


Fig. 1 — SWR curve of the AEA IsoPole-220

sion line result in a major lobe elevated several degrees above the horizon.

So much for the theory. How well does the IsoPole-220 perform? Because of an intermittent problem with a commercially manufactured gain antenna at W1AW/R, a quarter-wavelength ground-plane antenna built in the ARRL lab was installed. With the ground-plane antenna in service, I had difficulty accessing the repeater from my home (about 15 miles away) with 10 watts feeding an outside antenna. Things changed when we installed the IsoPole-220. Now I am able to key the repeater from inside my house while using a 1-watt portable rig with a "rubber ducky." I don't know what this means in terms of decibels, but I do know what it means with regard to performance.

A "junior" version of the antenna is also available. It is a 1/2-λ antenna with one decoupling cone. Price class for the IsoPole-220 is $40. Additional information may be obtained from Advanced Electronics Applications, Inc., P.O. Box 2160, Lynnwood, WA 98036 — *Peter O'Dell, KB1N*

M & M ELECTRONICS MODEL MSB-1 AUDIO FILTER

☐ With the influx of new operators to the amateur ranks, the hf bands seem more crowded than ever. This overcrowding and the state of the art have spurred several equipment manufacturers to hunt for different means of interference reduction in their new products. Variable bandwidth, tunable passbands and notch filters are definitely here to stay, along with large price tags for new gear with these features. In these tough economic times, many amateurs are opting for relatively inexpensive audio filters rather than springing for an expensive "state-of-the-art" transceiver.

If your late-model rig is still working like new, but lacks some of the modern i-f "goodies," an audio filter could be the answer. A wide variety of audio filters is available today, ranging from single-element cw to complex multistage units. The M & M Electronics MSB-1 falls into the latter category.

Features

The MSB-1 contains four separate filter sections, all designed to achieve optimum signal intelligibility. A brief description of each follows.

In ssb operation, very little intelligence is contained in the frequency spectrum below 300 Hz. The designers at M & M incorporated a high-pass section with a low-frequency cutoff of 300 Hz. This thoughtful inclusion eliminates both ac hum and off-frequency "rumble," while not reducing the intelligence of the desired signal. Most other audio filters rely on the selectivity of other stages to reduce low-frequency interference, while the MSB-1 eliminates this interference before processing the signal. This is a definite plus — less interference reaches the filter to begin with, so it can do a better job of signal handling.

If the i-f bandwidth of a rig is too wide, unwanted off-frequency (adjacent channel) signals will be heard. The band-pass and low-pass filter sections of the MSB-1 are designed to reduce this interference.

The adjustable band-pass filter allows the user to select the optimum band-pass center frequency and width for reception. Many other units offer only adjustable bandwidth while making no provision for adjustment of the center frequency. For true versatility, both should be adjustable, and in the MSB-1, they are.

After the passband is optimized, an adjustable low-pass section is available to eliminate any remaining "hiss" from off-frequency cw and ssb signals. This section is an 8-pole device, variable over the 300- to 3000-Hz range. During ssb and RTTY operation, this can be used to eliminate splatter.

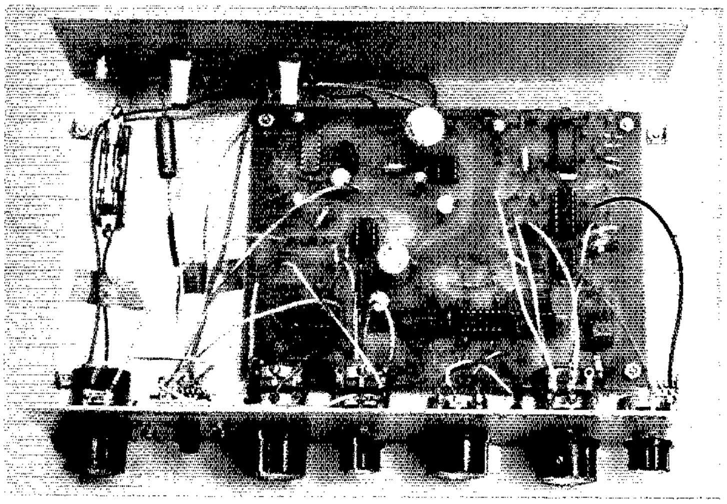
Last, but definitely *not* least is the adjustable notch section. If you have ever listened to the 40-meter band in the evening, you have undoubtedly noticed the presence of broadcast carrier "whistle." The MSB-1 rounds out its filtering capabilities with a notch filter designed to eliminate almost any single-tone signal that will be encountered in normal operation. Like the band-pass-filter section described previously, both the frequency and selectivity are completely variable over the 300-to 3000-Hz range. This is handy during RTTY operation. The notch depth is approximately 50 dB, which is more than adequate even under the most severe conditions.

Performance

Initial operation of the filter was attempted using a 9-V power supply. At this voltage level, the audio output of the filter was quite weak and distorted. These problems were cured immediately when the supply voltage was raised to 12. I used the MSB-1 for several months under widely varying conditions, from casual ragchewing and low-band DXing to contesting. The improvement in reception was quite surprising. Signals buried "in the noise" jumped to Q-5 copy almost every time with the filter in line. The four filter sections help to increase the signal-to-noise ratio while offering little or no additional noise.

During RTTY operation, the separate band-pass, low-pass and notch sections were quite useful in elimination of unwanted information contained in the ssb passband. This produced almost error-free copy while using the Apple II® microcomputer with no terminal unit. The notch is set between the mark and space tones, with band-pass and low-pass sections adjusted for a "double-hump" response.

The manufacturer offers an ac adapter as an accessory, but I would have preferred a built-in supply. Price class of the MSB-1 is $84.95; ac adapter, $8.95. Both units are available from M & M Electronics, P.O. Box 1206, Brewton, AL 36427. — *Michael B. Kaczynski, W1OD*



M & M Electronics MSB-1

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Notch filter: Adjustable from 300 to 3000 Hz, notch depth 50 dB.	As specified.
Band-pass filter: Tunable center frequency, 300 to 3000 Hz; variable bandwidth, from 75 to 1500 Hz.	As specified.
Low-pass filter: Tunable, from 300 to 3000 Hz.	As specified.
Power requirement: 9 to 12 V dc at 300 mA.	12 V required at 300 mA.
Size (HWD): 2-3/4 × 10 × 5-1/2 in.	As specified.

Technical Correspondence

Conducted By
Dennis J. Lusis,* W1LJ

PHASING SSB REVISITED

□ The December 1981 *QST* article, "An Introduction to the Bilateral Transverter," brought to mind the old phasing method of ssb generation. With proper choice of components, the phasing type of sideband generator can be made bilateral, and used for both generating and receiving signals. This idea is, of course, not new. Several articles in various magazines have detailed, for example, how to achieve "single-signal" selectivity with direct-conversion receivers using a phasing-type detector.

Recent ARRL Handbooks have gone into some detail on phasing methods and circuits for generating ssb signals. It is now more practical to generate a good ssb signal in this way than it was in the past. Inexpensive, high-quality parts and computer-generated networks have increased the accuracy of phasing networks to the point where it may be cheaper to make a phasing type of transceiver than one using expensive i-f filters. Combine this with stable, low-noise synthesized oscillators and low-distortion amplifiers, and you come up with a basic rig that could be reduced to one or two circuit boards. The majority of critical electronics could be integrated into one or two ICs. I have prepared a diagram of a "bare bones" transceiver incorporating these ideas (Fig. 1). It puts all of the audio phasing and switching on one chip, and the rf synthesizer and phasing on the other. While this may be a bit optimistic right now, it should eventually be possible; if it is not, it is certain that only a few components in the phasing networks would have to be discrete.

Whoever is able to produce ICs such as these would have the potential to reduce drastically the cost of radio equipment. Volume production of sophisticated ICs is one area in which the rest of the world has not yet surpassed the United States. Experimental proof of the concept would certainly make manufacturers less nervous about entering a "new" field. It would be nice to see a U.S.-built transceiver selling for hundreds of dollars less than the nearest foreign competition! — *Cortland E. Richmond, KA5S/DA1GI, APO NY*

*Assistant Technical Editor

MORE NOTES ON THE HALF-SLOPER ANTENNA

□ I needed an easy-to-construct antenna for 80 and 40 meters, and was tired of dipoles, inverted Vs, radials and tree climbing. I investigated half-slopers, and they seemed ideally suited for my QTH. I have a 64-foot[1] aluminum tower, a 4-foot mast, a Mosley CL33 beam and plenty of yard for experimenting.

W1CF[2] and W1FB[3] wrote articles that made half-slopers look promising. VE2CV's[4] article confused and discouraged me, for how could the thing possibly work at all? But other people had made the half-sloper work, so I decided to pursue it. I also wanted 40 and 80 meters on the same feed line, to simplify construction and conserve coaxial cable. So why not use a 7-MHz trap? Then I read the article by K9CZB[5] and got more confused and discouraged. But like a good amateur, I decided to persist.

I tried a different approach: Why not fan the radiator like a fan dipole? It should work just the same, right? Wrong! I put up a 40-meter half-sloper, and it worked perfectly after a small amount of trimming (very near the formula). Then I put them both on the same transmission line and attachment clamp, and fanned them one above the other. The 40-meter antenna was completely detuned, and the SWR was high. The 80-meter antenna also changed, but not so significantly.

I then experimented by spreading the two antennas apart rather than fanning them. What I found was that if the two antennas were spread at least 30° apart, the 40-meter antenna worked just fine. The farther they were spread, the lower the SWR would go until I reached about 60°. Also the resonant frequency would change with the different angles. Hence, any specific angle would require its own special trimming. The closer the antenna, the more trimming necessary for a change in angles.

An interesting thing happened to the 80-meter antenna: The fanning or spreading didn't seem to affect it much. However, after it was trimmed in an emperic manner, I found it was very broadband and had an unusual SWR curve (Fig. 2), completely different from the usual hyperbola of the isolated 80-meter anten-

[1] m = feet × 0.3048.
[2] D. Atchley, "Putting the Quarter-Wave Sloper to Work on 160," *QST*, July 1979, p. 19.
[3] D. DeMaw, "Additional Notes on the Half-Sloper," *QST*, July 1979, p. 20.
D. DeMaw, "More Thoughts on the Confounded Half-Sloper," *QST*, October 1981, p. 31.
[4] J. Belrose, "The Half Sloper — Successful Deployment is an Enigma," *QST*, May 1980, p. 31.
[5] G. Myers, "A Two-Band Half-Sloper Antenna," *QST*, June 1980, p. 32.

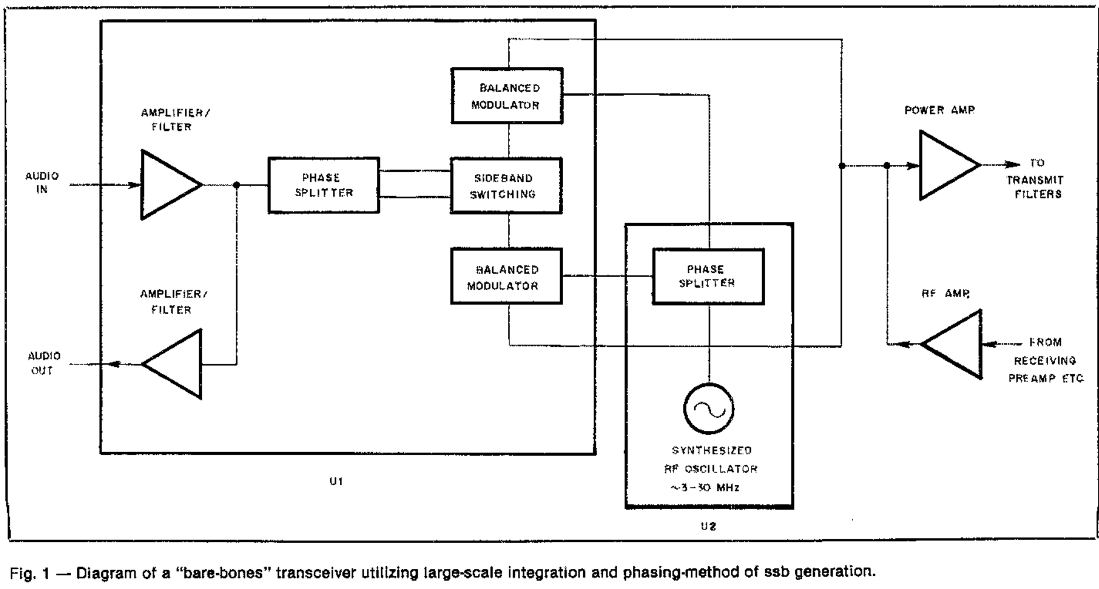


Fig. 1 — Diagram of a "bare-bones" transceiver utilizing large-scale integration and phasing-method of ssb generation.

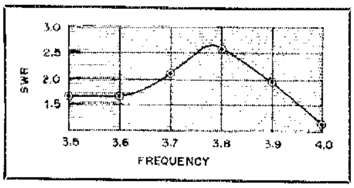


Fig. 2 — VSWR curve for the 80-meter half-sloper antenna.

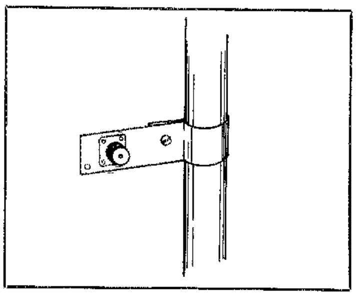


Fig. 3 — Mounting clamp for providing a feed point on one of the tower legs.

na. I now had my goal accomplished: 80 and 40 meters on the same transmission line.

I decided to try some traps anyway. I concluded they must work, despite K9CZB's failure. I cut the 80-meter antenna from the transmission line and experimented with the proximity of the single 40-meter half-sloper to a second antenna with a separate transmission line. This was a half-sloper for 4.550 MHz, which we use for our fixed-service church radio. I found that the close proximity of the two slopers indeed detuned the 40-meter antenna, but not as much as when they were on the same transmission line. I again noticed that, as the antennas got closer, the resonant frequency changed and the SWR went up. I found that the angle between the two antennas was less critical than when fed off the same transmission line, and that even when fanned one above the other the 40-meter antenna still worked.

I then spread the two antennas so that they caused no interaction (about 60°) and put a Reyco® KW-40 7-MHz trap at the end of the 40-meter antenna. Then I ran a piece of wire beyond the trap to an insulator. After minimal cut and trim the antenna performed perfectly with an SWR of 1.1:1 on 40 meters (less than 1.8:1 over 100 kHz) and 1.6:1 on 80 meters (less than 2.5:1 over 300 kHz). The SWR graph was the expected hyperbola. In short it worked just as expected. The 40-meter antenna must be tuned first.

Performance on the air is good. I am not a big low-band man, so my experience is limited for making expert comparisons. I can say that I am very pleased. I have as good a signal as anyone, and better than many on the West Africa Net (7060 kHz). It is also notably directional with significant gain in the direction of the slope, as previously described. 6W8IC gave me an S6 report on the sloper to the northwest, but an S3 report on the sloper to the east. XT2AU gave me a similar report, but favoring the sloper to the east over the one to the northwest.

So why all the controversy? I have come to the conclusion that VE2CV must be right with regard to 200 MHz, but not at 7 MHz. There must be things happening at these low frequencies that don't happen at 200 MHz. That is why antenna construction practices are quite different on vhf compared with hf. This makes studying this antenna more difficult, because there isn't a nice model to use. I'll leave the rest to the engineers.

Why all the varying reports on length, tuning, etc.? Well, I think it's clear that this antenna is very sensitive to nearby antennas and no doubt also to power lines, telephone lines and buildings. My theory is that this makes up all the individual variation. I bet if two hams in Iowa put up the same tower in the middle of their respective 80-acre cornfields, they would end up with the same antenna length — very close to the formula. I'll leave that experiment for some KØs to perform, however.

Why didn't K9CZB's trap work? I can't explain that one. I can only postulate a problem with the trap or some specific site object that was detuning the antenna.

Some additional comments: The angle from the tower also seems to affect the tuning of the antenna. I made a modification to W1FB's tower clamp by incorporating an SO-239 jack into the clamp (Fig. 3). Be sure to tape and cement the connection to protect your feed line. I took no other special precautions with the coaxial cable, and simply taped it to the side of the tower with the other lines. It also seems that the higher above ground the low end of your antenna is, the lower the SWR. I suggest that anyone wanting to get on 160 meters, but who isn't as lucky as W1CF to have a 92-foot tower, could easily put an inductor in the middle of the antenna to make an off-center-loaded[4] half-sloper. This would shorten the antenna to fit a more average tower at the expense of bandwidth. — *Mark H. Monson, EL5G/KB8NO, Box 1046, Monrovia, Liberia*

[4]G. Hall, "Off-Center-Loaded Dipole Antennas," *QST*, Sept. 1974, p. 28.

Feedback

☐ Greg McIntire, author of "Designing a Microprocessor Based RTTY Speed and Code Converter" (Jan. and Feb. 1982 *QST*), informs us of an error in the ASCII version of the software listing. The statement,

```
IF MODE = 03H THEN
  CALL CASCBDT; ELSE
```

at the beginning of the TXCNTRL routine should read,

```
IF MODE <> 03H THEN
  CALL CASCBDT; ELSE.
```

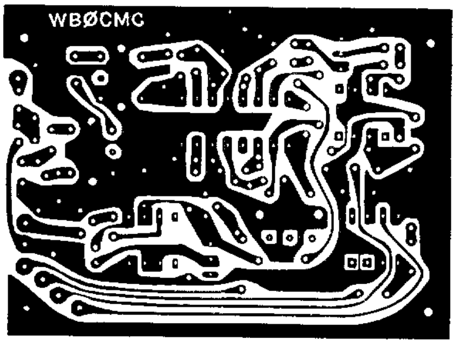
The object code at location 0493H should be changed from C2H to CAH.

☐ David Wiley, W7WYG, called our attention to two errors on the schematic diagram of the 6-Meter "Mini-Lini," April 1982 *QST*, p. 25. The plate voltage should be shown as 800- to 1200-V dc. Also, C3, a 220-μF electrolytic capacitor in the bias circuit, is shown connected backwards. The positive side of this capacitor should be wired to ground.

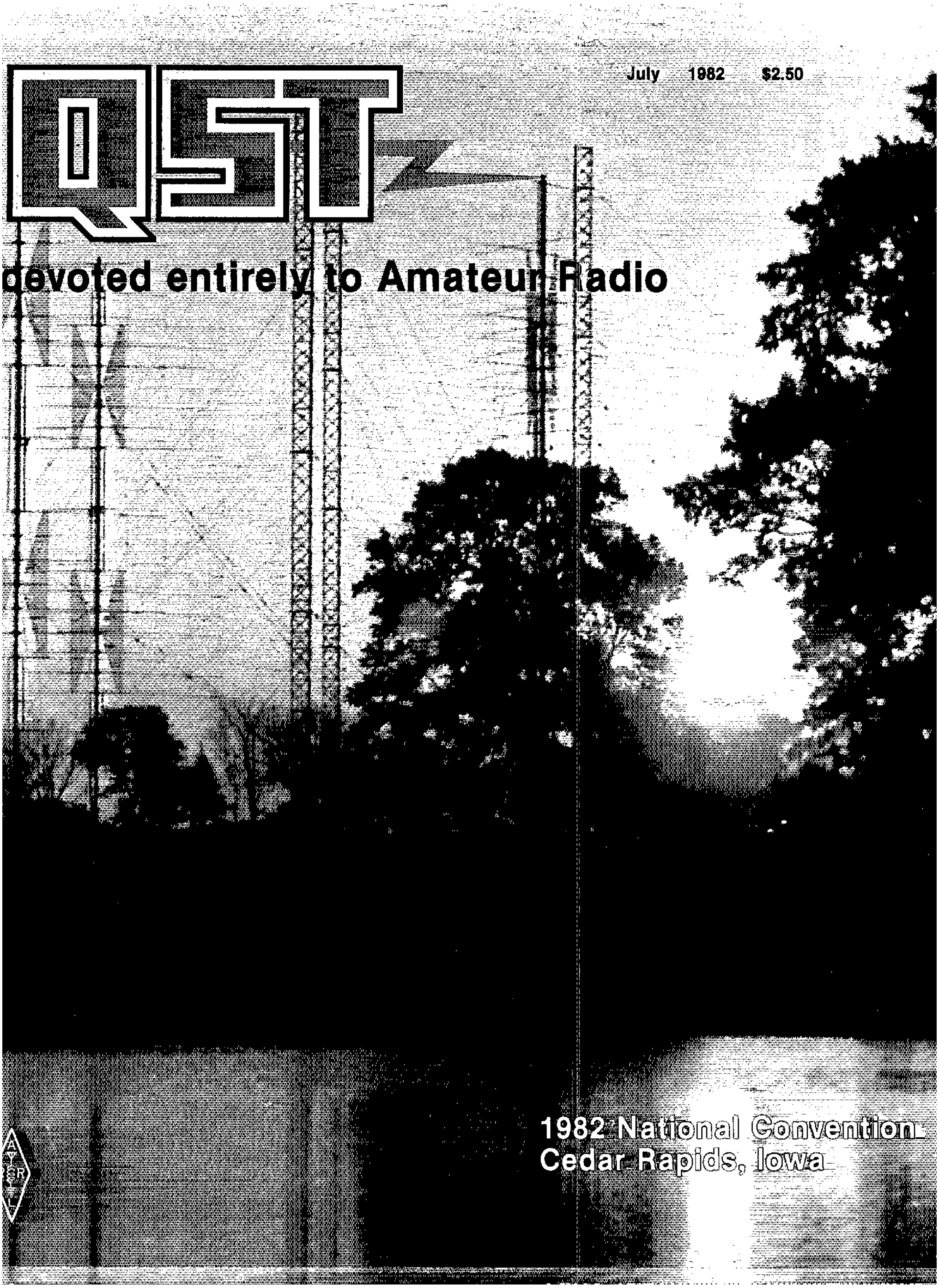
☐ In Fig. 2 of "Concept and Construction of a CW Filter and Enhancer," April 1982 *QST*, the 100-kΩ pot connected to U3D pin 13 should be labeled R4. The 100-kΩ resistor from U3D pin 14 should be labeled R5; the other end of R5 connects to U4 pin 5.

☐ In "Build an FM-Receiver Clone," March 1982 *QST*, the capacitor between T1 and T2 is incorrectly labeled as 0.001 μF. The correct value is 5 pF. Also, the pc-board etching pattern in Fig. 4B is missing a few traces. The entire pattern is again printed here.

☐ A sidebar ("Getting Involved") on page 13 of the April 1982 article, "A Happy Marriage: Amateur Radio and the National Weather Service," has an incorrect reference. Suggestions for organizing a weather or spotter group appear in an April 1979 *QST* article by Brian Peters.



Revised etching pattern for the FM-Receiver Clone. View is from foil side of the board; black areas represent unetched copper.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THE COVER

The antenna farm at the Rockwell/Collins worldwide communications system will be part of the tour for those attending the ARRL National Convention in Cedar Rapids, Iowa July 23-25, 1982.

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Equalize Your Microphone and Be Heard!

How does the audio sound at the other end when you are talking? How does your repeater sound? Build this equalizer and be surprised at the improvement!

By Bob Heil,* K9EID

Hams place emphasis on high-power transmitters, large antenna systems and accessories that are aimed at making Amateur Radio signals louder. Few take note of articulation (clear and effective utterance). Good articulation gives the listener the ability to clearly understand each syllable.

Manufacturers say very little about audio-frequency response and distortion levels. The audio section (of a transmitter) should be fairly flat in response — meaning that there are no big peaks or nulls in the overall response pattern — and have less than 0.2% distortion.

Choose the Correct Microphone

Microphones are designed for specific purposes. In the sound-reinforcement and recording-studio industry, a microphone is purchased only after evaluations are made to ensure that a particular one will produce the desired results.

Amateur Radio operators do not usually select a microphone on this basis. Few hams bother to listen to the output of a microphone before purchasing it. Microphones look "sharp," match the color of your transmitter or appeal to your spouse's sense of decor! One fellow recently commented on 40 meters that he purchased a particular microphone because it had a long cable.

A Proper Test

Recording studios have racks of expensive test instruments to help conduct a proper test. But what about you? You only need a good-quality tape recorder and one of your fellow amateur friends. Have him record directly from the speaker of his hf receiver into the line input of the tape recorder while you transmit a signal. Take the tape home and "digest" it. You will hear your station almost as others hear it. It is a simple method for finding out what your station sounds like.

To make the test properly, use three or four microphones that you think will do the job for you. Then select several that you don't think you will like. Using a 2-meter direct-frequency link for coordination, have your friend tape directly from his receiver, making sure to avoid input-overload conditions. If your signal is strong, have him disconnect his receiving antenna, or listen with his dummy load connected.

During the test, try each microphone with your transmitter. Be very careful to document each move, by mentioning each microphone by model, and note the level setting on the tape recording. You then have an accurate reference when listening to the playback.

After the test transmissions, you will want to listen to the results under conditions similar to those of others who will hear your signal. Don't listen to the tape while using a high-quality speaker system. Play the results back through the speaker of your Amateur Radio receiver. When listening, be ready for some surprises! Remember those three microphones you didn't think much of? Chances are, one of them might be the best of the lot! You will be listening for good articulation in the midrange and sibilance (the high frequency presence of "s" and "t") sounds with low or no distortion. Once you find a microphone that suits you, it's time to start equalizing your system for optimum audio characteristics.

Passive Equalization

Most modern ssb transmitters contain filter networks that limit the response from 300 to 3000 Hz. If you use a microphone that has a wider frequency response, the transmitter may produce a wider signal than is necessary. The lower-frequency audio (under 300 Hz) does nothing to help the receiving-station operator understand the information better. In fact, better articulation is achieved by passively rolling off the microphone response under 300 Hz. This can be accomplished easily by installing a disc-ceramic capacitor, such as a 0.01-μF unit. The impedance of the microphone and the capacitor value will determine the roll-off frequency.

This capacitor should be installed in series with the "hot" microphone lead. Placing the capacitor across the hot lead to ground will roll off the high frequencies, should you desire to do this. In most cases you will not want to roll off the high-frequency response.

Your end goal is to achieve good articulation without killing any of the natural midrange and low-frequency responses. You will want to roll off the low end, keeping your signal as narrow as

*Heil Sound, 2 Heil Dr., Marissa, IL 62257

possible. Most modern receivers have filters that pass only 300 to 3000 Hz audio. Transmitting any frequencies outside of this range causes the transmitter and final amplifier to work harder to produce suitable signals. Anyway, the receiver should filter out the responses outside the passband.

Active Equalization

To get the full advantages of proper audio equalization, active filter circuits should be used instead of passive ones. Active elements are capable of giving you ± 15 to 30 dB ("cut" and "boost") at precise frequencies. These can be selected easily or made completely variable by using parametric filters with variable passband slopes and adjustable filter Qs.

Using a dual 741 (LM1458), you can build a simple but effective active filter, providing the flexibility needed to equalize a microphone. You can add other functions, such as tape recorder, phone patch or inter-tie audio patches.

The circuit can be built with several bands of filtering, so you can control the spectrum from 300 to 3000 Hz. For communication-quality speech, two active filters are sufficient. For maximum utility, drive the filters from a high-quality microphone preamplifier that has been designed carefully so it will not overload the active filters, even at maximum gain.

Circuit Description

Two dual op amps are used in the circuit (Fig. 1). One half of the first IC is used as the microphone preamplifier. It has a transformer input to provide proper impedance matching, as well as protection from RFI. Using transformer-coupled input circuits (where high levels of rf are present) is a good practice. The ac audio signal passes through the windings, but rf will not pass; therefore, you have a good rf shield at the input. It would also be advisable to use ferrite beads on leads that enter the chassis, thus keeping stray rf from entering.

This preamplifier is coupled to the two active filters by means of C4. The filters are set at 500 and 2200 Hz. Filter slopes are fixed at 12 dB per octave, while the filter gain is set to the range of + 12 dB to − 12 dB. The Q of each filter is 1.7. Output of the Equalizer is variable from 0 to 0.9 volt. Be aware that it may overload your transmitter microphone preamplifier. The proper level will have to be set as a preventive measure.

W1AW/R Equalized

Like many other homemade repeaters, the W1AW/R 2-meter repeater had poor audio characteristics. Some operators' voices were virtually unrecognizable when operating through the machine. As suggested by author Heil, we installed an equalizer circuit in the repeater, thereby replacing the old coupling system.

The results have been better than expected. Based on experience with our old system, we classified two voices as our worst cases. We then equalized the audio to make these voices sound natural while coming through the "machine." It took a few visits to the repeater site, but it was worth it. Everyone agrees that the audio has improved dramatically. If you are having trouble with the audio on your repeater, we suggest you try an equalizer. *— Peter O'Dell, KB1N and Gerald Hull, AK4L*

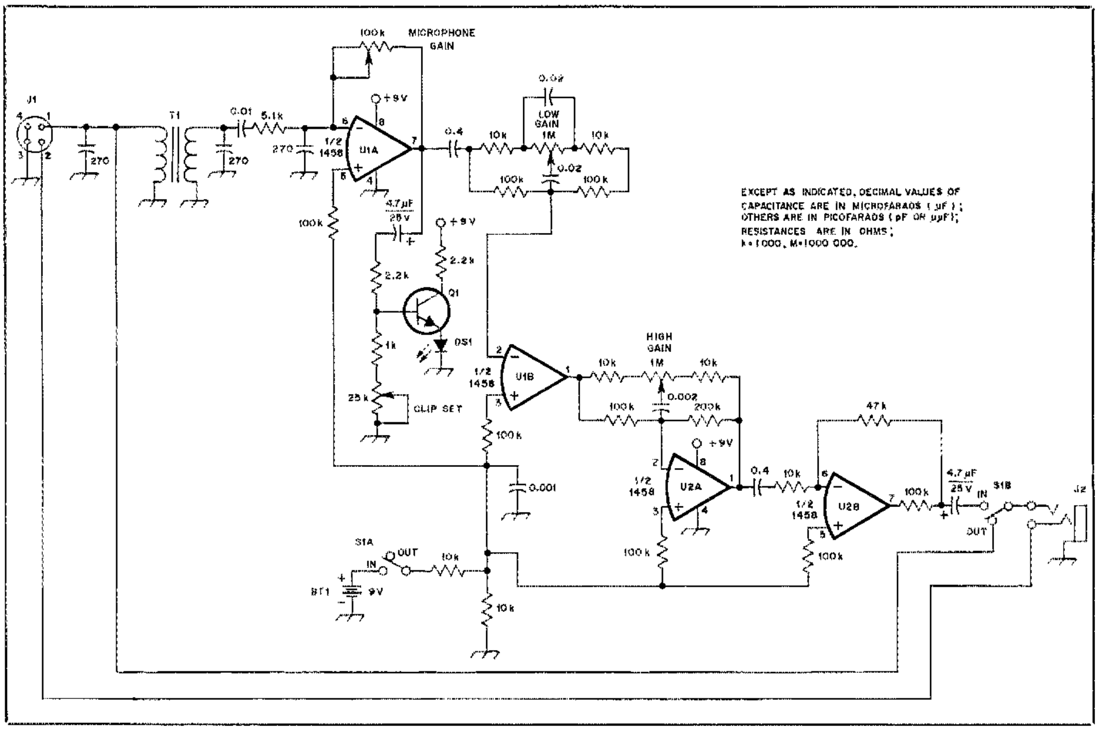


Fig. 1 — Schematic diagram of the Equalizer. All resistors are 1/4-watt carbon-composition or film types. Part numbers in parentheses are Radio Shack.

DS1 — LED, size and color not critical.
Q1 — Silicon, npn small-signal bipolar transistor, 500 mW, 2N2222 or equiv. (276-2009).
S1 — Dpdt toggle or slide switch (275-666, 275-403, etc.).
T1 — 2 K to 10 K audio-interstage transformer, RS273-1378 or equiv.
U1, U2 — Dual operational amplifier IC, type 1458 or equiv. (276-038).

The power supply can be a 9-volt battery or a well-filtered ac supply. If care is taken to avoid ground loops and magnetic fields affecting the high level microphone preamplifier, you can build a supply inside the housing.

Construction

The circuit is assembled on a small pc board (Fig. 2).[1] Mount the board, with either the battery or power supply, in a small metal enclosure. Take care to shield every connection to the outside. Use ferrite beads or feedthrough capacitors for each lead that enters the chassis. Subjecting any audio circuit to high levels of rf may cause problems.

An LED connects to the "clip" light circuit of the preamplifier. This circuit has a control, R1, to adjust the light threshold. Overloading the preamplifier will turn on the overload indicator. The light is best set to come on at 6 dB, before hard clipping is observed on an oscilloscope. If you don't have a scope, you may be able to set it by listening to the output of the preamplifier through a small audio amplifier and adjusting it so the light comes on just before distortion occurs.

Adjustment of the two filters is accomplished best by listening to another receiver, or by having a friend record your testing (as discussed earlier). Once the equalizer is set, it shouldn't have to be changed. Many of these units are tucked away behind the rig so that the controls aren't bumped and changed by mistake.

Equalization for Repeater Service

Many repeater systems can be improved by using an audio-filtering system similar to the one described here. A typical repeater system loses some articulation and sibilance because of losses encountered with improper coupling between the receiver and transmitter audio sections. Impedances between the two are often mismatched, further complicating matters. A simple group of variable filters set at 400 and 2500 Hz will aid audio articulation. Of course, once the filter is installed and set for maximum intelligence, it should not have to be adjusted again.

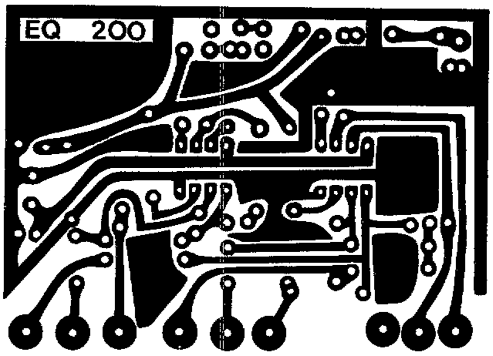
Don't Forget the Microphone

You can play a few "tricks" to enhance the response of some microphones. Again, you will have to rely on the tape recorder test to determine optimum performance, but it will be worth the effort.

One microphone that can be improved is the Kenwood MC-50. If you have one, make a transmission and have it tape recorded by a fellow operator. Then, wrap electrical or masking tape around the microphone to cover the long slots in the sides near the cartridge. About three turns will usually cover them sufficiently.

Record the signal again. The difference is remarkable! All low-end rumble should be gone. The midrange will be enhanced. You have equalized the microphone by dampening the back of the cartridge, and not allowing the element to travel as far in the basket by closing the air chamber. The cardboard tube inside a toilet-tissue roll fits perfectly over the end of the MC-50, providing a permanent, simple, but effective, modification. Many other microphones can be dampened in similar ways.

[1]Parts, partial kits and completed units are available from Heil Sound, Box 26, Marissa, IL 62257, tel. 618-295-3000. The ARRL and *QST* in no way warrant this offer.



Circuit-board etching pattern for the Equalizer. Black represents copper. The pattern is shown at actual size from the foil side of the circuit board. The parts placement diagram for the equalizer was unavailable at the time of publication.

Be Aware of Excess Room Resonance

One of the worst things done to Amateur Radio audio today is placing the microphone in a hard-surfaced room with lots of echo. Some operators crank the gain of the preamplifier up so that they can lie back 3 to 4 feet away, controlling the PTT with their toes! I think this "murders" a good signal. Most communication microphones are designed to be close-talked, using low microphone gain, and thus produce better presence and articulation. The room echo becomes practically nonexistent, while the speech audio comes out on top.

Even in recording studios, where acoustics are nearly perfect, microphones are "worked" very close. Many microphones exhibit a proximity effect: The closer you talk into the microphone, the more low and mid frequencies it produces, in relationship to the high-frequency response. When you back off from the microphone, the result is a "thin" sound, as the body of the voice characteristics is lost.

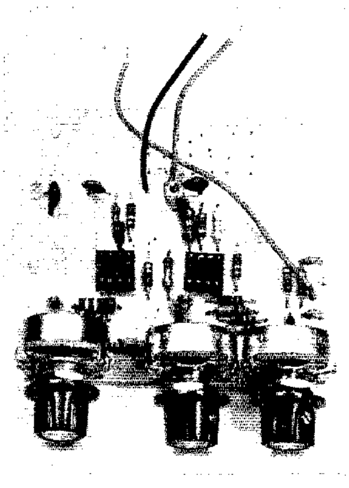
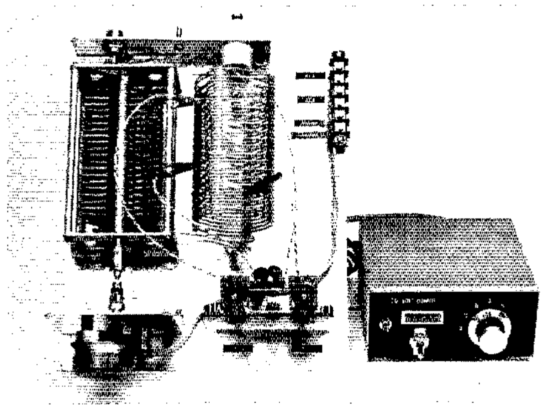


Fig. 2 — Equalizer board before mounting it in the W1AW/R 2-meter repeater.

Little things make stations sound big. Proper use of microphones, correct placement, small amounts of equalization and suitable gain settings are some of the most important "little" things. Are you aware of what you sound like, and do you want to make it better? Our bands are becoming more populated. Perhaps crowded bands can be tolerated, all things being *equalized.*

Antenna Matching, Remotely — Some Thoughts



Network switching for multiband antennas is no fun out of doors in foul weather. Remote control saves time and keeps you indoors. Here are some design thoughts.

By Doug DeMaw,* W1FB

Remote matching networks too complicated for you? Too much trouble with arcing and flashover at high power? And what about the cost of parts for a remotely controlled matcher? Well, I pondered the same questions during an extended period of practical deployment for the VE2CV Half-Delta Loop antenna.[1] Not only that, I grew weary of dashing out to the back lot in the rain, snow and darkness to change bands and adjust for a VSWR of 1:1. Fall and winter on the East Coast can bring with it some cold, dismal weather. That, plus the time lost in doing a manual adjustment, can leave one less than enthusiastic about hand-operated outdoor tuning systems!

I was in a hurry to correct the annoyance that beset me as winter hustled into Connecticut. I hoped that there were enough components in my workshop to permit the building of a three-band, remotely controlled network that would sustain 600 watts of rf energy. The first try was okay except for occasional flashover of the two control relays when running 1 kW of dc input power. A simple technique was developed to resolve the matter (more on this later), and the system was finalized, then installed in a homemade "dog house" to keep it high and dry. The general approach may be of interest to you if your station requires remote band switching or matching of an antenna for which the feed point is far removed from the shack.

Network Types

The choice of matching circuits is dependent upon the type of antenna in use — a truism for certain! There is no reason why one could not use any popular L-C network, Omega match, gamma match or whatever, assuming it was appropriate for the type of feed system in use. Wide-range Transmatch circuits like the Ultimate or SPC[2] are suitable for remote installations, but would require a reversible motor with stops for the rotary inductor (Fig 1). A fixed-value inductor with preselected taps would be a practical substitute for a rotary inductor, however, since the various impedance values for a multiband antenna would not likely change beyond the correction range of the variable capacitors.

My situation called for a simple L network for which the impedance transformation was up from 50 ohms on 80, 40 and 20 meters. The circuit is shown in Fig. 2. It is used with the Half Delta Loop, but could be employed for slant-wire feed of a tower (a poor man's form of delta matching). The latter is used among some amateurs by isolating the tower guy wires with insulators, but leaving one guy common to the tower, then feeding it at the ground end (Fig. 3). This can be an effective DX antenna for 160 and 80 meters, even when a triband Yagi is atop the tower. It does require a good ground system, such as a fan of buried radials.

The Half-Delta Loop (grounded half-wave loop at f_0) used at W1FB with the L network provides excellent DX results on 80 meters at f_0, on 40 meters (2f) and at 20 meters (4f). Radiation is vertically polarized on all bands and is essentially omnidirectional at f_0. There is increasing directivity as operation is carried out at progressively higher harmonics. The directivity is in the slope of the slant wire. If a good ground system is used with the loop the angle of radiation will be low, and some gain will prevail at the harmonic frequencies. The half-wave grounded loop is shown in Fig. 4. The maximum-current resonance is not exactly related in terms of the harmonics. Therefore, the feed impedance varies from band to band (90 to 250 ohms in my installation for 3.5 to 14 MHz). The L network was a good choice for obtaining a matched condition to 50-ohm coaxial cable.

L-Network Circuit

Moderate plate spacing for C1 of Fig. 2 is adequate for my installation, owing to the relatively low impedance transformation at the feed point of the loop. A plate spacing of 1/8 inch (3 mm) has been suitable for the output from my SB-221 amplifier. Higher feed impedances will probably require larger plate spacing. This can be calculated if the feed impedance is measured. Then, it's simply a matter of using $E_{rms} = \sqrt{WR}$, where W is the output power of the transmitter and R is the feed impedance in ohms. Thus, 600 watts across 150 ohms would produce an rms voltage of 300. This would equate to a pk-pk ac voltage of 846. The plate spacing should be chosen for 846 volts minimum, thereby allowing for dielectric (air) degradation when the air is damp or

[1]Notes appear on page 16.

*QST Senior Technical Editor

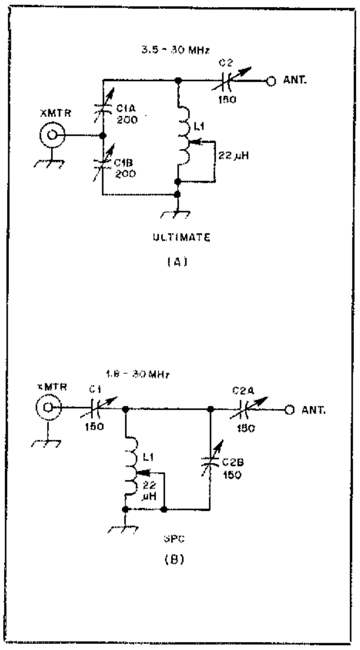


Fig. 1 — Basic circuit of the Ultimate Transmatch (A) and the SPC network (B).

polluted. Dust accumulations must also be considered. Most manufacturers of variable capacitors provide voltage ratings for the various plate spacings. If in doubt, consider that dry, clean air has a dielectric factor of 1 at 1 MHz. The breakdown voltage is 240 per mil (0.001 inch).[3]

Relays K1 and K2 of Fig. 2 were used because they happened to be on hand. Intuitively, one might prefer fancy, expensive antenna relays with steatite insulation. But, by "floating" the plastic-insulated relays at K1 and K2, the arc-over problem mentioned earlier was solved. The rf voltage no longer has a path to ground because of the toroidal chokes in the field-coil leads of the relays. The contact area of the relays must be able to sustain the rf current without losses, heating and subsequent heating damage. Again, if the feed impedance and rf power are known, we can determine the current rating for the relay contacts. This is obtained from

$$I = \sqrt{\frac{W}{R}} \qquad \text{(Eq.1)}$$

where I is in amperes, W is in watts and R is in ohms. Hence, if the antenna impedance is 150 ohms and the power is 600 watts, the maximum rf current through the contacts will be 2A. Always allow some leeway for this rating. A set of 5-A contacts should suffice for the example.

My relays are 24-V dc types. The mechanism for rotating C1 is a geared-down clock motor (surplus) that provides a 1-rpm speed. It requires 24 V ac for operation. I found this convenient because the motor voltage is taken off the 24-volt power transformer ahead of the rectifier diodes, and the relays are operated from the resultant dc voltage. The shortfall of using the clock motor is that it is not a reversible type. This means that if I adjust C1 past the setting that yields a VSWR of 1:1, I must wait nearly one minute before the capacitor is back to the setting I desire. A reversible motor is recommended if you are an impatient person! Check the surplus stores and flea markets for sources of clock motors, but look for a robust one. If possible, adjust the tensioning springs or bearings of C1 for minimum practical torque to lighten the load on the motor.

Power Supply

Fig. 5 contains the circuit diagram of the power supply for the tuning network. I modified an existing unit that I had built for controlling a remote coax switch at the top of my tower. Hence, there are some

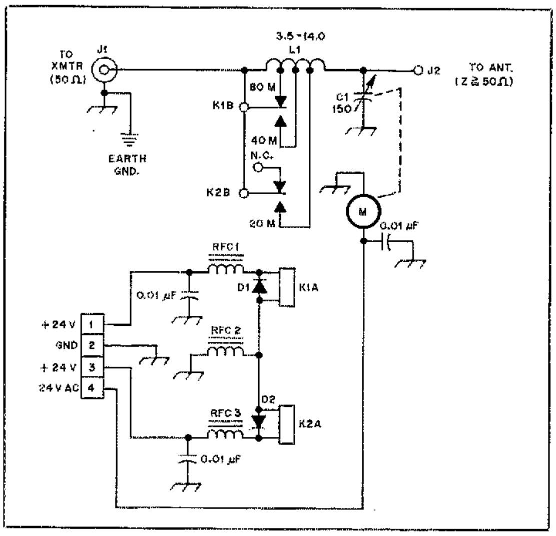


Fig. 2 — Schematic diagram of the L network used with the Half-Delta Loop. It is suitable for use with other types of antennas as well.
C1 — Transmitting variable rated for developed rf voltage (see text).
D1, D2 — Small-signal silicon diode, 1N914 or equiv.
J1 — Chassis-mount coaxial connector (SO-239).
J2 — Steatite feedthrough bushing.
K1, K2 — 24-V dc relay, spdt type (J. W. Miller Co. 1W6 suitable). A 2W6 was used at W1FB, with the extra spdt contacts wired in parallel with the first set on each unit.
L1 — Section of 2-1/2 in. diameter Miniductor stock to yield 18-20 µH of inductance. Home-made coil on low-loss form also suitable.
M — 1-rpm motor (see text).
RFC1, RFC2, RFC3 — 10 turns no. 20 insulated wire wound on stacked Amidon FT50-43 ferrite toroid cores. Use two cores for each choke.

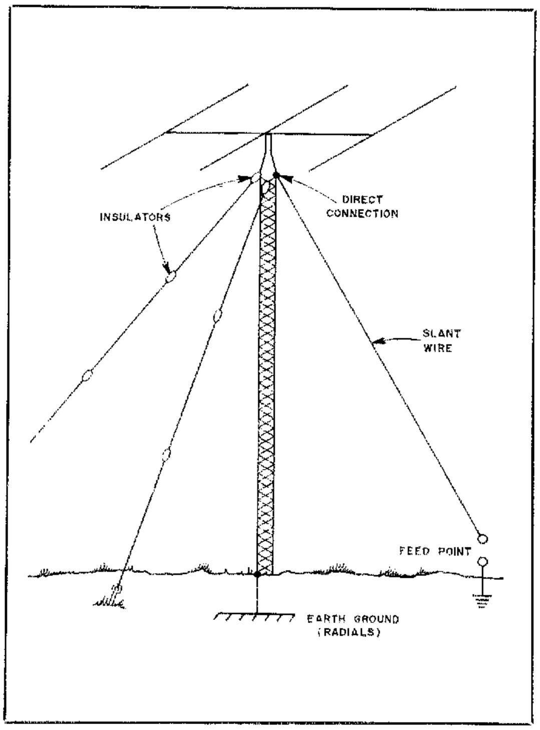


Fig. 3 — Example of slant-wire feed of a tower that contains a triband Yagi. One guy wire is used for feeding the tower. The remaining guys are insulated from the tower.

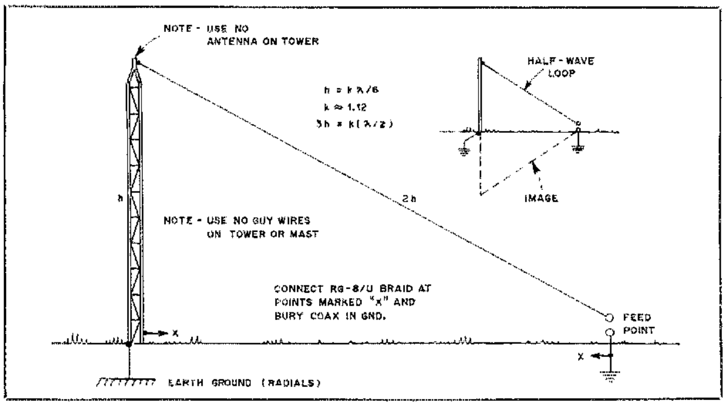


Fig. 4 — Essentials of the Half-Delta Loop antenna designed by VE2CV. The dimensional factors provided are for the ideal condition. Reasonable variations in h and 2h will not degrade the performance significantly.

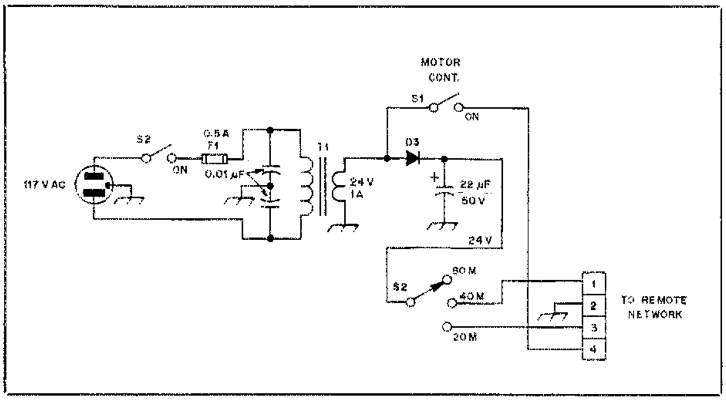


Fig. 5 — Schematic diagram of the control box and power supply for the circuit of Fig. 2. D1 is a 1-A, 50-PRV rectifier diode. S1 is a momentary push-button switch, and S2 is a single-pole, 3-position rotary switch. A Radio Shack 24-V transformer is suitable for T1. F1 is a 0.5-A fuse.

unused switch positions on the front panel.

The power unit contains a momentary switch for controlling the ac motor in the remote network. Four-wire control cable is buried in the ground (along with the 50-ohm feed line) between the house and the weatherproof box at the rear of my property. Since the current taken by the motor and relays is low, the conductor size of the control cable can be small (I used 100 feet of cable with no. 24 gauge conductors). The vinyl jacket of the cable is sealed at the far end (outdoors) to prevent moisture and dirt from entering it. The 50-ohm cable is Decibel Products VB-8, which is an impregnated type of RG-8/U, and is designed for underground use. Times Wire and Cable Co. makes a similar weatherproof, chemical-resistant line.

Construction Notes

A steatite feedthrough bushing is used for the loop-wire feed from the matching network of Fig. 2. A terminal strip (right top of picture) provides a connection point for the control lines. A 4-pin socket can be used instead of the strip.

K1 and K2 are mounted on a vertical section of plastic to further insure against rf flashover to the aluminum chassis, which is grounded. A transient-suppression diode is used in parallel with the field coil of each relay.

A flexible shaft coupling is employed between the motor shaft and that of C1. This will help to reduce tension on the motor in the event alignment of the mating shafts is not perfect. The motor is affixed to an aluminum L bracket. A second L bracket contains the coax connector, steatite bushing and a no. 10 screw for grounding. Miniductor L1 is elevated 1 inch above the chassis on steatite standoff posts. The completed assembly is placed in the wooden dog house, which is mounted on a 4 × 4-inch post, 3 feet above ground. The housing is situated at the feed point of the loop antenna.

Adjustment

The photograph shows alligator clips on the leads that form the coil taps. These clips are used during initial adjustment of the network. After the proper coil taps are found, the clips are removed and the wires are soldered permanently to the appropriate coil turns. I poked every other coil turn inward before starting the tuning. This provided clearance for the clips and prevented the creation of shorted turns.

A 2-watt QRP rig (HW-8) and a homemade, low-power VSWR indicator were used for the tune-up. The VSWR meter was connected between the 50-ohm feed line and the matching network. An extension cord provided 117 V ac to operate the control box and the HW-8 at the rear of my lot.

Tuning commenced at the lowest band (relays both turned off). C1 and the tap point on L1 were adjusted for a VSWR of 1:1 at 3.510 MHz. Next, K1 was energized with the rig tuned to 7.025 MHz. The 40-meter tap on L1 and the setting of C1 were juggled until a match was obtained. Finally, K2 was energized (K1 deactuated) and the 20-meter coil tap was set for a matched condition at 14.025 MHz. The wires were then soldered in place. ***Remember to keep your transmissions short and to identify your station periodically while testing.*** This completed the setup for a VSWR of 1:1 on each of the three bands.

My dog house is built so that the roof lifts off to expose the matching network. It is much easier to work from the top than to reach through a side door. An oval-shaped hole was cut on the bottom-rear surface (floor) of the enclosure to permit routing the ground wire, the 50-ohm line and the feed wire to the network.

Summary Comments

Although you may not be interested in using an L network or a Half-Delta Loop antenna, some of the ideas in this article should be helpful when designing other switching and matching systems. I can say in conclusion that the results and convenience resulting from this installation more than offset the work of building the network, burying the control line and feeder, and assembling the dog house! No more junkets into the back lot at night with a flashlight in hand, especially on those cold nights when it's pouring rain or snowing. QST

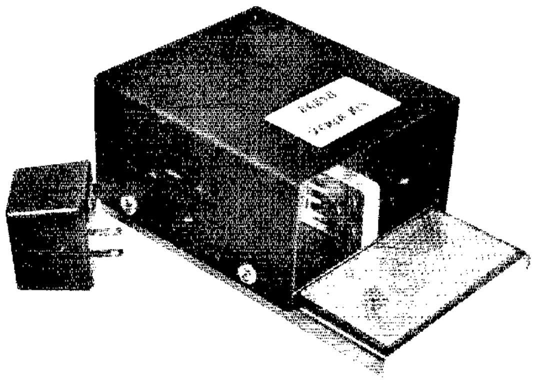
Notes

[1] J. Belrose, "The Half-Delta Loop — A Grounded, Vertically Polarized Antenna," *Ham Radio*, May 1982.

[2] Most commercial Transmatches employ the circuit of the Ultimate Transmatch, but some use coil taps rather than a roller inductor.

[3] mm = in. × 25.4, and m = ft. × 0.3048.

K6BSU Touch Keyer



Tired of adjusting those blasted keyer paddles? Try something different. K6BSU sheds new light on this "touchy" subject.

By Floyd E. Carter,* K6BSU

Electronic keyers have become a standard item for the cw operator. This version incorporates a basic electronic keyer circuit with some new ideas. The keyer was especially designed and built with the home constructor in mind. It features capacitive-touch keying and is built entirely from standard, readily available parts. All of the parts were obtained from well-known, nationwide retail stores.

The capacitive-touch feature greatly simplifies construction by eliminating mechanical switches. Since physical layout is not at all critical, creative packaging designs are possible.

A survey of the commercial keyers turned up things like "squeeze" paddles and other exotic features. With many years of experience behind a mechanical "bug," and not being in a mood to retrain, I wanted an electronic keyer and that was simple to operate. Even though this keyer features self-completing characters, my transition from bug to electronic keyer was natural and effortless.

Keyer Logic

The circuit was designed in two parts. Fig. 1 gives the complete circuit diagram. The basic logic was a construction project of several years ago and was originally fitted with Microswitches operated by a keying lever. In fact, commercial paddles will operate the circuit by grounding the inputs to gates U5E and U5F for dots and dashes, respectively.

U7A and U7B are connected as a keyed multivibrator, which always starts in the same phase when triggered and is activated for both dots and dashes. Dash keying also sets the dash flip-flop, U8. The dash flip-flop divides the dot multivibrator output by two. Output from the flip-flop is gated with the dot multivibrator output in the logic NAND gate, U7C. This has the effect of filling in the space between the first and second dot to produce a dash. If this same logic is followed, the flip-flop fills in every other space between dots and creates perfect dashes with the required 3:1 ratio.

Both dots and dashes are self-completing. It is necessary only to initiate a dot or dash. Feedback from both the dot multivibrator and the dash flip-flop is applied to gate U6A. Thus, the dot sequence always consists of a dot and a space. A dash sequence always consists of a dash, three dots in length, followed by a space.

Touch Switches

U3 is a comparator IC connected as a 100-kHz oscillator. The output is connected to the wrist plate. In operation, the wrist is placed on this plate, and the dot and dash plates are activated with the thumb and index finger in the usual manner. When the dot plate is touched, some of the 100-kHz energy is coupled into detector U1. The network R1, R2 and C3 form a high-pass filter to prevent 60-Hz pickup from activating the detector. U1 is normally biased with a fixed 1.7 volts such that in the absence of an input from the touch plate its output is high. When more than 3.7 volts pk-pk is coupled into U1, the peaks of the input signal exceed the reference bias, and the output transistor in U1 conducts to ground. This discharges C4 through the output stage. During the time when the instantaneous input is below the threshold, U1 is cut off, allowing C4 to charge through R3. Since the discharge path resistance is much lower than the charging resistance, C4 remains nearly discharged as long as the peaks of the input exceed the threshold. Operation of the dash detector U2 is identical.

U4 is connected as a latch to prevent simultaneous dot and dash activation. Whichever detector is first activated, the other is locked out by the latch. This is an important operator convenience, as it allows dot and dash "leading" for reduced wrist and finger motion. For example, after a dash has been initiated, a dot may be programmed to follow by touching the dot plate. When the dash is finished, the index finger (for dashes) is removed, and dots will result.

Construction

The cabinet I selected consists of two U-shaped pieces of sheet aluminum for the base and top. My cabinet base is fastened to a longer piece of aluminum, which extends out from the front panel by about 4 inches. This may be seen in Fig. 2. The wrist plate, made from a piece of single-sided circuit-board material, mounts to this extension. I decided to cut off the front panel and install a heavier one set back slightly to conserve space.

The paddle is made from 1/2-inch-thick plastic, and the dot and dash plates are fastened to it with short, flat-head screws. Wires connected to the plates are passed through holes drilled in the center of the plastic. The paddle is then fastened to the front panel. It doesn't have to move, so there is nothing more to it.

The circuit is constructed on a piece of perforated circuit board that has a 0.1-inch hole pattern. The IC sockets and components are fastened to the circuit

*11232 Crist Dr., Los Altos, CA 94022

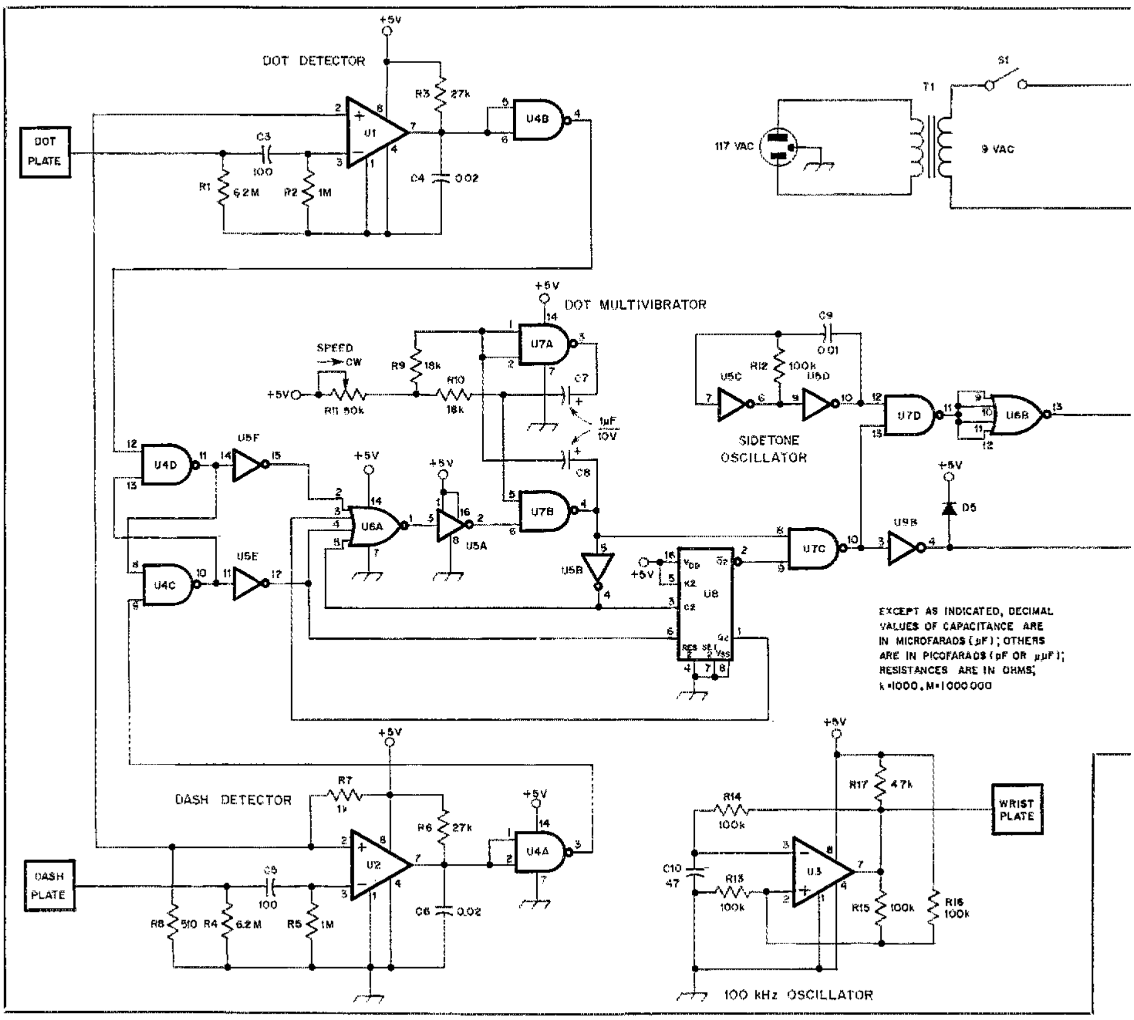


Fig. 1 — K6BSU touch keyer schematic diagram. All resistors are 1/4-W, 5% carbon-composition types; capacitors are 15-V disc ceramic, unless otherwise specified. [Note: Part numbers in parentheses are Radio Shack.]

C3, C5 — 100-pF silver mica.
C7, C8 — 1-µF tantalum.
C10 — 47-pF silver mica.
D1 — D5, incl. — 1-A/50-V diodes (276-1101).
J1 — 4-pin, Jones-type connector (274-206).
J2 — 2-conductor, closed-circuit 1/4-in. phone jack (274-255).
K1 — SPST-NO DIP 5-V reed relay, Magnecraft W107DIP-1 or equiv.
LS1 — 2-in. diameter, 8-Ω speaker.
S1 — SPST slide switch (275-406).
T1 — 9 V ac, 200-mA wall transformer.
T2 — Audio transformer, 1000-Ω ct primary to 8-Ω secondary (273-1380).
U1 — U3, incl. — Comparator, LM311N or equiv.
U4, U7 — Quad 2-input NAND gate, CD4011AE or equiv. (276-2411).
U5 — Hex buffer, CD4009AE or equiv.
U6 — Dual 4 input NOR gate, CD4002AE or equiv.
U8 — Dual J-K flip-flop, CD4027AE or equiv. (276-2427).
U9 — Hex buffer, 7416 pc or equiv.
U10 — 5-V regulator, LM209 or equiv. (276-1770).

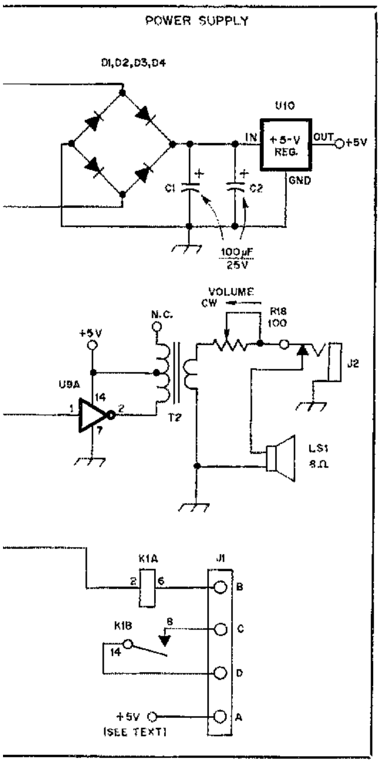
board with 5-minute epoxy glue. The socket and component leads are interconnected using no. 26 solid wire for Vcc and ground and no. 30 wire for signals. This method requires a small soldering iron and a good pair of eyes, but it is still a quick way to put circuits together, as it requires no planning in laying out the components.

Power Supply

Transformer T1 is a wall-plug type normally used to charge pocket calculators. Mine provides 9 V ac at 200 mA. The current consumption of the keyer is 30 mA, and most of that is used by the speaker amplifier and reed relay. A full-wave bridge rectifier, a filter and a monolithic voltage regulator convert the 9-V ac input to a regulated 5 V dc.

Usable Outputs

The signal from U7C consists of fully formed and perfectly timed Morse code. For local sidetone, this signal is gated with a 500-Hz oscillator in U7D. The sidetone is amplified by an open-collector TTL gate U9A and drives a small loudspeaker through output transformer T2. A headphone jack is provided for silent operation, and plugging phones into J2 disconnects the speaker. A second output of U7C is used to operate a keying relay for transmitters that require an isolated contact closure. The relay may be replaced by an optical isolator for low-current, low-



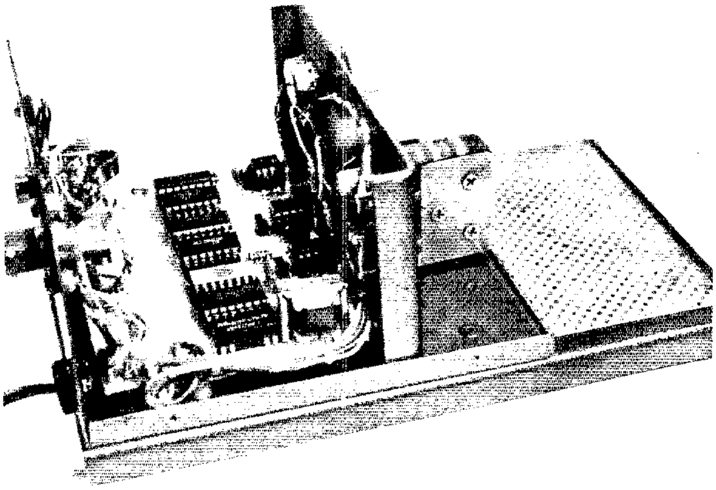


Fig. 2 — Inside view of the touch keyer. Note perf-board construction and chassis, as explained in text.

voltage keying requirements.

J1 is arranged so that K1 is not in use unless the interconnect cable is jumpered from pin A and B so that the relay circuit is completed. If 5 V is available from the host transmitter, this may be wired to J1 pin A to provide dc power for the keyer. In this case, the output terminal of U10 should be removed from the voltage source to prevent damage to the regulator.

Adjustments

To prevent operating fatigue, the ideal sensitivity is very light but definite contact with the plates. Sensitivity may be adjusted, if required, by changing R8. Raising the value increases the bias on U1 and U2, and thus requires closer contact with the touch plates. This couples enough signal into the detectors to trigger the keyer.

It is my hope that this keyer will provide an added thrill for the cw operator. Put away those mechanical paddles and give the touch keyer a try!

Next Month in QST

☐ August *QST* will feature a candid interview with Senator Barry Goldwater, K7UGA; it covers his views on a no-code license, WARC, S-929 and the state of Amateur Radio today. Don't miss it!

☐ The first of a two-part technical article delves into the always-relevant subject of 220 MHz, in the form of a construction project for a high-performance transverter system.

☐ Among the columns, How's DX? will identify the plethora of new country prefixes, and Washington Mailbox will feature answers to those nagging questions about third-party traffic.

☐ Although it was operational only a short time, the newest Soviet amateur satellite, ISKRA-2, managed to make history. Read about it in August *QST*.

Strays

NOMINATIONS OPEN FOR GREAT NORTHLAND HAM OF THE YEAR

☐ A feature of the Augusta (Maine) Emergency Amateur Radio Unit hamfest on September 10-12, 1982 will be the Great Northland Ham of the Year award, which will be given to a ham from northern New England, Quebec or the Maritime Provinces who has made a significant contribution to Amateur Radio. Nominations close August 1, 1982. For more information, write to the Windsor Hamfest Committee, c/o W. E. Jackson, W1WCI, RFD 1, Box 3970, Winthrop, ME 04364.

AROUND THE WORLD WITH 88 A DAY

☐ From 1976 to 1981, Richard Spenceley, Sr., KV4AA, of St. Thomas, Virgin Islands, logged a total of 195,000 overseas QSOs, making contacts with hams, on the average, in more than 25 countries daily. That works out to 88 contacts per day, or one every 16 minutes. Anyway you look at it, that's a lot of QSOs! KV4AA thinks he might have a world record, so he's applied to the *Guiness Book of Records* in hopes of making it official.

I would like to get in touch with . . .

☐ any amateurs interested in participating in a receiver dynamic range measurement session at the 1982 ARRL National Convention in Cedar Rapids, Iowa, on July 23. Receivers to be measured should be homebuilt or heavily modified units tunable over the 20-meter band and have an rf bandwidth greater than 20 kHz. Contact Lawrence Stoskopf, NØUU, 2413 Edgehill, Salina, KS 67401, tel. 913-823-9498, in advance.

WARC and LF on the TR-7

Will your TR-7 be ready when the new WARC bands arrive? Don't get caught short — the time is now! Here is an easy, inexpensive method for adding the new bands and more to this popular transceiver.

By Robert K. Morrow, Jr.,* WB6GTM

The Drake TR-7/DR-7 has been in production for a few years and has proven itself to be an outstanding transceiver. It is equipped with 1.5- to 30-MHz continuous receiver coverage and with transmit capability on all presently authorized amateur bands. Without the DR-7 digital-readout option, the receiver coverage is more limited, but the circuit described here will enhance the capabilities of this rig as well.

Another TR-7 option is the AUX-7 auxiliary program board, which is a small circuit board that plugs into the TR-7 chassis. This option allows the owner to install special ICs from the manufacturer, extending the receiver coverage below the 1.5 MHz lower limit and allowing the transmitter to operate in other band segments. In addition, the AUX-7 board provides crystal sockets to be used for fixed transmit or receive operation.

The AUX-7 features most useful to a ham would be the addition of transceive capability on the three new WARC band segments at 10, 18 and 24.5 MHz and the extension of receiver coverage down into the lf region. (Would you believe 0 Hz?) This article provides details for the construction of a circuit board that will give your TR-7 the same capabilities as with the AUX-7. No modification to the rig is required, since this board simply plugs into the AUX-7 connector within the unit.

Synthesizer Operation

Since this is intended to be a construction article, a detailed analysis of the TR-7 frequency synthesizer is not included. The service and instruction manuals describe the operation, and an excellent block diagram is included with the description.

The portion of the synthesizer relevant to this project is the *load number,* which is used to determine the lower end of the desired 500-kHz band segment tuned by the TR-7. This number is given by the formula

$$N = 86 - 2F \qquad \text{(Eq. 1)}$$

where N is the load number and F is the desired band segment in MHz. For example, one of the WARC bands is in the 24.5-MHz segment. The corresponding load number is $86 - [2(24.5)] = 37$. In a similar manner, load numbers may be calculated for any 500-kHz band segment within the tuning range of the TR-7.

Circuit Description

The AUX-7 control-signal pinout is shown in Table 1. The aux rotary-switch pins (1-8) are set to +5 V dc as each is selected by the AUX PROGRAM switch on the TR-7 front panel. These act as diode program source voltages for the band-select, transmit-enable and load-number logic. The band-select lines (9-12) are used to extinguish the SET BAND light on the front panel when the main rotary band switch is set to the proper range, as shown in Table 2. When the 24.5-MHz band segment is selected with the AUX PROGRAM switch, for example, the SET BAND light will illuminate until the rotary band switch is set to the 22- to 30-MHz range. This ensures that the correct low- and high-pass filters are inserted. Incidentally, the transmitter will not operate until the SET BAND light is out, to prevent spurious radiation and possible output-transistor damage. The transmit-enable pin (14) is brought to +5 V to allow transmitter operation in the new WARC bands, when they become available.

The next eight lines (15-22) are set to the load number corresponding to the desired 500-kHz band segment. The first load number digit is converted to binary-coded decimal (BCD) and placed on lines B3-B0, and the BCD code for the second digit is placed on lines A3-A0. Earlier, we calculated that the 24.5-MHz segment required a load number of 37. In this case, B3-B0 would be 0011 (BCD 3), and A3-A0 would be 0111 (BCD 7).

How are these binary codes implemented? Each binary "1" is realized by connecting a diode from a +5-V source to the AUX-7 pin requiring the "1." A binary "0" is automatic; pull-down resistors[1] are placed in the circuit to ensure that a line will default to logic "0." (CMOS logic is used in the TR-7.) For

Table 1
AUX-7 Plug Pin Functions

Pin	*Function*
1-8	Aux Rotary Switch
9-12	Band Select (A-D)
13†	+10 V
14	Transmitter Enable
15-18	A3-A0 Load
19-22	B3-B0 Load
23	GND
24†	Fixed Oscillator Out
25†	+10 V Fixed

†Not used in this circuit

Viewed from the front of the TR-7, the pins are numbered from left to right.

Table 2
Band Select Codes

Band (MHz)	*Decimal Code*	*BCD (Pins 9-12)*
0-2	2	0010
2-3	3	0011
3-4.5	4	0100
4.5-7	5	0101
7-10	6	0110
10-15	7	0111
15-22	8	1000
22-30	9	1001

*9792 Oma Pl., Garden Grove, CA 92641

example, let's completely outline the operation of the rig on the 24.5-MHz segment. We want this band to be selected by Aux Program 3 on the front panel and, of course, we want transmit capability. To implement this combination, we need the band select to be 1001 (BCD 9), the transmit enable to be activated, 0011 (BCD 3) to be on lines B3-B0, and 0111 (BCD 7) to be on lines A3-A0. From Table 1, it can be seen that pins 9, 12, 14, 16, 17, 18, 21 and 22 of the AUX-7 plug must be connected to pin 3, which becomes the + 5-V source when the AUX Program switch is in position 3. Diodes are used for the links so that isolation is provided from the other AUX Program lines.

Construction and Installation

Assembly of the AUX-7 substitute board is straightforward. Fig. 1 gives the schematic diagram. The foil and component sides of the circuit board are illustrated in the etching pattern (page 39) and in Fig. 2. The circuit board measures 2-1/2 × 4-1/4 inches, and the resistors are mounted vertically. Half-watt or smaller resistors will fit easily. Both connectors are DIP solder-type, with 0.156 (5/32)-inch pin spacing. Although the AUX-7 connector has 25 pins, it is easier to assemble a 24-pin socket on the circuit board using two 10-pin and one 4-pin connector. Since pin 25 on this AUX-7 substitute circuit is unused, it may be left open. The part numbers shown in Fig. 2 are for vertically mounted connectors, which can be adjusted for horizontal mount by bending each pin down with needle-nose pliers.

To install the board, first remove the top cover of the TR-7. The large horizontal circuit board you now see is the DR-7 digital-readout board. (If you own a TR-7 without the digital-readout option, there will be a small jumper circuit board substituted for the larger DR-7. The AUX-7 plug is already exposed, so removal of the jumper board is not necessary.)

After removing all five top connectors to the DR-7, take out the single screw located near the left edge of the board, as viewed from the front of the transceiver. A blue wire and coaxial cable must be disconnected from the filter module, located to the left of the DR-7. Now, using the "bent coathanger" tool that came with the TR-7, or a suitable screwdriver, carefully lift the DR-7 board away from the rig, starting from the rear edge. A 12-pin, a 9-pin, and two 3-pin connectors are mounted on the underside of the DR-7 and are pulled free as the board is raised. Use care at this point to avoid damaging the digital displays, which are attached to the DR-7. As soon as the board is free of the fixed connectors, withdraw it from the rig, allowing the coaxial cable to slide out of the clearance hole (Fig. 3).

At this point, it should be obvious where to plug the AUX-7 substitute board; there is only one unused chassis-mounted connector available. Be sure the component side is facing the rear of the transceiver, and push this circuit board onto the connector as shown in Fig. 4. A TR-7 equipped with the DR-7 must have this option board in place to function properly. You will have to completely reassemble the transceiver, except for the cabinet, before the new AUX-7 substitute board can be tested. Use extreme care when replacing the DR-7 circuit board. Ensure that the bottom (foil side) pins are properly aligned with their sockets before carefully pushing the board into position.

Operation

After replacing the DR-7 digital display, attach an antenna or dummy load to the TR-7, connect the power supply and a microphone or key, and turn on the

[1]Certain earlier TR-7s already have 100-kΩ pull-down resistors for the load-number lines on the digital-control board, which is located just behind the AUX-7 plug. If your digital control board has nine integrated circuits on it, you have the old style, and will not need the resistors shown for this AUX-7 substitute circuit. The inclusion of these resistors should not cause any problems, however. All TR-7 transceivers have proper logic levels on the four band-select lines, so no extra resistors are needed in this circuit for AUX-7 lines 9-12.

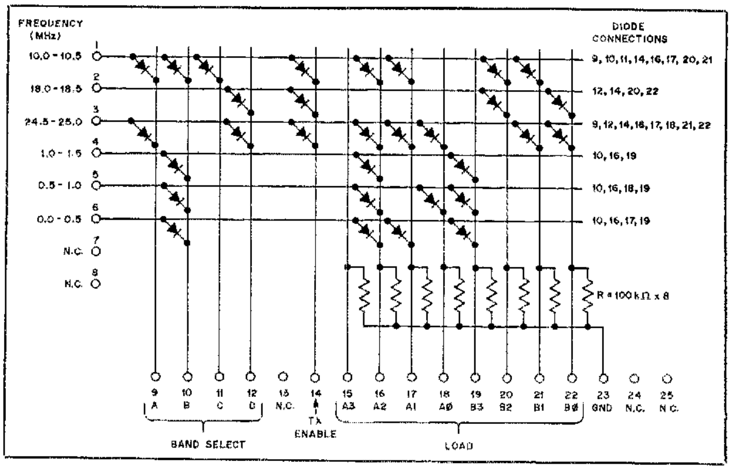


Fig. 1 — Schematic diagram of the AUX-7 substitute circuit. The pins of the AUX-7 connector are listed along the left and lower perimeter of the circuit. All diodes are 1N914, or equivalent. n.c. = no connection.

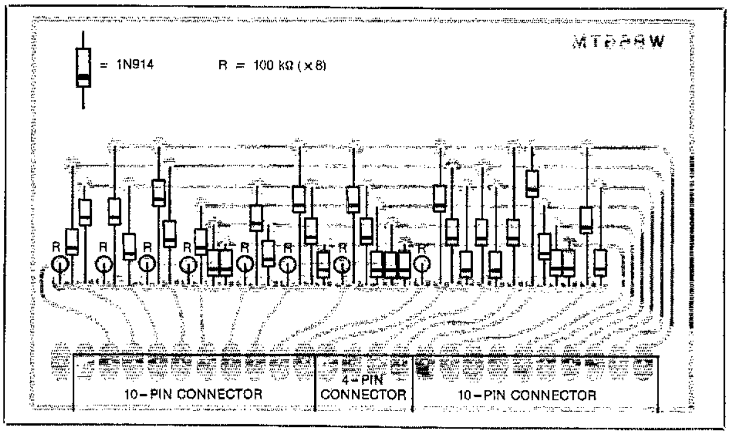


Fig. 2 — Parts-placement diagram for the TR-7 programming board. Components are mounted on the non-foil side. Gray areas represent unetched copper. The circuit-board etching pattern appears in the Hints and Kinks section of this issue. The connector consists of two 10-pin sockets (GC 41-210 or Molex 09-52-3103) and one 4-pin socket (GC 41-204 or Molex 09-52-3043).

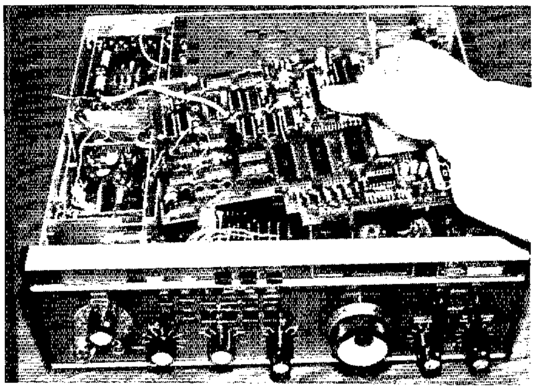


Fig. 3 — Removing the DR-7 digital display board from the TR-7.

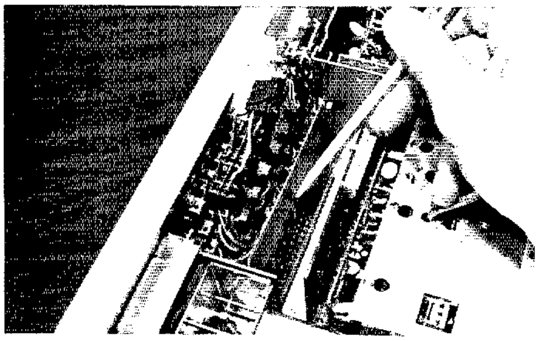


Fig. 4 — The pencil indicates where the AUX-7 substitute circuit board is mounted in the TR-7. Component side faces the rear. The pc connector shown near the middle finger is attached to the digital-control board.

transceiver. The rig should operate normally with the AUX PROGRAM switch set to NORM. Positions 1, 2 and 3 of the AUX PROGRAM switch should cause the rig to operate in the 10.0-, 18.0- and 24.5-MHz band segments, respectively, and the SET BAND light should extinguish only when the main band switch is set to the proper range for the particular band being used. Note that in some instances the synthesizer will not lock until the band switch is positioned correctly. Turn the CARRIER and MIC GAIN controls fully counterclockwise, to prevent rf transmission, and key the transmitter. As long as the SET BAND light is out, you should hear the transmit relay energize.

AUX PROGRAM switch positions 4, 5 and 6 should allow the TR-7 to receive the three 500-kHz band segments between 0 and 1.5 MHz. Maximum sensitivity in this region will be obtained by connecting the receive antenna to the vlf jack on the rear panel of the TR-7. This jack bypasses the antenna filter network, so the vlf antenna must be removed before transmitting or when receiving above 1.5 MHz. See the TR-7 instruction manual for more details.

Conclusion

The circuit provides an easy and inexpensive method for extending the capabilities of a popular transceiver. I have provided enough information to allow you to generate any combination of 500-kHz segments for this rig. A maximum of eight positions is available on the AUX PROGRAM switch, and the additional band capability should prove especially useful to those who own a TR-7 without continuous receiver coverage.

Even if you don't have access to photo-etch equipment to make the printed-circuit board, it can still be done by drawing the circuit onto the foil with a resist marking pen. I produced mine in this manner, and it works perfectly.

If you have any questions about this circuit, I will try to answer them if an s.a.s.e. is included.

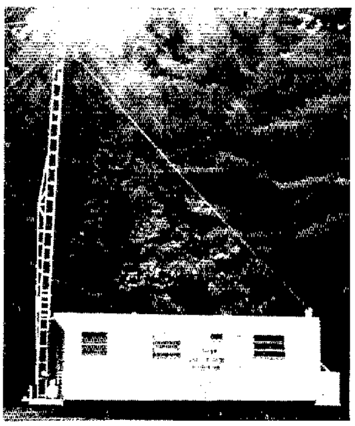
Reference

TR-7 Service Manual, R. L. Drake Co., Miamisburg, OH, Oct. 1980.

Strays

1982 INTERNATIONAL BOY SCOUT CAMPOREE ON THE AIR

☐ Boy scouts from around the world will get a special introduction to Amateur Radio when the Boys' Life ARC station, K2BSA, goes portable from the Connecticut International Boy Scout Camporee, to be held July 11-17, 1982 in the foothills of the Berkshires near Winsted. Through the courtesy of station trustee Harry Harchar, W2GND, members of the Southcentral Connecticut ARA (formerly the Hamden ARA) will operate K2BSA/1 from their club's specially equipped van to enable visiting foreign scouts to hear contacts with their own country. K2BSA/1 will operate 10, 15 and 20 meters on or near 28,650, 21,360 and 14,280 kHz at 0100-0200, 1400-1600 and 1700-2000 UTC. Contacts with any amateur stations will be welcome, and K2BSA/1 will QSL.



The SCARAVAN, with its three operating positions, 50-foot folding tower and TA-33 antenna, will keep scouts at the Connecticut International Boy Scout Camporee in touch with home. *(photo courtesy Vic Stancliff, W1LQZ)*

I would like to get in touch with . . .

☐ anyone who has a manual or knows how to program the cards for an SBE OPTI-SCAN Model 12SM. Ralph R. Minkler, K9ZCT, 6021 S. 1st St., Phoenix, AZ 85040.

Keying Improvements to the ICOM IC-730

Transform your IC-730 into a better cw rig by making simple, low-cost changes. No active devices are required.

By Don McClure,* KB2Z

Many features of the ICOM IC-730 appealed to me for mobile use, and as a second rig. Even before I purchased it I knew its keying characteristics left something to be desired, but figured that the deficiencies could be corrected with a little effort.

This article describes revisions that provide keying that is satisfactory to even this hard-core "cw freak." The changes will probably satisfy most of those CFO[1] "chicken cluckers" hanging around 7030 kHz and operators having lower speed requirements. Oscilloscope observations and on-the-air tests using my modified unit show the keying to be of good quality up to speeds of at least 70 wpm, with no clicks, tails, significantly shortened dots or other undesirable traits. Semi break-in can be used to over 40 wpm. Above 70 wpm, the dots shorten a little, relative to the spaces, but perfect machine copy of signals from this unit has been demonstrated at 100 wpm using the Microlog ATR-6800 to generate the code. Both the HAL DS-2000 KSR and the Radio Shack TRS-80® Model III microcomputer were used for reception.

Modification Objectives

Keying-circuit changes have been designed to achieve the following characteristics that were not provided in the original circuit:

1) Independent control of the keyed wave rise and fall times, with a goal of 2- and 5-ms, respectively. This waveshape provides a "hard-make, soft-break" sound.

2) Equal length dots and spaces at the minus 6-dB points on the rf envelope for keying speeds to at least 70 wpm.

3) Approximately a 9-ms delay prior to the rise of the rf wave to allow T-R relay closure before applying rf energy.

4) Elimination of leading-edge sharpening (and the resultant click) on the first code element after a pause. This click is caused by no alc voltage being present on the keyed stage after a pause.

5) Elimination of the shortened first element caused by the 7-ms interval required for VOX-relay closure.

6) Reduction of backwave to at least 60 dB below 100 watts (64 dB achieved).

7) Allowance of the radio to be keyed by an electronic keyer having more than 0.4-V output during key down.

8) Improvement of the sidetone-oscillator characteristics to closely approximate those of the rf wave.

Description of Revised Circuits and Their Functions

Most of the circuit changes are shown in Fig. 1. This figure is taken from the original schematic diagram and revised as needed, with the changed, added or deleted components being darker to draw attention to the revisions. Table 1 lists the parts changes.

New components added to the main circuit board have been given part numbers starting with 201, such as R201 and C201, to differentiate them from the original component lineup. The numbers are not changed for original components having different values. Components added to the PA module start with 301.

The first change made (Fig. 1) was to reduce the value of R117 so that my Heath HD-1410 keyer would key the radio. The HD-1410 puts out 0.46 V, key down, which is too high for the IC-730. This change upset the drive voltage to the sidetone-oscillator switch, Q16, and it would no longer turn off. The solution to that problem was to separate the drive for Q16 from that for IC5 by deleting R116 and taking the drive for Q16 from another source, as will be described later. A new resistor, R201, completes the IC5 bias path that was formerly through R116 and R115.

With the key down, the output on pin 1 of IC5 goes high and C81 charges through R202. When the voltage on C81 reaches about 3.9 V with respect to ground, Zener diode D201 and D202 conduct, causing Q10, the keying switch, to turn on. This occurs about 7 ms after key down. When the collector voltage of Q10 falls below 2.3 V, D19 and D203 turn off and C33 discharges through R52. As the voltage on C33 diminishes, Q9, the dual-gate FET i-f stage, turns on and allows rf output from the transmitter. The leading-edge rise time of the rf wave is controlled by the fall time of the C33/R52 combination. Prior to Q9 turning on, the drop in voltage on C33 provides some delay in addition to the 7-ms delay preceding the Q10 turn on. The total delay before the start of the rf wave is about 9 ms. Approximately 7 ms is required for the VOX relay to close, so the 9-ms delay in the rf keying path is adequate to allow relay closure before drive is applied to the rf power-amplifier stages. It should be noted that dots shorter than the time required to charge C81 sufficiently for D201 to conduct will not key the transmitter. This fact imposes an upper speed limit that is somewhat above 100 wpm.

When the key is up, the voltage on pin 1 of IC5 drops to 1.2, and C81 is quickly discharged to 1.4 V through D18 in preparation for the next key-down condi-

[1]Chicken Fat Operators — a group of high-speed, cw rag chewers.

*12 West Azalea La., Mt. Laurel, NJ 08054

tion. As C81 begins to discharge, D201 and D202 turn off. The keying switch, Q10, cannot turn off immediately because of the feedback network from collector to base. As C201 charges, some delay occurs before the voltage drops of D19 and D203 are overcome and C33 begins to charge. This delay causes a stretch in the keyed rf wave, so that the trailing edge of the waveform is delayed by an amount of time similar to that of the leading-edge delay. The time required for the voltage rise at the collector of Q10 is established primarily by the transistor gain along with C201 and R205. It has been made much longer than would be the rise time of the C33/R52 combination charging through R53 and the diodes. Since C33 cannot charge faster than at the rate of Q10 collector-voltage rise, the rf-wave fall time is made slower and independently adjustable relative to the leading-edge rise time. Rise and fall times of the rf envelope are 2 and 5 ms, respectively, by virtue of the component values chosen. Waveforms at various points in the keying circuit are shown in Fig. 2.

Note that the 4.3-V Zener diode, D201, does not fire at the rated breakdown voltage, but instead begins conduction with about 2.6 V across the terminals. This is because all Zener diodes made for breakdown at less than about 7 V have a "soft" turn-on knee. The 1N749A is rated for 4.3 V at 5 mA, but the current in this circuit does not exceed approximately 0.5 mA, so the regulating voltage is considerably lower than the rated value.

Keying switch Q10 is biased just below conduction, at 0.6 V, so the voltage to which C201 charges will be nearly the same regardless of whether the circuit has been keyed recently. The bias eliminates some pulse-length jitter. D206, in the feedback circuit, provides a discharge path for C201 as Q10 turns on. This discharge prevents the feedback network from driving the voltage on the base of Q10 downward, and thereby prolongs the time required for turn-on to be completed. The fixed value of R208 is established during final testing by trying various values

Table 1
Parts Changes to Main Board for Improved Keying

Changed Capacitors	*New Value*
C33	3.3 μF
C61	1.0 μF
C74	4700 pF
C81	3.3 μF
New Capacitor	*Value*
C201	0.18 μF
Changed Diode	*Type*
D18	1N34A (installed in reverse direction relative to original D18)
New Diodes	*Type*
D201	1N749A, 4.3-V Zener diode
D202	1N914, silicon
D203	1N914, silicon
D206	1N34A, germanium
Changed Resistors	*New Value* *All resistors are 1/4-W, 5% carbon-composition types.*
R54	10 kΩ
R116	Deleted
R117	2.7 kΩ
R122	Deleted
R128	51 kΩ
New Resistors	*Value*
R201	22 kΩ
R202	6.8 kΩ
R203	12 kΩ
R204	82 kΩ
R205	22 kΩ
R206	150 kΩ
R207	1.5 MΩ
R208	470 kΩ [nominal value; select final value on testing (see text)]

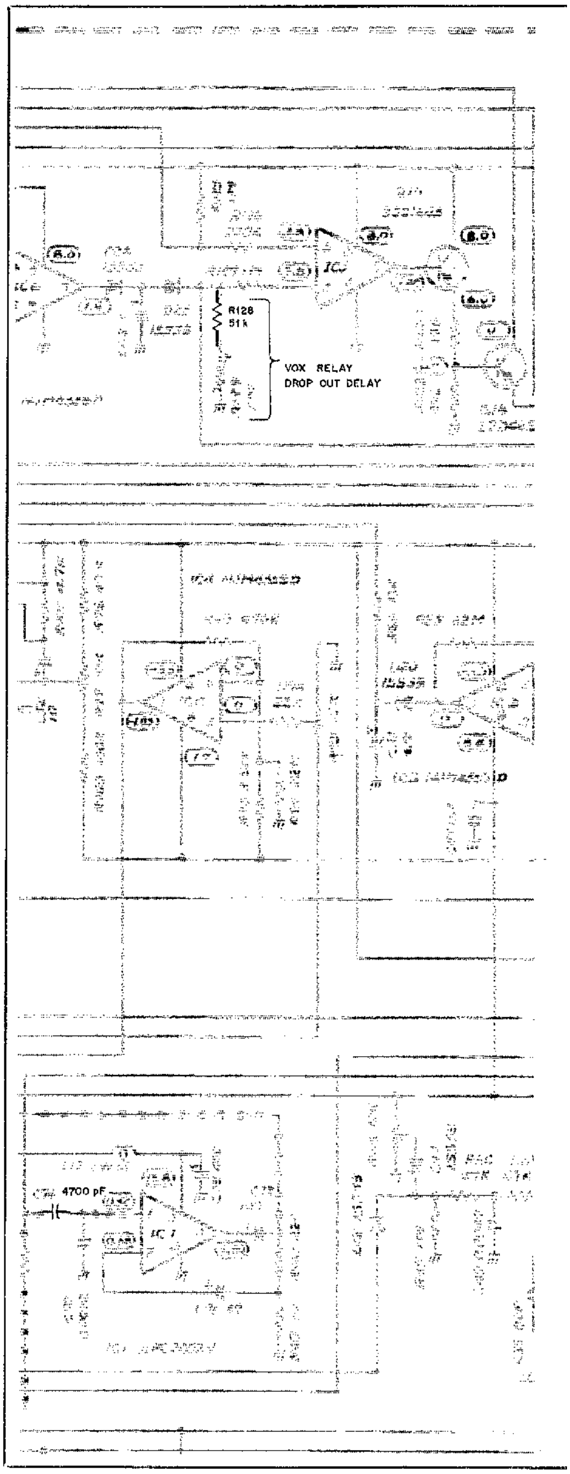
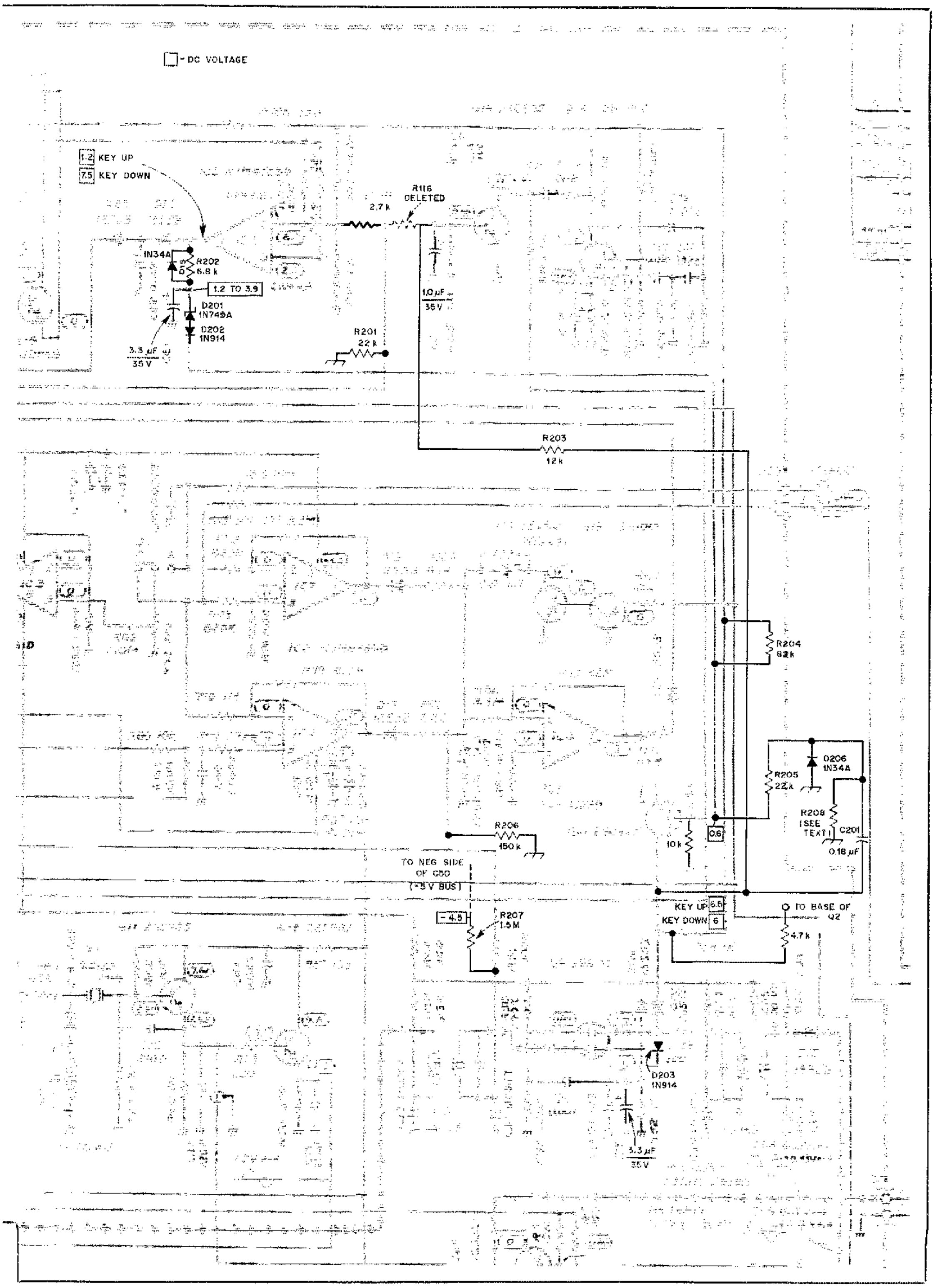


Fig. 1 — Changes to the IC-730 keying circuit, receiver audio circuit, alc circuit and VOX-delay circuit are shown. The schematic diagram is from the owner's manual.


□ - DC VOLTAGE
1.2 KEY UP
7.5 KEY DOWN
R116 DELETED
2.7 k
1N34A
R202 6.8 k
1.2 TO 3.9
D201 1N749A
D202 1N914
3.3 µF 35 V
1.0 µF 35 V
R201 22 k
R203 12 k
R204 82 k
D206 1N34A
R205 22 k
R208 (SEE TEXT)
C201 0.18 µF
R206 150 k
10 k
0.6
TO NEG SIDE OF C50 (-5 V BUS)
-4.5
R207 1.5 M
KEY UP 6.5
KEY DOWN 6
TO BASE OF Q2
4.7 k
D203 1N914
3.3 µF 35 V

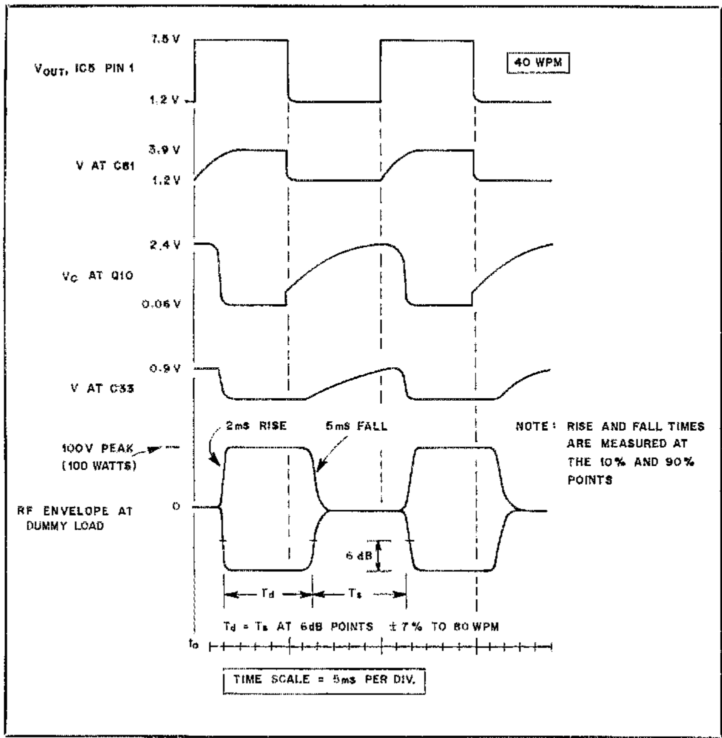


Fig. 2 — Keying waveforms, as taken at various points in the IC-730 circuit.

to equalize the dot and space duration. This adjustment can be made at any speed up to 65 wpm.

Sidetone-Circuit Keying

Drive for the sidetone keying switch, Q16, is taken from the collector of Q10 by way of R203. This arrangement allows the rise and fall times of the keyed audio wave to closely approximate the corresponding 2- and 5-ms times of the rf wave.

Reduction of Audio Ringing

Ringing at a frequency of about 22 Hz occurs at the audio output when Q16 is keyed. The ringing is present whether the sidetone volume is at zero or at an audible level, and it causes an annoying flutter in an external speaker or earphones. To reduce the ringing, capacitor C74 can be changed to 4700 pF. This reduces the very low frequency audio response without affecting appreciably the audio quality for voice reception. The cause of the ringing was not investigated.

ALC Bias

Since the keyed i-f stage also has alc voltage applied to one of the FET gates, the status of the alc voltage can affect the keying rise time and the degree of backwave. To minimize such effects, R206 and R207 have been added (Fig. 1). An alc bias of about -0.57 V is applied to the gate of Q9 when the alc system is in the relaxed state (key up). This bias is slightly less negative than the least negative alc voltage occurring during key down intervals. The least negative alc voltage establishes the 100-watt-power output level. Thus, the bias has a minimal effect on alc-system behavior. In the unmodified circuit, the alc potential in the relaxed state is zero. This means that without the alc bias resistors, only the 1.35-V potential on C33 is keeping Q9 cut off, which is not sufficient to reduce the backwave to acceptable levels.

With the bias resistors added, the backwave is reduced to 64 dB below 100 watts. The addition of R206 shortens the alc decay time considerably, but not enough to cause speech compression and the accompanying distortion in the ssb mode. After adding the two alc bias resistors, the 100-watt-power output level control, R150, had to be adjusted slightly to reset the rf-power output from 95 watts back up to 100 watts. This adjustment was made on the 21-MHz band.

VOX Delay

The resistor that establishes the minimum hold-in time for the VOX relay is R128. In the unmodified radio, the hold-in time is much too long to permit QSK operation at any but the slowest speeds. Reducing the value of R128 to 51 kΩ allows semi-QSK operation to speeds of 40 wpm. Fig. 1 shows the location of R128.

Physical Location of Changes

All of the modifications described so far are done on the main circuit board. This is the larger of the two boards under the top cover of the radio. The board is removed from its mounting by disconnecting J14 at the left center and J6 at the right center, and loosening the four mounting screws at the corners of the board. One or more tie wraps may have to be cut to free the cable going to J14.

Several of the new parts are mounted on top of the board by installing two components where there was one previously. For example, the combination of D201 and D202 mounts in the location of R122, which has been deleted. Components that cannot be mounted topside are mounted between solder pads on the printed-wiring side and are contained within sleeving where necessary to prevent shorts.

Test Points

Convenience of voltage measurement and waveform observations can be improved by adding a few test points on the main circuit board. Test points can be fabricated by attaching a stiff piece of bare wire, such as a scrap lead from a diode or resistor, to the appropriate leg of a component mounted at the top of the board. Bend the wire to stand alongside the component (Fig. 3). Test points are useful at the positive terminals of C33 and C81, the cathode of D18 and D202 and the anode of D19. These are worth the trouble, but care must be taken to avoid short circuits.

Fan-Motor Control

I find it annoying for the fan motor to be turning on and off as the radio is keyed. Since such rapid sequencing may shorten the motor life, it is desirable to have the option of running the fan continuously.

This change (Fig. 4) requires the addition of a switch that can be mounted on

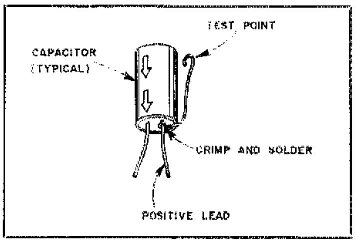


Fig. 3 — This sketch shows an easy method of providing test points in a circuit.

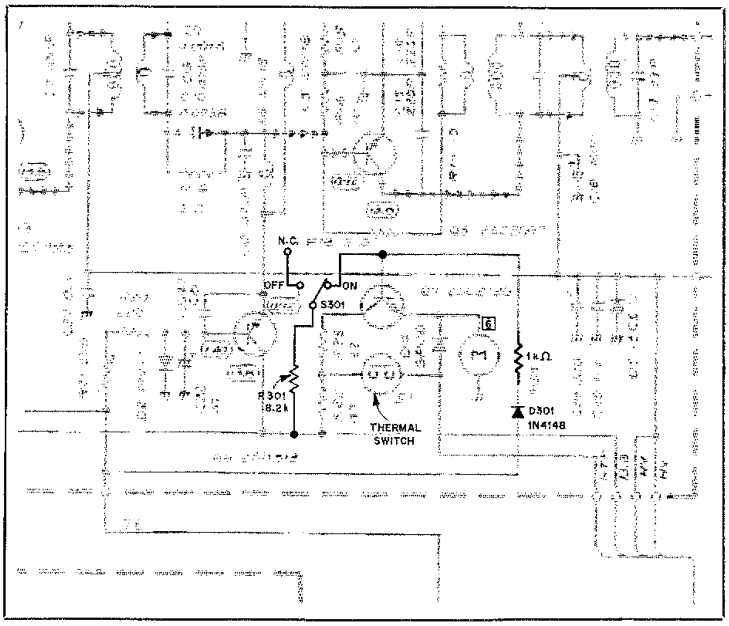


Fig. 4 — Schematic diagram showing changes to the fan-motor control circuit, which allows the fan to run continuously. This diagram is from the owner's manual.

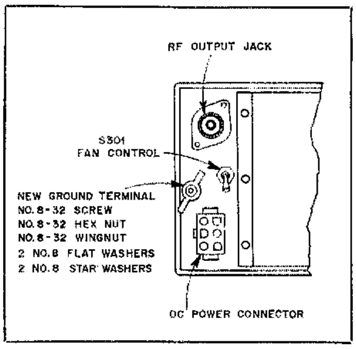


Fig. 5 — A portion of the rear panel is shown, giving the locations of the new ground terminal and the fan-motor control switch.

Table 2

Parts Changes in PA Unit to Allow Fan to Run Continuously

R24	*Change from 2.2 kΩ to 1 kΩ*
Added Parts	*Value*
R301	8.2 kΩ, 1/2 W
D301	1N4148, silicon
S301	spdt toggle switch

the rear panel below the rf-output connector. I removed the clamp type of ground connector and installed a no. 8-32 ground-stud screw with locking hardware, and a wing nut. The toggle switch was mounted next to the ground screw (Fig. 5). Care must be taken to locate S301 so the terminals and body clear the end of the band-switch shaft. Parts changes for the fan control are shown in Table 2.

Conclusion

Comments received from operators hearing the cw from this modified IC-730 have been gratifying. I hope others making the changes described here will be pleased with their results. I wish to thank Bill Skipper (KØARG), Jack Fewer (N2CJV) and Bob Ziolkowski (W2HER) for taking the time and trouble to machine copy my high-speed transmissions, and for making helpful comments. Thanks also to Dorothy Pratt (KA2MEU) for typing the original manuscript.

New Books

☐ *Why Do You Need A Personal Computer?* by Lance A. Leventhal and Irvin Stafford. Published by John Wiley & Sons, Inc., New York, NY. First edition 1981. Soft-bound, 7 × 10 inches, 278 pages, $8.95.

Computers, computers, computers — they're as much a part of our lives today as the family pet, car, or the air we breathe. We just can't seem to do without them in this fast-paced world. Grade-school kids are learning how to use them, and the chances are you have at least one member of the computer family in your ham shack. Many hams already have personal computers assisting them, and many more are contemplating planting one foot in front of the other on their way to the computer store.

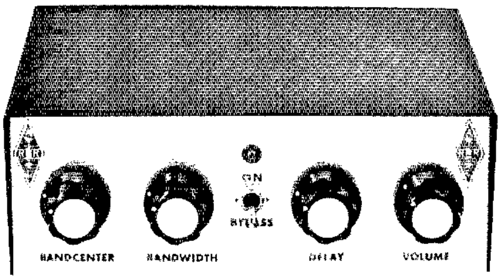
Before you take that decisive step and put your money on the counter, it might be a good idea to know a little about what you're getting into. You can find that information in this book. It's geared to the prospective personal computer owner as well as the person who already owns one.

While there a lot of computer primers on the market, many of them bury the newcomer in technical jargon — not so here! This text is easy to read, from the standpoints of clarity and size of type. You're given a bit of computer history; a description of the component parts of a computer and an explanation of what the terms and acronyms mean; a touch of BASIC programming; how to write programs; computer peripherals and how to select what you need; interfacing the components; some hints and kinks of computer operation and maintenance; and some ideas on how you can find out more about the fascinating world of computers and select the computer you need.

The 16-page glossary is a handy item to have when you run across some new terminology. A 22-page appendix will be helpful even after you've purchased your computer. It contains tables that provide interface pin-out information as well as pin and signal information for a number of popular buses: S-100, Heath H8, Radio Shack, SWTP, Apple, KIM and OSI. A table describing the different cassette data recording standards is included, too.

I'd recommend this book to anyone interested in learning something about computers, even if you don't have the purchase of a computer in mind at present. You'll want to have it around for a handy reference manual and a memory refresher as you continue the learning process. I think you'll find the $8.95 was well spent. *— Paul K. Pagel, N1FB*

The KC2FR QRM Fighter



Losing the battle with QRM? This filter makes you the champ!

By David Jagerman,* KC2FR

This article presents construction information for a nonlinear, audio cw filter intended to help reduce QRM, which every amateur faces! To alleviate interference, many filter circuits have been devised to operate in the i-f or audio sections of the receiver. These circuits are generally well designed. They allow many QSOs that otherwise might not have been attempted; however, it is still advantageous to consider alternative designs.

Consider some of the qualities desired in a cw audio filter. Its bandwidth should be narrow — otherwise noise and interfering stations will also be heard. Present-day i-f filters are quite narrow; hence the bandwidth of the audio filter should be even narrower — less than 400 Hz to provide an improvement. The passband should be flat, so that tuning in the desired station will be easy. Filter skirts should be nearly vertical, with the shape factor approaching a value of 1, in order to effectively eliminate interference. Furthermore, there should be no ringing under tight passband conditions. Typical linear-filter designs, whether passive or active, provide a narrow passband, but they have a sharply peaked "nose" and are often prone to ringing. Also, their shape factors cannot be made close to ideal, except with elaborate designs. Thus, to achieve the desired characteristics, I tried a nonlinear design.

Design and Construction

A block diagram of the QRM Fighter is given in Fig. 1, and the circuit diagram appears in Fig. 2. For the following discussion please refer to both figures. The first stage is a multiple-feedback, band-pass amplifier with a Q of 10 and a gain of 4. A 200-Ω control is used to adjust the center frequency. The second stage is a comparator whose output (pin 6) is high if the signal from the band-pass amplifier cannot overcome the bias set on pin 3. When the signal is strong enough to overcome the bias, pin 6 remains low. The net band-pass characteristic of these two stages is shown in Fig. 3. It can be seen that the characteristics of a good cw filter are obtained. The flat top in the passband is obtained because pin 6 remains at a constant low level, even though the output of the band-pass amplifier varies. A shape factor of 1 is obtained because of the sharp cutoff that occurs when the signal drops below the bias set on the comparator. A 500-Ω control is used to set the bias level of the comparator, which in turn determines the bandwidth.

The output from the first two stages is an audio signal that is amplitude modulated by the code elements. The signal frequency matches the offset frequency of the receiver. It is the function of the third stage to remove this audio signal and to leave only the baseband code elements. Essentially, it operates as an envelope detector. This configuration also facilitates the later introduction of delay, which serves as a noise blanker. The third stage consists of a pnp switching transistor (Q1) and an NE555 IC. Pin 3 of the NE555 remains at logic high for the duration of a code element, while during a space it remains low; thus the cw envelope is obtained. This detector stage drives a tuning indicator, consisting of an LED that remains lit only for the duration of a code element.

The fourth stage — comprised of a diode, Q2 and Q3 — is used to delay the generation of tone. This stage prevents noise impulses, which have triggered the first three stages and whose duration is *less* than the delay set into the stage, from creating an audible output. A 100-kΩ control is used to adjust the amount of delay from zero to over 16 ms. A code element is of considerably longer duration than most noise impulses; therefore, it will produce an audible output. The envelope detector has a pulse stretching effect of approximately 3 ms, so the net loss affecting a code element is the delay introduced by this stage (less 3 ms). This loss, even at maximum delay, does not affect readability of the code.

The fifth stage is a tone generator keyed through reset-pin 4 by the output of the delay stage. It produces a tone only when that output is high. A 5-kΩ Trimpot is used to adjust the pitch of the generator. The final stage is an audio power amplifier capable of driving a small loudspeaker. The 10-kΩ control is an audio-taper potentiometer.

The unit may be constructed on perf-board or a pc board. The foil side of the circuit-board etching pattern appears in the Hints and Kinks section of this issue, and the component side is shown in Fig. 4. Everything may be mounted in a cabinet measuring 7-3/4 × 4-3/8 in. (Radio Shack 270-232). The unit shown in Fig. 5 was constructed by Circuit Board Specialists,[1] using a pc board specially made for the circuit. An open chassis was also made from pc board.

The rear of the chassis holds three connectors — one for the audio output from the receiver, one for the output of the filter to a small speaker or phones, and one for the power-supply input. Front-panel features include a VOLUME control (with power switch), DELAY control, LED tuning indicator, BYPASS/ON toggle switch, BANDWIDTH and BANDCENTER controls. Small Radio Shack knobs (274-380) are used for the VOLUME control and the BANDCENTER control. Two somewhat larger knobs with calibrated skirts (Radio Shack 274-413) may be used on the DELAY and BANDWIDTH controls to permit calibration of their settings. Rub-on fiducial lines are put on the chassis front for these calibrated controls. A 9-V battery pack consisting of 6 AA cells, or a small dc plug-in wall adapter (at least 100 mA), may be used for the power supply.

Adjustment and Calibration

Adjustment of the BANDCENTER control may be done best through the use of a

*32 Mendell Ave., Cranford, NJ 07016

[1]A complete kit of parts, including etched pc board is available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002. The ARRL and *QST* in no way warrant this offer.

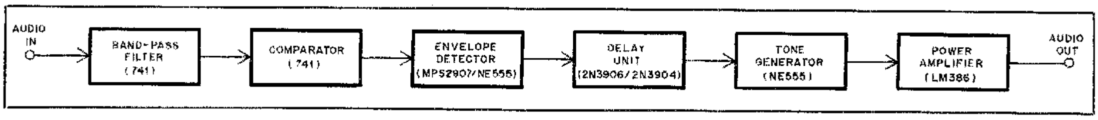


Fig. 1 — Block diagram of the QRM Fighter.

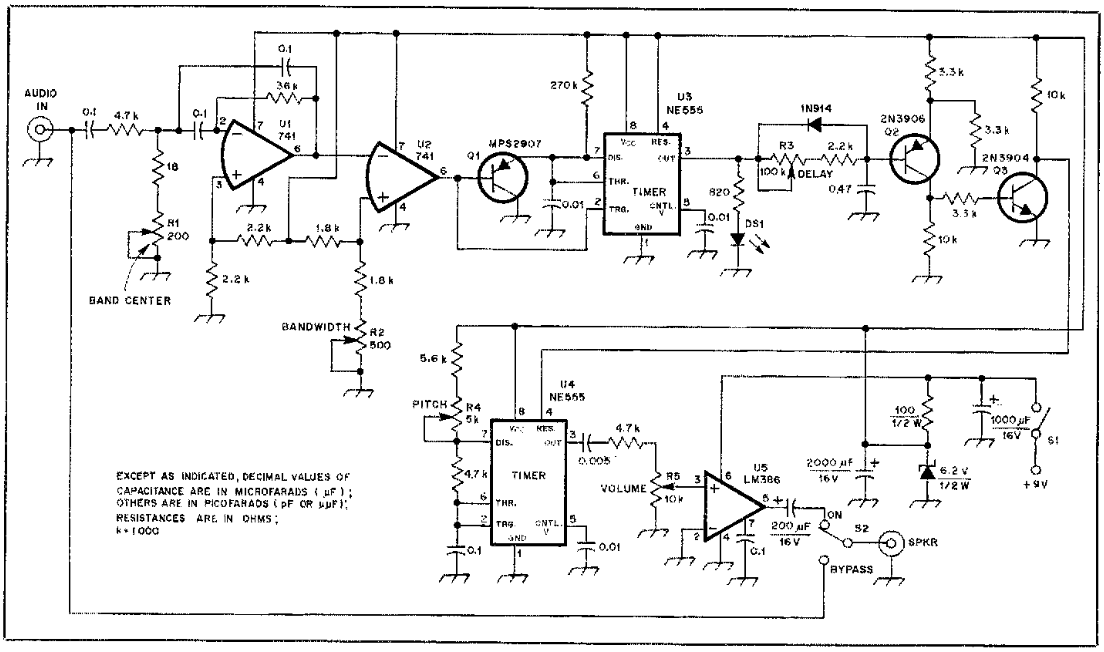


Fig. 2 — Schematic diagram of the filter. All resistors are 1/4-W, carbon-composition or film types; capacitors are 25-V, disc-ceramic types. Those with polarization marked are electrolytic.

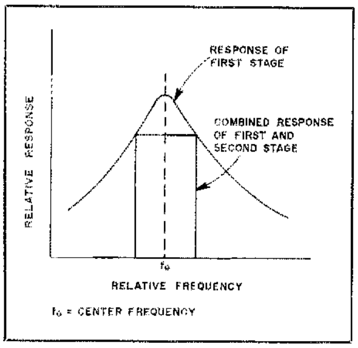


Fig. 3 — Graph showing relative response of first two stages.

steady carrier picked up by the receiver. A crystal calibrator can be used to supply the carrier. The receiver should be tuned for maximum deflection of the S meter and not disturbed for the remainder of the adjustments. With the receiver audio level set no higher than needed for detection by the filter, and the BANDWIDTH control set for maximum bandwidth, the BAND-CENTER control is adjusted until the LED is lit and a steady tone is heard. Filter bandwidth is reduced progressively, and the BANDCENTER control adjusted, always maintaining minimum excitation necessary from the receiver. Eventually, an adjustment of the BANDCENTER control is obtained, which exactly matches the receiver offset frequency. This control should thereafter not be disturbed. At this point, the 5-kΩ pitch-control Trimpot may be adjusted to produce a pleasing tone. The pitch may be lowered further, if necessary, by paralleling the 0.1-µF capacitor in the fifth stage with a 0.05-µF unit.

The BANDWIDTH control may be calibrated by use of an audio sine-wave generator set for 100-mV output. By "rocking" the frequency dial of the generator, the filter bandwidth may be determined. Dial calibration of the BAND-WIDTH control can then be noted.

For calibration of the DELAY control, a source of pulse-modulated audio set to the offset frequency of the receiver, and a dual-trace oscilloscope, are used. A suggested circuit for the signal source is given in Fig. 6. This circuit provides a series of dots with equal dot and space durations; the dots consist of several cycles of audio from the sine-wave generator, whose amplitude is set to 100 mV. If a known code speed is desired, the frequency of the NE555 switch should be set to 2.4 × wpm. This frequency is equal to 0.722/RC; for example: R = 91 kΩ, C = 0.47 µF produces a code speed of 40.5 wpm, which is a good speed to use.

The simulated cw signal is connected to the input of the filter. Pin 3 of the third stage, NE555, is connected to one channel of the oscilloscope, and the collector of Q3 is connected to the other channel. Relative time delay between the two signals may now be observed, and the dial of the DELAY control can be marked correspondingly.

When the QRM Fighter is connected to a receiver and has sufficient delay dialed in, the LED will occasionally flash on strong noise impulses, but no sound will be heard. This is indicative of the extraordinary noise filtration that the delay discrimination can produce.

Operation and Comments

It is my usual procedure to tune the

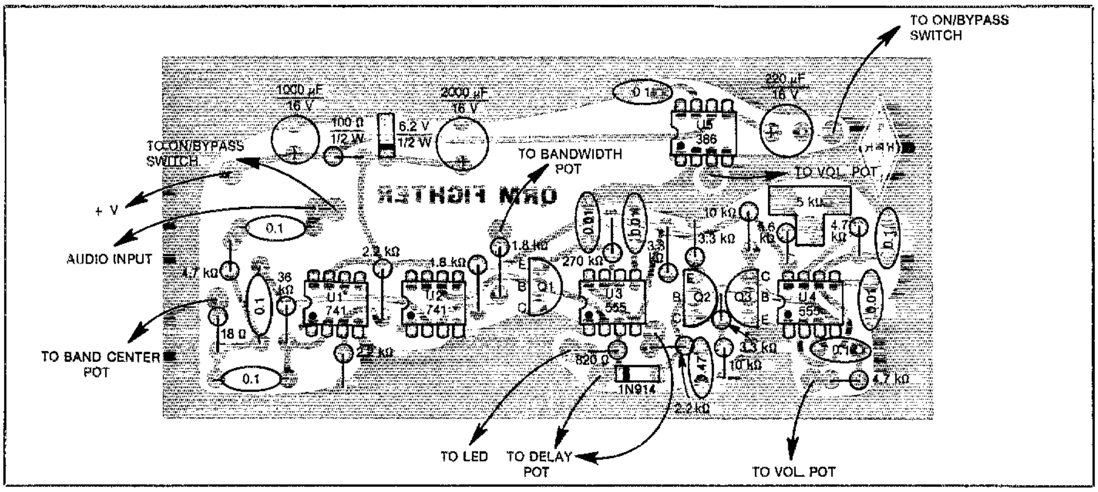


Fig. 4 — Parts-placement guide for the circuit board. Components are mounted on the non-foil side. Gray areas represent unetched copper. The circuit-board etching pattern appears on page 39.

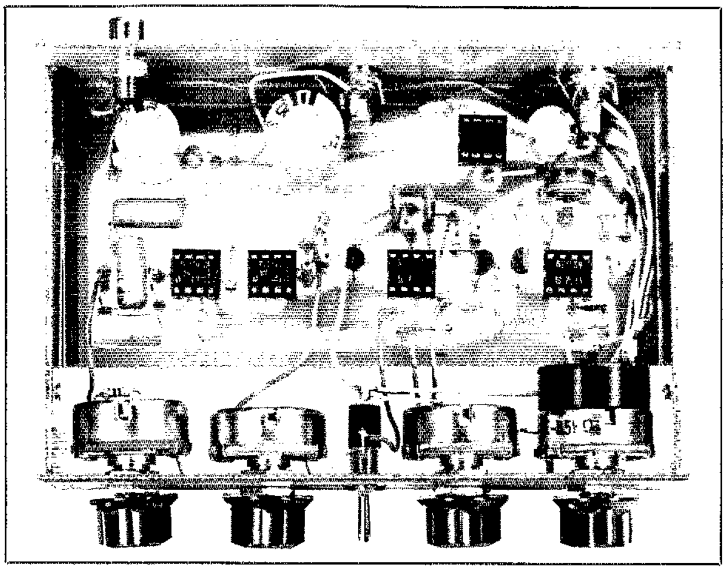


Fig. 5 — Inside view of completed QRM Fighter.

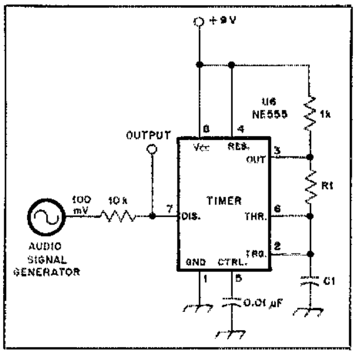


Fig. 6 — Simulated cw generator used for alignment purposes.

receiver with the filter in the BYPASS mode and while observing the LED, making sure the signal is properly tuned in. The BANDWIDTH control is normally set at 100 Hz, and the DELAY control at zero. If QRM suppression is desired, the filter is put into the ON position. Sometimes the filter is used when there is no QRM, simply for the pleasure of listening to a signal against a quiet low-noise background. If noise persists when the filter is in, delay may be dialed in to eliminate it. Usually a delay of 8 to 10 ms is adequate.

I was not able to test the QRM Fighter against the Russian Woodpecker. The duration of its pulse is known to be 15 ms, however, so the filter should be effective in suppressing it.

One characteristic of this filter is that the bandwidth increases with the input level. Also, noise that actually triggers the circuit will appear in the output at the same level as the desired signal (but not with the same duration or pitch). Both problems are alleviated by using minimum drive from the receiver, consistent with filter excitation.

Because of the narrow band-pass characteristic, it may not be possible to hear your transmitter sidetone. This can be corrected by adjusting the frequency of the sidetone oscillator, or simply by switching the filter back to the BYPASS mode while transmitting. It is an amusing consequence that listening to both sides of a QSO without readjusting the VFO is usually not possible because of the extreme selectivity!

The pleasure of using this filter will repay the time spent in designing and building it. It is my hope that you will derive as much satisfaction from it as I have.

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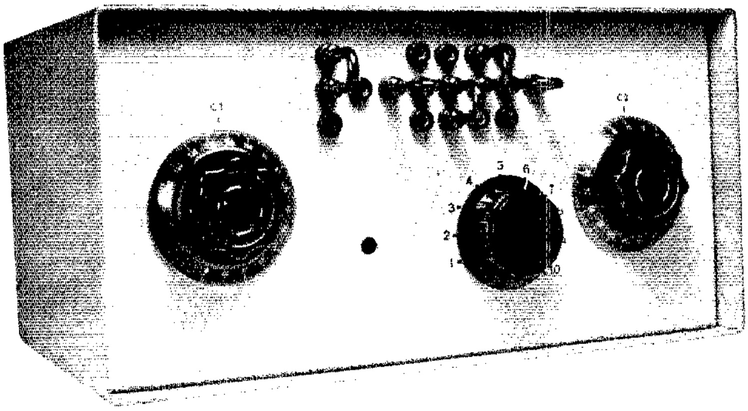
A New, More Versatile Transmatch



Another Transmatch? This one is different! It "jumps" to match your every need.

By Claude L. Frantz,* F5FC/DJ0OT

Technical articles show an increasing interest in impedance matching between the transmitter and antenna systems. This is amplified by the fact that more modern equipment uses solid-state final amplifiers with a fixed-value output impedance.

The matching problem can be resolved in an elegant manner if a tube PA (power amplifier) and a well designed Pi-L matching network are used. Unfortunately, only a few articles have been published on Pi-L matching-network designs with wide-range matching capabilities. The usual approach, using a given intermediate impedance between the Pi and the L sections, is not adequate for matching widely varying load impedances.

This article describes a matching device that can be used between any receiver, transmitter or transceiver and an antenna system having unbalanced connections. The unit will provide a matching range that is much broader than the range of most similar devices. Despite these capabilities, it remains simple and inexpensive.

The main feature is an ability to vary the structure of the matching network in a simple manner. Any L, Pi or T network

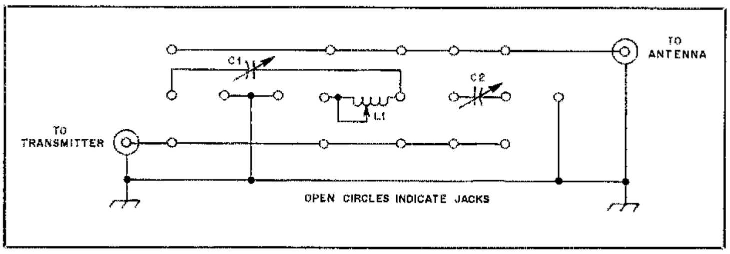


Fig. 1 — Schematic diagram of the Transmatch used at DJ0OT. Jacks for the wire jumpers are shown as circles. Any desired configuration can be wired by inserting jumpers at the appropriate points. C1 and C2 are air variable capacitors, 200 pF, with a large plate spacing. L1 is a 25-µH inductor (E. F. Johnson 229-203 or similar).

*Hauserstr. 43, 8035 Gauting-Königwiesen, West Germany

Table 1
Basic L Network

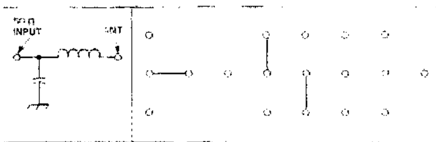
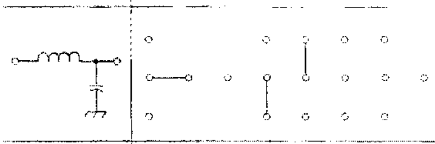
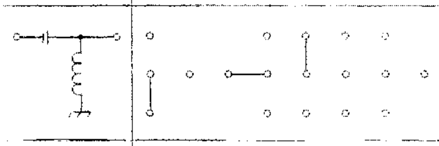
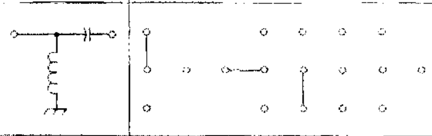
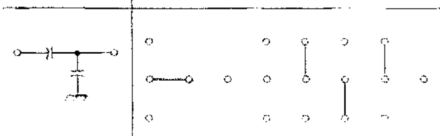
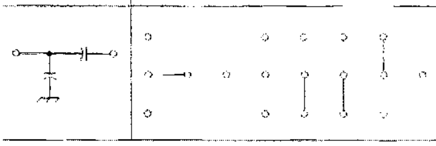
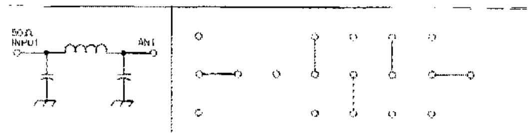
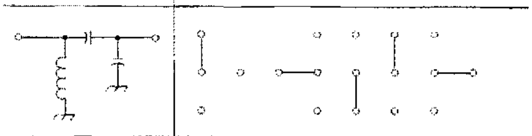
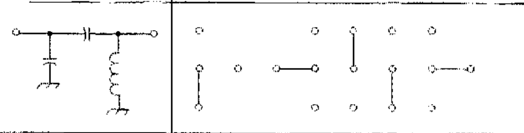
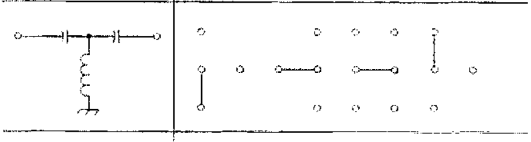
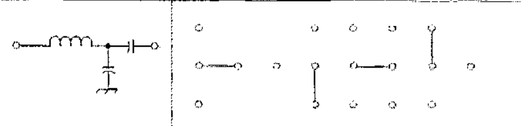
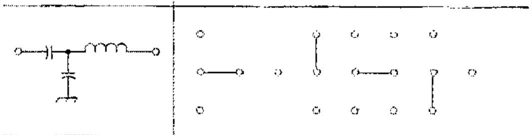
Configuration / Jumper Location	*Main Usage*
	R < 50 Ω X < 0
	R > 50 Ω X > 25 Ω
	R > 50 Ω X < 25 Ω
	R < 50 Ω X > 0
	R < 50 Ω X > 25 Ω
	R < 50 Ω X > 25 Ω

Table 2
Pi and T Networks

Configuration / Jumper Location







that can be built with three components (two capacitors and one inductor) is realized easily with this device. Component values are not critical. The inductor can be a roller coil or one with switched tap points (Fig. 1). In my Transmatch, jumpers are used to make the interconnections, so any configuration can be wired quickly. I prefer this method of interconnection because it is simple and economical. Expensive switches capable of handling large current or voltage, depending on the network used, are not required. Further, the required space is smaller. A maximum of five jumpers is required to make all interconnections. Tables 1, 2, 3 and 4 show possible networks; the location of the jumpers is given for each one.

I used variable capacitors that have ceramic-insulated supports and insulated shaft couplers. The inductor is a 25-μH tapped coil, but a larger inductance will be needed if you plan to use the Transmatch on 160 meters. A roller inductor will provide continuous matching capability. Banana jacks are used for front-panel connections. The jumpers can be made from pieces of heavy insulated wire with banana plugs on each end.

The adjustment can be made experimentally while using an SWR indicator in a manner similar to that of most matching devices. There is no explicit limitation on the antenna to be used. I have a multiband dipole for use between 80 and 10 meters. This device has worked well at my station. I was able to achieve DXCC, DUF 4 and DNF, using only 100 watts. All components are available from Radio-Kit, P.O. Box 429, Hollis, NH 03049.

Table 3
L-Network Variations

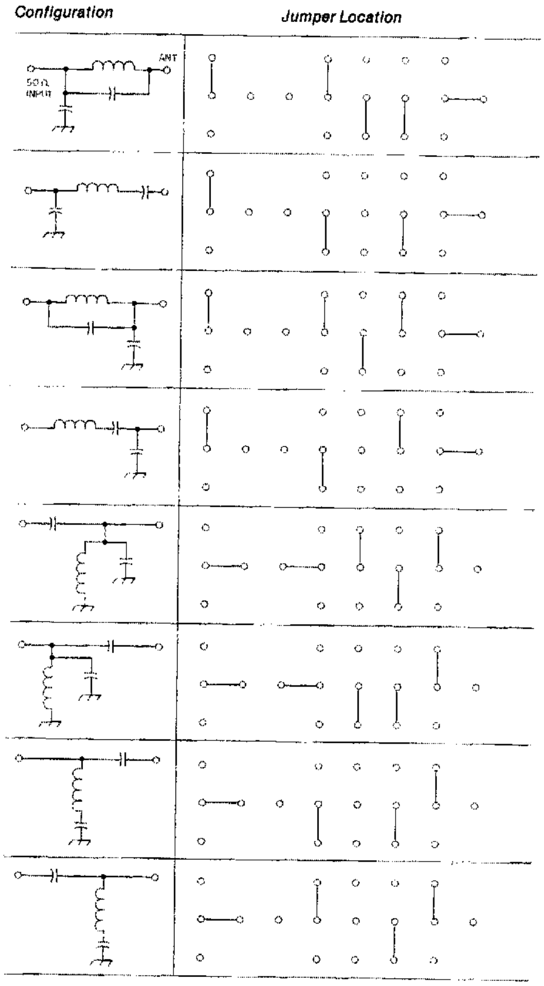
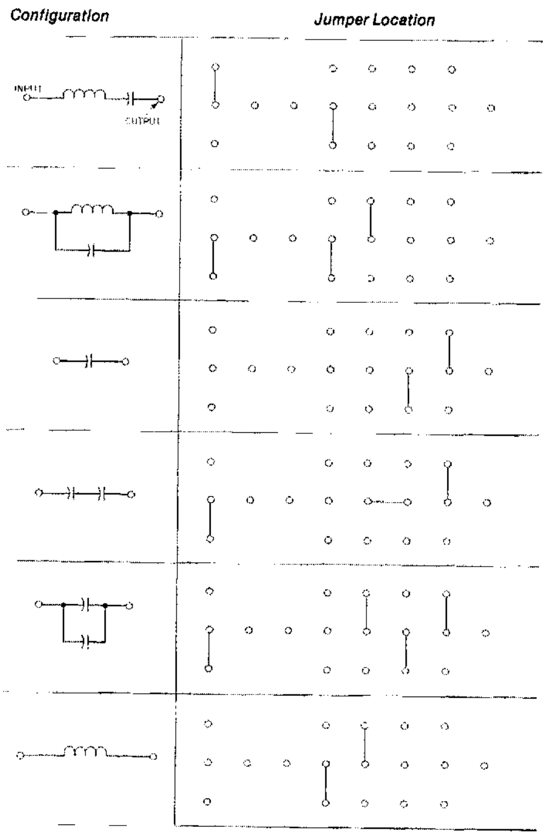


Table 4
Simple Series Networks



Strays

***QST* congratulates . . .**

☐ Astronaut Owen Garriott, W5LFL, who has been named mission specialist for NASA's Space Shuttle Mission 9 flight, scheduled for September 1983.

☐ Linsley M. Hamilton, KD6AU, of Hawthorne, California, who was recently named Configuration Management Administrator for the Space and Communications Division of Hughes Aircraft Corp.

I would like to get in touch with . . .

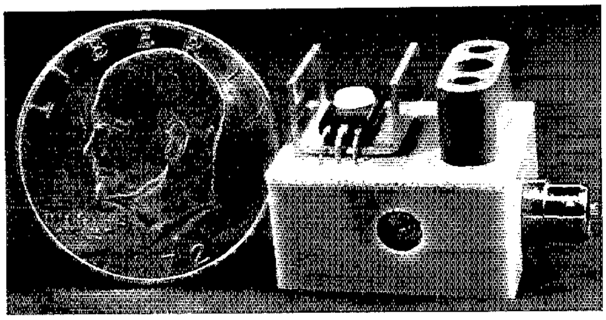
☐ anyone who has an interest in the Collins KW1 as a museum piece or for regular communications. Howard A. Miller, W2WLZ, 163 Hoover Rd., Rochester, NY 14617.

☐ someone with a book or diagram for an Eico 427 oscilloscope. Dan Eggers, N7DE/5, 1219 Westover, College Station, TX 77840.

☐ other hams who are interested in exchanging programming/interface ideas for the Motorola 6800 series MPU, particularly for Amateur Radio applications. Tom Winfield, WA9LKD, 543 Redwood, Bolinbrook, IL 60439.

☐ anyone who knew T. R. McElroy, world champion radio telegrapher. B. Neal McEwen, K5RN, 1128 Midway, Richardson, TX 75081.

BEGINNER'S BENCH



Build a 40-M Cubic Incher

Just a few hours and a few "bucks" will net you more watts per cubic inch — and fun — than any other rig.

By Dennis Monticelli,* AE6C

Having been afflicted with QRPer's disease[1] for the past 14 years, I found it natural to attempt to build a rig sized in proportion to its power. Of necessity, the circuit had to be simple and emphasize low parts volume as well as low parts count. The design effort was well worth the time because this rig has been more operating fun (per cubic inch or otherwise) than any other rig I have built. Other hams find it hard to believe that 2 watts and a good note can originate from such a tiny box.

Circuit Description

This rig is a crystal-controlled, 1-transistor power oscillator (Fig. 1), designed to generate power efficiently while maintaining a good cw note. A key to achieving the small size is the use of T1, a multifunction transformer. Wound on an iron-powder toroid, T1 passes dc to the transistor, couples power from that device to the tank circuit, forms one half of the resonant tank circuit, and transfers power to the antenna. The primary inductance is chosen deliberately to be unusually high (7.8 μH), so that the unloaded Q (Q_u) will be 140. By designing for such a high Q_u, the tank loss can be minimized. This, in turn, allows the loaded Q (Q_L) to be set high enough (Q_L = 14) to maintain waveform purity without the fear of consuming precious output power in the tank circuit. The impedance across the tank, as reflected by a 50-Ω load, is approximately 5 kΩ, resulting in a healthy 280-V pk-pk swing with a 12 V supply. Tuning is performed by adjusting the small, mica-compression trimmer capacitor, C3.

Normally, feedback for a simple, Pierce-type crystal oscillator is obtained by feeding the entire tank signal back to the base through the crystal. While this method results in quick starting and vigorous oscillation, it also drives the transistor harder into saturation than is necessary. This usually results in a collector current signal rich in harmonics and lower tank Q_L because of transistor input loading. A capacitive impedance transformation provided by C1 and C2 reduces the feedback signal to a more optimum level. The oscillator still starts willingly, and the output waveform is significantly cleaner than that obtained with excessive drive. Saturation still occurs on negative voltage swings, so efficiency is maintained. Start-up resistor R1 delivers about 1 mA to the base of Q1. For a typical β (current gain) of 50, this results in a collector current of 50 mA, which is ample for the circuit to develop the high-frequency voltage gain necessary to initiate oscillation. D1 is optional, but it seems to reduce harmonic output somewhat, perhaps by equalizing the loading on the tank for positive and negative swings. It also serves to protect the base-emitter junction of Q1 from inadvertant, but potentially damaging, reverse breakdown voltage. RFC1 is also optional, but it too reduces harmonics slightly and represents a certain measure of insurance that Q1 won't parasitically oscillate at vhf.

Q1 was chosen carefully, as it is the "heart" of the circuit. Originally designed for service in the Class C output stage of a CB radio, it exhibits good efficiency up to 4-W output at 27 MHz. It also possesses the noteworthy ability to handle infinite SWR when operated at 12 V or less. And although I've found this device to be virtually impossible to destroy in this circuit, that doesn't mean some particularly resourceful ham out there won't find a way to make me eat my words. In any case, the MRF472 is inexpensive, selling for as little as $1 at some outlets (see Fig. 1), and it comes in a tidy TO-126 package.

Construction

The little rig is built in an open-bottomed box constructed from single-sided printed-circuit-board material, and measures (you guessed it!) 1 cu in.[2] The circuit-board foil serves as an effective and convenient solderable ground plane.

*48617 Tonopah Ct., Fremont, CA 94538
[1]Notes appear on page 36.

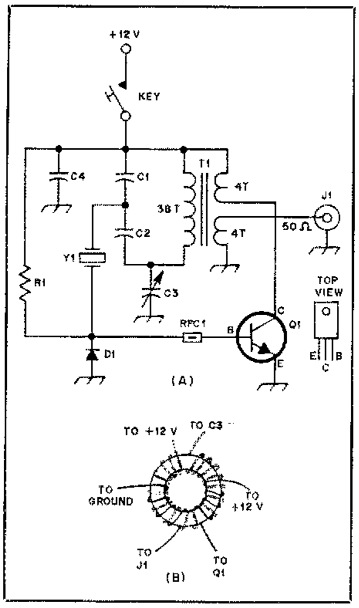


Fig. 1 — Schematic diagram of the 40-Meter Cubic Incher (A), and winding details for T1 (B).

C1 — 430-pF silver mica or disc ceramic (exact value unimportant; 390 or 470 pF will work).
C2 — 51-pF silver mica or disc ceramic.
C3 — 4- to 40-pF miniature mica compression trimmer, 3/8 × 17/32 in., ARCO no. 403[3] or equiv.
C4 — 0.01-µF and 0.001-µF disc ceramics in parallel. The 0.001-µF unit is optional (see text).
D1 — High-speed silicon switching diode, 1N914 or equiv. This diode is optional (see text).
J1 — RCA phono jack.
Q1 — Npn medium-power rf transistor, MRF472[4] or equiv.
R1 — 10-kΩ, 1/4-W carbon type.
RFC1 — Ferrite bead, FB-43-101 or equiv.
T1 — Toroidal transformer wound with no. 26 enameled wire on a T50-2 core,[2] 38 t. primary, 4 t. each secondary.
Y1 — Fundamental-cut crystal in FT-243 or HC-6/U holder.

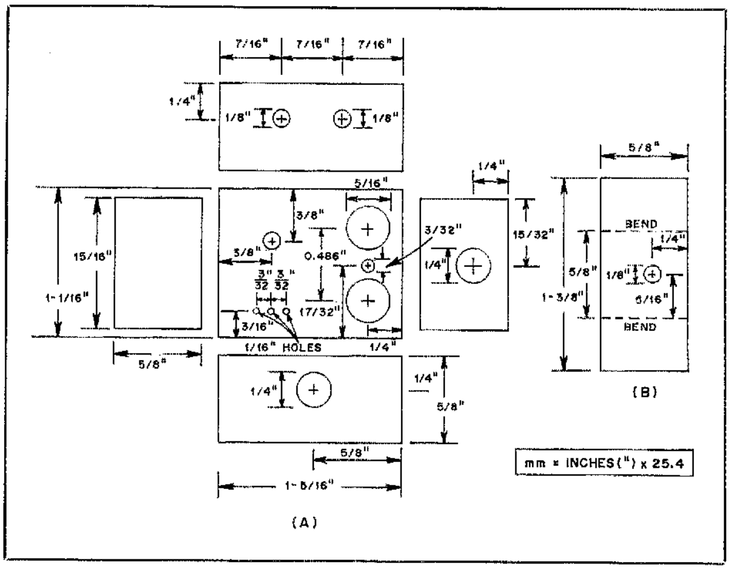


Fig. 2 — The five pieces of circuit-board material used to form the box are cut and drilled as shown in A before the box is assembled. The heat sink, B, is made from 1/16-inch aluminum or brass.

Surprisingly, the parts are not too tightly crammed into the box. Instead, the volumetric needs of each component were carefully considered in planning the layout to ensure efficient use of space. For example, T1, Q1 and the heat sink are all mounted to the box with one nylon bolt. The remaining parts are placed judiciously with regard to the constraints imposed by T1, C3 and the intrusive phono jack, J1 (now you know why I didn't use an SO-239!)

Begin construction by cutting the five pieces shown in Fig. 2 out of 1/16-inch-thick circuit board.[3] Drill all the indicated holes prior to assembly. If some of the parts, such as C3 or the crystal socket, are dimensionally different from mine, you will need to make allowances in your cutting and drilling. Assemble the box by first soldering the long sides to the top member. Next, solder the shorter end pieces to the top. Finally, solder the four corners together. Make it easy on yourself and the circuit board by using only a single blob of solder for each joint. A small box like this one will be plenty strong enough without drowning it in solder and flux and overheating the fiberglass in the process.

Install the two 4-40 bolts that serve as the supply (V+) and ground terminals, taking care to insulate the V+ bolt from the chassis. Scrape away the copper foil from around the immediate area of the V+ hole and use a fiber washer to ensure isolation from ground. Next solder one end of C3 to the underside of the top piece after aligning it carefully with the adjustment hole in the side piece. Cut and bend the heat sink, described in Fig. 2, out of aluminum or brass and drill the mounting hole. Wind T1 as detailed in Fig. 1, paying attention to the phasing direction and placement of the windings. Scrape away the foil from around the holes for the transistor leads as you did for the V+ bolt. Bend the leads of Q1 and install it along with the heat sink and T1 as one unit, using a 3/4-inch nylon bolt. Use nylon or fiber washers to sandwich T1, thus insulating it from the chassis and providing a flat surface for the nut to clamp down on. You may wish to use thermal conducting grease between Q1 and the heat sink, although this is not mandatory because the operating temperature of the device is normally low.

Referring to Fig. 3 for parts placement, first solder in imbedded capacitor C2, and then C1. Plan your routing scheme for the six leads from T1 and solder them in. Drop the ferrite bead over the base lead of Q1 and connect an insulated wire from the base to the crystal socket. The remaining parts, C4, D1 and R1, are all easy to wire in, as they lay near the surface. Note that two capacitors were used for C4 in this model, although one works just fine.

Testing and Tune-up

Apply a current-metered, 12-V power source (I use batteries) capable of supplying at least 300 mA, and connect a 50-Ω noninductive resistor or dummy load to J1. Plug in a crystal known to be active, and adjust C3 until the circuit breaks into oscillation as evidenced by a sudden jump in supply current. By adjusting C3, you can get the supply current to range from roughly 150 mA to 600 mA and still maintain oscillation. At the low current end, leading-edge keying will be soft and efficiency reduced. At the upper end, the power efficiency will be reduced and harmonics increased. It appears that about 300 mA yields the best combination of good keying and efficiency. The particular transistor you use, the crystal activity and your actual antenna impedance will all influence the optimum current value. Determine the optimum value yourself for your particular set-up. Once adjusted, C3 should not have to be changed when you change crystals, unless they vary widely in activity. Don't expect to find a current dip as you tune; a heavily loaded oscillator like this one will not behave like the 6146 final amplifier in your station rig.

Troubleshooting

Obviously there is very little to go wrong with this rig. Should trouble develop, however, here are a few hints. If the circuit refuses to oscillate and draws no supply current at all, you have a bad connection or a defective transistor. If the circuit pulls roughly 20 to 100 mA, but doesn't oscillate, then your transistor is good but the tank may be out of resonance. Use a grid dip meter to check it, or experiment up and down a bit with the value of C2. It is also possible that insufficient feedback is available to kick the circuit into oscillation. Try reducing the value of C1 by an octave or so to boost this feedback.

80-Meter Operation

I see no reason why this rig shouldn't work on 80 meters with simple modification. Although I haven't tried it, merely scaling up C1, C2 and C3 by two octaves should result in good performance because the primary inductance of T1 is already high at 7.8 μH. I would be pleased to hear from anyone who succeeds in putting a Cubic Incher to work on 80.

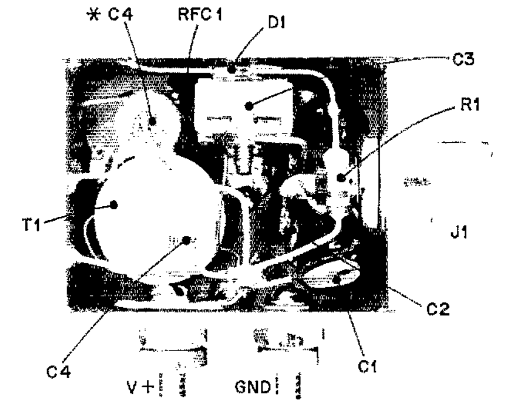
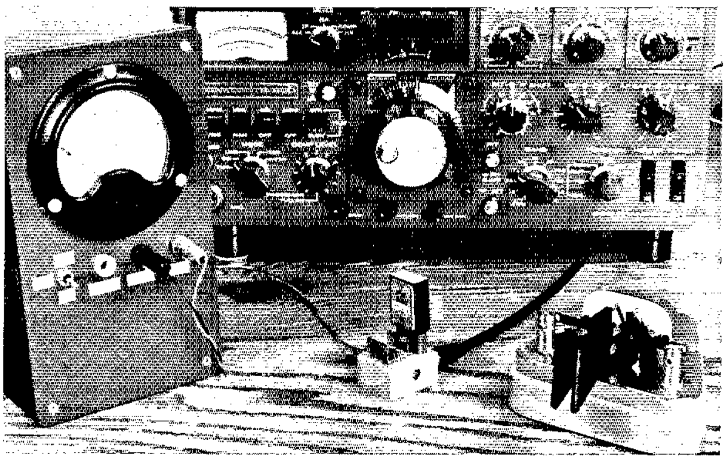


Fig. 3 — This bottom view shows the parts placement used to make the most of the tiny volume.

Performance

For such a simple circuit, the Cubic Incher gives a good account of itself. With a 12-V supply, the transmitter draws 300 mA while producing an output of 2.1 W. That's an efficiency of 58%, relative to total rig power consumption; try that test on your station rig! The Cubic Incher also works well on supplies from 6 to 18 volts, although the power efficiency and ability to withstand infinite SWR is impaired by high supply voltages.

I run the output from my Cubic Incher through the station Transmatch and low-pass filter (always good practice) to a roof-mounted Butternut vertical. This modest arrangement produces plenty of contacts and frequent comments on the nice sounding note. Other hams rarely believe me the first time I tell them the rig measures only 1 cu in. Contacts have been made with stations all over North America, in South America and frequently in Japan.


The QRP apparatus at AE6C. The metered power supply on the left contains two 6-V rechargeable gel cells. A flick of the switch changes the supply, from 12 to 6 volts for an extra QRP challenge.

QRP is a lot of fun for many hams, but others have found it somewhat frustrating. I have some thoughts (certainly not original) on this subject. First of all, it is a misconception that elaborate antennas are needed. All that is required is that your aerial be efficient and mounted up in the clear. If the practices outlined in *The ARRL Antenna Book* are followed, simple dipoles, verticals, Zepps, etc., will work fine. Second, don't call CQ expecting to receive a snappy response. It's much better to listen, select and call the stronger stations on the assumption that either propagation is favorable between the two of you or he has a good antenna. Either way, you stand a better chance of being heard. Third, QRM and especially QRN are your two worst enemies. Choose a clear frequency and avoid operating on days with very high atmospheric noise. Fourth, arm yourself with more than one crystal. Double your crystals and you'll virtually double your opportunity for a QSO. Shop the flea markets for "rocks" or take advantage of the good buys offered by some suppliers.[4]

Some Thoughts

No construction article is complete without mentioning the potential disadvantages of undertaking and completing the suggested project. No doubt about it, this rig is *small!* "How small is it," you ask? It's so small it gets lost on your operating bench. It's so small it dangles on the end of a stiff coaxial cable like some sort of coaxial terminator. It's so small my cat has claimed it as her personal toy, batting it about like a ping-pong ball. Best of all, though, it's so small it puts the thrill back into your QSOs.

Notes

[1]*Operatus lopowerus*, no know cure.
[2]mm = in. × 25.4; cu mm = cu in. × 16,390.
[3]A complete parts kit, including cut and drilled circuit-board parts, is available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002.
[4]FT-243-style crystals are available from CW Crystals, 570 N. Buffalo St., Marshfield, MO 65706.
[5]Available from Radio Kit, P.O. Box 411, Greenville, NH 03048.
[6]Available from Semiconductor Surplus, 2822 N. 32nd St., No. 1, Phoenix, AZ 85008.
[7]Iron-powder toroids and ferrite beads are available from Amidon Assoc., 12033 Otsego St., N. Hollywood, CA 91607, and from Palomar Engineers, 1925-F W. Mission Rd., Escondido, CA 92025.

Reference

Hayward, W. and DeMaw D. *Solid State Design for the Radio Amateur.* Newington: ARRL, 1977.

Conducted By Larry D. Wolfgang,* WA3VIL

TEN-WATT SCALE FOR THE "COMPUTING SWR METER"

☐ I recently added QRP operation to my station, and desired the convenience of the "Simple Computing SWR Meter" described by David L. Fayman, WØGI, in July 1973 *QST*. A 10-watt scale is provided by cascading a noninverting amplifier (Fig. 1) that's switched in for 10-watt, full-scale indication with the wattmeter in the 200-watt position. Wattage is read on the 1000-watt scale, with the readings divided by 100. Individual switching of forward and reverse channels of the 10-watt amplifiers is provided. This permits selection of the 10-watt reflected power in the 200-watt forward position for finer resolution of reflected power. The SWR readings are not correct when this combination is selected.

The amplifiers are of perf-board construction with Wire-Wrap® sockets. Switches for the 10-watt position are mounted on the rear panel.

Calibration is performed by first grounding the input of each channel and adjusting the offset null for 0-V dc. Switch the 10-watt scale off, and select the 200-watt scale. With a transmitter operating at 7 or 14 MHz into a dummy load adjust the power output of the transmitter for 10 watts as indicated by the 200-watt scale. Switch to the 10-watt scale. With 10 watts of rf energy applied, adjust the gain potentiometer of the 10-watt forward amplifier for full-scale deflection at 10 watts. Reverse the connection at the rf head between the transmitter and load. Depress the reflected-power switch and apply 10 watts of rf power. Adjust the gain potentiometer of the 10-watt reflected-power amplifier for a full-scale deflection of 10 watts. Reverse the rf head connections, and the device is now ready for use.

This 10-watt scale is adequate for my HW-8. It provides relative power-output measurements and SWR indications previously not attainable. Antenna matching adjustments during QRP operation are now easy to make.

My SWR meter has been battle tested through many Field Day operations and contests, with excellent results. The only problem encountered in its years of use has been thermal shutdown of the dual tracking voltage regulator. I replaced this regulator with three-terminal regulators (TO-220 case) for the plus and minus 15-V supplies to correct the difficulty. A change to the three-terminal regulators might be required because of the additional current drain of the extra amplifiers.

An attempt was made to add the 10-watt scale to the existing amplifiers by adding another gain control. The gain required was too great for a single amplifier. A noninverting amplifier with a floating input (10-watt scale switched off) causes the output to go into saturation. Another pole could be added to each switch for grounding the input when the 10-watt scale is off, if desired. No problems have been encountered by leaving the inputs in my installation ungrounded. — *Ronald W. Hooker, K9WTF, Big Bend, Wisconsin*

*Assistant Technical Editor

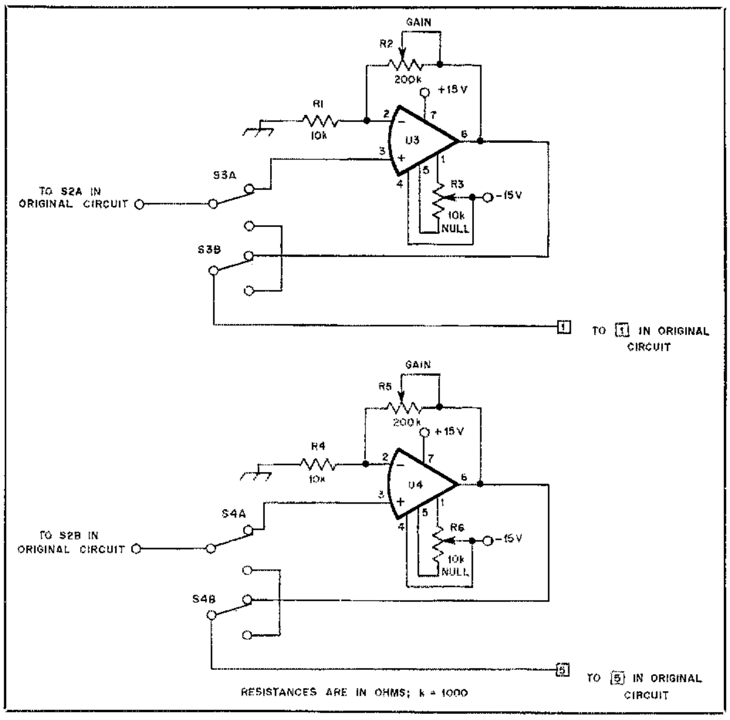


Fig. 1 — The schematic diagram of additions for providing a 10-watt scale for the "Simple Computing SWR Meter" (July 1973 *QST*). Circuitry added is between S2A and terminal 1 of the circuit board, and S2B and terminal 5 of the board as shown. Switches shown are in the 10-watt position.

U3, U4 — General-purpose operational amplifier, 741CN or TL081.
R1, R4 — 10 kΩ, 1/4 watt, 5%.
R2, R5 — 200-kΩ, multiturn potentiometer.
R3, R6 — 10-kΩ potentiometer.
S3, S4 — Dpdt, Radio Shack no. 275-1546 or equiv.

HIGHER POWER FROM THE HEATH HA-201A 2-METER AMPLIFIER

☐ After using my Kenwood TR-2400 hand-held transceiver and Heath HA-201A 10-watt amplifier for more than a year, I became disheartened by the low output power, especially each time the batteries in the TR-2400 would begin to lose their charge. I found that the 2N6081 transistor in the amplifier could be replaced by an MRF 238. This transistor has a 9-dB gain compared with 6.3 dB for the original. Other specifications are nearly identical.

The transistors have similar case styles, so replacement is simple. Retune the input and output capacitors for maximum power. A 2-watt input produces a 22-watt output. The MRF 238 transistor is rated at 30 watts, and costs about $10. I did not find it necessary to replace the 3-A fuse, but the greater current drawn by the higher-power device may require a larger fuse rating. — *Carl Nebelsky, AA1U, Pleasant Valley, Connecticut*

WIRE-TO-SPREADER CONNECTOR SYSTEM FOR QUAD ANTENNAS

☐ When I began building a quad antenna for 10, 15 and 20 meters, I wanted a durable method of connecting the wires to the fiberglass spreaders. It would have to last through widely varying weather conditions, and should allow the whole system to flex in the wind without breaking.

My basic idea was to construct a pulley system. The wire would go around a wheel whose axis would be perpendicular to the spreader, in this case a 2-in. diameter fiberglass pole. The wheel would allow the wire to move, decreasing stress at the connecting points when strong winds flex the spreaders. I used a groove in the pulleys that had the same width and depth as the wire diameter. I also fabricated a shield to go over each wheel to prevent the wire from jumping out of the groove.

Pulley wheels were fabricated from a piece of 1/2-in. diameter acrylic rod. I used a lathe to cut the grooves in the acrylic rod and then cut the 0.3-in. pulley wheels, as shown in Fig. 2. A 9/64-in. hole was drilled in each wheel to accommodate a no. 6 bolt. Each shield was cut from a sheet of galvanized steel.

These pulleys have been in use for two years, and they are as good as new. An added advantage is that they increase the radius at which the wire must bend, preventing a break at the corners. — *Peter Martin, WD9EKV, Oconomowoc, Wisconsin*

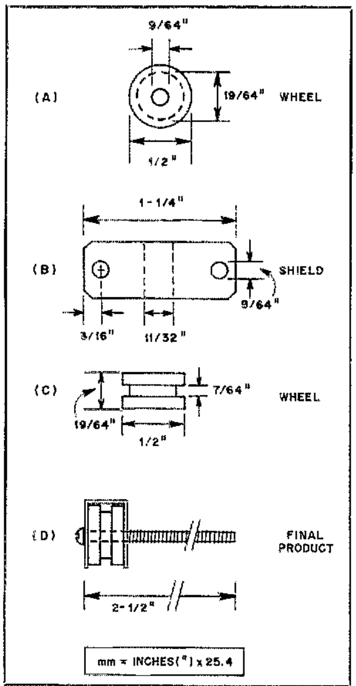


Fig. 2 — This diagram illustrates the steps in fabricating pulley wheels for use as quad-antenna wire-to-spreader connectors.

USING THE HEATH 1410 KEYER WITH THE TEN-TEC ARGOSY

☐ I found that my Heath 1410 keyer would not key my new Argosy transceiver. The Ten-Tec instructions specify the use of a reed-relay keyer output if a Ten-Tec keyer is not used. These keyers do not use a reed relay, so there must be a way to use other types. I found the voltage at the Argosy key jack to be +1.5 volts. The schematic diagram for my Heath keyer shows two sets of keying transistors, with diodes to ensure that the proper polarity is applied to each transistor. The diode voltage drop was the problem. Q6 and Q7 are used to key rigs with a positive keying voltage, so I put a jumper across D5 on the foil side of the board. The keyer and the Argosy transceiver work beautifully together now. If I need to use the keyer with another rig, I simply remove the jumper. An alternative solution would be to use one of the RCA jacks on the rear panel as a separate "Ten-Tec" output, with the hot line connected to the junction of the D5 cathode and the Q7 collector. — *Fred Wagner, KQ6Q, Omaha, Nebraska*

RECEIVER AUDIO QUALITY IMPROVEMENT

☐ I was never really satisfied with the sound of the audio from my Kenwood TS-520, especially while using the wide cw position. Fig. 3 shows a circuit that I built into a surplus headset-adapter box (model MC-385-C), which I picked up for 75 cents at a flea market. A small aluminum box will work just as well.

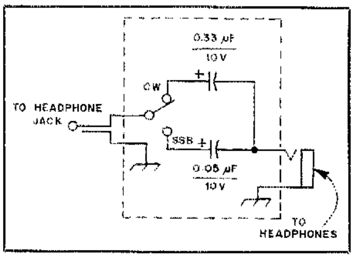


Fig. 3 — This simple circuit can be used to tailor the audio-response characteristics of your receiver.

I find that the 0.33-µF capacitor in series with the headset line sharpens the cw audio response nicely. The 0.05-µF unit gives a pleasant sound on ssb. Others may wish to experiment with different values to get a sound they like. — *John Fisher, K2JX, Huntington, New York*

THERMOFAX TRANSPARENCIES FOR PC BOARDS

☐ In his article on making printed-circuit boards,[1] David Malley, K1NYK, states that Thermo-Fax® positive transparencies can be used with positive photo resists, but often let too much light through. This results in ruined boards.

I have used these transparencies for several years with excellent results. The trick is to use two sharp transparencies superimposed on one another. This will yield blacks that are dependably opaque to ultraviolet light. The images must be kept carefully aligned. This can be done by cutting one of the exposed sheets a bit smaller, placing it on top, and fixing the corners with transparent tape after the patterns have been carefully aligned.

Another useful feature of this method is that the black image is on the film surface, and can be scraped off easily. Circuit changes can be made by removing unwanted traces with a knife blade and by using circuit board drafting tape for new ones. I have also used this technique to sharpen a fuzzy image on the original, or where conductive areas seemed too close for comfort. — *Marty Kleinfeld, K1FHR, Woodbridge, Connecticut*

SALVAGING PARTS FROM OLD PC BOARDS

☐ I had about a dozen pc boards from some old TV sets. Removing the components was a chore that I never seemed to get around to. When it came time to clean out the basement, I decided to try to save some of the board-mounted potentiometers. Even with a large soldering gun, I could not keep all the pins from one potentiometer hot enough at once.

Finally, I took out my propane torch! When I touched the flame to the board the pots fell right off. The biggest surprise was that the parts were cold! Some experimentation showed that it was possible to torch off everything from resistors to transistors with no damage to any of them. The trick is to mount the board in a vertical position and to start at the top. By working downward, the rising heat does not damage components still on the board.

Don't try this on a board you plan to reuse. But it really is a fast, easy way to strip old pc boards. — *Charlie Burke, WA2SLK, Farmingdale, New Jersey*

[1] D. Malley, "Circuit Boards From Scratch," *QST*, Feb. 1981, p. 29.

SMALL-VALUE GIMMICK CAPACITORS

☐ When I needed some small-value capacitors to use as coupling elements for a band-pass filter, I tested some twisted-wire "gimmick" capacitors on a Boonton RX meter. It was nearly impossible to obtain capacitances of less than 1.5 pF, and reproducibility was poor.

When I discovered a piece of ribbon cable of the type used for interconnecting computer equipment, I came up with the idea of using short pieces of this wire. Values down to 0.2 pF were obtainable and reproducible. Fig. 4 shows how pieces of this cable can be cut and formed into small capacitors.

Table 1 shows some typical values of capacitance for different lengths of cable that I had. The exact type of cable, insulation and wire size will cause the capacitance to vary, so these values should only be taken as typical.

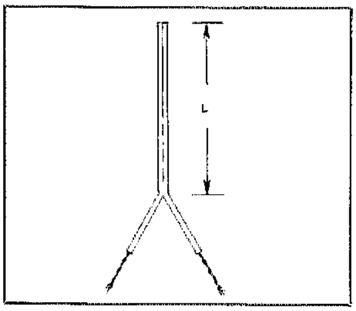


Fig. 4 — This drawing shows how to cut small-value capacitors from computer ribbon cable.

Table 1

Length and Capacitance Values from Some Common Ribbon Cable

Length (in.†)	Capacitance (pF)
Cable with no. 26 wire conductors	
1.3	1.0
0.55	0.5
0.15	0.2
Cable with no. 22 wire conductors	
1.1	1.5
0.7	1.0

†mm = in. × 25.4.

These capacitors should not be used at rf power levels above a few watts. The insulation may melt, as I found when I used a couple of them in a 144-MHz to 432-MHz varactor tripler. — *Joseph Fleagle, WØFY, Chesterfield, Missouri*

[Editor's Note: We tried making some of these capacitors in the ARRL lab, using a piece of ribbon cable found in a junk box. When the ribbon cable is cut to a given length from the same piece, the capacitance was nearly the same each time. Fine trimming of the value is easily accomplished with a pair of wire cutters. The Q of these capacitors compared very favorably with similar-value silver-mica units. We tested them up to 150 MHz.]

LOSS OF AUDIO ON THE ICOM IC-215

☐ My IC-215 had no audio output, even though the S meter indicated plenty of received-signal strength. I traced the problem to the audio-output chip, IC2, on the receiver board. This chip has an internal resistor connected between pins 2 and 6, which had failed, removing power from part of the IC.

The simple cure for this problem is to connect a 220-Ω, 1/2-watt resistor from J13 to IC2 pin 2 on the bottom of the board. Check your operator's manual for a schematic diagram and a parts layout to locate the connection points for this resistor. If the entire chip fails at a later date, be sure to remove the resistor before replacing IC2. A replacement chip is the GEIC-138, a 2-W af power amplifier. — *Lance Aue, KA2EJD, Bellmore, New York*

MURCH UT-2000A TRANSMATCH

☐ I had two problems with my Murch Ultimate Transmatch. Both had simple solutions from which others may benefit.

The first problem was that the brass roller wheel, which slides along a brass shaft to contact the inductor windings, would skip turns or even land between turns. This would cause false readings on the turns counter. The cure was to clean the mechanism, and then apply a thin coat of lubricant to the brass shaft. I used GC Electronics Tunerlub, no. 26-01. This reduced the sliding friction and eliminated the problem of the wheel jumping turns. Electrical performance remained the same.

Another problem involved arcing inside the cabinet when certain antennas were used. Examination revealed that the sheet metal screws protruded too close to the variable-capacitor stator. I replaced the six screws that fasten the wrap-around chassis bottom to the main unit with shorter ones. — *Richard Regent, K9GDF, Milwaukee, Wisconsin*

HEATH SA-5010 μMATIC KEYER MODIFICATIONS

☐ I like many of the useful microprocessor-controlled features of my new Heath keyer. I experienced some difficulty with the capacitive-touch paddles, though. Sensitivity settings were extremely critical, and the keyer was susceptible to stray rf pickup, causing erratic keying.

I made the following changes to correct these problems:

1) Add a 0.001-μF ceramic capacitor between pins 8 and 9 of U8.

2) Change C24 and C25 to 33 pF.

3) Provide a ground plane for your keying hand. This can be a sheet of aluminum foil under a plastic table-top cover. Staple a wire lead to the foil and connect it to ground. Do not place the keyer over the ground plane, however. — *Samuel Bases, K2IUV, Yonkers, New York*

OLD TIMERS' NOTEBOOK

Toothpaste-Tube Cap Insulators

☐ Toothpaste-tube caps are an excellent source of material for constructing feedthrough and standoff insulators, as illustrated in Fig. 6. The feedthrough in example A is made by mounting a toothpaste cap on each side of a metal plate and passing a threaded rod through both caps. A spacer of insulating material is mounted at the center of the rod to prevent accidental contact between the rod and the metal plate. The nylon wheel of a curtain runner is ideal for this purpose. In example B, the necessary hardware is bolted to the cap and the cap in turn glued to the plate.

A non-insulated standoff is constructed by directly bolting the toothpaste cap to the plate as illustrated in example C. An insulated version is made by cementing a machine screw to the concave recess in the top of the cap and gluing the cap to the plate. The cap can also be bolted to the plate as shown in example D. — *D. P. Taylor, ex-G8OD (Reprinted from* Hints and Kinks for the Radio Amateur, *8th ed., 1968, p. 123)*

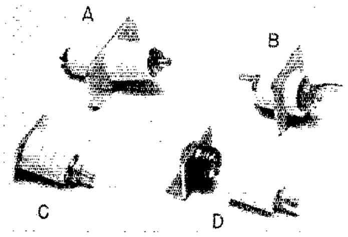
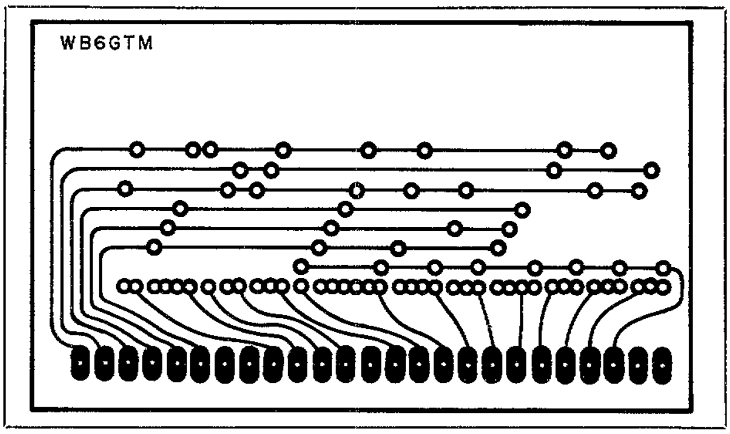
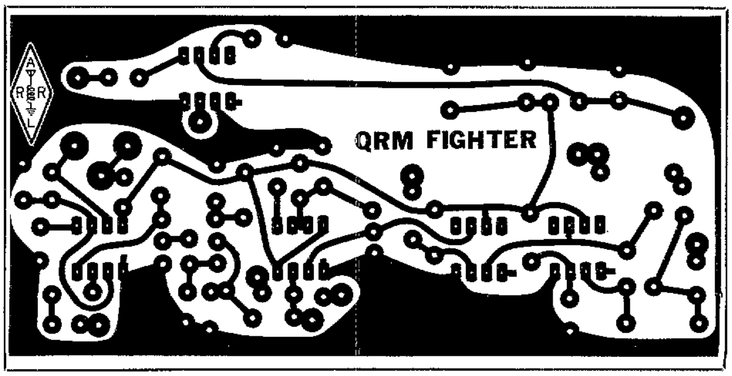


Fig. 6 — Toothpaste cap feedthroughs and standoffs.



Circuit-board etching pattern for the TR-7 programming board. Black represents copper. Pattern is shown in full-size from the foil side of the board. The parts-placement guide appears on page 21.

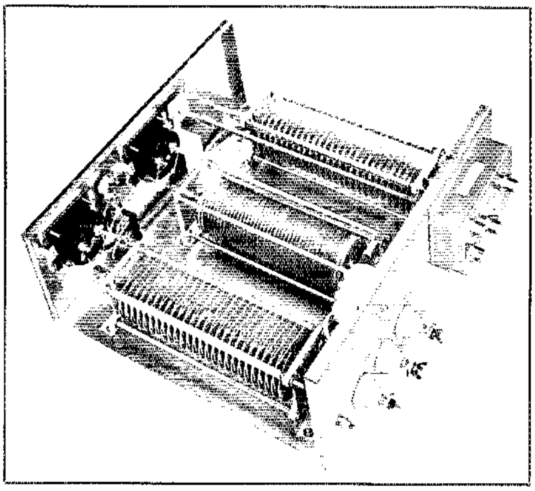


Circuit-board etching pattern for the QRM Fighter. Black represents unetched copper. View is from the foil-side of the board. Parts-placement diagram appears on page 30.

Product Review

Conducted By Paul K. Pagel,* N1FB

Heath SA-2060 Transmatch



Today, few amateur stations are not equipped with a Transmatch of some type. Whether it is used with open-wire feeders or a coaxial-cable-fed Yagi (for an occasional foray on the *other* mode), the versatile operator soon depends on his or her Transmatch. Most commercial units are one of two types: the T network or the modified T network, known as the Ultimate Transmatch.[1] The Heath SA-2060 is no exception. Heath has chosen the straightforward T network for their top-of-the-line "tuner," and it's an excellent choice. Few circuits can equal the T network in ease of adjustment and matching range.

To enhance the versatility of the unit, Heath has included switching to select one of two coaxial feed lines or a dummy load (bypassing the matching circuit). Also included in the SA-2060 are dual wattmeters for measuring forward and reflected power. An SWR function is also provided; a variable SENSITIVITY control is used to set the reference level, and a calibrated scale allows direct reading of SWR up to 3:1. The metering circuit is of the W. Bruene type,[2] the rf and calibration portion of which is factory assembled and calibrated. This circuit is contained in a shielded enclosure along with the antenna selection switch. Two power ranges are provided (200 W forward/50 W reflected and 2000 W forward/500 W reflected), making the SA-2060 suitable for low-power or "QRO" operation. The first calibration point on the forward power scale is 10 W (100 W on the high range). Below that point, the scale would be very nonlinear and thus is not calibrated. Dial scales on the capacitors (20 divisions) and a three-digit turns counter on the rotary inductor (1/10-turn resolution) round out the operational features.

The T network is designed for unbalanced to unbalanced matching — the case when a coaxial-cable-fed antenna or end-fed wire antenna is used. To accommodate balanced feed lines, a 4:1 toroidal balun is employed. This is an acceptable method, provided the impedance being matched is within the range suitable for the balun (less than 1 kΩ). At high impedance levels, the balun is not capable of providing accurate balance. This could impair the performance of some antenna systems. In practice, open-wire-fed dipoles and inverted Vs, used for casual multiband operation, are not seriously affected by a lack of feed line balance. A 130-ft[3] inverted V, fed with approximately 60 ft of 300-Ω ladder line, was used with the SA-2060 during operation from 80 through 10 meters, with good results. Even with 700 W of rf power applied, the SA-2060 never "voiced" an objection (no arcs, sparks or funny smells). The same antenna was also used on the 160-meter band, both as a dipole and as a top-loaded vertical, with satisfactory results. Output power was limited to 125 W on this band.

Heath SA-2060 Transmatch

Manufacturer's Claimed Specifications	*ARRL Lab Results*
Frequency range: 1.8 to 30 MHz	As specified.
Power-handling capability: Full legal limit.	As specified.
Input impedance: 50 ohms (at matched condition).	As specified.
Output impedance, balanced output: 100 to 1000 ohms; unbalanced output: a maximum SWR of 10:1, or an impedance-matching range of 50 to 500 ohms; single-wire output: 6:1 SWR using an odd-multiple 1/4 wavelength of wire.	
Forward power ranges: Low, 0 to 200 W; high, 0 to 2000 W.	As specified (see text).
Reflected power ranges: Low, 0 to 50 W; high, 0 to 500 W; SWR 1:1 to 1:3.	As specified.
Wattmeter accuracy (full scale): 200 W and 2000 W (fwd); 500 W (ref): ±5% (avg); 50 W (ref): ±7.5% (avg).	Measured at center scale, at 14.10 MHz with 50-ohm load; 200 W (fwd): −5%; 2000 W (fwd): −5%; 500 W (ref): +3%; 50 W (ref): +8%.
Size: 5-3/4 × 14-1/2 × 13-7/8 in. (HWD).	As specified.

Assembly and Operation

As with all Heathkits,® the instruction manual supplied with the SA-2060 is outstanding. Total assembly time, including a careful parts inventory, was approximately 10 hours. Much of that time was required to assemble the two variable capacitors.

After using the unit with a number of different antenna types, I found it to be a highly satisfactory addition to my station. It is versatile and reliable. The dial calibrations and turns counter allow the operator to accurately preset the controls, minimizing QRM - producing on-the-air tuning. The BYPASS jack also aids in this regard.

I have only two criticisms of the unit, both relating to the antenna switching. The particular switching arrangement used in the SA-2060 (see Fig. 1) results in two operational inconveniences. Because the terminal for single-wire antennas is connected directly to the output of the matching network, you must have at least one unused coaxial connector (ant. 1 or ant. 2) available if a wire antenna is to be used. When switching to coaxial line, the wire must be removed. If this is not done, the coaxial-cable-fed antenna and the wire antenna would be in parallel. The same holds true for balanced feed lines, as they are connected to the matching network through a jumper to the wire-antenna terminal. This is of no concern to the operator who uses only coaxial-cable-fed antennas.

The second criticism is of interest to all users. The switching arrangement does not allow the matching circuit to be switched in and out of the system. This forces the use of the Transmatch in situations where it is not really needed. For example, my triband Yagi has a fairly narrow SWR bandwidth when used on 20 meters, and the Transmatch is normally needed. On 10 meters, the bandwidth is such

[1] D. DeMaw, ed., *The Radio Amateur's Handbook*, 57th ed. (Newington: ARRL, 1980), p. 19-8.
[2] W. B. Bruene, "An Inside Picture of Directional Wattmeters," *QST*, April 1959, pp. 24-28.
[3] m = ft × 0.305; mm = in. × 25.4; kg = lb × 0.454.

*Assistant Technical Editor

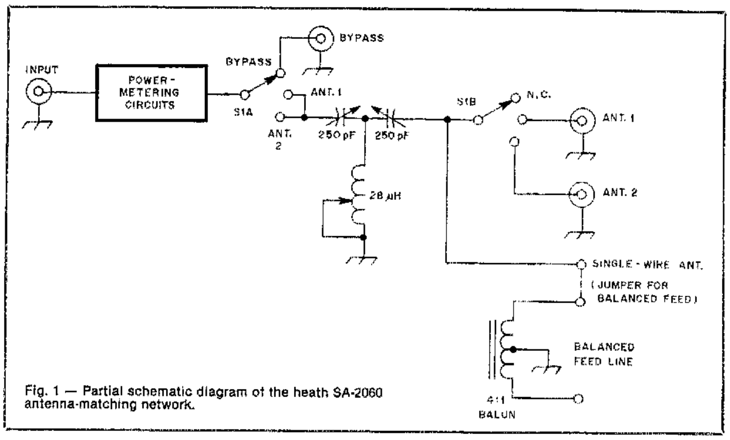


Fig. 1 — Partial schematic diagram of the heath SA-2060 antenna-matching network.

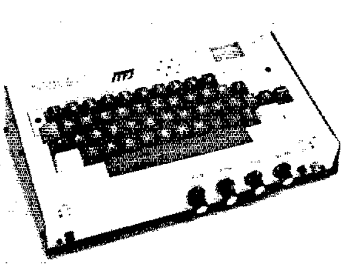
that the Transmatch is seldom required, but, because no "through" position is provided, I must readjust the SA-2060 when switching between these bands. The only option is to remove the feed line and attach it to the BYPASS jack normally used for the dummy load. I found that to be less convenient than readjusting the Transmatch. Considering the overall quality and usefulness of the SA-2060, I would classify both of these criticisms as minor.

Styled in the new Heathkit black and gray colors, the SA-2060 is both attractive and functional. Price class of the unit is $255. For additional information, contact Heath Co., Benton Harbor, MI 49022 — *George Collins, KC1V*

MFJ-496 SUPER KEYBOARD

☐ Wow! Since I became a ham back in the mid '70s, the technology of electronic keyboards used for amateur communications (cw and RTTY) has changed dramatically. Do you remember those keyboard circuits using toroid cores (as pulse input transformers), or large diode matrices? How about the boards that included only a few characters of buffer or storage memory? Today the microprocessor (µP) is firmly established in the amateur marketplace, and one use for the µP is the generation of cw and RTTY signals — hence the new rash of computerized keyboards on the market.

The MFJ-496 uses a microcomputer, which contains the µP, the random-access memory (RAM) for buffer/memory storage, and the read-only memory (ROM) to hold the control program — all on one chip! Curtis Electro Devices manufactures the component, called a "Keyboard on a chip." Since it is an easy task to generate cw and RTTY signals, the '496 uses the microcomputer to perform all kinds of functions.



Features

Morse, Baudot and ASCII are the standard codes available from the '496. The Morse speed range is 5 to 100 wpm; Baudot speed is 60 wpm; and ASCII is 110 baud. Two-hundred fifty-six characters of buffer and storage memory are available. The storage memory is unique in that it is soft partitioned into four sections. This means the operator may determine how many characters of memory are allocated to each of the four sections — as long as the total number of characters does not exceed 256. The keyboard speed and the relative buffer fullness can be monitored by means of a front-panel meter. A group of special automatic messages are programmed into the board. By programming your call into one of the four memories, for example, you may send any one of the following messages by simply pressing a key — CQ CQ DE (call), CQ TEST DE (call), DE (call) or QRZ (call). For contest operators, an incremental serial number generator is built in, with a range of 0 to 9999. For those learning the Morse code, the keyboard offers a training mode, which sends random code groups or pseudo-random five-character groups. The manual contains a list of the pseudo-random groups to check copy. Keyboard power requirements are 9 to 18V dc at 400 mA, or 117-V ac with the MFJ wall-plug transformer adapter. A paddle input is available for those who get tired of sending with the keys, and its operation is fully iambic, with dot and dash memories. For European users, several special characters are generated: Á, Å, É, Ó, Ü, Ñ and CH.

Operation

Testing keyboards is a lot of fun! I "hang out" around 7035 kHz on the weekends and, as most users of the band know, this is where the high-speed folks are. Comments about the on-the-air sound of the keyboard were varied — some operators said the Morse weighting was too heavy, and others said the sound was fine — it depended on the sending speed of the board. At high speeds, many operators prefer the cw signal weighting to be lighter than the standard 1:3:1 dot-dash-space ratio. Unfortunately, the '496 cannot be set for a lighter weight than the standard ratio. This makes copy difficult at speeds above 50 wpm. To test the memory and keyboard special functions, I used it in conjunction with a paddle, during the November Sweepstakes contest. The incremental number generator was a great help, and each of the special functions performed as specified. To check the RTTY modes, I fed the keyboard TTL output into another piece of RTTY equipment. What was typed in, was typed out! During each keyboard test, the station receiver was checked carefully for signs of RFI from the computer. MFJ must have done its homework in that regard, as no interference was noted through 144 MHz. Several accessories are available to complement the standard features of the board. These are a real-time clock, an afsk/fsk RTTY generator and a high-voltage loop-keying circuit. Each of these is on a separate plug-in board, which can be mounted inside the '496 cabinet.

Conclusion

As an operator who enjoys high-speed cw, I found the '496 a breeze to operate. Each of the special functions, including memory loading and dumping, requires only a few simple key strokes. The lack of an element-weighting adjustment disappointed me, as other keyboards on the market offer this feature. Overall, the MFJ-496 provided good service; it would be a worthwhile addition to the modern hamshack. The '496 is available from MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, MS 39762. Price class is $340. — *Gerry Hull, AK4L*

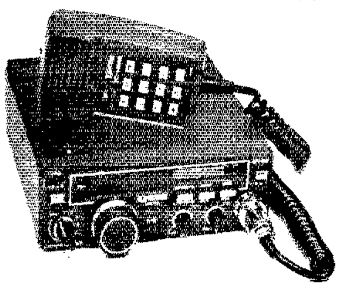
ICOM IC-25A 2-METER TRANSCEIVER

☐ This transceiver could have been made to order for James Bond. At least you'll feel like a secret agent when you hide one of these units in your car. It's small — I have seen one IC-25A hidden in the ash tray of a luxury car! This could be a major buying point if you live in a street-crime area and want to keep your mobile electronics out of sight of passing strangers.

Options

Small size does not mean that anything was left out. The panel is functional. Often-used controls are prominent. Less-often-used controls are accessible, but are best used when the vehicle is parked. "Set-and-forget" controls are internal. As the transceiver comes with all you could ask for built in, the choice of options is thereby limited, primarily, to microphones. Here you have a choice of a standard push-to-talk (IC-HM7), a tone pad (IC-HM8) or a frequency up-down mike (IC-HM10).

The basic transceiver comes in two models designated by an A/E suffix. This simply designates the transceiver for American or



ICOM IC-25A 2-Meter FM Transceiver

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: 143.800 to 148.195 MHz.	143.800 to 148.195 MHz.
Mode of operation: FM.	As specified.
Frequency readout: 4-digit, red LED display.	Three 0.34-inch digits; One 0.16 inch digit.
kHz/turn of knob: Not specified.	250 kHz/turn VFO A; 750 kHz/turn VFO B.
S-meter sensitivity: Not specified.	S1, 0.93 µV; S9, 3 µV; S9 + 20 dB, 3.4 µV.
Receiver sensitivity: Less than 0.6 µV for 20 dB quieting.	0.15 µV for 20 dB quieting.
Transmitter power output: 25 W/1 W.	32 W/0.9 W.
Size: (HWD) 2 × 5-1/2 × 7 in.	
Weight: 3.3 lb.	
Power supply requirements at 13.8 V dc: Approximately 4.8 A at high power.	4.3 A at 32 W output.

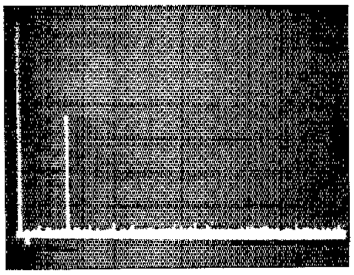


Fig. 2 — Spectral display of the IC-25A. Vertical divisions are each 10 dB; horizontal divisions are each 100 MHz. Output power is approximately 32 watts at 146 MHz. The fundamental has been reduced in amplitude approximately 33 dB by means of notch cavities; this prevents analyzer overload. All spurious emissions and harmonics are greater than 65 dB below peak fundamental output. The IC-25A complies with current FCC specifications for spectral purity.

European Frequency Plan.

The E model has a 1750-Hz tone-access generator, and the A model provides room to install one if needed. The A model synthesizer steps are 5 kHz/15 kHz; with the E model, these become 5 kHz/25 kHz. Other than that, there are no substantial differences between the two units.

Read the Instructions

At first, you may be tempted to scan through the manual quickly, chuckle over the cumbersome phrasing and put it away, assuming you can figure it out all by yourself. It won't take more than a few minutes of experimenting to realize that the old saying "when all else fails read the instructions" was never so true. The manual is complete and accurate. Following each functional description to the letter will indeed allow you to fully enjoy the IC-25 A/E.

If the transceiver has a "fault," it would be that it offers so much. For some operators, two or three channels for local repeaters are plenty. This unit, with its microprocessor-controlled memory scan, frequency split, invert normal-access frequency, simplex-duplex and alternate VFOs with transfer write control, may be a bit more than needed. But for the guy or spy on the go, this little rig could put extra pleasure into long automobile trips and family vacation tours.

A suggestion for the new owner: Use the unit at home on an ac supply for several nights to become familiar with the various functions before installing it in your car. Roaring down the highway at 55 mph is not a condition under which to take your mind off the road and try to figure out what your ICOM 25 just did for you — or to you!

Construction

Construction appears to be quite solid. Most of the circuit is contained on one printed-circuit card that is mounted by means of four corner posts. This allowed for some bowing in the review unit pc board, but no intermittents were noticed in two months of mobile operation.

Disconnecting the power connector causes a memory loss. A third wire is brought out of the radio for memory "keep-alive." Though the manual does not specify that an accessory battery pack is available, ICOM offers a BU-1 battery backup for $38.75.

Performance

If you operate the unit into a high VSWR, as I did (about 2:1), for more than a few short transmissions at the high power level, the unit will shut down to protect itself. In the 1-watt position, it ran without any shut-down. Finally, you should be aware that if you program an odd-ball split all frequencies stored in memory will take on the modified split. The first time that happened to me, I was sure the local gang was ignoring me. But slowly it came to me: Check the readout when you talk, and be sure you're where you're supposed to be. Price class: $349 with HM-8; available from ICOM East, Inc., 3331 Towerwood Dr., Suite 307, Dallas TX 75234. — *Phil Accardi, AJ1N*

New Products

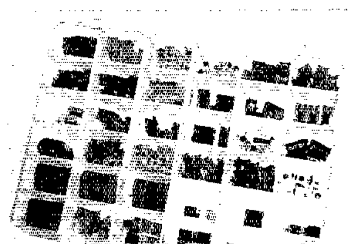
INLINE COMPONENTS DIP HEADERS

□ One product of possible interest to amateur experimenters is the DIP header series manufactured by Inline Components Company. A DIP header is a component holder that looks similar to an IC socket, but contains tie points to which components may be attached. The headers come in standard 0.100 × 0.300-inch (mm = in. × 25.4) package, designed to mate with 14- or 16-pin dual-in-line IC sockets. One practical use I found for the headers was in the construction of a repeater identifier, which used a diode matrix for programming. The diode matrix for any call sign can be placed on the header, and call signs altered by simply changing this "custom" IC.

Inline offers the headers in two kits. Each kit contains a set of five 14- or 16-pin headers, and 10 assorted covers. An option offered in the kits is the header width. Kit A headers have a 0.400-inch width, and Kit B headers have a 0.495-inch width, to accept larger components. Special orders for any number of pins or spacing are available on request. For more information on these components contact Inline Components Company, 250 17th, Suite 1, Costa Mesa, CA 92627. Price class is $8.50 per kit. — *Gerry Hull, AK4L*

ZENITH FIXED-VALUE AND VARIABLE INDUCTORS

□ The Zenith Radio Corporation has announced the availability of fixed-value and variable inductors in single-lot quantity. This should be of interest to the home-builder who has witnessed the widespread availability of these components dwindle in recent years. The inductors are manufactured in a broad range of values from 42 nH to 390 µH, and the experimenter can select from various values and current ratings. Zenith part numbers include the series 20-3849, 20-3907 through 20-3907-31, 20-3935 through 20-3938 and 20-3946. Prices range from 59¢ to $2.06 for the single-lot quantity. The components may be obtained from any of the 17,000 Zenith dealers or distributors, worldwide. Further information may be obtained from Terry C. Agpawa, Parts Sales Engineering, Components and Accessories Division, Zenith Sales Company, 11000 Seymour Ave., Franklin Park, IL 60131. — *Dennis Lusis, W1LJ*



UoSAT-OSCAR 9 BAND-PASS FILTER DESIGN

☐ A simple but effective band-pass filter for receiving the 1200- and 2400-Hz tones of OSCAR can be easily and inexpensively constructed with a single stack of five 88-mH inductors and one modified 440-mH inductor. See Fig. 1 for the schematic and pictorial diagrams of the band-pass filter. In particular, note the convenient capacitor values (all standard, with C3 being on the 2% low side of 0.33 μF), and the convenient 580-Ω source and load terminal impedance required by the filter. For those receivers having a 600-Ω output, an 18-kΩ, 1/2-watt resistor can be connected in parallel with the receiver audio output to obtain the desired 580-Ω source for the filter. The filter load should also closely approximate the 580-Ω value. A precise match is not necessary, and anything within ± 20% will suffice.

The computer-calculated attenuation response (based on an inductor Q of 40 at 1 kHz) is shown in Fig. 2. The measured insertion loss at the filter center frequency was 0.5 dB.

Construction Procedure

1) Remove the end inductor from the 88-mH stack. This is done easily by first unsoldering the wires connected to the four terminals of the stack. Two or three staples are removed from one end of the stack to allow the sides to be spread apart for removal of the end inductor. Cut the adhesive tape holding the end inductor with a hobby knife, and lift out the inductor. This inductor will not be needed for the filter.

2) Modify a bifilar-wound, 44-mH inductor by removing 57 turn-pairs to get an inductance of 27.2 mH in the series-aiding connection. Leave approximately 3 inches of lead for reconnection.

3) Pair up the red *start* with the green *finish* leads. Pair up the *green* start with the *red* finish leads.

4) Insert the modified 44-mH inductor into the place previously occupied by the 88-mH inductor. One pair of leads connects to the two vacant terminals on one side of the cardboard case, and the other pair connects to the two vacant terminals on the opposite side of the case. This completes the inductor modification.

5) Connect the capacitors as shown in the pictorial diagram, Fig. 1. The inductor terminals make a convenient tie point for all capacitors. The center taps of L1 and L5 provide an alternate input/output connection for source and load impedances of 145 Ω. This completes the filter construction.

This band-pass filter design is based on the transformation of a 5-element Butterworth low-pass filter having a 3-dB cutoff frequency of 1697 Hz and an impedance level of 580 Ω. The design center frequency of the band-pass filter is 1697 Hz, which is the same as the cutoff frequency of the low-pass prototype filter. These values were chosen to require only standard-value capacitors for ease in filter construction, and to provide the desired passband response. Of special interest was the fact that four of five inductors required by the filter could be obtained from unmodified 88-mH inductors. The only compromise necessary was that inductor L3 be 27.2 mH, which requires removal of turns from either the standard 88-or 44-mH inductor. A 44-mH inductor is recommended for this particular application because its modification requires fewer turns to be removed than if an 88-mH inductor is used.

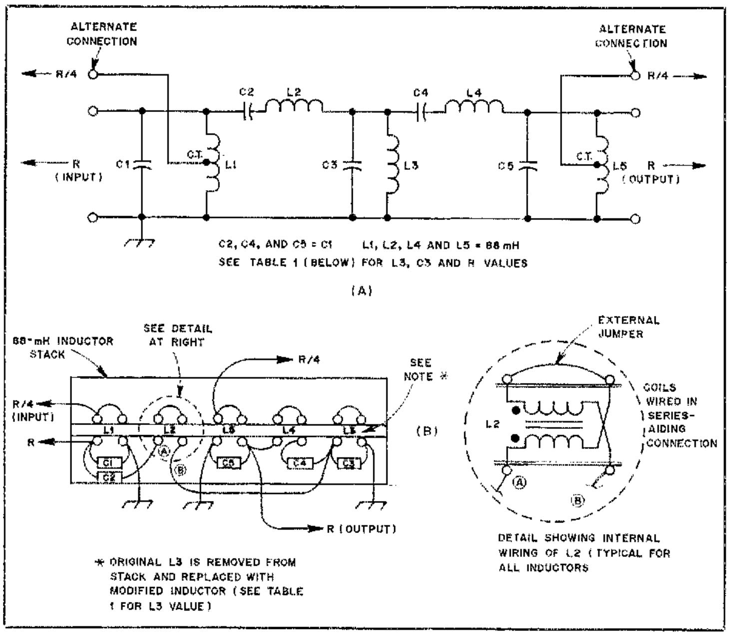


Fig. 1 — (A) Schematic diagram of the band-pass filter. (B) Pictorial diagram.

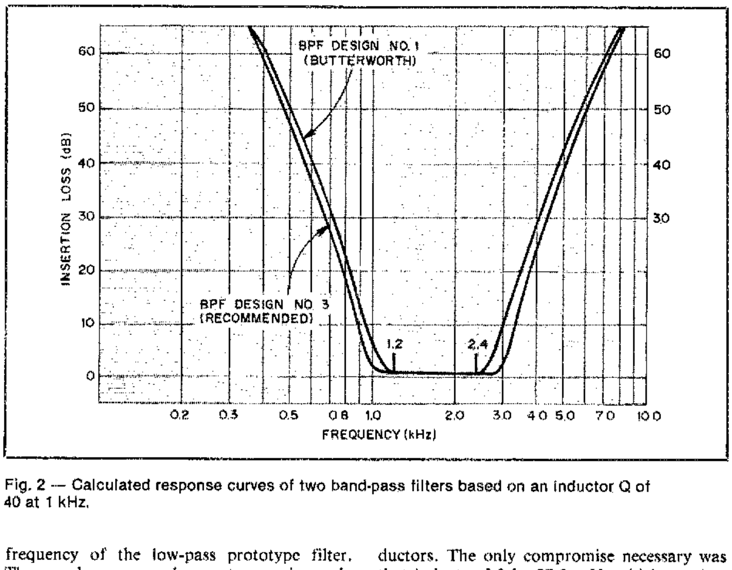


Fig. 2 — Calculated response curves of two band-pass filters based on an inductor Q of 40 at 1 kHz.

*Assistant Technical Editor

Table 1

Band-pass Filter Component and Calculated Performance Values

BPF No.	F_C (Hz)	F_B (Hz)	$F3_{LO}$ (Hz)	$F3_{HI}$ (Hz)	R (Ω)	C1 (µF)	C3 (µF)	L3 (mH)	BW (%)	R.C. (%)	C3/C1 Ratio	G1
1	1697	1697	1049	2746	580	0.100	0.324	27.2	100.0	0	3.236	0.09836
2	↑	1883.7	999	2883	619	↑	0.270	32.6	111.0	0.42	2.700	0.1166
3	↓	2114.5	942	3057	688	↓	0.220	40.0	124.6	3.29	2.200	0.1455
4	1697	2358.8	887	3246	814	0.100	0.180	48.9	139.0	11.8	1.800	0.1920

Notes

1) F_C = center frequency; F_B = 3-dB bandwidth.
2) G1 is the normalized value of C1 obtained from the 5-element low-pass prototype having a 3-dB cutoff frequency of 1 Hz.

Equations relating the parameters in Table 1

$$F_C\ (\text{kHz}) = \frac{1}{2\pi\sqrt{LC}};\ L(\text{H}),\ C(\mu\text{F}) \quad \text{(Eq. 1)}$$

$$F_C = \sqrt{(F3_{LO}) \times (F3_{HI})} \quad \text{(Eq. 2)}$$

$$F_B = \text{BW}\ (\%) \times \frac{F_C}{100} \quad \text{(Eq. 3)}$$

$$F3_{LO} = \frac{-F_B}{2} + \sqrt{F_C{}^2 + \frac{F_B}{2}^2} \quad \text{(Eq. 4)}$$

$$F3_{HI} = F3_{LO} + F_B \quad \text{(Eq. 5)}$$

$$L3\ (\text{mH}) = \frac{88}{\left(\frac{C3}{C1}\right)} \quad \text{(Eq. 6)}$$

$$R\ (\Omega) = \frac{(1000 \times G1)}{C1 \times F_B};\ C1\ (\mu\text{F}),\ F_B\ (\text{kHz}) \quad \text{(Eq. 7)}$$

The inductors for this filter are provided free of charge to the radio amateur fraternity through the courtesy and cooperation of the C & P Telephone Co. of Maryland. I am serving as liaison between the C & P Tel. Co. and radio amateurs for the distribution of these inductors. Amateurs who have a legitimate and well-thought-out design application are encouraged to write to me requesting an 88-mH inductor stack and one 44-mH bifilar-wound inductor for the L3 modification.[1] Because of uncertain availability of these inductors, I may have none when your request is received; consequently, be prepared to wait for as long as 60 days for your order to be shipped. As an alternative source, check the Ham Ads in *QST* for these inductors. In addition, I have a number of related components available to radio amateurs.[2] I am providing these parts at minimum cost to make it as easy and inexpensive as possible for those who wish to construct a filter.

At the time of writing this letter, I am out of the 88-mH inductor stacks, but I do have a few hundred of the individually potted 88-mH inductors. If you are willing to use individually potted inductors, you should so state in your request.[3] The potted inductors are contained in a plastic shell having an outside diameter of either 1-1/2 or 1-3/4 inches. The height of both types is 1 inch. The potted inductor mounts in a 1/4-inch hole and is held in place with a Timmerman clip, which I provide. The 44-mH inductor (bifilar-wound) is in very short supply and can be provided only to those who have a bona fide application. The priority of delivery to those requesting these surplus inductors will be dependent on the information provided with their letter. First priority will, of course, be given to ARRL-affiliated clubs. — *Ed Wetherhold, W3NQN, 102 Archwood Ave., Annapolis, MD 21401*

[1]Please include $3 to cover shipping and handling costs. The inductor stack may be mounted with 3M Scotch® mounting tape, or with a component clip, available for 50 cents each. The ARRL and *QST* in no warrant this or any other offer.

[2]A 1% matched capacitor set is available for $5. Individuals with an 8-Ω audio source may obtain a 0.4-W, 8- to 500-Ω matching transformer for $1 each. If the capacitors and transformer are ordered separately from the inductors, please include $1 for shipping and handling.

[3]Please include $4 to cover shipping and handling costs for the potted inductors.

References

Wetherhold, E., "Modern Design of a CW Filter Using 88- and 48-mH Surplus Inductors," *QST*, December 1980, pp. 14-19.

Wetherhold, E., "High Performance CW Filter," *Ham Radio*, April 1981, pp. 18-25.

PREDICTING SPORADIC-E OPENINGS ON VHF

☐ This is a good time of the year to think about our E_s season, and to become prepared to catch those elusive band openings. As many of us have observed, these openings return each year during late spring and continue through the summer months, bringing strong DX signals to the 6- and 2-meter bands.

The mechanism that results in ionization of this nature is not clearly understood, and several interesting theories exist. An understanding of the mechanism might allow one to predict their occurrence somewhat, or at least to aim his or her array in the direction of a possible opening.

Many researchers have noticed some connection between E_s and violent- or bad-weather areas. One contemporary theory states that sharp and violent "rips" in the continuity of the stratosphere result in wind shears at very high altitudes; this effect results in strong charges of static electricity, which ionize lower levels of the ionosphere, including the E layer.

Through an in-depth study lasting several summers, I found that a relationship does exist between certain types of severe weather and E_s cloud formation. Specifically, severe thunderstorms and E_s clouds often exist simultaneously. Aside from heavy rain, turbulence, hail and tornado potential, severe thunderstorms produce wind shears and large, static-electric charges, which may develop E_s clouds. Wind-shear areas can also develop during any season as a result of jet stream movement.

After comparing hundreds of weather maps and other bits of data, I found that in most cases a severe-weather area existed near the midpoint of the path between two stations who worked on 6- or 2-meter E_s, and that this same point was used by other stations in various path directions. In a fewer number of cases, the reflection point was just behind or perhaps *directly over* one end of the QSO!

Another interesting factor was the altitude of the thunderstorm area below the reflection point, or E_s cloud. I found that storm activity above 40,000 ft[4] usually produced an opening on 6 meters, and that storms above 60,000 ft often allowed 2 meters to open. Although 60,000-ft cloud tops are rare, I have found some near 72,000 ft!

These massive, disturbed areas all appear to have something in common; they grow vertically to a point where they punch through a region known to meteorologists as the "tropopause." This region is where the normal cooling of air with increasing altitude reverses, and the air temperature begins to rise with altitude. The height of the tropopause varies according to many factors, but once a thunderstorm builds vertically and rises into it, warm air can be drawn and the storm will possibly build higher.

If you wish to forecast E_s openings, look toward the areas where severe weather is expected to form. If the distance to the reflection point is approximately 700 miles, you may be rewarded with an opening. The other, more rare type (where the reflection point is near or above you) may be looked for just after a severe weather area has passed. Try beaming directly into the storm system to see if backscatter exists. Rotating the antenna will often have no effect on signal strength if the E cloud is directly overhead. Such conditions exist typically for less than an hour.

Severe weather areas are forecast well in advance by the National Weather Service. This information may be obtained direct from the NWS, or by watching television weather programs.

Perhaps these hints will help you catch the one that got away last summer. Boost the state count on your favorite vhf band! — *Jim Stewart, WA4MVI, ARRL TA, Greer, SC*

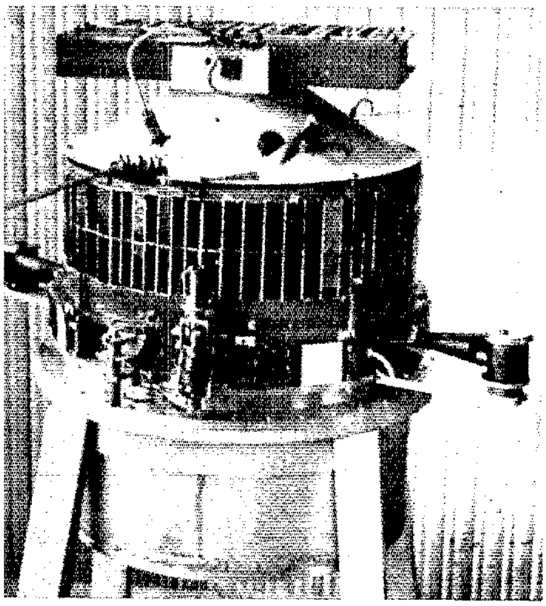
[4]m = ft × 0.3048

Feedback

☐ The correct price of the Apple II® User's Guide is $15, not $7.95 as shown in May *QST* New Books.

☐ Howard Weinberg, WA6JCH, informs us that there was an error in his Hints and Kinks article, "Low-Cost Active Audio Filter" in May *QST*. Fig. 6, page 36, should show R2 as 100 Ω, not 100 kΩ.

Amateur Radio Sputniks



Six new Soviet satellites were placed in orbit on December 17, 1981. These new generation RADIO satellites add another dimension to long-distance amateur communication.

By Bernie Glassmeyer,* W9KDR

Soviet Amateur Radio satellite efforts began in 1974, when the Coordinating Committee of *RADIO*, the official publication of the USSR's Federation of Radiosport, organized a group in Moscow to build Amateur Radio satellites. [Editor's Note: Translations of several *RADIO* articles were used for some of the information in this article. Thanks to Dex Anderson, W4KM, for translating them.] Members of the committee included workers of the DOSAAF USSR (Voluntary Society for Assistance to the Army, Air Force and Navy of the USSR), and representatives of higher education institutions in Moscow and of a series of agencies and organizations. The DOSAAF has a membership of 86 million, which is comparable to the military reserves of the USA. About 46,000 DOSAAF members are Amateur Radio operators. The Central Radio Club also joined in the work.

In 1978, the DOSAAF committee opened the DOSAAF Space Technology Volunteer Laboratory at the Technical Sport Club of the Zhdanov Rayon in Moscow. With the cooperation of the radio amateurs of a number of higher education institutions, the first two USSR Amateur Radio communication satellites, RADIO 1 and RADIO 2 (shown in the photo), were built. These two satellites provided communication to more than 700 Amateur Radio operators from 70 countries in all continents. Communication range was 8000 km (5000 miles).

*OSCAR Program Manager, ARRL

The DOSAAF Space Technology Laboratory was soon given the unofficial name of "Lyudmila," the namesake of a modern department store across the street. "Such an informal name for the laboratory was appropriate," said N. Grigor'yeva in his article, "Without a Table of Organization," in *RADIO* 1 1979, "since everything was done here unofficially, voluntarily, out of selfless love of technology." Grigor'yeva also said, "While the rest of Moscow settled in for a pleasant evening after the work day, here, on the 10th floor of an apartment building, work got under way, and people didn't go home 'til close to midnight." The common bond that held this group together was Amateur Radio.

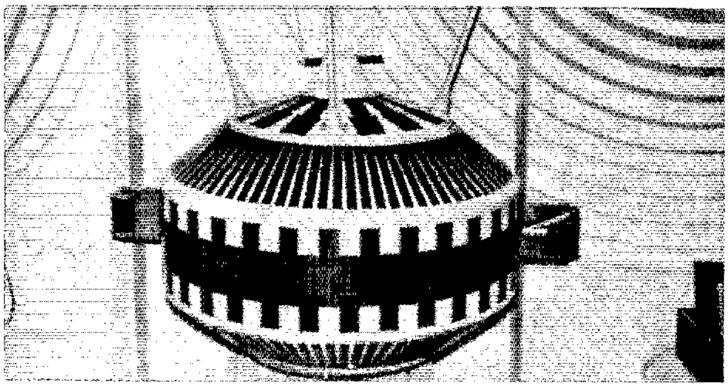
RADIO 1 and RADIO 2 were launched from Plesetsk, 475 miles north of Moscow, on October 26, 1978, into a 1700-km (1060-mile) polar orbit. Both of these satellites had 2- to 10-meter transponders that were extremely sensitive, requiring only a few watts of power to access the satellites. Launched with the Cosmos 1046 navigation series, RADIO 1 and RADIO 2 were dedicated to space experimentation commemorating the 60th anniversary of the Lenin Komsomol. RADIO 1 and RADIO 2 are no longer operational, but they did serve as useful pioneers.

The New Generation

Construction of the new generation of Radio satellites was the work of many of the pioneers of the first RADIO satellites. The six new satellites, RADIO 3 through RADIO 8, launched on December 17, 1981, differ from RADIO 1 and RADIO 2 in their more advanced power supply and heat-regulation and telemetry systems. Besides beacons and transponders, some of the satellites have an automatic answerer called ROBOT. These ROBOTs have on-board logs and operational memories for bulletin-board announcements. Frequencies for RADIO 5 through RADIO 8 are listed monthly in the *QST* Amateur Satellite Operating Schedule.

High Altitude Orbit

The orbits of the new RADIO satellites are similar in altitude to their predecessors, RADIO 1 and RADIO 2. Maximum communication distance is in excess of 8000 km (5000 miles). To plot the position of the RADIO satellites, you will need orbital information and the New OSCARlocator Package, available from your local radio store or from ARRL Hq. The package is $7 in the U.S. and $8 elsewhere. The OSCARlocator may be modified easily by referring to February 1982 *QST*, page 56. AMSAT has made available an accessory RADIO tracking overlay for the OSCARlocator Package for a $2 donation. Write to AMSAT, P.O. Box 27, Washington, DC 20044. Orbital information and net frequencies are listed monthly in *QST*. Updated reports are transmitted daily by W1AW, and weekly by AMSAT nets. Project OSCAR has an orbital calendar available for $8.75. Write to them at P.O. Box 1136, Los Altos, CA 94022.



A model of the new generation RADIO satellite. The 2-meter antennas on top of the spacecraft are mounted in a canted configuration, similar to OSCARs 7, 8 and 9. Ports for the 10-meter antenna, which are on opposite sides of the spacecraft center, were deployed after launch.

Beacons

Listening for the beacons of the RADIO satellites can be a lot of fun. Sometimes, with the extended propagation on 10 meters, you may be able to listen to one or more of the six satellites all the way around the world. RADIO 6 and RADIO 8 each have a beacon at each end of the 40-kHz transponder. Both of these beacons have two power levels, 0.1 and 1 watt, switchable by command from earth. The beacons of RADIO 5 and RADIO 7 are 0.1 watt and are at the high end of their 40-kHz transponders. RADIO 3 and RADIO 4, which are designed for experiments only, have 1-watt beacons. All RADIO beacons transmit alphanumeric text in Morse code at a speed of 50 to 90 characters per minute. The telemetry of the beacons tells the status of the onboard system.

Table 1
RADIO Telemetry Parameters

Group	Address	Parameter	Unit of Measure	Decoding Formula
	K	Output power of transponder	mW	$N^2/5$
	D	Voltage of power source	V	0.2N
	O	Load current	mA	20(100 − N)
(E)	G	Telemetry test		
	U	Hermetically sealed container pressure		
	S	Temperature of stabilizing unit	°C	N
	W	Temperature of transmitter radiator	°C	N
	K	Output power of transponder	mW	$N^2/5$
	D	Zero setting of telemetry mV meter		N
I	O	Output power of beacon	mW	$N^2/5$
(S)	G	Repeater sensitivity control	dB	N
	U	S-meter for 1st service receiver	S	0.1(N − 10)
	S	S-meter for ROBOT receiver	S	0.1(N − 10)
	W	S-meter for 2nd service receiver	S	0.1(N − 10)
N(R)		Parameter being completed		
	K	Output power of transponder	mW	$N^2/5$
	D	9 V voltage at transponder	V	0.1N
A	O	7.5 V voltage at transponder	V	0.1N
(U)	G	9 V voltage at 1st stabilizer	V	0.1N
	U	7.5 V voltage at 1st stabilizer	V	0.1N
	S	9 V voltage of 2nd stabilizer	V	0.1N
	W	7.5 V voltage at 2nd stabilizer	V	0.1N
	K	Output of transponder	mW	$N^2/5$
	D	Filling out of ROBOT log	QSO	N ± 1
M	O	Power of turned-on heaters	W	0.1N
(W)	G	Power of ROBOT transmitter	mW	20N
	U	Power of service-channel transmitter	mW	20N
	S	Sensitivity control for ROBOT transmitter	dB	N
	W	Sensitivity control for service-channel transmitter	dB	N

Group letters shown in parentheses indicate the spacecraft is in service condition. They will precede the Address.

Telemetry

The telemetry information is presented in 35 channels, grouped into five groups of seven address channels: K, D, O, G, U, S and W followed by two numbers ranging from 00 to 99. The first group is the basic one and is always present in the telemetry frame; the remaining groups with letter indicators I, N, A and M may be switched in when needed. The beginning of each group is preceded by the spacecraft call sign (RADIO 3 through RADIO 8 would be sent RS 3, RS 4, RS 5, etc.). When service operations are being carried out, an E may appear before the address, so that, for example, the address K in the basic group would change to EK, ED, EO, EG, EU and ES. Other groups would change according to the supplementary meanings shown in parentheses in Table 1.

The letter K in any group shows the output power of the transponder. K∅∅ indicates the transponder is off and the power of the telemetry beacon can be read at the IO address. The RADIO transponder output power is determined by the number and strength of signals in the receiver input. Attenuation of the receiver inputs, reported on channels IG, MS and MW, is used to prevent overload of the spacecraft battery. With this arrangement, it helps prevent operators from running excessive power on the satellite uplinks. If the uplink receiver is saturated, attenuation is switched in. If signals in the downlink passband are stronger than the beacon, that is an indication of excessive uplink power.

Operating Through the New RADIO Satellites

From operating experience obtained so far, it seems that the new generation satellites have very sensitive receivers. Long-distance contacts have been made using 2-meter uplink powers of less than 10 watts. My first Hawaii contact, with KH6IBA via RS 6, was the fourth New England-to-Hawaii two-way ever made through any Amateur Radio satellite. The first station to achieve this feat was K1HTV, second was W1NU and third was W1PV. Since then, WA1ZUB (Massachusetts) and K1DS (Rhode Island) have made the long connection to Hawaii.

Several important points have to be understood when operating through the RADIO satellites. The most important operating hint is to listen first to the satellite beacon. The beacon will tell you if the transponder is operating and if the receiver sensitivity is at maximum. Remember that the K address with a reading of greater than ∅∅ indicates output power from the transponder. Sensitivity of the transponder and the ROBOT (automatic-operator) receivers can be determined by the readings of address IG for the transponder and MS for the ROBOT. Readings of ØØ mean maximum sensitivity. RADIOs 3, 4, 5, 6, 7 and 8 have transponders; only RADIOs 3, 5 and 7 have ROBOTs. RADIO 3 and RADIO 4 are designated for experiments only and will probably be used for special operating events.

Receiving RADIO satellite downlink signals on 10 meters requires the use of a good low-noise receiver preamplifier. This one simple feature can make more difference than you can imagine. During a pass you may have to switch from a beam to a dipole or a turnstile to get best reception. Using a turnstile antenna (shown in Fig. 1) will help reduce fading caused by polarization and spacecraft spin. This antenna will give you circular polarization and a match to a 50-ohm feed line. Mount dipoles A and B at 90 degrees from each other in the same horizontal plane and in the clear 3/8 wavelength above ground. There are a lot of CB ground-plane antennas around just waiting for your modification. If you go this route, make sure it has four radials that can be converted to dipoles.

Insulate each of the four ground-plane radials used in this type antenna with wood dowel or plastic stock. Discard the vertical portion of the ground plane. Connect the feed line and the delay line as shown in the drawing. Cut each dipole for the center of the downlink frequency, 29.400 MHz, and you have a first-class antenna for receiving the RADIO satellites. This antenna will work equally well for the OSCAR satellites. If you can't find a ground plane to modify, a pair of wire dipoles suspended in the same plane will work just as well. An article in May 1980 *QST*, "Circular Polarization and OSCAR Communications," describes several antenna systems that may be used for the RADIO uplink and downlink frequencies.

Develop good listening habits. Listening and timing are as important to the satellite operator as they are to the DX contester in a pileup. One thing is certain: You will not become a seasoned satellite user overnight or even in a week. Don't give up; keep trying. If you hear some station calling CQ, break in and start the QSO without delay. One advantage Amateur Radio satellite transponders offer is full duplex operation (being able to hear both input and output signals simultaneously). Why waste valuable operating time calling one CQ after another? Break in or listen for someone to break your call. Keeping your operating time brief can only enhance your operating pleasure and skill.

Satellite passes are predictable, making it very important to have accurate tracking information. A few minutes of error can ruin all your efforts. Plan your passes, and double check times and dates. If possible, coordinate the entire pass. Write down the time and antenna tracking information so you know where the satellite is at all times.

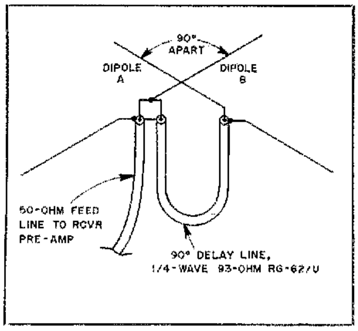


Fig. 1 — 10-meter turnstile for circular polarization.

What most successful operators of the RADIO Mode-A-type satellites try to do is to regulate their uplink power so the return signal from the transponder is never stronger than the beacon signal. The beacon can also provide you with some idea of what to expect in the way of propagation. One of the more interesting uses of beacon propagation is to follow each of the six RADIO satellites in sequence, noting the propagation and operating mode of each. This will help you predict what to expect from one satellite to the next. Whether propagation is good or poor, you can expect the next satellite's pass to be similar.

Talking to the ROBOT

A unique feature of the new generation RADIO satellites is the ROBOT, an automatic operator. Listening to this highly skilled electronic cw operator, you may wonder if there is a human aboard the satellite. The ROBOT remembers call signs, assigns the terrestrial operator a QSO number and, if necessary, asks for a repeat call. The ROBOT can also ask the sender to QRS (slow the sending speed) or even to QRQ (send faster). Other replies are RPT (repeat) and QSD (your keying is defective). The QSD Q signal is one that operators of the RADIO automatic answerers learn to appreciate very soon; the ROBOT insists that the input transmission be clear and your fist perfect.

Very few operators are able to get a QSO number on the first try. Working the ROBOT requires operating skill and quite a bit of patience. If you are keen on space-age video games and you like to compete with other operators, this is something you must try. Satellite communicating is always a challenge, but the RS ROBOT has to be one of the greatest new ideas to come along, creating new excitement for even the seasoned satellite operator.

To communicate successfully with the ROBOT, you must first know where to listen, what to listen for and what to send. The ROBOTs even send their input frequency (remember to allow for Doppler frequency shift). The greatest shift is on an overhead pass, during which the uplink frequency can vary plus or minus 3 kHz. Even if RS 5 is sending, CQ CQ DE RS 5 QSU ON FQ 145830 KHZ K, it will almost always be necessary to call several kilohertz lower than the ROBOT-announced frequency. The passband of the ROBOT is very narrow; if you cannot monitor your own signals coming back without any QSD, stop sending and find the proper input frequency. Correct calling procedure is RS (#) DE (your call) $\overline{\text{AR}}$.

Operating Challenge

Solar activity is declining now, which will improve 10-meter reception of Amateur Radio satellites. Improving your satellite receiving antennas, listening and planning could be the keys to new operating excitement. If this challenge is met successfully, you will be ready for yet more sophisticated satellites in the future.

The first step for the beginner to try is listening in on the contacts being made. If this generates a little interest and excitement, watch out! If you take the next step and send a signal to the satellite, that's when it starts. When the circuit is completed, and your signals come back for the first time, you're involved and on the way to step three of completing a first satellite QSO. That's when the addiction begins. After a few more contacts, you will be saying, "Wow, why didn't I try this a long time ago?" With awards to shoot for, like WAS, DXCC, WAC and the Soviet operating events, set your goals and settle back for some real operating pleasure.

After you are "hooked" on satellite communication, it becomes a pleasure to explain your funny-looking antennas. "Oh! I use those for sending and receiving satellite signals," you say proudly. After a few bewildered looks, there is a pause and a flashback to when you first heard or read about Amateur Radio satellites. Only then will you realize that you have taken a step into the future and Amateur Radio satellite communication is the way to get there.

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QST

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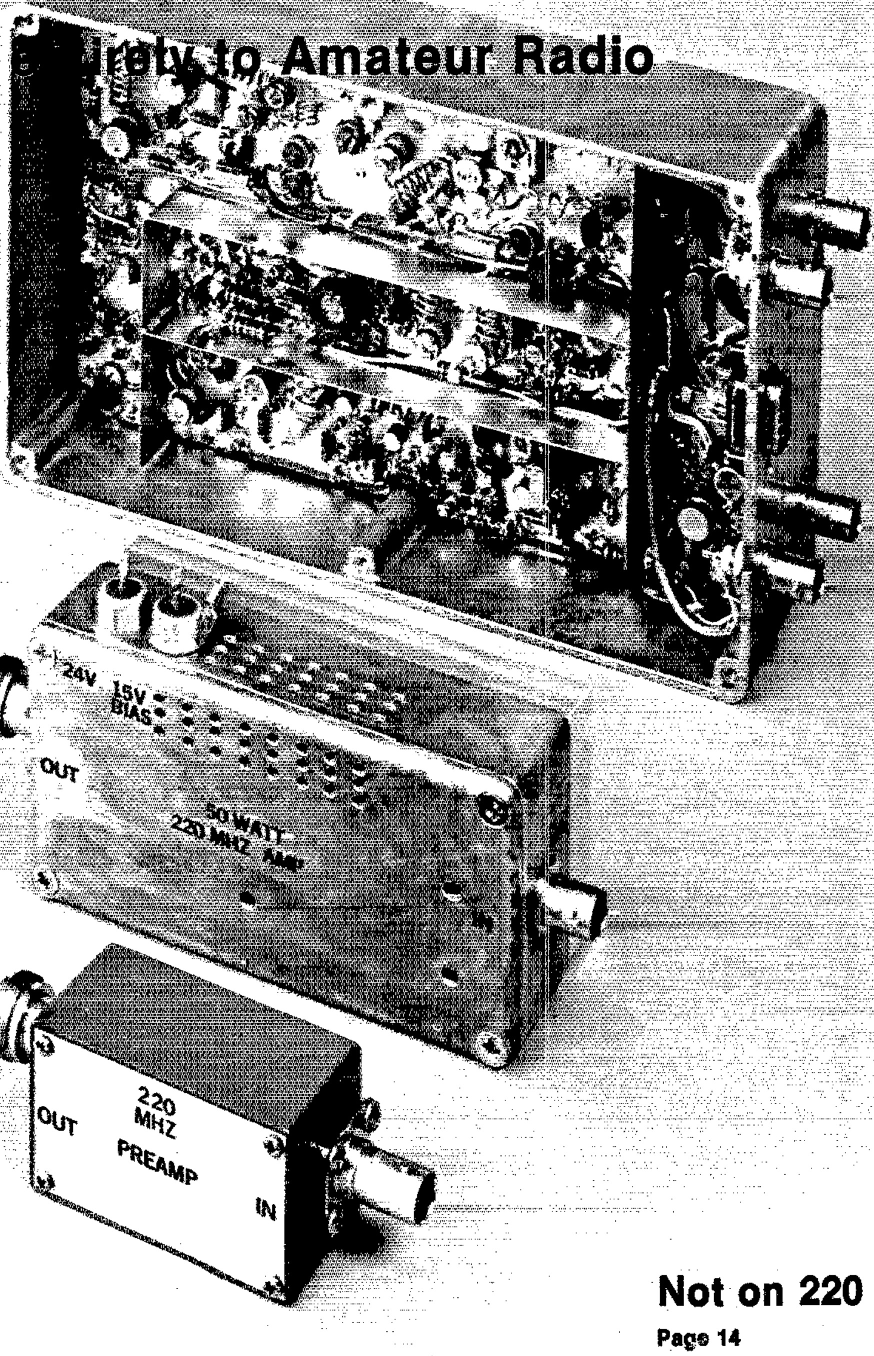

Not on 220 yet?

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QST

August 1982 — *Volume LXVI Number 8*

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THE COVER

Have a 28-MHz transceiver? Transvert it to 220, and have a blast on vhf!

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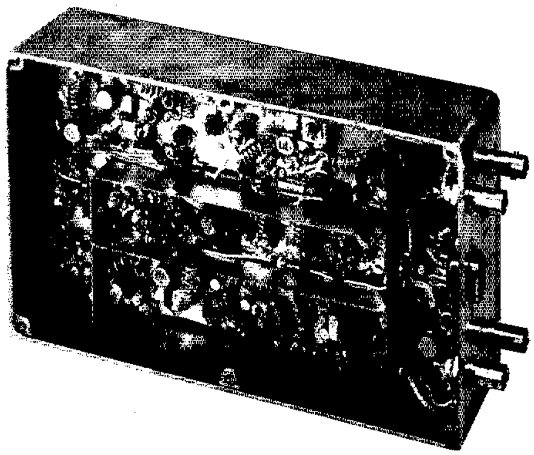
Beginner's Bench

Operating

Organizational and Regulatory

Departments

Explore "220" with this State-of-the-Art Transverter!



Part 1: You've never tried your hand on the 1-1/4 meter band? No equipment? Building this high-performance system could be your ticket to a new band and much excitement!

By Richard Stroud,* W9SR/W9BRN

This modern 220-MHz station is an ideal project for hf operators who want to advance to the higher frequencies. It is great also for dedicated vhf enthusiasts who wish to expand their band coverage. A solid-state transverter forms the basic station, and a low-noise remote preamplifier, a 40-W linear amplifier and a dc supply complete the high-performance system. A system block diagram is shown in Fig. 1. Part 1 of this article covers the transverter construction; the preamplifier, power amplifier and dc supply will be presented in Part 2.[1]

Circuit Highlights

While the transverter was designed for use with the 28-MHz Kenwood TS-820 transverter interface, it can be used with any 28-MHz transceiver capable of delivering +5 dBm (3.2 mW) of power. Rf output from the unit is 5 W, and the receiver noise figure is less than 1.5 dB. The transverter is composed of five sections. For convenience, the low-noise front end and the mixer/i-f amplifier section will be discussed together.

Receiver: The receiver design goal was good sensitivity with minimum susceptibility to overload and intermodulation distortion (IMD). This was accomplished by using a low-noise front end followed by an rf power amplifier, a high-level doubly balanced mixer and a low-gain i-f amplifier. Shown in Fig. 2 is the rf-section circuit diagram, while the mixer/i-f section is shown in Fig. 3.

An Avantek AT25A bipolar transistor is used in the low-noise front end. This is an excellent device for this application because it provides a low noise figure *and* good strong-signal performance. It is available directly from the manufacturer.[2] The input to the AT25A is matched for the optimum noise figure, resulting in a noise figure (measured with an AIL 75 Automatic Noise Figure Meter) of 1.4 dB.

Following the first rf amplifier is a double-tuned circuit. Close spacing (5/8 inch, center to center) between the inductors in this circuit results in inductive coupling.[3] This, and the capacitive coupling of C6, produces a 3-dB bandwidth of approximately 3 MHz. A 2N5109 power amplifier follows the double-tuned circuit. Output from this stage is applied to the mixer.

A PIN-diode-switched SRA-1H diode-ring functions as the receive and the transmit mixer. During receive the mixer input is switched to the amplified received signal, and the output is switched to the i-f amplifier, Q3.

A power JFET (junction field-effect transistor) is used as the i-f amplifier. This device appears as a near 50-Ω termination for the mixer at all frequencies of interest. Proper mixer termination ensures that the mixer IMD characteristics specified by the manufacturer will be obtained. The conversion gain during receive is 32 dB. With −46 dBm input signals at 220.1 and 220.2 MHz, the third-order IMD products at the 28-MHz output are 60 dB below the desired signals.

Transmitter: The transmitter design meets the goals of good linearity and low spurious output. In the transmit mode, the mixer input is switched to the 28-MHz input attenuator and the output is switched to the transmitter predrivers. Each predriver (Fig. 4) contains a 2N5109. These stages have been optimized for linearity. Use of a 440-MHz trap and a harmonic filter ensures good spectral purity.

Dc voltage to the predrivers and the bias voltage for Q4 and Q5 are applied when the companion transceiver is placed in the transmit mode. The bias-circuit components for Q4 and Q5 are located below the circuit board. Component placement is not critical, but the cathode lead of each reference diode should be grounded to a solder lug that is placed under the associated transistor mounting stud. This provides bias temperature compensation.

[1]Notes appear on page 18.

*P.O. Box 73, Liberty Center, IN 46766

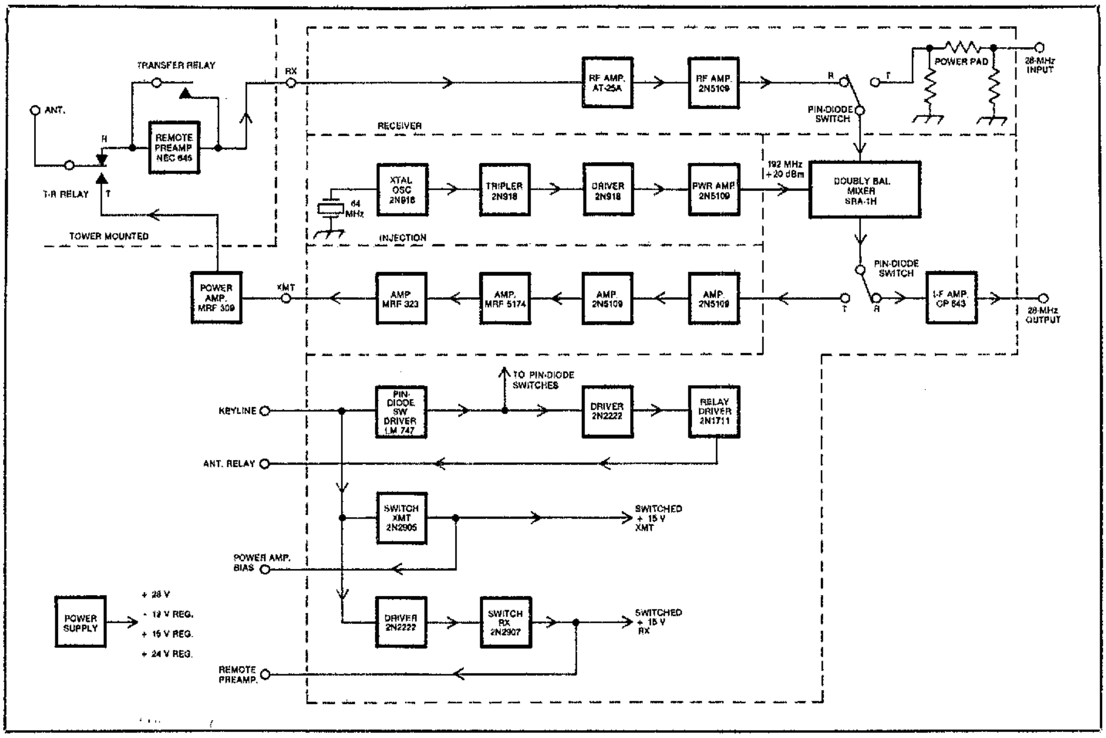


Fig. 1 — 220-MHz station block diagram.

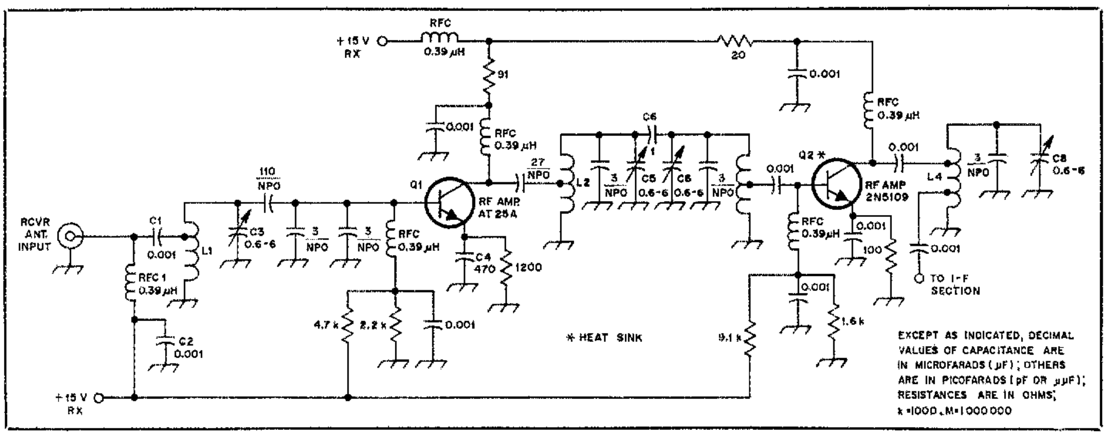


Fig. 2 — Receiver rf-section schematic diagram. NP0 capacitors are miniature ceramic, and 0.001-µF units are low-inductance disc ceramic or equivalent. Unless specified otherwise, resistors are 1/4-W carbon types, and capacitors are rated at 50 V.

C3, C5, C7, C8 — 0.6-6 pF piston trimmer, Johanson 4640.
C4 — 470-pF ceramic chip, ATC, JFD or equiv.
L1 — 4 t no. 18 bus wire, 5/32-in. ID × 3/8 in. long, tapped 2-1/2 t from gnd.
L2 — 6-1/2 t no. 18 bus wire, 5/32-in. ID × 3/16 in. long, tapped at 1-3/4 t from gnd.
L3 — 5-1/2 t no. 18 bus wire, 5/32-in. ID × 7/16 in. long, tapped at 1/2 t from gnd.
L4 — 3-1/2 t no. 18 bus wire, 3/16-in. ID × 1/2 in. long, tapped at 5/8 and 1-1/4 t from gnd.
Q1 — Avantek AT25A (see note 2).
RFC — Miniature rf choke, inductance given in µH.

If you intend to use the transverter without the power amplifier, a filter, such as the one shown in Fig. 5, should be included in the output path. There is ample room near the transverter output connector for filter installation.

Local Oscillator: A 64-MHz crystal oscillator, a frequency tripler and two amplifier stages comprise the local-oscillator (LO) chain. (Fig. 6). The oscillator voltage is regulated at 8.2, and the oscillator output is routed to the tripler through a 50-Ω resistive pad. These measures result in good frequency stability. A 2N5109 power amplifier supplies +20 dBm (100 mW) of LO power to the mixer. This LO level is necessary for good mixer IMD performance.

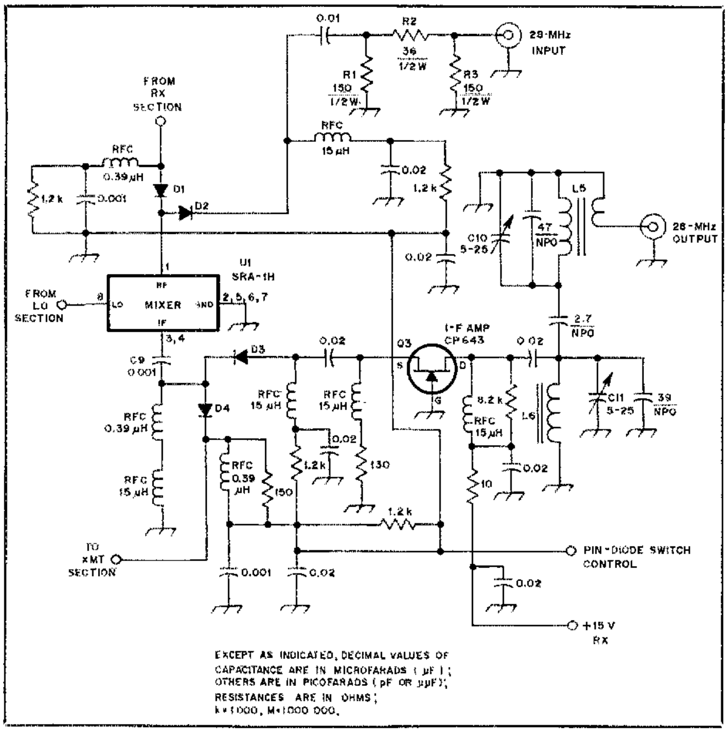


Fig. 3 — Mixer and i-f amplifier schematic diagram. NPO capacitors are miniature ceramics. Other fixed-value capacitors are low-inductance disc ceramics or equivalent. Unless specified otherwise, resistors are 1/4-W carbon types, and capacitors are rated at 50 V.

C10, C11 — 5- to 25-pF miniature ceramic, Erie, JFD, Murata or equiv.
D1-D4, incl. — PIN diode, Unitrode UM6601, HP 1N5719, Motorola MPN 3401 or equiv.
L5, L6 — 13 t no. 28 enameled wire on a Micrometals T25-6 core.[4] L5 secondary is 2 t closewound over gnd end of primary.
Q3 — CP643 power JFET, Teledyne Crystalonics, 147 Sherman St., Cambridge MA 02140.
RFC — Miniature rf choke. Inductance given in μH.
U1 — High-level diode-ring mixer. Mini-Circuit Labs SRA-1H or equiv.

Switching and Control: Straightforward switching circuits (Fig. 7) are used to control the transverter. An LM-747 dual op-amp is used as the PIN-diode-switch driver. The op-amp sections are connected in parallel to supply sufficient current to the diodes. A 2N2907 saturated switch provides receiver on/off control, and a 2N2905 is used to switch the transmitter voltage and the power-amplifier bias. Grounding the transverter key line through the mating transceiver enables the transmit circuits. The key line is connected to transverter connector pin 4 of the TS-820. Pin 4 is wired to a normally open relay contact (RL-2) that is

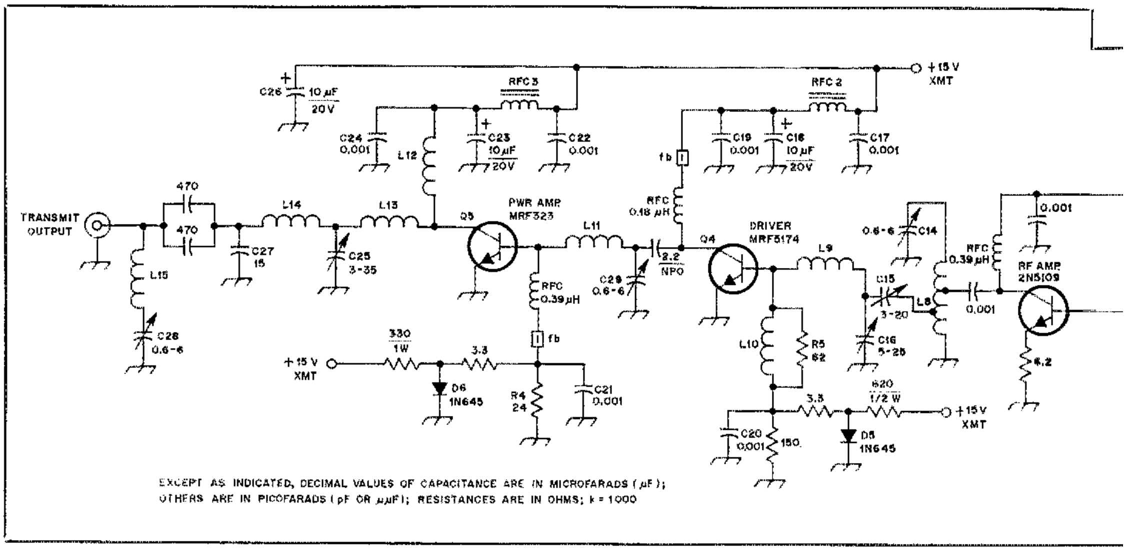
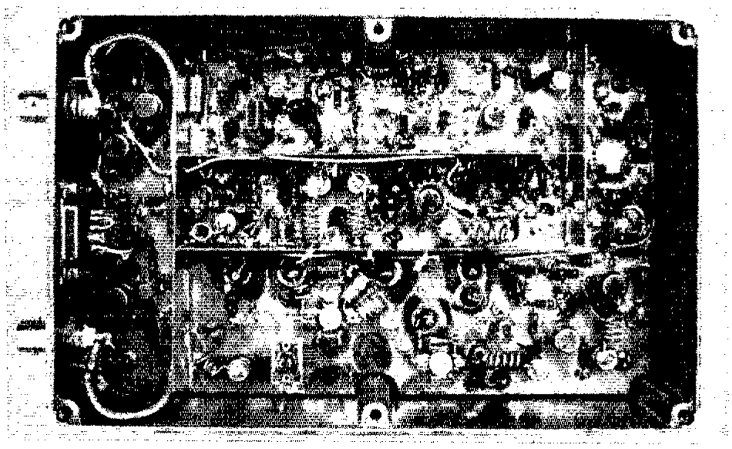


Fig. 4 — Transmitter section schematic diagram. NPO capacitors are miniature ceramics. Unless otherwise specified, 0.001-μF capacitors are low-inductance disc ceramics, resistors are 1/4-W carbon types, and capacitors are rated at 50 V minimum.

C12, C17, C19-C22, incl. C24 — 0.001-μF feedthrough, Allen Bradley FA5C, Spectrum Control 54 794 001 or equiv.
C13, C14, C29 — 0.6-6 pF piston trimmer, Johanson 4640.
C15 — 3-20 pF miniature ceramic, Erie, JFD, Murata or equiv.
C16 — 5-25 pF miniature ceramic, Erie, JFD, Murata or equiv.
C18, C23, C26 — 10-μF, 20-V tubular electrolytic or tantalum.
C25 — 3-35 pF compression trimmer, Arco 403 or equiv.
C27 — 15-pF dipped mica.
L7 — 5-1/4 t no. 18 bus wire, 5/32-in. ID × 7/16 in. long, tapped at 1/2 and 1-1/2 t. from gnd end.
L8 — 5-1/2 t no. 18 bus wire, 5/32-in. ID × 1/2 long, tapped at 3/4 and 1-5/8 t from gnd end.
L9 — 3-1/2 t no. 22 bus wire, 5/32-in. ID × 1/4 in. long.
L10 — 7 t no. 28 enameled wire wound on R5.
L11 — 5 t no. 18 bus wire, 5/32-in. ID × 7/16 in. long.
L12 — 2 t no. 22 bus wire, 3/16-in. ID × 5/16 in. long.
L13 — 3/4-in. length (total) no. 18 bus wire in a hairpin shape.
L14 — 2 t no. 18 bus wire, 5/32-in. ID × 1/2 in.



Interior view of the 220-MHz transverter. The LO chain occupies the upper center section with the receiver front end immediately below it.

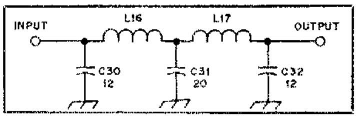
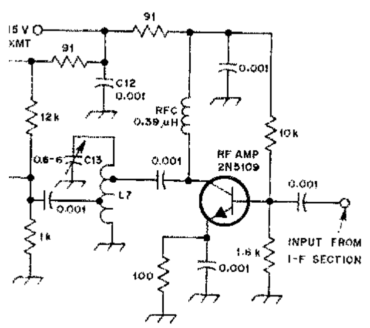


Fig. 5 — Schematic diagram of low-pass harmonic filter. This same circuit is used in the power amplifier (Part 2).
L16, L17 — 5 t no. 20 bus wire, 1/8-in. ID × 7/16 in. long.
C30, C32 — 12-pF dipped mica.
C31 — 20-pF dipped mica.



long.
L15 — 3 t no. 22 bus wire, 1/16-in. ID × 3/8 in. long.
Q4 — Motorola MRF5174.
Q5 — Motorola MRF323.
RFC — Miniature rf choke, inductance given in µH.
RFC2, RFC3 — 1-1/2 t ferrite choke, Ferroxcube VK 200 19/4B or equiv.

grounded during transmit. This contact is normally unused, and wiring it to pin 4 is a simple modification.

A 2N1711 (Q6) is used to switch the antenna relay. It is capable of sinking 250 mA of collector current. The antenna relay should be connected between a suitable voltage source and the collector of Q6. The power supply described in Part 2 has provisions for powering a 28-V relay.

I used separate input and output connectors rather than internal antenna switching to have the flexibility to add a remote preamplifier and a power amplifier. Use of a PIN diode T-R switch was discounted because of the slight loss involved, and because I planned to use a tower-mounted preamplifier and relay.

A remote preamplifier is desirable if a long feed line is necessary, or if you want the minimum noise figure. The transverter has a receiver noise figure of less than 1.5 dB, however, and it will do a commendable job without the preamplifier. If the preamplifier is not used, RFC1, C1 and C2 may be omitted and the input connector may be attached directly to L1.

Construction

Anyone familiar with vhf techniques should be able to duplicate my results without difficulty if the layout shown in the photographs is followed carefully. I built the transverter around many "on-hand" and surplus components; other builders may wish to substitute noncritical components as availability and their junk boxes dictate.

The construction method I used is a good alternative to etched circuit boards when breadboarding and building prototypes. A 1/16-inch thick, double-sided copper-clad board is cut to size and tinned on both sides. Teflon press-fit terminals, inserted at key locations as construction progresses, are used to support component leads. Ground connections are made by soldering directly to the tinned board. Teflon terminals are available in many sizes and styles from surplus outlets. I use 3/16-inch-high units that mount in a 0.089-inch diameter hole. Before inserting the terminal, hand chamfer the hole slightly on the circuit side of the board with an oversized drill bit.

A diecast box (Bud CU247), measuring approximately 4-1/2 × 7-1/4 × 2 inches, houses the unit. The circuit board is mounted above the bottom on 5/8-inch threaded aluminum spacers. I drilled 1/8-inch holes in the bottom to allow adjustment of the piston capacitors. Each transverter section is isolated by 3/4-inch-high tinned brass shields. To avoid unintentional coupling, all coils should be positioned as shown in the photographs. All rf leads should be kept short. Low-inductance 0.001-µF capacitors, connected with short leads, should be used for bypassing. The LO crystal can be held in place by means of GE RTV® silicone adhesive.

All rf input and output connections are made through UG-1094 (BNC type) connectors. The power and control connections are made through a 9-pin jack. Short lengths of miniature coaxial cable connect the receiver input and the transmit output connectors to glass-insulated feedthrough terminals mounted on the shield wall. These terminals are the rf termination points for the receiver and transmitter circuits. The 28-MHz input and output connectors are also attached to feedthrough terminals by miniature coaxial cable. These "feedthroughs" are mounted on the circuit board at appropriate points, and the cables pass under the board to the connectors.

The doubly balanced mixer is located under the circuit board, with the pins protruding into the receiver compartment. Notches at the bottom of the shields near the mixer allow clearance for the lead from L21 and the mixer output-coupling capacitor, C9.

Q3 is mounted by inverting it in a hole drilled in the board (leads on the circuit side of the board). The index tab is then soldered to the board. This provides a good rf ground (the gate is connected to the case) and heat sinking of the device.

Adjustments

A 6-dB resistive pad (R1, R2 and R3) is included in the 28-MHz input line. This pad terminates the transceiver output and reduces the drive power to the correct level for the mixer. If your transceiver output differs from that of the TS-820 (+5 dBm), adjust the pad resistor values to obtain approximately +2 dBm (1.6 mW) at the mixer. Do not exceed 1/2 W of drive, or damage to the mixer may result.

The value of R4 should be selected to provide a Q5 quiescent collector current of 25 mA. Resting current for Q4 should

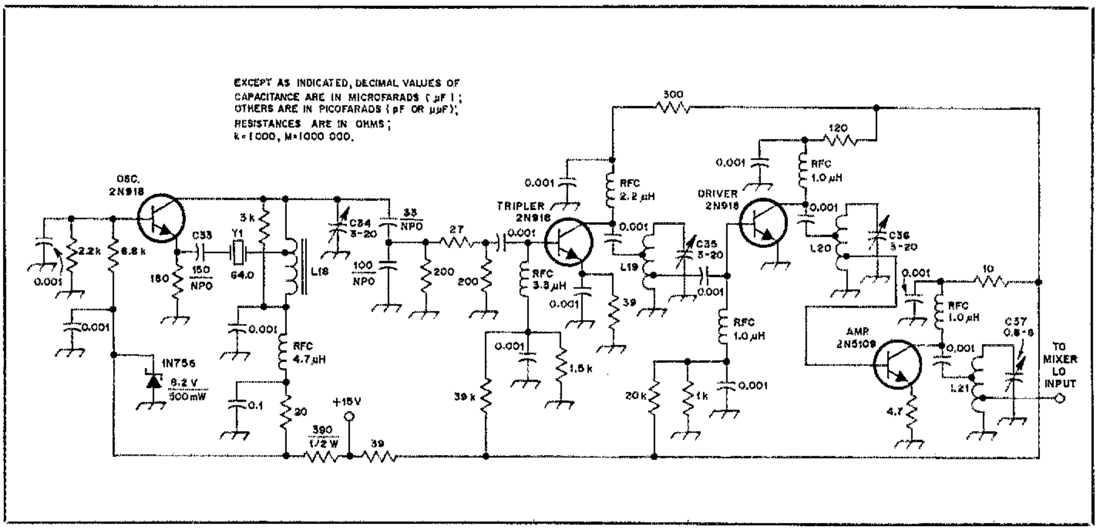


Fig. 6 — Local-oscillator section schematic diagram. NP0 capacitors are miniature ceramic, and 0.001-µF units are low-inductance disc ceramic. Unless otherwise specified, resistors are 1/4-W carbon types and capacitors are rated at 50 V.

C34-C36, incl. — 3-20 pF miniature ceramic, Erie, JFD, Murata or equiv.
C37 — 0.6- to 6-pF piston trimmer, Johanson 4640.
L18 — 11 t no. 28 enameled wire on a Micro-metals T20-22 core, tapped at 3 t from gnd end.
L19 — 4 t no. 18 bus wire, 3/16-in. ID × 9/16 in. long, tapped at 3/4 and 3-3/4 t. from gnd end.
L20 — 4 t no. 18 bus wire, 3/16-in. ID × 1/2 in. long, tapped at 3/4 and 3 t. from gnd end.
L21 — 3-3/4 t no. 18 bus wire, 3/16-in. ID × 9/16 in. long, tapped at 3/4 and 1-1/2 t from gnd end.
RFC — Miniature rf choke, inductance given in µH.
Y1 — 64.00-MHz series-resonant crystal, CR80 style, McCoy, Jan Crystals or equiv.

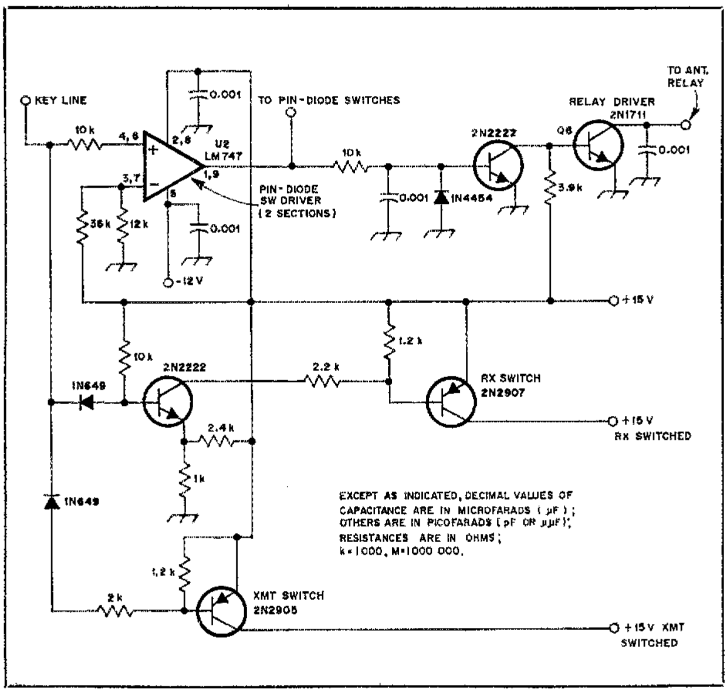


Fig. 7 — Transverter switching and control section. Resistors are 1/4-W carbon types, and capacitors are disc ceramic. U2 is a dual op-amp with the sections connected in parallel.

be approximately 15 mA.

Adjust the harmonic trap (L15 and C28) for minimum output at 440 MHz. This adjustment will interact with the setting of C25 slightly, so both should be optimized for maximum desired output and minimum second harmonic.

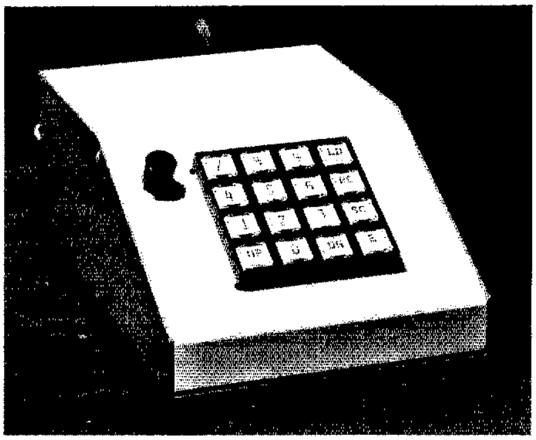
The LO-injection frequency can be adjusted to 192.0 MHz by selecting the correct value for C33. Measure the frequency with a counter connected to mixer-pin 8. As an alternative, the LO frequency can be adjusted until a received signal of known frequency appears at the proper dial point on the 28-MHz receiver. If a high-quality crystal is used, the frequency should be close to 192 MHz with the value shown.

All remaining adjustments are made in the conventional manner; the receive circuits are peaked for best signal-to-noise ratio, and the transmit stages are adjusted for maximum output power. This completes the transverter portion of the system. With it, you are ready to begin exploring 220!

Notes

[1]Part 2 of this article will appear in a subsequent issue of *QST*.
[2]Avantek, Inc., 3175 Bowers Ave., Santa Clara, CA 95051. Approximate cost is $12.
[3]mm = in. × 25.4.
[4]Cores are available from Amidon Associates, Inc., 12033 Otsego St., N. Hollywood, CA 91607.

A Three-Chip Microcomputer for Your Station



Been thinking of computer-controlling your synthesized radio equipment? Here's a microcomputer you can build — and the three ICs cost less than $20!

By Glenn Williman,* N2GW

Up till now, most microprocessor-oriented articles have shown how to interface various commercially available mini/microcomputers to certain pieces of amateur equipment. This is great if you happen to have purchased that particular system. The material may be fun to read and dream about, but how long will it be before you own your own computer system?

A microprocessor (μP)-based controller in the shack has a variety of uses. Fig. 1 shows one possible configuration: an interface to a synthesized vhf/uhf radio. The 16-key pad can control frequency selection and up to five other programmable functions. Provision can also be made, for example, to handle scan interrupt on busy or clear channels.

Assume that you need to control the MHz units, and 10s and 100s of kHz selection, of a synthesized vhf/uhf radio (the 0/5-kHz switch could be used as is). Four output lines for the BCD code and three lines for the counter latch control are required. To expand this to a synthesized hf radio, an additional line would be used so that four inputs to the synthesizer could be had: units, 10s and 100s of kHz, and 100s of Hz, with the MHz decision being determined by the band-switch circuit.

*612 Auth Ave., Ocean, NJ 07712

System Configuration

The Micro-3 is designed around a 6802 8-bit μP. This μP is identical to the 6800 with respect to the instruction set, but advantageously has 128 bytes of on-chip RAM, and a clock generator, requiring only the addition of an external crystal (4 MHz maximum) and a power supply for operation. System program memory is in EPROM for design flexibility. A 2516/2716 (single-voltage supply 2K × 8) EPROM is used, which most likely will provide more program memory than required. A single-voltage supply 2508/2708 (1K × 8) could be used, but the 2516 is now cheaper and more readily available than almost all other EPROMs.

The I/O functions are handled by a 6821 PIA (peripheral interface adapter). This IC is identical to the older 6820 PIA, but has TTL interface capability on both A and B registers, and is also more readily available. A block diagram of the system is shown in Fig. 2.

Micro-3 has memory partitioned as follows: RAM is fixed and must be located at 0000 to 007F; program instructions are written in EPROM starting from 1000. Address decoding for the EPROM is simplified by doing this, since address line A12 can then be used to chip select (CS) the EPROM. The VMA (valid memory address) line from the 6802 is NANDed with line A12 to ensure correct timing of the EPROM enable. One NAND gate is required for this, and two other NAND gates are used to debounce the reset line for the 6802 and 6821. The I/O PIA is located at 8000 to 8003; therefore, no decoding is necessary for PIA chip select, since address line A15 is connected to the PIA CS input and address line A12 is connected to the $\overline{CS}$ input.

Assembling the Micro-3

The Micro-3 was built initially on a small wire-wrap pc board, allowing generous foil areas for ground and power connections and thus permitting future changes or additions. The data and address lines were wire wrapped. This method works well and has the advantage of flexibility.

Once the circuit was debugged, a pc board was designed. No special provisions are necessary, but the more grounding, shielding and bypassing you include the less the potential for EMI. With both the wire-wrap and pc-board versions, there has been minimal EMI generated and the unit is not sensitive to rf energy. The system requires a regulated 0.4-A, 5-V supply. A 5.6-V Zener diode across the supply line helps protect against power supply transients during on/off switching.

The IC-701 Micro-3 System

The IC-701 synthesizer and control circuity accept a modified BCD code input and perform data latching, so only six output lines are required to load four frequency selection units. Two other PIA output lines are used to control up/down tuning, since inputs for these signals are already located on the '701 accessory connector.

The required frequency input data format consists of a load bit followed by five parallel input data bits for each of the four digits to be entered. The digital data must be entered sequentially, starting with the 100s kHz position and ending with the 100s Hz position. This format is shown in Fig. 3. Each channel or frequency consists of five time slots with each data bit being approximately 350 μs long and having an off time of approximately 350 μs between data bits.

Fig. 4 shows all the interconnections between the μP, the EPROM and the PIA. The 6821 PIA A register is programmed as the output register (pins 2 to 9), and the B register (pins 10 to 17), programmed as the input register, acts as a keyboard interface. The interface to the A and B registers of the PIA is shown in Fig. 5. Those resistors on each of the B register lines are terminations used to eliminate in-

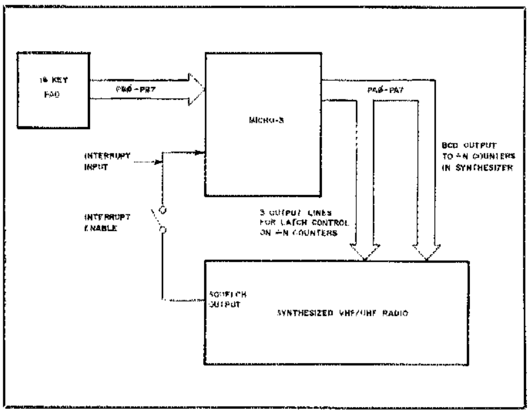


Fig. 1 — A microprocessor-based controller may be used as an interface to a synthesized radio.

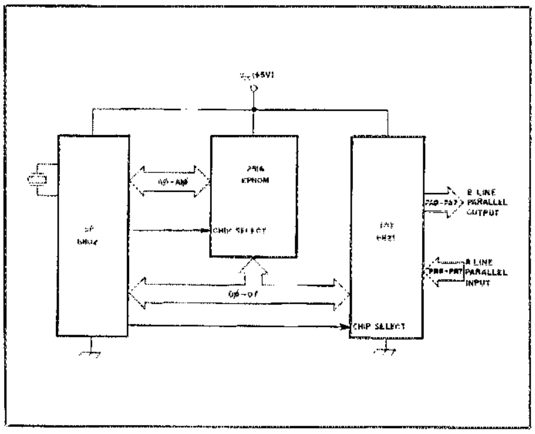


Fig. 2 — Block diagram of the Micro-3 system.

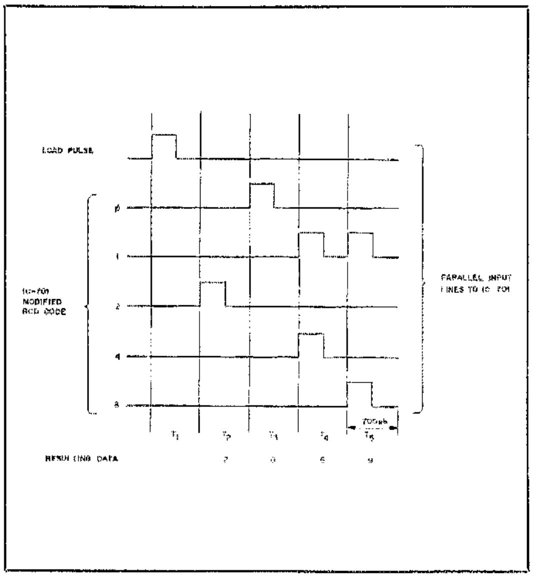
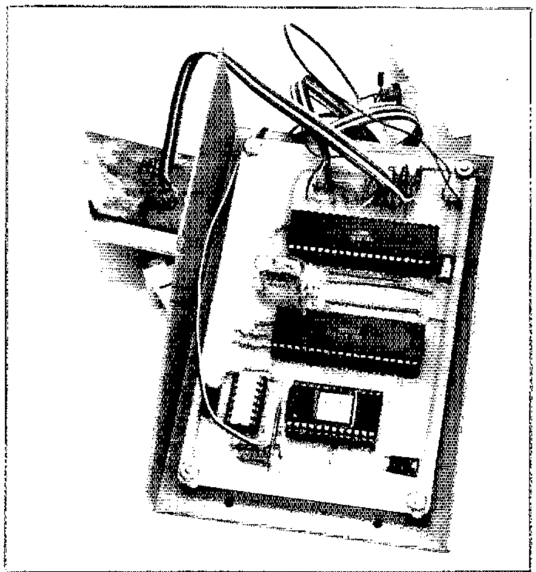
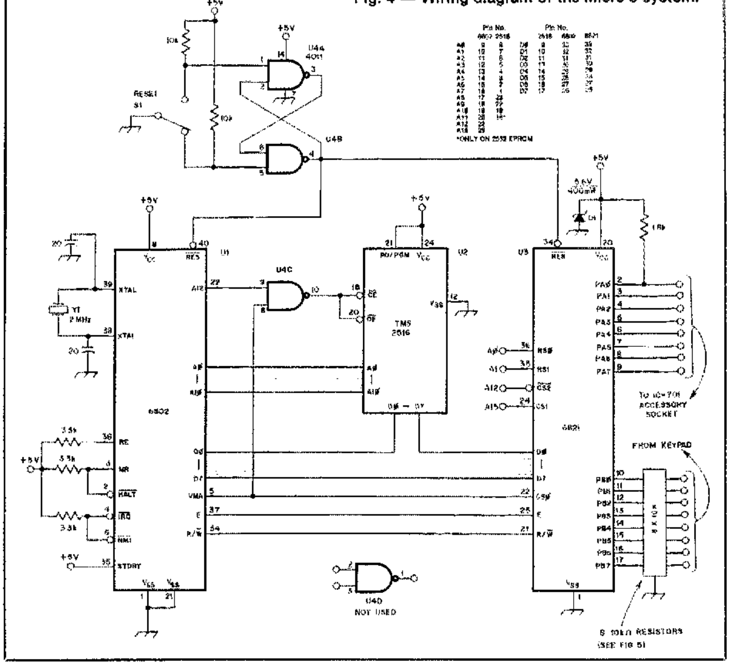


Fig. 3 — Frequency input data format used with the Micro-3 and an ICOM IC-701 transceiver.



This inside view depicts the neat simplicity of the Three-Chip Microcomputer.

Fig. 4 — Wiring diagram of the Micro-3 system.



put line stray-signal pickup that could be interpreted as keyboard signals. The B register will interface to any 4 × 4 matrix switch arrangement (two of eight connect), and the keyboard routine for the IC-701 program is robust enough to debounce most anything. A 1.8-kΩ pull-up resistor on line PAØ (pin 2) of the PIA is necessary because the internal load in the '701 is slightly more than the drive capability of the PIA.

The IC-701 Program

Since my ICOM IC-701 accepts frequency-control information in a different format than the traditional divide-by-N, multiple-counter type of synthesizer, the software developed initially for the Micro-3 was tailored specifically for that rig.

The program functions are divided into separate subroutines, each responsible for performing a distinct operation. Essentially, the main program waits with a keyboard scanning routine until one of the six function keys is activated. Then it decides which subroutine to access, and the selected subroutine takes over from there. Fig. 6 is a simplified flow chart of the procedure.

Operation of the IC-701/Micro-3 is simple, and the key strokes are explained

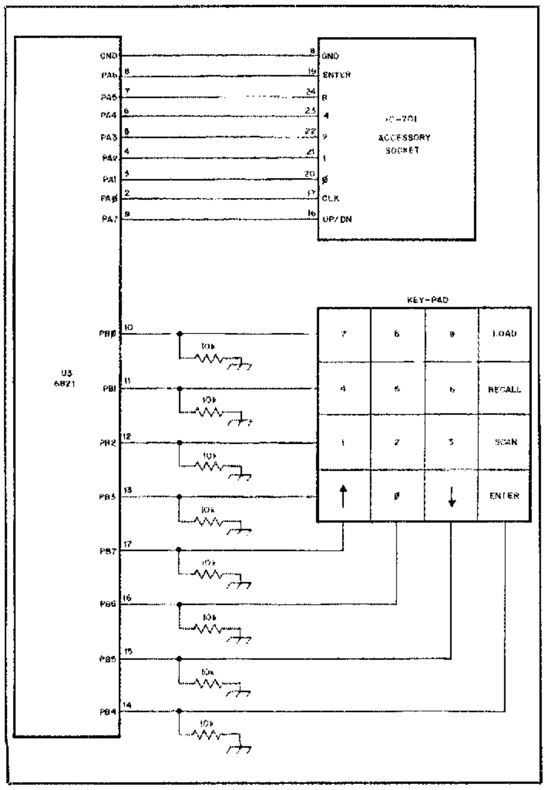


Fig. 5 — PIA A and B register interfacing.

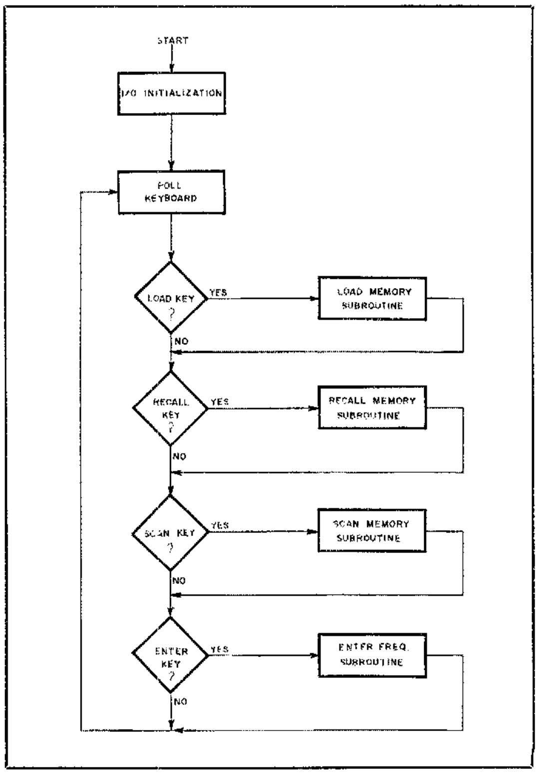


Fig. 6 — Simplified flow chart of the Micro-3 program designed for use with the IC-701 transceiver.

Table 1
Keypad Functions

Key	*Operation*
LOAD	Used for keying in memory locations and frequency to be stored. LOAD 12049 stores 204.9 kHz in memory 1.
RECALL	Recalls frequency stored in a particular memory. RECALL 5 recalls the frequency stored in memory 5.
SCAN	Used to select memory channels to be scanned. SCAN 15 permits scanning memories 1 through 5, and repeats. The lowest memory number must be entered first. An entry such as SCAN 51 will initiate scanning memories 5 through 9 and proceed into invalid RAM; the RESET key may be used to stop the scan function.
ENTER	Permits direct four-digit frequency input. ENTER 2049 enters 204.9 kHz.
↑ ↓	Initiates up or down incremental tuning of the radio. Pressing either key again will stop the tuning.
RESET	Used to stop any of the above functions, and does not alter memory information.

Table 2
Program Listing (Used with the IC-701)

	Ø	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*A*	*B*	*C*	*D*	*E*	*F*
1ØØØ	8E	ØØ	7E	7F	8Ø	Ø1	7F	8Ø	Ø3	86	FØ	B7	8Ø	Ø2	86	FF
1Ø1Ø	B7	8Ø	ØØ	86	Ø4	B7	8Ø	Ø1	B7	8Ø	Ø3	CE	ØØ	Ø4	DF	ØØ
1Ø2Ø	BD	1Ø	51	96	Ø4	81	11	26	Ø3	BD	1Ø	83	81	12	26	Ø3
1Ø3Ø	BD	1Ø	94	81	14	26	Ø3	BD	11	AA	81	18	26	Ø3	BD	1Ø
1Ø4Ø	A3	81	28	26	Ø3	BD	11	4C	81	88	26	CF	BD	11	4Ø	2Ø
1Ø5Ø	CA	86	1Ø	B7	8Ø	Ø2	CE	Ø4	FF	Ø9	26	FD	F6	8Ø	Ø2	D7
1Ø6Ø	Ø2	CA	FØ	C1	FØ	26	Ø7	49	81	ØØ	27	E5	2Ø	E5	8A	ØF
1Ø7Ø	97	Ø3	D4	Ø3	DE	ØØ	E7	ØØ	Ø8	DF	ØØ	F6	8Ø	Ø2	D1	Ø2
1Ø8Ø	27	F9	39	CE	ØØ	Ø4	DF	ØØ	BD	1Ø	51	BD	11	DE	DF	ØØ
1Ø9Ø	BD	11	3Ø	39	CE	ØØ	Ø4	DF	ØØ	BD	1Ø	51	BD	11	DE	BD
1ØAØ	1Ø	B4	39	CE	ØØ	Ø4	DF	ØØ	BD	11	3Ø	CE	ØØ	Ø4	DF	ØØ
1ØBØ	BD	1Ø	B4	39	C6	Ø3	86	4Ø	B7	8Ø	ØØ	86	2Ø	4A	26	FD
1ØCØ	86	ØØ	B7	8Ø	ØØ	86	2Ø	4A	26	FD	A6	ØØ	BD	1Ø	EA	B7
1ØDØ	8Ø	ØØ	Ø8	86	2Ø	4A	26	FD	86	ØØ	B7	8Ø	ØØ	86	2Ø	4A
1ØEØ	26	FD	C1	ØØ	27	Ø3	5A	2Ø	E1	39	81	48	26	Ø3	86	Ø2
1ØFØ	39	81	84	26	Ø3	86	Ø4	39	81	44	26	Ø3	86	Ø8	39	81
11ØØ	24	26	Ø3	86	ØC	39	81	82	26	Ø3	86	1Ø	39	81	42	26
111Ø	Ø3	86	14	39	81	22	26	Ø3	86	18	39	81	81	26	Ø3	86
112Ø	1C	39	81	41	26	Ø3	86	2Ø	39	81	21	26	Ø2	86	24	39
113Ø	4F	97	Ø8	BD	1Ø	51	96	Ø8	4C	97	Ø8	81	Ø4	26	F4	39
114Ø	86	8Ø	97	Ø9	86	81	97	ØA	BD	11	58	39	86	ØØ	97	Ø9
115Ø	86	Ø1	97	ØA	BD	11	58	39	96	Ø9	B7	8Ø	ØØ	BD	11	76
116Ø	96	ØA	B7	8Ø	ØØ	BD	11	76	BD	11	7D	C1	88	27	Ø6	C1
117Ø	28	27	Ø2	2Ø	E3	39	CE	Ø8	ØØ	Ø9	26	FD	39	86	1Ø	B7
118Ø	8Ø	Ø2	CE	Ø3	ØØ	Ø9	26	FD	F6	8Ø	Ø2	CA	FØ	C1	FØ	26
119Ø	Ø7	49	81	ØØ	27	13	2Ø	E7	8A	ØF	97	Ø3	D4	Ø3	D7	Ø3
11AØ	F6	8Ø	Ø2	D1	Ø3	27	F9	D6	Ø3	39	CE	ØØ	Ø4	DF	ØØ	BD
11BØ	1Ø	51	BD	11	DE	DF	Ø6	CE	ØØ	Ø4	DF	ØØ	BD	1Ø	51	BD
11CØ	11	DE	DF	Ø8	DE	Ø6	BD	1Ø	B4	DF	ØA	BD	12	2A	DE	ØA
11DØ	9C	Ø8	27	Ø2	2Ø	FØ	BD	1Ø	B4	BD	12	2A	2Ø	E6	96	Ø4
11EØ	CE	ØØ	ØC	81	48	27	42	CE	ØØ	1Ø	81	84	27	3B	CE	ØØ
11FØ	14	81	44	27	34	CE	ØØ	18	81	24	27	2D	CE	ØØ	1C	81
12ØØ	82	27	26	CE	ØØ	2Ø	81	42	27	1F	CE	ØØ	24	81	22	27
121Ø	18	CE	ØØ	28	81	81	27	11	CE	ØØ	2C	81	41	27	ØA	CE
122Ø	ØØ	3Ø	81	21	27	Ø3	7E	1Ø	ØØ	39	96	ØC	CE	1Ø	ØØ	Ø9
123Ø	26	FD	4A	26	F7	39	ØØ	ØØ	ØØ	ØØ	ØØ	ØØ	ØØ	ØØ	ØØ	ØØ
13FE	1Ø	ØØ														

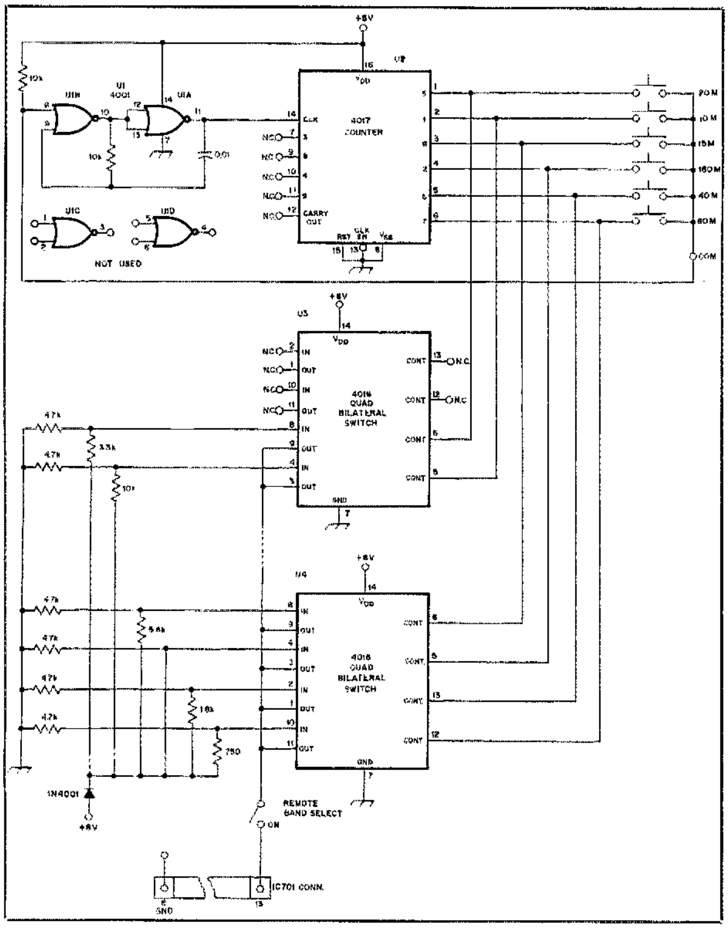


Fig. 7 — Schematic diagram of a push-button band-switching system employed by the author with his IC-701 transceiver. Resistance values are in ohms, k = 1000. Resistors are carbon composition or film, 1/4-W, 5% types.

in Table 1. A program listing is shown in Table 2. Using the LOAD key in sequence with 0 and four digits (i.e., LOAD 01111) will load a time-delay factor used in the scan mode. Using digits from the 9 column will provide about a 1.5-second scan delay; the 8 column, about 3 seconds; and the 7 column, about 6 seconds. Four digits must be entered for the delay factor to be used properly. An entry such as LOAD 09874 is valid, since the first digit (9) determines the scan delay (1.5 seconds).

Summary

I built an earlier version of this controller without the μP, which contained a relatively simple circuit for push-button band switching. This could easily be included for a fully functional digital-control system. The schematic diagram is shown in Fig. 7.

I hope the ideas presented here encourage some experimentation by novice μP users and allow others to use the 6802 system design for their μP-based project that has been waiting on the drawing board. For those interested in using the Micro-3 system described here, a kit is available from the author that includes a drilled and plated pc board, all ICs and sockets, for $38 postpaid. If you are interested in obtaining the IC-701 program, the same kit with a programmed EPROM is $43.[1]

[1]The ARRL and *QST* in no way warrant this offer.

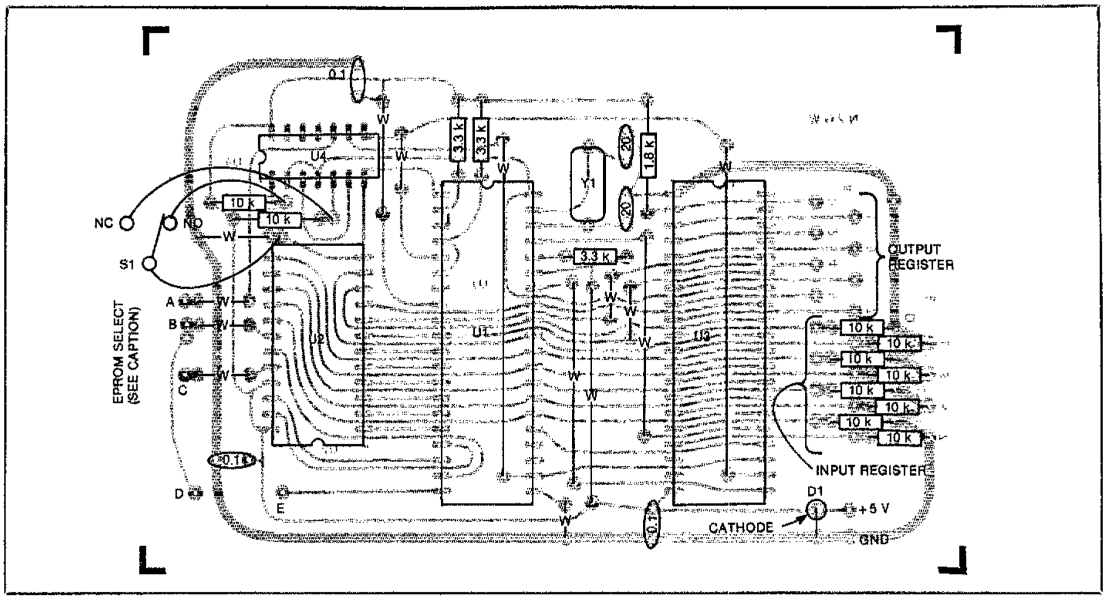


Fig. 8 — Parts- placement guide for the Three-Chip Microcomputer. Parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern. (The etching pattern appears in the Hints and Kinks section of this issue.) Resistances are in ohms; k = 1000. Capacitors with whole-number values are in picofarads. Capacitors with decimal-value numbers are in microfarads. W = wire jumper. With 2508 or 2516 EPROMS, jumper A to B and B to C. For 2532 EPROMS, jumper A to C and D to E.

Strays

ATTENTION AFFILIATED CLUBS

☐ All affiliated clubs who have not filed an annual report between January 1 and June 1, 1982 are delinquent. Contact the Club and Training Department if your club has *not* completed a 1982 form or needs a copy. — *Sally O'Dell, KB1O, Club Program Manager, ARRL*

WESTLINK EAST

☐ The Metroplex Amateur Communications Association of Leonia, New Jersey, is providing the only East Coast telephone outlet for the Westlink Radio Network. To hear the latest news on amateurs' activities, FCC decisions and local antenna rulings, call 212-224-1555. To contribute news to Westlink, call 805-251-7180. — *Hank Goldman, WA2OVG*

NEW MICROWAVE FET

☐ General Electric Company scientists have developed a MESFET field-effect transistor (silicon-on-sapphire metal semiconductor) that provides a 6-dB gain with 50% efficiency. It delivers 0.6 watt at 3 GHz. The manufacturer states that this transistor has the highest efficiency yet achieved by a silicon device at 3 GHz. The MESFET is intended, apparently, for use in MICs (monolithic microwave ICs).

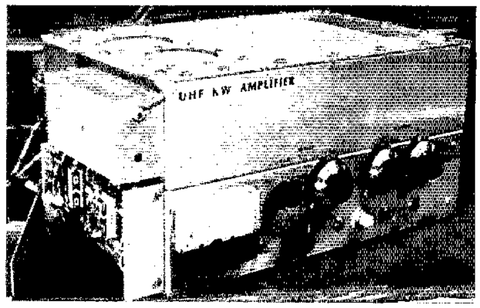
Researchers are striving to develop devices with greater gate lengths (the present unit has a gate length of 1 μm). This should make it possible to produce several watts of power at 50% efficiency. GE contemplates expanding the use of silicon devices to 4 GHz. These developments offer promise to amateurs who are involved with microwave circuit design and communications. The principal scientists in this technological advance are Dr. John Eshbach and Dr. Se Puan Yu. — *Doug DeMaw, W1FB*

ELMER OF THE YEAR NOMINEES SOUGHT

☐ Nominations are being accepted for the 1982 Northern New Jersey Elmer of the Year award. Sponsored by the Northern New Jersey chapter of the Quarter Century Wireless Association, the award is given each year to the radio amateur who is judged to have done the most to help others become Amateur Radio operators. Nominations must be received on or before September 1, 1982. For more information, write to or call Carl Felt, N2XJ, 8 Charles Place, Chatham, NJ 07928, tel. 201-635-7686.

Members of the Radio Society of Great Britain soon will be able to "visit" ARRL/IARU Headquarters, thanks to the efforts of RSGB General Manager David Evans, G3OUF. David carried a complete videorecorder system "across the pond" in late April to chronicle his trip to the Dayton Hamvention and to Newington. Unfortunately, we weren't able to preview the tapes, because European and American television standards are different and the RSGB equipment is, of course, made to the European standard!

The Care and Feeding of Linear Amplifiers for ATV



Your amplifier doesn't like to be fed ATV signals? Careful grooming will give it a healthy appetite for this delectable mode!

By Tom O'Hara,* W6ORG

The increased availability and affordability of video equipment has helped account for the growing number of fast-scan ATVers. Microcomputers, video cassette recorders, color cameras, and video Teletype and cw converters have encouraged hams to want broadcast-quality, real-time pictures. Just receiving a snowy, black-and-white call-letter plate from 40 or more miles away is "old hat." Emphasis today is on getting good-color, snow-free pictures with which to play computer games, coordinate public-service events, or show the latest home movies or videotapes.

Once your 10-watt ATV station is working well, and all the antenna and tower height the wife and neighbors will allow have been put up, thoughts turn to more power. This article covers trade-offs between transistor- and tube-type amplifiers, gives test results of three popular transistor amplifiers, and discusses system considerations to enable you to decide which suits your needs best.

Tubes vs. Transistors

What is the difference between a tube amplifier and a transistor amplifier? Watts are watts, aren't they? Well, if you are using fm or cw, it may not matter. With ATV you need to reproduce the video without degrading the linearity, video-to-sync ratio, or bandwidth (to the point of poor contrast), tearing or jittering, or lack of sound and color. With a-m, the choice of amplifying device must be made with these characteristics in mind, or results can be disappointing.

Let's consider bandwidth first. Uhf power transistors are low-impedance devices (input and output impedances are often around 1 ohm), while tubes have much higher impedances, in the thousands of ohms. This high impedance dictates input and output loaded Qs that limit bandwidth. It also determines the level of sound and color subcarriers, and resolution. Transistor loaded Qs are often below 10 because of the relatively high resistive- to reactive-component ratios. These values determine the matching-circuit strip-line dimensions. Tubes, on the other hand, usually have high grid capacitance and lead inductance — the limiting factor in the values used to make a resonant circuit at 400 MHz. Grid Qs can end up being more than 75 in tubes, such as the 4X150, with all the matching tricks normally employed. In tube amplifiers of this kind, the grid is the major killer of resolution, color and sound. For this reason, many hams end up using their 10-W ATV rig as an rf driver and adding a high-power video modulator.

Linearity is a factor that enables tubes to fare better than transistors, so a trade-off is often considered between bandwidth, (favoring transistors) and linearity (favoring tubes). Tubes are linear up to the abrupt point of limiting in Class C operation, so you can expect good gray scale and little reduction of sync. With transistors, input-to-output gain varies greatly, depending on the power-output level. Generally, the last 3 dB of output increase takes more than 6 dB of input increase. Many hams like this characteristic for ssb because the soft limiting effect gives a higher average power, termed "talk power." Voice recognition suffers little from the peak distortion, and it does improve the signal-to-noise ratio. With video, you must have the sync to enable the TV set to sweep correctly and give a stable picture. Since the sync tip is transmitted at peak envelope power, a transistor power amplifier can compress the sync amplitude to half or less, giving a jittery, torn or rolling picture in the TV. A rule of thumb for using power transistors in the linear mode is to set the peak envelope power at half the manufacturer's rating. For instance, a Motorola MRF648 is rated at 60 W and should be run at 30-W PEP for ATV.

I ran tests using a video-processor amplifier, which enables setting the sync-to-video ratio at any level. Among six TV sets tested, all would lock up with the sync level cut in half. So, as a minimum, set 50% sync compression as the worst case, or 20 IEEE units out of 40. This varies with each TV model and assumes the camera is properly set with 40 IEEE units of sync and 100 units of video. More than 50% of rated PEP can be obtained by use of sync expansion, but more on that later.

Kilowatt ATV

Before we turn to the three tested transistor amplifiers, a discussion of one of the popular tube amplifiers is in order. The K2RIW KW amplifier[1] is available in

*ARRL TA, Fast Scan ATV, 2522 Paxson La., Arcadia, CA 91006

[1]Notes appear on page 28.

kit or complete form from ARCOS.[2] On cw, 10 W of input power from my P. C. Electronics TC-1 transmitter/converter (with no video applied) gave 325 W of output power. The only change I could see in this amplifier over the original K2RIW design was that, rather than the original 4CX250s, the tubes are now Eimac 8930s (100 watts more dissipation each). I stopped testing at 450 watts out (14 watts of drive) because the coaxial cable to my dummy load got very warm to the touch after a few minutes.

The grid loaded Q caused the 4.5-MHz sound subcarrier to roll off 11 dB in the linear mode. Color was almost nonexistent, and the resolution of the 10-W ATV transmitted signal was gone. There is a simple way to overcome this deficiency. With a P. C. Electronics VM-2 grid modulator, the grid loaded Q does not restrict the transmitted-video bandwidth. This leaves only the plate circuit loaded Q to roll off the response.

The modulator was put into a chassis and mounted to the side of the amplifier, as shown in the lead photo. A P.C. Electronics FMA5 sound subcarrier board is mounted in the covered box. A short piece of RG-174/U cable connects the modulator with the amplifier grid circuit. Best results were obtained with −65 V grid bias and no video applied. The modulator is clamped to the video sync so that, regardless of what is in the picture or the average picture level, the power level at the sync tips remains constant. With the 10-W drive, I got 325 W of output power, and then added video. I measured about 250 W of output after adjusting the video gain for best contrast, just above white limiting. The average power on the wattmeter will change, decreasing for a predominantly white picture and increasing for a principally black picture, but the peak envelope power will remain constant at 325 watts.

Amplifiers are best compared by stating PEP, because this eliminates modulation type as a factor. With clamped or dc-restored video modulators, this is as easy as removing the video and reading the power directly from a wattmeter. I will state power as PEP, or power as read on a wattmeter with no video modulation applied. The wattmeter will read PEP in the cw case (no modulation) with a clamped video modulator.

Fig. 1 shows how the P. C. Electronics VM-2 modulator is connected to the K2RIW/ARCOS amplifier. Q3 was added for improved clamping and linearity, and to set the bias point. The plate Q is still high enough to warrant fine adjustment of the plate and output tuning to the high-sideband side of the response. The roll off is just about 1 to 2 dB at the sound subcarrier, and can easily be compensated for by a little extra 4.5-MHz injection. Color is down about 1 dB and is not degraded noticeably except in weak reception cases. Resolution is great, with the TV set i-f bandwidth being the limiting factor (most are only 3 to 3.5 MHz). A resolution rule of thumb is 75 to 80 lines per MHz. I let this amplifier run for 1/2 hour continuously at 325-W PEP, and it seemed to be loafing. So, for a really strong signal, I can recommend this unit, but suggest high-level modulation for quality video work.

50-Watt Triode Amplifier

The old faithful 2C39 (and newer variations) also makes a good linear amplifier. These tubes can give full bandwidth in grounded-grid operation if the plate line is modified to a half-wave section. All cavities have a loaded Q that is much too high for good bandwidth, if they are 1/4-wave lines. They are physically very short because the internal capacitance of the tube is high. Again, this limits the resulting Q that can be achieved without loading the tube down so far as to make the stage gain too low.

The flat plate line (1/2-wave circuits) allows a much lower loaded Q, seems to work better, and is quite simple to build. You can tell a 1/2-wave line from a 1/4-wave line by the tuning capacitor placement. The 1/4-wave line capacitor is placed next to the tube plate and resonates with the tube plate capacitance. The 1/2-wave line has the tuning capacitor at the end opposite the tube, and usually the B+ rf-choke connection is near the middle of the line.

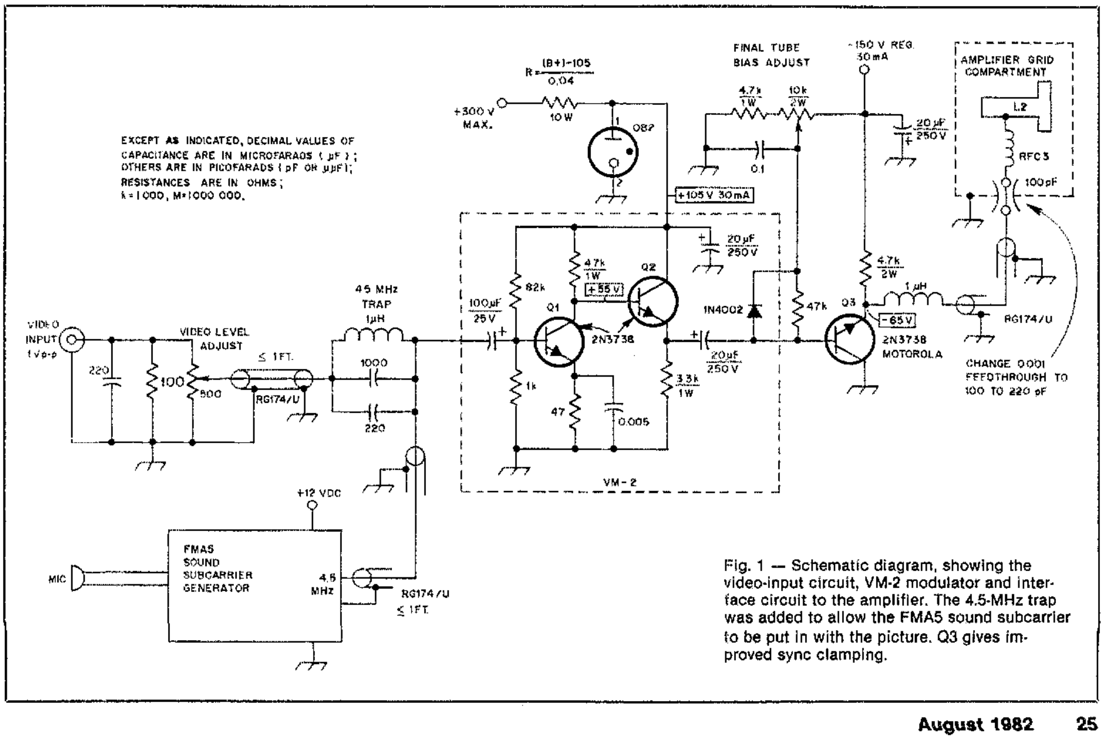


Fig. 1 — Schematic diagram, showing the video-input circuit, VM-2 modulator and interface circuit to the amplifier. The 4.5-MHz trap was added to allow the FMA5 sound subcarrier to be put in with the picture. Q3 gives improved sync clamping.

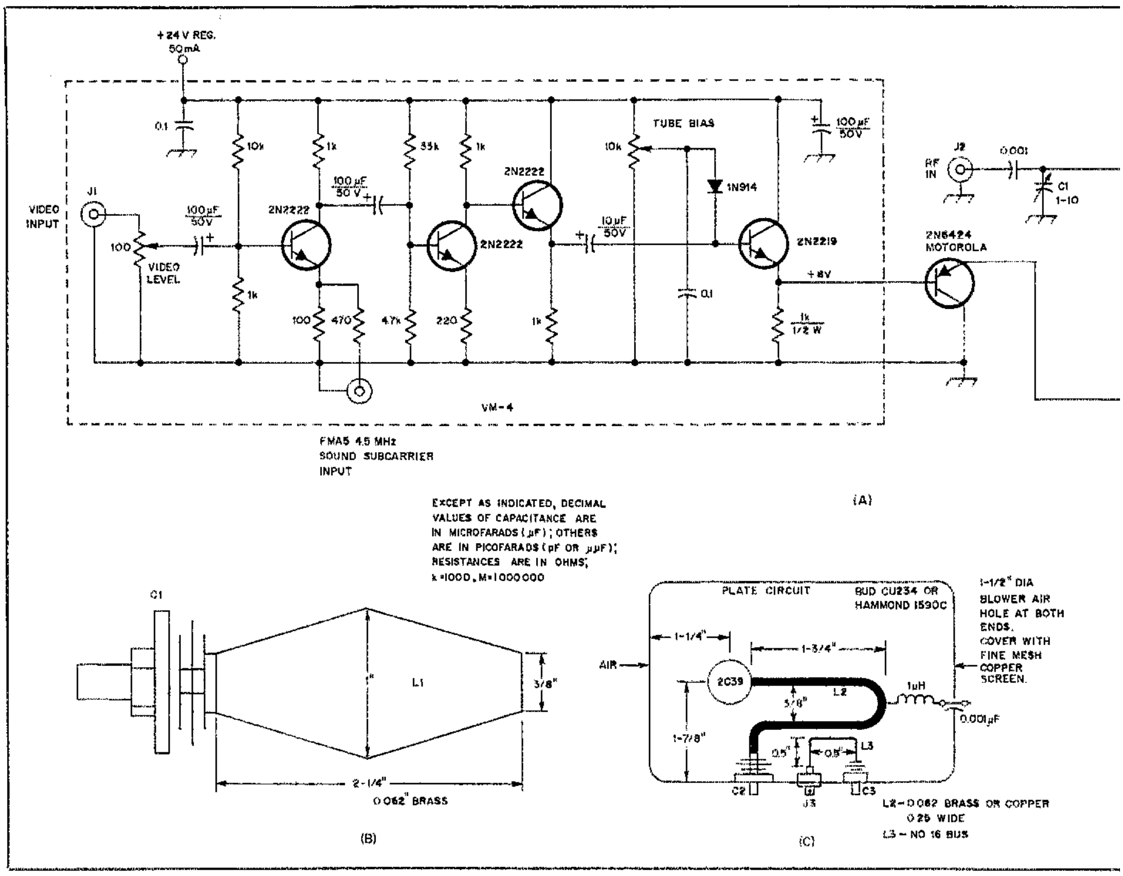


Fig. 2 — Schematic diagram showing a VM-4 modulator with an added 2N6424 transistor as a cathode modulator for a 2C39 amplifier tube. The grid is grounded for dc and rf to provide stability and efficiency. Operating bias is set by means of a 10-kΩ potentiometer on the VM-4 modulator. The 6-V filament transformer must be isolated from ground so that it doesn't attenuate the video. mm = inches × 25.4

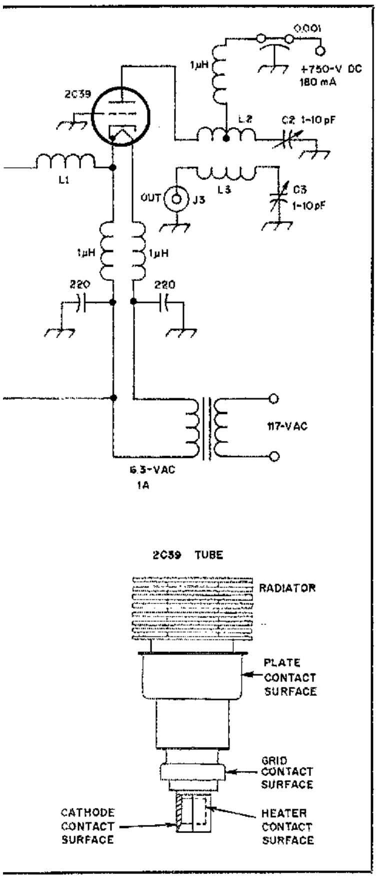
Tests on a Sota EDL432P amplifier, which has a 1/2-wave line, gave good linear sound and color with 50- to 60-W PEP out and 4- to 5-W PEP drive. These units are no longer being built, but the test proved the principle. Many long-time ATVers are familiar with the Motorola T44s, which use a 1/4-wave line and only give about 200 lines of resolution, with poor color and sound. The 2C39 tubes from these rigs can be used to provide nice 50-W linear amplifiers or cathode-modulated final amplifiers (Fig. 2).

The conversion description basically involves removing the housing, discarding the plate line, and removing the grid capacitor. The grid must be dc-grounded for video stability and rf efficiency. The cathode tuned circuit is also changed to lift it above ground. A 100-Ω, 5-W potentiometer can be used to set the tube operating bias at 10 mA under no-drive conditions, or, if high-level cathode modulation is desired, a P. C. Electronics VM-4 modulator can be inserted and the on-board, tube-bias potentiometer used. A blower is necessary at these power levels to keep the tube cool. The cathode is close to 50-Ω impedance as is, so a simple low-loaded-Q tuned circuit is put in for fine adjustment and does not affect the linear-mode video bandwidth significantly. The existing T44 plate line can be used if top-quality color and sound are not important to you. Or, you can build a video equalizing amplifier ahead of your modulator to compensate for the higher plate loaded Q. I think the change to a 1/2-wave line is much easier, and you can build it for best efficiency at the ATV frequency, rather than taking the lower efficiency of the existing 1/4-wave line designed for the 450-to 470-MHz commercial band. To make a nice neat assembly, the top cage can be replaced with a Hammond 1590C or Bud CU234 diecast aluminum box. Actually, it might be cleaner to use the T44 2C39 socket assembly and discard the rest. After all, the hard-to-get part is the concentric-ring socket assembly and mount. It can all be put on a chassis with blower, 750-V, 180-mA power supply, and may be self-contained with a 5-W exciter.

Solid State Amplifiers

Transistor amplifiers have the advantage of wide bandwidth. All three amplifiers I tested showed very little change in output power when switched between 439, 434 and 426 MHz. For an area that has many ATVers, all wanting to get on the air at the same time, it is as easy as flipping the frequency switch to QSY if the favorite calling frequency is busy. There is no need to retune. The color and sound are not degraded because of the low-Q matching circuits typical of these high-power uhf devices.

The other side of the coin is poor linearity. If you look at the input-power versus output-power curves of some of the popular uhf power transistors (Motorola RF Data Manual, for example) you will notice that the curve bends quite a bit, especially as the maximum-power point is reached. This nonlinearity will cause gain compression at the high-power end of the



signal (sync pulse and black levels). The average picture level will shift in favor of the darker shades of gray. Some people may actually prefer this picture, but, unless the system is adjusted to compensate for the compression, there may not be a stable picture if the sync is not at a sufficient level.

Different biasing methods can make small improvements in linearity, but only at the low-power end of the curve. A common-emitter rf-power amplifier with the base dc biased to ground through an rf choke may be considered Class C, but as drive is applied it may quickly approach Class B with a near 180 degree conduction of the rf sine wave. For ATV this would show up as turning the lighter shades of gray into white. A bias that allows a trickle of collector current ensures conduction at the low power modulation swing, providing a full range of grays and white.

Broadcast TV transmitters often have linearity-adjustment circuits in their modulators to compensate for any nonlinearities in the transmitter. For ATV, the most important part of getting a good picture to another ATVer is to have the TV receiver lock up to the transmitted sync. Included on the P. C. Electronics TXA5 exciter/modulator pc board is a sync-stretcher circuit that detects the incoming camera video sync, separates it from the video, and pulls up the modulator output only during sync time. This results in an output waveform that has much more sync than the camera is putting in. Rf-amplifier sync compression is thereby equalized (Fig. 3). The PEP output can be brought up from around 50% of the saturated power capability of the uhf power transistor to roughly 80%. The video portion does not have to be stretched because the maximum power point, or black level, is approximately the 50% point on the power curve, and goes downward, staying in the linear portion.

Tested Amplifiers

The three amplifiers sent by manufacturers to be tested for ATV were: a Microwave Modules MML432-50-W amplifier with a built-in receive "preamp" from Spectrum International, a KLM PA15-110CL 100-W amplifier and the Mirage D1010 100-W amplifier. All are basically the same type, consisting of a pair of power transistors in push-pull on a strip-line board. They all require an external regulated 13.8-V dc supply. The internal T-R relay or the PIN diodes switch automatically from receive to transmit, using rf sensing. All ATV PEP levels are given with full sync stretching; if you use an amplifier without sync stretching on ATV, try running it at 50% of full rated power.

Microwave Modules MML432-50

This unit took 5-W PEP drive to give 40-W PEP out on ATV. It has a single CTC CM50-12, which drew 8 A at 13.8-V dc. For fm or cw, the full 50-W output will require 10 watts of drive. The receive preamp is listed as a BFR34A on the schematic, but turned out to be an NE021. It provided 14.5 dB of gain and a noise figure equal to that of the popular MRF901. T-R switching is done by detecting some of the rf and activating a small relay, which turns on some UM9401 PIN diodes. The documentation that came with this unit was poor. While the basic schematic is given, the parts may be a little different. The diagram shows an 8-A fuse in the B+ line, but there is no fuse in the circuit! The "klutz" who always reverses the red and black power leads will have a "crispy critter" for an amplifier. I suggest you add a fuse in this line. Also, nowhere on the schematic or in the literature does it say which of the 5 pins on the DIN plug is the B+, or which one is ground. You have to open the case and trace the circuit to be sure. Pin 3 is ground, pin 5 is +13.8-V dc, and pin 1 can be grounded for push-to-talk with an ssb rig. The rf sensing does not have a switchable time constant for ssb. The amplifier does perform well and will give superior station performance if mounted at the antenna rather than in the shack.

100-Watt Transistor Amplifiers

The KLM and Mirage 100-W transistor amplifiers are similar and will be discussed together. Both use Motorola MRF648 60-W transistors in push-pull, driven by a single transistor. The Mirage unit uses a Motorola 25-W device (MRF644) as the driver transistor, and the KLM uses a TRW J03037 37-W driver transistor. The Motorola transistor curves show it to be loafing and linear at the required 20-W output level. It is well underrated at 25 W. The TRW device, on the other hand, is internally matched for zero reactance from 450 to 512 MHz, and is rated at 37 W full output with lots of compression. It's hard to say what the linearity is at 20 W, since the curves are not given in the TRW catalog. The Mirage amplifier also has a resistive input pad.

The KLM unit ran best at 65- to 70-W PEP with only 2.5 W of drive and full sync expansion, to give at least 50% sync output. The Mirage gave better than 75% sync at up to 90-W PEP output with 4 W of drive. Efforts to push it to the full 100-W output with 5 or more watts of drive just flattened the sync pulse. For fm or cw, 10 watts is more than enough to fully saturate either amplifier. The KLM unit had a maximum output of 100 W, but the Mirage amplifier delivered over 110 W.

Current draw at 70-W PEP was 15 A with the KLM, and 17 A at 90-W PEP with the Mirage. My Astron RS-20M 20-A power supply served well on ATV, but the 35-A version was needed for fm.

Antenna Mounting

If you consider that a 100-W signal in the shack will lose half the power going through 75 feet (23 m) of Belden 8214 foam dielectric RG-8/U cable to the antenna, the Microwave Modules amplifier will deliver the same power to the antenna when mounted next to it. Not only that, you will not have to adjust the bias potentiometer on your 10-W transmitter for 5-W output, since the 3-dB loss in the coaxial cable will take care of it. But the big plus is the extra 3 dB gained by the preamplifier on receive. Why give the guys watching your pictures all the benefits of your new system when you can double your station sensitivity on receive, too?

There is the effort and special considerations for mounting the box on the tower, but there are always practical trade-offs for improved performance. The amplifier will have to be mounted in a weatherproof aluminum box with a 13.8-V regulated supply. Even though the heat given off is lower with ATV, the amplifier will have to be silicone-greased

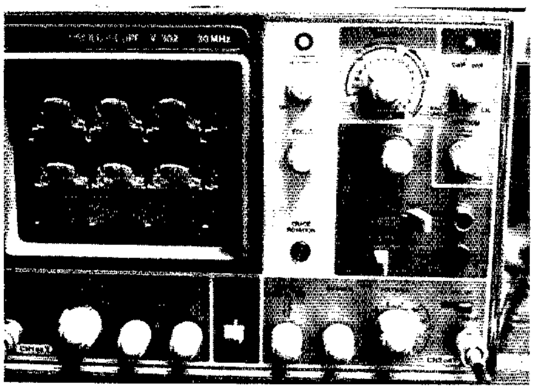


Fig. 3 — Oscilloscope used to observe the video waveform. The lower trace is the video signal as it comes out of the sync stretcher. The upper trace is the signal from the Mirage D1010-N amplifier.

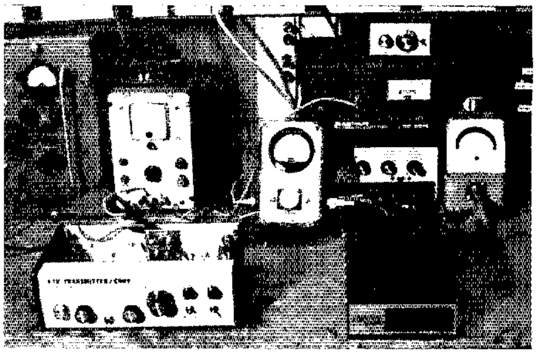


Fig. 4 — Setup used to test the three transistor amplifiers. Shown left to right is a TC-1 transmitter/converter with a DM-1 detector/monitor to sample the sync-stretched waveform, a Bird 43 Thruline wattmeter, the amplifier under test, another DM-1 inline to monitor the output waveform, and a Bird Termaline wattmeter/dummy load.

and mounted against the aluminum box. Use the rule-of-thumb temperature test! After the amplifier has been on a few minutes put your thumb on the heat sink. If, after gritting your teeth, and with tears forming in your eyes, you can hold your thumb on it, it will probably be okay. The power supply should also be tested for temperature rise, but aluminum angle brackets and direct mounting should do it. If running 117-V ac up the tower bothers you, try running the 20-V ac at 8 A between the power transformer in the shack and the bridge rectifier and regulator at the amplifier.

Why does the power supply have to be right next to the amplifier for ATV? Most regulated power supplies are designed for presenting a low impedance at the terminals, with good line and load regulation for 120-Hz ripple. With a-m, the load varies at the modulation rate. This amplifier draws 8 A at 13.8-V dc during sync pulses and at maximum signal levels, but draws only a few hundred milliamperes for the white level. It would not be so bad if we only transmitted vertical blanking pulses 60 times per second, because the big filter capacitors, regulator devices and time constants do a good job at these frequencies. But the current changes at video rates up to 5 MHz. The larger the filter capacitance, the higher the impedance at any given frequency above the audio range. This is caused mainly by the internal inductance and by what is called "equivalent series resistance." Add to that the small but significant resistance and inductance in the leads between the amplifier and the power supply, and a scope on the B+ supply at the amplifier will show a few volts of ripple that look like horizontal sync and video.

This ripple is another cause of sync compression, besides the normal gain curve of the uhf power transistors. Consider that the gain of the transistor is going to be much lower if the ripple component on the 13.8-V line swings down as much as 2 V to 11.8 V during the horizontal sync pulse. There are two ways around this problem; both things should be done, if possible. The only capacitors in the amplifier are for low-frequency stability in the uhf power transistors. They usually consist of a good quality bypass for 450 MHz, a 0.1- or 0.01-μF unit for the vhf frequencies and a 22-μF unit for hf and lower frequencies. But these won't do a thing for frequencies between 3 kHz and 500 kHz. Before I added 100-μF and 470-μF capacitors (25 V), the circulating current in the Mirage amplifier was too much for the 22-μF unit after 10 minutes of continuous video at 90-W PEP. Next, the power leads should be as short in length and as large in wire size as possible to ensure a good regulated supply. Anything over 3 feet (1 m) may be too long, so building a supply next to the amplifier is ideal.

Test Setup

The test setup consisted of a P. C. Electronics TC-1 Transmitter Converter with the sync stretcher built into the TXA5 exciter modulator, a DM-1 rf demodulator to sample the driving video waveform, a Bird Model 43 Thruline wattmeter with a 25-W, 400- to 1000-MHz slug and the amplifier under test. Also included were another DM-1 to sample the high-power video waveform and a Bird Termaline wattmeter with a 100-W, 400- to 1000-MHz slug and dummy load (Fig. 4). The sound subcarrier was shut off to display a clear video-only waveform on the dual-trace 30-MHz scope.

To set up any amplifier without a scope or a DM-1 demodulator, try this procedure:

1) Add the sync-stretcher parts to the TXA5 exciter, or the P. C. Electronics SS-1 sync-stretcher board to your transistor modulator.

2) Remove all video from the modulator input. The sync stretcher will put out sync if the video is still connected but turned down. Also, turn the 4.5-MHz subcarrier injection-level potentiometer to minimum.

3) Rotate the bias potentiometer, which controls the clamped PEP power output, to minimum (fully ccw).

4) Turn on the amplifier and the transmitter. Slowly rotate the bias control until just reaching the suggested PEP output for best ATV operation.

5) Now, the video can be reconnected and the video gain can be increased slowly for the best picture. Turn the sync-stretcher control cw for a good, stable picture. For most amplifiers this is fully cw or within 10 degrees of full rotation, and there is some interaction with the video-gain control. Turn the 4.5-MHz subcarrier-injection potentiometer back to the original position.

Linear, full-bandwidth, a-m video requires a little extra care and consideration. Whether you select a tube or a transistor amplifier to throw your pictures farther and clearer, I hope the results of these tests will help you achieve good, stable video.

My personal thanks to Mel Farrer, K6KBE, at KLM; Ken Holladay and Everett Gracey, WA6CBA, at Mirage; John Beanland, G3BVU/W1, at Spectrum International; and Fred Merry, W2GN, at ARCOS. The loan of their off-the-shelf amplifiers made this study possible.

Notes

[1]R. Knadle, Jr., "A Strip-Line Kilowatt Amplifier for 432 MHz," *QST*, April 1972, pp. 49-55 and May 1972, pp. 59-62.

[2]ARCOS, P.O. Box 546, 35 Highland Dr., East Greenbush, NY 12061.

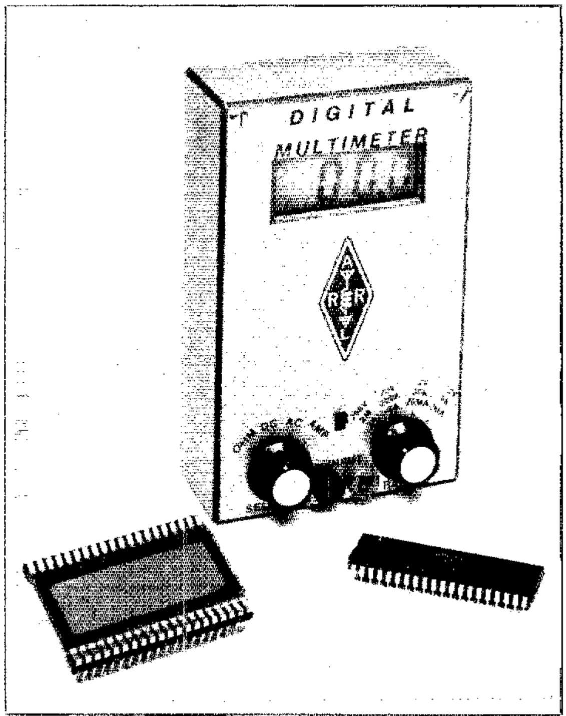
References

Rusgrove, J. and G. Woodward, eds. *The Radio Amateur's Handbook* (59th edition). Newington: The American Radio Relay League, Inc., 1981.

A good continuing source of ATV information is *A5*, P.O. Box H, Lowden, IA 52255.

BEGINNER'S BENCH

Learning to Work with Integrated Circuits, 1982 Style



Ever wished you had a digital multimeter? We'll show you how easy it is to build one and learn about modern ICs at the same time.

By Bob Shriner,* WAØUZO and George Collins,** KC1V

It is well known that one of the best ways to learn is by *doing*. This idea prompted the 1976 *QST* series, "Learning to Work with Integrated Circuits."[1] It was an outstanding series and is still recommended reading today. The "doing" part of the series involved the construction of a digital voltmeter/frequency counter. Both of these are handy items in the ham workshop, but the meter contains over 25 integrated circuits (ICs), weighs 4-1/2 lb and consumes 5 watts of power.[2] Today, six years later, the world of integrated circuits has changed — drastically. Using the same learn-by-doing approach, let's examine some modern ICs.

We could have entitled this article "Learning to Work with Integrated Circuits, LSI Style," because LSI (large-scale integration) ICs represent the technology of today. The "large" in LSI refers to the number of components (such as transistors) formed on the IC "chip" or substrate. LSI devices contain several hundred to a few thousand components. Most LSI ICs are digital rather than analog in nature, although some combine both types of circuitry on the same chip. Many functions for which LSI devices have been designed were, in the past, performed with standard TTL (transistor-transistor logic) or CMOS (complimentary metal-oxide semiconductor) devices, such as the 7400- and 4000-series ICs. It takes large numbers of these small-scale-integration (SSI) devices to implement complex functions, such as a multimeter or a frequency counter. This made the equipment large, expensive and power-hungry. The introduction of LSI ICs has solved these problems in many cases.

"Great, but what can *I* do with LSI?" For one thing, you can build a digital multimeter weighing just 10 oz that will operate (for over 200 hours) from a 9-V transistor-radio battery. Oh yes; the meter will fit easily into your coat pocket! Our "doing" project this month is the construction of just such a meter. Along the way, we'll look at how you can apply these LSI marvels to your own projects.

Our workshop project is a 3-1/2 digit multimeter with a liquid-crystal display (LCD). With it you will be able to accurately measure ac and dc voltages and currents. You can also measure resistances as low as 1 Ω. Other features include automatic zero adjustment and automatic polarity indication.

First, how do we find out about the various LSI devices that are available and how to use them? You don't need a library of data books from every IC manufacturer to locate the more popular LSI ICs. Many electronic-component suppliers' catalogs are good sources of information about new ICs. Often, along with the device number, the manufacturer and the price, a brief description of each IC is given in the catalog. This can help you "zero-in" on appropriate devices. The next step is to obtain data sheets (and application notes) from the manufacturers. These contain all the important specifica-

[1]Notes appear on page 33.

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**Basic Radio Editor

tions, and will be essential when you start designing LSI ICs into your own projects.

Selecting the IC

For this project, the Intersil[3] ICL 7106 looked promising. It is described as a 3-1/2 digit, single-chip A/D (analog to digital) converter. A quick look at the data sheet showed that it is exactly what we needed. Intersil provides detailed application information, making the job of applying the 7106 to our multimeter project easy. All the active components needed for our project are contained in the 7106. It consists of over 2000 tran-

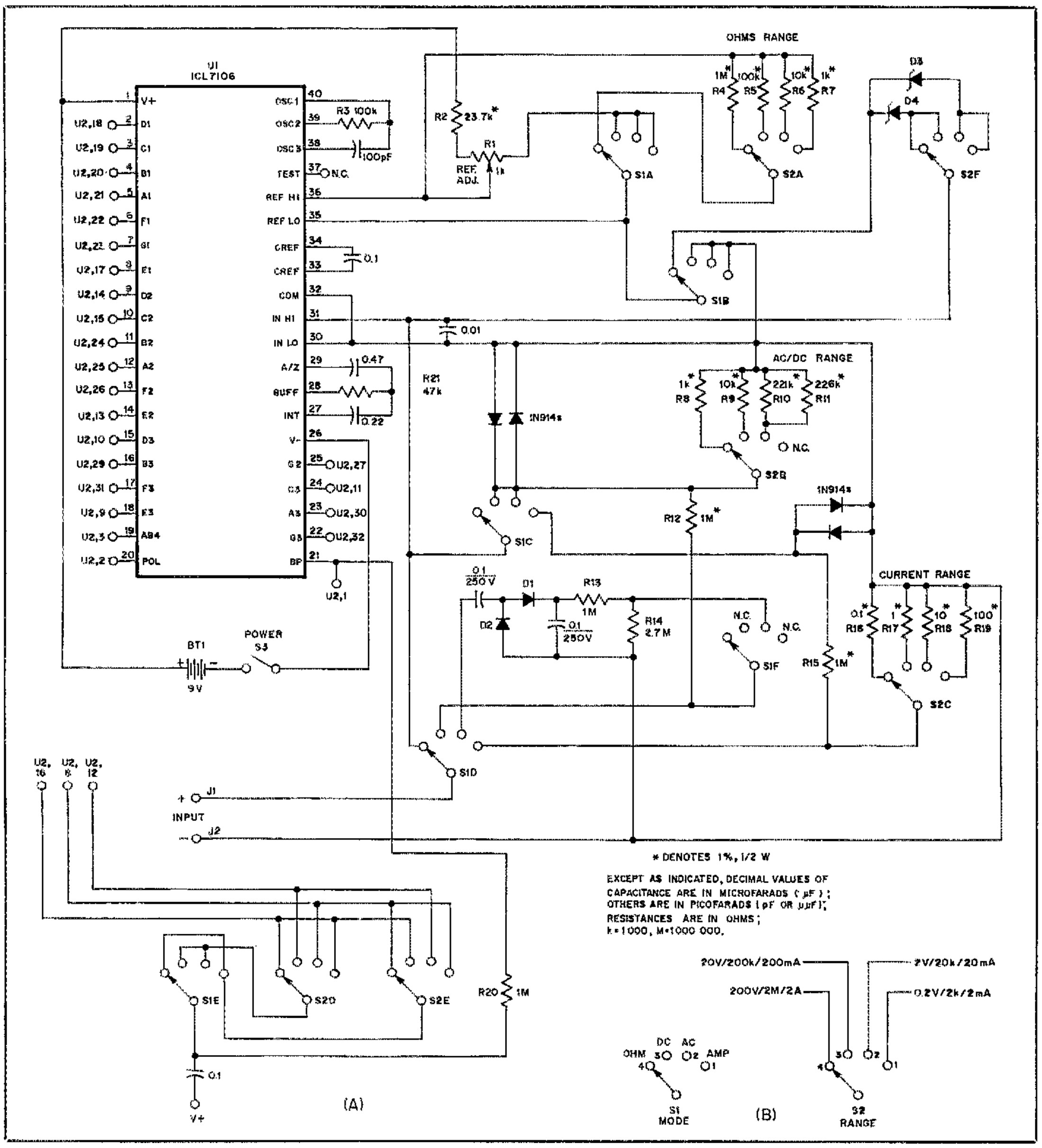


Fig. 1 — Digital multimeter schematic diagram (A). S1 is shown in the OHMS position, and S2 is shown in the 2-MΩ position. The switch-position numbering (B) corresponds to the numbering used in Fig. 3. Resistors marked (*) are 1%, 1/2-W units; others are 5%, 1/4-W carbon types.[5]

BT1 — 9-V transistor-radio battery.
D1, D2 — 1N4007 silicon rectifier diode.
D3 — 1N5228B 2.5-V, 1/2-W Zener diode.
D4 — 1N5231B 5.1-V, 1/2-W Zener diode.
J1, J2 — Banana jack.
R1 — 1-kΩ, 10-turn, pc-mount potentiometer.
S1, S2 — 6-pole, 4-position rotary switch, Mouser[4] no. 10WR064 or equiv.
S3 — Miniature slide switch, spst, Mouser no. 10SP008 or equiv.
U1 — Intersil ICL 7106 single-chip A/D converter.
U2 — 3-1/2 digit liquid-crystal display, Hamlin 390 23 155 or equiv.

sistors and other components on a semiconductor chip about the size of a match head. A 40-pin dual-in-line package houses the chip. One important reason for selecting this IC is the type of display with which it is designed to be used. The LCD used with the 7106 consumes very little power, making it ideal for battery-powered equipment.

Circuit Description

The A/D converter used in the 7106 is known as a dual-slope integrating converter. This converter type is highly accurate, but relatively slow. In our application, speed is not an important factor, and the 3 conversions-per-second rate at which the 7106 is operated is satisfactory. In fact, if the rate were too high the display would be difficult to read. The conversion rate (and the display update rate) is controlled by an internal oscillator. The oscillator frequency is determined by the value of R3 and the capacitor connected to pins 38, 39 and 40 of U1 (see Fig. 1). A frequency of 48 kHz gives us the desired 3 conversions-per-second rate and also yields optimum rejection of line-frequency (60 Hz) noise.

With an analog voltmeter, you measure voltage directly. This is not the case when you are using a digital meter. Instead, the unknown voltage is compared, in the A/D converter, to a known reference voltage. The output from the converter is equal to the *ratio* of the two voltages. For example, if we chose a 50-mV reference and the voltage we are measuring is 150 mV, the ratio is

$$\frac{150\ \text{mV}}{50\ \text{mV}} = 3.00 \qquad \text{(Eq. 1)}$$

To determine the unknown voltage value, we multiply the ratio by the reference value

$$3.00 \times 50.0\ \text{mV} = 150\ \text{mV} \qquad \text{(Eq. 2)}$$

If we had to multiply the display reading by some number every time we made a measurement, we would soon be using our analog meter again! Fortunately, we can solve the problem by choosing the reference voltage carefully. If the reference is a multiple of 10, we can take care of the multiplication simply by moving the decimal point. If, instead of a 50-mV reference, we use 100 mV and position the decimal point properly, the meter will read directly in millivolts.

$$\frac{150\ \text{mV}}{100\ \text{mV}} = 1.50 \text{ (or 150 mV)} \qquad \text{(Eq. 3)}$$

S1E, S2D and S2E are used to select the correct decimal-point position as we change ranges and modes.

Our reference-voltage choice also determines the full-scale meter sensitivity. With a 3-1/2 digit meter, the largest ratio that can be displayed is 1.999 (left-most digit is called a half digit because only 0 or 1 can be displayed there). With a 100-mV reference, our maximum reading is 199.9 mV. This is rounded off and referred to as 200 mV full-scale.

An internal regulator maintains the voltage between V+ (pin 1) and COMMON (pin 32) at 2.8 V. This is used to supply the reference voltage by connecting a divider (R1 and R2) between these pins. By adjusting the divider, the reference voltage can be set to the required 100-mV value.

To extend the full-scale reading to higher voltages, a range divider (R8 through R12) is used. The resistance values have been selected so that the desired full-scale voltage results in 200 mV being applied to the meter input.

To use the basic meter as an ammeter, we measure the voltage drop across a series resistor (R16 through R19). The full-scale current is determined by the value of the series resistor selected. Alternating current and voltage are measured by converting the input to a dc voltage. A half-wave voltage doubler (D1, D2 and the 0.1-μF capacitors) is used for this conversion. The dc voltage from the doubler is equal to the peak-to-peak ac signal value. R13 and R14 are used to scale the dc voltage so that our meter reading will reflect the ac-input rms value.

When measuring resistance, the reference voltage is not needed. Instead, a known-value resistor, or standard, is placed across the REF input, and the unknown resistance is connected across the unknown input. The standard and unknown are connected in series through D3 or D4 (depending on the resistance ranges), and a current is passed through the two resistances. A voltage drop is developed across each resistance and, because the same current is flowing in both, the ratio of the voltage drops is equal to the resistance ratio. We can select any resistance range we like, simply by changing the standard resistor value. The full-scale reading is always twice the value of the standard resistor. D3 and D4 are needed to ensure that the voltages developed at the IC inputs are within the correct range.

Diodes across the input are used to protect the IC from excessive voltage. The auto-zero and integration capacitors (pins 39 and 27) must have good dielectric properties. The Mylar capacitors we used have proven to be satisfactory.

Construction

To simplify construction, we have used an etched-circuit board.[4] This eliminates a "rat's nest" of wires between U1 and the LCD (Fig. 2). Only the connections to S1 and S2 require point-to-point wiring. These connections are shown pictorially in Fig. 3.

Part of every home-construction project is packaging the finished equipment in a case or cabinet. It seems that every builder has his or her favorite style of enclosure, and you can package this multimeter almost any way you like. We used a homemade circuit-board case for the unit shown in the photographs. This makes a compact and inexpensive enclosure. One advantage of this construction style is that you can tailor the case to fit your project, rather than making your project fit someone else's

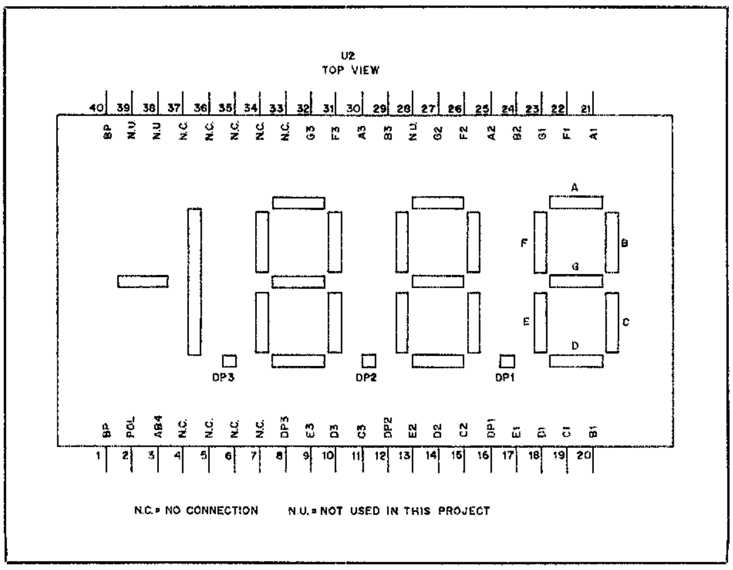


Fig. 2 — Pinout of the LCD. Display is shown as viewed from the top (viewing side). The right-hand digit is number one.

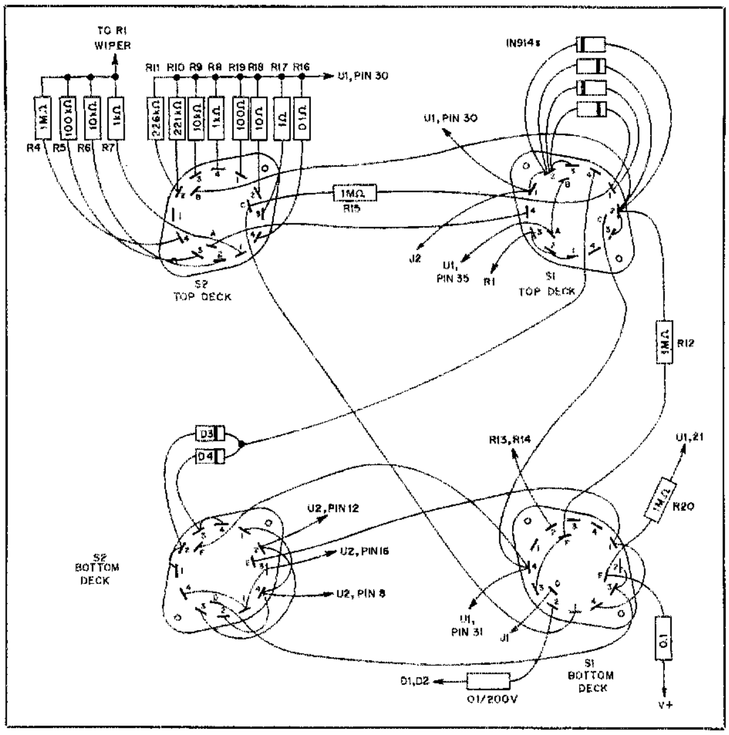


Fig. 3 — Pictorial wiring diagram of the multimeter. The switches are shown as viewed from the rear. Each switch section has three poles, and the arm of each pole is labeled with a letter. These letters correspond to those used in Figs. 1 and 5.

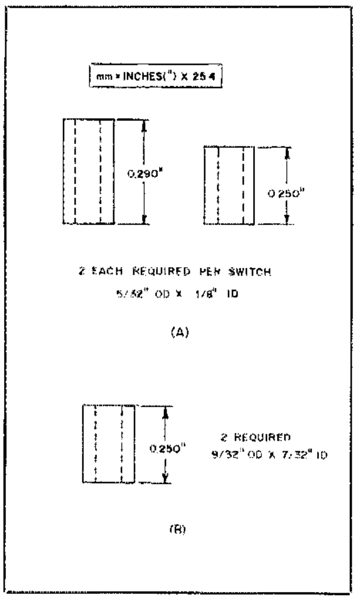
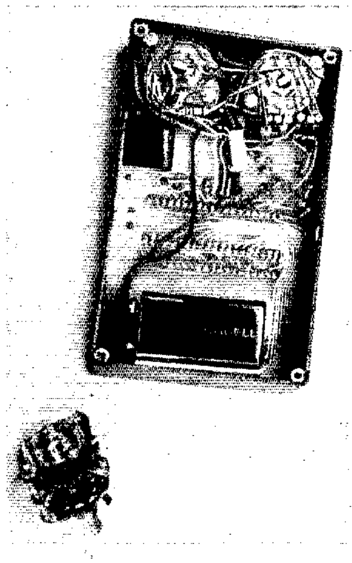


Fig. 4 — Six spacers are required for each switch. Those shown at A are placed over the switch screws. The larger spacers (B) are placed over the switch shaft.



Inside view of the digital multimeter. The battery is held in place by means of double-sided adhesive tape. Also shown is an unmodified switch. The loop portion of each terminal is cut off before the switch is wired into the circuit. R20 is not shown (see Fig. 5). A pad for this resistor is included on later circuit boards.

case. With a little practice and careful workmanship, you can produce attractive circuit-board cases using simple hand tools. If you choose another type of enclosure, be sure to plan the mounting details before you begin assembling the meter.

Our first step is to prepare the switches for mounting on the circuit board. Carefully disassemble one switch. You will need to make six spacers shown in Fig. 4. These can be made by filing the original spacers to the correct lengths. Two more 1/4-inch-long spacers will be required later. These can be made from 5/32-inch diameter metal tubing available at many hobby stores.

After preparing the spacers, place the switch detent assembly on the component side of the board. Pass the switch screws through the board, and then place one of the longer spacers over each screw. Orient the first switch section as shown in Fig. 3 and slide it into place. Now, drop a short spacer onto each screw and place the large-diameter spacer over the switch shaft. Place the remaining switch section in position. Check to make sure you have assembled the sections correctly, and then put the nuts on the screws. If the spacers are the correct lengths, and all the parts are in the proper positions, the screws will extend about 3/16 inch beyond the surface of the nuts. Cut or file the screws flush with the nuts. Be sure to remove any filings that fall into the switch. Repeat this procedure for the second switch. When you have finished, a final check against Fig. 3 and the photographs is a good idea. The last switch-assembly step is to cut off the loop portion of each switch terminal. These loops are not needed; removing them allows us to mount the switches closer to the sides of the case. You can easily solder wires and component leads to the remaining tabs. First, tin the tab and the wire. Place the wire in contact with the tab and heat them with your soldering iron. Most of the time you will not have to apply additional solder. Always keep your soldering iron tip clean and tinned.

You can now begin mounting the components on the circuit board. Start with the resistors and capacitors that are located on the top (component side) of the board. This is a good time to install the three jumper wires and S3 (see Fig. 5). Use a small amount of quick-setting epoxy cement to fasten the larger capacitors to the circuit board. Next, install the LCD (U2). It is mounted slightly above the board surface. In this way the display face will fit flush against the case front panel. Here is a simple way to ensure that the display is positioned in exactly the correct location: Place a mounting nut on each switch shaft and screw them on approximately 1/4 inch. Slip the LCD in place. Be sure it is oriented properly. It's no fun unsoldering 40 IC pins, so check it carefully! You can see the display digits by viewing the LCD in reflected light (hold the display at an angle to your light source). Place the front panel in position. Use no. 4-40 hardware and two 1/4-inch-long spacers to secure the panel to the circuit board near the display. By turning the switch mounting nuts, adjust the panel-to-board spacing until it is 1/4 inch at each end. Secure the panel with two more switch nuts. Put the unit face down on your bench, and tap the display pins gently to seat it against the panel. Solder *one* LCD pin in each row and recheck the alignment. If all is well, solder the remaining pins.

U1 can be installed next. While it is difficult to damage this IC, some precautions are worthwhile. Static is your greatest enemy at this point. Don't walk across a carpeted room and then pick up the IC! Touch a grounded surface before handling the IC. Use of a grounded-tip soldering iron is advisable. Once the IC is soldered in place, it is relatively safe from static damage. Before you solder all 40 pins, double-check the position against Fig. 5.

Each wire that connects a circuit-board pad to a switch terminal is routed through the hole between the switches. Use no. 28 solid-conductor insulated wire for these connections. It is wise to use wire with color-coded insulation, as this makes circuit tracing easier. It's also a good idea to record the color code of each wire on your schematic diagram for future reference.

After connecting all the wires that go to and between the switches, install those components that mount on the etched side of the board. Put in the resistors (last) that connect to S2. Pieces of slip-on insulation should be placed over any resistor leads that might short circuit to another lead or to the switch. Most of the resistors used in this meter are 1%-tolerance types. There are five color-code bands on these resistors. The first, second and third bands are the significant figures, and the fouth band is the multiplier. The last band is always brown. Generally, the first is narrower than the others. A 221-kΩ resistor is coded: red (narrow band), red, brown, orange, brown. If you are not sure about a resistor value, check it with a VOM (volt-ohm-milliammeter) to determine the approximate value.

Attach temporary test leads to S1 (in place of the leads going to J1 and J2), and you are ready to test your multimeter. Short the test leads together, and check to see that the meter reading is zero on all ranges. This meter has no zero adjustment (the IC "takes care" of it for you), so if you don't obtain a zero reading it's time for a little troubleshooting. Most likely, the problem is a wiring error. A thorough inspection should reveal the source of the trouble.

Next, you must set the reference adjustment, R1. This is the only adjustment required, but it is an important one. The meter accuracy depends on how precisely you can make this setting. If possible, borrow a digital voltmeter known to be accurate to 1% or better for use as a reference. Connect the reference meter between U1 pins 35 and 36. Adjust R1 until the reference meter reads 0.100 V (100 mV). That finishes the calibration, and you are set to go!

"I can't borrow a precision voltmeter. What do I do?" Don't worry, there is a way to adjust the multimeter without a second meter. All you need is a fresh carbon-zinc flashlight battery. The open-circuit voltage at the terminals of an unused cell is close to 1.54. To calibrate your meter, place the MODE switch in the dc-voltage position. Connect the test leads to the battery, and adjust R1 for a reading of 1.54 V (set the meter to the 2-V full-scale range). That's all there is to it.

You'll want to check the operation of the other ranges and modes before putting your multimeter in the case. A regular VOM can be used for this. Because we used 1%-range resistors, you can be fairly certain that the multimeter is accurate if the readings are within 10% of the VOM readings.

Even with all the features offered in this meter, you can be sure someone is wondering why we didn't include a frequency counter. Remember what we said about projects of your own? Perhaps an LSI IC frequency counter would be just the right project for you to learn a little more about ICs — LSI style!

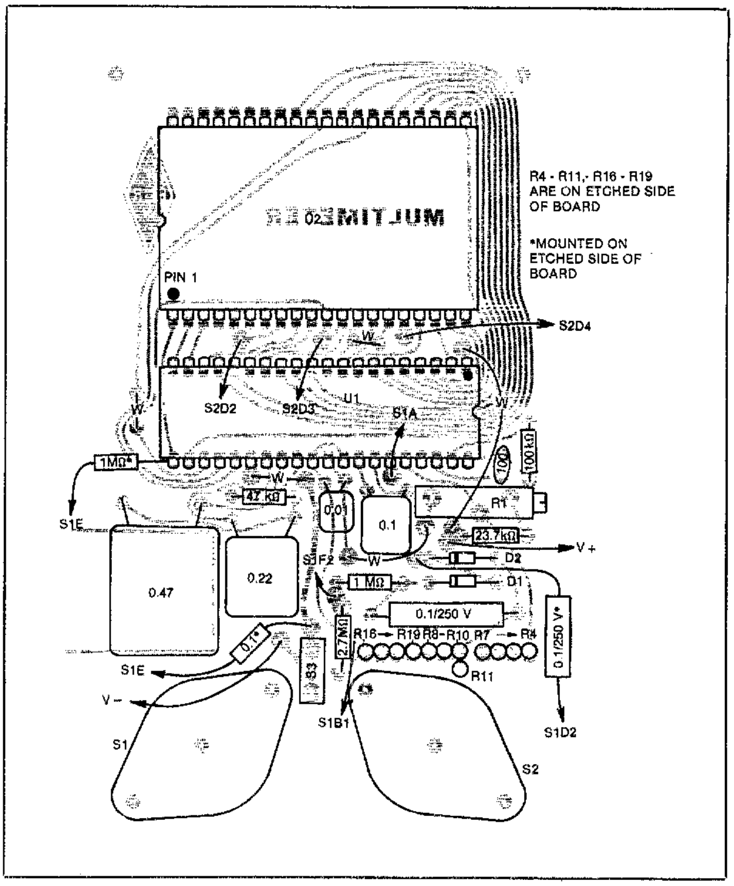


Fig. 5 — Full-scale parts-placement diagram. The circuit board is shown as viewed from the component side. Gray areas represent an X-ray view of the unetched copper. A number of components are mounted on the etched side of the board; these are marked (*).

Notes

[1] J. L. Hall and C. Watts, "Learning to Work with Integrated Circuits," *QST*, Jan. through Oct. 1976 and June 1977.

[2] kg = lb × 0.454; g = oz × 28.4.

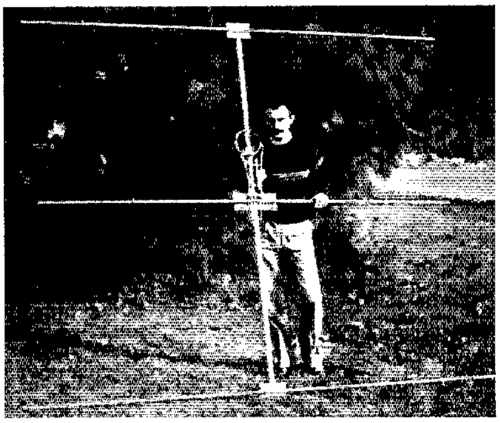
[3] Intersil, Inc., 10710 N. Tantau Ave., Cupertino, CA 95014. Intersil components and data books are available from Jameco Electronics, 1355 Shoreway Rd., Belmont, CA 94002.

[4] Circuit boards, negatives and complete parts kits for the digital multimeter and the circuit-board case are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002.

[5] Precision resistors and other components are available from Mouser Electronics, 11433 Woodside Ave., Santee, CA 92071.

[6] See note 5.

Go for the Gain, NBS Style



Ever wonder why some vhf Yagis seem to have that extra oomph? Learn about the NBS formula for success!

By Dennis J. Lusis,* W1LJ

Have you been in a vhf pileup lately? If so, then you recognize the demand for high-performance antennas. While a number of excellent commercial Yagis are available, the home builder is often left to outdated designs that provide marginal performance by today's standards. This article introduces a generation of gain-optimized Yagi antennas originally described by Viezbicke in *National Bureau of Standards Technical Note 688.*[1] These antennas have been reproduced for use in the amateur vhf and uhf bands with excellent results. Construction guidelines are provided for a 3-element, 50-MHz NBS Yagi that may be used for fixed-station or portable use. Additional data provided allows the builder to construct a larger 50-MHz array, or one for another vhf or uhf band.

The NBS Yagi

Since its conception in 1926, the Yagi-Uda antenna,[2] commonly known as the Yagi, has become the most widely utilized directive array in vhf and uhf communications. Many technical reports have been published regarding the proper tuning of Yagis. Until recently, practically no information was available regarding how element diameter, element length, spacing of the elements, boom diameter and overall length affect the gain. The National Bureau of Standards (NBS) attempted to determine these relationships in their study. Viezbicke's report describes the results of testing carried out for nearly a decade by the NBS at its Sterling, Virginia, and Table Mountain, Colorado, antenna test ranges. The results were used later by others such as Lawson and Reisert[3] who used the data to verify computer-generated models of Yagi performance. Although discrepancies exist between the Lawson and the NBS findings, the greater number of similarities between computer and empirical data add credibility to both.

NBS Test Procedures

All NBS modeling was done at 400 MHz. The test antenna was placed at the receiver end, and was separated approximately 1000 feet[4] from the transmitter and its antenna. Both antennas were mounted 3 wavelengths (λ) above ground. The test Yagi was compared to a reference dipole position 5 λ to one side, and at the same height as the Yagi. The test Yagi and the reference dipole were matched to 50 Ω and compared using a calibrated step attenuator. Gain was reproducible to within 0.2 dB throughout the test.

NBS Test Results

The NBS antenna testing provided useful information for antenna builders. Here, for the first time, experimenters could determine how dimensional aspects of their designs would interact and ultimately affect the performance of their antennas. A complete overview on how all design parameters interact is beyond the scope of this article; the reader is referred to *NBS Technical Note 688* for more detailed information. For convenience, the element dimensions yielding maximum gain for vhf and uhf Yagis are given in Tables 1 through 4. These lengths were calculated from the NBS test results. Element spacing for the various arrays are shown in Fig. 1.[5] Note that the tables specify exact boom and element diameters. Strict adherence to these dimensions will result in a Yagi of exceptionally high gain. If the builder wishes to construct a Yagi from available materials differing in size from those specified, he should consult Table 5 and the charts in Figs. 2 and 3 for conversion data.

Using the Conversion Charts

It has long been known that the diameter-to-wavelength ratio of a supporting boom affects the tuning of Yagi elements. Determining the characteristics of this effect was one of the primary objectives in the NBS study. Fig. 3 illustrates how optimum element length varies with boom diameter changes. When boom diameter increases, elements must be lengthened proportionately to remain at optimum length. For example, using 50.1 MHz as a design frequency, let us see exactly how much element length must be increased for given increases in boom and element diameter.

Table 1 gives a 3-element, 50-MHz Yagi boom length of 7 ft. 10 in. (0.4 λ), and a diameter of 1-1/4 in. Element diameter is 1/2 in. We would like to substitute a 2-1/2 in. diameter boom, and 3/4-in. diameter elements. To calculate the proper element lengths for any NBS Yagi, the following information must first be specified:

$$\lambda = \frac{299.01}{50.1 \text{ MHz}} = 5.97 \text{ m or } 235 \text{ in.} \quad \text{(Eq.1)}$$

(The velocity of light is expressed as 299.01×10^6 m/sec.)

Element diameter (d): 0.75 in. Element diameter, expressed in terms of wavelength (d/λ)

$$\frac{0.75 \text{ in.}}{235 \text{ in.}/\lambda} = 0.0032\,\lambda \quad \text{(Eq. 2)}$$

Boom diameter (D): 2.5 in. Boom diameter, expressed in terms of wavelength (D/λ)

$$\frac{2.5 \text{ in.}}{235 \text{ in.}/\lambda} = 0.0106\,\lambda \quad \text{(Eq. 3)}$$

After calculating these values, refer to

[1]Notes appear on page 38.

*ARRL Assistant Technical Editor

Table 1

NBS 50.1 MHz Yagi Dimensions

meters = 0.3048 × feet
mm = 25.4 × inches

Boom Length	Boom Diameter	Element Diameter	Ref.	Driven	Dir. 1	Dir. 2	Dir. 3	Dir. 4	Dir. 5	Dir. 6	Dir. 7	Dir. 8	Dir. 9	Dir. 10
7' 10"(0.4 λ)	1-1/4"	1/2"	9' 7-3/4"	9' 1-3/4"	9' 1 3/8"									
15' 8-1/2"(0.8 λ)	2"	3/4"	9' 7"	9' 1-3/4"	8' 9-5/8"	8' 8-7/8"	8' 9-5/8"							
23' 6-7/8"(1.2λ)	2"	3/4"	9' 7-3/4"	9' 1-3/4"	8' 10-1/4"	8' 8-7/8"	8' 8-7/8"	8' 10-1/4"						
39' 3-3/8"(2.2λ)	2"	3/4"	9' 7-3/4"	9' 1-3/4"	8' 11"	8' 8-1/8"	8' 6-1/2"	8' 4-5/8"	8' 3"	8' 3"	8' 3"	8' 3"	8' 4-5/8"	8' 6-1/2"

Table 2

NBS 144.1-MHz Yagi Dimensions

meters = 0.3048 × feet
mm = 25.4 × inches

Boom Length	Boom Diameter	Element Diameter	Ref	Driven	Dir. 1	Dir. 2	Dir. 3	Dir. 4	Dir. 5	Dir. 6	Dir. 7	Dir. 8	Dir. 9	Dir. 10	Dir. 11	Dir. 12	Dir. 13	Dir. 14	Dir. 15
5'5-9/16"(0.8λ)	1"	3/16"	3'4-5/8"	**3' 2-3/16"**	3'1-1/2"	3'1-3/8"	3'1-1/2"												
8'2-5/16"(1.2λ)	1"	3/16"	3'4-5/8"	**3' 2-3/16"**	3'1-1/2"	3'1-1/8"	3'1-1/8"	3'1-1/2"											
15'1/4"(2.2λ	1 1/4"	3/16"	3'4-13/16"	**3' 2-3/16"**	3'1-15/16"	3'5/8"	3'	2'11-3/8"	2'11-3/8"	2'11-3/8"	2'11-3/8"	2'11-3/8"	3'	3'5/8"					
21'10-1/16"(3.2λ)	1 1/2"	3/16"	3'5-1/16"	**3' 2-3/16"**	3'1-15/16"	3'1-3/8"	3'13/16"	3' 3/16"	3'	2'11-5/8"	2'11-3/8"	2'11-3/8"	2'11-3/8"	2'11-3/8"	2'11-3/8"	2'11-3/8"	2'11-3/8"	2'11-3/8"	2'11-3/8"
28'8-1/8"(4.2λ)	1 1/2"	3/16"	3'4-1/2"	**3' 2-3/16"**	3'1-5/8"	3'1-5/8"	3'1-7/16"	3'11/16"	3'9/16"	3'3/16"	2'11-7/8"	2'11-5/8"	2'11-5/8"	2'11-5/8"	2'11-5/8"	2'11-5/8"	2'11-5/8"		

Table 3

NBS 220.1-MHz Yagi Dimensions

meters = 0.3048 × feet
mm = 25.4 × inches

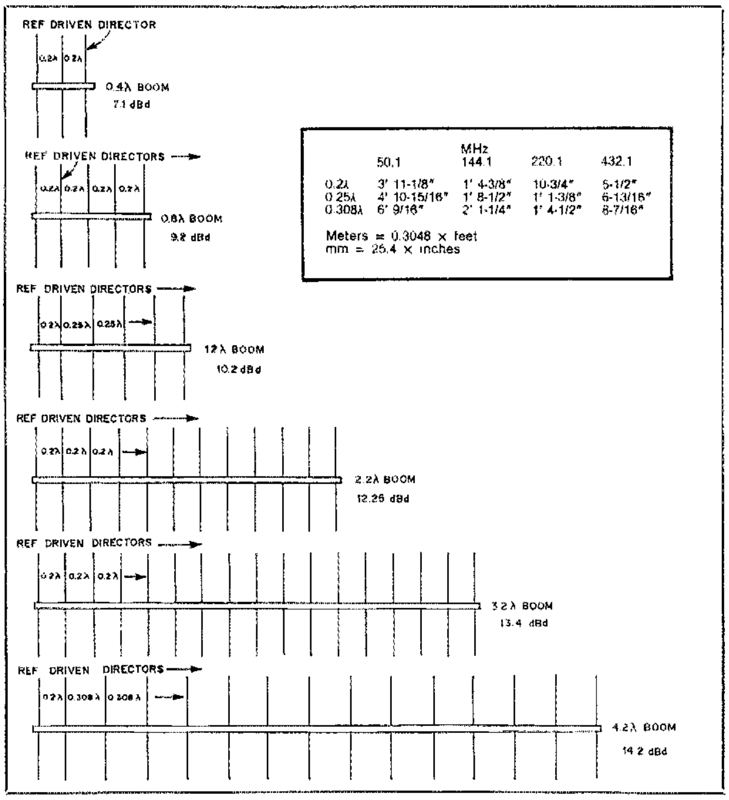
Boom Length	Boom Diameter	Element Diameter	Ref	Driven	Dir. 1	Dir. 2	Dir. 3	Dir. 4	Dir. 5	Dir. 6	Dir. 7	Dir. 8	Dir. 9	Dir. 10	Dir. 11	Dir. 12	Dir. 13	Dir. 14	Dir. 15
3'6-15/16"(0.8λ)	1"	3/16"	2'2-1/16" 2'2-3/4"	2'1"	1'11-13/16" 2'1/2"	1'11-11/16" 2'3/8"	1'11-13/16" 2'1/2"												
5'4-3/8"(1.2λ)	1"	3/16"	2'2-1/16" 2'2-3/4"	2'1"	1'11-13/16" 2'1/2"	1'11-9/16" 2'1/4"	1'11-9/16" 2'1/4"	1'11-3/16" 2'1/2"											
9'10"(2.2λ)	1"	3/16"	2'2-1/16" 2'2-3/4"	2'1"	2'1/16" 2'3/4"	1'11-5/16" 2'1/16"	1'10-15/16" 1'11-5/8"	1'10-1/2" 1'11-1/4"	1'10-1/8" 1'10-7/8"	1'10-1/8" 1'10-7/8"	1'10-1/8" 1'10-7/8"	1'10-1/8" 1'10-7/8"	1'10-1/2" 1'11-1/4"	1'10-15/16" 1'11-5/8"					
14'3-11/16"(3.2λ)	1 1/4"	3/16"	2'2-1/16" 2'3"	2'1"	1'11-13/16" 2'3/4"	1'11-9/16" 2'7/16"	1'10-15/16" 1'11-7/8"	1'10-1/2" 1'11-7/16"	1'10-5/16" 1'11-1/4"	1'10-1/8" 1'11"	1'9-7/8" 1'10-13/16"	1'9-7/8" 1'10-13/16"	1'9-7/8" 1'10-13/16"	1'9-7/8" 1'10-13/16"	1'9-7/8" 1'10 13/16"	1'9-7/8" 1'10-13/16"	1'9 7/8" 1'10 13/16"	1'9-7/8" 1'10-13/16"	1'9 7/8" 1'10 13/16"
18'9-5/16"(4.2λ)	1 1/2"	3/16"	2'1-11/16" 2'2-3/4"	2'1"	1'11-5/8" 2'11/16"	1'11-5/8" 2'11/16"	1'11-7/16" 2'1/2"	1'10-7/8" 2'	1'10-3/4" 1'11-13/16"	1'10-1/2" 1'11-9/16"	1'10-5/16" 1'11-3/8"	1'10-1/8" 1'11-3/16"	1'10-1/8" 1'11-3/16"	1'10-1/8" 1'11-3/16"	1'10-1/8" 1'11-3/16"	1'10-1/8" 1'11-3/16"	1'10-1/8" 1'11 3/16"		

Table 4

NBS 432.1-MHz Yagi Dimensions

meters = 0.3048 × feet
mm = 25.4 × inches

Boom Length	Boom Diameter	Element Diameter	Ref	Driven	Dir. 1	Dir. 2	Dir. 3	Dir. 4	Dir. 5	Dir. 6	Dir. 7	Dir. 8	Dir. 9	Dir. 10	Dir. 11	Dir. 12	Dir. 13	Dir. 14	Dir. 15
2'8-13/16"(1.2λ)	1"	3/16"	1'1-15/16"	**1' 23/32"**	1'17/32"	1'11/32"	1'11/32"	1"17/32"											
5'1/8"(2.2λ)	1"	3/16"	1'1-15/16"	**1' 23/32"**	1'21/32"	1'3/16"	1'	11-3/4"	11-17/32"	11-17/32"	11-17/32"	11-17/32"	11-3/4"	1'					
7'3-15/32"(3.2λ)	1"	3/16"	1'1-15/16"	**1' 23/32"**	1'9/16"	1'11/32"	1'	11-3/4"	11-5/8"	11-17/32	11-13/32"	11-13/32"	11-13/32"	11-13/32"	11-13/32"	11-13/32"	11-13/32"	11-13/32"	11-13/32"
9'6 25/32"(4.2λ)	1"	3/16"	1'1-3/4"	**1' 23/32"**	1'7/16"	1'7/16"	1'11/32"	1'	11-7/8"	11-3/4"	11 5/8"	11-17/32"	11-17/32"	11-17/32"	11-17/32"	11-17/32"	11-17/32"		



	MHz 50.1	144.1	220.1	432.1
0.2λ	3' 11-1/8"	1' 4-3/8"	10-3/4"	5-1/2"
0.25λ	4' 10-15/16"	1' 8-1/2"	1' 1-3/8"	6-13/16"
0.308λ	6' 9/16"	2' 1-1/4"	1' 4-1/2"	8-7/16"

Meters = 0.3048 × feet
mm = 25.4 × inches

Fig. 1 — Element spacing for the various Yagi arrays, in terms of boom wavelength.

Table 5

Optimized Lengths of Parasitic Elements For Yagi Antennas of Six Different Lengths

	Length of Yagi in Wavelengths 0.4	0.8	1.20	2.2	3.2	4.2
Length of Reflector λ	0.482	0.482	0.482	0.482	0.482	0.475
Lenth of Director, λ 1st	0.442	0.482	0.482	0.432	0.482	0.424
2nd		0.424	0.420	0.415	0.420	0.424
3rd		0.428	0.420	0.407	0.407	0.420
4th			0.428	0.398	0.398	0.407
5th				0.390	0.394	0.403
6th				0.390	0.390	0.398
7th				0.390	0.386	0.394
8th				0.390	0.386	0.390
9th				0.398	0.386	0.390
10th				0.407	0.386	0.390
11th					0.386	0.390
12th					0.386	0.390
13th					0.386	0.390
14th					0.386	
15th					0.386	
Spacing Between Directors, in λ	0.20	0.20	0.25	0.20	0.20	0.308
NBS Claimed Gain Relative to Half-Wave Dipole in dB	7.1	9.2	10.2	12.25	13.4	14.2
Design Curve (See Fig. 2)	(A)	(C)	(C)	(B)	(C)	(D)

Element diameter = 0.0085λ
Reflector Spaced 0.2λ behind driven element

Table 5, which provides the optimized lengths of parasitic elements for Yagis of six different boom lengths, as shown in Fig. 1. (Note that these values are based on a specific element d/λ of 0.0085, and are not yet compensated for boom diameter.) Find the Yagi boom length that you want to work with at the top of Table 5. In our case, it is 0.4 λ. The numbers 0.482 and 0.442 listed below represent the lengths of the reflector and the director, respectively. Mark these two values on the graph found in Fig. 2. These points should be placed along reflector and director design curves "A" which correspond to the 0.4-λ Yagi. Notice that both points fall exactly on the vertical design reference line at d/λ = 0.0085.

To determine what our element lengths should be, refer back to Eq. 2. This equation states that our Yagi has an element d/λ of 0.0032. Draw a vertical line on the graph in Fig. 2 from the point d/λ = 0.0032, found on the horizontal axis. Since both the reflector and the director points fall exactly on the vertical line d/λ = 0.0085 in the design example, it is a simple matter to determine our "new" element lengths. Mark the two points where the vertical line d/λ = 0.0032 intersects reflector and director design curves "A." The element lengths may now be read from the scale on the left:

Ref. = 0.487 λ

Dir. = 0.457 λ

This example, using the 3-element, 0.4-λ Yagi is quite simple because both the director and reflector points fall directly on the vertical design-reference line. Element lengths for the five longer Yagis require a slightly different technique to be determined. Take the 5-element, 0.8-λ antenna, for example. Because this antenna has multiple directors (of varying lengths) there will be more than one point to plot along director design curve "C." It is first necessary to plot all the points and, using a set of dividers, measure the distance between each point on the design curve and the vertical reference line at d/λ = 0.0085. You must then transpose these distances away from the new vertical line that represents your particular Yagi element d/λ. Just be sure to mark the distance off on the proper side of the line, for some points will lie to the left, and others to the right! Also, be sure to plot the new points on the proper design curve "A"-"D." After all points have been plotted, the new element lengths may be read directly from the scale on the left, as in the previous example.

So far, the procedure I have outlined deals strictly with compensation that is necessary because of varying element diameter. Boom diameter also has a considerable effect on optimum element length. The NBS Yagi is not complete without taking this into account.

Referring to Eq. 3, we know that our boom D/λ = 0.0106. The graph in Fig. 3

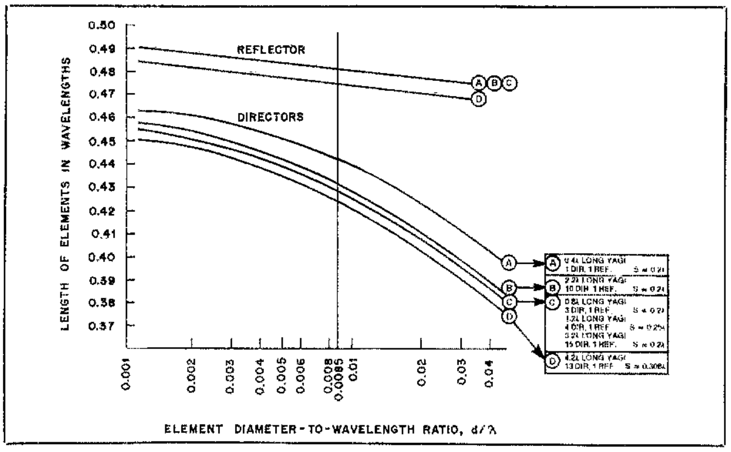


Fig. 2 — Curves showing the relationship between element diameter-to-wavelength ratio and the element length for different Yagi arrays.

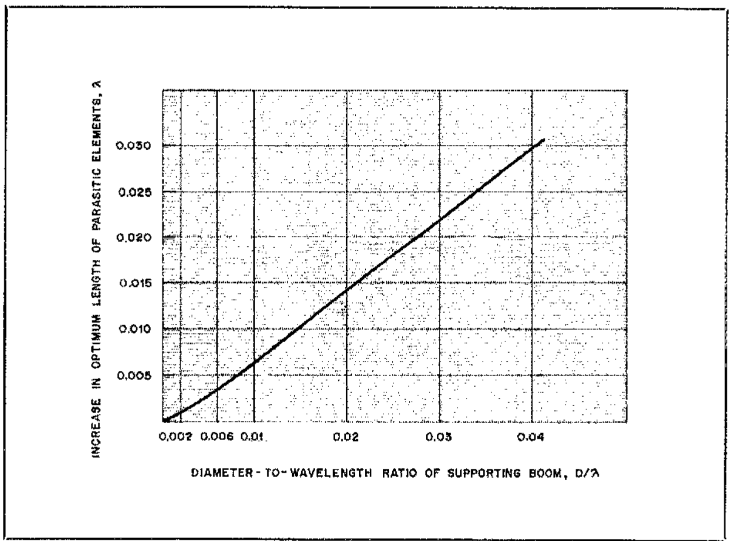


Fig. 3 — Curve showing the effect of a supporting boom on the length of Yagi elements.

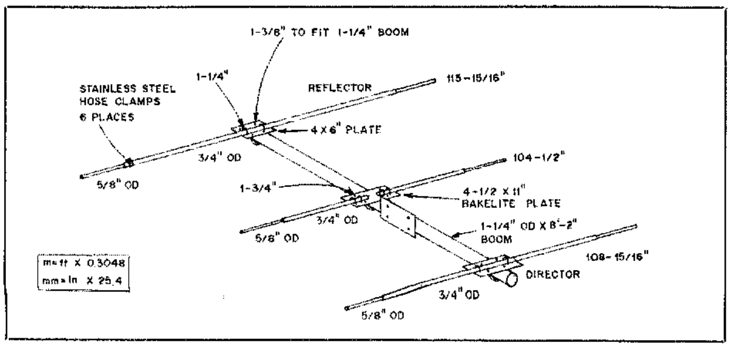


Fig. 4 — Dimensional drawing of the 3-element, 50-MHz Yagi described in the text.

indicates that, with this boom D/λ, it is necessary to lengthen all elements by 0.0065 λ to remain at optimum length. Simply add this amount to the previously determined element lengths for our 3-element, 50-MHz Yagi. The final, optimum parasitic element lengths are:

Ref. $= 0.487\ \lambda + 0.0065\lambda = 0.4935\lambda$

$0.4935\lambda \times 235\ \text{in.}/\lambda = 115.97\ \text{in.}$

Dir. $= 0.457\lambda + 0.0065\lambda = 0.4635\lambda$

$0.4635\lambda \times 235\ \text{in.}/\lambda = 108.92\ \text{in.}$

No mention is made concerning driven-element length, because the choice of matching system exerts considerable influence on it. Standard methods for determining driven-element lengths can be used, or the measurements found in Tables 1 through 4 can be used as starting points. An in-depth discussion of driven element/feed systems may be found in *The ARRL Antenna Book.*[6]

The W1LJ NBS Yagi

To illustrate the procedures described in this article, I constructed a 3-element Yagi for the 50-MHz band. No special attempt was made to procure materials of the exact dimensions called for in Table 1. A quick look through the ARRL laboratory junk box turned up enough scrap aluminum for the project. Elements were fashioned from 3/4-inch OD tubing, with short pieces of 5/8-inch OD tubing telescoped in the ends for fine adjustment. Overall dimensions can be seen in Fig. 4. Boom-to-element clamps were made of scrap heavy-gauge aluminum plate, U-bolts and plated muffler clamps. Likewise, the boom-to-mast plate was made from aluminum plate — only heavier gauge than used on the element clamps. Construction details can be seen in Fig. 5. The 8-ft 2-in.-long boom was salvaged from a piece of 1-1/4 inch OD heavy wall aluminum electrical conduit.

Feed System

A hairpin feed system was chosen for the Yagi.[7] Because it is balanced, this type of feed tends to prevent pattern skewing and unwanted side lobes. Details of the hairpin construction can be seen in Fig. 6.

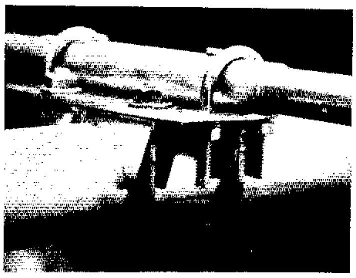


Fig. 5 — Photograph illustrating the element-to-boom clamp. Heavy-gauge scrap aluminum, U-bolts and plated muffler clamps were used to make up the assembly.

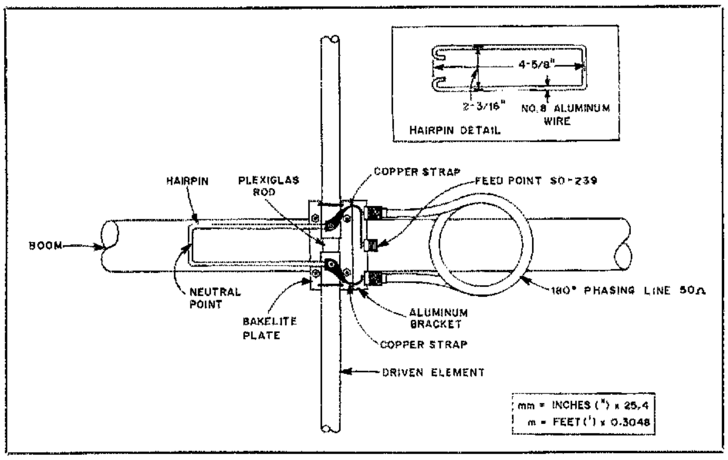


Fig. 6 — Detail of the hairpin matching and the feed system used with the 3-element, 50-MHz Yagi. Coaxial phasing-line lengths are discussed in the text.

The driven element and the feed assembly are insulated from the boom through the use of a 3/16-inch-thick bakelite mounting plate. Plexiglas rod is used as an insulator between the two halves of the driven element. An aluminum bracket is used to mount the three SO-239 connectors to the bakelite plate. The hairpin is made from no. 8 aluminum grounding wire, and is connected across the split element halves. The hairpin is electrically neutral at the exact center, and either may be fastened to the boom at this point or allowed to hang freely. A coaxial 1/2-λ phasing line is also connected across the driven element halves to provide a 180-degree phase shift between them. For cable with a 0.8 velocity factor, the phasing line should be 7 ft, 10-3/8 in.; for cable with a 0.66 velocity factor, 6 ft, 5-3/4 in. These phasing-line lengths will remain constant for any of the 50-MHz Yagis in Table 1. Hairpin and driven-element length must be determined experimentally for Yagis with different numbers of elements. It should be noted that with a hairpin match the driven element will be considerably shorter than specified in Table 1. Both parasitic elements were lengthened slightly from the Table 1 dimensions, as previously determined.

Performance

Upon completion, the 3-element NBS Yagi was installed at a 75-foot level above the ARRL Hq. building. The Hq. operators' club station, W1INF, was used to test and evaluate the antenna. A quick check indicated a good match at 1.25:1 VSWR. Delivering under 10 watts to the antenna, it took only a few minutes to see the exceptional performance the Yagi would provide. My first contact was a 6-to 10-meter crossband QSO with SM6PU! A few moments later the Yagi was rotated west, and a score of W6 and W7 stations were contacted. All signal reports from the West Coast were 59+. Not bad for less than 10 watts! A week of casual operating with never more than 50 watts to the antenna snagged the following prefixes: TF, HK, 8P6, T32, XE, KL7, EL, C5 and my best DX — AH8 in American Samoa! Although my signal was not quite as strong as those of the "kilowatt boys," I was never far behind in the pileups. In short, the gain seems very good, especially when one considers how small the Yagi is. The NBS data claims a gain of 7.1 dB over a dipole. Keep in mind that the NBS Yagi is optimized for maximum gain. The claimed front-to-back ratio is between 15 and 20 dB — not an extremely high figure, but acceptable for most vhf work. An outstanding feature of this Yagi is the clean and symmetrical pattern, which may prove to be a more valuable measure of performance than front-to-back ratio.

I would like to thank ARRL Hq. staff members Gerry Hull, AK4L, Pete O'Dell, KB1N, and Bernie Glassmeyer, W9KDR. They provided much help in constructing, tuning and installing the 3-element, 50-MHz Yagi.

Notes

[1]P. Viezbicke, "Yagi Antenna Design," NBS Technical Note 688, U.S. Department of Commerce, Washington, DC., Dec. 1976.

[2]H. Yagi and S. Uda, *Proceedings of the Imperial Academy*, Feb. 1926.

[3]J. Lawson, "Yagi Antenna Design: Experiments Confirm Computer Analysis," *Ham Radio*, Feb. 1980, pp. 19-27. J. Reisert, "How to Design Yagi Antennas," *Ham Radio*, Aug. 1977.

[4]m = ft × 0.3048; mm = in. × 25.4.

[5]Tables 1 through 4 and Fig. 1 are taken from *The Radio Amateur's Handbook*, 59th ed. (Newington: ARRL, 1981).

[6,7]G. Hall, ed., *The ARRL Antenna Book*, 14th ed. (Newington: ARRL, 1982), Chapter 5.

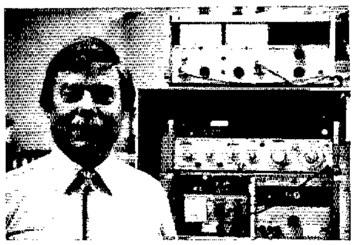
Strays

TA PROFILES

☐ ARRL Technical Advisor Roy Hejhall, K7QWR, joined our official consultant family five years ago. During this period, his expertise in rf-power semiconductor devices and circuits has been invaluable to the League and to Amateur Radio. He has contributed many articles for *QST*, and is the recipient of a Cover Plaque award (*QST*, March 1972). Roy has also written technical articles for leading professional publications, and has been a technical speaker at ARRL conventions and at numerous radio-club meetings and hamfests.

Licensed as WØTRH in 1954, Roy now holds an Advanced class license. Vhf and uhf fm (including linked remote-base systems) are his primary interests in Amateur Radio. He is a Life Member of ARRL, with memberships in QCWA, the Arizona Repeater Association, the Motorola Amateur Radio Club and the Saguaro Amateur Remote Base Association.

Roy received his BS degree from the U.S. Naval Academy. He now resides in Phoenix, Arizona, and is the principal staff engineer for the Motorola Semiconductor Products Sector. For 20 years he has been involved in product-development engineering (vhf and uhf bipolar and field-effect power transistors), starting as a member of the engineering team that introduced the first 15-W, 50-MHz transistor (the 2N2947). Roy enjoys music, photography and sharing his Amateur Radio activities with his XYL (WB7RPB). — *Marian Anderson, WB1FSB*

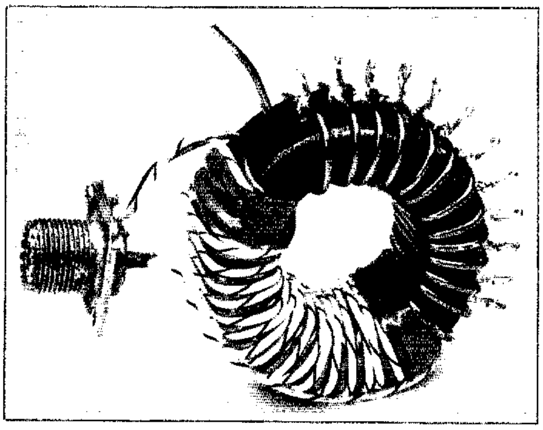


We don't know whether K7QWR's big smile was caused by a recent success in some job-related work with the test gear in the picture, or if it's because the 5 o'clock whistle just blew and he's thinking of firing up his fm mobile rig. But Roy smiles a lot, and he is definitely one of the "good guys."

I would like to get in touch with . . .

☐ owners of Collins KWM-380 rigs who are using Alpha amplifiers. Andrew Caughey, Jr., W8QIT, 15256 Levan Rd., Livonia, MI 48154.

A "Multipedance" Broadband Transformer



A tapped broadband transformer helps solve problems in experimental work. Here's a toroidal type that covers a wide range of impedance transformations.

By Doug DeMaw,* W1FB

Is a multi-impedance transformer a scientific wonder? Shucks, no! The concept is as old as electronics, but is often overlooked by amateur experimenters. Being an inveterate experimenter myself, I find it useful to have as many "fudging" tools in the workshop as possible. Certainly, a broadband switchable-impedance transformer qualifies as an important piece of test apparatus. Furthermore, this type of device can be used for determining the necessary number of turns for a fixed-ratio transformer that will be put to permanent use in a circuit.

Applications

A variable-impedance transformer can be used to approximate the value of an unknown impedance within its matching range. It is necessary only to know one of the two impedances with which we are dealing. For antenna work we can generally assume that the feed line to the transmitter or receiver is 50 ohms, although in some cases it may be 75 ohms. This becomes our known factor, and a fixed number of turns are laid on the transformer core to comprise the 50- or 75-ohm winding. Although an rf noise bridge or a sophisticated rf impedance bridge can be used to measure unknown impedances, they require associated items of test equipment and ac or dc power to operate them. The variable-impedance transformer needs nothing other than a VSWR indicator, thereby making it more convenient for field use.

I find my greatest application for the transformer in experimental work with antennas. Many times when a new idea is being tried, the impedance of the antenna feed point is unknown. The variable-impedance transformer provides a match to 50-ohm coaxial line and gives me a reasonable idea of what the feed impedance is. I can then leave the transformer in the line and test the antenna under transmitting and receiving conditions. Later, if I consider the antenna worth using over a longer period of time, the transformer can be replaced with a suitable matching network, or I can wind a fixed-ratio transformer and install it at the feed point. Practically, the gadget is a time-saver.

Another application for the transformer would be between the exciter and a linear amplifier, if the amplifier did not present a suitable impedance to the exciter. The correct transformer tap point would be selected to provide a low VSWR.

Construction Notes

I elected to wind a transformer that would handle the output from a 1-kW transmitter. Therefore, if I wanted to leave the unit in the line for extended on-the-air testing, it would accommodate the full power from my station without arcing or saturating. Owing to the high flux densities of powdered-iron cores over ferrite ones (per unit cross-sectional area), the former was chosen. The circuit is shown in Fig. 1. The core is an Amidon (Micrometals Corp.) jumbo T-225A-2, which is roughly equivalent to a pair of T-200 cores stacked one on top of the other.

The fixed-value winding has an X_L of 200, four times (recommended) the 50-ohm level at which it will be used. If the lowest operating frequency is to be 3.5 MHz, the required inductance of the winding will be 9 μH (17 μH for use at 1.8 MHz). The A_L factor of this toroid core is 275, which requires a winding of approximately 18 turns for an X_L of 200 ohms. This is determined by

$$\text{turns} = 100\sqrt{L/A_L}$$

where A_L is the manufacturer's index, and L is in μH. Hence, for use at 1.8 MHz, the fixed winding would require 25 turns. The tapped winding (secondary) would have to be increased accordingly to provide the range of impedances represented in Table 1.

The blank core should be wrapped with a layer of 3M brand glass epoxy tape or something of equivalent dielectric strength. This will help to prevent arc-over and abrasion of the windings. The tapped winding is laid on the core first. My transformer (see photograph) has only 12 taps, and was set up to give transformations upward from 50 ohms. However, each turn can be tapped to obtain a range from less than 50 ohms to greater than 50 ohms. Table 1 contains data for a transformer with 27 taps. The enamel insulation is scraped from the winding at each tap point. Then, a short piece of heavy bus wire is formed into a loop and soldered to the winding at each tap point.

The fixed-turn winding of the transformer is wound last. The turns lie between the turns of the larger winding. I used some Teflon-insulated no. 18 wire I

*QST Senior Technical Editor

had on hand. This is recommended to provide a high degree of insulation between the two windings. Alternatively, one might use Teflon sleeving over enameled copper wire, or glass epoxy tape could be wound over the larger winding (beneath the fixed winding) to isolate the windings. A durable version of this transformer could be had by encapsulating the completed transformer in casting resin of good dielectric quality. I have had good results with the resin sold by Tandy Corp. The terminals of the transformer would need to be brought out of the mold for access later on. A coating of silicone grease will prevent the resin from adhering to the terminals.

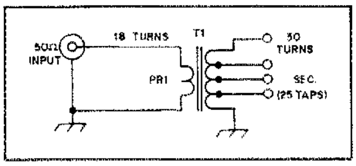


Fig. 1 — Schematic diagram of the variable-impedance transformer.

Table 1

Approximate Load Resistance and Transformation Ratio of the Broadband Transformer

Turn No.	*Impedance Ratio (approx.)*	*Load Resistance (Ω) (approx.)*
5	13:1	3.85
6	9:1	5.55
7	6.6:1	7.57
8	5:1	9.87
9	4:1	12.50
10	3:1	15.43
11	2.5:1	18.80
12	2.2:1	22.22
13	1.9:1	26.25
14	1.6:1	30.51
15	1.4:1	34.72
16	1.2:1	39.85
17	1.1:1	45.35
18	1:1	50.00
19	1.1:1	55.70
20	1.2:1	61.72
21	1.4:1	68.00
22	1.5:1	74.70
23	1.6:1	81.63
24	1.8:1	88.88
25	1.9:1	96.45
26	2:1	104.32
27	2.2:1	112.50
28	2.4:1	120.98
29	2.6:1	130.00
30	2.8:1	139.00

Numbers have been rounded off in some instances. Values are based on a fixed impedance of 50 ohms at the transformer input. Higher step-up ratios can be had by increasing the number of turns on the transformer secondary. This may be necessary for obtaining a matched condition between some exciters and the input of a power amplifier.

Application

When one is dealing with low impedances, it is important to keep the leads to the transformer taps as short as possible. The slightest amount of lead length will introduce reactances that can confuse the results of measurements. This means that a switched version of the transformer should be laid out carefully to avoid unwanted stray inductance or capacitance.

The most accurate test results will be had if the fixed-value winding (50 ohms) is terminated in a known 50-ohm resistance. A 6-dB pad can be built easily for inclusion in the line to the transformer primary. It must be capable of accommodating the power of the signal source. A pad made with 2-watt resistors would be entirely suitable for use with a 2-watt transmitter during antenna-matching experiments. A pad of this type is shown in Fig. 2, which contains a block diagram of a typical test setup for using the transformer.

Having a multi-impedance transformer in your workshop could prove useful for a variety of test applications. Try one — you might like it!

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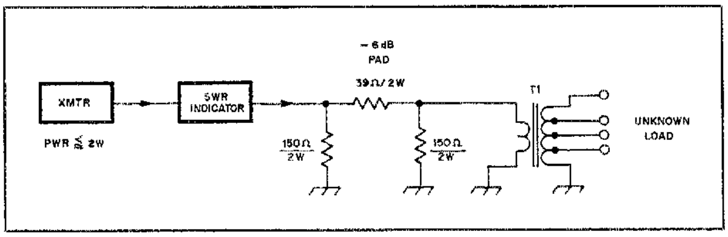


Fig. 2 — Hybrid diagram showing a typical arrangement for using the transformer discussed in the text. Values for the resistors in the 6-dB pad are given to the nearest standard values. Noninductive carbon resistors should be used, with the pigtails and connecting leads as short as possible.

Strays

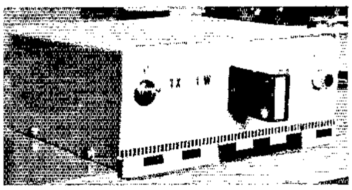
QRP, DL STYLE

☐ Many times we have heard about the masterful work done by the elves in the Black Forest, and the photographic example seen in this Stray might easily suggest that the equipment was built by those famous gnomes in Germany. Not so, but the equipment was built in DL-land, by Adolf Vogel, DL3SZ.

Building one's own radio gear is a popular pastime abroad, perhaps more so than in the USA. Adolf says that most of his transmitters have been homemade for years, but he couldn't resist constructing the "Little Joe" universal QRP rig from August 1981 *QST* ("Experimenting for the Beginner").

Adolf uses the QRP transmitter on 40 meters along with three FT-243 style crystals. The package size is approximately 12 × 12 × 45 mm. With his micro power he has worked the USA, Europe and other DL stations. He worked N3EA and received an RST 339 report. Adolf says that N3EA was a "Big Joe" station, running a kW into a 3-element Yagi!

Adolf says further that the *QST* article was very helpful for newcomers, and the project will be discussed at the local DARC meetings. Keep up the good work, Adolf. And, just think what your "Little Joe" could do if you had a 3-element, 40-meter Yagi to use with it! — *Doug DeMaw, W1FB*



This rig may not be the work of elves, but, judging from the excellent results Adolf Vogel, DL3SZ, gets with his homemade 40-meter QRP transmitter, the unit may indeed be charmed. *(photo courtesy DL3SZ)*

MOVING? UPGRADING?

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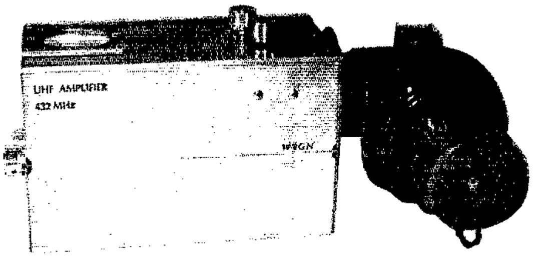


Phase III with a Tetrode UHF Amplifier

Build a 70-cm amplifier with the power to reach the new generation of high-flying satellites.

By Fred J. Merry,* W2GN

Are you ready for the AMSAT-OSCAR Phase III satellites? The first one, Phase III B, should be up soon. A lot of fun and DX can be yours if you take advantage of this exciting mode of communication. Fig. 1 is a block diagram of the W2GN Phase III earth station. By using different i-fs for transmit and receive, I can listen while I transmit.

We don't know how much power it will take for reliable contacts through the new satellite. AMSAT suggests a 100-watt output amplifier with a 13-dBd gain antenna on an az-el mount. With 50 ft of RG-8/U feed line, that should give you about 1000 watts of erp.[1] We will know if this is the right amount only after the satellite is in operation.

Today the cost of a solid-state, 100-watt output uhf amplifier with power supply makes a homebuilt 4CX250 or 8930 tetrode tube amplifier seem attractive. A tetrode amplifier will deliver 300 watts of output with less than 10 watts of drive. The tube amplifier is no more difficult to construct than a solid-state version, and some amateurs may already have many of the parts. That is why I built this amplifier for 435-MHz satellite uplink communications.

To minimize line losses, the amplifier can be placed in a remote, weatherproof location, such as an attic. (See Fig. 1.) The transmitting converter should be located next to the amplifier. A downlink band-pass filter and low-noise receiving preamp or converter can be installed at the same location. This puts the rf circuitry where it belongs — near the antenna.

The amplifier is a simple circuit. See Fig. 2. Any of the 4CX250 series or similar tubes are suitable. If a purchase is required, the 8930 seems to be the best bargain. It has the same electrical characteristics as the 4CX250R, but the anode is larger (2-inch diameter).[2] The

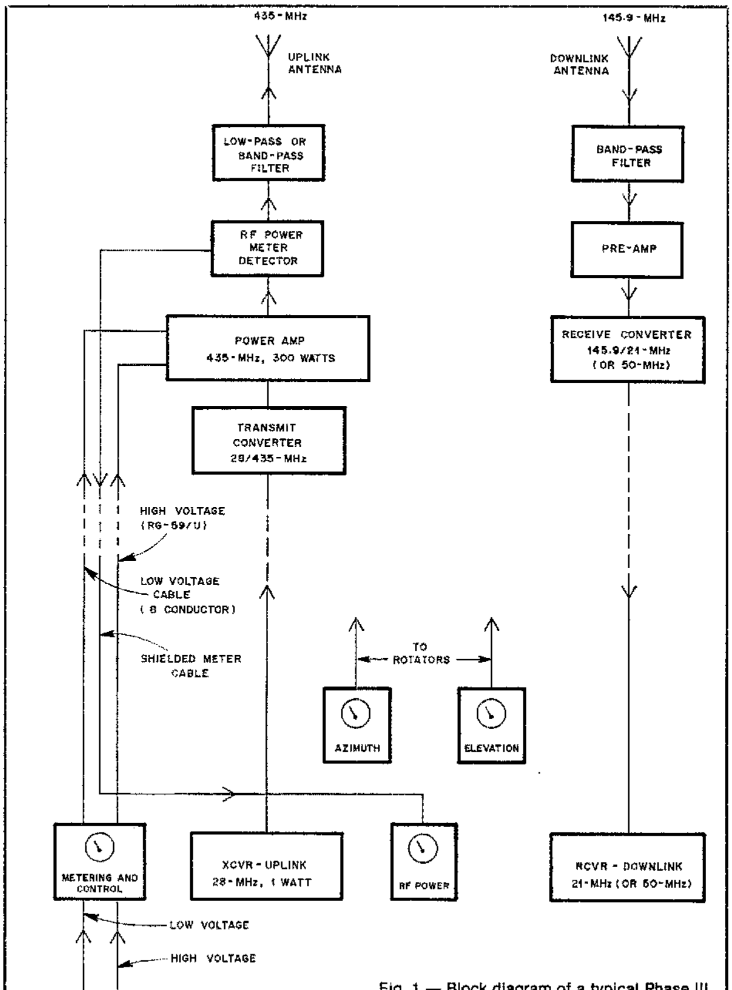


Fig. 1 — Block diagram of a typical Phase III station. This configuration allows full duplex operation.

[1]Notes appear on page 44.

*35 Highland Dr., East Greenbush, NY 12061

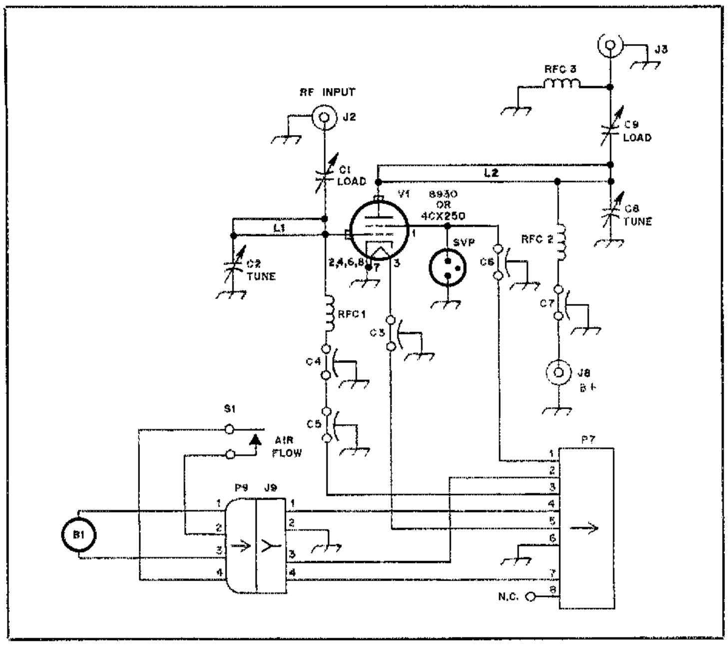


Fig. 2 — Schematic diagram of the uhf amplifier.

B1 — 100-cfm blower (Dayton 4C443 or equiv.).
C1, C2 — See Fig. 5.
C3-C6 — 0.001-μF feedthrough capacitor.
C7 — 0.001-μF, 4000-volt feedthrough capacitor.
C8, C9 — See Fig. 6.
J1 — Multipin socket (Cinch S-304-AB or equiv.).
J2, J3 — Chassis-mount, N female connector, UG-58A/U.
J4 — High-voltage connector (Amphenol UG-931/U or equiv.).
L1, L2 — See Figs. 5 and 6.
P1 — Multipin plug (Cinch P-304-CCT or equiv.).
P2 — Multipin plug (Cinch P-308-AB or equiv.).
RFC1, RFC3 — 5 turns no. 16 enam. 1/4 inch dia., 1/2 inch long.
RFC2 — 5 turns no. 16 enam. 1/4 inch dia., 1 inch long.
S1 — Air-flow switch.
SVP — 470-volt surge-voltage protector (Siemens B2-B470 or equiv.).

grid and plate circuits are strip lines, tuned and coupled by flapper-type capacitors. A surge voltage protector (SVP) is used in the screen-grid circuit. If the voltage exceeds 470, the SVP conducts and lowers the potential to almost zero.

Construction

The amplifier is built on two 5 × 10 × 3-inch chassis (Bud AC-404 or equiv.). The top is made of 3/16-inch-thick aluminum. To ensure that the two chassis and the top and bottom covers line up, lay out the top, drilling 1/16-inch pilot holes. Use the top as a template for drilling pilot holes in the top and bottom of the upper chassis, the top and bottom of the lower chassis and the bottom cover.[3,4]

See Figs. 3 through 9. When all drilling and punching is completed, begin the assembly. Position the tube socket (Eimac SK630A or equiv.) so that the connections to the screen and heater are as short as possible. Install two 1-1/2 inch long Teflon rod supports (tapped 8-32 on each end) for the plate and one for the grid line. The chimney is made by rolling up two pieces of 1-11/32 × 12 × 0.01-inch Teflon. The units are spliced end to end with Teflon adhesive tape, which is also used to secure the roll. See Fig. 8.

Connection of RFC2 to the plate line is made at the 6-32 tapped hole. A 1/4-inch

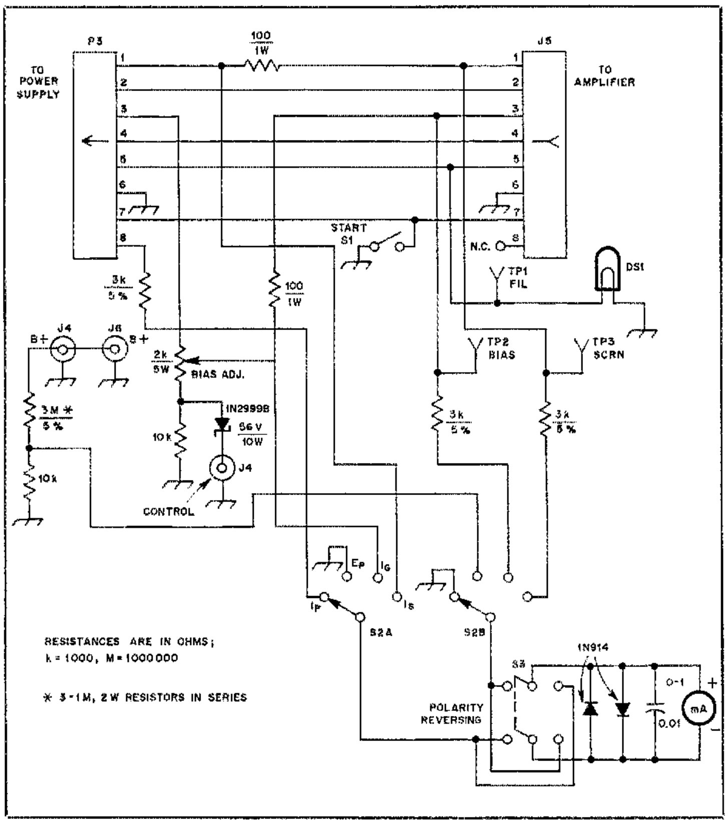


Fig. 3 — Schematic diagram of the metering and control unit. Resistors are 1/2-watt composition types unless otherwise specified.

DS1 — 6-V pilot lamp.
J1 — Multipin socket (Cinch S-308-AB or equiv.).
J2, J3 — High-voltage connector (Amphenol UG-931/U or equiv.).
J4 — Phono jack.
P1 — Multipin plug (Cinch P-308-AB or equiv.).
S1 — Spst toggle switch, spring return.
S2 — Two-pole, 4-position rotary switch, non-shorting contacts.
S3 — Dpdt toggle switch, spring return.

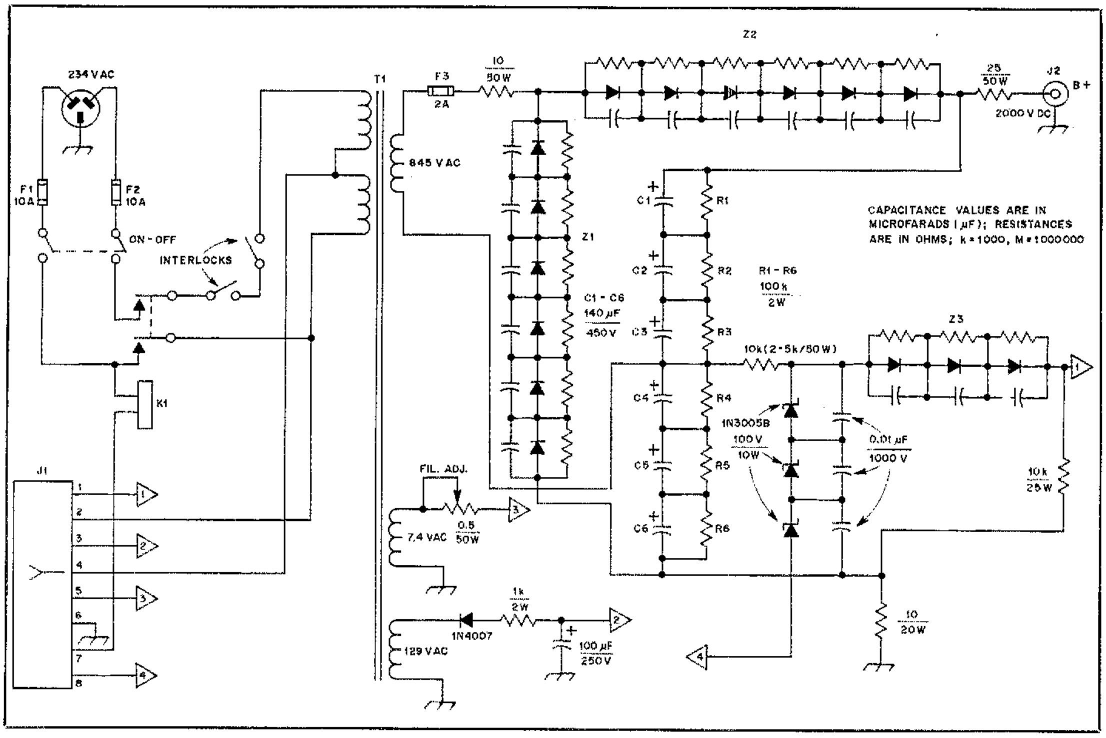


Fig. 4 — Schematic diagram of the power supply.

J1 — Multipin socket (Cinch S-308-AB or equiv.).
J2 — High-voltage connector (Amphenol UG-931/U or equiv.).
K1 — Dpst relay, 15-A contacts, 117-V coil.
T1 — Transformer, dual 117-volt primaries, wound for W2GN by H. E. Johnson and Assoc., Inc., 211 S. Ewing Ave., Clearwater, FL 33516.
Z1, Z2 — Six series-connected 1000-PIV, 2.5-A diodes, each shunted by a 0.01-µF disc-ceramic capacitor and a 470-kΩ, 1-watt resistor.
Z3 — Three series-connected 1N4007 diodes, each shunted by a 0.01-µF disc-ceramic capacitor and a 470-kΩ, 1-watt resistor.

screw is installed in the hole with the head on the bottom of the line. On top, a nut secures a no. 6 lug to which RFC2 is connected. This arrangement allows the plate line to be removed without a soldering iron.

The power supply, and the metering and control units are built in separate chassis. That allows the metering and control unit to be moved readily from the operating position to the amplifier location for tests and adjustments.

Test points are provided in the metering and control unit for measuring bias, screen-grid and heater voltages. A momentary-action start switch is used to energize the power relay (located in the power supply chassis). The air-flow switch is used to keep the power relay energized during operation. The milliammeter has 0 to 1 and 0 to 3 scales. The full-scale values are I_p = 1 A, I_g = 100 mA, I_s = 100 mA and E_p = 3000 volts. A polarity-reversing switch allows metering of negative screen and grid currents, which are characteristic of the tetrode amplifier under certain operating conditions. A four-position switch is indicated for S2 in Fig. 3. You may want to use a switch with more positions. Those additional inputs could be used to meter other parameters, such as relative output power. I elected to use a commercial wattmeter, with the detector at the amplifier output and the meter at the operating position. (See Fig. 1.)

I have designed several protective features into this amplifier (Fig. 4). The operation of the SVP was explained earlier. Current through the SVP, should it "fire," is limited by two 5-kΩ series resistors. Z3 protects the 1N3005B Zener diodes from high voltage on the screen lead. The 10-kΩ resistor at the cathode of Z3 sinks 30 mA to ground so that screen voltage will not go out of regulation when current is negative. Finally, a 2-A fuse and 10-Ω resistor protect the diode stacks in the power supply, while a 25-Ω resistor in the B+ lead protects the tube from excessive current. I learned to add these features the hard way.

Using the Amplifier

Once the project is assembled, you are ready to interconnect the units and begin testing. With power applied, but no rf drive, adjust the bias control for 50 mA of plate current. The 0.5-Ω resistor should be adjusted for 5.6 volts at the heater.

Apply about 2 watts of excitation. Plate current should increase as the grid tuning control is adjusted. Plate and grid loading controls should be set at midrange. Adjust the plate tuning control for maximum output. Plate current should read about 200 mA and the output will be 50 to 80 watts. Increase the drive to 5 watts and optimize the settings of the GRID TUNE, PLATE TUNE and LOAD controls for maximum output.

Continue to increase drive and tweak the adjustments until the desired power output is obtained with minimum plate current. Keep the plate loading on the heavy side. It is important that the PLATE LOAD control be optimized with the amplifier delivering full output. I tuned my amplifier for best efficiency at 500 watts of output and then varied the drive level. The results are shown in Table 1. The amplifier should be operated only briefly under these conditions. (The plate dissipation for an 8930 is 350 watts.) I reoptimized the adjustments for 300 watts of output; input was 600 watts with 7 watts of drive.

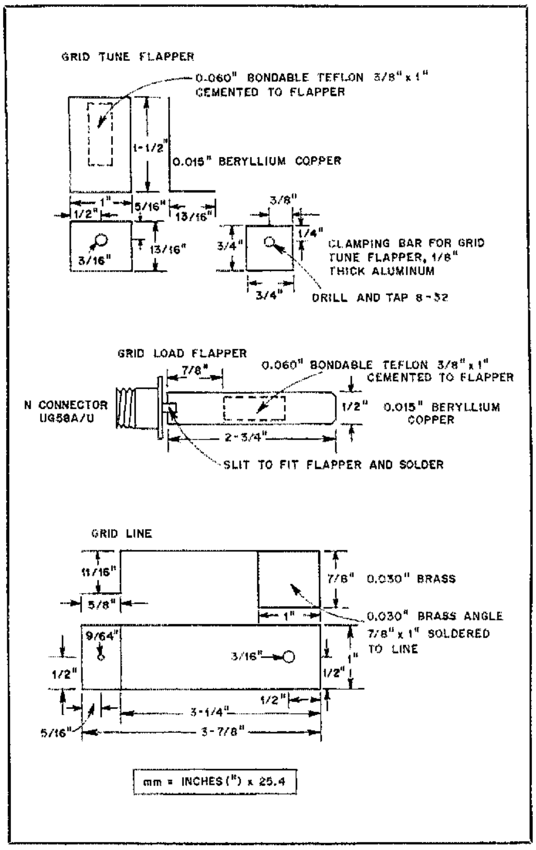


Fig. 5 — Mechanical details of grid-circuit components.

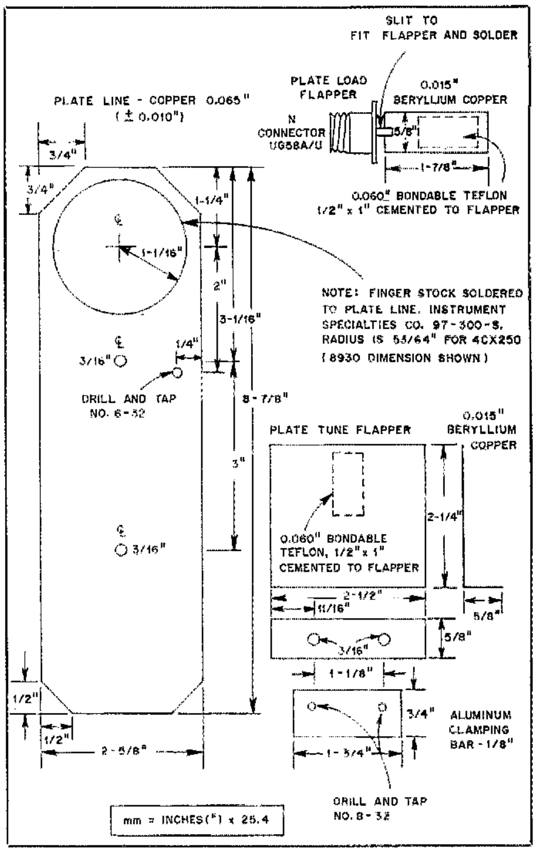


Fig. 6 — Mechanical details of plate-circuit components.

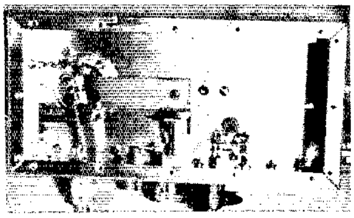


Fig. 7 — Bottom view of the amplifier showing grid-circuit components.

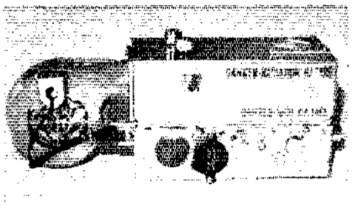


Fig. 9 — The rf portion of the completed amplifier.

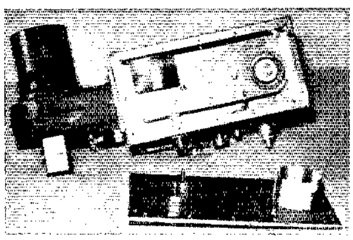


Fig. 8 — Top view of the amplifier showing plate-circuit components. The top cover is in the foreground.

I made extensive tests of the amplifier early in 1980. Further tests were made in the ARRL laboratory during December of 1981. There are no detectable spurs or harmonics when using a low-pass filter on the output.

Starting in 1980, I began demonstrating the amplifier at various meetings and hamfests. Since then I have been using it regularly on 432 MHz. Performance has been completely satisfactory in every respect. I sure hope the Phase III B satellite is in orbit soon. I'm ready! Are you?

Table 1
Operating Conditions for the Tetrode Amplifier

Tuned for maximum efficiency at 500 watts of output. Voltages: plate, 2000; screen, 300; grid, −56; heater, 5.6.

Drive Power (watts)	*Plate Current (amperes)*	*Output Power (watts)*
0.0	0.050	0
2.5	0.200	100
5.0	0.290	200
7.5	0.390	300
10.0	0.440	400
12.5	0.500†	500

†[Editor's Note: When computing the input power of a grounded-grid amplifier, the rf drive power must be added to the dc plate power because some of the drive appears at the output. With 12.5 watts of drive, the unit can be loaded to a plate current of 493 mA for a power input of 1 kW at 2000 volts. The actual PEP input under the conditions listed in Table 1 is 1012.5 watts, which is suitable for ssb service.]

Notes

[1]m = feet × 0.3048
[2]mm = inches × 25.4
[3]For additional construction ideas see R. T. Knadle, Jr., "A Strip-Line Kilowatt Amplifier for 432 MHz," *QST*, April and May 1972, pp. 49-52 and 59-62, 79.
[4]S. J. Powlishen, "A Grounded-Grid Kilowatt Amplifier for 432 MHz," *QST*, October 1979, pp. 11-14.

Hints and Kinks

Conducted By Larry D. Wolfgang,* WA3VIL

QRP PERSON'S VSWR INDICATOR

☐ I needed to shrink the bulk of the radio-gear package for a 1982 Hamcation to Barbados. One of the items that could be greatly reduced in size was the VSWR indicator. Fig. 1 shows the end result, referenced to a U.S. 25-cent piece.

*Assistant Technical Editor

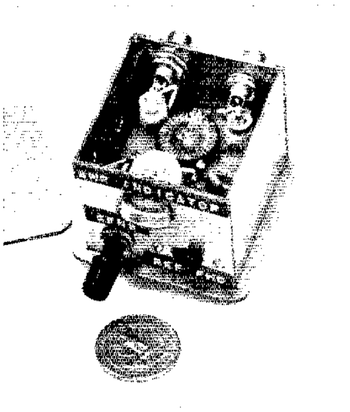


Fig. 1 — Photograph of the assembled VSWR indicator in the homemade pc-board material box. A commercial cabinet or a Minibox can be used to obtain a more professional effect.

The circuit (Fig. 2) is fashioned after the classic Walter Bruene model that was described some years ago in *QST*[1] and revisited by W1FB in a 1969 *QST* article.[2] The principal difference in this circuit from some other ones is that a two-turn link is wound on T1 to increase the low-power sensitivity of the instrument. Normally, a single wire is passed through the center hole of the toroidal transformer for sampling the 50-ohm transmission line.

Most of the components I used were garnered at hamfest flea markets. A miniature fm tuning meter is used at M1. It has a 100-μA movement, but microampere meters of other full-scale characteristics will work nicely in this circuit. A miniature slide switch is used for S1, while nulling trimmers C1 and C2 are surplus pc-mount trimmers. Piston trimmers can be used in place of the units shown for C1 and C2. The type chosen should be mechanically stable and capable of withstanding at least 87 volts rms (typical maximum voltage for 150 watts at 50 ohms). Greater voltages may be present in a mismatched system. Use care in choosing the capacitors, with special attention to the *minimum capacitance* available. Only 2 or 3 pF of capacitance should be needed when the bridge is nulled for 50-ohm use.

[1] W. Bruene, "An Inside Picture of Directional Wattmeters," *QST*, April 1959, p. 24.
[2] D. DeMaw, "In-Line RF Power Metering," *QST*, Dec. 1969, p. 11.

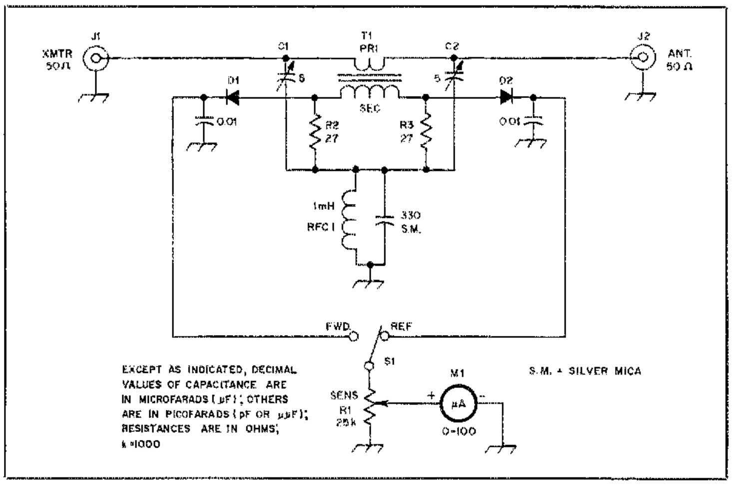


Fig. 2 — Schematic diagram of the VSWR indicator. Fixed-value capacitors are disc ceramic except those marked with S.M., which are silver mica. R2 and R3 are 1/4-watt carbon-composition units.

C1, C2 — Miniature pc-mount air trimmer (see text).
D1, D2 — Silicon switching diode, 1N914 type, matched for equivalent forward resistance (use an ohmmeter).
J1, J2 — Single-hole-mount phono jack.
M1 — Miniature 50- or 100-μA dc meter (see text).
R1 — Linear-taper miniature control, 25 kΩ.
RFC1 — Miniature 1-mH rf choke.
S1 — Miniature spdt slide or toggle switch.
T1 — Toroidal transformer. Secondary: 60 turns no. 30 enam. wire on an Amidon, Radiokit or Palomar T68-2 powdered-iron core. Primary is two turns over secondary winding.

Double-sided pc-board material is used for the case. It is soldered together along the inner seams of the walls and the base plate. The top plate is tacked to the case, using one solder blob on each side. This should be done after the circuit has been adjusted and is considered ready to use.

I supported the pc board[3] in the box by means of a single standoff post, directly under T1. The rear edge of the pc board butts firmly against the back wall, as shown in the photograph. Be sure to connect the ground foil of the pc board to the box walls. I used two short lengths of bus wire for the purpose. A glob of noncorrosive RTV sealant is placed in the center hole of T1 to keep the transformer in position. Similarly, I glued M1 to the front panel by means of quick-drying contact cement. Four adhesive-backed plastic feet are attached to the bottom plate of the instrument. I used Dymo® tape labels to identify the controls and the input/output jacks on the rear of the box.

Adjustment is done by connecting a 50-ohm resistive termination to the antenna jack, applying rf energy to the transmitter jack and adjusting R1 for a full-scale reading (S1 in the FWD position). Next, switch S1 to REF and adjust the trimmer that causes the meter reading to change (one of the trimmers will be unresponsive in this setting). Set the trimmer for minimum meter deflection. It should read zero. Next, reverse the cables at J1 and J2. Put S1 in the REF position. Apply rf energy. The meter should read full scale. Switch S1 to FWD and adjust the remaining trimmer for minimum meter reading (again, it should fall to zero). The bridge has now been balanced for 50 ohms. This set of adjustments should be done on 20 or 15 meters to ensure proper high-range performance.

When using the instrument, always adjust R1 for a full-scale reading with S1 in the FWD mode. Adjust the antenna or antenna-matching network for the lowest reading attainable with S1 in the REF position. A zero reading in REF will be equivalent to a VSWR of 1:1.

My tests show the instrument is suitable from approximately 1 watt to 150 watts. It is not designed for power levels in excess of 150 watts. It will function properly from 1.8 to 30 MHz. It may look ugly, but it's small! — *Doug DeMaw, W1FB, ARRL Hq.*

A BROADBAND 80-METER INVERTED V

☐ I have a solution to the problem of constructing a broadband antenna for 75 and 80 meters. My antenna consists of two inverted Vs, connected to a single 50-ohm coaxial-cable feed line. My version uses one antenna cut to resonance at 3512 kHz and another at 3790 kHz.

I have experimented with different angles between the two Vs, and the optimum broadband condition seems to occur at maximum

[3] Pc boards for the VSWR meter are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81001. The ARRL and *QST* in no way warrant this offer.

separation, 90° to each other. The apex of my antenna is at a height of 65 feet (20 meters), and the legs all come down at about a 45° angle. In addition, there seem to be no directional effects with this antenna. — *Tim Cotton, N4UM, Plantation, Florida*

[Editor's Note: See a related article by Lawson, Nov. 1970 *QST*, p. 17.]

GASOLINE-ENGINE POWER SUPPLY

☐ When Dwight and Ann Mueller were planning to spend a year in the Alaskan wilderness, they needed a small, portable power supply.[4] Dwight built a gasoline-engine-powered unit that included a 12-V automobile alternator and a 2500-W, 117-V alternator (Fig. 3).

A 5-hp engine is used to drive either the 12-V or the 117-V alternator. The pulley sizes are the same on the engine and both alternators. Full output from the 117-V unit was achieved at 3500 rev/min, and at a slightly slower speed for the 12-V alternator. Both alternators were never driven simultaneously, but this should be possible if a slightly larger pulley is used on the 12-V unit so it can be run somewhat slower than the 117-V alternator. A larger engine may be needed if both alternators are to be driven at once, but a smaller one would be sufficient to run only a 12-V alternator.

Fig. 4 shows how this device can be wired with an automotive voltage regulator to maintain the charge on a 12-V battery. The Muellers' installation had meters and a battery inside the cabin. Large gauge wire must be used between the alternator and battery. — *Roger Barnard, WA0HAM, Mercer Island, Washington*

[4] R. Barnard, "An Alaskan Adventure," *QST*, March 1982, pp. 54-55.

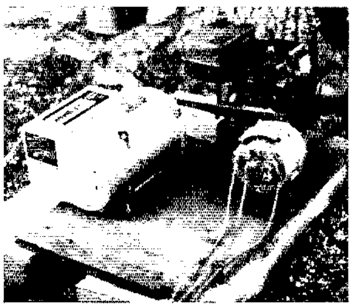


Fig. 3 — Photo of a gasoline-engine power supply for 117-V ac and 12-V dc.

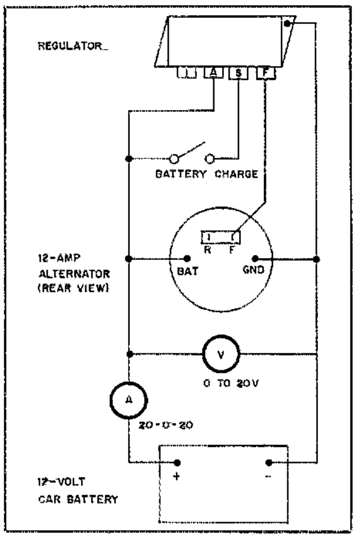


Fig. 4 — Sketch of the connections used to maintain the charge on a 12-V battery. The battery can be used to power a small transceiver and even some 12-V lamps for reading.

INDOOR-ANTENNA SUPPORT

☐ After moving to an apartment that has a restriction against outside antennas, I decided to try my 2-meter beam indoors. I mounted the antenna on a wooden pole, and fastened the pole in a Christmas-tree stand. This provides a sturdy, small, portable support. The results from my second-floor apartment are gratifying. My "armstrong" rotator easily points the beam in any direction, and stands the antenna flush with the wall and out of the way when not in use. — *David J. Tomaszek, WD4CBZ, Hialeah, Florida*

A 2-METER J BEAM WITH TRIGONAL REFLECTOR

☐ This antenna was developed as a combination of ideas from two previous *QST* articles.[5,6] I wanted a beam antenna with vertical polarization, and I wanted to avoid the problems of fastening a conventional Yagi type of antenna directly to the metal mast above my tribander.

The vertical J-driven radiator (and boom-support piece) is constructed from odd lengths of 3/4-in. conduit that I welded together.[7] The matching stub is welded to the radiator by means of a bracket formed from scrap iron. I use a radiator that is more than 7 feet long, but any additional length below the stub (58 inches from the top) raises the antenna higher above the mast. The main boom is made of 3/4-in. PVC pipe, and the secondary boom is 1/2-in. PVC pipe. The directors and reflectors can be copper tubing, aluminum rods, hard-drawn copper wire or any similar material. Fig. 5 gives dimensions and construction information.

I found the best feed point by trial and error, using an SWR indicator. The coaxial-cable center conductor and shield were attached to the radiator and the matching stub. The points of attachment were moved up and down until the lowest SWR reading was obtained. These adjustments were made at ground level.

With the beam mounted on my tower, I was able to access a repeater about 50 miles away. The signal received from the repeater almost pinned the S meter. Access had been impossible with a 1/4-λ vertical at the same height. I am very pleased with the results from this antenna. — *Jack Ratzlaff, VE7DDS/VE5, Regina, Saskatchewan*

[5] J. McDonald, "A J-Driven 2-Meter Beam Antenna," *QST*, Nov. 1979, p. 32.
[6] V. Quaresima, "A Tri-Yagi for 50 MHz, *QST*, June 1980, pp. 14-15.
[7] mm = inches × 25.4.
m = feet × 0.3048.
km = miles × 1.6.

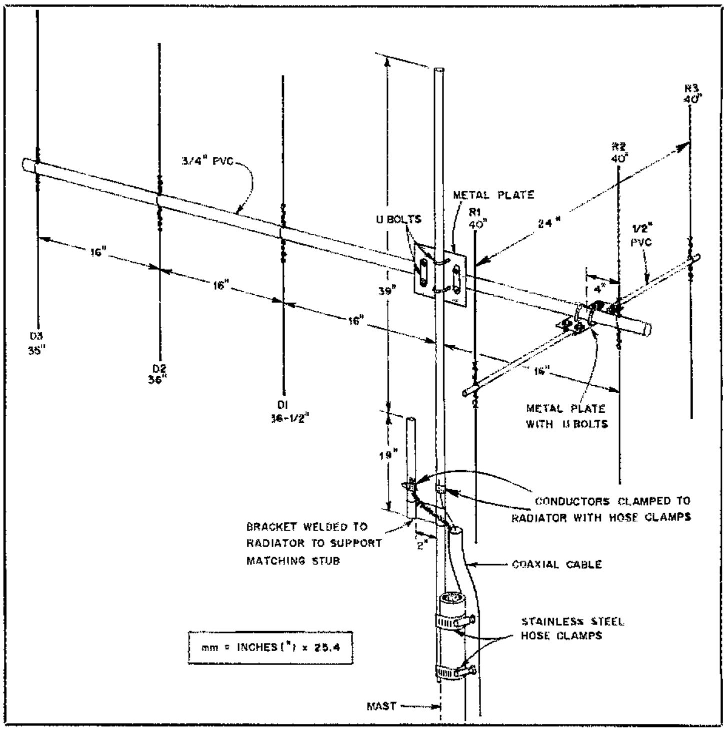
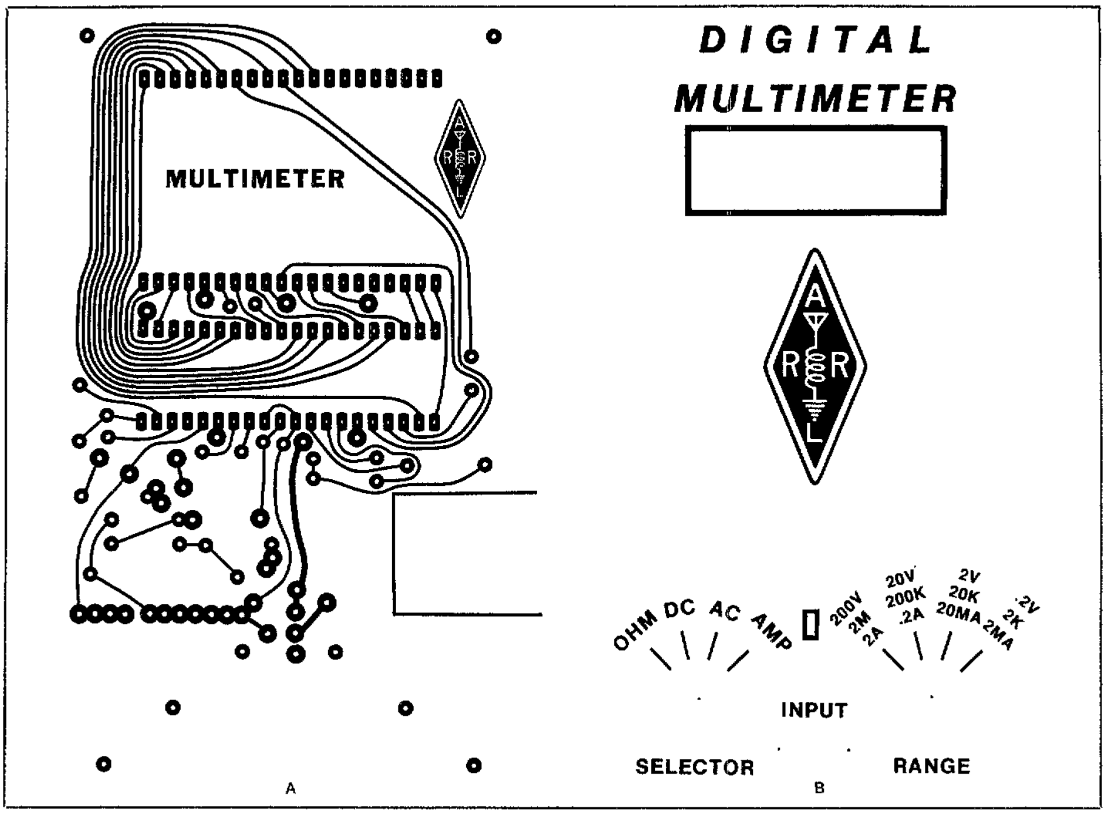
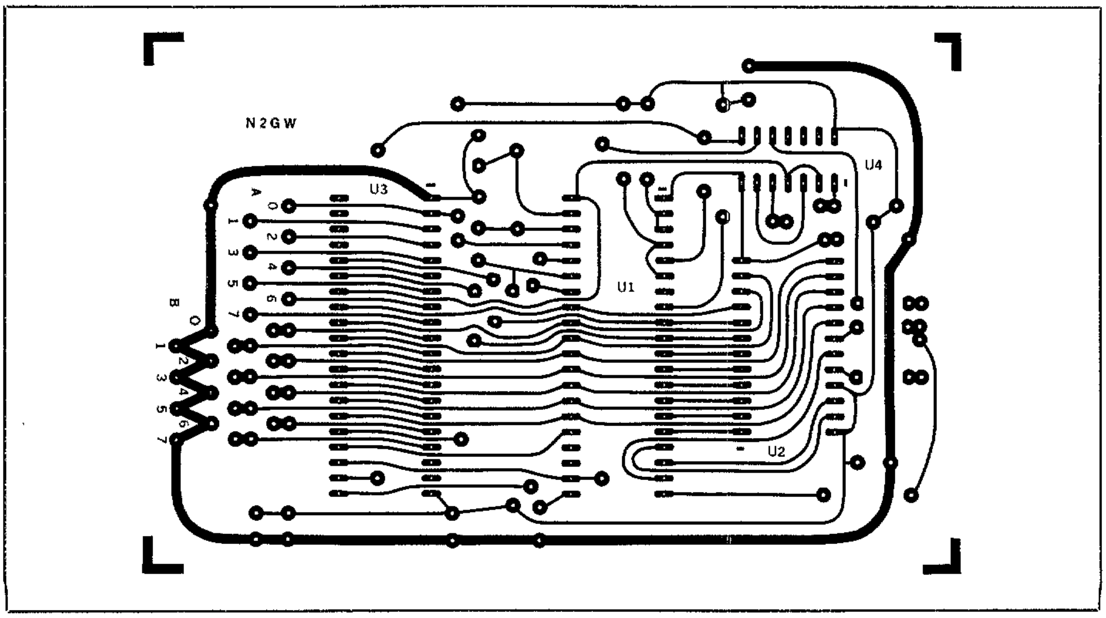


Fig. 5 — Dimensions and construction details are shown for a 2-meter J beam using a trigonal reflector.



Etching patterns for the Digital Multimeter circuit board (A) and case front panel (B). At A the black areas represent unetched copper, viewed from the etched side of the board. At B the black areas represent etched copper. A parts-placement diagram appears on p. 33.



Circuit-board etching pattern for the Three-Chip Microcomputer (see the parts layout of Fig. 8, p. 23 of this issue). Black represents copper. The pattern is shown at actual size from the foil side of the circuit board.

Product Review

Conducted By Paul K. Pagel,* N1FB

ICOM IC-720A HF Transceiver

□ A compact, full-featured hf transceiver, the ICOM IC-720A covers all amateur bands from 1.8 through 30 MHz, including the 10-, 18- and 24-MHz WARC frequencies. It incorporates a general-coverage receiver tuning 0.1 through 30 MHz in 1-MHz segments. Cw, usb, lsb, a-m or RTTY (fsk) operation is selectable by front-panel push-button controls. The matching IC-PS15 ac-operated power supply provides 13.8 V dc at 20 A, and is connected to the transceiver by a 2-1/2 foot† cable. The power supply is switched by the transceiver.

The review unit included the optional SM5 electret-condenser desk microphone with a built-in preamplifier (powered by the transceiver) and the optional FL-32 500-Hz cw filter. Other options available include the SP3 external speaker (the '720 has a built-in 2-1/2 inch round speaker), HP1 headphones, an MB5 mobile mounting bracket, a BC-10A memory backup power supply and an FL-34 a-m filter.

Among the features standard on the '720 are a digital readout, an rf speech processor, a VSWR indicator, receiver incremental tuning, a noise blanker, band-pass tuning, an rf attenuator, VOX with separate cw and ssb delays, a selectable tuning rate and two built-in VFOs.

Frequency Control

The IC-720A operating frequency is determined by a microprocessor-controlled phase-locked-loop (PLL) local oscillator. Tuning is available in 10-, 100- and 1000-Hz steps, selectable from the front panel. Tuning in the 10-Hz-per-step mode is a bit slow (1 kHz per knob revolution), but it gets around the very noticeable frequency changes found in the 100-Hz-per-step mode. During normal operation, either the 10- or the 100-Hz setting is used, while a touch of the TS (tuning speed) button switches to 1-kHz steps for making larger frequency excursions. A dial-lock control locks the VFO at the displayed frequency, preventing unwanted frequency change through accidental operation of the tuning knob. Red LEDs indicate when the TS and the dial lock functions are in use.

One feature not found on most radios is the method of band selection. Instead of a conventional band switch, the '720A employs a multisection, motorized rotary switch controlled by front-panel push buttons. The band switch control circuit can be accessed remotely through a rear-panel connector. When power is first applied to the transceiver, the band switch steps around to 7.100 MHz (15.000 MHz in the general-coverage mode) from wherever it was when the rig was last turned off. The UP control will move the operating frequency to the next higher amateur band (10 MHz), while the DOWN button will move the frequency to the next lower band (3.5 MHz). In the general-coverage mode, the controls move the receiver frequency to the next higher (or lower) 1-MHz segment. Whenever the band is changed in the HAM mode, the transceiver will always arrive 100 kHz up from the bottom of the selected band (3.600, 7.100, 14.100 MHz, etc.). In the GENERAL-COVERAGE mode, the frequency will move up or down exactly 1 MHz; for example, if you are listening on 16.372 MHz, a touch of the UP button will change the frequency to 17.372 MHz. The motorized switch is loud enough to wake family members sleeping in the next room, so beware of the late-night DX chasing!

The '720A incorporates two separate built-in VFOs, both controlled by the main tuning knob. Through proper operation of the front-panel push-button controls, the following arrangements are possible: transceive on VFO A; transceive on VFO B; receive on A, transmit on B; receive on B, transmit on A. The VFOs may be set to frequencies on different bands, but split operation (selected by the SIMPlex/DUPlex push button) is available only on the same band; the rig will not transmit on one band and receive on another. Another push button will automatically set both VFOs to exactly the same frequency, eliminating much knob-twirling when split operation is needed in a hurry, as when you stumble across that rare DX station who has just announced that he's listening "up 5."

The RIT control, activated by a front-panel push-on, push-off switch, will vary the received frequency ± 800 Hz. A red LED above the frequency display indicates when the RIT is activated. As the rig comes from the factory, the RIT will pulse off each time the main tuning knob is moved, but this feature can be deactivated by an internal switch. Any receiver frequency change made with the RIT is *not* indicated on the display.

The displayed frequency does not change during transmit. In addition, indicators on the left-hand side of the display indicate which mode and which VFO (A or B) is in use. A thorough reading of the operating manual is encouraged because, in the GENERAL-COVERAGE mode and on the 28-MHz amateur band, the displayed frequency and actual operating frequencies are different at the band edges. For example, at the lower edge of the 15-MHz general-coverage segment, the display will read 15.000.8 in the lsb or cw mode, but the actual operating frequency will be 16.000.8 because of the way the frequency "rolls over" from 15.999.99 MHz at the high end and returns to 15.000.00 MHz on the display. By the same token, on the 28-MHz ham band, for a displayed frequency of 28.000.8 on cw, the transceiver is actually operating on 29.000.8. Don't be surprised if you hear ssb signals when tuning around the low end of 10 meters; they're perfectly legal ssbers operating around 29 MHz.

Receiver

The '720A uses a dual-conversion superheterodyne receiver with the first i-f at 39.7315 MHz and the second i-f at 9.0115 MHz. There are separate RF and AF GAIN controls. The PBT (passband tuning) control is moderately effective in eliminating adjacent-channel interference. Agc operation is selectable from the front panel. The slow or "normal" setting is intended for ssb operation, and features a

*Assistant Technical Editor

hang-agc characteristic, while the FAST setting is intended for cw work. The receiver also features an ATTenuator control. When the ATT switch is depressed, the rf amplifier is removed from the circuit and a 10-dB attenuator is inserted in the receive line. The built-in noise blanker (NB) is somewhat effective against pulse-type noise, such as ignition noise. Care should be taken when using the noise blanker, however, because strong signals tend to overload the receiver with it switched in.

Front-panel push buttons also provide for mode selection. The choices include cw with the 2.3-kHz ssb filter; CW-N with the optional 500-Hz filter; AM; SSB-N, which automatically chooses the proper sideband for the band of operation; SSB-R, which gives the reverse sideband; and RTTY. CW and CW-N are on the same push button, as are SSB and SSB-R. The function of each switch is controlled by the FUNC button, much like the function button on a calculator.

Shortwave listening with the '720 is a joy. Normally used amateur antennas provide satisfactory reception on all of the shortwave bands, and their sensitivity is every bit as good as on the ham bands. At lower frequencies, the receiver is somewhat picky about antenna impedance. A matching network is required on the a-m broadcast band. At my QTH, the receiver would pick up only the strongest local broadcast station, when using an 80-meter half-wave dipole without a matching network.

For serious SWLing, the optional a-m filter probably should be used. The standard 6-kHz filter is rather broad, making crowded-band reception difficult at times. The optional FL-34 5.2-kHz a-m filter has a better shape factor, providing better selectivity.

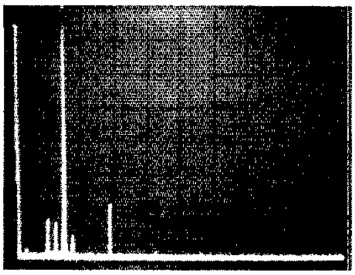


Fig. 1 — Worst-case spectral display of the IC-720A. Vertical divisions are each 10 dB; horizontal divisions are each 10 MHz. Output power is approximately 100 watts at 14 MHz. All spurious emissions are at least 58 dB below peak fundamental output. The IC-720A complies with current FCC specifications for spectral purity.

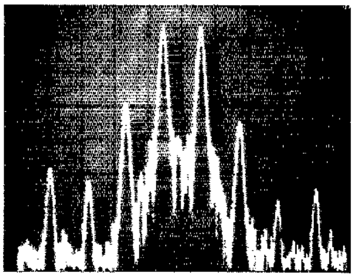
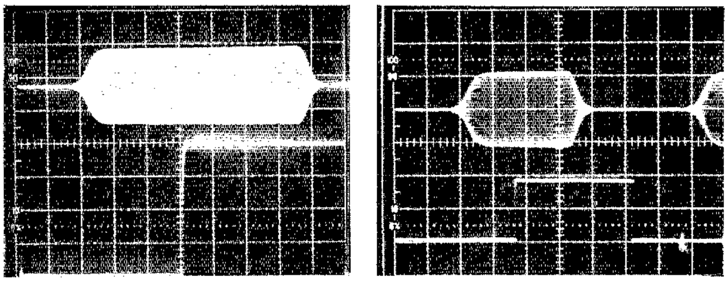


Fig. 2 — Spectral display of the IC-720A during the transmitter two-tone IMD test. Third-order products are 28 dB below PEP output and fifth order products are about 52 dB down. The seventh-order product is higher than the fifth at 48 dB down. Vertical divisions are each 10 dB; horizontal divisions are each 1 kHz. The transceiver was being operated at rated input power on the 20-meter band.



(A) (B)

Fig. 3 — At A, keyed cw waveform of the IC-720A prior to modification. Horizontal divisions are each 5 ms. The lower trace is actual key closure, while the upper trace is the rf output envelope. Heavy weighting is experienced by the elongated envelope. The rf output envelope, after modification, is shown at B.

Transmitter

The '720 incorporates a solid-state broadband transmitter, providing about 100 watts of output on each band. No tuning is required. The finals are SWR-protected; if the load connected to the transmitter is other than 50 Ω, the transmitter power output is reduced. I found that the power output started to drop off at an indicated SWR of about 1.8 to 1. The input SWR on my linear amplifier is greater than that on some bands, so the '720 would not drive the amp to the full legal input power.

The finals are cooled by a quiet fan that runs whenever the rig is in the transmit mode. If the finals get hot during extended operation, the fan will run continuously until the temperature reaches an acceptable level. If the temperature reaches the point where it will hurt the '720, the fan shifts to a faster speed. Should this occur, the instruction manual advises that you stop operating and find the cause of the problem.

Front-panel controls include a MIC GAIN control and an RF POWER control, which also turns the built-in rf speech processor on and off. On cw and RTTY, the RF POWER control allows continuous adjustment of the output power from about 7 watts to maximum. On ssb and a-m, with the processor in use, the MIC GAIN control sets the clipping limits while the RF POWER control sets the drive level.

The '720 has a built-in VOX that also provides semi break-in on cw. The VOX GAIN, ANTI-VOX and separate DELAY controls for phone and cw are located under a panel on the top cover. VOX operation is smooth, and the T-R relay is quiet. The separate delays are nice because, once set, they don't require much adjustment.

When the review unit first arrived, I noticed a problem with the cw waveform: The transmitter would continue to generate rf after the keyer pulse stopped, effectively altering the ratio between the transmitted dots and dashes. Listening in another receiver, this made the cw sound "soft," and, at speeds of 20 wpm or more, the signal was extremely difficult to copy. ICOM recommends changing R15 on the main circuit board from 47 kΩ to 10 kΩ. This fix eliminated the problem. However, because of the crowded circuit boards and the vague board layouts, this modification would best be attempted by an experienced technician.

Other Features

A large-scale, multifunction meter takes up a chunk of the front-panel space. In receive, this meter functions as an S meter. Because of the widely varying meter sensitivity (see specification table), this meter isn't too useful on 160 and 80 meters. Requiring only an 11-μV signal for an S9 reading, almost every signal is at least S-9, and many signals "peg" the meter. On transmit, the meter indicates ALC, relative power output or collector current, depending on the position of the front-panel RF/ALC control and the meter switch under the top-cover access panel. The meter also serves as an SWR indicator.

The rear panel, although primarily a heat sink for the final-amplifier transistors, contains an impressive number of input/output terminals. There is an SO-239 antenna connector, a 1/8-inch key jack, a 1/8-inch external speaker jack, a ground terminal, a dc power input and a fuse holder. The '720 includes receiver input and receiver antenna output RCA-type phono connectors for use with an external preamp or a separate receive antenna (e.g., a Beverage antenna for 80 or 160 meters). The MEMORY phono jack is for the connection of an external 9- to 12-V dc supply, to hold the operating frequency in memory in case of a power failure. The LOW BAND ANT (RL) phono jack serves two functions. By changing internal

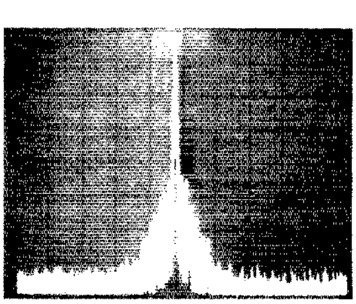


Fig. 4 — Synthesizer noise about the carrier. This photograph was taken with the IC-720A operating at 60 watts of output on 14 MHz. Vertical divisions are each 10 dB; horizontal divisions are each 1 kHz.

ICOM IC-720A HF Transceiver, Serial No. 05082

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: Ham band — 1.8-2.0, 3.5-4.1, 6.9-7.5, 9.9-10.5, 13.9-14.5, 17.9-18.5, 20.9-21.5, 24.5-25.1, 28.0-30.0 MHz; general-coverage receiver — 0.1-30 MHz in 1-MHz segments.	As specified.
Modes of operation: Ssb, cw, RTTY, a-m.	As specified.
Readout: 6 digit.	1/2-in. high, 6-digit fluorescent-blue display.
kHz/turn of knob: Not specified.	100/10/1.
Frequency resolution: 100 Hz.	As specified.
Backlash: Not specified.	Nil.
RIT range: ± 800 Hz.	As specified.
Receiver attenuator: 10 dB.	Not measured.
S-meter sensitivity (μV/S9 reading): Not specified.	160 m, 12; 80 m, 11; 40 m, 80; 20 m, 90; 15 m, 100; 10 m, 120.
Transmitter rf power input: 200 W, cw; 200 W PEP, ssb; adjustable.	Greater than 100 W output all bands.
Harmonic suppression: Better than 40 dB.	− 58 dB (see photo).
Third-order IMD: Not specified.	− 28 dB (see photo).
Spurious suppression: Better than − 60 dB.	− 63 dB (see photo).
Receiver sensitivity: Less than 0.25 μV for 10 dB S + N/N.	Receiver dynamics measured with optional FL-32 500-Hz i-f filter installed.
Color: Gray/green.	
Size (HWD): IC-720A — 4-3/8 × 9-1/2 × 12-1/4 inches;† IC-PS15 — 4-3/8 × 7 × 11-1/2 inches.	As specified.
Weight: 16.5 lb.	As specified.

	80 m	*20 m*
Noise floor (MDS) dBm:	− 132	− 132
Blocking DR (dB)	noise limited	
Two-tone 3rd-order IMD DR (dB), worst case:	97	92
Third-order intercept:	+ 13.5	+ 6

†mm = in. × 25.4, kg = lb × 2.2, and m = ft × 0.3048.

jumpers, this jack serves either as a T-R relay control (for an external amplifier) or as a low-band (1600 kHz and below) antenna input. The TRANSVERTER SCOPE (ALC) phono connector can be used for any one of the following by changing internal jumpers: either as the TX output for a transverter; or access to the 39.7 MHz i-f for observation on a scope; or ALC input from an external amplifier. A 24-pin ACCESSORY socket provides many input/outputs, including RTTY keying, transverter control and external band switching.

Operation

The first thing I noticed when getting ready to operate the '720 was its size. For such a small transceiver, the front panel contains many controls, and these controls take some getting used to. For example, I was so "tuned-in" to a conventional band switch that it took a long while to get familiar with the push-button scheme.

Initial hookup also posed some interesting choices. Should I set the LOW BAND ANTENNA (RL) jumpers for the a-m broadcast antenna or for the relay control? I often use an external amplifier for DXing and contesting, but I also like to DX the a-m broadcast band. Taking off the covers to change the jumpers each time is a chore, so I opted for the relay control.

On cw, I noticed that, although it was difficult to overload the receiver front end, the high synthesizer phase-noise level generated with strong signals in the passband made weak-signal copy difficult. Even with the optional cw filter installed, the selectivity could have been better. The rig just doesn't make it on the low end of 40 at night.

I like the ability to reduce the output power to just a few watts for QRP operation. I also liked the feel of the controls and switches. They have a definite "quality" about them that makes the '720 a pleasure to use. The cooling fan and the T-R relay are quiet.

In summary, the IC-720A is a nice radio for general-purpose use. It is small and quiet, and has just about any feature you would want built in.

Price class: IC-720A, $1349; IC-PS15, $229; FL-32, $60. Available from: ICOM, 3331 Towerwood Dr., Suite 307, Dallas, TX 75234. — *Mark Wilson, AA2Z*

YAESU FT-680R 6-METER MULTIMODE TRANSCEIVER

☐ As this review is being written, Ole Sol continues to stir up the ionosphere. The 50-MHz band is still producing worldwide DX in this late portion of cycle 21! When the F_2-layer DX finally dies, sporadic E (or E_s) will still provide DX excitement for many 6-meter operators. During the review period, a few of the Hq. gang used the '680R in conjunction with a 3-element home-built Yagi to earn an "almost" 6-meter WAC (missing only Asia!) for the Hq. operator's club station, W1INF.

The Yaesu FT-680R is a fully synthesized, microprocessor-controlled, 6-meter transceiver that operates on cw, ssb, a-m and fm. Maximum input power is specified as 20 watts, and frequency coverage is from 50 to 54 MHz. This transceiver is a 6-meter version of the Yaesu FT-480R, which appeared in this column in October 1981.[1]

Features

Microprocessor control in the '680R provides many features, and allows flexibility not found in the older 6-meter designs. The digital VFO system features discrete tuning steps of 0.01, 0.1, 1, 20 and 100 kHz, depending on the operating mode and tuning-rate selection. Four memory channels are available, and in the fm mode these may be scanned for a busy or clear channel. A priority function allows one memory channel to be used as a priority frequency. In the priority mode, the radio will "monitor" this priority channel and alert the operator when it is in use.

Probably the most important feature of the transceiver is the small size. It easily can be located under the dash of small cars, or be placed in a briefcase for a business trip. To ensure versatility, Yaesu has ganged many of the control functions together, which allows for the small front panel. A complete description of each function of the controls of the Yaesu FT-480R was given in the October 1981 review by Wilson. The '680R SAT switch allows the transceiver frequency to be changed while the unit is in the transmit mode. This feature is very useful when operating through an amateur satellite — but amateurs have no satellite allocation on the 50-MHz band!

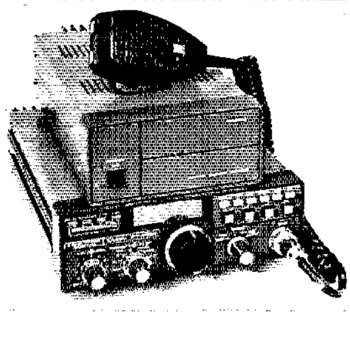
Other Features

As in the 2-meter version, the '680R has an input for both tone-burst and Continuous Tone-Coded Squelch generators. An optional FTS-64E tone generator, which will synthesize 32 different CTCSS or tone-burst frequencies, is available. The tone input is located on the rear panel, which also has 1/8-inch jacks for the cw key, an external speaker and a 2-pin dc power connector along with an SO-239 antenna connector.

Installation and Operation

During the review period the FT-680R was operated in fixed, mobile and portable environments. Fixed operation was from W1INF, in conjunction with a 3-element homemade NBS Yagi.[2] This system worked well, and the receiver dynamic range was put to the test, as there are many 6-meter operators living very close to ARRL Hq.! Only the *very* strong local

[1] M. Wilson, "Yaesu FT-480R 2-Meter Multimode Transceiver," *QST*, Oct. 1981, pp. 46-47.
[2] D. Lusis, "Go for the Gain, NBS Style," pp. 34-38, this issue.



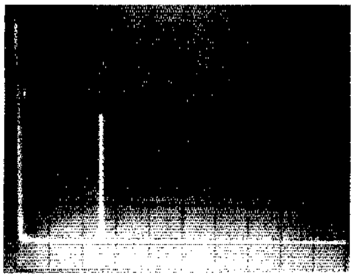


Fig. 5 — Spectral display of the FT-680R. Vertical divisions are each 10 dB; horizontal divisions are each 20 MHz. Output power is approximately 10 watts at 6 meters. The fundamental has been reduced in amplitude approximately 33 dB by means of a notch filter; this prevents analyzer overload. All spurious emissions are approximately 70 dB below peak fundamental output. The FT-680R complies with current FCC specifications for spectral purity.

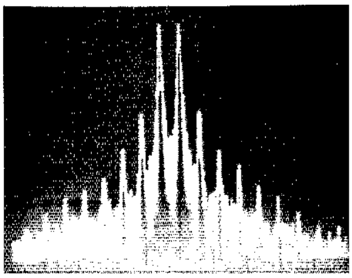


Fig. 6 — Spectral display of the FT-680R output during the transmitter two-tone IMD test in the SSB mode. Third-order products are approximately 33 dB below PEP and fifth-order products are approximately 45 dB down. Vertical divisions are each 10 dB; horizontal divisions are each 2 kHz. The transmitter was being operated at rated input power on the 6-meter band.

Yaesu-Musen FT-680R 6-Meter Transceiver, Serial No. 020460

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: 50.000-53.999 MHz.	Same.
Operating modes: Usb, cw, a-m and fm.	As stated.
Frequency display: Blue-fluorescent digital display	As stated.
Power requirements: 13.8-V dc at 5A.	As stated.
Transmitter rf power output: Not specified.	Greater than 10 W on ssb, cw and fm; 4 W carrier on a-m.
Transmitter third-order IMD: Not specified.	Approximately −33 dB (worst case).
Spurious suppression: Better than 60 dB.	>−60 dB.
Harmonic suppression: Not specified.	>−60 dB.
Frequency stability: Not specified.	Less than 100 Hz from a cold start to one hour later.
Receiver audio power output: 2 W at 10% THD.	1.3 W into 8 Ω.
S-meter sensitivity: Not specified.	Relative type, 27 μV required for full scale deflection.
RIT range: Not specified.	± 10 kHz.
Receiver sensitivity: Ssb, 0.5 μV for 20 dB S/N; fm, 0.35 μV for 20 dB QS; and a-m, 1.0 μV for 10 dB S/N.	Receiver dynamics measured with a 2.4-kHz i-f bandwidth; Noise floor (MDS): −136 dBm; Third-order IMD dynamic range: 81 dB; Blocking dynamic range: 111 dB.
Size: (HWD) 2.4 × 7 × 9.4 in.†	
Weight: 6.4 lb.††	
Color: Not specified.	Tan body with gray front panel.

†mm = in. × 25.4. ††kg = lb. × 2.2.

signals overloaded the receiver front end. The one fault in the '680R that makes it difficult to use is the slow delay time of the receiver agc. Sometimes when DX stations were calling, the local splatter would cause the agc to decrease the sensitivity of the receiver enough to mask the DX station calling. Mobile operation of the transceiver was flawless, except for the noise-blanker performance. It never seemed to be of any help with ignition noise during use in several vehicles.

Portable operation with the FT-680R was done from several mountain tops in the Connecticut area. Power consumption is a little too much for a dry-cell battery pack to handle, so an automobile dc supply or an ac supply/generator is the best bet. As in base-station operation, the receiver was never really "crunched" by signals other than the strong local ones. I was impressed by the synthesizer in the transceiver; the lack of severe synthesizer noise was evident.

Conclusions

I found the transceiver to be a "workhorse." It was used as an exciter for lab testing, as a portable contest rig and as a source of excitement for the off-duty Hq. staff when working 6-meter DX. At one point during the review period the unit required major repair. A high-voltage spike from the optional FP-80 13.8-V supply destroyed a few semiconductor devices in the '680R, but the unit was soon repaired by Yaesu. Yaesu cautions that the power supply switch should not be used as the ON/OFF switch for the transceiver.

Strictly from an operator's viewpoint, I found the transceiver to be somewhat cumbersome to operate, but once the layout is understood the performance is appreciated. I would recommend to anyone looking for a new 6-meter "box" to take a serious look at the FT-680R. The FT-680R is sold by Yaesu Electronics Corp., 6851 Walthall Way, Paramount, CA 90723. Price class is $520. — *Gerry Hull, AK4L*

New Products

DUFFY ENTERPRISES TOOL-AID®

☐ A new product of possible interest to hams is Tool-Aid. It looks like candle wax and is intended to create a temporary bond between components of almost any kind during assembly. A common application is in starting small screws or nuts in tight places. The substance is applied to a screwdriver tip; when the screw is picked up, it sticks to the tip. If a small part is dropped inside a chassis, Tool-Aid can be used on a screwdriver tip or probe tip to retrieve the part. The material doesn't leave any mess, and only a small amount is needed to achieve a good grip. Tool-Aid is available from Duffy Enterprises, 2212 Bedford St., Johnstown, PA 15904. Price per package: $3.99. — *Sandy Gerli, AC1Y*

CERMETEK TELEPHONE LINE INTERFACE

☐ The Cermetek Microelectronics, Inc., CH1810 is a stand-alone, direct-connection device that was primarily designed to allow data terminal equipment to be connected directly to the telephone line. This device has received FCC approval under Part 68. FCC recertification is not required when integrated into systems, provided the included label is externally attached; it contains the registration number and ringer equivalence.

The CH1810 can be used as a telephone-line interface in a variety of environments. These include use with modems, answering machines, FAX machines, auto dialers, burglar alarms, remote metering devices, etc. Pc-board mountable, the DCPH (Direct Connect Protective Hybrid) occupies less than 5 square inches[1] of space. Connection to the DCPH is made by means of 0.1-inch-on-center pins. A ±12-V power supply is required.

These devices are manufactured by Cermetek, Inc., 1308 Borregas Ave., Sunnyvale, CA 94086, and are available from P and L Associates, P.O. Box 481, East Setauket, NY 11733. Price class in 1 to 9 quantities: $95. — *Paul K. Pagel, N1FB*

[1]mm^2 = in.^{2} × 645.16.

Technical Correspondence

Conducted By
Dennis J. Lusis,* W1LJ

WHEN IS A BALUN A "BALUN"?

☐ It is important to recognize that a 4:1 or a 1:1 balun (balanced to unbalanced) is essentially a broadband transformer. It needs to be if it will be called upon to perform the prescribed function of joining an unbalanced transmission line to a balanced load.

Assuming that a balun or any broadband transformer is designed correctly, and that it does not introduce appreciable unwanted reactance in the system, it will function well into a resistive load. This is not difficult to realize in circuits where the load remains relatively constant, such as in the case of a solid-state Class-A driver being transformer-coupled to the bases of two transistors in Class-A amplifier service. Furthermore, broadband transformers are used mainly at low impedance levels (say, under 500 ohms) if proper performance is expected. Also, the bandwidth of a balun is governed by the design, and, with proper attention to leakage and stray reactance, it can provide the expected performance over several octaves. Not all baluns meet this criterion. A balun can be tested for bandwidth by placing an SWR indicator between it and a transmitter. The balun (or other broadband transformer) is terminated in the appropriate resistance (noninductive). The balun is then "swept" over the intended operating range, band by band, and the VSWR is noted. Ideally, it will remain 1:1, or nearly so, if all is as it should be. High VSWR readings indicate poor performance. It is wise to check this before committing a balun to an antenna system. This is particularly important when magnetic-core baluns are employed (ferrite or powdered-iron); if the VSWR is high, and so is the rf power, core saturation can occur. If this happens in an antenna system, the balun will generate harmonic energy and can be damaged permanently. Also, the effective inductance of the balun coil will change, which can contribute further to inferior performance.

There are other considerations when a broadband transformer is used in an antenna system. Typically, an amateur antenna presents a resistive condition at resonance. This can be at some discrete frequency within a band, or at a very narrow segment of a given band. If that resistive characteristic is of the proper value for the transmission-line impedance, all will be okay. But, at either side of that frequency there will be a reactive condition. This will affect the performance of the transformer and can make the VSWR seen at the transmitter end of the line much worse than it would be without a balun in the system. Proof of this phenomenon is seen in Tables 1 and 2. Table 1 shows the VSWR of a commercial triband Yagi when a 1:1 balun was connected to the balanced feed point. The transmission line was 60 feet[1] of 50-ohm aluminum-jacketed Hardline. The Yagi was adjusted for the cw portions of each band (20, 15 and 10 meters). Note that the apparent antenna resonance appears to be outside the low end of each band. Also, the VSWR bandwidth is very poor.

Table 1
VSWR Measurements for Yagi Antenna with Balun

Frequency (MHz)	*VSWR*	*Frequency (MHz)*	*VSWR*
14.000	1.3:1	21.300	4:1
14.100	1.7:1	21.400	6:1
14.200	2.2:1	28.000	1.5:1
14.300	3:1	28.100	1.6:1
		28.200	1.75:1
21.000	1:1	28.300	1.85:1
21.100	1.6:1	28.400	2:1
21.200	1.85:1	28.500	2.47:1

VSWR measurements were taken with a Bird Thruline wattmeter for a commercial triband Yagi with 60 feet of Hardline. A commercial 1:1 balun was installed at the antenna feed point, and the antenna was adjusted for operation in the cw portions of the three bands.

Table 2
VSWR Measurements for Yagi Antenna with Decoupling Coil

Frequency (MHz)	*VSWR*	*Frequency (MHz)*	*VSWR*
14.000	1.5:1	28.000	1.4:1
14.050	1.3:1	28.050	1.35:1
14.100	1.3:1	28.100	1.3:1
14.200	1.57:1	28.200	1.3:1
14.300	1.9:1	28.300	1.22:1
		28.400	1.22:1
21.000	1.5:1	28.500	1.23:1
21.050	1.3:1	28.600	1.3:1
21.100	1:1	28.700	1.43:1
21.200	1.4:1	28.800	1.57:1
21.300	2.54:1	28.900	1.75:1
21.400	4.44:1		

VSWR measurements were taken with the same antenna and conditions specified in Table 1, but with the balun replaced by an RG-8/U decoupling coil, 8 turns (solenoidal), 6-in. ID.

Table 2 contains VSWR data that was obtained from the same antenna, one day later, with the commercial balun removed. It was replaced by a coaxial decoupling coil (8 turns of RG-8/U cable, solenoidal-wound, 6-in. ID). This type of device is recommended by a number of beam-antenna manufacturers to prevent feed-line radiation. Note that the VSWR now "bottoms out" well within each band, and that the VSWR bandwidth of the antenna has increased markedly.

Tables 1 and 2 clearly illustrate the undesirable effects caused by the balun. Obviously, there was a sufficient reactance present to disturb the system performance. This is especially true of the 10-meter performance.

The losses must be considered also. When a balun is attached to an improper load, it can be subjected to considerable heating, depending on the amount of rf power supplied to the antenna. Heat causes losses and, if severe enough, it can destroy the balun. I have experienced high levels of heat in balun coils with only 100 watts of rf power when attempting to couple a balanced transmission line to a Transmatch. This was most prevalent when the line reflected a fairly high impedance to the balun.

If you've had problems with baluns, perhaps your balun isn't a *balun* in your particular system. These problems apply even to dipole antennas, and the lower the operating frequency (160 and 80 meters especially) the worse the problem, because of the restricted antenna bandwidth. — *Doug DeMaw, W1FB, ARRL Hq.*

[1]mm = in. × 25.4; m = ft × 0.3048.

*Assistant Technical Editor

Feedback

☐ In "TS-830S Final-Amplifier Current Monitoring," (*QST*, October 1981 Hints and Kinks) an incorrect pin number is given. The first sentence in the third paragraph should read: " . . . solder R4 and R5 between V2 pin 4 foil and the ground foil."

☐ Please note this correction by author Palmer to Fig. 7 of "Refining the SB-104," March 1982 *QST*. Delete the wire joining pc board connections 14 and 2. This wire is adjacent to the 0.1-μF input coupling capacitor.

☐ Owing to nonuniformity in the characteristics of transistors and ICs, some builders of the "Bare-Bones CW Superhet" in June 1982 *QST* may have less than the desired 2 V pk-pk of LO injection to the mixer. If this is the case, delete the 4:1 balun (T7 of Fig. 4) and replace it with a 1-mH rf choke. The 0.1-μF output capacitor then connects directly to the collector of Q10. Also, change the 100-pF coupling capacitor between Q9 and Q10 to a 470-pF value. These changes do not apply to the VXO model. Also, if audio feedback is noted when using 8-ohm or other low-Z phones, add a 0.1-μF capacitor between pins 3 and 7 of U1.

☐ The article, "New Life for ARRL Sections" (June 1982 *QST*), contains an error which may confuse the reader. On page 54, at the beginning of the last full paragraph in the third column, the italicized words "*Section Emergency Coordinator*" are superfluous and should be deleted. The paragraph is a continuation of the discussion about the *State Government Liaison*.

☐ In "Results, 1981 Simulated Emergency Test," published in June 1982 *QST*, the report of Bexar Co. EC WA5RNV was inadvertently overlooked. Total points for the Bexar Co. ARES was 456, which gives Southern Texas a corrected total of 1670 points. Also, the Lee Co., Iowa, SET total, as reported by WBØVYG, was 99 points. The Iowa Section's adjusted total is now 1381 points.

☐ The sunspot number listed on page 73 of June 1982 *QST* should be 107, not 110.

QST

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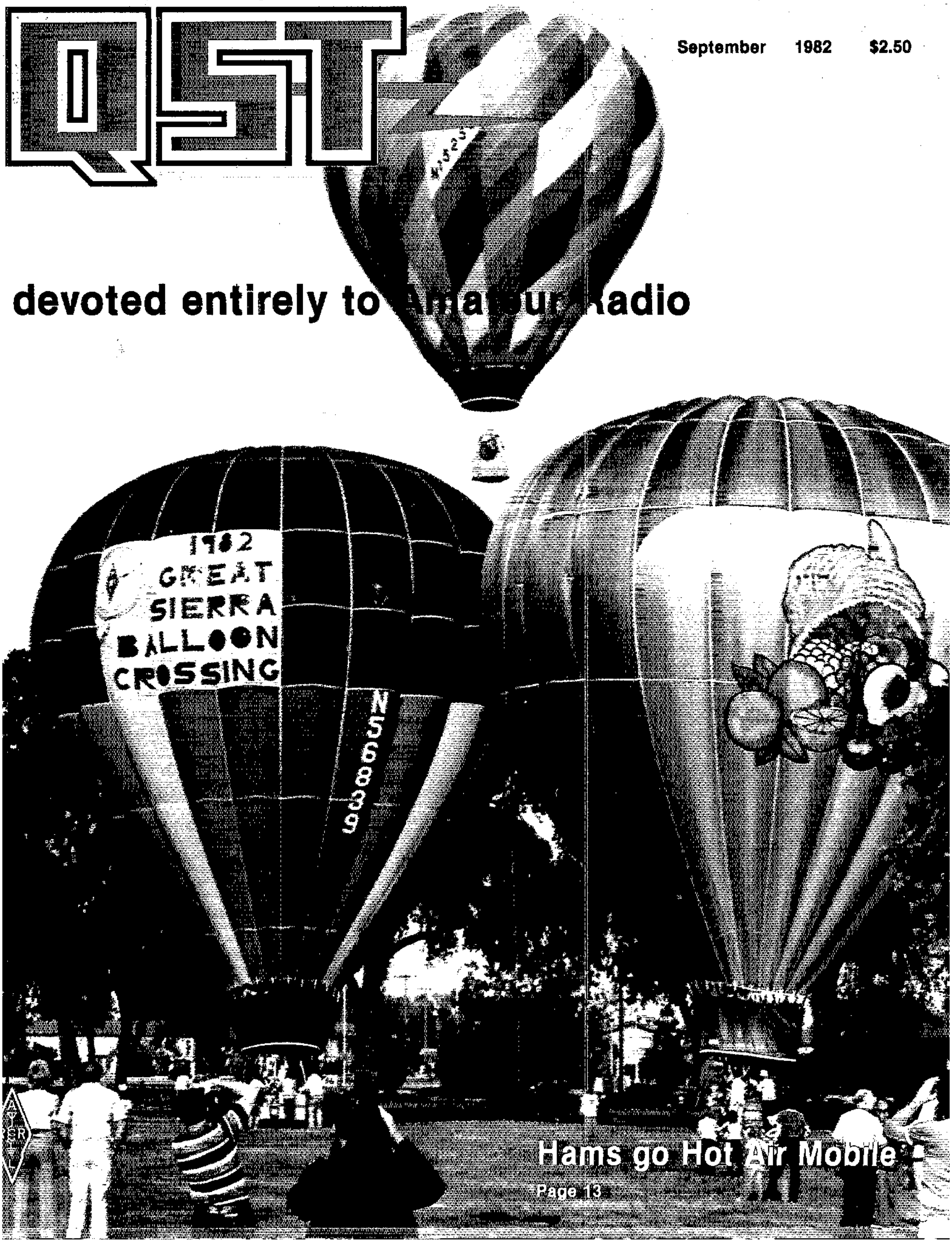

Hams go Hot Air Mobile

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QST

September 1982 *Volume LXVI Number 9*

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THE COVER

There'll be hot air galore at the California Balloon Festival Sept. 23-26. Contact a HAM operator and earn a certificate! See p. 13.

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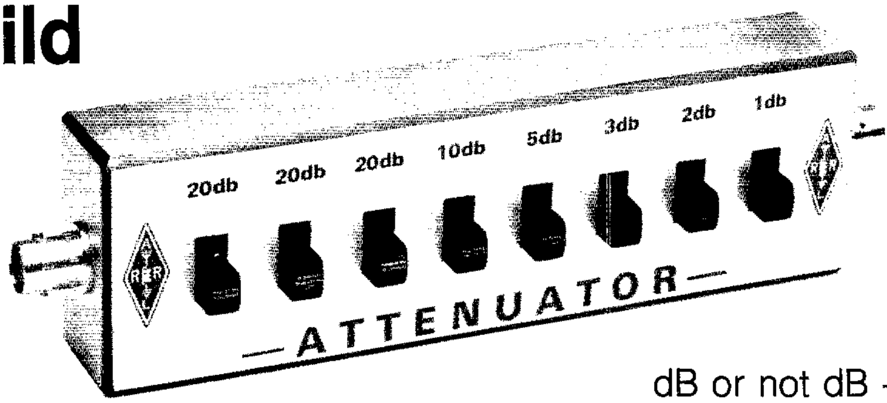
A Step Attenuator You Can Build



dB or not dB — you decide! This low-cost, high performance addition to your shack or workshop is a worthy project.

By Bob Shriner,* WAØUZO and Paul K. Pagel,** N1FB

There probably are a number of *Handbook* and *QST* readers who need a low-cost, 1-dB step attenuator for the workbench or shack. Purchasing a commercially made unit may be out of the question because of the expense involved. Certainly the concept of the attenuator is simple, the formulas and resistor values are at hand,[1] and the components are inexpensive and readily available. But layout of the unit and concern for the careful assembly involved (if good, reliable results are to be obtained) are, for many, enough to put the idea far out of mind.

Well, take heart! At last you can have that attenuator without agonizing over the parts layout! The mechanics have been worked out for you. If you have an aversion to cutting rectangular switch holes, a complete kit — with prepunched switch holes — may be purchased.[2] Doesn't that sound attractive?

Description

Fig. 1 is the schematic diagram of the attenuator. Eight pi-network resistive sections are employed; the attenuation is variable in 1-dB steps. A total attenuation value of 81 dB may be had with all the sections switched in. The maximum attenuation of any single section is limited to 20 dB because leak-through would probably spoil the effect of higher attenuation sections and result in inaccuracy.

This is a low-power attenuator; it is not designed for use at power levels exceeding 1/4 watt. If for some reason the attenuator will be connected to a transceiver, a means of bypassing the unit during transmit periods must be devised.

Parts

All the switches are dpdt standard-size slide types. Stackpole S-5022CD03-0 units are used here. Other switch types may work as well, but have not been tested. The use of subminiature switches should be avoided. An earlier prototype using such switches was constructed, but the results obtained were inadequate, owing to poor isolation and mechanical switch construction.

Carbon-composition or film, 1/4-watt, 5%-tolerance resistors are used. The calculated resistance values and the actual values used are shown in Table 1. Ideally, the resistors should be selected using a reliable ohmmeter; this will ensure accuracy.

Double-sided pc board is used for the enclosure. Dimensions for the model described here are given in Fig. 2. The kit version of the attenuator has identification lettering etched into the top surface (or front panel) of the unit. This adds a nice touch, and is a permanent means of labeling. Of course, rub-on transfers or Dymo tape labels could be used as well.

Female BNC single-hole, chassis-mount connectors are used at each end of the enclosure. These connectors are small and easy to mount, have excellent rf qualities, and provide a means of easily connecting and disconnecting the attenuator by a simple twist of the wrist. They are available from many suppliers, including Radio Shack.[3] For the economy-minded builder, perhaps the best place to scrounge this type of connector is at flea markets. They are usually offered as "pull outs" and at attractive prices.

Construction

After all the box parts are cut to size and the necessary holes are made, scribe light lines to locate the inner partitions. Carefully tack-solder all partitions in position. A 40-watt pencil type of iron should provide sufficient heat. Dress any pc-board parts that do not fit squarely. Once everything is in proper position, run a solder bead all the way around the joints. Caution: Do not use excessive amounts of solder, as the switches must later be fit flat inside the sections. The top, sides, ends and partitions can be completed. Dress the outside of the box to suit your taste. For instance, you might wish to bevel the

[1]Notes appear on page 13.
*P.O. Box 969, Pueblo, CO 81002
**Assistant Technical Editor, ARRL

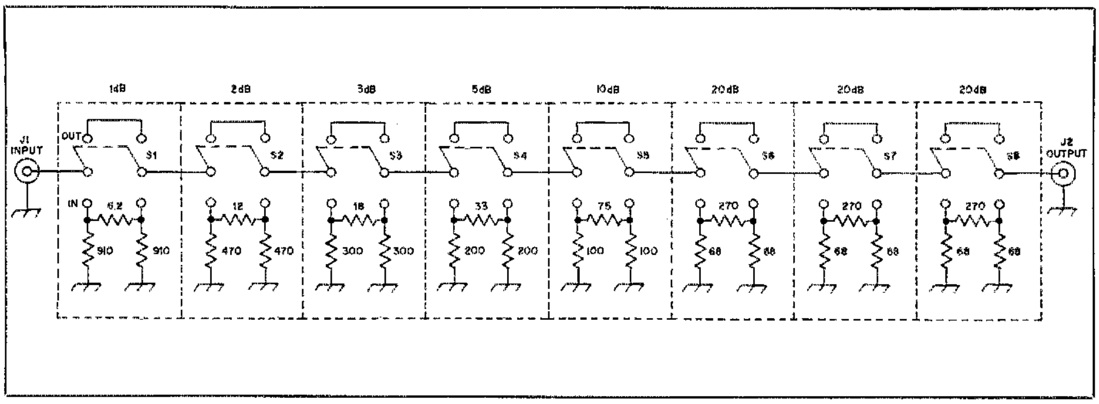
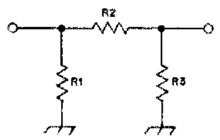


Fig. 1 — Schematic diagram of the attenuator. Resistors are 1/4-W, 5%-tolerance, carbon-composition or film types. Resistances are given in ohms.

Table 1

Pi Network Attenuator Resistance Values for 52 Ohm Impedance

Calculated Value			*Standard Value Used*	
dB	*R1, R3*	*R2*	*R1, R3*	*R2*
1	904	6	910	6.2
2	453	12	470	12
3	304	18	300	18
5	185	31	200	33
10	100	74	100	75
20	63	257	68	270



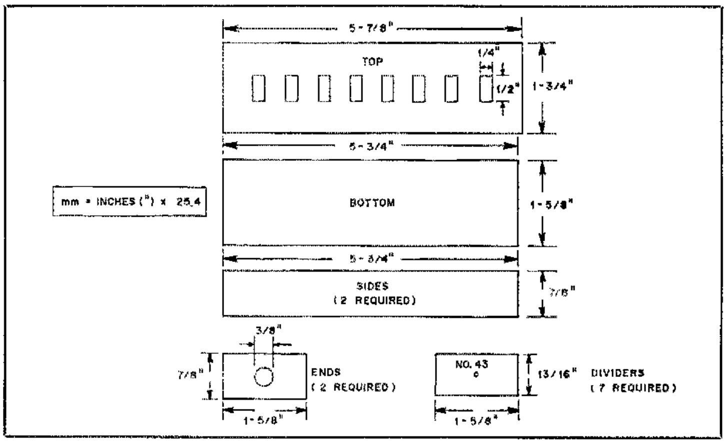


Fig. 2 — Mechanical dimensions of the attenuator enclosure.

box edges. Buff the copper with steel wool, add lettering, and finish off the work with a coat of clear lacquer or polyurethane varnish.

Using a little lacquer thinner or acetone (and a lot of caution), soak the switches to remove the grease that was put in during their manufacture. When dry, spray the inside of the switches lightly with a TV-tuner cleaner/lubricant. Using a sharp drill bit (about 3/16 inch will do),[4] countersink the mounting holes on the actuator side of the switch mounting plate. This ensures that the switches will fit flush against the top plate. At one end of each switch, bend the two lugs over and solder them together. Cut off the upper halves of the remaining switch lugs. (A look at Fig. 3 will help clarify these steps.)

Solder the horizontal members of the pi sections between the appropriate switch lugs. Try to keep the lead lengths as short as possible, and do not overheat the resistors. Now solder the switches in place to the top section of the enclosure by flowing solder through the mounting holes and onto the circuit-board material. Be certain that you place the switches in their proper positions; correlate the resistor values with the degree of attenuation. Otherwise, you may wind up with the 1-dB step at the wrong end of the box — how embarrassing!

Once the switches are installed, thread a piece of no. 18 bare copper wire through the center lugs of all the switches, passing it through the holes in the partitions. Solder the wire at each switch terminal. Cut the wire between the poles of each individual switch, leaving the wire con-

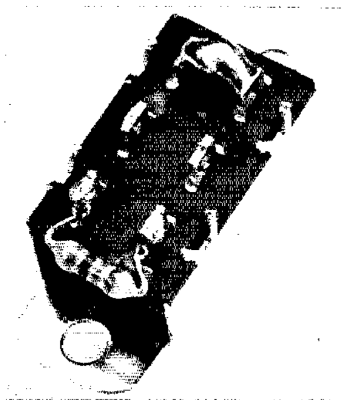


Fig. 3 — Close-up of the switch detail.

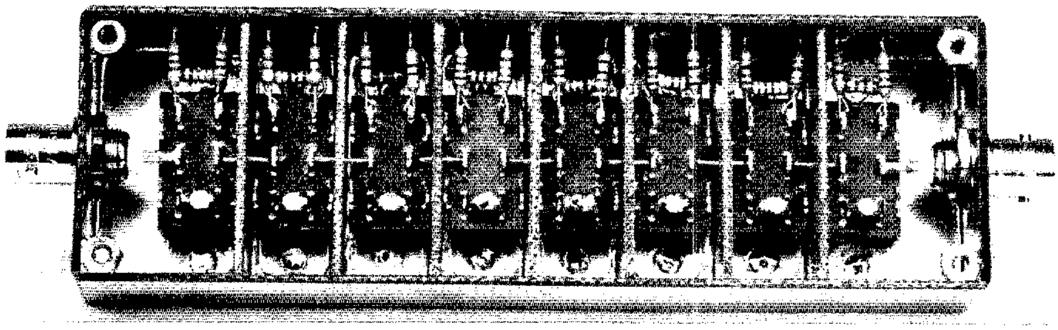


Fig. 4 — An inside view of the completed attenuator. Use of short, direct leads enhances the performance of the unit. Brass nuts soldered at each of the four corners allow machine screws to be used to secure the bottom cover. File one corner of each nut to permit a flat, two-sided fit within the enclosure.

necting one switch pole to that of the neighboring one on the other side of the partition, as shown in Fig. 4.

At each of the two end switch terminals, leave a wire length of approximately 1/8 inch. Install the BNC connectors, and solder the wire pieces to the connector center conductors.

Now install the resistors that comprise the vertical (grounded) legs of each pi section. Use short lead lengths. Remember that physical symmetry is conducive to good performance. Do not use excessive amounts of heat when soldering.

Solder a no. 4-40 brass nut at each inside corner of the enclosure. Recess the nuts approximately 1/16 inch from the bottom edge of the box to allow sufficient room for the bottom panel to fit flush. Secure the bottom panel with four no. 4-40, 1/4-inch machine screws and you're done!

The End Result

ARRL lab tests proved the attenuator to be a good performer. A Hewlett-Packard 8640B signal generator and a 8554B spectrum analyzer were used with a Tektronix 2701 step attenuator in the test setup. Results of the insertion-loss measurements, with no attenuation switched in, are shown in Table 2. The homemade attenuator exhibited a maximum error of less than ±1 dB through 450 MHz, the maximum error occurring in the 20-dB attenuator sections. Such a degree of accuracy should be more than adequate for most applications.

We hope you enjoy building this weekend project. You're sure to find a number of uses for it in the shack and in the workshop. It's a simple — and accurate — piece of test equipment you can build yourself!

Table 2
Attenuator Insertion Loss

Frequency (MHz)	29.7	50	144	220	450
Insertion loss (dB)	<0.1	<0.2	0.5	0.5	1.2

Notes

[1]D. DeMaw, *ARRL Electronics Data Book* (Newington: ARRL, 1976), p. 32.
[2]A complete kit of parts is available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002. Price: $15.
[3]Part no. 278-105.
[4]mm = in. × 25.4.

Strays

RIDING HIGH WITH AMATEUR RADIO

☐ Things really will be looking up on September 23-26, when members of the Tulare County Amateur Radio Emergency Service provide communications for the 1982 California Balloon Festival in Visalia. As in the past two years, the Tulare ARES hams will be kept busy with a host of on- and off-the-air activities, which include handling emergency medical traffic and manning a public display booth for the 50,000 people expected to attend the four-day event. A special attraction during the weekend will be a helium balloon race, which the amateurs will monitor for race officials.

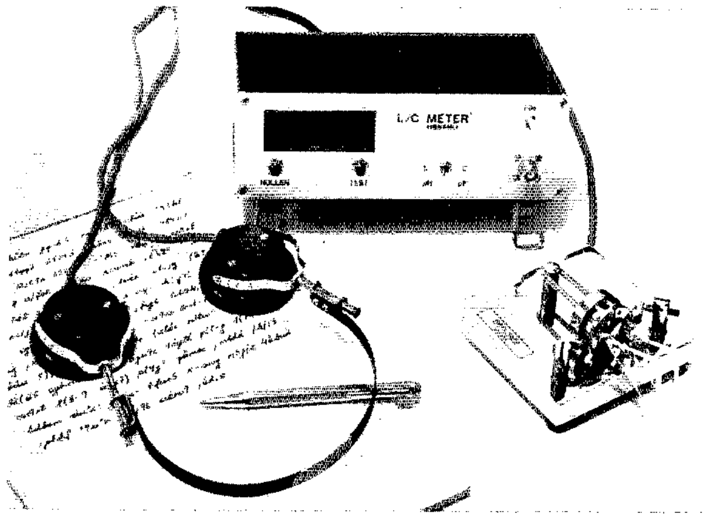
In addition, Tulare County hams expect to make contacts with amateurs around the world while operating a special-event station at the launch site, where nearly 75 colorful hot-air balloons are also scheduled to fly. A certificate will be awarded to those contacting KB6AR or KB6CC on 7.235, 14.285, 21.360 or 28.510 MHz from 0100Z September 25 to 0100Z September 27. QSL with a business size s.a.s.e. to KB6CC at the address below for your certificate. Who knows; maybe you'll be able to complete a QSO with a H.A.M. (Hot Air Mobile) operator! — *Scott Thompson, KB6CC, 4024 W. Monte Vista Ave., Visalia, CA 93277*

Radio amateurs who contact the 1982 California Balloon Festival special-event stations will receive an attractive certificate similar to this one, which was awarded last year.

Next Month in QST

- It's nonpolluting, renewable and, best of all, free. What is it? Solar power. If you've ever thought about using the sun to run your amateur station, you'll want to read the article in October *QST*.
- Need a paddle for use with an iambic keyer? You can build the "CHIP" quickly and cheaply.
- If you're a contester who has access to a computer, check out the On Line column. It will provide insights on automating your contest efforts.

Build a Microprocessor-Controlled L-C Meter That Sends Morse Code



Part 1: This classic-looking unit has much to offer the active amateur. Its good looks are exceeded only by its accuracy.

By Urs Hadorn,* HB9ABO

This L-C meter complements those low-cost R-C or R-L-C measuring instruments that do not cover the ranges suitable for hf and vhf work; inductances of 0 to 2000 μH and capacitances of 0 to 2000 pF can be measured. It can also be used as an electronic keyer or as an automatic Morse code generator, with the sending speed being displayed in both cases. Two software versions are available for this microprocessor-based unit. The operating parameters and differences between the two software versions are presented in Table 1.[1]

One might wonder why an L-C meter has been mated with such an unrelated function as that of an electronic keyer. The evolution occurred because my keyer and an old L-C meter were constantly "struggling" for the limited space available on my operating table. Furthermore, it provided an opportunity to replace hardware with software, as there was still some free space in the program memory, once the L-C meter functions had been accounted for. The cost of the additional keyer parts (one IC and three jacks) is a fraction of the cost of a separate electronic keyer!

[1]Notes appear on page 17.

*Im Riedtli 1, CH-8154 Oberglatt, Switzerland

Fundamentals

Measuring principle: Ideas for the measuring method were taken from the Tektronix type 130 L-C meter (refer to Fig. 1). An oscillator operates at an idling frequency, f_0. The inductance to be measured is connected in *series* with the oscillator inductance; the capacitance to be measured is connected in *parallel* with the oscillator L-C circuit. With an "unknown" connected, the oscillator frequency is shifted to a lower frequency, f_2. With f_2 and both resonant-circuit constants (L and C) known, the unknown component value can be calculated by

$$L_x = \frac{1}{(2\pi f_2)^2 C} - L \qquad \text{(Eq. 1)}$$

$$C_x = \frac{1}{(2\pi f_2)^2 L} - C \qquad \text{(Eq. 2)}$$

where

L_x = unknown inductance in henrys
C_x = unknown capacitance in farads
L = inductance of the oscillator resonant circuit in henrys
C = capacitance of the oscillator resonant circuit in farads
f_2 = oscillator frequency in hertz (with the unknown connected)

The relationships of Eq. 1 and 2 assume stable and constant values for L and C. This condition normally cannot be met in practice because a free-running oscillator often has a tendency to drift, especially when a flexible piece of cable and two movable clips form part of the frequency-determining circuit, as is the case in this setup.

The following premises determined the assignment of values for f_0, L and C in the design phase:

1) Inductance resolution should be more refined than that of capacitance, because 1 μH is more significant than 1 pF in practical shortwave work (a fact that seems to be often ignored by manufacturers of test equipment). Hence, the ratio of picofarads to microhenrys in the L-C circuit should be greater than 1:1.

2) The maximum counting frequency of the microprocessor (μP) used is 133

Table 1

Differences Between Software Versions

Parameter	*Standard Software*	*USA Software*
Display for overflow	UEb	OFLO
Display for underflow	-UL-	-UF-
Cw speed display	Characters per minute	Words per minute
Cw speed range	30 to 250 cpm	6 to 50 wpm
Cw speed increment	1 cpm	0.2 wpm
Number of characters in set	51	44
Character set	ABCDEFGHIJKLMNOPQRSTUVWXYZ 1234567890..?/-äëöüéà( ),'':	ABCDEFGHIJKLMNOPQRSTUVWXYZ 1234567890..?/-),:;

kHz; f_o must not exceed this value.

With these conditions in mind, I chose f_o = 120.000 kHz and L = 700 μH. This dictates a C value of 2513 pF.

Assume the oscillator idles at 120,050 Hz instead of the theoretical f_o of 120,000 Hz. Further assume a small value C_x is connected to the measuring terminals. This detunes the oscillator to frequency f_2 of, say, 120,005 Hz. Because f_2 is higher than f_o, Eq. 1 yields a negative result! Although this can happen only with small values of C_x and L_x, this fundamental type of error is not acceptable, even for amateur equipment.

If the inevitable oscillator instability and the movableness of the measuring terminals are taken into account, the *actual* idling frequency (f_I) must be recorded just before connecting the unknown. This frequency must be included in the calculation together with *one* of the resonant-circuit constants (L or C) as shown by

$$L_x = L\left(\frac{f_I^2}{f_2^2} - 1\right) \qquad \text{(Eq. 3)}$$

$$C_x = C\left(\frac{f_I^2}{f_2^2} - 1\right) \qquad \text{(Eq. 4)}$$

where

f_I = actual idling frequency — the oscillator frequency when there is no unknown connected. When measuring L_x, test terminals are shorted; when measuring C_x, test terminals are open circuited.

Any error caused by the drift or the measuring setup is included in f_I. In Eq. 3 and 4, the error (if any) is assigned to that resonant-circuit constant that does not appear in the equation. This means that when measuring capacitances any deviation of the actual idling frequency (f_I) from its theoretical value (f_o) is credited to the circuit L; whereas when measuring inductances the circuit C is blamed for any deviation. With these assumptions the overall accuracy is barely influenced, as will be shown later.

Oscillator: The active portion of the oscillator of this instrument is an NIC (Negative Immittance Converter) circuit.[2] See Fig. 2. The NIC yields a negative resistance (−R) at the output terminal, A, provided that R1 = R2. This negative resistance compensates for the loss resistance in the oscillator tank circuit. The now "lossless" tank starts to oscillate, hence the circuit becomes an oscillator.

Accuracy

A number of factors determine the practical accuracy of this L-C meter: oscillator instability, resolution, losses in the unknown.

Oscillator instability: The oscillator frequency is allowed to deviate ±0.17% from the nominal value. If this limit is exceeded on either side, measurement is inhibited by the controlling software. In the worst case, the circuit L or C is therefore allowed to miss the nominal value by not more than ±0.33%, which is equal to the effective error for the measurement. In practice, this oscillator drifts only about 0.05% in the temperature range of 15 to 25° C.[3] The error to be expected because of drift is therefore 0.1% — negligible for an instrument of this category.

Resolution: Two factors determine the resolution:

1) Because the oscillator frequency is being measured during 0.25 second, the smallest frequency change that can still be detected is 4 Hz. If f_I = 120,000 Hz, f_2 = 119,996 Hz, L = 700 μH and C = 2513 pF are used in Eq. 3 and 4, the smallest measurable inductance amounts to 47 nH (0.047 μH), and the smallest measurable capacitance amounts to 0.167 pF.

2) The program computes with an accuracy of 16 bits, the binary point being to the left of the fifth least significant bit. This can produce a maximum computing error of 0.03125 μH or pF.

To determine the overall worst-case instrument resolution, the counter and computer resolution values have to be added: 0.047 μH + 0.03125 μH = 0.08 μH, and 0.167 pF + 0.03125 pF = 0.2 pF. The effects of resolution are most restrictive when small values are being measured. They can, however, be minimized by interpolation between two adjacent values.

Losses in the unknown: Although they are restricted almost exclusively to inductors, losses in the unknown are the most important source of error for this L-C meter. During the alignment procedure the oscillator is adjusted so that an equivalent series loss resistance of 0 to 10 ohms does not affect the oscillator frequency. The compensation circuit involved (C11, C13 and R2 of Fig. 3), however, introduces reactances of unknown magnitude. Oscillator adepts are kindly invited to contemplate about this mechanism so as to find a rule of thumb for predicting the amount of error due to losses in the unknown.

Practical accuracy: To check the instrument accuracy, a number of various types of inductors and capacitors were measured, using 11 L-C meters constructed according to the information given here. The results were compared to those obtained using a Hewlett-Packard 4274A L-C-R meter — a lab type of instrument. From the results the following conclusions were made:

1) Readings of less than 1 pF and of less than approximately 0.4 μH are just rough estimates because of resolution limitations.

2) The lower range readings differ in accuracy and deviation between units. In the medium and higher ranges, where the

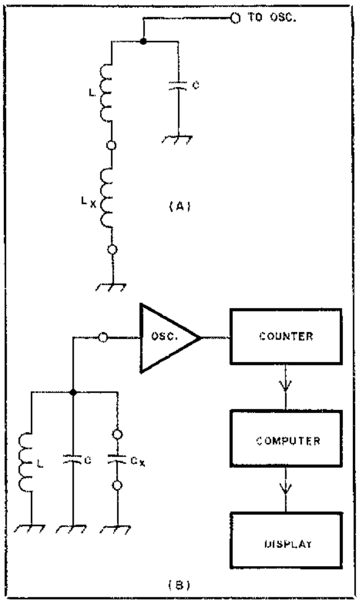


Fig. 1 — Basic circuit of the L-C meter for measuring inductance (A) and capacitance (B).

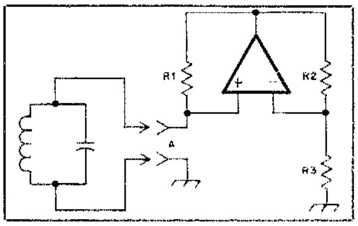


Fig. 2 — Basic circuit of an oscillator using an NIC circuit as the active element.

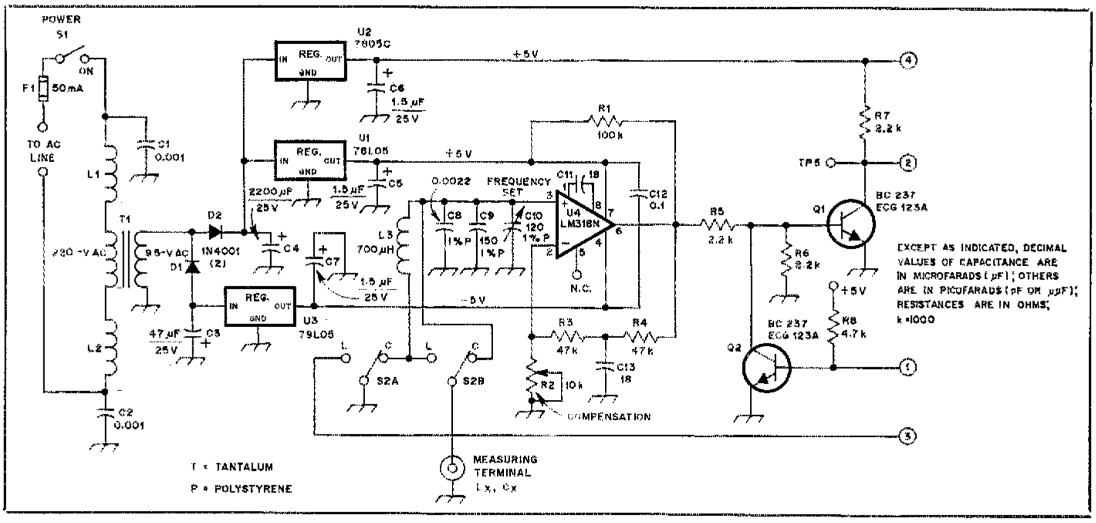


Fig. 3 — The L-C meter analog-section schematic diagram. T1 is of European manufacture. It bears the identification TUP.7W9, and has secondary ratings of 9.5 V and 7.5 W, and a 220-V primary. (Purchased from Grieder AG, Nauenstrasse 63, CH-4002 Basel, Switzerland).

resolution is of less importance, the deviation in results becomes more uniform and the variation decreases.

3) Some inductors yielded rather small errors; others produced greater deviations, but with a remarkable unanimity among the L-C meters.

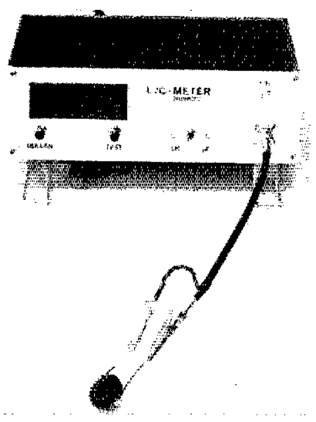
4) Obviously, the error in inductance reading depends on the coil design. High-Q inductors produce more accurate readings. Capacitance-measurement errors are less dependent on the different capacitor types. However, the deviations are so remarkably uniform that a correction factor of + 1% is justified. This factor has been incorporated into the latest software version.

Rather than predict a definite figure of accuracy for this instrument, as is customary for industrial equipment, all aspects affecting accuracy have been discussed or at least mentioned. This should enable the reader to judge the degree of accuracy that can be expected from this L-C meter. Compared with other instruments in the lowest price class, this unit has a high degree of accuracy that is sufficient for the purposes of the hf constructor.

Circuit Description

Analog Section: This section (shown in Fig. 3) consists of the power supplies and the oscillator. U1 and U3 form the split supply for the oscillator. U2 is the main regulator, feeding + 5 V to the digital circuit and the display. S2, the L-C selection switch, establishes the configuration according to Fig. 1A or 1B, and signals the position to the microprocessor.

The 2513-pF capacitance value required is formed by the sum of the capacitances of C8, C9, C10, the capacitance of the measuring setup and a capacitance introduced by the op-amp circuit. C10 is used to tune the oscillator frequency to exactly 120,000 Hz.



The L-C meter in action, measuring inductance.

Circuit inductance (L) is concentrated in L3, which has to be prealigned to 700 µH. R2 is used to compensate for losses in the unknown.

Q1 is driven into saturation by the output signal of U4. It translates the symmetrical signal into a 5-V pk-pk square wave (TP5) to suit the needs of the microprocessor. Q2 is used by the µP to lock out the oscillator signal in the ELECTRONIC KEYER and CW TUTOR modes.

If desired, only the analog part of the instrument and a simplified power supply can be built. Such a "barefoot" L-C meter requires the use of a frequency counter and a calculator. The counter is connected to test point TP5. With no unknown connected, f_1 is read from the counter and entered into the calculator. Then the unknown is connected, and the new frequency (f_2) is entered into the calculator. The unknown then can be calculated using Eq. 3 or 4. Circuit constants remain the same: L = 700 µH, and C = 2513 pF.

Digital Section: This section, shown in Fig. 4, is dominated by the µP, U6. To reduce costs, a circuit with more than one chip is used, with the 8035 being chosen for the µP. U6 measures the incoming frequency at input pin T1 by means of an internal frequency counter, and then computes the value of the unknown inductor or capacitor. Signals from S3 (NULL) and S2 (L-C) affect the process of calculations.

U6 is connected to the "outside world" via the DOT and DASH lever inputs and the TONE and TX outputs. These connections are routed through buffer stages (U5) to protect U6 from unpredictable conditions that sometimes prevail in a ham shack. The TX output is able to handle + 30-V amplitudes and sink keying currents of up to 40 mA. The TONE output emits a 5-V pk-pk, 781-Hz signal so that keying may be monitored. A small speaker can be connected in series with a 1.5-µF capacitor (acting as an impedance transformer) to the TONE output.

The data bus links U6 with the address latch (U7), the program memory (U8) and the display driver (U9). On this bus, the latch and the display driver are data receivers. The program memory is a data transmitter, and the processor is a receiver and transmitter of data. The processor releases the data bus to one of the connected components for exchanging data at a specific time. It also ensures that only

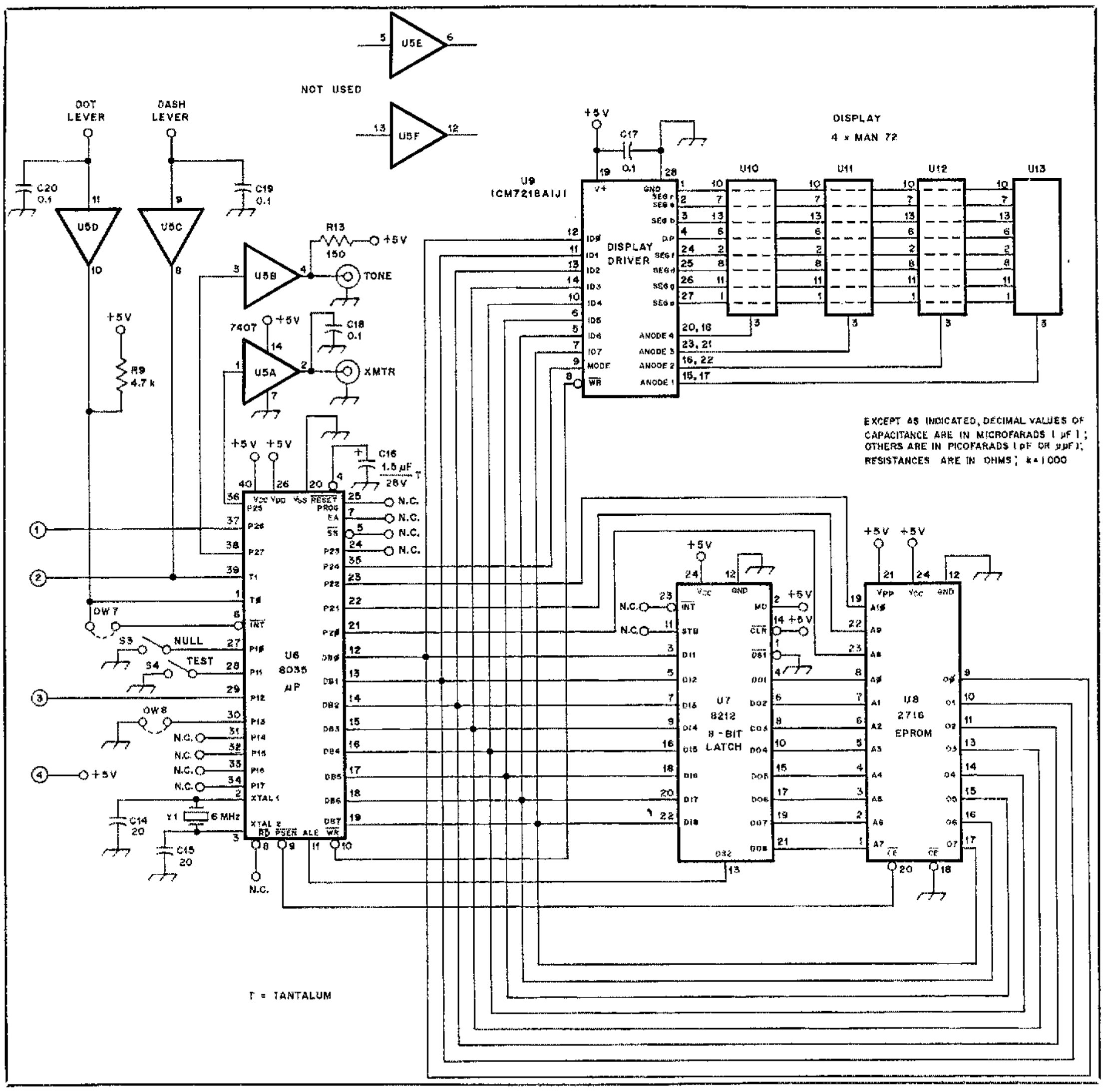


Fig. 4 — The L-C meter digital-section schematic diagram. Most, if not all, of the parts shown here may be obtained from Jameco® Electronics, 1355 Shoreway Rd., Belmont, CA 94002. See note 1 regarding U8.

the entitled addressee reads the data on the bus. This task is accomplished by means of three control signals: $\overline{PSEN}$, $\overline{ALE}$ and $\overline{WR}$. U6 generates its own clock signal using a built-in oscillator for which the frequency (6 MHz) is controlled by the external crystal, Y1.

Every 2.5 μs, the processor fetches a new instruction from U8 and executes it. U8 is an EPROM (erasable programmable read-only memory) containing the whole instrument program. In designing this instrument, about half the work consisted of developing and adapting the controlling software.

Display driver U9 receives the data to be displayed from the μP. Data are stored and displayed until there are new data coming in. Segment information distribution to the individual digits, as well as the multiplexing of the different on and off signals, is performed by U9, independently from the μP. U9 also delivers the necessary voltages and currents, limiting the latter without any external components. Part 2 of this article (to appear in a forthcoming issue) describes the microprocessor software and the construction of the L-C meter. Complete alignment and operating instructions are included. QST

Notes

[1]EPROMs (2716) containing the program can be obtained from the author for $15 U.S. or 25 Swiss Fr., prepaid air-mail delivery included. Please specify the desired software version, standard or U.S. This offer is valid for radio amateurs only, and does not include any rights to the software. Two etched, tinned and drilled pc boards (the display and main circuit boards) are also available from the author for $25 U.S. or 45 Swiss Fr., air-mail delivery included. The ARRL and *QST* in no way warrant these offers.

PC-board patterns, parts overlays, information pertinent to the original boards and an object code listing are available from the ARRL for $2. Readers should recognize that the main board is designed specifically for use with the particular power transformer, fuse holder and inductor (L3) used in the original version. However, a suitable power transformer and fuse holder may be mounted off the main circuit board, on a chassis wall, at the builder's discretion.

[2]H. Dauch, *Operationsverstaerkertechnik*, Lehrinstitut Onken, CH-8280 Kreuzlingen, Switzerland, Lehrbrief 6, S6-21.

[3]F° = 9/5 C° + 32

A Programmable Serial-Communication Interface

Frustrated by a computer that can't "speak" with your radio gear? Build this interface system and overcome the communication barrier!

By Edward B. Kalin,* K1RT

Almost any personal computer can be used as an RTTY terminal if a suitable interface to a demodulator is available. I designed such an interface for use with my Radio Shack TRS-80® (Model I, Level II) microcomputer.[1] The interface may be used to provide transmission and reception of the 5-bit Baudot code or the ASCII code using most of the popular bit rates. As the interface is general purpose in nature, it may be used to provide communication between the microcomputer and a variety of input/output (I/O) devices, such as printers, tape recorders and telephone modems. It can also be used to provide relay control of many types of electronic equipment. While this interface is designed specifically for use with the TRS-80, the same techniques can be applied to most microprocessor-based computers with little modification.

I built the interface in three parts: A port decoder, a serial-communication interface and a relay controller (Fig. 1). The port decoder is used to select up to 16 input and 16 output functions under program control. Translation between the serial-by-bit RTTY transmission format and the parallel byte-oriented structure of the microcomputer data bus is performed by the serial-communication interface. The relay controller is used for station-control functions, such as transmit-receive (T-R) switching and automated cw i-d transmission. Code format and bit rate are set by a computer program. This program must also handle the translation of the received code into a format suitable for display, and the conversion of the characters entered on the keyboard into the desired transmission code. Relay

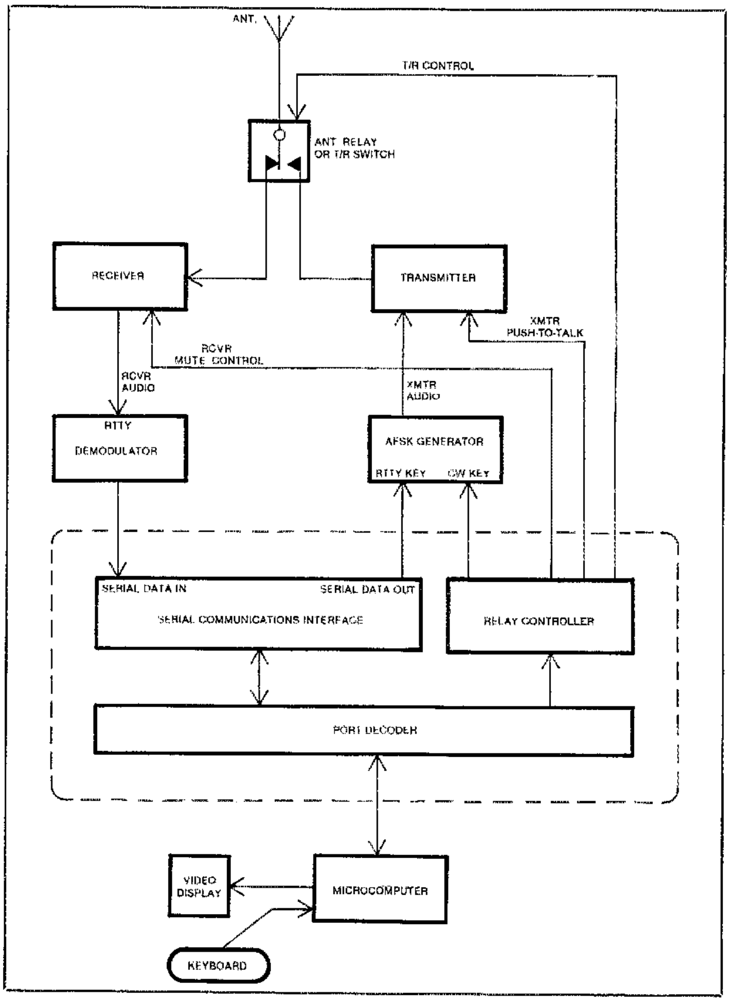


Fig. 1 — System block diagram of a typical "all-electronic" RTTY station. The microcomputer interface consists of the sections within the dashed lines.

[1]TRS-80® is a registered trademark of Tandy Corporation.

*83 Kenmore Rd., Bloomfield, CT 06002

operation is also determined by the program.

Port Decoder

At the "heart" of the TRS-80 is a Zilog Z-80 microprocessor. The Z-80 can communicate with the outside world by means of programming instructions that use I/O ports. Implemented in the Z-80 are 256 input and 256 output ports. When an instruction that references one of these ports is executed, the Z-80 places the binary address of the specified port on the eight low-order address bus pins (AØ through A7) and sets the active-low I/O request pin ($\overline{IOREQ}$) to Ø (Fig. 2). If the instruction calls for output to a port, the contents of a Z-80 register are placed on the data bus and the $\overline{WR}$ (write) pin is activated. It is the responsibility of the external device to detect the occurrence of these events and latch the eight data bits during the brief interval that they are present on the bus. If the external device latches the bus data at any other time, it will receive invalid data.

Similarly, if the instruction calls for input from a port, the Z-80 activates the $\overline{RD}$ (read) pin, and the external device must place eight bits of data on the bus during the appropriate time interval. This allows the Z-80 to read the data into a register. If the external device places data on the bus at any time other than when the appropriate port is selected, it will interfere with the normal operation of the Z-80.

The port-decoder circuit (Fig. 3) is designed to monitor the state of the address, $\overline{IOREQ}$, $\overline{RD}$, and $\overline{WR}$ signals. It can be set to recognize 16 input and 16 output ports. When the decoder senses that one of these ports has been activated, the decoder will signal the appropriate external device. In this case, the external devices are the serial-communication interface and the relay controller. Additional devices, such as digital-clock circuits, digital-to-analog and analog-to-digital converters, and LED drivers may be selected by the port decoder as well.

By ORing the $\overline{RD}$ and $\overline{WR}$ signals with the $\overline{IOREQ}$ signal internally, the TRS-80 generates active-low $\overline{IN}$ and $\overline{OUT}$ signals. These I/O signals are buffered and made available to the outside world on the 40-pin TRS-80 bus connector. A 40-conductor ribbon cable is used to connect the $\overline{IN}$ and $\overline{OUT}$ signals and the buffered address lines (AØ through A7) to the port-decoder board. The bidirectional buffered data bus is also routed to the decoder board for distribution to the serial-communication interface and the relay controller. The ribbon cable should be kept as short as possible, as it carries high-frequency square-wave signals that can interfere easily with broadcast and amateur reception.

In the port decoder, U3 buffers the $\overline{IN}$ and $\overline{OUT}$ signals and address lines AØ through A3. This results in only one LS

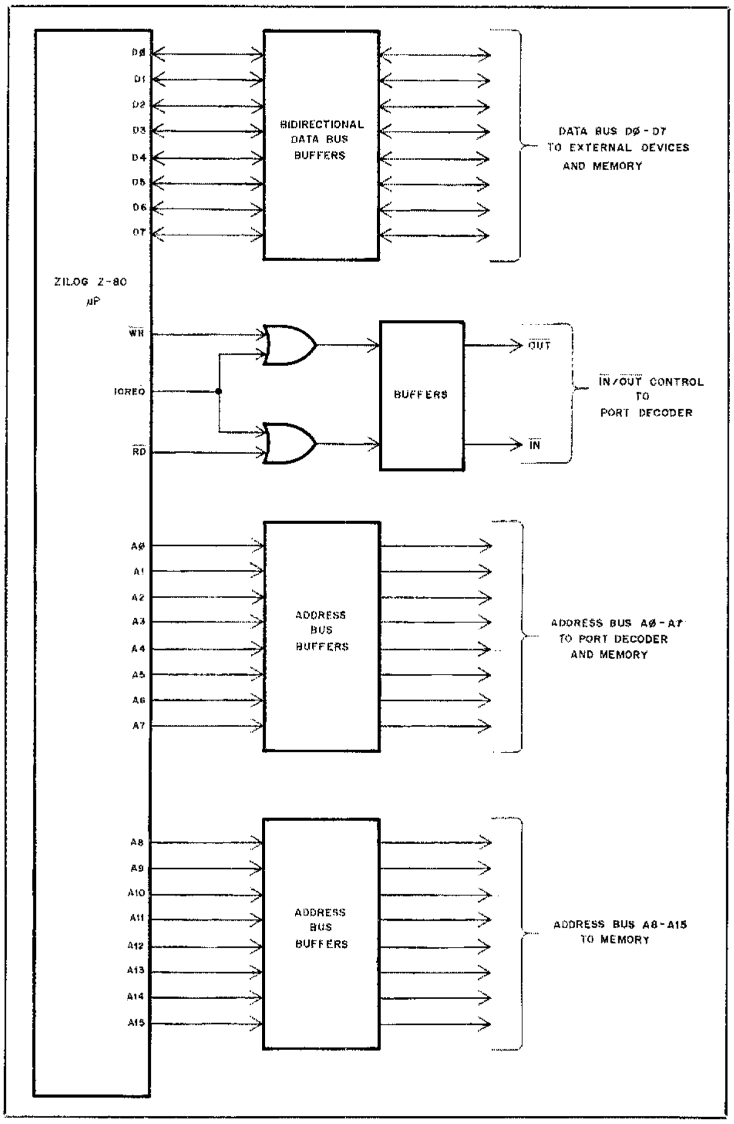


Fig. 2 — Simplified diagram showing the Z-80 microprocessor pins referred to in the text.

TTL load on each TRS-80 bus line, instead of the two TTL loads represented by U4 and U5. 74154 data demultiplexers (U4 and U5) are used to decode input and output ports Ø through 15, respectively. When an input instruction for any port in that range is executed, the $\overline{IN}$ signal and the ORed address lines A4, A5, A6, and A7 at the output of U2A are simultaneously low. This enables U4. The U4 output pin selected by the binary combination of address lines AØ, A1, A2 and A3 goes to a low logic level, while the other U4 outputs remain high. When an output instruction for any port in the proper range is executed, U5 is enabled and the appropriate output pin goes low to indicate the selected output port. The serial-communication interface and the relay controller monitor the U4 and U5 outputs and respond to the appropriate port-select pulse.

The I/O ports may be located at positions other than Ø through 15 by selecting other combinations of A4 through A7 to activate U4 and U5. As the TRS-80 uses several of the high-numbered ports for internal functions (such as activating the built-in cassette interface), it is advisable to assign user-defined ports to the lower

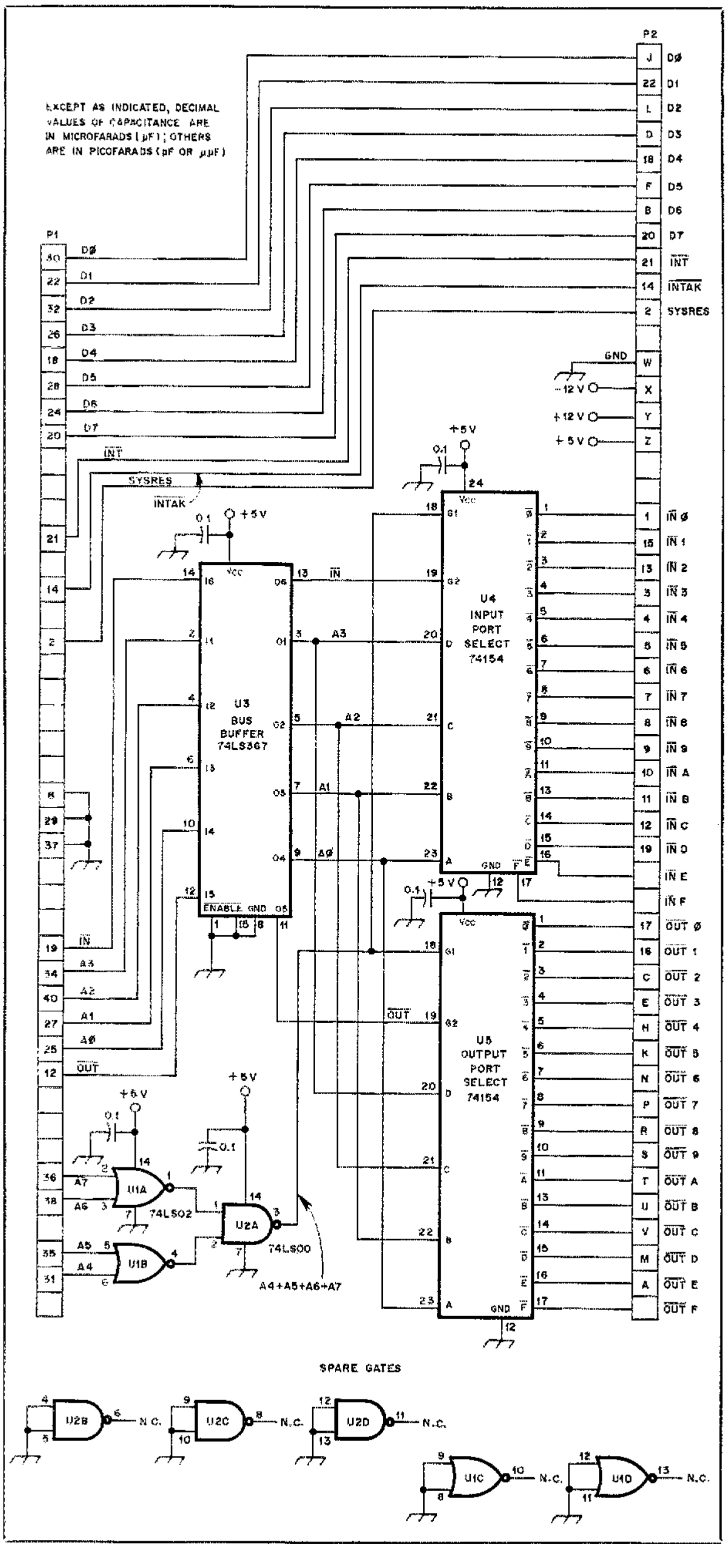


Fig. 3 — Port decoder schematic diagram. Connections to the TRS-80 bus are made through P1 (see text). P2 is a 44-contact card-edge connector used to make the connections to the other interface boards. All capacitors are 16-V, disc-ceramic. Numbered components are for text reference only.

port ranges in order to prevent conflicts from arising.

Relay Controller

The relay-controller circuit permits two relays to be actuated independently under program control. With the addition of three ICs, the controller can be expanded to accommodate a total of four relays. A relay-control word output to port ∅ governs the function performed by K1 and K2 (Table 1). Using this scheme, it is possible to turn either relay on or off, or to simultaneously actuate or de-energize both relays.

Controller operation is understood best by examining the sequence of events required to turn K1 on and off (refer to Fig. 4). In order to actuate K1, a program can output a relay-control word of ∅3 to port ∅. As a result, the port decoder will generate a short, negative-going port ∅ output-select pulse, which is applied to pin 11 of NOR gate U1D. Simultaneously, data bit D∅ (which is at a logic 1) is inverted by U1C and applied to the other U1D input. These inputs result in a positive-going pulse at the U1D output (pin 13). This pulse clocks U2A, causing the data present at the D input to be transferred to the Q output. Since D1, which is at a logic 1, is connected to the D input of U2A, the Q output will go to a high level. When the clock pulse goes away, the Q output will remain latched high. The Q output drives three paralleled sections of an open-collector inverting buffer (U3), which energizes the K1 coil. Each section of U3 can sink up to 30 mA, for a total capability of 90 mA. Radio Shack type 275-214 4pdt 12-V relays, with coil-current requirements of 75 mA each, are used for K1 and K2. LEDs connected across the coils indicate the relay status.

To de-energize K1, the program can output a relay-control word of ∅1 to port ∅. The operation of the circuit will be identical to the description above, except that D1 will be at a logic ∅ level, with the

Table 1

Relay Control Word

Bit Position								*Function*
D7	D6	D5	D4	D3	D2	D1	D∅	
X	X	X	X	X	X	1	1	Actuate K1.
X	X	X	X	X	X	0	1	De-energize K1.
X	X	X	X	1	1	X	X	Actuate K2.
X	X	X	X	0	1	X	X	De-energize K2.

X = Don't care

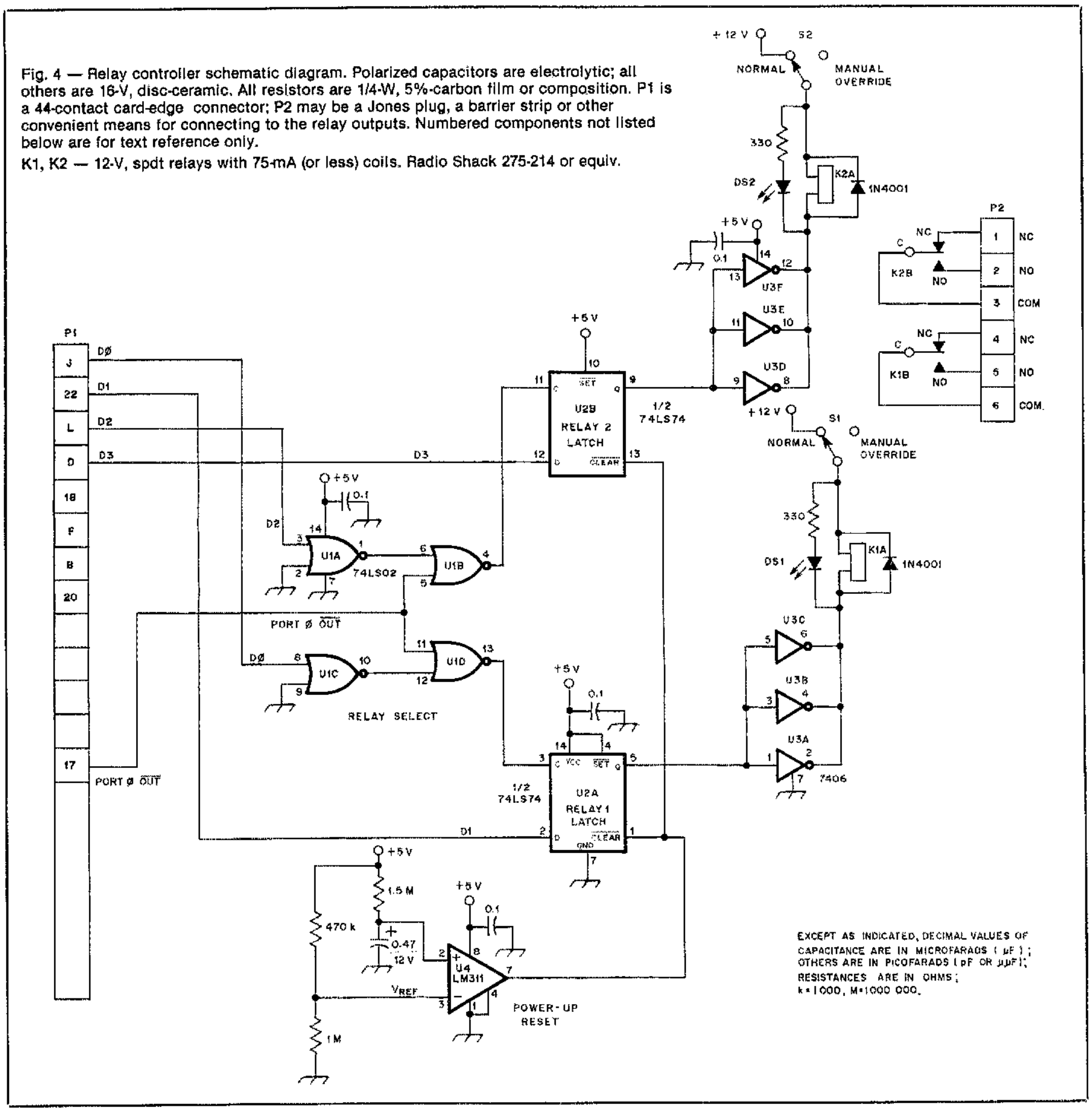


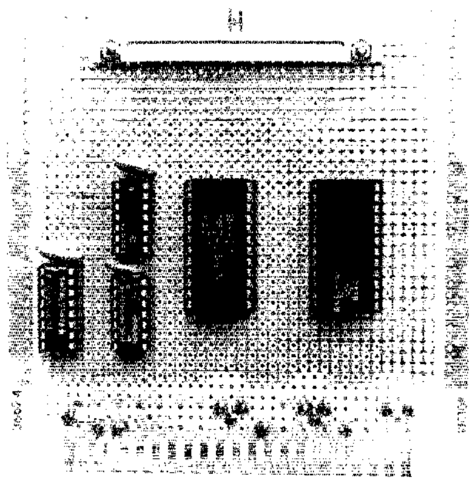
Fig. 4 — Relay controller schematic diagram. Polarized capacitors are electrolytic; all others are 16-V, disc-ceramic. All resistors are 1/4-W, 5%-carbon film or composition. P1 is a 44-contact card-edge connector; P2 may be a Jones plug, a barrier strip or other convenient means for connecting to the relay outputs. Numbered components not listed below are for text reference only.

K1, K2 — 12-V, spdt relays with 75-mA (or less) coils. Radio Shack 275-214 or equiv.

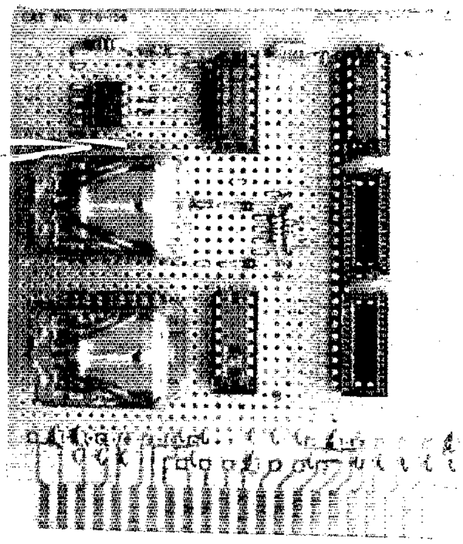
result that a logic Ø is clocked through to the U2A Q output. This output is inverted by U3, thereby turning off K1. K2 operation is similar.

Whenever a computer is used to switch potentially hazardous voltages, it is important to pay close attention to safety measures. It is entirely possible for a malfunctioning program to actuate either of the relays unexpectedly. If the relays are used to apply line voltage to a high-voltage power supply or to control an antenna rotator, the unintentional activation could lead to disaster. Because of this, manual-override switches have been included in series with the relay coils. Whenever the computer is in use for purposes other than relay control, or the equipment controlled by the relays is being serviced, it is a good idea to defeat relay operation by opening the override switches.

It is also necessary to ensure that every time the computer and the relay controller are turned on the relays remain de-energized. A power-up initialization circuit, consisting of comparator U4 and associated resistors and capacitors, sets flip flops U2A and U2B to known states by briefly holding their CLEAR inputs low when power is first applied. After a short delay, the CLEAR is released and the operation of the relays may be controlled by the computer. The delay length is governed by the time constant of the 1.5-MΩ resistor and the 0.47-µF capacitor. The reference point is set by the voltage divider connected to the inverting input of U4. If it is necessary for the computer to actuate a relay as part of its power-up initialization program, it should be possible to add a three-state buffer (a 74LS367, for example) that is enabled by a port Ø input operation. This buffer can direct the CLEAR signal onto the data bus, so the computer can monitor the status of the relay initialization. Similarly, it may be desirable to direct the flip flop outputs onto the data bus through three-state buffers, so that the computer can determine the state of each relay.



A Vector 3662-4 plugboard serves as the foundation for the port decoder. The 44-pin card-edge connector is used to make connections to the other interface boards. Connections to the TRS-80 bus are made through the 40-pin double-row connector at the top of the board.



The relay controller was constructed on a Radio Shack no. 276-156 plugboard. Wires connected to the relay contacts are soldered directly to the plugboard.

With the addition of another 74LS02, a 74LS74 and a 7406, the circuit can be expanded to allow the control of four relays. The new circuitry should be wired identically to the schematic shown in Fig. 4, except that the connections to D0 through D3 should be replaced by connections to D4 through D7, respectively. Table 1 can be expanded to reflect the additional relays.

Serial-Communication Interface

An RTTY character is transmitted by sending a bit pattern corresponding to the character across a communication link, one bit at a time. The serial-communication interface reassembles a received data stream into bit patterns corresponding to the original transmitted characters, and provides those patterns in parallel format to the microcomputer. The interface also works in the other direction, accepting parallel bit patterns from the microcomputer and sending them bit-by-bit to an AFSK generator, a modem or another computer interface.

The serial-communication interface characteristics are flexible — they may be changed under program control. A program may set the transmission bit rate to any of ten common speeds. An asynchronous data format is used. The number of data bits per character may be set to 5, 6, 7 or 8, and the number of stop bits may be set to 1 or 2, to accommodate the transmission of Baudot, ASCII and other common codes. Parity checking is not selectable by the interface software. If parity checking is desired, it may be "hard wired" onto the board, or it may be implemented in software for character lengths of up to 7 bits. Three output ports and two input ports are used to control the interface operation. Inputs from and outputs to the communication equipment (RTTY demodulator, AFSK generator, etc.) correspond to a subset of the EIA RS-232C standard.

The serial-communication interface circuit (Fig. 5) may be broken into three major functional blocks: programmable bit-rate selection, serial-to-parallel and parallel-to-serial conversion, and communication equipment interface.

The software-selectable bit rate may be set to any of the four common Baudot transmission speeds corresponding to 60, 66, 75 and 100 words per minute, or to any of six common ASCII bit rates (110, 300, 1200, 2400, 4800 or 9600 bps). A single clock controls the transmit and the receive data rates, but, if the interface is operated in the half-duplex mode (alternating transmission and reception), it is possible for the controlling software to select different transmit and receive rates. The basis of the bit-rate-selection circuit is a Motorola MC14411 bit-rate generator. This large-scale integrated circuit functions as a combination oscillator and multistage frequency divider. A 1.8432-MHz quartz crystal controls the oscillator frequency, and the divider provides a selection of standard clock frequencies at the output pins. The serial-to-parallel conversion circuit requires a clock frequency of 16 times the desired data bit rate. The common ASCII bit-rate clock frequencies are available directly from the bit-rate generator. External dividers (U7, U9 and U10) are used to derive the standard Baudot speeds (60, 75 and 100 wpm) from the MC14411 output frequencies. The resultant Baudot clock frequencies are not exact, but they are quite close, typically differing from the desired frequencies by about one percent. Errors this small are insignificant. The available frequencies are listed in Table 2.

Software selection of the bit rate is accomplished by directing a Communications Control Word (CCW) to output port B (B is the hexadecimal representation of decimal 11). The four low-order bits of the CCW are latched from the microprocessor data bus when the port B output-select pulse, generated by the port decoder, clocks U2. The four high-order bits of the CCW are simultaneously latched by U1. These bits are used to select the characteristics of the serial conversion circuit, which will be described shortly. Three of the low-order CCW bits are used as inputs to a 1-of-8 data selector, U4, which routes the chosen bit-rate

Fig. 5 — Serial-communication interface schematic diagram. P1 is a 44-contact card-edge connector. All resistors are 1/4-W, 5%-carbon film or composition. Unless otherwise noted, all capacitors are 16-V, disc-ceramic. Numbered components not listed below are for text reference only.

P2 — 25-pin male D-type connector.
U3 — General Instruments AY5-1013, AY5-1013A, AY5-1014 or equiv. UART.
U8 — Motorola MC14411 bit-rate generator.

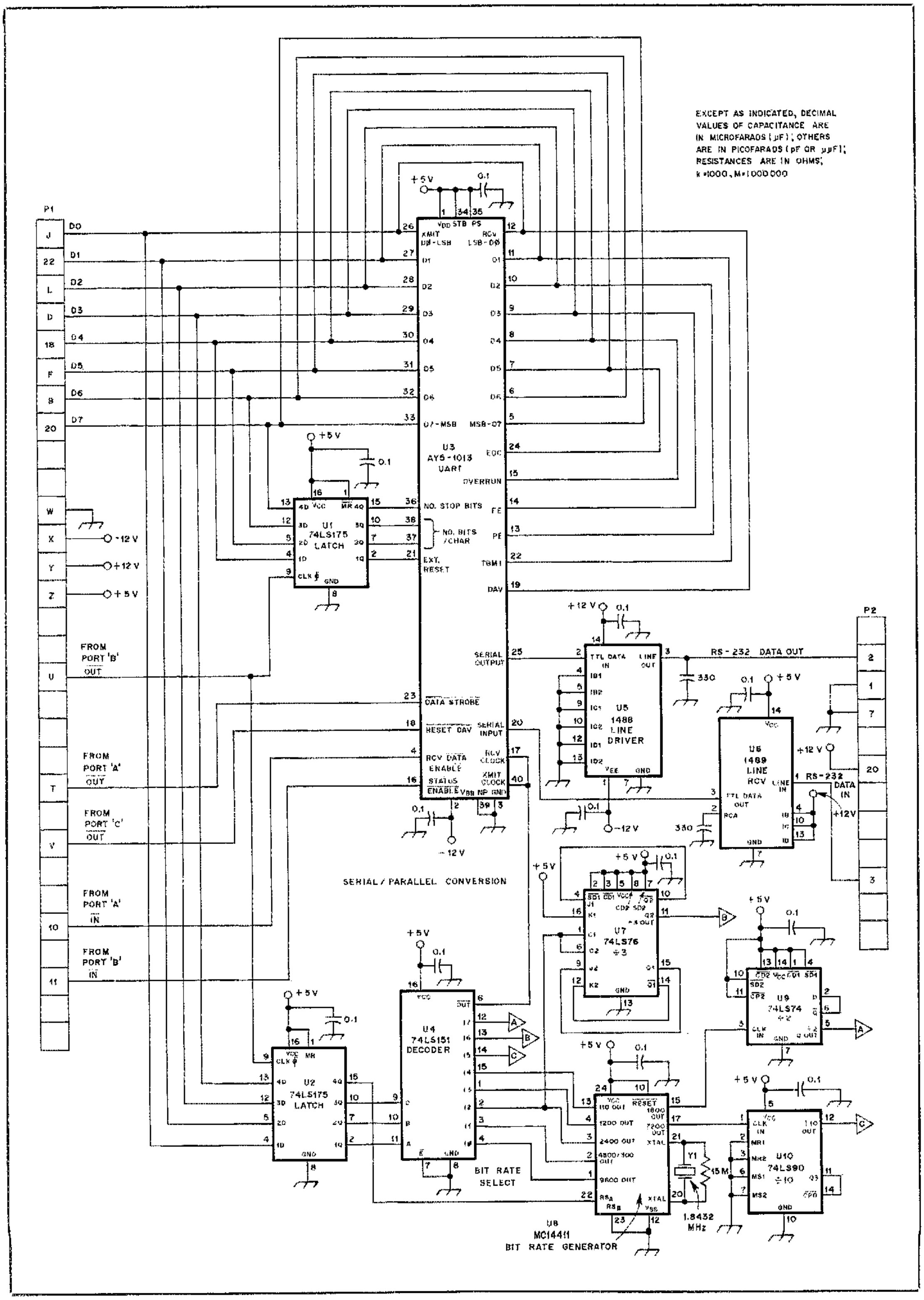

EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF); OTHERS ARE IN PICOFARADS (pF OR μμF); RESISTANCES ARE IN OHMS; k=1000, M=1000000
U3
AY5-1013
UART
U1
74LS175
LATCH
U2
74LS175
LATCH
U4
74LS151
DECODER
U5
1488
LINE
DRIVER
U6
1489
LINE
RCV
U7
74LS76
÷3
U9
74LS74
÷2
U10
74LS90
÷10
U8
MC14411
BIT RATE GENERATOR
BIT RATE SELECT
SERIAL / PARALLEL CONVERSION
RS-232 DATA OUT
RS-232 DATA IN
FROM PORT 'B' OUT
FROM PORT 'A' OUT
FROM PORT 'C' OUT
FROM PORT 'A' IN
FROM PORT 'B' IN
1.8432 MHz

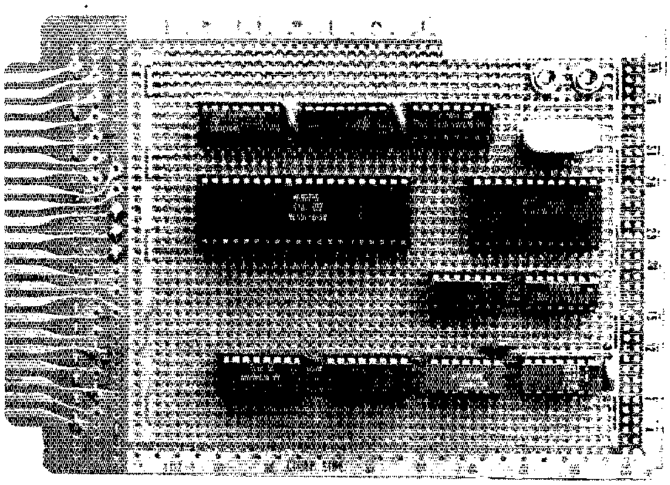
Table 2
Available Bit-Rate Frequencies

Bit Rate (bps)	*Desired Freq. (Hz)*	*Actual Freq. (Hz)*	*Error (%)*	*Format*
45.45	727.2	720	−1.0	60-wpm Baudot
50	800	800	0.0	66-wpm Baudot
56.92	910.7	900	−1.2	75-wpm Baudot
74.2	1187.2	1200	+1.1	100-wpm Baudot
110	1760	1758.8	−0.07	ASCII
300	4800	4800	0.0	ASCII
1200	19,200	19,200	0.0	ASCII
2400	38,400	38,400	0.0	ASCII
4800	76,800	76,800	0.0	ASCII
9600	153,600	153,600	0.0	ASCII

clock signal to the serial conversion circuit. The fourth CCW bit is used as an input to a rate-select pin of the MC14411; it chooses an appropriate internal division ratio for the desired output frequency. The proper settings for the CCW bits are given in Fig. 6.

Serial-to-parallel and parallel-to-serial conversions are performed by a single large-scale integrated circuit called a Universal Asynchronous Receiver Transmitter, or UART. The UART can be divided logically into two independent sections: A receiver section, which converts a received serial bit stream into a parallel bit pattern, and a transmitter section, which converts a parallel bit pattern into a serial-by-bit data stream. Characteristics common to both sections include the number of data bits and stop bits per character, parity generation and detection and (in this circuit) the data rate. Three of the high-order CCW bits are used to select the number of data and stop bits per character. The remaining CCW bit may be used by a program to reset the UART to a known state prior to starting data transmission or reception. Fig. 6 defines CCW bits used to select these functions, and some typical CCWs are shown in Table 3.

A Status Control Word, or SCW, is provided in the UART. This allows the microcomputer software to determine when the UART receive buffer contains a complete character, as well as to ascertain when the UART transmit buffer is prepared to accept a character from the microprocessor. There are two bits in the SCW that provide these important functions (Fig. 7). Execution of an input from port B causes the SCW to be applied to the data bus, where it is captured by the microprocessor. The SCW Data-Available bit (labeled DAV on the schematic) is set to 1 by the UART after a character has been received properly. After checking the SCW for the presence of the DAV bit, the microcomputer may retrieve the received character by performing an input operation from port A. The port A input select pulse causes the UART to place the received character on the microprocessor data bus, and the input operation places the character in a CPU register. It may then be examined and manipulated by the program. Following the character input operation, it is necessary for the program to reset the DAV bit by performing an output to port C. This prepares the UART to receive the next RTTY character. It is not necessary to output any specific data byte to port C to reset DAV, as the output select pulse



A Vector 3662-6 plugboard was used for the serial-communication interface board. The bit-rate generator and crystal are located at the upper-right-hand corner of the board. The 40-pin IC near the board center is the UART.

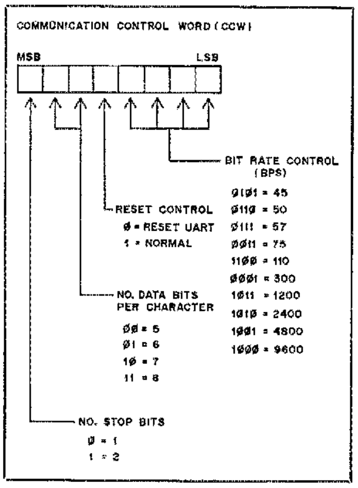


Fig. 6 — A Communication Control Word (CCW), output by the program to port B, controls the selection of the bit rate and the number of data and stop bits per character.

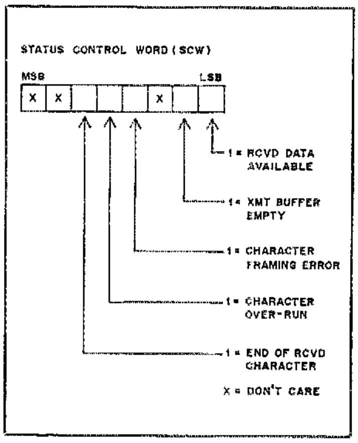


Fig. 7 — The UART Status Control Word (SCW) allows the program to determine the state of the UART and the action to be performed next. The program reads the SCW by executing an input from port B instruction.

Table 3
Typical Communication Control Words (CCW)

Mode	*CCW (MSB) (LSB)*	*Hex Equiv.*
60-wpm Baudot Transmit	1ØØØØ1Ø1	85
60-wpm Baudot Receive	ØØØØØ1Ø1	Ø5
110-bps ASCII	Ø11Ø11ØØ	6C
300-bps ASCII	Ø11ØØØØ1	61

performs that function. This type of operation is often referred to as "handshaking." The UART informs the microprocessor that data is available, the microprocessor reads the data, then alerts the UART that the data has been read and allows the UART to process the next received character.

A form of handshaking is required on the transmit side as well. Before sending a character to the UART transmit buffer, the program must verify that the transmit buffer is empty (and hence prepared to accept a new character) by checking the SCW bit labeled TBMT. If TBMT is set to 1, the transmit buffer is empty and the microprocessor may output a character to the UART. If TBMT is set to zero, the UART is not ready to accept another character, and the program will have to check the TBMT status in a loop until the UART is ready to proceed. A summary of the usage of input and output ports used by the serial-communication interface is given in Table 4.

The serial-data in and serial-data out pins of the UART are TTL compatible. To connect the serial communications interface to "real-world" devices, it is necessary to convert the TTL output level to RS-232C levels, and to convert RS-232C input levels to TTL. In its simplest terms, the RS-232C standard defines a logic 1 as a negative voltage within a certain voltage range, and a logic Ø as a positive voltage within a specified range. U5 performs the TTL to RS-232C conversion for the output data. A TTL logic 1 applied to pin 2 of U5 results in a negative 12-V signal at the output, pin 3, and a TTL logic Ø at pin 2 is converted to a positive 12-V output at pin 3. U6 performs the level conversion for received RS-232C data. Both U5 and U6 have spare sections, which may be used to implement some of the other functions defined by the RS-232C standard.

The functions provided by the port decoder, the relay controller and the serial communication interface may be accessed by programming statements in machine or assembler language, or in a higher-level language such as BASIC. Although a program can be written in BASIC to send and receive RTTY at 60 wpm, it is doubtful that a BASIC program will execute fast enough to permit copy at full machine speed for any of the higher data rates. Programs should be written in machine or assembly language to take advantage of the higher execution speed available. It should be possible to write relay-control programs in BASIC, including keyboard-to-Morse programs for moderately fast code speeds.

Table 4

Serial-Communication Interface Port Assignments

Port	*Output*	*Input*
A	Transmit Data Out	Receive Data In
B	Communication Control Word	Status Control Word
C	Reset Data Available Indicator	Unused

Construction

The interface is constructed on three plug-in perforated boards using wire-wrap techniques. A 40-conductor ribbon cable terminating in a Radio Shack type 276-1558 or equivalent card edge connector is used to bring the address, data and control buses from the TRS-80 to the port decoder board. The cable may be wired directly to terminals on the board, or a special 40-pin connector, such as the one shown in the photograph, may be mounted on the port decoder board. The schematic diagrams show the Radio Shack bus pin numbers for the TRS-80 signals that are used with the interface. Be certain to double-check that the card-edge connector is inserted properly in back of the TRS-80, and that the pin numbers on the connector match the TRS-80 board pin-numbering scheme. While a common ground is necessary between the TRS-80 and the interface boards, separate +5 V, +12 V, and −12 V power supplies must be used to power the interface. It is not possible to use the TRS-80 supplies for this purpose. The port decoder is constructed on a Vector 3662-4 plugboard, which mates with a 44-pin pc card connector. The serial-communication interface is built on a 3662-6 plugboard, and the relay controller uses a 3662-4 board. With this scheme, three 44-pin edge connectors could be mounted in a card cage, with like pins on each connector wired in parallel to form a bus or "motherboard." The signals available on this bus include input and output select lines for each port, the eight bits of the data bus and the power and ground connections. The schematics of the three boards designate the Vector socket/plugboard pin-numbering scheme. The port-decoder schematic shows three TRS-80 signals, labeled $\overline{SYSRES}$, $\overline{INT}$, and $\overline{INTAK}$, replacing three of the port-select lines to allow for future expansion. It may be possible to construct the relay controller on the same board as the port decoder to maximize the utilization of the available ports within the constraints of a 44-pin bus. If additional functional modules are added to this bus, it may be necessary to include a bidirectional data bus buffer on the port-decoder board to satisfy the drive requirements of the additional devices.

With the addition of this interface system, your TRS-80 microcomputer will become a versatile part of your amateur station. In addition to the obvious RTTY applications, the interface will allow you to implement many other station functions. Your imagination may be your only limit.

Strays

Bob Heil, K9EID (right), of Marissa, Illinois, receives the Radio Amateur of the Year Award from Judge Stanley S. Phillips at the 1892 Dayton (Ohio) Hamvention. Bob, who has written many articles for *QST* (most recently, July 1982), was cited for his many personal and technical contributions to Amateur Radio, particularly his work in vhf and audio. *(photo by Harrison Church)*

***QST* congratulates . . .**

☐ Commander John Scott Redd, KØDQ, of the *USS King,* on earning the Navy Battle Efficiency Competition award.

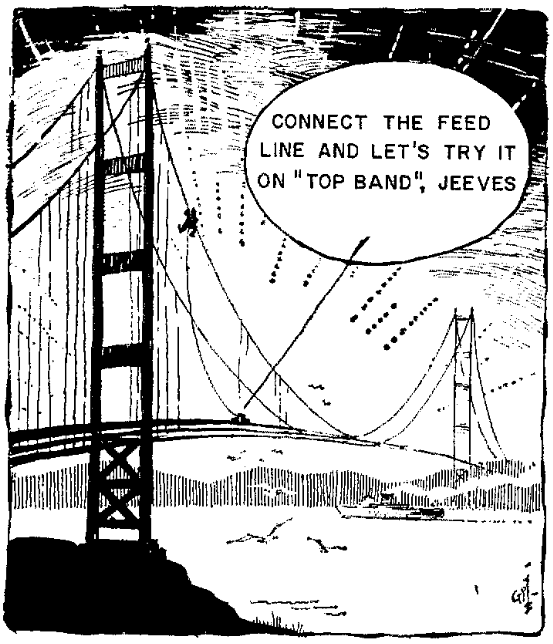
AMATEUR RADIO COURSES IN BRAILLE

☐ The Hadley School for the Blind in Illinois has available two courses of study in Braille for radio amateurs: Amateur Radio Course I, which prepares the student for the Novice exam, and Amateur Radio Course II, based on the ARRL *Radio Amateur's License Manual,* which prepares the student for the Technician/General exam.

For more information, write to the attention of Byron Eguiguren, WD9IAN, Hadley School for the Blind, 700 Elm St., Winnetka, IL 60093. — *Jon Hollingshead, K9BIO, Zion, Illinois*

Bruce Humphrys, KØHR, gives his acceptance speech at the Dayton (Ohio) Hamvention last April after receiving the Special Achievement Award for his many years of service to handicapped persons through Amateur Radio. Humphrys is director of the Handi-Ham System in Golden Valley, Minnesota, a local project he has helped build into an international operation. *(photo courtesy N8ADA)*

The "K4YF Special" Antenna



Need a compact, broadband antenna for 80 and 160 meters? If size is an overriding consideration, this antenna will provide good performance in a minimum of space.

By John L. Wilson,* K4YF

My 70-ft × 20-ft backyard[1] is far too small to accommodate an 80-meter dipole or ground-plane antenna. Operation on 160 meters appeared entirely beyond consideration. I wanted a good match over the entire 80-meter band, with a low radiation angle to work DX. Early experiments with an inverted L for 80 meters evolved into the present configuration. Only an accident revealed the possibility of using it on the newly expanded 160-meter band.

Construction Details

On 80 meters, the radiator of the K4YF Special is a closed wire rectangle, 60 × 4 feet, fed at a corner by the center conductor of a 52-ohm coaxial cable. The cable shield is connected to two radials. The radiator is supported near its center by a PVC-pipe spreader, mounted at right angles to a 40-foot mast that is bracketed to the side of the house. The radiator forms a narrow inverted V.

Fig. 1 shows the details of my installation. The two end spreaders and the center support are pieces of 3/4-inch PVC pipe. This material is available from most hardware and building supply stores. Holes are drilled 4 feet apart in each end of the spreaders, and the antenna wire is threaded through the holes. The center spreader is 5 feet long, to hold the antenna about a foot away from the house. The 4-foot spacing is not critical, and even a 2-foot spacing gives good bandwidth on 80 meters.

I keep the V tightly closed so that most radiation will be vertically polarized. The use of 1-foot lengths of PVC pipe at the apex to slightly spread the top of the V might be useful. Tie the antenna off at a corner rather than at the center of each end spreader. Otherwise, it will twist "slowly, slowly in the wind."

The Ground System

It would have been desirable to have an extensive system of 1/4-wavelength radials, but that was not feasible. I was surprised to find that something far less involved will work well on 80 meters, and acceptably on 160 meters.

I "made do" with two 70-foot radials. They are not extended in a straight line, as would be preferred; rather, they follow a convenient path around the side of the house and along the fence of my yard. Prior experience taught me that earth grounds using metal stakes are not generally satisfactory for grounding antenna systems. These radials provide a reasonable ground system for the antenna.

The angle between the ground radials and the feed line affects the antenna input impedance. A gentle 30° droop below horizontal produced a matched condition between the feed line and the antenna.

160-Meter Operation

One evening, a temporary splice in the antenna wire broke. Since the antenna would no longer work on 80 meters, I commenced tuning the newly expanded 160-meter band. To my surprise, the antenna was nearly resonant. The radiator was now a 130-foot wire, albeit bent in a peculiar fashion.

Currently, to operate on 160 meters, an spdt relay breaks the rectangle at the corner next to the feed point and adds 20 feet of wire to that end. This resonates the

[1]Notes appear on page 27.

*3824 North Woodrow St., Arlington, VA 22207

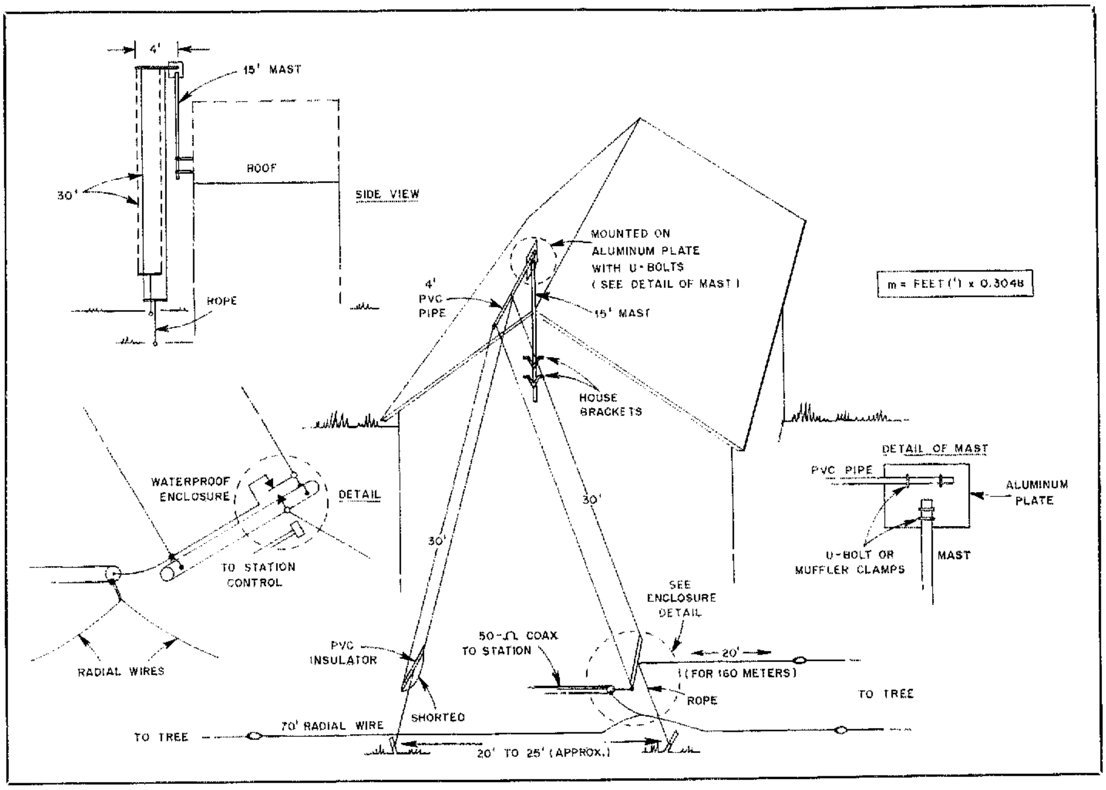


Fig. 1 — Construction and mounting details for the K4YF Special.

system at 1805 kHz. I mounted the relay in a waterproof box fastened to the end spreader.

Tuning the Antenna

I recommend the use of an antenna noise bridge to adjust the length for resonance at your favorite operating frequency on 160 meters. For best results, this also requires the use of an electrical 1/2 wavelength of coaxial cable, inclusive of the velocity factor (approximately 180 feet). A noise bridge permits accurate measurement of the resonant frequency and the impedance of the antenna. When antennas are high and in the clear, textbook formulas and an SWR indicator may suffice; but when the antenna is crowded and the ground system is makeshift, the noise bridge is quite helpful.

On 80 meters, the antenna has a feed-point impedance of approximately 60 ohms at the resonant frequency of 3575 kHz. It has an SWR of less than 2:1 over the entire 3.5- to 4-MHz range. The antenna also has a feed-point impedance near 60 ohms at the resonant frequency on 160 meters (1805 kHz), but the SWR rises rapidly beyond ±40 kHz from that frequency.

Performance

As expected, the antenna exhibits a low radiation angle because of the mostly vertical configuration. The antenna works quite well on 80 meters for paths over 2000 miles.[2] It is not as good as a full-size ground-plane antenna, but seems better than a dipole at 50 feet. Like most verticals, the K4YF Special is noticeably poor for daytime operation. The first time I used the antenna on the 160-meter band, I managed to work stations in Idaho and French Saint Martin. This antenna does not appear to work as well as a 160-meter dipole at 50 feet, or a top-loaded vertical — but then it fits into my yard.

If space and height are not severely limited, the performance of the K4YF Special may be appreciably improved by treating it as a 1/4-λ sloper. This would be easy to construct, puts the current point high above ground, and radiates a maximum signal in the direction of slope.

With a 60-foot tower, the radiator rectangle would slope down from near the top of the tower at a 30° angle with the vertical. No center spreader is needed in this case. The shield of the coaxial cable should be grounded to the tower. The antenna will exhibit broadband characteristics on 80 meters, which distinguishes it from a simple 1/4-λ, ground-plane antenna.

If you break the rectangle at the feed point, this antenna can be used on 40 meters as a full-wave loop. It will have a feed-point impedance of about 200 ohms, and so will require a matching system for use with 52-ohm coaxial cable. This would involve a more complex switching arrangement. Since I have no need for another 40-meter antenna, I did not undertake this work.

If your antenna space is limited, try a K4YF Special. Experiment with different configurations. Perhaps you can improve the performance, but one thing is for certain: It works better than no antenna at all.

Notes

[1]m = ft × 0.3048.
[2]km = mi × 1.6093.

The Half-Delta Loop: A Critical Analysis and Practical Deployment

A delta-shaped, grounded half-wavelength loop offers superior performance over the half- and full-sloper antennas. Low-band DXers should find this antenna effective for multiband operation.

By John S. Belrose,* VE2CV and Doug DeMaw,** W1FB

Is DXing one of your pursuits? Are you having inferior results with wire antennas for the 160-, 80- and 40-meter bands? Or, would a particularly good multiband antenna satisfy your needs for general communications in the mf and hf spectrum? If the answer to any of these questions is "yes," this paper will provide the information you may be looking for.

The Half-Delta Loop contains a sloping wire, approximately $\lambda/3$ in length, which is attached to the top of a grounded tower about $\lambda/6$ high. Feed to the antenna is applied between the lower end of the sloping wire and ground. Radial wires should be connected to the feed-point ground and the grounded end of the tower. This antenna is the grounded equivalent of a full-wavelength Delta Loop, apex down, apex-fed, that has been rotated through 90 degrees. The lower half is replaced by its image in the ground plane (see Fig. 1).

In a previous paper by author Belrose,[1] data obtained on an outdoor antenna-pattern range were presented to show the polar diagrams for the modeled antenna, measured at f_o, $2f_o$, $3f_o$ and $4f_o$, where f_o is the antenna fundamental frequency, or the frequency at which the half loop and its image equal one wavelength. Radiation is to some extent like that of a monopole-antenna array: The radiated field is dominantly vertically polarized, and the maximum in the vertical-plane pattern is directed at the horizon. However, the azimuthal pattern is complicated. At f_o it is elliptical, with maximum gain (5 dBi) in the directions that are broadside to the half loop. At $2f_o$, $3f_o$ and $4f_o$ the antenna is bidirectional, with maximum gain in opposite directions in the plane of the half loop. Nulls in the pattern are found in the broadside directions.

It was noticed that while the input impedance was low at f_o and at all harmonics, resonance did not occur at exact multiples of f_o. This paper (1) examines in detail the impedance-frequency variation; (2) describes experience in practical deployment of the antenna at full scale; and (3) discusses the practical situation where the supporting tower, which is part of the radiator, bears a triband Yagi, which is typical of most amateur situations.

Half-Delta Loop Modeled

A Half-Delta Loop was modeled at 200 MHz; i.e., the half loop and its image in the ground plane was a 1-wavelength loop with 200-MHz resonance. The mast was a copper rod that was 0.3175 cm in diameter and 28.25 cm high.[2] The sloping wire was twice this dimension — 56.5 cm long. Antenna mounting was done on a 1-1/2 meter square ground plane. A Hewlett-Packard 4191A rf impedance analyzer was used to measure the impedance. This microprocessor-controlled instrument provides, among other facilities, electrical-length compensation. This permits extension (up to 100 cm) of the test-port-to-measurement point, as needed to measure antennas. The machine-plotted impedance-value measurements are, therefore, the impedance of the Half-Delta Loop at its input. Measurements were made via a type-N chassis-feedthrough connector, fed through the ground plane to the measurement instrument located beneath.

The impedance |Z| and θ for the frequency range of 180 to 980 MHz are shown in Figs. 2 and 3. Notice the loop resonance (low Z and θ equal to zero) occurred at 203, 350, 545, 737 and 873 MHz. The Half-Delta Loop and its ground image was 1, 2, 3, 4 and 5 wavelength loop-resonant at these frequencies (Table 1).

If λ_n is the wavelength at a resonant frequency, f_n, where n is the integral number of electrical wavelengths around the loop and its image of length ℓ, then

$$\ell = k_n n \lambda_n \text{ and} \quad \text{(Eq. 1)}$$

$$k_n = \frac{\ell}{n \lambda_n} \quad \text{(Eq. 2)}$$

[1]Notes appear on page 32.

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**ARRL Senior Technical Editor

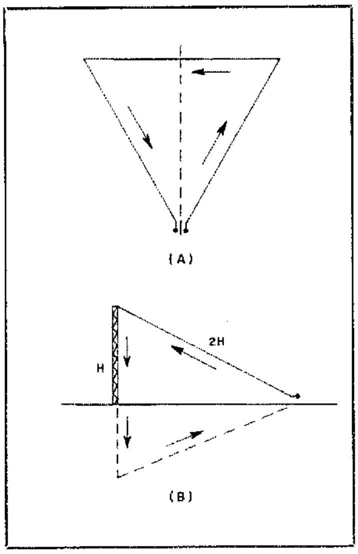


Fig. 1 — Illustration of (A) a conventional full-wave Delta Loop and (B) the grounded version with its image half in the ground plane.

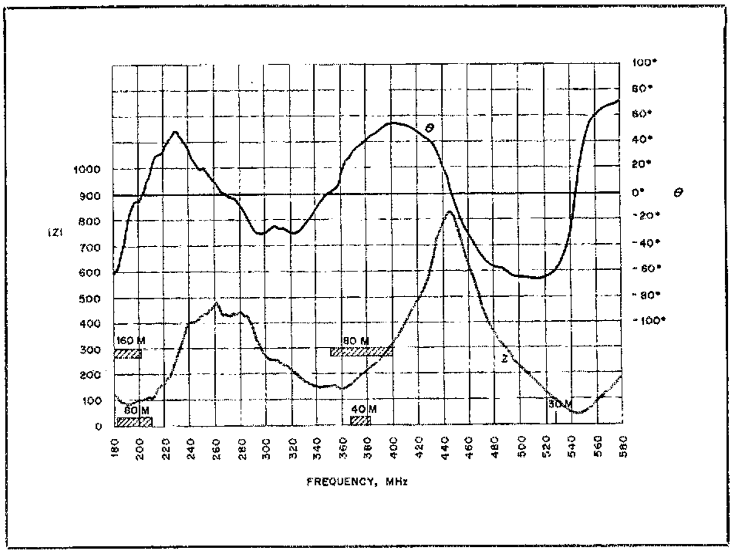


Fig. 2 — Curves that show the feed impedance of the Half-Delta Loop versus operating frequency for the scaled model. The upper curve relates to θ. Corresponding full-scale model frequencies are noted.

where k_n is a factor that relates the physical and electrical lengths. Values for k_n, deduced from the measured values for f_n, are also given in Table 1.

Notice that except for the 1-wavelength loop resonance, the electrical and physical lengths are approximately equal; i.e., $k_n \approx 1$, within an uncertainty that is probably experimental error (±3 percent). While this is an interesting fact, since the electrical and physical lengths at f_0 are significantly different (15 percent), the higher-order resonant frequencies are not integral multiples of f_0. If the Half-Delta Loop is employed for amateur communications, therefore, the physical size and resonant conditions must be a compromise. Table 2 contains dimensions (estimated) for a Half-Delta Loop for use on 80, 40, 30 and 20 meters. The average scale factor is, therefore, 52.26, and for this scale factor the band edges can be marked on Figs. 2 and 3. The mast height at full scale would be 14.76 m (48.4 feet), the length of the sloping wire 29.53 m (96.8 feet) and the diameter of the mast would be 166 mm (6.5 inches).

A similar analysis for a Half-Delta Loop designed for use on 160, 80 and 40 meters yields a scale factor of 100.44. This corresponds to a tower height of 28.37 m (93 feet). The length of the slope wire would be 56.76 m (186.2 feet).

Half-Delta Loop, Tower and 20-M Yagi

The curves in Fig. 4 show impedance-frequency plots for a Half-Delta Loop alone, and connected to a tower that supports a 3-element, 20-M, wide-spaced Yagi. For these measurements, since a

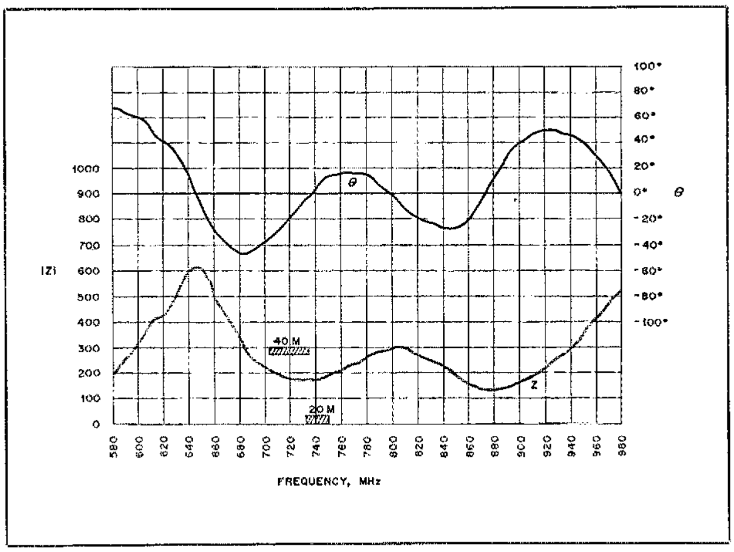


Fig. 3 — Impedance and θ curves that show the corresponding full-scale performance at 40 and 20 meters.

Table 1

Scale-Model Characteristics

N	*F (MHz)*	*R_a (ohms)*	*k_n*
1	203	100	1.15
2	350	150	0.99
3	545	40	1.03
4	737	170	1.04
5	873	133	0.98

Table 2

Harmonic Resonances

Band (m)	*Midband f (MHz)*	*Model Resonant f (MHz)*	*Scale Factor*
80	3.75	203	54.13
40	7.15	350	48.95
30	10.10	545	53.96
20	14.17	737	52.00

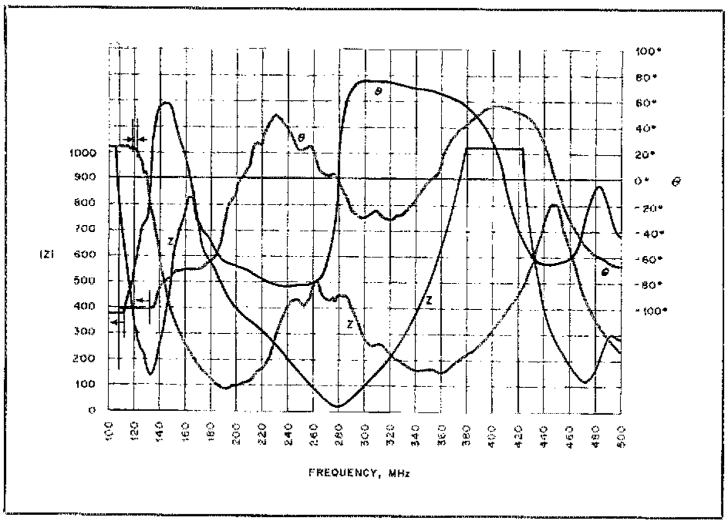


Fig. 4 — Impedance-frequency plots for a Half-Delta Loop alone, and plots for the same system with a 20-meter Yagi atop the tower. (See text.)

Yagi was modeled, the measurements refer to a particular scale factor — 53.33. It was assumed that the tower height was 15.06 m (49.4 feet), and that the beam antenna was attached to a mast that extended 1.6 m (5.25 feet) above the top of the tower. Notice that, as expected, the beam antenna had a marked effect on the resonant frequency of the loop antenna. The loop alone was resonant at 202 MHz (3.787 MHz at full scale), whereas the loop-mast-Yagi system was resonant at 132 MHz (2.475 MHz at full scale) and at 280 MHz (5.25 MHz). Clearly, the radiation pattern (not measured) would also be different from that of the Half-Delta Loop alone. Therefore, a Half-Delta Loop can't be deployed on a tower that supports a beam antenna. Although an antenna-matching circuit could be employed (needed even for the Half-Delta Loop alone), the resultant antenna configuration is more like a shunt-fed tower with top loading (the Yagi) than a Half-Delta Loop.

Minimizing the Beam-Antenna Effect

It is possible to stub-tune the tower to minimize reradiation from it. More than one stub can be used to "detune" a tower at more than one frequency. A possible arrangement is seen in Fig. 5. The Half-Delta Loop would be made completely from wire and insulated from the tower, and the tower would be stub-tuned to minimize reradiation from it. The optimum stub length is critical. While it should be "field tuned," a nominal length (total length plus the length of the shorting element) is about 5 percent less than a quarter wavelength. This should provide satisfactory results.

Ideally, *each* leg of the tower should be stub-tuned, since this arrangement reduces the reradiation best and provides the greatest bandwidth. If the tower is less than a quarter wavelength, it will be necessary to tune the stub by connecting a capacitor across the open end of it. But, this will reduce the bandwidth of the system. It will also complicate the mechanical/electrical construction. Optimum tuning will be tricky without instrumentation. The simplest adjustment method is to tune for minimum current in the portion of the tower below the stub. A current probe will be required if this is done. A suggested technique is shown in Fig. 6. It has been used successfully by author DeMaw for probing shunt-fed towers. A T200-2 Amidon or a Micrometals powdered-iron toroid core (μ_i = 120) is sawed in half, then taped together with the tower leg inside the center hole.

Practical Deployment at Full Scale

The VE2CV professional test-range results were confirmed generally during practical analysis of the Half-Delta Loop at full scale (Fig. 7). The differences in test conditions were the two ground systems (an ideal ground plane at VE2CV and a mediocre buried-radial system at W1FB) and a disparity in the cross-sectional area of the slant wire at W1FB with respect to that of the scaled version at VE2CV. The latter would have required no. 40 wire to represent approximate scaling of the no. 16 wire used in the full-scale example, which would have been impractical. No. 22 wire was used for the 200-MHz scaled model. Therefore, at full scale the impedances at the anti-resonant frequencies should be greater than those of the modeled version, but the impedances at resonance should not be much different. A cage-type or parallel-pair slope wire could be used to lower the Q of the loop, and the impedances would be reduced. Several months of testing took place at W1FB in Newington, Connecticut, during 1981 and 1982. Evaluation was carried out at 3.5, 7.0 and 14.0 MHz, with short-term

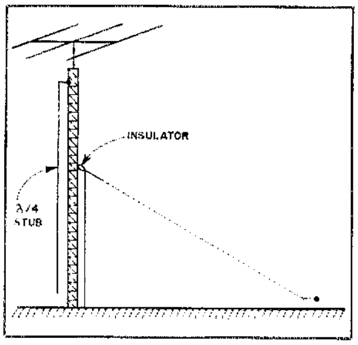


Fig. 5 — Suggested arrangement for stub-tuning the tower when the loop is insulated from the tower and a 20-meter or other beam antenna is affixed to the tower. (See text.)

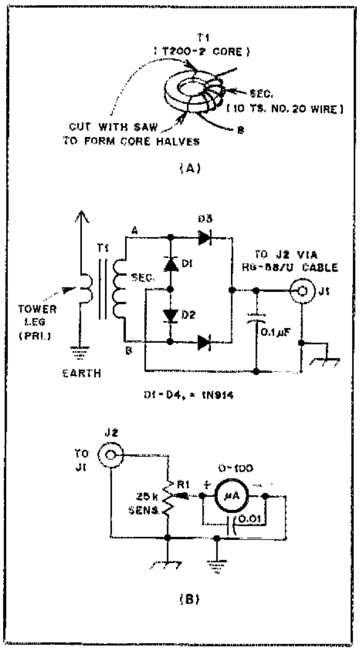


Fig. 6 — Current-probe arrangement that can be applied when adjusting the tuning stub of Fig. 5. Illustration A shows the sampling transformer, which is cut in half and installed on a tower leg (see text). The bridge rectifier and metering circuit is shown at B.

tests at 21.0 and 28.0 MHz.

Initial tests involved the use of a 50-foot[3] Rohn-25 tower (unguyed). No antennas other than the Half-Delta Loop slant wire were attached to the tower. A system of 16 buried radials extended out from the tower. These wires varied in length from 60 to 110 feet. They were complemented by a 6-foot ground rod driven into the earth at the base of the tower. Four more ground rods (4 feet each) were used at the loop feed point, plus four on-ground 40-meter radials and two on-ground 80-meter radials. The composite ground system was obviously less effective than that at the VE2CV professional test range, but the results were good. It is important to recognize the need for an effective ground system when using this and other ground-dependent antennas, such as grounded quarter-wavelength verticals. The integrity of the tower-section continuity is vital also: A quality electrical joint must prevail at the junction of each tower section. A copper bonding strap across the tower-leg joints will help ensure proper electrical integrity. Crank-up towers will require special attention in this regard. This rule is applicable also in the case of Half-Sloper antennas, since the tower is an integral part of the antenna.

Early Results

The first practical model of the Half-Delta Loop was based on the VE2CV k-factor for overall length. It did not follow exactly the H-2H rule of Fig. 1, but it was close. Indeed, the harmonic relationship was not precise as performance was checked from 80 through 10 meters. In fact, the feed impedances, as measured with a General Radio 1606-A rf bridge, were substantially higher than those obtained by VE2CV on the 200-MHz model. Fortunately, the impedances were greater than 50 ohms, but not greatly so (see Table 3). The notable exception was at 7 MHz, where the value was about 1000 ohms. The advantage of having a terminal impedance greater than 50 ohms on all of the bands is that an L network can be used to provide a step-up transformation. Therefore, there is no need to reverse the network for one or more bands to shift to a step-down condition. Fig. 8 shows the network used at W1FB during practical analysis of the system.[4]

It is probable that a more effective ground system would have had some effect on the impedances measured for the full-scale model. A Kenwood TS-820S transceiver was used during the tests to provide a signal source. The resistive-resonance condition was noted for the bands of interest, as were band-edge impedances.

Some peculiar results were obtained during the first set of tests. The impedance values made little sense on certain frequencies, and suddenly the cause was found: The tower still contained a 30-foot shunt arm (feed line disconnected from the lower end of it) that was used to feed the tower as an 80-meter vertical. Removal of the feed arm resolved the problem. This illustrates clearly the effect of a tuned stub, as discussed earlier, on the loop system. In this example the "stub" was not desirable, since there was no beam antenna atop the tower.

Performance Characteristics

Owing to the small city lot (5/8 acre) at W1FB, it was not practical to deploy a reference dipole for performance com-

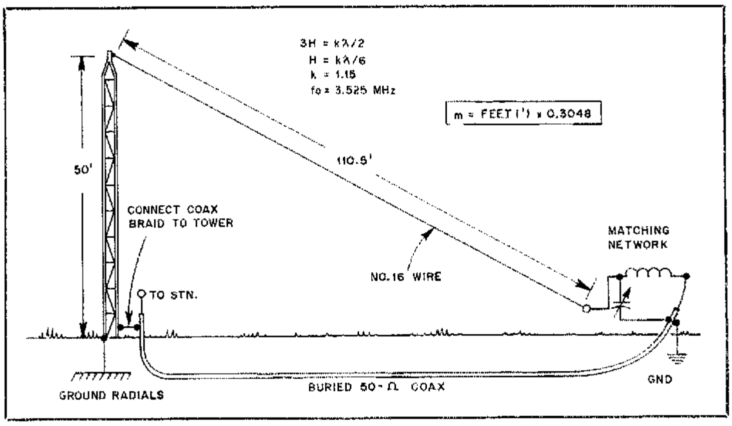


Fig. 7 — Diagram of the Half-Delta Loop deployed at full-scale for practical analysis. The matching network was controlled remotely, and was switchable for 80, 40 and 20 meters. It was housed in a weatherproof box on a short pole at the antenna feed point. The network control cable and the RG-8/U feed line were buried 3 inches in the ground and routed back to the tower (note shield braid connections to ground at each end of the antenna). See text for details of the earth- and radial-ground system.

Table 3

Full-scale Characteristics

F (MHz)	*R_a (ohms)*	*Reactance*
3.5	228	+j43
3.7	620	+j14
4.0	140	−j306
7.0	1000	−j571
14.0	251	+j18
14.3	345	+j70
21.0	100	−j238
1.8	290	−j1775

Measurement results obtained at the feed point of a full-scale Half-Delta Loop. The rf impedance bridge was connected directly to the loop feed terminals. The loop was dimensioned as indicated in Fig. 7.

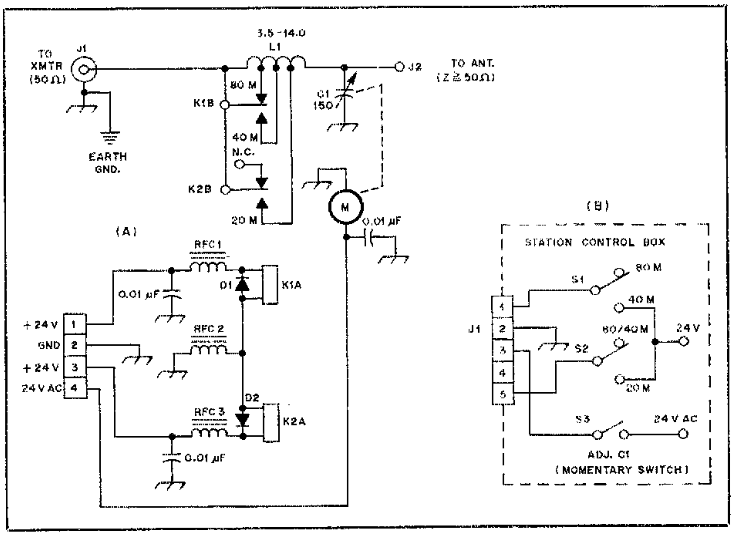


Fig. 8 — Schematic diagram of the three-band L network used to provide a match to 50-ohm cable. Specific circuit data are available from *QST* (see ref. 4). K1 and K2 are rf-isolated from ground to prevent arcing at high rf-power levels. L1 is a large piece of Miniductor® stock.

parisons. Furthermore, the dipole would necessarily have been in the immediate field of the Half-Delta Loop. This would have affected the accuracy of the performance comparisons. However, the loop proved to be very effective for DX work, and is perhaps the best wire antenna that W1FB has used for that purpose at 3.5 and 7.0 MHz. Previous 80- and 40-meter antennas included full slopers, half slopers, inverted Vs and shunt-fed towers.

Many reports of RST 599 were received from European, South American and Australian stations. Some DX stations reported, "OM, you have the loudest signal from the U.S." Such reports were consistent over several months. Calls were received via "long path" from JA stations on 40 meters as early in the day as 2100 UTC. This did not happen with previous 40-meter antennas at W1FB. It was a nice experience!

Reception with the loop was somewhat superior to that while using the shunt-fed tower and half-sloper antennas. There was less man-made noise heard in the receiver, owing to the closed-loop characteristics of the new antenna. Initial receiving tests implied that something was amiss — a short or open circuit somewhere in the system: The S meter registered no noise, as opposed to the more normal noise reading of S1 to S3 on 80 and 40 meters. But, upon tuning the bands, it was learned that all was well: Signals popped up to S9 and higher, despite the otherwise quiet reception! In some locations, depending on non-ionospheric noise levels, this feature could be an asset for weak-signal reception.

Performance out to approximately 1000 miles on 40 meters seemed to be on par with that of the sloper and half-sloper antennas. This was based on a three-year weekly schedule with W8PLC and W8EEF (ARRL TA) in Michigan. At greater distances, the Half-Delta Loop appeared to outperform the slopers greatly, based on historical observations.

Indications are that the loop is rather omnidirectional at f_o, but that it becomes increasingly directive (with gain) at the harmonic frequencies. Directivity appears bidirectional in the plane of the slant wire (north-south at W1FB), confirming the test-range findings of VE2CV. Excellent coverage was had over relatively short north-south distances on 20 meters, with S9-plus reports from as far away as Nova Scotia and southern New Jersey (in-plane); this was never the case when using the triband Yagi at 50 feet. This demonstrated the gain and directivity of the loop at the higher harmonics.

The loaded Q of the matching network of Fig. 8, plus the loop bandwidth, has been entirely suitable for covering 50 kHz on 80 meters, 100 kHz on 40 meters and 200 kHz on 20 meters without readjusting the network. This provided operation well within the 1.5:1 VSWR points for each band. The network is remote-controlled from the shack, thereby negating a need to go to the rear of the property to change bands or tune the network.

Recent Tests

A Cushcraft A4 triband Yagi was placed atop the tower in early 1982. The results were devastating with respect to the loop performance. In order to reestablish resonance and obtain a matched condition, the slant wire had to be shortened by some 25 feet. Although performance remained good, it no longer equalled that of the correctly dimensioned loop. Resonance was checked with a calibrated dip meter before the slant wire was shortened. The readings changed from 3.5 and 7 MHz to 2.5 and 5 MHz, indicating the effect from the Yagi. This supports the findings of VE2CV, reported earlier in this paper. It appeared that the revised system performed as a shunt-fed tower with delta feed (or slant-wire feed).

Summary Comments

One need not have a tower to use the Half-Delta Loop antenna. A telescoping mast (joints bonded electrically) can be used as the vertical member of the loop. Similarly, a tree can serve as a vertical support. In this instance, it will be necessary to employ a drop wire from the top of the tree to ground, thereby providing the necessary conductor that would otherwise be formed by the tower. The drop wire should not touch the trunk, limbs or leaves of the tree.

A Half-Delta Loop should serve admirably for multiband use during Field Day operations. It offers an excellent alternative to complicated directive arrays on the lower bands. It should appeal also to those with small city lots.

Acknowledgments

Author DeMaw wishes to express his gratitude to Jack Belrose for providing early-on information concerning the scale-model tests. Thanks is given to Jerry Hall (K1TD) and George Collins (KC1V) of the ARRL staff for their help in making peformance measurements on the first model of the full-scale Half-Delta Loop.

Notes

[1]J. Belrose, "The Half-Delta Loop: A Grounded, Vertically Polarized Antenna," *Ham Radio*, May 1982.

[2]Ft = m × 3.281; in. = mm × 0.03937; in = cm × 0.3937. The diameter of a triangular lattice mast 8 in. on a side equals 0.84 b = 0.84 (8) = 6.7 in. See Belrose, "The Half-Wave Vertical," *Ham Radio*, Sept. 1981, pp. 36-39.

[3]m = ft × 0.3048.

[4]D. DeMaw, "Antenna Matching, Remotely — Some Thoughts," *QST*, July 1982.

[5]The disparity between the impedances measured by VE2CV and by W1FB may be due in part to a difference in the conductor-size ratios of the scaled and full-scale models. Also, the slope angle of the full-size model at W1FB was different from that of the 200-MHz professional model, owing to the feed point being elevated some 3 feet above the ground plane (snow problems).

Strays

TA PROFILES

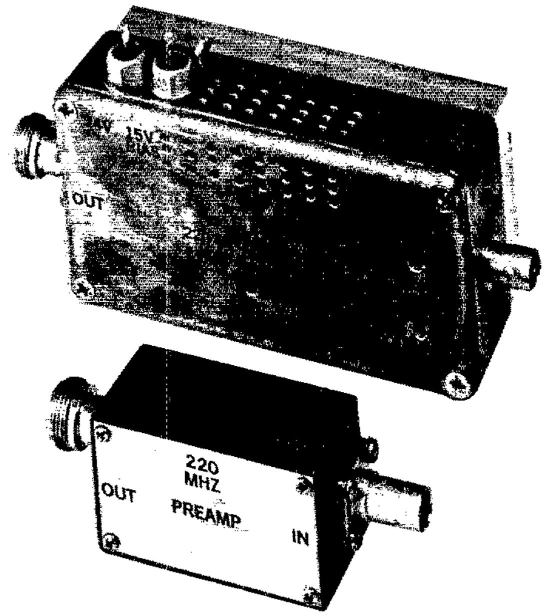
With our thanks for the expert advice we've received on rf power amplifiers and radio transmitters, we are pleased to introduce ARRL Technical Advisor Nathan O. Sokal, WA1HQC. He joined our TA family in 1979.

Nat has been a licensed radio amateur since 1967. He holds an Advanced class license. As a technical speaker, he has given several outstanding papers at radio clubs and at ARRL-organized IEEE seminars. He is the holder of a Bachelor's and a Master's degree in electronics from the Massachusetts Institute of Technology. While attending MIT, he was elected to the Eta Kappa Nu electrical engineering honor society and the Sigma Xi research honorary society. After graduating from MIT, Nat held engineering and supervisory positions with several companies. He was involved primarily with design, manufacture, field installation and operation of a wide variety of analog and digital equipment for instrumentation, control, communication, computation, and signal and data processing.

In 1965, Nat founded Design Automation, Inc., an electronics consulting company. Here he has been involved with the design (and design review) of a wide variety of electronic equipment. He is engaged also with computer simulation of electronic systems and circuits, and development of high-efficiency switching-mode power amplifiers (including rf power amplifiers) and power converters. He is a co-inventor of the Class E switching-mode rf power amplifier and of a high-efficiency, high-linearity rf power amplifier. Nat resides in Lexington, Massachusetts. He is a busy fellow, but when he has any time to spare he can be found in his ham shack and, we hope, reading *QST!* — *Marian Anderson, WB1FSB*

Meet TA Nat Sokal, WA1HQC.

Explore "220" with this State-of-the-Art Transverter!



Part 2: Ready to improve the performance of your 220-MHz station? Building a remote preamplifier and a 40-W linear amplifier is a great way to do it.

By Richard Stroud,* W9SR/W9BRN

If you have completed construction of the transverter described in Part 1, you probably have begun exploring the 220-MHz band.[1] You can make your explorations more enjoyable by increasing the effectiveness of your station. In addition to improving the all important antenna, there are two approaches to enhanced station performance. First, the receive capability can be improved by using a low-noise preamplifier (Fig. 8) mounted near the antenna. Remote preamplifier mounting reduces the effect of feed-line loss on the system noise figure and allows full utilization of the low preamplifier noise figure.

The second approach is to increase the transmit power level. An output power of 40 to 50 W is suitable for general operating. The amplifier in Fig. 9 provides a minimum output of 40 W with good IMD characteristics. This power level is compatible with many of the high-power amplifiers used in this band. Using this equipment and an 11-element Yagi at 50 feet,[6] I have been able to work similar stations regularly at a distance of 150 miles.

[1]Notes appear on page 36.

*P.O. Box 73, Liberty Center, IN 46766

Signal-quality reports on ssb and cw have been good. A spectrum analyzer was used to evaluate the transverter/amplifier combination for spectral purity. All harmonics and spurious emissions are 70 dB or more below the carrier (Fig. 10). Shown in Fig. 11 is a power supply capable of providing the necessary voltages for the transverter, the preamplifier and the linear amplifier.

Construction

The preamplifier and the linear amplifier follow the construction techniques used for the transverter. A piece of 1/16-inch-thick, double-sided copper-clad board is the circuit foundation and ground plane. Grounded component leads are soldered directly to the board. Teflon press-fit terminals are used where insulated supports are required. The power supply has conventional point-to-point wiring.

Preamplifier: A 1-1/2 × 1-1/4 × 2-1/4-inch aluminum box (Pomona no. 2417) houses the remote preamplifier. Two no. 4-40 screws are used to mount the circuit board to the bottom of the box. No. 8 nuts, placed over the screws, serve as spacers between the box and the circuit board. Both sides of the board are tinned, and short lengths of bus wire connect the clad surfaces. The bus wires are passed through drilled holes, then are soldered on each side.

A BNC connector was chosen as the antenna input for its compatability with the transfer relay I used. Others may wish to use a type-N connector, which generally yields a lower VSWR. Copper straps (3/16-inch wide) are placed under the upper connector mounting screws and soldered to the circuit board below. This continues the ground path from the connector to the board without a significant impedance variation.

The transistor used in the preamplifier is an NEC 645-35 uhf device. It is operated at a collector voltage of 8 V and a current of 7 mA. A 5/8-inch-high shield across the transistor isolates the input and output circuits. Power is routed to the preamplifier through the output coaxial cable. An internal regulator prevents voltage variations resulting from long cable runs. If you wish to power the preamplifier directly, disconnect RFC6 from the output jack and apply 12 to 15 V to the choke. If this is done, C49 can be omitted and R13 can be connected directly to the output jack.

Two 470-pF chip capacitors are used to bypass the Q7 emitter leads. One capacitor is placed under each emitter

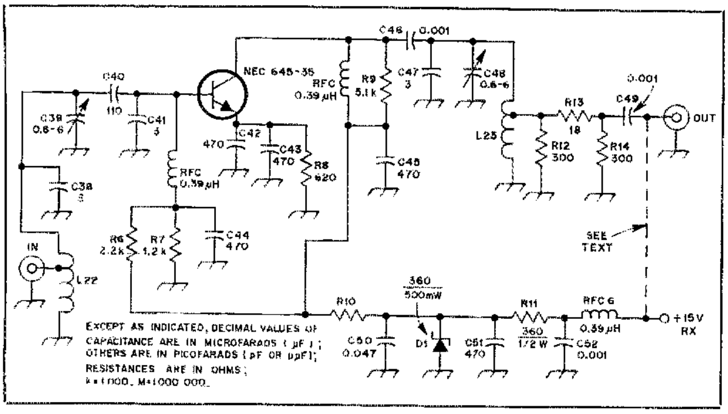


Fig. 8 — 220-MHz remote preamplifier schematic diagram. The power supply may be connected to RFC6 rather than through the coaxial line, if desired (see text). Unless specified otherwise, all resistors are 1/4-W, 5% carbon types.

C38, C40, C41, C47 — NP0 disc ceramic.
C39, C48 — 0.6- to 6-pF piston trimmer, Johanson 4640.
C42-C45, incl. — Ceramic chip capacitor (ATC, JFD or equiv.).
L22 — 4-1/2 t no. 20 bus wire, 1/8-in. ID × 7/16 in. long, tapped at 4 t from gnd.
L23 — 5 t no. 20 bus wire, 1/8-in. ID × 1/2 in. long, tapped 1-1/2 t from gnd.
Q7 — NEC 645-35. Available from California Eastern Laboratories, 3 New England Executive Park, Burlington, MA 01803 (unit cost is approximately $7).
RFC4-5, incl. — 0.39-µH miniature rf choke.

Interior view of the remote preamplifier. A BNC type of connector is used at the preamplifier input. A shield isolates the input and the output circuits.

lead. Access to the trimmer capacitors is provided by drilling two 1/8-inch-diameter holes in the box bottom. Be sure to have the cover in place during final alignment. Adjust the trimmers for the lowest noise figure attainable.

Measured noise figure of the preamplifier is 0.8 dB, and the gain is 24 dB. Because of the high gain, the overall system dynamic range is degraded slightly — a tradeoff to obtain minimum noise figure. A remote transfer relay is used to bypass the preamplifier. This avoids overload when strong interfering signals are present. I used a surplus Amphenol 360-11890-20 relay. It is located with the T-R relay and the preamplifier on the tower. It should be housed in a watertight enclosure as close to the antenna as possible. The transfer relay cannot be used with an antenna having a dc path across the feed line, as the preamplifier supply voltage appears at the antenna when the relay is in the bypass position.

Linear amplifier: A Bud CU-124 diecast box (approximately 2-1/4 × 4-1/4 × 1 inch) houses the power amplifier. A 1/2-inch-thick aluminum plate, cut to the outline of the box bottom, serves as the heat sink. I cut two 1/8-inch-wide grooves in the plate to increase the surface area and to improve the heat radiation. Each groove is 1/4-inch deep and runs the full length of the plate. The plate was drilled and tapped for the no. 4-40 screws that are used to attach it to the box. The box bottom is cut away to clear the transistor mounting flange. Oversized holes drilled in the box provide clearance for the feedthrough capacitors and the Teflon terminals that protrude from the bottom of the circuit board. The transistor mounting flange is bolted directly to the heat sink. Heat-sink compound (Dow Corning 340 or equiv.) is applied to the transistor flange and the heat sink. This heat sink is satisfactory for normal ssb and cw operation; if long key-down periods are expected, a larger heat sink may be required.

For ease of assembly, the solder-in standoff capacitors and most other components should be mounted before the circuit board is secured in the box. All six transistor leads are cut to a length of 1/4 inch. The copper foil under the base and collector tabs is removed to avoid shorting to the ground plane. Input and output connections are made directly to the transistor tabs. The threaded stud of the reference diode (D8) is used as one of the transistor mounting screws. This places the diode in good thermal contact with the transistor, thus providing bias temperature compensation. The diode body is soft copper, so don't over tighten it. After the circuit board, the box and the transistor are bolted to the heat sink, the four emitter leads are laid flat against the circuit board and soldered in place.

Capacitors C56 and C57 should be low-inductance chip types. One capacitor is mounted on each side of the transistor base lead and soldered directly to the ground plane (see photo). C63 should also be a low-inductance capacitor. The harmonic-filter capacitors (C66, C67 and C68) are small dipped-mica units with the leads cut to a length of approximately 1/8 inch. It is important to position the filter inductors (L29, L30 and L31) as shown in the photograph. This will prevent inductive coupling across the filter. If a spectrum analyzer is available during alignment, the lead length of the mica capacitors and the inductance of L30 and L31 can be adjusted to minimize or "notch" the second harmonic.

A pattern of holes is drilled in the cover and the side of the box near R19 to allow air flow around that resistor. Adjustment holes (1/8-inch diameter) are also drilled in the cover above C54, C55 and C62.

The resting (no drive) Q8 collector current should be adjusted to 45 mA by selecting the value of R16; the resistance needed depends on the individual transistor. Raising the resistance of R16 will increase the collector current. To protect Q8, start with a low resistance and work up to the desired current. Do not apply collector voltage with R16 open, even momentarily, as the transistor can be damaged by the resulting high collector current.

Feedthrough power-line filters (FL1 and FL2) were used for the 24-V and the bias-voltage connectors. Feedthrough capacitors of 470- to 1000-pF capacitance could be used as substitutes for the filters. The 24-V supply is connected permanently to the amplifier. Applying the 15-V bias potential turns the unit on. Bias switching is controlled by the T-R circuitry in the transverter.

This amplifier has a gain of nearly 10

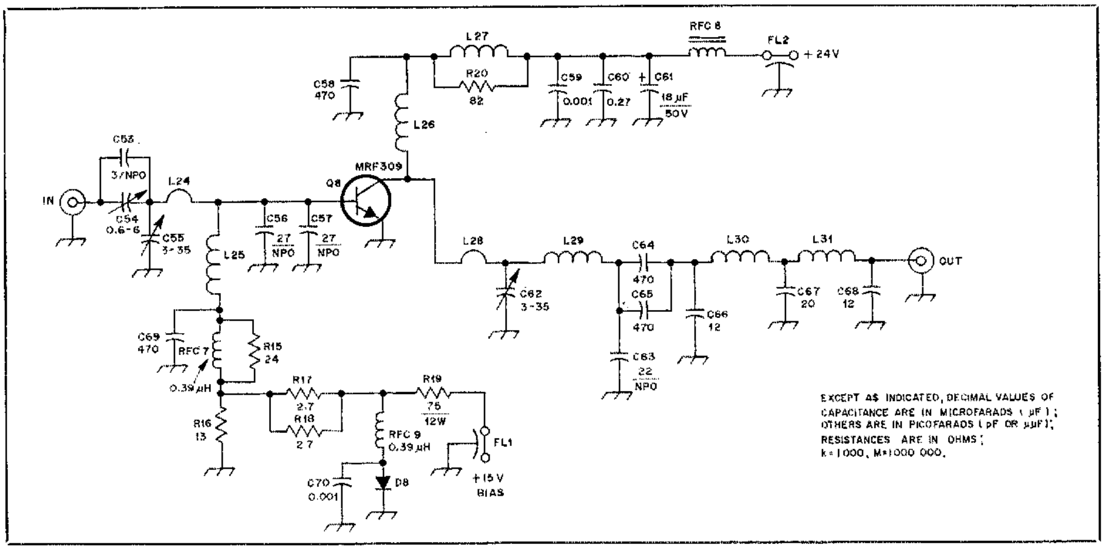
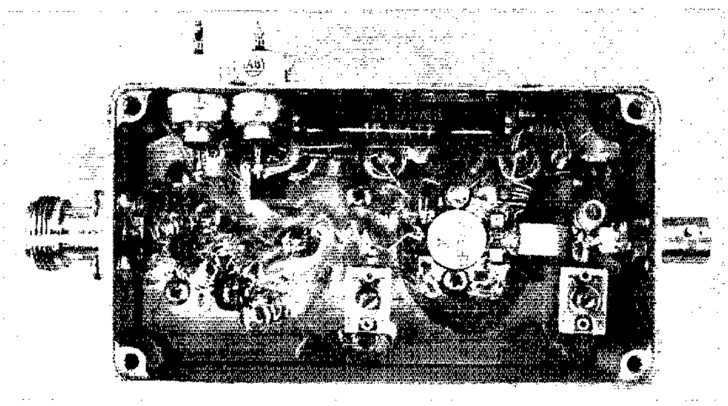


Fig. 9 — 40-W linear power amplifier schematic diagram. Unless otherwise specified, all resistors are 1/4-W, 5% carbon types. Capacitors are rated at 100 V.

C54 — 0.6- to 6-pF piston trimmer, Johanson 4640.
C55, C62 — 3- to 35-pF mica compression trimmer, Arco 403 or equiv.
C56, C57, C63 — Ceramic chip capacitor (ATC, JFD or equiv.).
C58, C59, C69 — Standoff capacitor, Allen Bradley SS5D, Spectrum Control 54 803 003 or equiv.
C64, C65 — Disc-ceramic capacitor.
C66-68, incl. — Dipped-mica capacitor.
D8 — Silicon diode, Unitrode UT5105 or equiv.
FL1, FL2 — Feedthrough line filter, Allen Bradley F1B or equiv. 470- to 1000-pF feedthrough capacitors may be used as substitutes.
L24 — 1-in. length of 1/2-inch-wide copper strap formed in a 1/2 turn.
L25 — 3 t no. 20 bus wire, 1/8-in. ID × 1/4 in. long.
L26 — 2 t no. 18 bus wire, 5/32-in. ID × 3/8 in. long.
L27 — 9 t no. 28 enameled wire wound on R20.
L28 — 9/16-in. length of no. 18 bus wire.
L29 — 2 t no. 18 bus wire, 1/8-in. ID × 7/16 in. long.
L30, L31 — 5 t no. 20 bus wire, 1/8-in. ID × 7/16 in. long.
Q8 — Motorola MRF309 rf power transistor. A 2N6439 or a TRW J02015A may be used as a substitute.
RFC7 — 0.39-μH miniature rf choke.
RFC8 — 1-1/2 t ferrite choke, Ferroxcube VK200 19/4B or equiv.



Interior view of the linear amplifier. It is important that the harmonic-filter inductors (near the type-N output connector) be positioned as shown to prevent unwanted coupling across the filter.

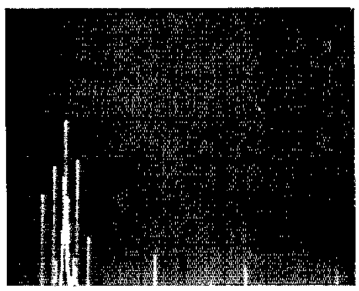


Fig. 10 — Spectral display of the transverter/amplifier signal at the 50-W output level. The largest signal is the 220.1-MHz carrier. It has been notched 60 dB to permit viewing on the spectrum analyzer. The carrier reference level is actually 30 dB above the top of the display. Each vertical division is 10 dB, and each horizontal division is 100 MHz. Display center frequency is 500 MHz. All spurious signals resulting from oscillator harmonics and undesired mixer products are more than 70 dB below the carrier, and all harmonics are at least 90 dB down. This meets FCC requirements for commercial equipment.

dB, and, when operated from a 24-V, 3-A supply, is capable of over 50 W of output. Linearity is very good up to an output level of approximately 42 W. During two-tone IMD testing at an output power of 40 W, the third-order products were found to be 35 dB below the desired output signals.

An input VSWR of 1:1 can be obtained by adjusting C54 and C55. The output network is aligned by adjusting C62 for maximum output power. Final adjustment of C62 should be performed at full output power.

Power supply: A conventional design using IC voltage regulators was used for the power supply shown in Fig. 11. None of the supply components are critical, and builders are encouraged to use any suitable materials they have on hand. It is necessary only to ensure that the output voltages are near the specified values and that the current capacity is ample. I obtained my transformers from a scrapped

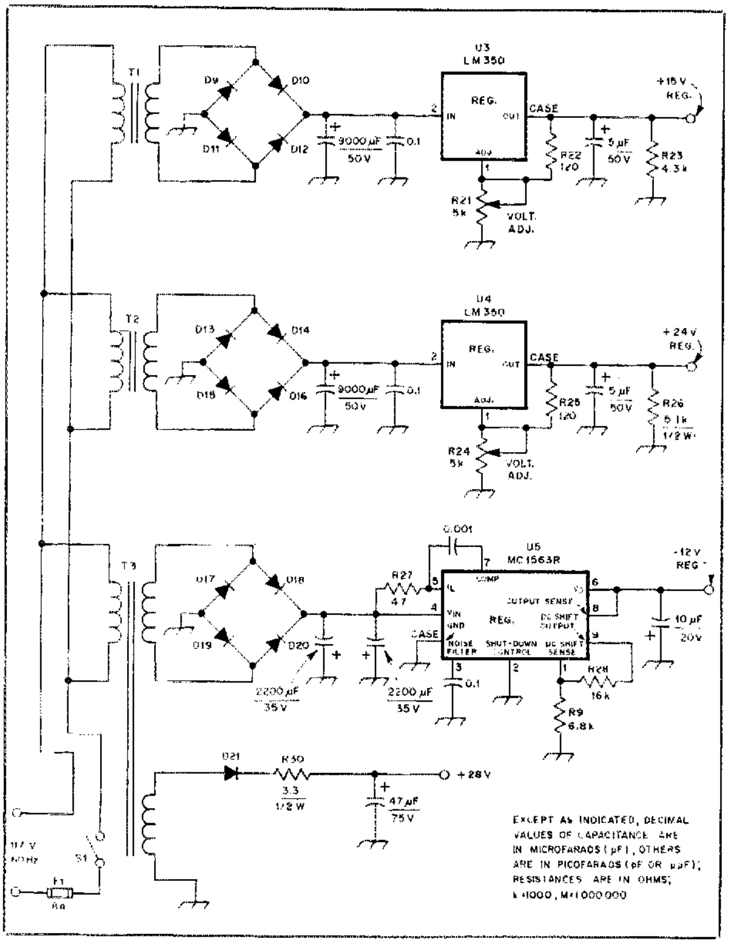
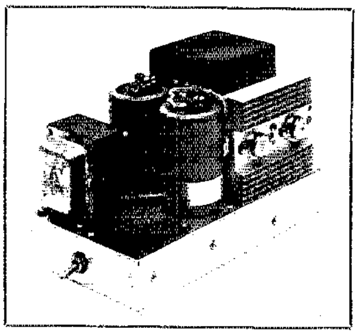


Fig. 11 — Power supply schematic diagram. This supply provides all the necessary voltages for operation of the transverter system. Unless otherwise specified, all resistors are 1/4-W, 5% carbon types, and capacitors are rated at 100 V. Polarized capacitors are electrolytic. Others are disc ceramic.

D9-12, incl. — 3-A, 100-V silicon rectifier diodes.
D13-16, incl. — 5-A, 100-V silicon rectifier diodes.
D17-21, incl. — 1/2-A, 100-V silicon rectifier diodes.
S1 — 10-A spst toggle switch.
T1 — 18-V, 2-A power transformer.
T2 — 26-V, 3-A power transformer.
T3 — 12.6-V, 0.5-A power transformer.
U3, U4 — Adjustable 3-A voltage regulator, National LM350 or equiv.
U5 — Adjustable 0.5-A negative voltage regulator, Motorola MC1563R, MC1463R or equiv.



This version of the transverter power supply was constructed around surplus transformers. The devices mounted on the finned heat sink are the regulators for the positive supplies.

stereo amplifier and from a local "junk" dealer.

A 5 × 9 × 1-1/2 inch chassis serves as the power-supply base. You may wish to use a larger chassis, especially if larger transformers are used.

The LM350 regulators are mounted on a standard heat sink which is bolted to the chassis top. Aluminum brackets under the chassis support the −12 V regulator and the power diodes. Mica insulating washers are used under the LM350s and the diodes. Be sure to apply heat-sink compound to the mounting surfaces of these devices and to the heat sinks.

The value of R28 can be selected to set the negative supply output to −12 V. R21 and R24 are adjusted to set the voltage of the +15- and +24-V supplies. An octal socket is used as the supply output connector.

With the addition of these units, the performance of your 220-MHz station will rival that of many stations currently active on the band. It is my hope that with the construction of this transverter system many new "explorers" will be heard on 220 MHz.

Notes

[1]R. Stroud, "Explore '220' with this State-of-the-Art Transverter!" *QST*, Aug. 1982, pp. 14-18.
[2]mm = in. × 25.4; m = ft × 0.305; km = mi × 1.6.

Strays

HIS DISABILITY ISN'T A HANDICAP

□ Success stories like this one are heartening, for, despite being blind, Dr. Walter Horn (I4MK) of Persiceto (Bologna), Italy, is a chief electronics engineer at Akron, Bologna, and has designed many sophisticated circuits over the years. He believes that he is the only unsighted person in the electronics profession in Italy.

Dr. Horn has designed amateur equipment that has been described in *QST* and other amateur literature. He is currently developing a general-coverage receiver, a low-noise synthesizer, a 150- to 170-MHz synthesized transceiver and a solid-state a-m broadcast transmitter. (I wonder what he does to keep busy during his spare time!)

Walter equates his career to that of Marconi by saying, "G. Marconi proceeded from long waves to short waves, perhaps because he was tired of winding coils!" Walter has also gone from long waves (relative) to short ones (vhf). He summarizes by saying that, for the blind, "the most difficult task is certainly that of coil winding, especially if they are taped."

Other blind amateurs may get inspiration from talking to I4MK on the air. I'm sure he has some interesting tales to relate. — *Doug DeMaw, W1FB*

I would like to get in touch with . . .

□ anyone who has an operating manual and/or a schematic for a Sigma AF-250L a-m/fm analyzer. Bob Witte, KBØCY, 2253 Evelyn Ct., Loveland, CO 80537.

Technical Correspondence

Conducted By
Dennis J. Lusis,* W1LJ

The publishers of QST assume no responsibility for statements made herein by correspondents.

NOTES ON CATVI

☐ With many cable TV systems now operating inside the amateur vhf bands, concern is mounting over potential interference to either service. Because there is a great deal of misinformation concerning this subject, we would like to address the technical aspects of CATV/Amateur Radio band sharing.

The typical amateur 2-meter transceiver requires an input of 0.25 μV for 20 dB of quieting, or 0.2 μV for 12 dB SINAD. If we assume a legal limit point-source radiation of 20 μV/m at 10 feet[1] on 145.25 MHz (CATV Ch. E), and the amateur station is 100 feet away, this gives us a field strength of 2 μV/m. This 2 μV/m equals 0.66 μV, more than enough to break the squelch and, because of the capture effect on fm, probably enough to prevent weaker signals from getting through. Most likely, the amateur's antenna will be closer than 100 feet to the cable, and it will have gain, thereby worsening the situation.

A typical signal-level meter for the CATV industry goes down to −40 dBmV.[2] Preamps can extend this range an additional 16 dB. This −56 dBmV equals 1.59 μV and, at 145.25 MHz, relates to a field strength of 4.85 μV/m at 10 feet. Routine cable monitoring will discover radiation that is as low as 12 μV/m and that averages 16 μV/m at a distance of 10 feet. If we assume the average 2-meter antenna to be 50 feet from a potential radiation source (about average for northern New Jersey), this distance equates to a signal strength of 0.787 to 1.05 μV. Even a 1-μV leak would equal 0.2 μV at 50 feet. One microvolt is −60 dBmV, and could *not* be measured on the signal-level meter plus preamp just discussed.

With the above in mind, let us examine a properly installed cable drop, in which many people believe most radiation problems originate. We will assume a level of +15 dBmV for the 145.25-MHz signal at the output port of the tap. This is a worst-case situation, as the level at this frequency is normally several decibels lower. Modern triple- and double-shielded drop cable connected to an "F" fitting with integral 0-ring and secured by a hex-crimper has an isolation figure of −90 dB. Therefore, right up against the port (say, 1 inch away), *maximum* leakage would be 0.178 μV (−75 dBmV) — insufficient to meet even the 12-dB SINAD figure given previously. With a 50-ft distance between the amateur antenna and the cable, there would be only 0.000297 μV of signal appearing at the antenna. Sixty decibels of gain would be needed to have this low-level signal create problems; the most elaborate antenna installations have a maximum gain of 25 dB, so there should never be any trouble from a properly installed drop. There *is* the potential radiation problem caused by people illegally hooking up their TVs at the tap or adding another TV using components available from many vendors. Improperly hooked-up video games or computer terminals may also cause problems.

The most serious threat, of course, would be an illegal hookup at the tap. Generally, the radiation occurring would be in the order of millivolts rather than microvolts, and would cause interference (ghosting) to televisions *not* hooked up to the cable system at all, as well as to Amateur Radio stations. A problem of this sort would most likely be taken care of promptly, as *everybody* would be complaining. The two cases cited above are more insidious, as radiation may be fairly low and possibly frequency selective; they will usually affect only adjacent neighbors, whose complaints will be the first indication that something is amiss. Often, the uniqueness of the problem (e.g., only on channel 13 at 2 to 3 P.M., and then it goes to channel 10) will be the giveaway clue.

Although cable egress and ingress always coexist, it is more difficult to protect against the latter. Amateur signal levels, even at QRP, are far higher than cable levels. One-hundred and fifty milliwatts (21.76 dBm) is much more than 15 dBmV (−33.75 dBm). The only thing that can be done is to make sure all connections are rf tight and properly terminated, which help protect against egress, too. At our system on Long Island, we were troubled by 2-meter ingress at our main head-end in Farmingville. This caused reception problems on Channel E throughout the entire cable system. While the amateurs running the repeater were very cooperative, it was obvious that the head-end had to be made impervious to the amateur signal — no simple feat when only 300 feet separated the two sites. However, by ensuring that all connections were tight, all unused ports were terminated and other rf-integrity improvements were made, the ingress directly into the head-end was eliminated. The only problem remaining was with the CATV customers immediately adjacent to the head-end site. Although this is an ongoing problem, it is in the process of being rectified through the use of double-shielded drop cable and the other cures cited previously.

How should we resolve the problem of CATVI without going to extremes? We believe the possibility of peaceful coexistence does exist. We recommend that your amateur frequency coordinators: (1) make themselves known to cable operators in their areas of responsibility and, (2) not assign the 144.65/145.25-MHz repeater pair unless no other pair is available. On the other side of the coin, the cable operator can offset his channel. Offsetting will "buy" a good 20 dB of margin.

A numerical example will explain. Assume there is a problem at 145.24 MHz (say, 1 μV, −60 dBmV). If we shift the video carrier up about 38 kHz, the second sideband (downward in frequency) will be 6.5 kHz above the repeater frequency and the third sideband will be over 9 kHz below. This second sideband, in addition to being pretty much out of the repeater passband, is 20 dB down from the level of the carrier frequency. As proven already, −75 dBmV will not cause interference to amateurs; — here we are talking about −80 dBmV or better. Even if there is more signal than 1 μV, this greater than 20-dB margin may be the difference between making the repeater totally unusable and just being a source of minor interference.

It is very important that there be a liaison between the frequency coordinators and the cable operators for the purposes of choosing an offset that will eliminate the problem at one repeater without causing problems at another. Tolerances have to be taken into account, but a minimum of 20 dB can be gained by merely offsetting. An offset of 55 kHz or less is feasible, and can be done by any cable operator without having to modify the converters or worry about adjacent cable channels. The offset solution has been accepted by the FCC and the FAA to resolve interference problems in the aeronautical band, 108-136 MHz. — *Stephen Raimondi, W2QUU, Director of Engineering, and Robert Wanderer, KT2D, Special Projects Engineer, Rogers UA Cablesystems, Inc., Oakland, New Jersey*

[1]m = ft × 0.3048
[2]dBmV = decibels referenced to 1 millivolt

*Assistant Technical Editor

Feedback

☐ An incorrect address for Radiokit was given in the July 1982 *QST* article, "A New, More Versatile Transmatch." The correct address is: Radiokit, P.O. Box 411, Greenville, NH 03048.

☐ There was a connection missing in the schematic of the equalizer in "Equalize Your Microphone and Be Heard!" in July *QST*. There should be a connection from the junction of the 10-kΩ and 100-kΩ resistors connected to the LOW GAIN control and pin 1 of U1B. The parts-placement diagram for the equalizer is available by sending an s.a.s.e. to: Audio Equalizer, TIS, 225 Main St., Newington, CT 06111.

☐ In "Go for the Gain, NBS Style," (August 1982 *QST*), there are errors in Table 5. The length of the 1st director on the 0.8-, 1.20- and 3.2-λ long Yagis should be 0.428, rather than 0.482.

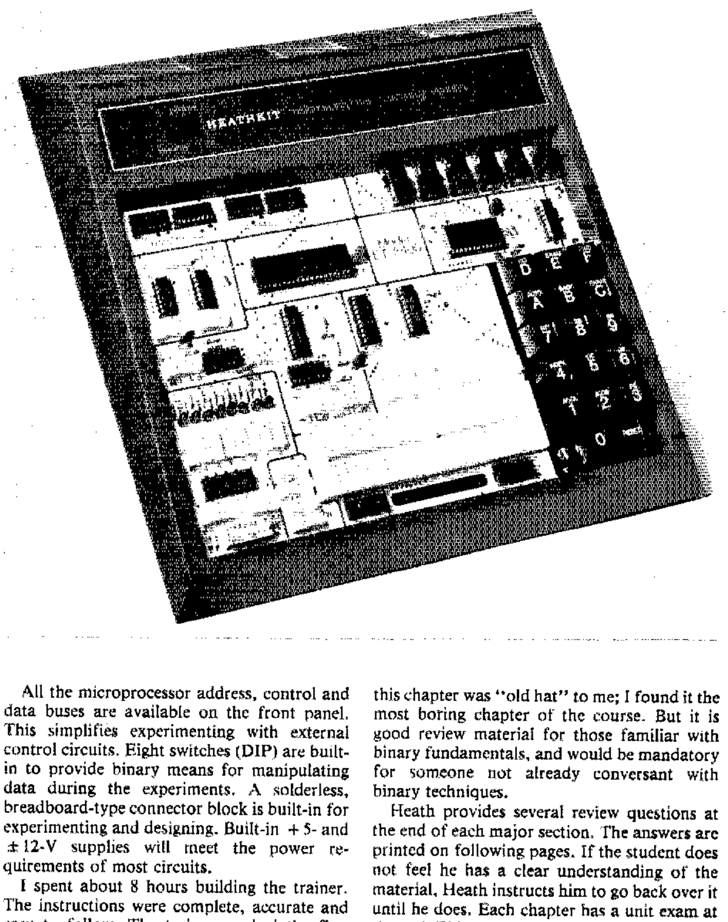
☐ Author Morrow, WB6GTM ("WARC and LF on the TR-7," July 1982 *QST*), wishes to add a clarification note to his text: The BCD band-select code should be reversed before placing it on pins 9--12 of the AUX-7 plug; that is, the most significant bit of the code should be on pin 12, and the least significant bit on pin 9. In addition, the author is providing etched and drilled printed-circuit boards for $7.50, postpaid. A complete parts kit including board, resistors, diodes and connectors is available for $15. The ARRL in no way warrants this offer.

Product Review

Conducted By Paul K. Pagel,* N1FB

Heathkit® ETS-3401 Microcomputer Training System

The Heathkit® ETS-3401 system is a package designed to train someone with little or no knowledge of computers. It is an ambitious goal on the part of Heath — and they succeed! ETS-3401 consists of the ET-3400 Microprocessor Trainer, an EE-3401 Microprocessor Self-Instruction Course, the ETA-3400 Accessory and the ETA-3400-1 Memory Expansion IC set. My first reaction was that I needed a computer just to keep track of all these numbers, but, as with any Heathkit®, everything proceeds logically, one step at a time.



ET-3400A Microprocessor Trainer

The trainer is the "heart" of the course. With it, the student gets plenty of hands-on experience. Without it, the program would be little more than just another good book on computer basics. A Motorola MC6800 microprocessor IC is the "brains" of the trainer. A small ROM monitor controls the operation of the MC6800. The ET-3400A has 256 bytes of memory (RAM), with provisions for an additional 256 bytes (512 bytes total).

A hexadecimal 17-key pad (16 value keys plus a RESET button) provides the user with a means of entering data and instructions. The data readout system consists of six 7-segment LEDS, which display hexadecimal data. The student has tremendous flexibility while using the two together. The memory address or the contents of the memory associated with that address may be changed at will. After depressing the AUTO key, the user has but to enter the first address of the program. The student then enters the instruction (or data) for that first address. As soon as the two keys have been pushed, the trainer advances automatically to the next memory location and awaits the next two key strokes. Meanwhile, the LEDs have displayed the first address and, momentarily, the first two keystrokes, before changing to the next memory location and two blanks. After a little practice, I found it easy (a lot easier than I originally anticipated) to enter moderately long (for me) programs.

Once the programming is complete, Heath advises the user to examine the contents of each memory cell to make sure no mistakes have been introduced. This can be accomplished semiautomatically once the first address has been entered. The user can call the contents of each memory cell (1 byte, 2 hexadecimal numbers) to the display for checking by hitting the FORWARD or BACKWARD key. The user then can tell the microprocessor to execute the program one step at a time (SINGLE STEP). After each step, the memory location of the next step and the contents of that step appear in the LEDs. Additionally, after each step, the student can call for the display to show the contents of either accumulator or the status flags. This is a powerful learning tool, when trying to teach yourself to think like a computer!

All the microprocessor address, control and data buses are available on the front panel. This simplifies experimenting with external control circuits. Eight switches (DIP) are built-in to provide binary means for manipulating data during the experiments. A solderless, breadboard-type connector block is built-in for experimenting and designing. Built-in +5- and ±12-V supplies will meet the power requirements of most circuits.

I spent about 8 hours building the trainer. The instructions were complete, accurate and easy to follow. The trainer worked the first time and ever since. It is an easy kit to build.

Heath now has a new version of the trainer, the ET-3400A. According to Heath, the only difference is that the "A" meets the new FCC standards on rf emissions. Operation is the same in both units.

EE-3401 Microprocessor Self-Instruction Course

Two large loose-leaf notebooks containing several hundred pages of material, two tape cassettes, a flip chart and a bag of electronic components make up the course. Heath has done a skillful job of preparing the text to lead the neophyte through the inner workings of the computer. The first chapter deals with binary arithmetic and number systems used with computerized devices. It also covers octal and hexadecimal number systems and binary codes (BCD, ASCII, etc.). Most of the material in this chapter was "old hat" to me; I found it the most boring chapter of the course. But it is good review material for those familiar with binary fundamentals, and would be mandatory for someone not already conversant with binary techniques.

Heath provides several review questions at the end of each major section. The answers are printed on following pages. If the student does not feel he has a clear understanding of the material, Heath instructs him to go back over it until he does. Each chapter has a unit exam at the end. This is similar to the review questions, and it carries the same advice for the student dissatisfied with his performance.

Each of the eight text chapters has a list of experiments to perform from Chapters 9 and 10 using the trainer. The experiments in Chapter 9 deal with programming techniques. Those in Chapter 10 involve interfacing the trainer with external circuitry. More than one experiment may be associated with each chapter. Chapter 1 calls for experiments 1 and 2. Experiment 1 has $7C_{16}$ (124_{10}) entries — I told you the AUTO feature of the trainer is a good one! A second program requires more entries! The good news with the experiments is that they become more demanding mentally, but require fewer entries.

Chapter 2 introduces the basic concepts and jargon of computers. A hypothetical microprocessor is discussed. Heath describes the function of each of the major sections of the

*Assistant Technical Editor

μP IC. Diagrams show the routing of information between these sections and the other components outside the microprocessor. The student sees how various instructions are implemented.

Chapter 3 covers computer arithmetic. In addition to binary adding, subtracting, multiplying and dividing, the chapter contains information about two's complement arithmetic and the four basic Boolean logic operations.

Heath presents an introduction to programming in Chapter 4. The unit covers the difference between machine, assembly, interpretive and compiler languages. Other topics included are flow charts, branching, addressing for branching and flags.

Chapters 5 and 6 present the MC6800 microprocessor IC. Not surprisingly, most of the statements about the hypothetical microprocessor turn out to be applicable to the MC6800. For the most part, the points of divergence are those where the MC6800 has features more advantageous than those of the hypothetical μP. In fact, this is one of the things that I found most helpful in the course. Heath has deliberately provided some programs that will not work properly. The student has the task of finding out why they do not work and correcting them.

Heath compares and contrasts the block diagram and the programming model of the MC6800. This helps make clear the functioning of the instruction set, which is covered in detail. Extended and indexed addressing can be used with the MC6800; Heath demonstrates why these methods make a more versatile computer. The text points out that the memory stack of the MC6800 is superior to the cascade stack found on many other microprocessors; it also covers the instructions associated with the stack. Subroutines and instructions associated with them constitute another portion of the discussion. The text covers other pertinent operations, including input/output and interrupts. At points, I felt overwhelmed by the amount of new information in each paragraph. Repeated reading and doing the experiments did much to alleviate these feelings.

The final two chapters of the text portion, 7 and 8, discuss interfacing. As Heath points out, there are basically two things that you can do with a computer: program it and interface it. The text defines 3-state logic, and explains the need for it. Heath covers the MC6800 control lines and timing relationships. Memory devices (RAM), address decoders and readout devices are analyzed. The Peripheral Interface Adapter (PIA), one of the most important devices that can be interfaced with a computer, is covered in detail.

Interfacing experiments (Chapter 10) associated with Chapters 7 and 8 use the bag of electronic components, and are among the best that I have seen. One of the first involves loading data into a RAM with the DIP switches on the trainer. George Collins, KC1V, has told me some "war stories" about loading massive programs into computers with switches. This short experiment has given me a much deeper appreciation for what he is talking about.

Heath has given me a deeper understanding of and an appreciation for the "easy way" by first making me do it the "hard way." Some of the experiments involve numerous connections. The resulting "rat's nest" of wires is enough to send me running for a bottle of aspirin. All the experiments worked — after I found my wiring mistakes. That was an education, too!

Once the course is completed, the student has the option of taking a final examination. If the student scores a passing grade of 70% or better, he earns 8.0 Continuing Education Units (CEUs) and a Certificate of Achievement. A classroom version of the course is also available.

ETA-3400 Memory Accessory

The ETA-3400 turns the trainer into a full-fledged personal computer, lacking only more sophisticated input/output devices. It contains a 32- × 8-bit ROM programmed to provide seven outputs selecting various expansion functions. The RAM memory expansion is made up of eight 1K × 4-bit memory ICs. Two of the ICs come with the ETA-3400 itself, while the other six ICs make up the optional ETA-3400-1 kit. Alone, the ETA-3400 has 1 kilobyte of user memory; with the expansion ICs, the total comes to 4 kilobytes. The trainer by itself has 512 bytes of memory.

A Peripheral Interface Adapter (PIA) handles the input/output functions. It has two 8-bit bidirectional data ports and four control lines. Each line can be programmed to act as an input or an output. One port connects to a terminal device, while the other connects to a cassette tape recorder.

The terminal input can be configured for an RS232 standard connection or for a 20-mA current loop. A builder has the option of connecting to an ASCII keyboard and a video display or to a Teletype-style ASCII keyboard and printer. Alternatively, he can write a program that would allow connection with a Baudot Teletype machine. Heath does not supply any information on this.

Another ROM installed in the ETA-3400 carries the instructions for Tiny BASIC, an abbreviated version of standard BASIC. With this provision, the user has the option of running programs found in the popular literature without extensive modifications. I have not been able to use this feature, because I do not have a terminal attached to the computer yet. I did perform the diagnostic tests listed in the assembly manual, and all seems well.

Construction is simple and straightforward. It took me about 8 hours to assemble the ETA-3400 and another 2 hours to modify the trainer to function with it. The modifications to the trainer consist of removing the four RAM ICs from the trainer, adding a 40-pin connector, and changing a few components affecting the clock (oscillator) frequency and stability. Although this improves the functioning of the computer, it affects the outcome of some of the experiments in Chapter 10. Heath advises the student to finish the experiments (and the remainder of the course) before modifying the trainer and attaching the ETA-3400. The Trainer can be used independent of the ETA-3400 by removing the 40-conductor connecting cable and reinstalling the four RAM ICs on the Trainer.

I would recommend the ETS-3401 Microcomputer Training System to anyone wanting a fundamental understanding of computers. (With today's trends, that may be anyone wishing to remove the top cover from an amateur transceiver.) The course is well written, logical and thorough. It compares quite favorably with the "three-day seminars" costing two to three times as much. On the other hand, if your primary interest is simply running game programs, the ETS-3401 may not be your best bet. It's not a toy — it's an education (and fun)!

The ET-3400 Trainer and the ETA-3400 Accessory can be wired for 117- or 234-V ac operation. The Trainer is 3-1/2 × 12-1/8 × 11-3/4 inches (HWD),[1] and weighs 4 pounds. The Accessory is 3-1/2 × 11-1/4 × 13 inches (HWD), and weighs 6 pounds. Price classes for the units are: EE-3401, $100; ET-3400A, $225; ETA-3400, $175; ETA-3400-1, $50. Package price: $480. Additional information may be obtained from the Heath Company, Benton Harbor, MI 49022. — *Peter O'Dell, KB1N*

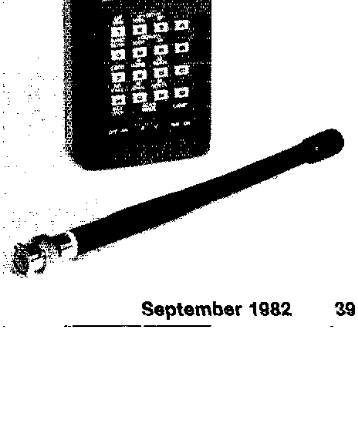
AZDEN PCS-300 2-METER HAND-HELD TRANSCEIVER

□ Move over, Atari: The Azden PCS-300 is here! This small 2-meter fm hand-held transceiver has a multitude of attractions, including CMOS microprocessor (μP) control, eight memory channels, a pleasing keyboard actuation tone, full 2-meter coverage, an LCD readout with S/RF meter, a DTMF key pad and programmable scanning.

"Taking the controls" of this rig perhaps can be accomplished best by examining the symmetrically placed operating controls and functions. The rotary POWER switch/VOLUME control is easily maneuverable by even the largest and clumsiest fingers. A PL TONE switch (push button) controls the optional tone encoder.

The 16-button keyboard functions as a full DTMF encoder. The HI/LO power switch selects transmitter output of either one or three watts. A rotary SQUELCH control switch, identical to the VOLUME control switch, has a TONE position from which the squelch will open only for signals accompanied by a certain designated subaudible tone frequency (using the optional board). An external microphone with a PTT jack and an accompanying earphone jack share a dust-cover cap for protection when they are not in use. The TX-OFFSET switch has four positions (MW [memory write], +M [plus offset], −M [minus offset], and S [simplex]), and allows for the use of nonstandard offset frequencies, which is handy for MARS operation. This

[1] mm = in. × 25.4, m = ft × 0.3048, kg = lb × 0.454.



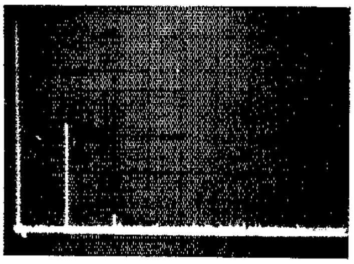


Fig. 1 — Spectral display of the Azden PCS 300. Vertical divisions are each 10 dB; horizontal divisions are each 100 MHz. Output power is approximately 3 watts at a frequency of 146 MHz. All spurious emissions are at least 62 dB below peak fundamental output. The fundamental has been reduced in amplitude approximately 35 dB by means of notch cavities; this prevents analyzer overload. The Azden PCS-300 complies with current FCC specifications for spectral purity.

switch selects a memory channel independent of the eight regular ones, and it can store an offset value that may be as small as zero or as large as 7.995 MHz. A BNC antenna connector completes the layout of the top of the PCS-300. Azden warns not to transmit with the antenna twisted or held in your hand — the antenna impedance will be affected!

Attractive Appearance

The '300 is attractive, compact and light. It is as wide as, and just a little longer than, a dollar bill. The built-in electret microphone and the internal speaker are located above the readout. Both are disconnected when an external microphone is used. (Though certainly typical for audio in most hand-held transceivers, the sound quality of the PCS-300 wasn't as natural as I would like — some voices were too "tinny" for my taste.)

The display is the focal point of this radio, and obviously was designed with users in mind. It is large and can be read easily, even in bright sunlight. The frequency display indicates the lower four operating frequency digits; for example, 5.450 means 145.450 MHz. When an offset is used, the display shows the transmit frequency during transmit, and the receive frequency at other times. An incandescent lamp (its switch is located on the bottom front panel) lights up the display. The lamp remains on for about 20 seconds, then turns off to preserve the batteries (the display flashes on and off when the charge is getting low). The lamp is useful at night, though I still haven't figured out how to change frequencies safely while driving.

Other Functions

Indicators (+600 and −600) show when a standard offset is in use. If an offset would cause an out-of-band transmission, the radio goes to the simplex mode even if the offsets are activated. "+" and "−" indicators are used when nonstandard offsets are employed. MM indicates memory mode, and the S/RF S-bar LCD indicator shows relative signal strength when receiving and relative output when transmitting. M ADRS is provided by the same eight-bar indicator; the memory channel being used is indicated by flashing of the corresponding memory address bar (which also occurs when receiving a strong signal). For example, if 6.79 is in memory 3, then the memory address bar directly above 3 will flash on and off, independent of the S/RF indications.

The bottom front of the PCS-300 includes a KEY LOCK switch, which prevents accidental change of frequency, and a SCAN MODE switch, which directs the scanner to look for either busy (B) or vacant (V) channels. Located on the bottom of the radio, the charging terminal connects to the NiCd battery charger. The belt hanger, logically, is on the back of the radio.

Fun to Use

Operating the PCS-300 is where the fun begins. The 16-key pad, which directs all the µP control functions, produces an electronic "beep" every time a key is pressed to let you know that the µP has received the command. In the transmit mode, this function is disabled, and the key pad operates as a DTMF encoder pad. Put the KEY LOCK switch ON to prevent changing frequencies, instead of accessing a number, while using autopatch.) Frequency is changed by the 5K UP and 5K DOWN keys. When one holds either of these keys for longer than 1/2 second, the frequency will move continuously up or down at the rate of eight channels per second. As with all the UP or DOWN keys, it is easier to depress the key for the required time for continuous frequency change, and release the key as the desired frequency is approached. Then, merely actuate the key a few times to reach the goal frequency. The 100K UP and 100K DOWN keys move the frequency up or down by 100 kHz; they do not affect the MHz digit. The MHz UP key changes megahertz upward only from two to nine, and does not affect the 100-kHz and 5-kHz digits. "Upward only" must be emphasized, because I became accustomed to pressing a DOWN button to change the 100- and 5-kHz digits, and automatically pressed the key below the MHz UP key to try to decrement the frequency in MHz steps. That didn't work because that key is the BAND SCAN key — not the desired function. The BAND SCAN key initiates scanning in 5-kHz steps between the two preprogrammed limit frequencies. The lower-limit frequency is in memory seven, and the upper limit is in memory eight. A M ADRS key changes the memory address from channel one through channel eight.

No matter what frequency or memory is in use, the MI CALL key calls the contents of memory channel one. M WRITE places the displayed frequency into the memory channel indicated by the memory address bar. Don't forget to include ±600 when you store the desired frequency using this function. M SCAN actuates scanning of the eight memory channels, and any busy channel stays on for six seconds before scanning proceeds.

Sound complicated? It isn't really. I chose to put the W1AW repeater frequency, 145.450 (−600), in memory one and several other local repeater and most-used simplex frequencies in the other memories. All I had to do to find out what was going on locally was to use the M SCAN function. I could always stop at an interesting channel by pressing M CALL and then M ADRS. To continue scanning, I simply pressed M SCAN again. The programmable scan limits are a real convenience: One doesn't have to scan the entire nearly 8-MHz-wide band. For example, 5.000 to 7.399 could be programmed in memories seven and eight to hear the most-used 2-meter fm segments. If scanning for busy channels, the scanner stops for six seconds, then goes on. If you want to stay on that busy channel, press either the 100K UP, 100K DOWN, 5K UP or 5K DOWN buttons. To begin scanning again, press the BAND SCAN key, and on it goes. I would have liked the function to begin scanning once more at the point where I had stopped it, but the scan proceeds each time from the limit set in memory seven. To prevent accidental transmissions or "sitting on the microphone button," a transmit lock switch is provided on the transmit bar.

Comments

What didn't I like about the Azden PCS-300? Of major significance was the poor-quality transmit audio. On-the-air reports confirmed that my transmissions sounded terrible. A few internal audio output adjustments fixed that, and my voice quality (and ego) was back to normal. The schematics included in the manual gave little information. Another annoyance was the low (0.023-µV) squelch sensitivity. Some signals broke squelch, even with the control set at its highest level. After three weeks of use, two loose screws were found rattling around inside. Luckily, any disasters were avoided; replacement of the screws was quick and easy. I have also developed a penny-pinching preference for a rechargeable, individual NiCd battery system instead of the sealed NiCd packs the Azden uses.

Good Overall

What did I like about this radio? — everything else! The Azden PCS-300 shows good adjacent-channel rejection of signals, and the radio is quite stable. The receiver, in general, is as good as or better than other similar radios I have used. Having had some experience with other µP-controlled, hand-held transceivers, I was surprised and pleased that this µP didn't go wild in normal use and even in extremes of temperature. Admittedly, I am far from immune to the flashy features of the rig;

Azden PCS-300, Serial No. 81001

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency Range: 142.000 to 149.995.	As specified.
Mode of operation: Fm.	As specified.
Current drain: 40 mA in receive mode — no input signal; 800 mA in Hi transmit mode; 400 mA in Lo transmit mode; 0.01 mA in memory backup (with power switch off).	Not measured.
Size (HWD): 7.24 × 2.55 × 1.75 in.	As specified.
Weight: 1.4 lb.	As specified.
Transmitter power output: Hi — 3.0 W; Lo — 1.0 W.	Hi — 3.1 W; Lo — 1.0 W.
Spurious radiation: Better than −60 dB.	See Fig. 1.
Receiver 1st i-f: 10.7 MHz; 2nd i-f: 455 kHz.	As specified.
Receiver sensitivity: Better than 0.2 µV for 12 dB SINAD.	0.2 µV (20 dB quieting).
Squelch sensitivity: Less than 0.15 µV.	0.023 µV.
Audio output: More than 200 mW (8-ohm load and 10% distortion).	500 mW.

in fact, using the PCS-300 is almost comparable to a good game of Space Invaders or Pac-Man. These flamboyant features, combined with the solid basics this 2-meter radio has, make the '300 a joy to use. Even better, I don't have the feeling that next year the radio will be passé. The PCS-300 is manufactured by Japan Piezo Co., Ltd., and distributed by Amateur-Wholesale Electronics, Inc., 8817 S.W. 129 Terrace, Miami, FL 33176. Price class: $290. — *Carol L. Colvin, AJ2I*

CUSHCRAFT 617-6B "BOOMER" 6-METER YAGI

☐ Over the past several years, I have seen a revolution in commercially manufactured amateur vhf antennas. The new generation of computer-designed, long-boom Yagis offers forward gain and front-to-back ratios that were unheard of a few years ago. Evidence of this fact is the great number of operators making successful contacts on the more difficult propagation modes (EME, tropo scatter) using small antenna arrays.

On 6 meters, the primary interest of serious operators is the antenna performance over terrestrial paths. The use of ionospheric and/or meteor scatter will increase in the coming years as we head for the bottom of the solar cycle. Antenna gain is an important factor when determining scatter system range.

Cushcraft's latest Yagi for 6 meters is the 617-6B, a six-element, computer-designed, long-boom Yagi that appears to have good forward gain and front-to-back ratio. Called a "Boomer," this Yagi is by no means portable! Its boom is 34 feet long, 2 feet longer than the full-size Cushcraft "Skywalker" 20-M Yagi.

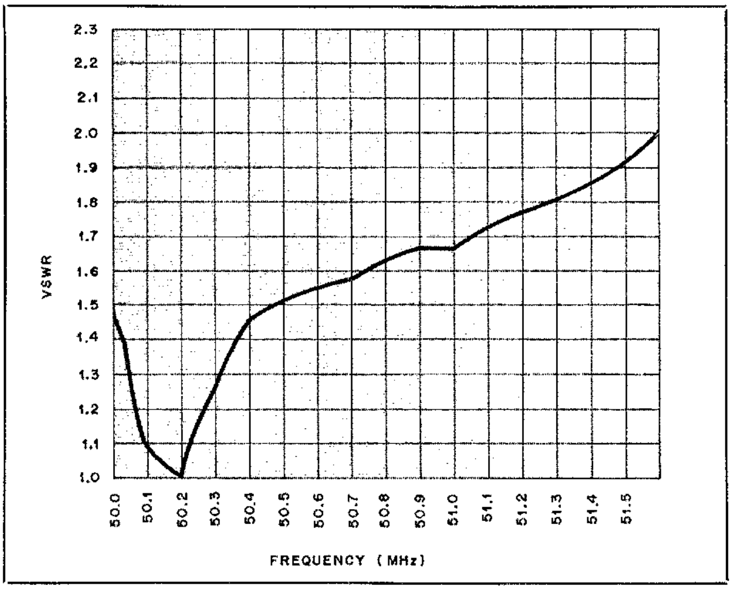


Fig. 2 — VSWR curve of the 617-6B.

Construction

The Boomer arrived in a single shipping box. (Luckily, Murphy did not strike — all the hardware was accounted for!) Construction took approximately 2-1/2 hours. Each boom and element section is premarked at the factory to speed assembly. Hose clamps hold the boom sections together, and U bolts clamp the elements to the boom. Two sections of tubing are used as boom struts to keep the 0.058-inch-wall boom from sagging. A T-match is used to feed the driven element, and a coaxial balun transforms the balanced feed to the unbalanced coaxial line.

The antenna material is 6063-T832 aluminum, and stainless steel clamps are supplied. Plastic end caps are provided for each of the elements and the boom. The SO-239 connectors have protective plastic boots, and a silicone compound used to keep out moisture and prevent corrosion is supplied.

Installation and Operation

After construction, the Yagi was placed on top of a 40-foot tower on the roof of the ARRL Hq. building. The thin-wall boom lowers the weight of the Boomer to just 26 pounds; I brought it up on the tower and clamped it down myself. Only one mechanical weakness was noticed during the installation: Hose clamps are used to secure sections of the boom together; if these hose clamps are not extremely tight, the boom can twist easily, causing the elements to become misaligned.

How does the Boomer perform? To say it in a single word — "fantastic." I was very impressed with the forward-gain and front-to-back ratio characteristics. During the 1982 January ARRL VHF SS, I used the Boomer in conjunction with a 250-watt amplifier and exciter. During the contest I had no trouble working stations in Illinois and Ohio on scatter — not bad for low transmitter power. The antenna has been on the Hq. tower for several winter months, and none of the hardware has corroded. Performance remains the same as it was the day it was put up.

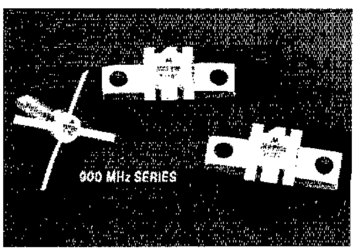
The Boomer is not for everyone. The limited bandwidth would discourage fm operators, and the large size could be prohibitive to hams living on some city lots. But for those wanting a potent signal on 50 MHz, the Boomer certainly justifies the bill. Price class of the 617-6B Boomer is $260. It is manufactured by Cushcraft Corp., P.O. Box 4680, Manchester, NH 03108 — *Gerry Hull, AK4L*

New Products

MOTOROLA HIGH-POWER 900-MHz TRANSISTORS

☐ Motorola has introduced a new 24-V dc, 900-MHz power transistor series. This new line includes the MRF890, a 2-W, 9-dB minimum gain predriver; the MRF892, a 14-W, 8.5-dB driver; and the MRF894, a 30-W, 7-dB final amplifier. These new rf transistors are fully characterized across the 804- to 960-MHz frequency range, and are intended for large-signal, common-base amplifier applications in industrial and commercial cellular fm radiotelephone equipment.

The three devices are designed for ease of interstage matching, and feature all-gold metallization and emitter ballasting for increased reliability and ruggedness. All devices have guaranteed gain performance at 900 MHz and collector efficiencies of 55% minimum, and will withstand 30:1 VSWR load-mismatch conditions at rated output power and supply voltage. For more information, contact Tom Bishop at Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, AZ 85036, tel. 602-244-6394. — *Paul K. Pagel, N1FB*



Hints and Kinks

Conducted By Larry D. Wolfgang,* WA3VIL

DIVERSITY COMBINER FOR RTTY RECEPTION

☐ The circuit of Fig. 1 is useful for combining two (ideally) identical but independently demodulated data streams for display or further processing. Typical data inputs would be from envelope detectors, tone decoders or phase-locked loops, each responding only to one tone (mark or space). The data streams must be in phase. If they aren't, U2D can be used to invert one channel by wiring one input HIGH. As shown, the circuit accepts logic levels of +12 volts and ground. Other levels can be accommodated by scaling the input resistors.

Here's how it works: When both inputs are toggling with full logic swing, the summing amplifier is saturated and the output is a full-swing inverted replica of the input. This signal is then fed to the comparators, U1B and C. Since these comparators have complementary outputs, the output of U2A will be a constant HIGH. Meanwhile, the signal from U1A has been applied to Schmitt trigger U1D and inverter U2C. The signal is finally gated through U2B, which acts as an inverter because one input has been programmed HIGH by the comparators and U2A. Because the signal path has an even number of inverters, the output data is in phase with the input.

Now suppose one of the data channel inputs remains constantly LOW while the other toggles normally. A loss of one tone, either to deep selective fading or transmitter malfunction, could cause this condition. With one channel input held LOW, the summing amplifier toggles not at full logic swing, but from +6 to +12 volts. This swing triggers the noninverting comparator (U1B), but the inverting comparator (U1C) output stays LOW because the summing amplifier output does not cross the +3-volt threshold. Thus one input of U2A is held LOW while the other toggles, making U2A a noninverting buffer. While the summing amplifier toggles only between +6 and +12 volts, the Schmitt trigger output remains LOW. This stage has a 10-percent hysteresis band, preventing unwanted toggling at the +6-volt level. The LOW output of U1D is inverted to a HIGH by U2C, which places U2B in the inverting mode. Two data inversions have taken place, so the output data sense is erect.

The other abnormal condition is a constant HIGH at one input with valid data at the other. This situation could arise when an interfering carrier falls on one of the RTTY tones. A frozen HIGH input biases the summing amplifier output swing to the 0 to +6-volt region, which triggers the inverting comparator (U1C). The noninverting comparator output stays LOW, because no part of the U1A signal crosses the +9-volt threshold. U2A becomes a noninverting buffer by virtue of the comparator outputs. The LOW-region swing of the summing amplifier forces the Schmitt trigger HIGH and U2C LOW, causing U2B to act as a noninverting buffer. Here again, the number of logic inversions is even.

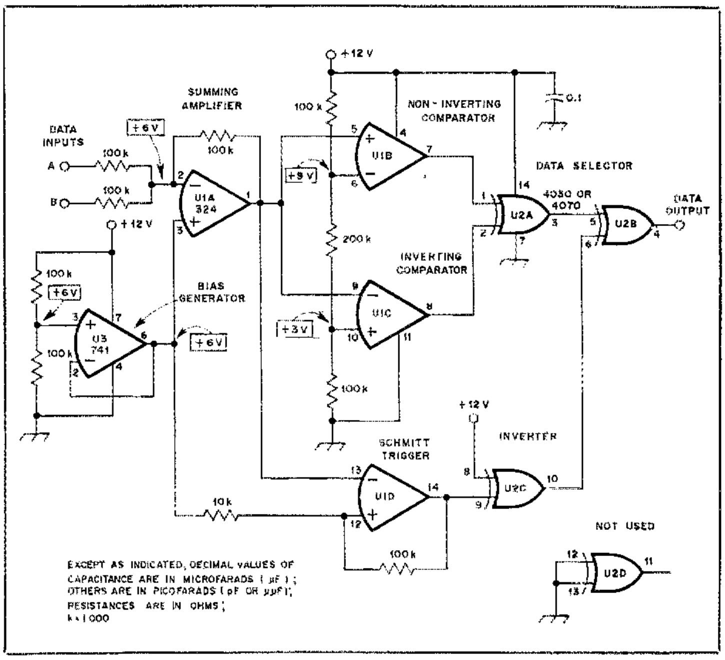


Fig. 1 — Schematic diagram of the diversity combiner for RTTY reception.

This diversity combiner is a worthwhile addition to any RTTY receiving system. Automatic single-tone copy when one tone is lost *or* jammed is a feature not obtainable with combinational logic alone. However, the circuit is not entirely jam-proof. If one tone is lost or interfered with during an RTTY character, that character will be erroneous. Intermittent or pulsed jamming of one tone can be combatted by forcing the affected input HIGH or LOW. —*George Woodward, W1RN, ARRL Hq.*

TVI FROM THE HEATH REMOTE COAXIAL-CABLE SWITCH

☐ I was plagued by an intriguing TVI problem. I tried the normal methods to correct the problem, then traced it to my Heath SA-1480 coaxial-cable switch. The eight-conductor cable that connects the remote switch to the control unit was picking up rf energy. This energy was being fed into the control unit, and the LEDs on the front panel were generating harmonics. The subject of harmonics being generated by diodes that are excited by rf has been covered in many publications, but many people may overlook LEDs as a source of harmonics.

To determine how much harmonic radiation your station is producing, first connect the exciter directly to a shielded dummy load. With the transmitter tuned to full power in the cw mode, you should not see any pattern on a nearby TV receiver tuned to any of the vhf channels. Be especially sure to check unused channels. If there is any signal on the screen, your exciter must be TVI-proofed using the methods described in *The Radio Amateur's Handbook*. After your transmitter passes this test, connect the coaxial-cable switch and the station antenna. Check again for interference on the TV. If your switch is generating harmonics you will see evidence of it on the screen. Now, by disconnecting the eight-conductor cable from the rear of the control unit, you can determine if the harmonic energy is being produced by the LEDs in the control box.

To correct this problem, you must prevent the transmitted signal from getting into the control circuit. This can be accomplished by bypassing each control lead and filtering the ac power lead. The terminal strip on the back of the box is a convenient place to add 0.01-μF bypass capacitors. I ran a ground bus made of no. 14 copper wire between ground lugs under the two no. 6-32 bolts that hold the terminal strip. One end of each capacitor is connected to the inside solder lug of each terminal, and the other end is soldered to this ground bus.

*Assistant Technical Editor

I also added 100-μH rf chokes (Radio Shack 273-102) in series with each ac power lead. Be sure these are insulated to prevent short circuits. These steps completely cured my TVI problems. — *Jim Abercrombie, Jr., N4JA, Augusta, Georgia*

RG-8/U AND THE PL-259

☐ One of the most common feed line/connector combinations in Amateur Radio is the PL-259 connector on RG-8/U coaxial cable. Many amateurs have difficulty installing these fittings properly. A connector that is mechanically or electrically insecure invites trouble. Fig. 2 illustrates a method I have used both at home and on the job without failure.

Prepare the body of the connector by using a small file to roughen the metal around the solder holes. Tin the area around each hole, but do not get solder inside the body or on the threads. Remove 1-1/4 inches of the outer jacket using a sharp knife. Be careful not to nick the braid. Next, lightly tin the exposed braid, but try not to melt the inner dielectric. Cut through the tinned braid, 5/8 inch from the end, with a small tubing cutter. Now cut through the dielectric, 1/16 inch from the edge of the braid. The tubing cutter works fine for this, also. The easiest way I have found to remove this piece of dielectric is to grasp it with a pair of pliers and twist it in one direction while slowly pulling it off. After you tin the center conductor, you are ready to put on the barrel, and then thread the connector all the way onto the cable. Solder the center pin and braid, using only enough heat to achieve good solder flow. Remove any excess flux, and use an ohmmeter to check for continuity and shorts. Weatherproof all outside connections, and you will have a reliable assembly. — *Kirk Carter, VY1CC, Whitehorse, Yukon Territories, Canada*

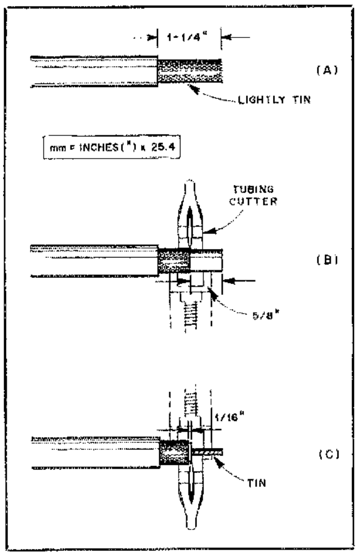


Fig. 2 — The steps used by VY1CC to prepare a piece of RG-8/U coaxial cable for the installation of a PL-259 connector are shown in parts A, B and C.

DRAKE L7 AMPLIFIER FAILURE

☐ The power supply in my Drake L7 amplifier failed after several months of use. This problem is apparently a common one, because my dealer told me that four of the 15 amplifiers he sold recently have had the same problem. Apparently, arcs occur from the 50-kΩ, 50-W bleeder resistors to the mounting screws that hold them in place. I found one of these screws blackened and with two rows of threads missing apparently because of this arcing. Of all the failures reported to my dealer, each occurred when the amplifier was in the ssb mode, and was not keyed. This places a maximum voltage on the bleeder resistors, up to 2.8 kV.

Each resistor is mounted between two metal tabs that are grounded through the mounting screws, which tighten the tab against mica insulators at each end of the resistors. If the resistor is not aligned properly, the insulators do not separate the resistors and screws sufficiently to prevent arcing.

I bought some nylon bolts, nuts and spacers to lift the tabs above ground. I also bought some protective acrylic spray (Radio Shack no. 64-2317) and applied it liberally to the tabs, mounting screws and power-supply frame. An engineer for the resistor manufacturer told me that the specifications call for the use of a centering washer to ensure that the mounting screws are centered if the resistor is more than 500 V above ground potential. — *Denny Warrick, WB0MWJ, Watertown, South Dakota*

RELAY DRIVER FOR THE IC-551 AND IC-251A TRANSCEIVERS

☐ No provision is provided on the IC-551 or IC-251A vhf transceivers for switching an external linear amplifier. However, 9-V dc is present at pin 6 of the accessory socket during transmit. This supply can not drive a relay directly because it can only provide up to 5 mA.

Fig. 3 shows how this 9-V supply can be used to switch Q1 into conduction and to activate K1 during transmit. Pin 2 on the accessory socket provides 13-V dc at 300 mA, and pin 8 is ground. The current-limiting resistor, R1, provides the proper base current to turn on Q1. — *Hamp Richardson, K5EFW, Albuquerque, New Mexico*

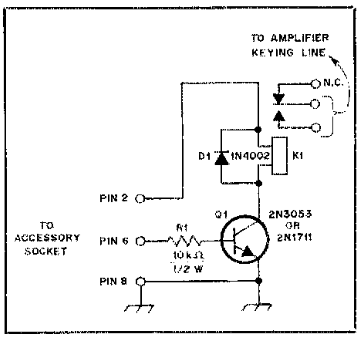


Fig. 3 — Schematic diagram of a relay driver that can be used with an IC-551 or an IC-251A to key a linear amplifier. K1 is any 12-V relay with a coil resistance of approximately 185 ohms.

WORN MARKINGS ON INDICATOR KNOBS

☐ Pointer lines and numbers on dial knobs can become worn off after hard use. In most cases, the markings are etched into the plastic, and then filled with paint. Here is an easy way to renew these marks. Liquid Paper® or Wite-Out® is perfect for the job. Simply fill the number or pointer groove with the paint. The small brush-applicator cap is just right. Scrape off the excess with a fingernail once the paint is dry; the markings will look as good as new. — *Sandy Gerli, AC1Y, ARRL Hq.*

TTL LEVELS FROM THE RADIO SHACK TRS-80® MICROCOMPUTER CASSETTE-OUTPUT PORT

☐ Software for Morse code generation with the Radio Shack TRS-80® microcomputer typically uses the cassette-output port to develop the keying signal. The keyed output is achieved by opening and closing the motor-control relay contacts. This relay was not designed for keying service, and it is simply not fast enough to respond properly at high keying speeds.

Fig. 4 shows how standard TTL output-level changes can be obtained for a keying circuit. A transistor switch capable of handling the current and voltage requirements of your transmitter is the only additional requirement.

The larger of the two gray plugs is removed from the AUX jack on the cassette player and inserted into J1. Before keying can start, the motor-control relay must be on, so your program must initially include a statement line with the command "OUT 255, 4." Thereafter, if the program executes "OUT 255, 5," a TTL high will be developed at the comparator output. If the program executes "OUT 255, 6," the comparator will develop a TTL low at the output. — *C. T. Isley, W7KIM, Greenville, Texas*

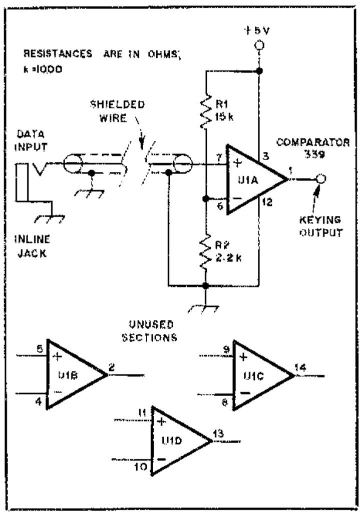
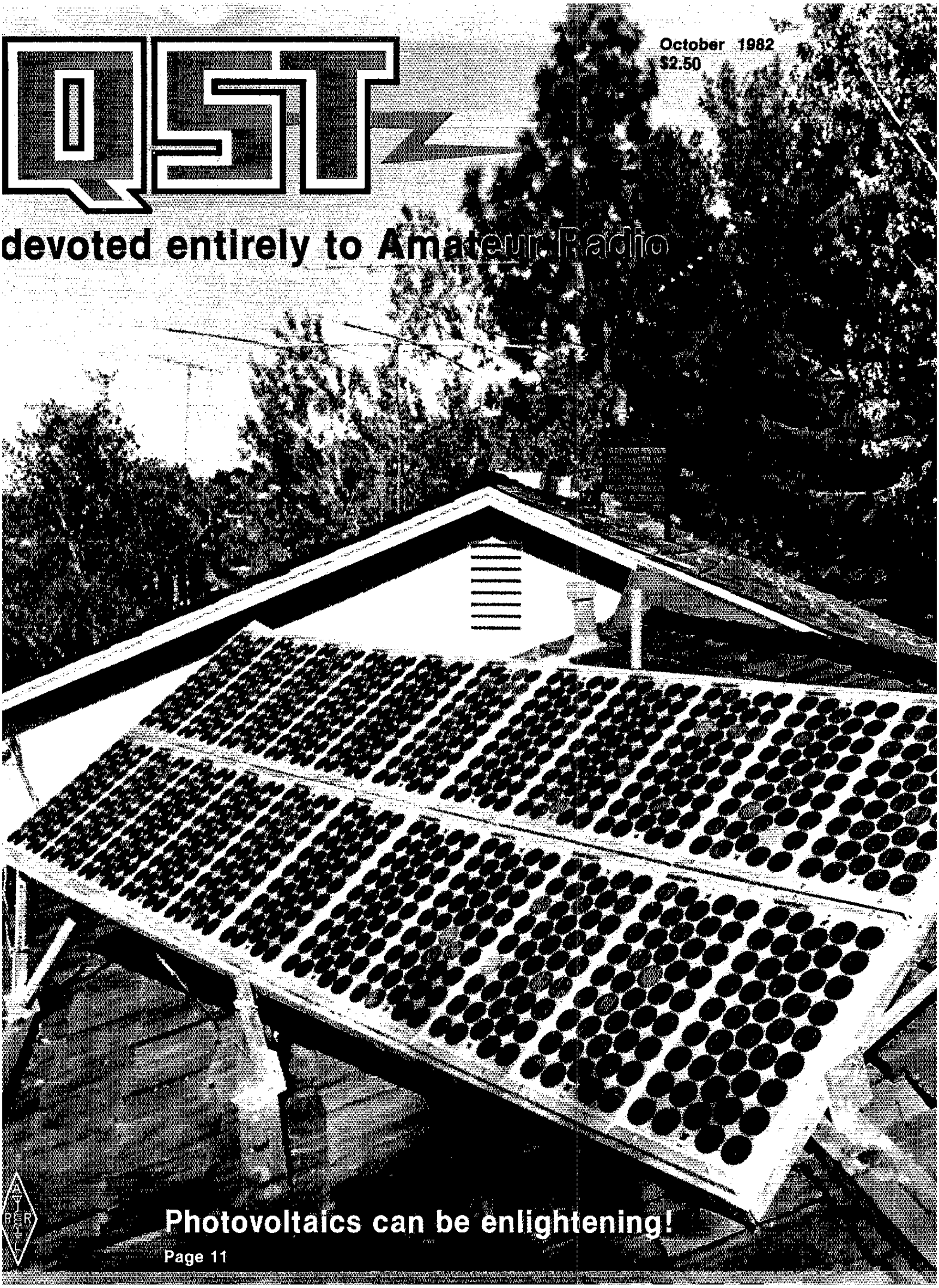


Fig. 4 — Schematic diagram of a circuit to develop TTL output levels from a microcomputer cassette-output port. U1 is a 339 quad comparator. Any one of the four sections may be used.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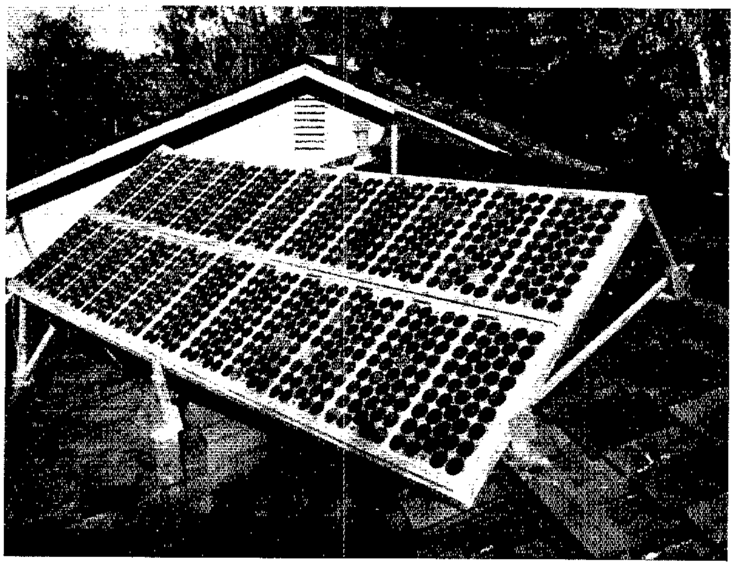


Part 1: Powering radio equipment using sun energy is attracting increasing attention. This might just whet your appetite to try a similar scheme.

By C. Philip Chapman,* W6HCS, Paul D. Chapman and Alvin H. Lewison

This is a description of the design and construction of a solar-powered Amateur Radio emergency-communications center. While the requirements placed on such a system are more stringent than those of the average Amateur Radio station, the approach is one that should provide a sound foundation for the design of smaller or larger systems. Such systems should appear in ever-increasing numbers as the cost of photovoltaic (PV) cells becomes more attractive.

There are no moving mechanical parts, except for a single relay and some analog meters, in this system. It can power the associated emergency Amateur Radio communications equipment for about 72 hours of continuous operation without sunlight. The radio equipment operates from storage batteries having approximately 500 ampere-hours (Ah) of energy storage. The batteries are charged by means of sunlight converted to electrical energy through the action of PV modules composed of a number of silicon solar cells. This system is entirely independent of utility-delivered electrical energy, and is noiseless and nonpolluting.

Design Approach

When sizing a PV array and energy-storage system for emergency-communications equipment, answers must be found to such questions as: How long do emergencies last? What is the expected duty cycle (ratio of transmit to receive time)? How long should it take to recharge the battery pack after a practice drill or emergency? How much storage capacity is required? Except for the last question, the others normally are not encountered in most PV-systems applications. System lifetime must be considered, and provisions included, for component and equipment expansion over that period.

In general, PV modules for any application have to be connected in parallel and, perhaps, in series-parallel to meet the equipment voltage and current requirements. Table 1 lists the current and power requirements for this system. Worst-case conditions occur when both the hf and vhf radios are in the transmit mode at the same time, drawing 24 A (at 13.6 V) from the battery pack. There could be additional battery drain from the dc-to-ac inverter (used for antenna-rotator-motor power) and emergency lighting in the radio room.

Duty cycles defined the size of the battery-pack, which consists of a number of improved electric-car, deep-discharge, 6-V lead-acid modules. A worst-case condition assumes no output from the PV array, but with the batteries fully charged. The final design provides for 72 hours of continuous operation in total darkness, using the critical emergency-traffic duty cycle (10% transmit, 90% receive time)

†Adapted from Jet Propulsion Laboratory publication 82-2, "A Low-Power Photovoltaic System With Energy Storage for Radio Communications," Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91103.

*2922 Alta Terr., La Crescenta, CA 91214

Table 1

Communications Equipment Current and Power Requirements

Frequency Band	*Receive Mode Amps (A)*	*Power (W)*	*Transmit Mode Amps (A)*	*Power (W)*
High	0.20	2.72	9.10	124
Low	6.00	81.6	15.0	204
Both	6.20	84.3	24.1	328

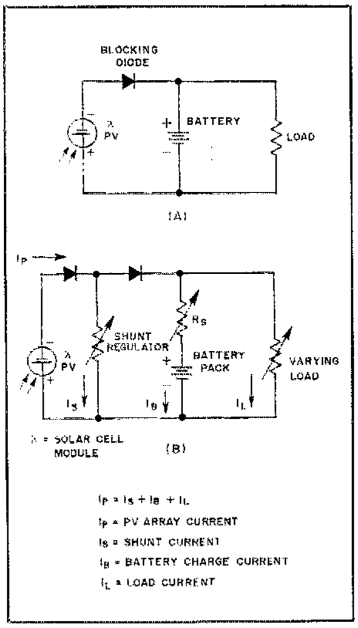


Fig. 1 — Representations of a simple (A) and advanced (B) PV system.

Table 2

Standard Operating Characteristics, PV System Module

Power, maximum	10.1 W
Voltage at maximum power	18.3 V
Current at maximum power	550 mA
Voltage, open circuit	22.5
Current, short circuit	620 mA
Module efficiency	6.1%

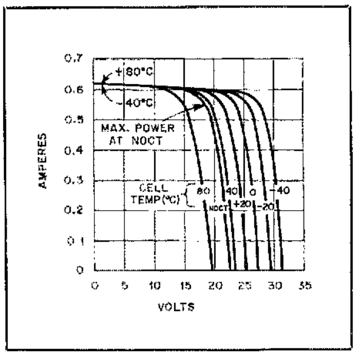


Fig. 2 — PV module I-V characteristics.

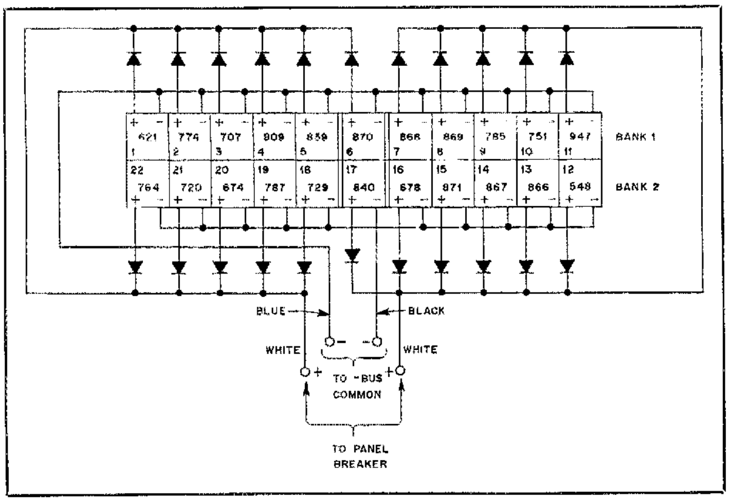


Fig. 3 — Schematic diagram of a PV array.

determined from information applied by manufacturers of emergency service equipment.

System Concept

Fig. 1A illustrates the simplest system concept. A blocking diode prevents the battery pack from discharging through the PV array during no-sun periods. The problem with this setup is that all the battery electrolyte would boil away when the batteries became fully charged and the equipment was not in use. A more advanced concept is shown in Fig. 1B. Here a shunt regulator is used to maintain the battery-pack voltage, independent of the battery-pack state of charge (R_S) or the load. When the battery pack is fully charged and the equipment is not operating, the PV array energy is dissipated as heat in the shunt regulator, and the system efficiency is at its worst. If the battery pack is partially discharged, or if the equipment is operating, or if both of these conditions exist, the PV-array current will be allocated to meeting the load requirements, and any surplus current will be used to recharge the battery pack with no heat being dissipated in the shunt regulator. During this time, the system efficiency is highest. The dynamic resistance of the array, regulator, battery and the load, and the associated time constants of the system, are important parameters that will affect the system stability.

Photovoltaics

Typically, PV modules are rated under standard operating conditions (SOC). The following SOC are defined for the modules used:

1) Performance is evaluated when the module is irradiated (illuminated) with 100 mW/cm^2 of an air mass 1.5 spectrum.[1,2]

2) Nominal operating cell temperature (NOCT) is defined to be 146° F under no-load conditions when the air temperature is maintained at 68° F with air motion of 2.2 mi/h.

Table 2 lists the performance of a sample module based on the foregoing conditions. Fig. 2 shows the I-V characteristics.

Twenty-four Sensor Technology (Photowatt) model 20-10-1674 (block III) PV modules are used. Of this number, 22 are used for the array and two are kept as spares. Within the 39.5 ft^2 module area, there are 25.6 ft^2 of active cell area.

Fig. 3 is a PV-array schematic diagram. The last three serial number digits of each module are indicated, and each module is numbered 1 through 22 in order to indentify each protective diode in the diode box. Code tags are wrapped around each cable within the protective diode box. This will allow quick indentification of each module in the event of failure.

[1]Notes appear on page 14.

The protective diodes are 1N4004s; their purpose is twofold. As shown in Fig. 4A and B, the diodes prevent good modules from being short-circuited by a defective module. If resistance R2 is much less than the load resistance, R1, current from modules 1 through 3 will flow into shorted module 4. Protective diodes will prevent this from happening. Fig. 4C and D illustrate the same diodes being used to prevent potential problems from shadowing. Overheating can destroy cells or modules being shadowed partially or totally. The unshadowed modules will effectively back bias shadowed-module diodes, preventing current flow and heat generation. As an alternative, Schottky diodes, which have a forward bias voltage drop less than that of a normal PN junction diode, may be used.

The diodes are mounted between solder terminals in a black metal box secured beneath, and always in the shadow of, the array. To ensure that the diode matrix could dissipate about 8 W at high sun, holes were drilled in the box top and bottom to allow convection cooling.

All the module positive leads are connected to the diode anodes within the diode box. The diode cathodes are terminated in a bus bar, effectively paralleling the module positive terminals. The negative leads of the modules are "daisy chained" underneath the array, completing the parallel configuration. No. 14 Teflon-insulated wire is used for the interconnections.

As shown in Fig. 3, the array is divided physically into two banks. There are two reasons for this. First, the current path to and from the battery box can be divided into two loops, reducing the cable voltage drop and associated energy loss. Second, comparisons of voltage and current can be made at the battery box to determine array performance. Any difference will indicate a module performance problem.

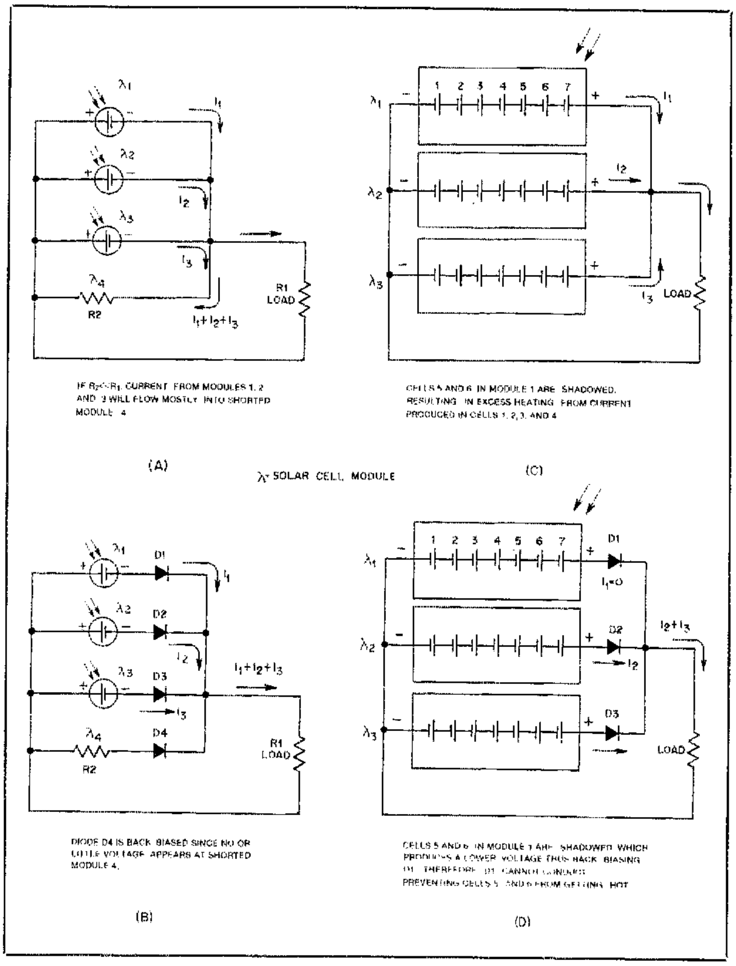


Fig. 4 — Schematic diagrams of solar-cell modules and the ways in which protective diodes may be used. Shown at A, shorted cells, no protective diodes; B, shorted cells with protective diodes; C, shadowed cells without diodes; D, shadowed cells with protective diodes.

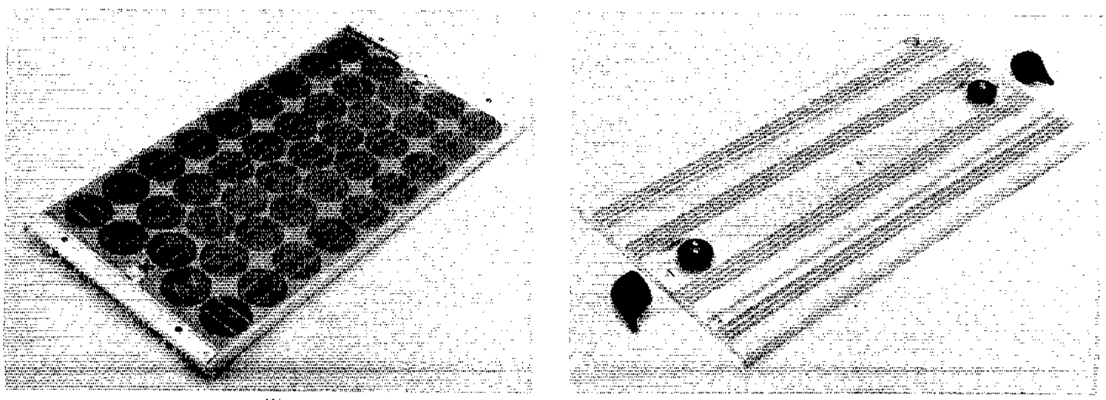


Fig. 5 — Front (A) and rear (B) views of the Sensor Technology PV modules showing the heat sink.

The two positive leads are tied together at a panel circuit breaker in the breaker box, and the two negative leads are connected at an ammeter current shunt where current comparisons can be made.

PV Module Mechanical Aspects

Each of the 22 modules measures approximately 28 × 11 inches, is 1.8 inches in depth, weighs 8.2 lb, and is constructed within an aluminum heat sink. The silicon cells (44 per module) absorb heat from the sun; this derates their performance. Therefore, the modules are mounted in an aluminum framework that allows heat to be transferred from the heat sink by convection and radiation (see Fig. 5). Care is taken not to mount the array too close to the roof surface, which itself transfers heat by convection and radiation.

Strength, rigidity, weight and absence of maintenance are important module-structure considerations. Based on cost, weight and availability, 6061 aluminum (6063 for extruded shapes) was selected for the structure. The array rests on six legs made of extruded rectangular aluminum tubing. These legs are set inside aluminum channel sections. The entire assembly is butted to 90° angle brackets. Lag bolts fasten the angle brackets to studs, which are secured by means of 12-inch bolts through the roof to the ceiling rafters below. This type of design provides the greatest degree of flexibility when positioning the platform at the desired tilt and wall angles.[3]

After the array is positioned, the legs are braced diagonally to ensure strength and rigidity. Wind gusts of 50 mi/h are not uncommon at the site during the windy season, so guy cables are used to anchor the structure to the studs. Clearance is provided to prevent air compression under the structure and to allow the prevailing breezes to cool the PV module heat sinks convectively.

Part 2, the conclusion of this article, will cover the method of storing the energy collected by the PV modules. Part 2 will appear in a subsequent issue of *QST*.

Notes

[1]in.^{2} = cm^2 × 0.155; m^2 = ft^2 × 0.0929; mm = in. × 25.4; °C = (5/9 °F) − 32; km = mi × 1.609.

[2]The sun spectrum at the top of the atmosphere is defined as AMØ. AM1 is the air mass penetrated by sun rays in the most direct optical path. Other air-mass values indicate the ratio of the optical path length through the atmosphere to the path length through AM1. Different air-mass ratios imply differently shaped light spectra and, therefore, different module performance. The standard air mass 1.5 spectra is an analytically derived spectra, and represents the mean spectra of sunlight. For detailed information on the subject of performance reference conditions for PV-array measurements, see R. G. Ross and C. C. Gonzales, "Reference Conditions for Reporting Terrestrial Photovoltaic Performance," *Proceedings of the AS/ISES 1980 Annual Meeting*, Phoenix, Arizona, June 1980.

[3]Array azimuth angle terminology used in PV engineering is also known as the *wall angle* in solar heating and cooling engineering. The angle will be referred to as the wall angle in this report, and is simply the projection of the array normal to the horizonal plane. Angles east of south are positive; angles west of south are negative.

Tune in the World — It's Really Quite Elementary

□ Many of us talk about educating the public about Amateur Radio, but few do anything about it. As science coordinator of an elementary school in Brooklyn, New York, I've had many opportunities to describe to my students and colleagues the wonderful experiences and the fascinating people I've met through Amateur Radio. Recently, however, I decided to turn theory and secondhand stories into a series of hands-on real-time lessons.

I brought to school a converted 11-meter rig, a 12-V power suppy and a mobile antenna. Setting up took about five minutes.

On the first start-up, I was pleasantly surprised to hear how crowded the band was. It takes a strong signal to move the "conservative" S meter on the rig, but stations from the 4, 5, 7 and Ø call areas were really booming in. Tuning closer to 28.5 MHz brought in fairly strong G, D, I and U stations. Additional careful tuning brought out at least six more European countries.

Since I come in contact with most of the classes in the school, students from 6 to 12 years of age got their first exposure to ham radio. With each class, the sound of the radio alone was sufficient motivation for the lesson ahead. Most, of course, thought it was CB, but as I tuned around, their casual air, laced with adolescent sophistication, dissolved into wide-eyed amazement and a flood of questions. The lesson that was planned as an introduction to ham radio turned out to be the beginning of a multi-lesson unit.

Day two with radio in school was even better than the first. Several classes were thrilled to learn of the wonderful long-distance capabilities of the radio, but more than that they met Ken Dahlmeier, WØMFR, from Sturgeon Lake, Minnesota. When I explained to him on the air that my classes were interested in learning about different areas of the country firsthand, he volunteered to field any questions the kids could throw at him. I was as thrilled as the kids were, listening to his answers regarding such things as the weather in his area, the nature of the land around his home, local wildlife and more.

At the end of the period, the students didn't want to leave. What great motivation! At the request of a 6th-grade teacher who also was excited by the idea of using a ham radio transceiver in school, Ken agreed to run a sked for the following Wednesday at 1500 UTC.

On the following Wednesday, Larry's students came to my room early; they didn't want to miss anything. At precisely the designated time, the kids heard Ken calling me. Smiles broke out all over when they recognized my call now coming through the speaker. With Ken's help, we ran a *great* 60-minute lesson.

What can ham radio contribute to a classroom, even in the primary grades? Briefly, it can be used as a self-motivating addition to a host of subjects, and also can be taught as a unit in itself. Follow-up lessons can be planned, along with developing letters of thanks to hams contacted. This aids grammar, spelling and writing. I hope this school will be able to initiate a trial program using Amateur Radio as described above, and that interest in such a program can be developed by the school district and by the Board of Education.

Perhaps a net can be formed to meet between the hours of 1400 and 2300 UTC, enabling schools, as well as individual stations throughout the country, to contact one another to conduct such lessons. The wealth of knowledge to be gained is incomparable, the possibilities are endless, and the potential for good education is infinite. Anyone interested in forming such a net should contact this writer.

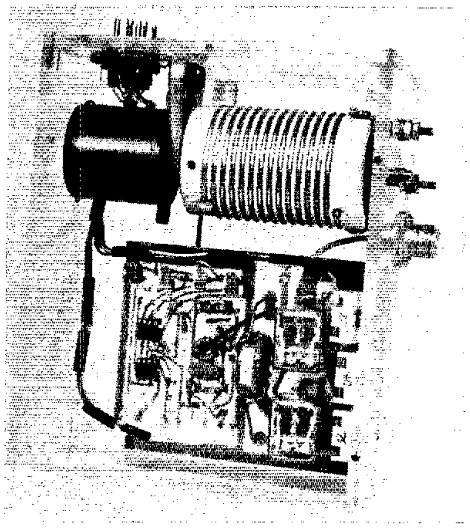
Epilogue

In the weeks since this project was initiated, there have been several important developments. Ken, WØMFR, was so gracious to one of my 6th-grade classes that each student with whom he spoke drafted and sent to him a letter of thanks. Ken, in turn, used these letters, and the wonderfully candid enthusiasm contained in each, to convince his local Board of Education in Minnesota to allow him to begin an Adult Education ham radio course. Additionally, Ken and I are attempting to set up an on-the-air "radio pals" club for students in my school and students (on the same grade level) in a school near Ken's home in Sturgeon Lake.
— *Richard Wolfert, WB2EYI, P.S. 309K, 794 Monroe St., Brooklyn, NY 11221*

Next Month in QST

- It could be the most significant law affecting Amateur Radio during the 1980s. Thanks to hard work by many, S.929/H.R. 5008, sometimes known as the "Goldwater Bill," is now law. A recap will appear in November *QST*.
- Beginner's Bench covers the use of station accessories — those you can't live without, and those that make operating more enjoyable.
- Ready for the new 900-MHz band? Construction details for a high-power cavity amplifier are provided in a November article.

Mobile Antenna Matching — Automatically!



The ultimate in hf mobile operation is here! Band hop or operate band edge to band edge with ease. Before you can transmit your call sign, antenna matching is completed!

By Don Johnson,* W6AAQ

An automatic antenna-matching network opens up a new world of hf mobiling. By using one of the multiband mobile antennas available today,[1] it is possible to switch from band to band and operate anywhere in that band without stopping the vehicle to make adjustments. There's no need to be concerned about antenna matching — it's automatic! And, it is done so rapidly that you can beat most fixed-station operators to the new band or frequency. Numerous "mobileers" have built and enjoyed this low-cost, one-weekend construction project. The design was originated by Bruce Brown, W6TWW,[2] and a number of units were constructed by West Coast hams with his help, starting in 1976.

A glance at the bibliography will show that automatic antenna-matching networks have been on the mobileer's mind for a number of years. I remember a trunk full of dual triodes being used in the first attempt at employing an automatic antenna-matching network for 75 meters in the early '50s.

During the last couple of years I have helped a number of mobileers get their matching networks operational. With all this activity, my place became the clearing house for a few who had construction problems or suggestions. It's time this helpful information is passed to others.

[1]Notes appear on page 20.

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To ease construction and installation for the newcomer, this article provides a complete checkout procedure, from workbench to final on-the-air checks.

Twenty-meter capability has been added to the original circuit, and an improved matching section is included. The main pc board is smaller and has been rearranged. A pc board is added to accommodate the modified input circuit, and another is included for the redesigned control head. The parts used are few in number and aren't exotic. Schematic diagrams for the input, main boards and control head are shown in Figs. 1 and 2, respectively.

Packaging and Parts

Before starting a construction project, the builder usually decides on the shape and size of the final assembly. In view of the variety of variable inductors and gear-head drive motors that may be used, no firm packaging suggestions are presented.

Parts layout is not critical. The only requirement is that the roller inductor be as close as possible to the antenna base, and connected to it with a short length of *unshielded* wire.

Rotary Inductor: A minimum inductance of 10 μH is needed to cover the 75-m band. Some old a-m transmitters with rotary inductors are still around, and in many cases the price of the whole transmitter is less than the cost of a new rotary inductor! One available unit is the ARC-5 "Command Set" transmitter.[3] The rotary inductor from a 4- to 5.3-MHz transmitter is ideal.

Mounting and connecting the ARC-5 inductor to the gear-head motor may take a little work and ingenuity (see Fig. 3 and the title photo for some ideas). Over the years, good use has been made of small-diameter gas-line hose for couplings. It is an insulator, it's flexible, and, if the piece is long enough, you can even make it go around corners.

A word of caution: The ARC-5 inductor trolley wheel has a wedge shape and a nonconducting material on one side. With this configuration, an extremely small area of the wheel makes contact with the inductor wire. These 40-year-old coils may have small pits on the wire surface, which can cause an intermittent contact. Before installing the coil, move the wheel the entire length of the inductor while checking the resistance between the input and output terminals. If the resistance deviates from zero, do some investigating, because later on (during testing or after installation) you can have some very frustrating experiences caused by intermittent wheel/wire contact. To remove the oxidation and grime from the coil and mating parts, disassemble it and use household silverware tarnish remover.

Clutch: Using a rotary inductor that has a stop at each end of travel presents a problem when it is to be motor-driven. Limit and automatic-reversing switches are not practical with this circuit. A slipping clutch that goes into action when the

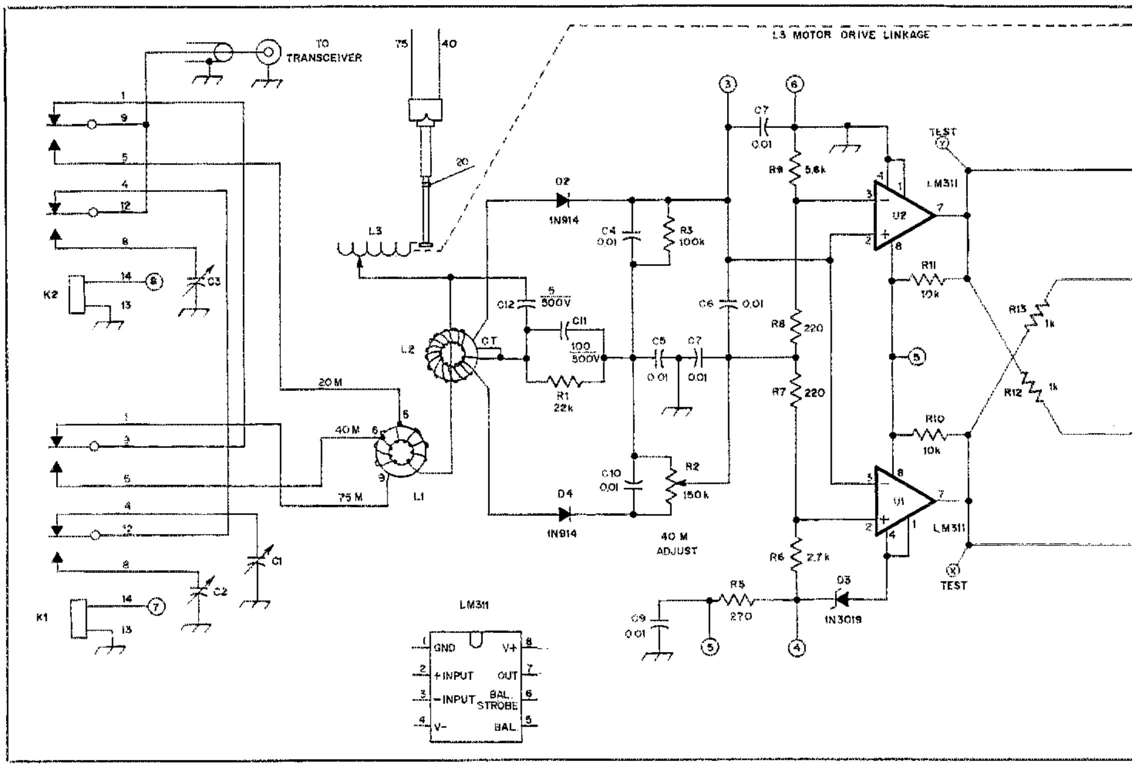


Fig. 1 — Schematic diagram of the antenna-matching unit. Fixed-value resistors are 1/4-W, 5%-tolerance, carbon-composition types.

C1 — 1000-pF, 500-V dc mica compression trimmer (Arco 310 or equiv.). See text.
C2 — 750-pF, 500-V dc mica compression trimmer (Arco 307 or equiv.)
C3 — 180-pF, 500-V dc mica compression trimmer (Arco 304 or equiv).
C4-C10, incl. — 0.01-µF, 50-V dc disc ceramic.
C11 — 100-pF, 500-V disc ceramic or silver mica.
C12 — 5-pF, 500-V disc ceramic or silver mica.
D1, D2 — Switching diode, 1N914 or equiv.
D3 — 9.1-V, 1-W Zener diode, 1N3019 or equiv. (any Zener-diode voltage from 7.5 to 11 will suffice).
K1, K2 — Dpdt, 12-V dc relay (Radio Shack 275-206B or equiv.).
L1 — 9 turns no. 18 enameled wire on Amidon T-106-2 core; tap at fifth and sixth turn (Amidon Associates, 12033 Otsego St., North Hollywood, CA 91607).
L2 — 15 turns no. 26 enameled wire, bifilar

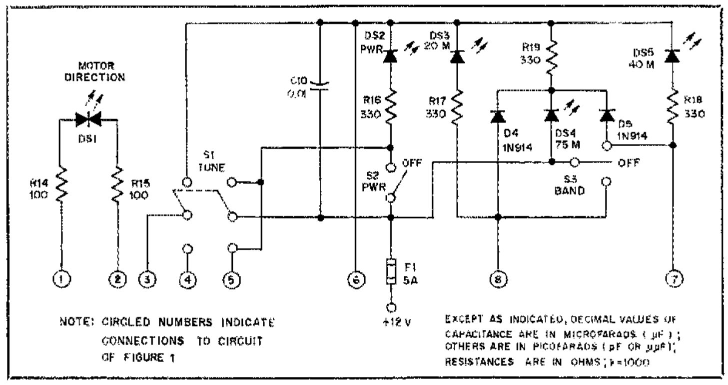


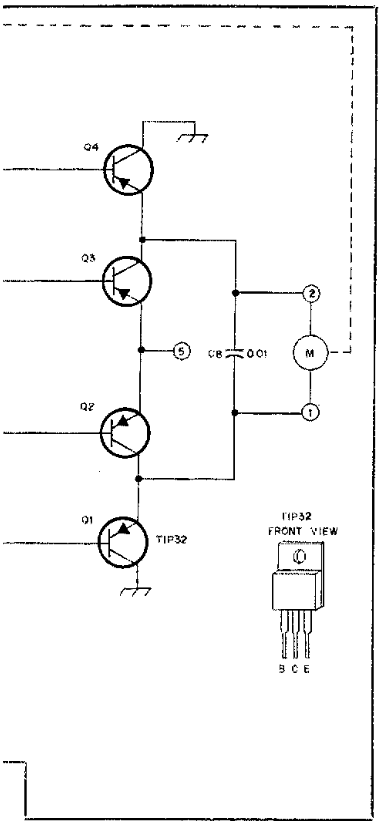
Fig. 2 — Schematic diagram of the control head. Resistors are carbon composition, 1/4-W, 5% types. [Note: Part numbers in parentheses are Radio Shack items. Equivalent units may be substituted.]

DS1 — Bipolar LED (276-035).
DS2, DS5 — Green LED (276-022).
DS3 — Red LED (276-041).
DS4 — Amber LED (276-021).
S1 — Dpdt, momentary contact, center-off toggle (275-637).
S2 — Spst toggle (275-612).
S3 — Spdt center-off toggle (275-325).
The control-head pc board may be cut to fit in a Radio Shack project case (275-220).

inductor hits the stop solves the problem and prevents motor damage.

A National Radio Velvet Vernier[4] drive works perfectly. Install the vernier between the motor drive shaft and the coil drive shaft, but *do not* secure the large outer flange that is normally bolted to the panel. There is enough drag in the vernier to rotate the inductor. When the inductor strikes the stop, the motor continues to run and the panel flange starts rotating while the coil remains stationary. In the event the vernier does not have enough drag, disassemble it, remove the grease, and bend the friction fingers to produce more friction.

Drive Motor and Gear Head: For the average constructor, a 12-V, gear-head drive motor has been the most difficult item to procure. Initially, some military surplus 1-rpm, 35-V gear-head motors were used, but that speed is much too slow; 60 rpm would be ideal. The gear-head had six planetary gears in series, but it wasn't much of a task to remove three



wound on Amidon T-44-2 core.
L3 — Variable inductor, see text.
M1 — See text.
Q1 - Q4, incl. — 1-A, 40-V power transistor, TIP-32 (Radio Shack 276-2025) or equiv.
R2 — 150-kΩ, 1/4-W (minimum) potentiometer (see text).

gears and get about 40 rpm with a 12-V supply.

A telephone rotary dial mechanism can provide the gear reduction. It may be driven with an automobile windshield-washer pump motor. Couple the rotary inductor shaft to the shaft that ordinarily connects to the dial.

The 12-V reversible motors used for raising and lowering automobile door windows are another source of gear-head motors. They rotate at the proper speed, and are easy to couple to. However, they demand heavy current, and an auxiliary relay circuit must be used. A suitable circuit is shown in Fig. 4.

Other parts: L2 is usually mounted on the pc board.[5] An insulated, unshielded lead from one of the two output terminal pads on the input pc board is passed through the center of L2 and on to the input end of the rotary inductor. Use as short a lead length as possible.

Type 30 mica compression padder capacitors are used for C1, C2 and C3. These units measure 7/8 × 15/16 inch (22.23 × 23.8 mm), and are rated for 500 dc working volts. While these capacitors are found frequently in junk boxes and at flea markets, they are often difficult to locate as new items. Even when a source is located, the particular unit desired may not be stocked.[6] The only difference between units in the type-30 series is the number of plates in each padder. If a quantity of *any* value can be obtained, they may be modified so that C1 has a total of 10 plates; C2, 7 plates and C3, 4 plates. Before installation, each capacitor should be adjusted to the value shown in the parts list. If this is not done, the tune-up will be complicated.

Almost any pnp power transistor with ratings equivalent to or greater than those

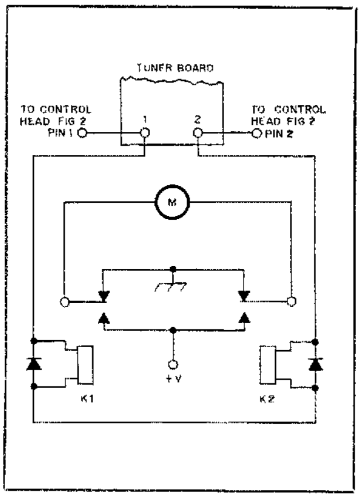
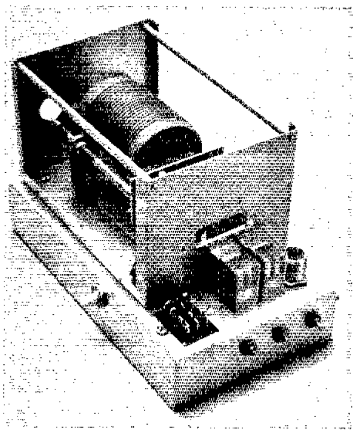


Fig. 4 — An alternative circuit using relays to control a heavy current motor.



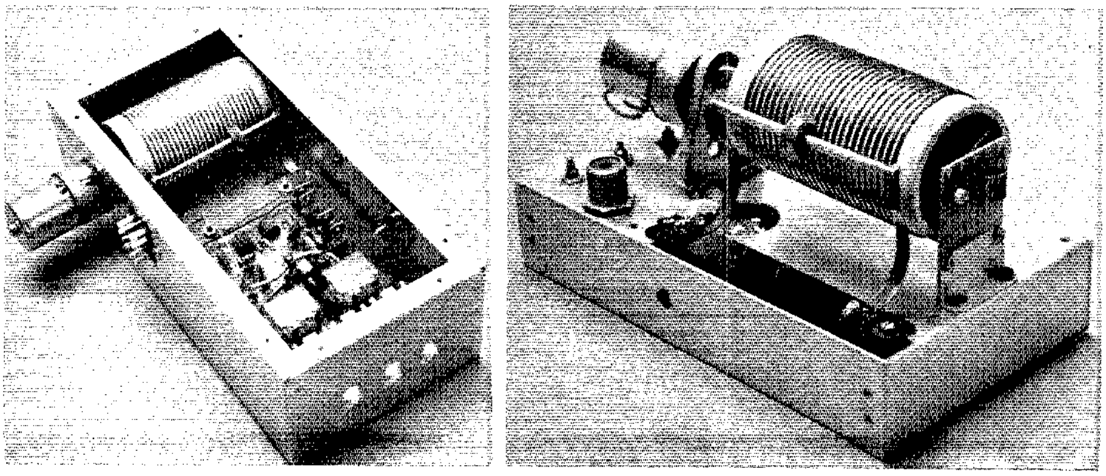


Fig. 3 — Some of many ways in which the automatic antenna-matching network may be constructed. The unit shown in the title-page photograph is used for demonstration purposes only.

of the TIP-32 can be used for Q1 through Q4. These transistors are normally in an off state, and are fully on only when the motor is running. No heat sinking is required.

If surplus LM311s are purchased, they should be checked before use (testing is covered later). R2 may be mounted on or off the pc board. Once it is adjusted, R2 need not be touched again, so it is okay to "bury" it. When R2 is installed on the pc board, set the wiper arm so a resistance reading of 1 kΩ is obtained between the potentiometer arm and the cathode of D1. Final adjustment (if required) will be made later.

Fixed-resistor values are not critical. However, the resistances of resistor pairs R7/R8, R10/R11 and R12/R13 should be kept within 5% of one another.

An eight-conductor rotator cable (such as Belden 8448) may be used to connect the control head to the matching-network chassis. Note that no ground connection is made directly to the vehicle at the control-head end of the cable. A ground strap is connected to the vehicle frame at the network chassis location. That is the *only* ground connection in the system.

Control Head

The operator's position control panel is the only part of the system that is continually on display. You can customize it to fit the dashboard or just twist a couple of wires together and let them hang around your knees. One flashy Mercedes has a control head built into an unused ashtray. When the ashtray is opened the control head is turned on automatically and is indirectly illuminated! Others have been incorporated into the face of an analog clock and an on-board computer.

S1 permits operator control of the rotary inductor. It is a spring-return, center-off dpdt switch. While the transceiver accessory socket usually supplies the 12 volts required for the control head, it may be desirable at times to turn the unit off independently of the transceiver on/off switch. S2 performs this function. Note that S2 does not have to be activated for S1 or S3 to function. S3, an spdt center-off switch, selects the proper input matching network for the band in use.

You may want to control the network band switching from the transceiver band switch (see Fig. 5). If control voltages from the band switch are not brought out to an auxiliary socket, you might be able to make connections without even putting a soldering iron to your cherished rig; diodes can be used to achieve this. Locate a connector in the rig with pins that have the band-change voltages on them. This should be a positive 8- to 12-V potential. Push the anode lead of a diode (one for each band desired) in alongside the proper pin, and bring out an insulated lead from the diode cathode. This lead should not be connected directly to the relay coil.

Indicators: A bipolar LED (DS1) is in parallel with the motor winding. It indicates the direction of motor travel and extinguishes when tuning is completed. DS2 shows when power is applied and the system is ready to function automatically. DS3 through DS5 are band indicators. Color coding is used, so the selected band can be determined by noting the LED color: red, 20 meters; yellow 40 meters; green, 75 meters.

DS4 can be turned off only when power is removed from the control-head supply lead. If the supply voltage is derived from the transceiver accessory socket, DS4 should extinguish when the transceiver is turned off.

Workbench Checkout

Before heading out to the car with the finished unit, make the following checks (it is a lot easier to do this on the workbench than standing on your head in the trunk!):

1) Locate pads X, Y, C and B on the main pc board. Solder short pieces of bus wire to these pads and let the wires protrude through the board about 1/4 inch (6 mm) on the component side. Do *not* install U1 and U2. (The control head is not needed for the following steps.)

2) Apply 12-volts dc to the main board (positive to terminal 5, ground at terminal 6).

3) Connect a jumper wire between test point X and ground. The drive motor should run. Note the direction of travel. Remove the jumper.

4) Connect a jumper wire between test point Y and ground. The drive motor should run in the opposite direction. Remove the jumper. (So far, the motor circuit and four power transistors have been checked.)

5) Remove the power connection to the board and insert U1 and U2 into their sockets. Note that the ICs face in opposite directions.

6) Reconnect the supply voltage. The motor may start to turn, but *should not* continue to run. If the motor stops turning, proceed to step 9.

7) If, in step 6, the motor continues to run, swap the ICs in the sockets. If the motor now runs continuously in the other direction, you probably have a bad IC.

8) In the event the motor continued to run in the *same* direction as it did in step 6 after swapping the ICs, remove the ICs. With power applied to the main board, measure the voltage distribution across voltage divider (R5, R6, R7, R8 and R9). The voltage at the junction of D3, R5 and R6 should be equal to the Zener-diode voltage of D3. If a 9-V Zener diode is used, the voltage at pin 2 of U1 should be about 6.5 and about 6 at pin 3; the voltage at pin 3 of U2 will be slightly less.

9) With the ICs installed and power applied, connect 1.5 V across test points B and C (a battery will do). The motor should run. Reverse the battery polarity, and the motor should run in the opposite direction.

10) Temporarily connect a jumper from terminal 3 to terminal 4 on the main board. The motor should run. Remove the jumper and connect it from terminal 3 to terminal 6. The motor should run in the opposite direction. Remove the jumper. This completes the workbench checkout.

Preliminary Checks in the Vehicle

The final resting place of the matching-network chassis must be as close as practical to the base of the antenna. An insulated, *unshielded* lead, as short and direct as possible, is connected from the output of the rotary inductor to the antenna base. This wire actually becomes part of the antenna and a long lead here would

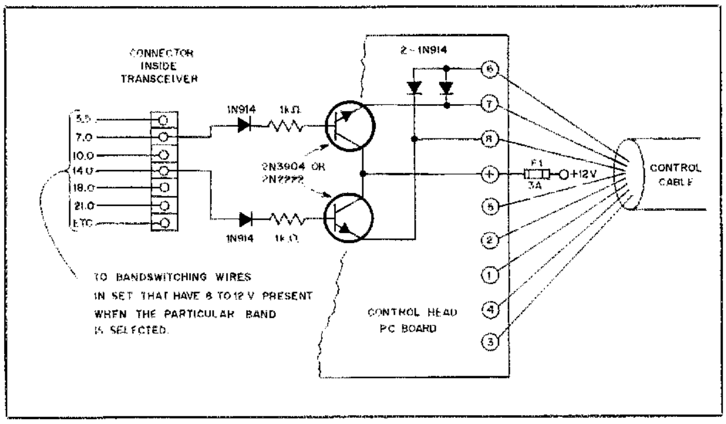
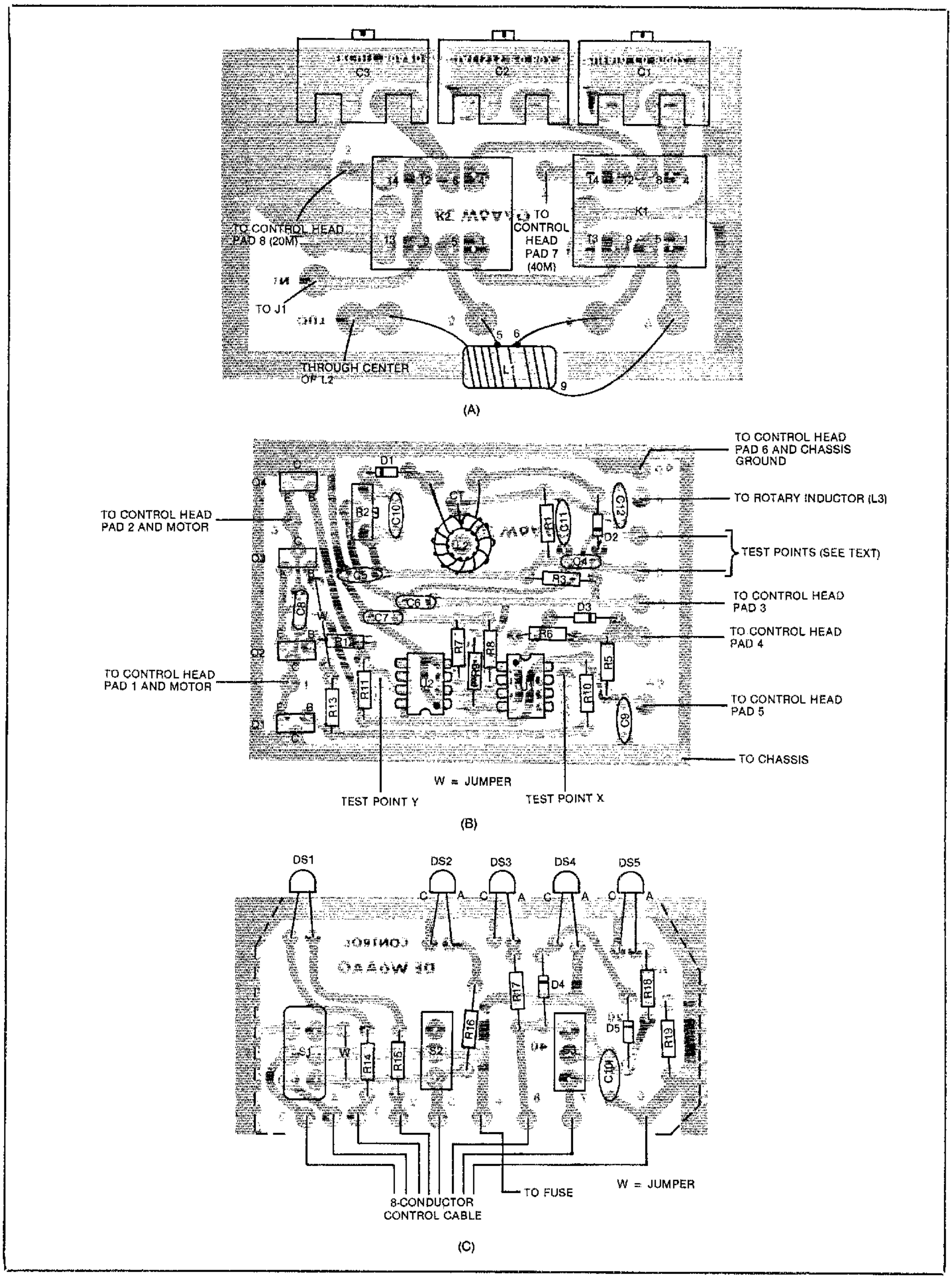
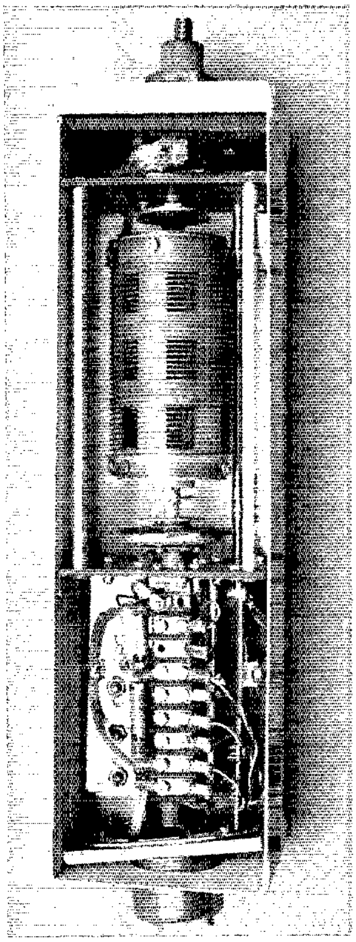


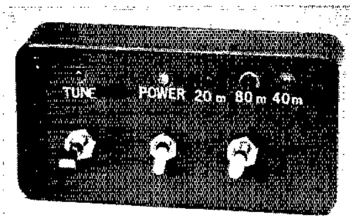
Fig. 5 — If the transceiver used provides band-switching voltages at a connector, this method may be used to control band switching of the antenna matching network automatically.



Parts-placement guides for the mobile antenna-matching network. Components are mounted on the nonfoil side of the boards. Shaded areas represent copper on the foil sides of the boards. At A is the input-network board; at B, the main board; at C, the control-head board. The circuit-board etching patterns appear on page 44. Designations C and A near the LEDs indicate the cathode and anode leads.



In this version of the matching network, a vernier drive mechanism is employed as a slipping clutch.



This control head is built into a small, plastic enclosure.

be undesirable. Do not use coaxial cable between the inductor and the antenna base! This error has been one of the most common ones made.

1) With the matching network at the chosen location, place it in a position where you can observe the operation of the relays and reach the padder capacitor adjustment screws.

2) Connect a heavy, short ground lead from the matching-network chassis to a clean electrical ground spot on the vehicle chassis. Connect the control head to the network assembly.

3) With S2 OFF, actuate S3 (the BAND switch) to determine if the proper relay closes, as indicated by the control-head LEDs. K1 closes in the 40-m position, K2 closes in the 20-m position, and no relays should be energized in the 75-m position of S3.

4) S2 is still in the OFF position. Move S1 (TUNE) from the center-off position to one side and then the other. The motor should first turn in one direction and then the other as the switch is operated. During this test, the motor should not run with the switch in the center-off position.

5) With S2 in the OFF position, connect a 50-ohm coaxial-cable lead from the transceiver to the input of the matching-network chassis. Manually, position the pickup on the rotary inductor for minimum inductance.

6) S2 is still OFF. Turn on the transceiver and set it for operation on 75 meters. Set the control head BAND switch to 75 meters. (It is assumed that your antenna is already resonant on this band at the highest intended operating frequency.) Switch to transmit, and tune the transceiver to the frequency of lowest indicated VSWR. (This will not necessarily be 1:1.) Return the transceiver to the RECEIVE mode.

7) Now place S2 in the ON position. Switch to TRANSMIT and move the transceiver down the band about 15 kHz from the point of lowest VSWR. The motor should turn the inductor to increase the inductance until the system is in resonance and it is back at the point of lowest VSWR.

If the motor turned in the wrong direction (decreasing the inductance), reverse the leads that interconnect terminals 1 and 2 of the main board to the motor. Don't move the leads to the control head. There's no way to predict the direction of motor travel initially because the number of reversals in the gear head, the direction in which L2 was wound and the direction the wire was passed through L2 from L1 all affect motor direction. If it ran correctly the first time, consider yourself lucky! Don't install the unit permanently yet.

Tune-Up and Adjustment in the Vehicle

Do not park the vehicle under or near other antennas, telephone- and power-line drops. Get out from under that shade tree too!

With S2 OFF, set the transmitter to the center of the band being used. Key the transmitter, and operate S1 to move the rotary inductor to produce resonance as indicated by the lowest VSWR. Now adjust the appropriate padder capacitor for lowest VSWR indication. If the padders were set accurately to the values indicated, they will have to be moved very little. If the VSWR did not come down to 1:1, move the inductor (using S1) as before, and readjust the padder capacitor. Repeat this procedure for the other bands.

Adjustment of R2

Once the padder-capacitor adjustments have been completed, return the transceiver and matching network to the 40-m frequency at which you adjusted C2. Place S2 in the ON position. Switch the transceiver to transmit, and adjust R2 for the lowest VSWR reading as you rock the transceiver VFO back and forth 10 or 20 kHz. This can all be done while using low power.

Install the unit permanently, and don't forget to use a heavy ground lead to the chassis. Unless you've wired the band-changing relays to be operated by the transceiver, remember to set the control-head BAND switch to the band of operation. If you don't, the first thing you will notice is that the receiver sounds dead. Then all you have to do is key the transmitter and the matching network will adjust itself automatically!

With the antenna mentioned earlier,[7] and a 20-m adapter, you will be pleased to see the VSWR will be at "rock bottom" from end to end on each band. Using the information presented here, you should experience success from the first time the switch is turned on.

I'd like to thank all the mobileers who brought their problems, solutions and suggestions to my attention. Maybe a number of readers have the "upstairs gears" grinding with ideas and other applications for this or a similar circuit. I'd be interested in hearing of them.

Notes

[1] D. Johnson, "Build a Weird 2-Band Mobile Antenna," *73*, Oct. 1976, p. 20.

[2] B. Brown, "Tennamatic: An Auto-Tuning Mobile Antenna Tuner," *73*, July 1979, p. 132.

[3] [Editor's Note: Fair Radio Sales, P.O. Box 1105, 1016 E. Eureka St., Lima, OH 45802.]

[4] [Editor's Note: Available from Strux Corp., 100 E. Montauk Hwy., Lindenhurst, NY 11757.]

[5] A complete set of drilled pc boards is available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002. A set of wound and dipped toroids (L1, L2) is available from the same source.

[6] [Editor's Note: Types 302 through 306, inclusive, are available from Allied Electronics, 401 E. 8 St., Fort Worth, TX 76102. They are listed in catalog 810 on p. 80.]

[7] See Note 1.

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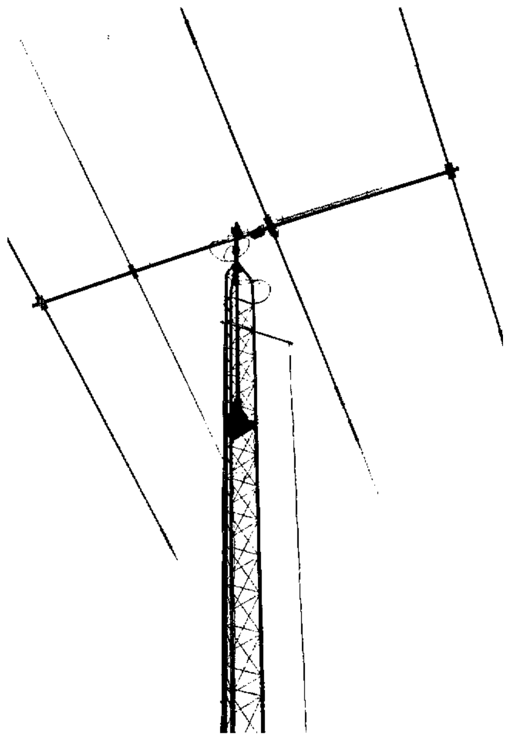
● *Basic Amateur Radio*

Shunt-Fed Towers: Some Practical Aspects



The mechanical basics of using a tower as a vertical antenna raise many questions. This article illustrates and describes some of the simple methods amateurs use.

By Doug DeMaw,* W1FB

Shall we start with a truism? Like, "One ham's tower installation will be mechanically unlike that at another amateur's site." That pretty well establishes the bottom line for any discussion about shunt-fed towers. But, the feed methods and grounding techniques remain essentially the same, no matter what the physical considerations are.

I have given a number of technical lectures at hamfests and ARRL conventions and have, therefore, been asked many questions about antennas. One area of high interest encompasses the use of existing towers as low-band vertical antennas. I have promised many times to write a *QST* article that spelled out some ground rules (pun not intended) for shunt-fed tower verticals. This treatise is aimed at fulfilling that pledge. It deals more with the physical than the theoretical nature of tower verticals.

I want to say early on that you need not have a tower to apply the principles discussed here. Any vertical conductor that can be used as an antenna is suitable for use with most of the methods described here. That is, a telescoping TV mast, a vertical drop wire (or slanted one) from a tall tree or a nonconductive building, a wooden mast with side-mounted metal tubing, or whatever, can be used as a vertical antenna. But, most amateurs have a tower of some kind for supporting hf or vhf beam types of antennas, and this paper is based principally on that consideration.

First Things First

Regardless of the type of conductor used for the vertical antenna, the electrical integrity must be excellent. This means that all joints between tower or tubing sections must show a low resistance under all conditions, especially when the wind is blowing! The shield braid from RG-8/U coaxial cable is suitable for ensuring a good electrical connection across tower-section joints and the sections of telescoping masts. The pieces of shield braid (or thin flashing copper) can be affixed by means of stainless steel hose clamps. This, of course, brings up the question about corrosion at those points where dissimilar metals are joined. Yes, oxidation can occur. I have been able to retard corrosion by applying a thin coat of silicone grease to the mating surfaces of dissimilar metals, or by wrapping a tight layer of vinyl electrical tape around the jumper joints. Coax Seal® tape is excellent for the purpose, but is the more expensive method of preventive maintenance.

Crank-up and tilt-over towers present the greatest problem with respect to top-to-bottom continuity. The best approach to solving the dilemma is to run a continuous length of shield braid or other flexible conductor from the top of the tower to ground level. This will permit raising and lowering the tower without restrictions. Be sure to allow sufficient slack in the flexible conductor at the break-over point on tilt-down towers.

Another point of concern for proper continuity is between the beam-antenna mast and the collet at the top of the tower, especially if the rotator is installed part-way down the tower. A flexible jumper with adequate slack for 360° rotation can be connected between the collet and the mast at the point where the mast exits from the collet. If this is not done, the VSWR is apt to change erratically when the wind is blowing (likewise with poor tower-section joints). This is caused by changes in top-loading capacitance (the beam antenna acts as a capacitance hat). I have experienced this problem, and the jumper cured it.

We must be concerned about poor joints in any antenna system for another reason: TVI, RFI and harmonic generation in general are likely to become manifest through unwanted rectification at inferior joints (as with a galena crystal and a cat's whisker). Interference to reception may occur also if commercial or amateur stations are near your location. Signals from those sources can be rectified by the poor joints in your antenna system,

*Senior *QST* Technical Editor

causing "blurps" and spurious signals in your receiver.

What About Guy Wires?

I am asked many times, "What if there are guy wires on my tower?" Factually, guy wires can be a blessing or a handicap. It depends on the electrical height of the tower and what you have placed atop the tower in the way of a beam antenna. If the overall tower system is a 90° (quarter wavelength) or less radiator, the guy wires can be used as additional top loading to provide resonance. Top loading will increase the bandwidth of the antenna, as compared to a nonresonant short vertical. This will be helpful on 160 meters especially. If the guy wires are commissioned as a top hat, they will need to be trimmed to the proper length for resonating the composite antenna. This is a cut-and-try proposition, which can be accomplished by means of a dip meter (Fig. 1).

Resonance can be checked by dropping a shunt-feed wire from the top of the tower to ground level. A two- or three-turn loop (small) of wire is connected between the lower end of the shunt arm or wire and the ground. The dip meter is used to probe the loop. A dip in the meter reading indicates system resonance, inclusive of the shunt wire. It's best to beat the dip-meter signal against the station receiver to determine the precise frequency of resonance. Although a VSWR meter can be used to find resonance (the point of lowest VSWR, generally), it might require that the transmitter be operated outside the amateur bands (don't do it!) when looking for the resonant frequency. This makes the technique impractical until resonance is *within* the band of interest.

Once the correct guy-wire length is determined for top loading, isolate the remainder of each wire by installing a strain insulator. If the guy wires aren't needed for establishing resonance, be sure to divorce them from the tower by placing insulators between each of them and the tower. The remainder of each wire should be broken up in nonresonant lengths by means of additional insulators.

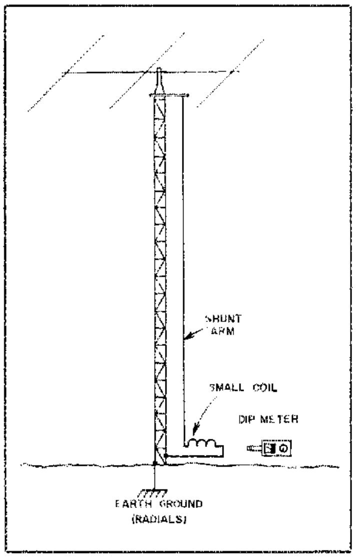


Fig. 1 — Method used by W1FB for checking the resonant frequency of a tower with or without an hf-band beam antenna mounted on top of it. A dip meter is coupled to a coil that is placed in series with the shunt-feed arm.

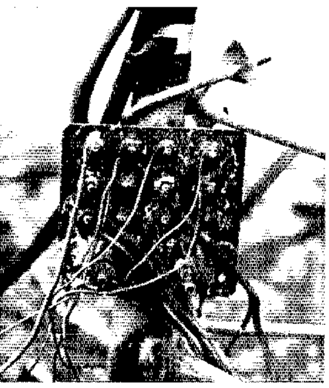


Fig. 2 — An aluminum plate (1/8-inch thick) is attached to one leg of the tower by means of a U bolt for use as an attachment point for some of the ground radials. No. 8 bolts and nuts are used with star washers to connect the wires to the ground end of the tower. Since there is no critical diameter for radial wires, various gauges are shown here. A coating of paint protects the attachment points from corrosion.

Ground Systems

The question of ground systems (radials) seems to frighten some of the hams I've talked to. Many of them envision the need for a so-called "ideal" ground screen. They feel that it is pointless to use a vertical antenna if they can't duplicate, for example, the W2FMI system described in *QST*.[1] As a result, they capitulate before they get started. Sure, the better the buried or on-ground radial system, the better the performance. But, don't "toss in the towel" if you can't develop an elaborate ground screen under your vertical.

I use a 50-foot Rohn 25 tower, which has a Cushcraft A4 tribander atop it (no guy wires). Experts like W2FMI would doubtless cry themselves to sleep if they saw my radial system. I have only 16 buried wires, and none of them are a quarter wavelength long (Fig. 2). The longest are 110 feet in length, and the shortest ones are only 40 feet long.[2] Furthermore, they are not deployed linearly. They run north on one side of the tower and south on the other side. The north radials wrap around my house. My east-west radials are the short ones. A 6-foot metal fence post is driven into the ground at the base of the tower. It serves as additional grounding. The system is aided further by the copper water-pipe network in the house, which is also connected to the ground system of the tower. Despite this mediocre ground screen, I worked 72 countries on 160-meter cw in two winter seasons of casual DXing, while running 100 watts. On 80 meters (casual again), I worked 78 countries in three months.

The moral of this story is that you should use what you can manage for a ground system. It might yield very good results! I recall working W7DOL/6 a number of times on 1.8 MHz. He always had one of the better West Coast signals into Connecticut. He told me he was using a 90-foot tower with *no* ground radials! In the final analysis it will be the conductivity of the earth in your region that determines how well your vertical performs.

Tower Height

We've already discussed towers that are less than 1/4 wavelength high. But what about those that exceed 90 degrees at 80 meters? So much the better for 160 meters, and if they are resonant at some frequency lower than 3.5 MHz, they will still perform well on 80 meters. Many operators prefer a 3/8- to a 1/4-λ vertical. They feel that the added electrical length elevates the point of maximum current, which makes the radiator more effective for DX work. Shunt excitation is effective, regardless of the tower height, assuming the tower does not exceed 1/2 wavelength overall. Beyond a half wavelength, the radiation angle increases (becomes higher), making the antenna more effective for short-haul communications than for DX work. My experiments on 40 meters with shunt-fed, 1/2-λ verticals have left me somewhat "underwhelmed" during DX efforts.

Shunt-Feed Methods

A single-band, quarter-wavelength (resonant) vertical that is grounded at the base can be fed effectively with a gamma match. Details for the gamma-arm length, diameter and spacing from the tower are given in Chapters 5 and 11 of *The ARRL Antenna Book*, 14th edition (1982). If the tower is less than a quarter wavelength electrically, a horizontal extender wire can be attached at the top of the tower for use as a resonator. Alternatively, you can install a loading coil and a tubing extension above the beam antenna, as was done by W9UCW.[3] Or, as discussed earlier, you can use guy wires as a top-loading mechanism.

My ultimate preference favors the use of a shunt arm that runs from the top of the tower to ground level (Fig. 3). The

[1]Notes appear on page 23.

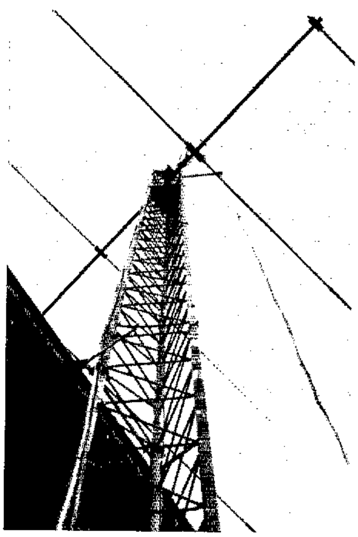


Fig. 3 — The shunt-feed arm consists of a drop line made from RG-59/U cable. A yardarm near the top of the tower supports the drop wire (see text). This photograph shows a Heath tri-band Yagi. It was replaced by a Cushcraft A4 tribander after the photographs were taken.

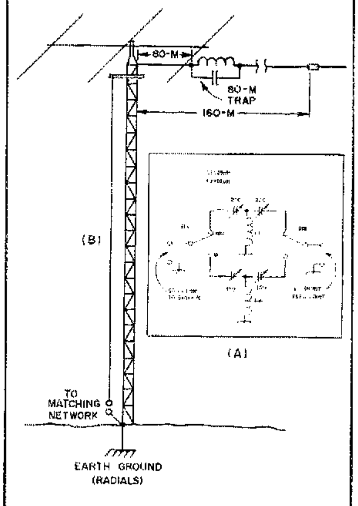


Fig 4 — Details of the two-band T network used at W1FB for providing a 50-Ω match on 160 and 80 meters (A). At B is the method used to effect resonance on each band. An 80-meter trap is installed a few feet out from the tower in the horizontal resonator wire for 160 meters. The wire that extends out to the trap resonates the tower and Yagi at 3525 kHz, and the trap divorces the remainder of the wire from the system during 80-meter operation. All of the extender wire is used for 160-meter operation. Resonance for the latter is set at 1810 kHz.

height of the attachment point is not critical. Neither is the diameter of the shunt-arm conductor. I use an arbitrary spacing of 1 to 3 feet (not critical) between the shunt arm and the tower. This method will work fine if you're willing to install a matching network at the feed point. Fig. 4 shows the L-C network I have used for two-band operation (160 and 80 meters). A remote-control type of network can be employed for multiband matching.[4]

My shunt arm is attached by means of two yardarms made from 1-1/4 inch diameter aluminum tubing (Fig. 5). Each is affixed to the tower legs with U bolts. A turnbuckle is used at the bottom of the arm to maintain tension in the drop wire. I desired a heavy-gauge conductor for my shunt-feed wire, so a suitable length of RG-59/U coaxial cable was used. I joined

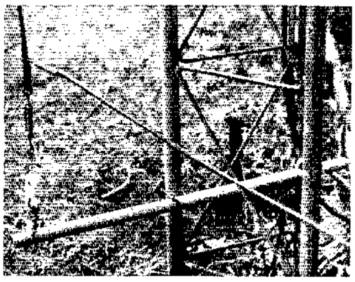


Fig. 5 — Closeup of the lower yardarm. Two U bolts are used to attach it to the tower. In this example, the shunt arm extends away from the bottom of the tower and is routed into the shack some 10 feet away. A Transmatch in the station permits multiband matching. The tip of a 6-foot metal fence post (used also as a ground) is visible on the far side of the tower. A run of Hardline, and another of RG-8/U cable, can be seen taped to one tower leg. The rotator cable is taped to the leg in the foreground (see text).

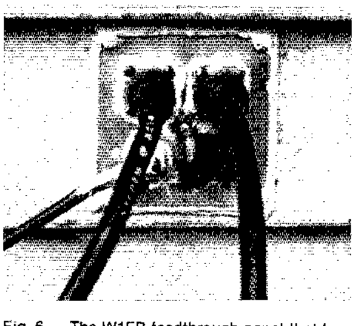


Fig. 6 — The W1FB feedthrough panel that has an identical plate on the inside wall of the shack. The end of the shunt-feed arm is shown at the lower left of the plate. Coax Seal® protects the cable fittings from corrosion, and caulking compound seals the outer edges of the plate to prevent leakage.

the center conductor to the shield braid at each end of the cable. No. 12 or 14 enameled wire would probably work just as well.

Feed Lines and Rotator Cables

Another area of concern among hams seems to be, "How can I keep rf out of my shack if I shunt feed my tower?" They assume that rf will enter the station via the rotator cable and the beam-antenna feeder. This can be prevented by bringing those wires down to ground level at the base of the tower. The cables then are run along the ground (or buried in it) to the station. This technique always has provided excellent decoupling for me. I have not experienced unwanted rf on my equipment or in the rotator control box. A feed-through panel on the side of my house (Fig. 6) where the station is located provides ingress for my feed lines. The rotator cable enters through a window.

Summary Comments

Some amateurs are concerned about what the family or neighbors might think about burying radials in the lawn. They also believe it to be a monumental task. I slit the turf with a lawn edging tool, then bury the radial wires two or three inches in the ground. The tiny trenches can be closed easily by stepping on them with my shoe. Sure, there will be trace lines visible for a short while, but soon the lawn will reinstate itself where the cuts were made, and the radials will be out of sight forever! I've always held to the belief that any reasonable act for the cause of better signals was worth the effort, even if the XYL was tempted to question my motives. After she was licensed (W1CKK), such debates ended, and she has even helped install our buried radials!

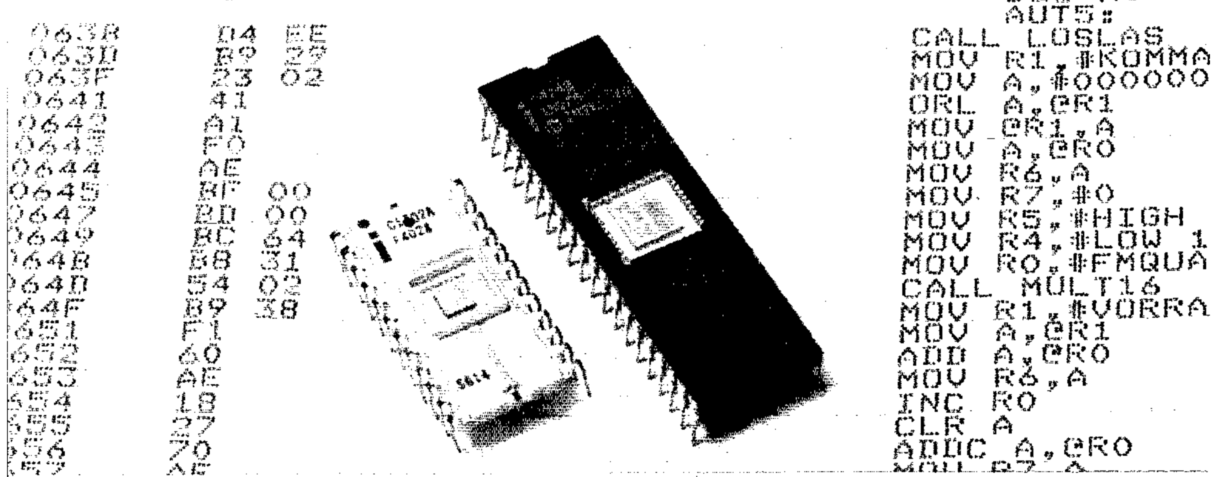
I've had good results also with on-ground radials. The first two winters after I became revitalized for DXing on 160 meters I had no choice but to use on-ground radials (the earth was frozen and covered with snow). In the spring, I coiled the wires and tied the rolls to the tower. The following October, the radials were unrolled and used again. This method may appeal to seasonal DXers on 160 and 80 meters, assuming they live in areas where winter is a cold, snowy season.

A shunt-fed tower is handy for emergency use on all hf bands when one or more of the regular antennas are down for repair or disabled from acts of nature. In any event, I hope these ideas will inspire you to try using your tower as a DX vertical.

Notes

[1]J. Sevick, "The Ground-Image Vertical Antenna," *QST*, July 1971.
[2]m = ft × 0.3048; mm = in. × 25.4.
[3]B. Boothe, "The Minooka Special," *QST*, Dec. 1974.
[4]D. DeMaw, "Antenna Matching, Remotely — Some Thoughts," *QST*, July 1982.

Build a Microprocessor-Controlled L-C Meter That Sends Morse Code



Part 2: Sorry to have kept you in suspense for a whole month! Let's get down to the nitty-gritty of putting the unit together, after we examine how the program works.

By Urs Hadorn,* HB9ABO

Last month the fundamentals of the meter circuit were presented with a circuit description.† This installment describes the program action and provides alignment and operating instructions for the unit.

Program Sequence

After power up, the program initiates at the starting point, reporting readiness by displaying L-C. Thereafter, the program waits to allow the oscillator to stabilize. The oscillator is assumed to be stable as soon as two consecutive counting sequences have produced the same result. Then the "nuLL" display prompts the user to depress the NULL button, S3. By so doing, the program is informed that the existing frequency should be stored as f_1 and that there is no component in the test terminals. After receiving the NULL signal, the program proceeds by verifying that the frequency is within the ±0.17% tolerance allowed. If this is the case, the program enters the main measuring loop; if not, the warning "FrEq" is displayed for one second, and the program returns to the starting point. "FrEq" indicates an oscillator malfunction or that there was already a component in the test terminals when the NULL button was depressed.

The main measuring loop, which is executed four times per second, performs the following steps:

1) Count the frequency, and store it as f_2.

2) Verify f_2 (if any of the following conditions is true, the program displays an error message and returns to step 1; otherwise, it continues at step 3):

2A) f_2 is too low — the value of the unknown is too large. Display: "OFLO" (overflow).

2B) $f_2 = 0$, i.e., the oscillator does not oscillate. This happens regularly when measuring inductances when there is no inductor connected momentarily. Display: "----"

2C) f_2 is higher than the stored value of f_1. Display: "-UF-" (underflow).

3) Compute the value of the unknown using Eqs. 3 or 4, depending on the position of S2.

4) Display result; return to step 1.

Note that condition 2C theoretically can occur only when the oscillator drifts. In practice, we have to deal with the typical behavior of a digital counter, which may cause such an effect because of the limited resolution, even when the oscillator is stable. Consider this example: Suppose the idling frequency (f_1) is 120,000.5 Hz, and when you are pressing the NULL button a value of 120,000 Hz has

†See Sept. 1982 *QST*, pp. 14-17.

*Im Riedtli 1, CH-8154 Oberglatt, Switzerland

been stored (because the last digit doesn't fit into a six-digit counter). Subsequent measurements may well produce a result of 120,001, even with the oscillator stable at 120,000.5 Hz. Because 120,001 is greater than 120,000, the program has to issue the -UF- warning to prevent a computation yielding a negative result.

The program leaves the main loop when:

1) S2 (L-C) has been operated. The idling frequency of the two configurations differ by about 400 Hz. For that reason, f_1 has to be measured and tested again.

2) TEST (S4) has been depressed. The instrument enters a test mode, displaying the four least-significant digits of the oscillator frequency. This mode is useful for alignment and maintenance purposes. If TEST is pressed again, the program quits this mode. In both cases, the program returns to the starting point.

Electronic-Keyer Program Sequence

When the key dot contact is closed, the L-C meter immediately switches into the keyer mode. In doing so, the display shows "E20.0," E being an identifier for the Electronic keyer mode and the figures being an indicator for the speed in words per minute. Because the keyer program is not as straightforward as the L-C meter program, it will be described in the form of operating instructions.

Speed Variations: Every time the NULL switch is depressed, the speed decreases by 0.2 wpm. If NULL is held down during transmission, the speed decreases by 10% after each dot or dash. When you are not transmitting, pressing NULL for more than 0.3 second causes the speed to be reduced by 10%, 5 times per second. Increasing speed is done similarly by using the TEST switch. Thus, sending speed is adjusted easily and rapidly to any value within the range of 6 to 50 wpm. Attempting to increase speed beyond 50 wpm sets the speed to 6 wpm, and decreasing speed below 6 wpm sets the speed to 50 wpm. Any speed change is displayed immediately. The speed indication in words per minute is based on the standard PARIS. The keyer speed (and its displayed value) is accurate and stable, as it is derived from the computer clock.

Keying Modes: If both keying contacts are held closed simultaneously, then that element whose contact has been closed last is transmitted. If, for example, P is to be keyed, the dashes can be "squeezed" into the string of dots; the dot contact remaining closed. On the other hand, if a hyphen is keyed, the dash lever can be left closed, and the dots dominate the dashes by closing the dot contact after the dash contact. An investigation of all Morse code characters reveals that this method (I call it the "dominant mode") is preferred to the so-called iambic keying method with the majority of characters because the keying levers have to be moved less often. Those who prefer iambic can inform the processor by tying pin 30 to ground (jumper OW8 of Fig. 4). Then, dots and dashes are sent alternately when both contacts are closed. I have tried a dot/dash memory, but since I couldn't see any advantage to using it, the present software does not have it.

To send a continuous signal for tuning, the L-C switch (S2) has to be toggled. The actual position of this switch is not important because the program, when initializing, automatically defines the "other" position as KEY DOWN.

The internal counter of the 8035 operates as a timer in the keyer mode. It produces the audio signal of 781 Hz, which may be used to monitor keying.

Automatic Morse Tutor

This feature seems to have had the greatest impact on the builders of this instrument. I was surprised to learn that a number of them rediscovered the attractiveness of cw. More than one was then in the market for a new keying paddle, and I have been told that there are some among them considering the L-C meter as a secondary function to that of the cw modes of the instrument!

In this mode, the unit serves as a training aid for cw operators of all levels by sending randomly composed groups of characters. Word length can be adjusted from 1 to 10 characters. The characters sent are taken from a character subset whose size can be operator-defined. (A beginner might select a subset of 8, i.e., the first eight characters of the set.) The character set is comprised of 44 characters (U.S. version), as shown in Table 1. The selected subset always starts from A. Subset size is entered by using a number from 1 (A only) to 44 (all characters).

After 65,535 characters are sent, the random sequence selecting the characters repeats itself. This equates to almost nine hours of continuous sending at a speed of 30 wpm! As it is desirable for practice purposes to repeat the same random sequence several times, the computer must be told where to start in this cycle of 65,535 characters. This is done by sending a *key character* (to be described).

The automatic cw-tutor function can be entered from the keyer mode by simultaneously depressing NULL and TEST. The program responds by displaying "Auto." After exiting the keyer mode, the following parameters are set:

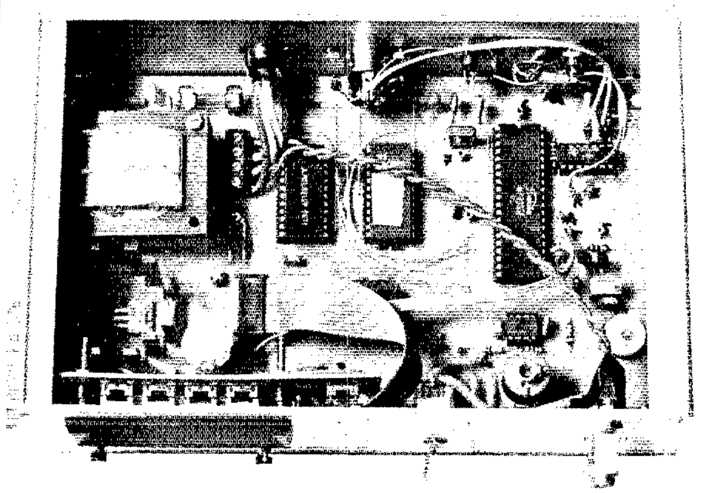
Word length: five characters
Character subset: first 40 of 44
Speed: same as in the keyer mode.

"Auto" marks the readiness of the program to accept commands. At this time, the following commands can be entered:

1) Optional Commands

A) Increasing word length by depressing NULL. A word length of 11 will cause the computer to generate word lengths of 1 to 15 characters in random sequence.

B) Increasing the selected character subset size by depressing TEST. As soon as one of the previously mentioned controls is activated in the "Auto" mode, the selected word length and character subset size are displayed on the left and right, respectively, separated by a decimal point. Increasing either parameter beyond the



An inside view of the L-C Meter. L3 is located near the front panel on the right-hand side. The sidetone and transmitter-keying-line jacks and the multipin keyer paddle jack are on the rear panel.

respective maximum of 11 or 44 causes the count to resume at 1.

2) Key Character

The key character is mandatory and entered by means of the keying paddle exactly as in the keyer mode. A key character is any combination of one to seven consecutive dots and/or dashes. Hence 127 different key characters are possible, corresponding to 127 different starting points in the cycle of 65,535 characters.

Immediately after reception of the key character, the program assumes a *standby mode* with A followed by the speed indicated on the display (A = Automatic). In standby, characters can be sent (e.g., framing characters for a recording), and the speed can be adjusted just as in the keyer mode. Characters sent in the standby mode do not influence the code sequence, which was previously defined by the key character.

Toggling the L-C switch to the opposite side starts the tutor sending the code sequence which continues for as long as you want. The sequence can be interrupted by using the L-C switch, putting the program into standby. After switching back S2, the generator resumes sending at the place it stopped before. A return to "Auto" (to change parameters) can be achieved by closing the dot contact during the automatic transmission. If P is entered as a key character, then the transmitted code sequence is PARIS PARIS PARIS. This feature has been included merely for fun, but it is nice to prove to others that the speed indication is correct.

Construction

Twenty of these units have been built as a project of the Zurich Airport Dippers ham group. Except for minor wiring errors, we have had no problems in duplicating the instrument. As this is being written, another group of 30 units nears completion within the ranks of the Airport Dippers. If circuit operation is understood and the hints described are observed, no problems should be encountered when building this instrument.

L3 is a key component of this L-C meter. The particular coil form used has a threaded ferrite core and a removable ferrite cap. This inductor[4] was purchased locally, but there is no reason why other adjustable inductors of suitable quality could not be used. A suggested replacement is a Miller 4412 or 4514-1.[5,6] The inductor has to be adjusted by means of a lab type of instrument to produce an inductance of 700.0 μH. Any deviation of the inductance value from this figure will cause measurement errors of the same percentage. The inductor used for L3 has a Q of 87 at 100 kHz.

Mechanical Construction

To keep costs low, a single-sided pc board is used. More than a dozen hand-wired jumpers are necessary because of the circuit complexity. A pc board is not absolutely necessary; we have hand-wired "breadboard" units performing well. While other stages are not critical with regard to layout, the oscillator should be built like a VFO, using short, mechanically stable leads.

The unit is built in a steel enclosure measuring approximately 2.6 × 8 × 5 inches (HWD)'. Choose a cabinet that provides sufficient cooling for the internal components. The transformer used in this unit runs hot after hours of operation, although it is loaded to only half of its nominal power rating. This is because of the high pulse load of the half-wave rectifier circuit. U2 must be mounted on a heat sink with a thermal resistance of about 9 C°/W.

It is advisable to use sockets for U4 through U13. The display with U10 through U13 is on a separate pc board and is linked to the main pc board with a 14-conductor flat cable that is terminated with DIP plugs. A 6.3-in. length of RG-58/U coaxial cable with two alligator clips on one end acts as a test lead. The opposite end of the cable is equipped with BNC hardware for connection to the instrument.

Alignment

The following alignment procedure assumes that the inductance of L3 has previously been adjusted to exactly 700.0 μH. Plug the test lead into the L-C meter and place S2 in the C (pF) position.

1) Set C10 to approximately half capacitance.

2) Turn on the power; depress the NULL switch after being prompted by "nuLL" in the display.

3) If the display shows "FrEq" after "nuLL," slightly detune C10 and press NULL again. If "FrEq" persists, try another setting of C10.

4) Press TEST. After one second, the display should show the last four figures of the oscillator frequency. Using C10, tune the oscillator to 120,000 Hz.

5) Place S2 in the L (μH) position.

6) Short the test-lead clips, and record the frequency displayed.

7) Connect a 10-ohm resistor to the test clips, and record the frequency displayed.

8) If the frequency obtained in step 7 is higher than that obtained in step 6, decrease the value of R2. If the frequency obtained in step 7 is lower than that of step 6, increase the value of R2.

9) Repeat steps 6 through 8 until the frequency difference obtained with the clip leads shorted and with the 10-ohm resistor between them is no more than about 20 Hz.

10) Set S2 to C again.

11) Adjust C10 to get a display of 0000 (120,000 Hz). Keep the "hot" test clip clear of your hands and other objects when tuning.

Table 2

L-C Meter Technical Data

Range†	*Resolution*
0 to 9.9 μH	0.08 μH
10 to 203.9 μH	0.1 μH
0 to 203.9 pF	0.2 pF
204 to 2030 pF/μH	1.0 pF/μH

Automatic range selection.
Cw speed: 6 to 50 wpm.

†Extending the measuring range beyond 2 mH/2nF is not possible because of the properties of the oscillator used. A low-cost instrument that will cover this range is the BR-8 AC Bridge, manufactured by Belco Electric Works, Tokyo, Japan.

Table 3

Text and Error Messages

Display	*Meaning*	*Action to be Taken*
L-C	Self-test of oscillator	C: Open test clips. L: Short test clips. Wait for NULL.
nuLL	Oscillator frequency okay	Depress NULL switch.
---	Idling frequency stored or oscillator ceased to oscillate	Release NULL switch, connect an inductor, or short test clips.
OFLO	Overflow (Ueberlauf)	Remove unknown.
UEb	unknown too large	
FrEq	Idling frequency out of tolerance	Remove anything connected to the test clips or connect coaxial cable with test clips, or check oscillator and realign.
-UF-	Underflow (Unterlauf) — the frequency is now	No action if UF (UL) flickers with 0.0..
-UL-	higher than when pressing NULL	When measuring C: Clear test clips, depress NULL; L: Short test clips, depress NULL.
E	Instrument is in the keyer mode.	
A	Instrument is in the automatic Morse tutor mode.	
Auto	Ready to accept commands in the automatic Morse tutor mode	Send a key character or increase character set size (NULL) or word length (TEST) and then send key character.

'Notes appear on page 27.

12) Press TEST again. The instrument is now ready for use.

Operating Instructions

To measure capacitance, set S2 to C. Check that the test-lead clips are open and clear, and apply power to the unit. "L-C" and then "nuLL" should be displayed. Depress the NULL switch. The display should now show a value of about 0.0. Because of the counting uncertainty of ±1, the display may flicker between "-UF-" and 0.0 or between 0.0 and 0.2. Connect the unknown and read the value in picofarads. When using the instrument for a protracted period of time, especially when small values are being measured, press NULL from time to time to compensate for any oscillator drift or change in the position of the test clips.

When measuring inductances, the procedure is similar to that just described, with the exception that "----" is displayed when there is no inductor between the test clips, or they are not shorted. To measure inductances, set S2 to L and short the test clips, then follow the foregoing procedure.

Resolution and range information can be found in Table 2. Refer to Table 3 for an explanation of the display indications, the error messages and actions to be taken.

Summary

I highly recommend the construction of this instrument as a group project for a number of reasons: Quantity purchases reduce costs, more "junkbox power" is available, labor can be distributed according to individual skills, test equipment and know-how can be made accessible to all members of the group, and ham spirit — often said to be dead — is raised by mutual help and support.

Notes

[1]An HVS.2349 form, purchased from Grieder AG, Nauenstrasse 63, CH-4002 Basel, Switzerland, is used in the unit described here. This form has a threaded ferrite core and a removable ferrite cap. A total of 180 turns of no. 30 enameled wire is hand wound on the form, and the inductor is adjusted to a value of 700.0 µH. These forms are not available from the author.

[2]Our group had no trouble finding access to a laboratory-grade L-meter with which the inductors were adjusted. Within an hour of placing a request on the local repeater net for information leading to the availability of such an instrument, we had our answer.

[3]J. W. Miller Division of Bell Industries, 19070 Reyes Ave., P.O. Box 5825, Compton, CA 90224. These inductors are available from Radiokit, Box 411, Greenville, NH 03048

[4]mm = in. × 25.4

Born in Berne, Switzerland, Urs Hadorn has been licensed as HB9ABO since 1961. He has also operated under the calls VU2ABO and HB9ABO/LX. Urs has been a radio operator in the Fixed and Mobile Aeronautical Telecommunications Services and in the Maritime Radio Services. Since 1963, he has been employed as an air-traffic controller at the Zurich airport. His favorite hobbies include software development for microprocessors, the technical side of Amateur Radio, and cw QRP and QRQ operating.

Strays

RFI PROBLEMS AND QRP — A BLESSING?

☐ We usually hear that QRP (low power) operation is done because it's fun, a challenge or an exercise in learning for a beginner. But, we seldom recognize a perhaps greater advantage of QRP involvement: freedom from RFI and TVI! Norm Fleming, W8PJ, writes in with some interesting observations that are worth sharing with the readers of *QST.*

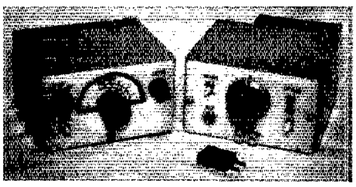
Norm says he acquired a shiny, new commercial transceiver "with all of the bells and whistles implanted." Alas, the rig turned out to be a prolific generator of RFI in his neighborhood. This led him to some research concerning QRP circuits in *QST.* He had never been very keen about cw operation or QRP work, but he was impressed with the W7ZOI "Universal QRP Transmitter" by DeMaw in *QST,* and with the W1FB/WAØUZO VFO article in another issue of the League's journal.[1]

The two units were "built and united," in his words, and the result sounded great . . . except for his "fist," which he says had grown old and stiff along with the rest of his body. The photograph shows the gleanings of his workshop efforts (congratulations, Norm).

Norm has worked 35 states, Canada and several maritime-mobile stations with his 1-W rig on 20 meters. He was especially elated when he worked UB5ZBX in Odessa from his QTH in Ohio. Despite heavy QRM, he received an RST 559 signal report! The antenna is a 2-element Delta Loop, as described in Norm's June 1973 *QST* article.

In addition to curing his RFI problem, he reports a much lower utility bill these days, because his "old linear amplifier doesn't gobble up power" since he went the QRP route. RFI, he has learned, can be a blessing in disguise! — *Doug DeMaw, W1FB*

[1]D. DeMaw, "Experimenting for the Beginner," *QST,* Sept. 1981, p. 11. Also, D. DeMaw and R. Shriner, "A Beginner's 3-Band VFO," *QST,* Jan. 1980, p. 19.



The result of W8PJ's workshop union of the W1FB/WAØUZO VFO (left) and the W7ZOI Universal QRP Transmitter, two construction projects gleaned from past *QST* articles. In addition to curing an RFI problem, W8PJ reports lower utility bills since going the QRP route.

W4CIZ HONORED FOR WORK WITH ARRL RFI TASK GROUP

☐ The ARRL Board of Directors passed a motion at its September 1981 meeting to commend ARRL TA Hal Richman, W4CIZ, for his untiring efforts as a technical advisor to the ARRL RFI Task Group since its inception. Because of his work, and because the results of his endeavors have been of significant help to amateurs and the public, Board Minute 36 directed that Richman be awarded a commemorative plaque. A Life/Senior Member of the IEEE and currently a director and advertising manager of the *IEEE Northern Virginia Section Bulletin,* W4CIZ was nominated recently as an IEEE Fellow. — *Doug DeMaw, W1FB*

Hal Richman, W4CIZ (right), receives the special commemorative plaque from Bill Grenfell, retired chief of the FCC Personal Radio Division.

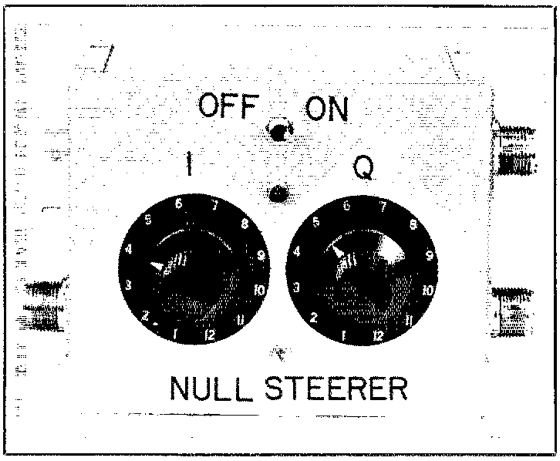
MOVING? UPGRADING?

☐ When you change your address or call sign, be sure to notify the Circulation Department at ARRL Hq. Enclose a recent address label from a *QST* wrapper if at all possible. Address your letter to Circulation Department, ARRL, 225 Main St., Newington, CT 06111. Please allow six weeks for the change to take effect. Once we have the information, we'll make sure your records are kept up-to-date so you'll be sure to receive *QST* without interruption. If you're writing to Hq. about something else, please use a separate piece of paper for each request.

I would like to get in touch with . . .

☐ anyone with information on using a frequency counter to hook up the Drake TR-4CW transceiver for direct frequency readout. Fred Simon, WA3MVP, 444 King St., Milton, PA 17847.

Electrical Antenna Null Steering



Take some readily available components, add a few hours of enjoyable assembly time, and you've got an effective means of combating QRM.

By John Webb,* W1ETC

This null steering work began as an experimental solution for a deliberate jamming problem on the 27-MHz band. An undesired signal from a nearby source on an adjacent channel prevented reception of desired signals. The null steerer solved the problem, eliminating the need for other "less technical" countermeasures that were being contemplated. Later, the device was employed in controlled jamming environment tests for the U.S. Air Force on government-used frequencies. That demonstration produced tape recordings of intelligible a-m and ssb signals with jammer-to-signal ratios as high as 30 dB.

Another unit was built for further experiments. That model was tested at Eglin Air Force Base on 6 MHz. There, jammers were nulled effectively, except in cases where multipath conditions required more than one null. Throughout these demonstrations, the device was used successfully by a number of people, most of whom were only briefed on how it was supposed to work.

Results indicate that although a null will not solve *all* QRM problems, it is beneficial when interference comes from sources free of large multipath spreads.

*The MITRE Corporation, Burlington Rd., Bedford MA 01730

Description

Null steering is a technique that is used to cancel undesired interfering signals. It combines the signals received by the main antenna with those from an auxiliary antenna positioned near the main antenna. The device shown in the photographs is the null steerer control unit. It provides the phase and gain adjustments necessary for cancellation of one undesired signal at a point where signals from both antennas are combined. The two controls on the unit are operator adjusted for the most favorable ratio of desired to undesired signals. The resulting audible effect is similar to that of adjusting a notch filter that attenuates one of several signals.

Placement of the auxiliary antenna is not critical, and the technique works equally well with a-m, cw, ssb and noise in any combination. The null may be directed against interfering signals within the receiver bandwidth or on nearby frequencies from which strong signals may overload the receiver front end.

This electrically steered null capability does not require mechanical rotation of an array. It is implemented with two simple antenna elements located close to one another.

Principles

The elementary null steering antenna principle shown in Fig. 1 will be recognized as a two-element interferometer. A plane wave from some arbitrary direction passes through the antennas, arriving first at antenna A, and later at antenna B. Baseline (d) is the distance between the antennas and the angle between the baseline and the wave is θ. The time differential occurring between the wave passing the two antennas is given by

$$d \sin \theta / s \qquad \text{(Eq. 1)}$$

where s = speed of light.

Thus, signals from all directions appear at the two antennas, with a time difference depending on the direction of wave arrival. One signal from A can cancel the same signal from B, provided the signal from A is delayed by the time corresponding to $d \sin \theta / s$ and the voltages from the two antennas are equal and of opposite phase. The cancellation, or null, of that signal is effective for the bandwidth over which the time delay and antenna responses remain equal. However, the time delay function is neither easy nor inexpensive to obtain. Instead of a time delay, the null device is designed around a continuously variable gain and phase shift concept that does almost the same thing as a variable time delay. The phase-shift device adjusts the relative amplitude and phase of signals over a wide range for any relative phase from zero to 360°. It is implemented with simple circuitry at low cost. While the nulls are effective over small frequency spreads, the bandwidth is sufficient for use on amateur frequencies.

The variable phase and amplitude approach is usable at a single frequency because signals that are delayed by the distance d sin θ appear at the second antenna with some phase difference within 360° of the same signal at the first antenna. Then, the electrical length of the baseline becomes involved as a limitation of null depth, bandwidth and width of the null angle.

There are two or more directions of arrival that will satisfy the null phase condition, but antenna responses to all signals do not necessarily satisfy the null amplitude requirements simultaneously. Phase shift and gain values required for a null are different for each direction. Thus, the likelihood of nulling both a desired and undesired signal is remote. As the baseline increases from 1/2 wavelength to one or more wavelengths, the number of simultaneous possible null directions increases because the number of wavelengths in d sin θ increases. (A detailed analysis of these relationships is available from the author.[1]) Generally, the baseline should not be more than 1 wavelength long on the lower hf bands (1.8 to 4 MHz) for good null depth within the amateur bands. Figs. 2 and 3 are graphs of idealized geometric limitations of null angular width and bandwidth for 0.5- to 2-wavelength baselines.

[1]Notes appear on page 32.

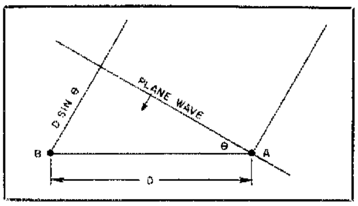


Fig. 1 — Representation of a plane wave passing two antennas, A and B.

Antennas

Auxiliary antenna requirements are not critical. The antenna must receive the interfering signal, but does not have to be a good receptor for the desired signal. If it receives less interference than the main antenna, the null steering unit must provide enough gain to satisfy the equal-amplitude requirement. Both antennas should have the same polarization, although dissimilar antennas using different polarizations may work. This is an area in which experimentation remains to be done for various types of interference.

For example, a vertical auxiliary antenna is preferred for countering radiated power-line noise, which is vertically polarized. When an omnidirectional auxiliary antenna is used with a beam antenna, it may be possible to null signals only outside the main lobe because of the gain limits of the control unit. Or, if the control unit has enough gain to null signals in the main lobe, the unit amplifiers may oscillate when the beam antenna is pointed at the auxiliary antenna. If a beam antenna is employed, using an attenuator with the beam antenna accomplishes the same result as control unit gain while diminishing the potential for oscillation.

At this point one might ask, "Aren't the receiving antenna patterns just like all the published patterns for two elements with various relative spacing and phasing values?" Not necessarily! If the two antennas are both vertical dipoles, then the patterns will be about the same as those ideal patterns for vertical radiators over perfect ground. However, if one or both antennas is horizontally polarized, or if the antennas are of dissimilar types, then it may be hard to find published patterns representative of practical antenna installations. Also, the pattern with respect to the desired signal and the interference may be different, particularly if each signal has different polarization characteristics.

The next question that seems almost invited is, "Will mutual coupling between the antennas prevent it from working?" No, because the null is a cancellation of waveforms and any mutual coupling effects can be compensated for in the control-box phase and amplitude adjustments. The null depends only on both antennas receiving the interfering signal and correlation of the interference waveform at the combination point. Decorrelation occurs when two antennas are separated at such a distance as to cause a received signal to fade independently at the two antennas, or to otherwise allow the waveforms to change phase or amplitude independently. This property has been widely used for space-diversity reception; however, it is not desired in this case. Therefore, the recommended antenna separation is on the order of one wavelength. As the antenna separation is increased, the null depth for skywave signals will decrease rapidly because of decorrelation of the signals at the two antennas.

A block diagram and a schematic diagram of the null steerer unit are shown in Figs. 4 and 5, respectively. The auxiliary antenna feeds a broadband input transformer which couples a balanced output to two 250-ohm potentiometers (R1 and R2) that function as bipolar quadrature gain controls. A sample of the input signal is taken from R1 and passed to a broadband amplifier, while R2 sends a sample of the input signal through a quarter-wavelength delay line (or 90° phase shifter) to the second amplifier. Component values are chosen to provide an input impedance near 50 ohms for a wide range of R1/R2 settings. The two

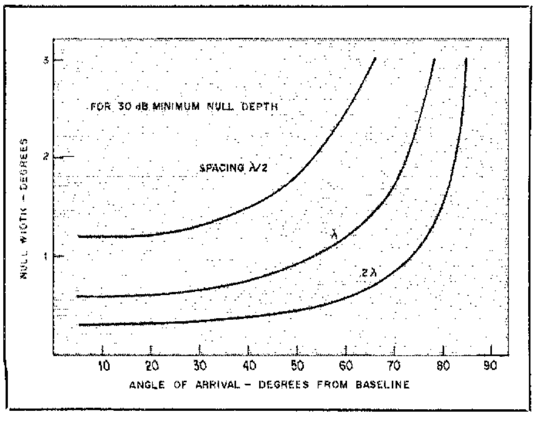


Fig. 2 — Angular null width versus direction of wave arrival.

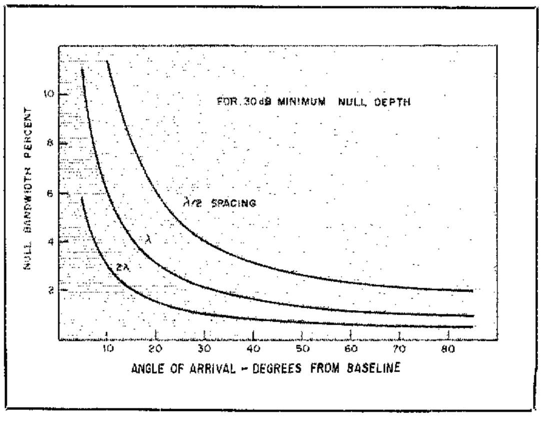


Fig. 3 — Null bandwidth versus direction of wave arrival.

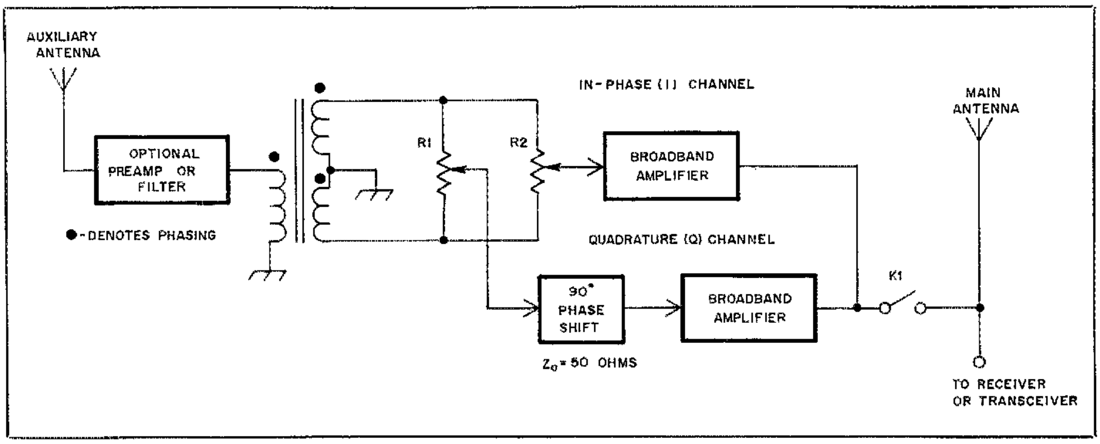


Fig. 4 — A block diagram of the manually controlled null steerer.

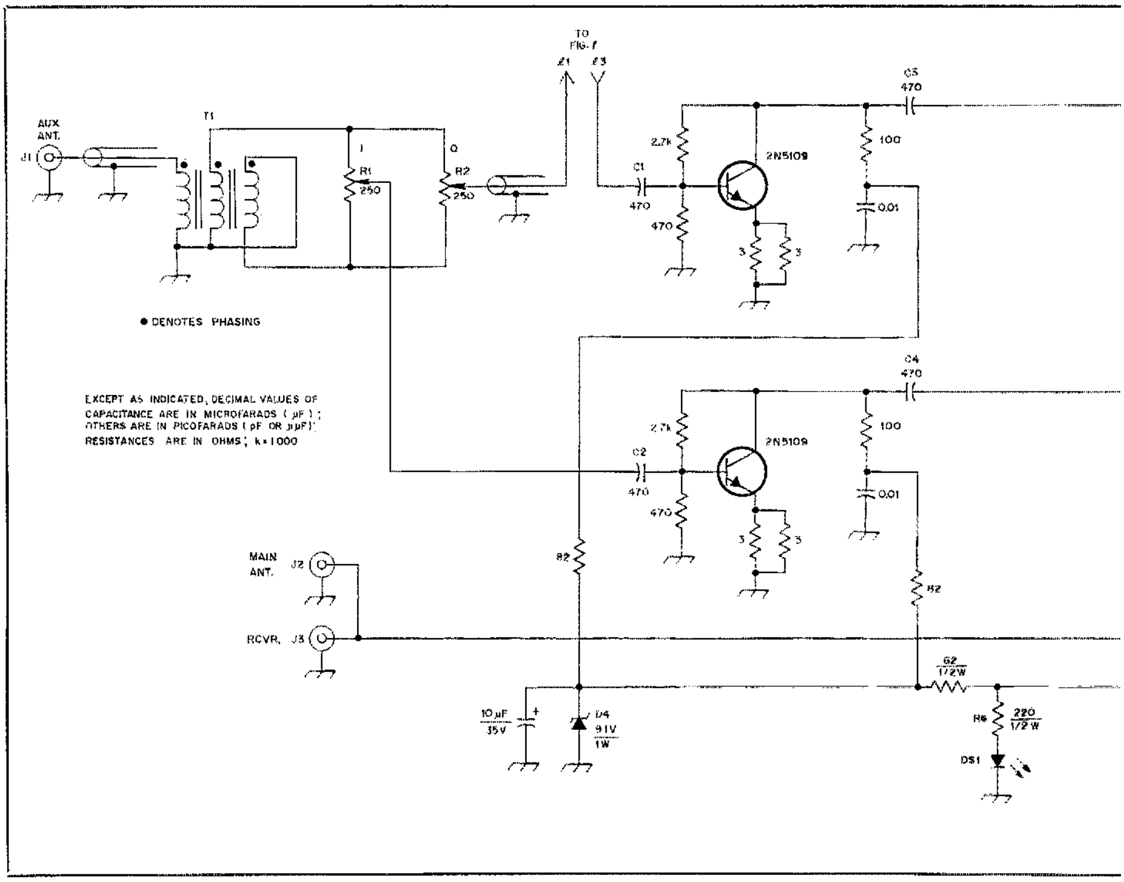


Fig. 5 — Schematic diagram of the null steerer control unit. A positive control voltage should be applied to P1-4 in the receive mode. Unless otherwise specified, resistors are carbon composition, 1/8-watt types. Capacitors marked with polarity are tantalum units.

J1-J3, incl. — SO-239 female, chassis-mount connector.

K1 — Sigma 191TE2A1-5G dpdt DIP relay, 200-ohm coil or equiv. A heavier-duty relay should be used with transceivers having input powers over 100 watts.

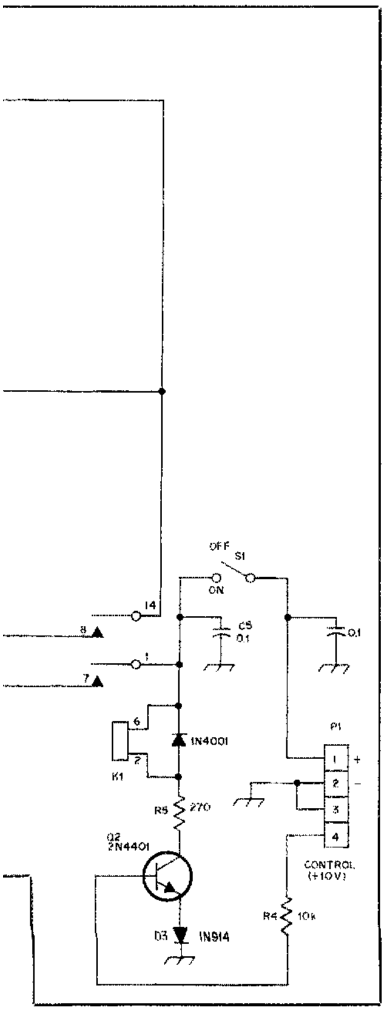
P1 — Chassis-mount plug, four-contact.

R1, R2 — 250-ohm, linear-taper, carbon potentiometer.

T1 — 5 trifilar turns on Palomar F37-Q2 core (Amidon FT-37-63).

amplifiers, each with an output impedance of 100 ohms, are paralleled to provide an output impedance of 50 ohms. Adjustment of R1 and R2 causes the input signal to appear at the output, amplified and phase shifted by any angle over 360°. This output is combined with signals from the main antenna, and algebraic addition of equal-amplitude, opposite-phase signals creates the null. When several signals appear on both antennas from different directions, the settings of R1 and R2 will be different to null each signal. S1 disconnects the amplifiers from the main antenna when the device is not used, such as during transmitting periods.

The amplifiers use transistors such as the 2N3866, 2N5109 or TRW LT1001A. With 2N5109 devices, the gain at all phase shift angles was measured as 10 dB up to 15 MHz, decreasing to 4 dB at 30 MHz. The linearity was good at input signal levels to just below 0 dBm with R1/R2 set



for maximum gain. Linearity is important because all signals received by the auxiliary antenna appear in the amplifiers.

Input filters may be required to reject nearby strong signals, such as those from broadcast stations or multiple-transmitter stations. Fig. 6 is a schematic diagram of a high-pass filter for attenuation of broadcast signals. The cutoff frequency is 3.4 MHz, and the attenuation exceeds 70 dB below 1.6 MHz.

Gain controls in the control unit can cause a decrease in the receiver noise figure. This can be offset by using a preamplifier at the control unit input port.[2]

The quarter-wave phase shifter can be made from 50-ohm coaxial cable, but at lower frequencies the physical length is great and packaged delay lines become attractive.[3] Cable length may be determined by

$$\text{Length}_{(m)} = \frac{(75\text{ m})\,(V)}{f} \qquad \text{(Eq. 2)}$$

where

f = the quarter-wave frequency in MHz
V = velocity factor of the cable
m = meters[4]

The equivalent time delay is equal to 250 ns divided by the quarter-wave frequency in megahertz. Three delay values are sufficient to cover the requirements for the present and future amateur bands from 3.5 to 29.7 MHz with a gain decrease of no more than 1.0 dB because of departure from the exact quarter-wave or 90° condition (see Table 1).

Fig. 7 diagrams a method for implementing the delay values listed in Table 1. The 25-MHz delay line consists of the total length of the coaxial-cable segments from R1 through S1 and S2 to the input of the Q amplifier. The total length of that cable ($\ell 1 + \ell 2 + \ell 3$) should be 6.4 feet. S1 and S2 are dpdt switches used to select two additional delay increments or jumpers. With S1 connecting a second 10 ns ($\ell 4$) delay line, the total delay is 20 ns, and with S2 selecting $\ell 5$, the 30-ns delay line, the total delay is 50 ns. Inserting $\ell 5$ alone (S1 switched to the jumper) provides a 40-ns total delay. Addition of another 50-ns delay line (for a total delay of 100 ns) would permit coverage from 1.8 to 3.3 MHz; however, this would require the use of a high-pass filter with a cutoff frequency below 1.8 MHz.

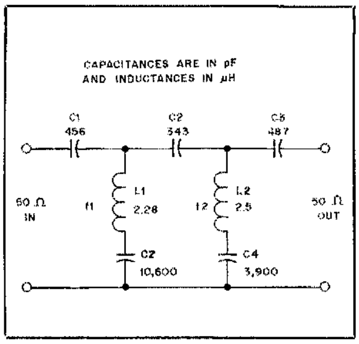


Fig. 6 — Schematic diagram of an elliptic high-pass filter for use with the null steerer.

The given delay line values are calculated to produce a gain decrease of 1 dB at the edges of the frequency ranges given in Table 1. Note that the cable shields of $\ell 1$ and $\ell 3$ are connected to a nearby circuit ground at the input and output ends. Also, the shields of the leads and delay line segments are connected together at each switch. The line between S1 and S2 ($\ell 2$) does not need to be coaxial cable if the switches are separated by no more than 1 inch. Because the circuits operate at low rf impedances, no special layout provisions are required, except that short lead lengths and a shielded enclosure should be used.

Results

Observations recorded after many hours of null-steerer use throughout the hf spectrum include:

1) The available null depth on signals propagated over short paths of up to 20 miles[5] is large and stable, limited only by how finely the controls are adjusted.

2) Nulls on signals arriving over short skywave paths of up to a few hundred miles are in the order of 30 dB, provided there is a single mode of propagation and one direction of arrival. Nulls are usually stable.

3) Signals propagated over paths of 10 to 100 miles may arrive as a mixture of ground wave and skywave. A single null is thus ineffective.

4) Signals propagated by skywave over long distances frequently involve several paths each having a different number of

Table 1
Null Steerer Delay Values

Frequency Range (MHz)	*Quarter-Wave Frequency (MHz)*	*Delay (ns)*	*Length (V = 0.66) (m)*	*(ft)*
3.5-6.5	5.0	50	10	33
4.4-8.0	6.25	40	8	26
10.0-14.4	12.5	20	4	13
18.0-29.7	25.0	10	2	6.4

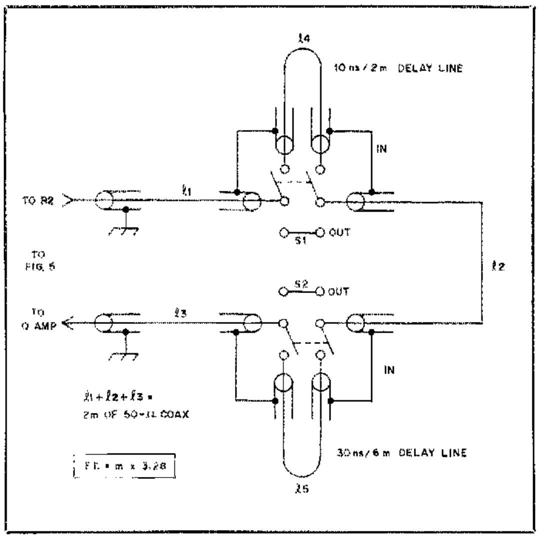
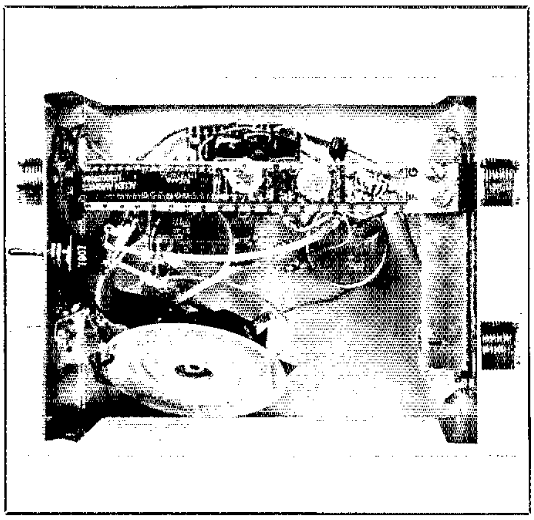


Fig. 7 — Schematic diagram of the delay line for use with the null steerer control unit at frequencies from 3.5 to 29.7 MHz.



An inside view of the null steerer control unit. In this unit, a 10-ns coaxial-cable delay line is wound on a small spool. A 40-ns delay line is encapsulated in the 14-pin DIP package at the upper left of the unit.

reflections. A single null will have little effect.

5) Broadband radiated noise can be nulled as deeply as any radio signal. This seems to be a more effective counter to noise than any blanking or limiting technique. These observations have some special meanings when propagation differences between desired signals and interference are considered. When the desired signal is of a type that nulls poorly, then it is almost certain that only interferers will be nulled. Close, strong interferers have the deepest nulls.

Acknowledgments

I would like to thank Arthur Truckenbrodt (W1GMM) for his support during the controlled jamming tests, and to acknowledge the sponsorship of the demonstrations by the U.S. Air Force.

Notes

[1] J. K. Webb, "Electronic Steering of Antenna Nulls for HF Interference Reduction," British IEE Conference on HF Communications Systems and Techniques, London, Feb. 1982.

[2] W. Hayward and D. DeMaw, *Solid State Design for the Radio Amateur* (Newington, CT: ARRL, 1977).

[3] Delay lines in 14-pin DIP packages are manufactured by Allen Avionics, Inc., Division of A. K. Allen, Co., Inc., 255 E. 2nd St., Mineola, NY 11501.

[4] ft = m × 3.28.

[5] km = mi × 1.609.

New Books

☐ *Electronics Engineers' Handbook,* by D. Fink and D. Christiansen. Published by McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, NY 10020. Hardbound, 9-1/2 × 6-3/4 inches, 2253 pages and 2189 illustrations, $75.

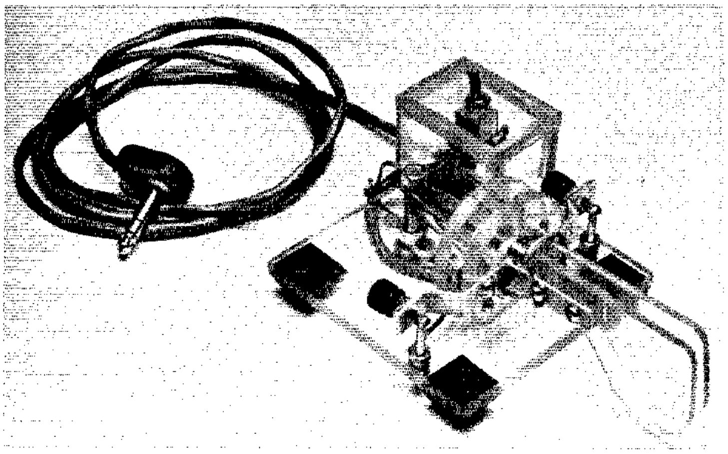
Technically inspired amateurs and professional engineers should find this second edition of *Electronic Engineers' Handbook* a fine reference to use as a sophisticated adjunct to the ARRL *Radio Amateur's Handbook.* The volume covers a full range of engineering themes that are germane to the technology of today, including a substantial amount of logic and digital information. This will no doubt have considerable appeal to those amateurs who are involved with microprocessors, computer-aided circuit design and other computer applications of interest to hams.

Other sections of the publication deal with (1) principles of electrical engineering; (2) materials, devices, components and assemblies; (3) electronic circuits and their functions. (4) electronic systems and their functions. Each of the four major book sections breaks down into numerous subcategories. Notable among the topics treated throughout the book are the properties of materials, discrete components, integrated circuits, uhf and microwave devices, transducers and sensors. Other subjects covered are filters, attenuators, amplifiers, oscillators, modulators, demodulators, detectors, converters, pulse circuits and waveform generators. Another part of the massive book deals with sound reproduction and recording systems, TV and FAX, broadcast systems, radar, medical electronics, electronic navigation and underwater sound.

It should be stressed that this is not an experimenter's handbook. That is, one should not expect to find myriad practical circuits with assigned parts values. There are plenty of circuit examples, but those wanting to work with specific circuits must be willing to apply the design principles that are given. If mathematics frightens you, don't buy this book: there are numerous equations (necessary in any routine design work), and some are pretty complex. But, they are not beyond the capability of those who know how to use a scientific calculator.

This reviewer has only scratched the surface in describing the comprehensive contents of this reference. It would require two *QST* pages to provide an in-depth rundown of the themes the authors have covered. If you maintain an up-to-date technical library, you'll want this book in your collection. If you're merely a tinkerer, this book is probably not for you. — *Doug DeMaw, W1FB*

The "CHIP" (Cheap, Homemade Iambic Paddle)



Paddles on a chip? No, but for a next-to-nothing investment you can have a first-rate paddle for your keyer!

By Larry Wolfgang,* WA3VIL

Good, inexpensive keyer paddles are hard to come by. I tried several designs at friends' shacks and at hamfests but they cost too much; I have always felt that a good paddle could be made from scrap material if a little care is used. After taking some mental photographs of the construction methods used in the various designs, I concluded that the W8FYO design (such as the Bencher paddle) was about the best I had tried. When I decided to build a paddle to go with my Accu-Keyer, that one formed the basis for my project. Several ideas for variations were incorporated into my design.

I studied the mechanical details of the Bencher paddle by taking one apart to see what made it "tick." When I understood the principles that allow it to work as smoothly as it does, I drew some sketches of the parts I would have to make. My father provided an almost limitless supply of scrap Plexiglas®, so there was no question what material to work with!

The parts were cut and shaped in one weekend. Since the initial assembly, I have made several improvements in the mechanical details, and will probably continue to make changes as I become more familiar with the operation. The reaction of some dedicated Bencher users has been that I have almost matched the smooth operation that paddle is known for.

Working With Plexiglas

When I started to build this paddle I decided to see if the job could be done using only hand tools. If you have a drill press, by all means use it! If you are using a hand drill, take extra care to drill the holes perpendicularly through the plastic. The best tool I have found for cutting Plexiglas is a bandsaw. The blade cools itself, and does not melt the material as you cut. A sabre saw with a thin, fine-toothed blade can be used, but you may have to go through the cut a second or third time to clean out the fused material. A hacksaw works very well for straight cuts, but not on curves. A coping saw will do a nice job on fine curves, but is slow. Too much pressure will break the blade.

I like to round the edges and corners and smooth any rough spots after cutting. I clamp my electric hand drill in a vise and put the sanding disc in the chuck. With the drill running, I lightly touch the Plexiglas to the sandpaper until I'm satisfied with the edges.

Construction Details

The dimensions for the parts are not very critical. You must be careful to maintain the symmetry of mating sections, however. The dimensions used on my paddle are given in Fig. 1.

Use a scribing compass to draw the circles for the armature and armature-support pieces, or choose a suitable round object and trace around it. If this method is used, it will be more difficult to mark the exact center for the hole in the middle. Cut out the two pieces, then clamp them together in a vise. Use a wood bit to drill both center holes at once. It may be helpful to drill a pilot hole for the center of the wood bit first. Complete the hole by drilling from the other side (so the bit doesn't break through and chip the Plexiglas).

Mark and center punch the holes for the stop screws (no. 8-32) and for the armature-retention screws (no. 6-32). Clamp both pieces together in a vise, and drill these holes. Next, they should be tapped for the thread sizes indicated. The holes in the armature (for the armature-retention screws) will have to be several sizes larger to allow free movement. Now, the holes for the armature-support pins will have to be marked and center punched in the armature-support piece. Cut the head off one of the nails that will be used for the support pins, and use it as

*Assistant Technical Editor

a drill bit to bore through the armature support. After these holes have been made, clamp the armature and armature-support pieces together and use the nail to start small holes in the armature. Drill all four holes to the same depth (about 1/32 inch).[1]

Cut the base section to size, and mark the position of all holes, being careful to keep everything square. I made the slot for the tension-adjusting bolt by drilling a series of smaller holes close together in a straight line. When I enlarged these to size, the drill bit opened the space between holes. Then, by holding the drill in the top hole, with the base clamped in my vise, I slid the bit downward, cutting the slot to size. A small file was used to smooth the edges as I completed this part of the job.

Carefully center the armature support over the mounting holes in the base. Mark the position of these holes on the armature support, and drill the holes to be tapped for no. 4-40 hardware. Be careful when you drill these holes; if they are a little crooked, the support will not mount straight, or you may bore through the sides of the support. Drill to a depth of about 3/8 inch, then tap the holes.

[1]mm = in. x 25.4.

You are now ready to install the armature-support pins. Mine are made from small wire nails. No. 18 nails, 1 inch or longer, should work fine. Cut the heads off four nails with a wire cutter. Force the pins through the holes in the armature support; the tighter the fit the better. To ensure that all four pins were even, I laid the armature support face down on my desk and put a small level across it. Check it two ways at a 90° angle to be sure it is even. When you are satisfied, apply a small drop of Super Glue® (or other acrylic cement) on each pin. Place the armature face down on the table and stand the armature support on top of it. The pins should line up perfectly with the holes in the armature. Again, check to be sure the system is level and solid; if not, note which holes need to be drilled a bit deeper in the armature. Work a little at a time until the pieces line up properly. Cut the armature in half, as shown in Fig. 1. I used a hacksaw, with the blade flat along the surface, to help ensure a straight cut. Use a sanding disc to smooth the cut and round the corners. You may have to sand a little extra, so the two pieces will move freely when mounted.

Use 1/8-inch Plexiglas for the paddles. The ones shown in the photo may seem too large; Fig. 1 shows a smaller pattern. Cut two identical pieces. The shape is a matter of personal choice.

To make the mounting brackets and contacts you will need some narrow strips of metal. I used pieces of scrap 1/16-inch aluminum chassis material, but thin steel might be better. The aluminum tends to give a little when the contacts are closed. The strips I used were 3/8 inch wide × 3-1/4 inches long. Make a 90° bend about 1 inch from the end of the strip. Drill two holes in the 1-inch section of each bracket, then match these up and drill holes in the paddle pieces. The holes in the bracket should clear no. 6-32 bolts, and the Plexiglas should be drilled and tapped to accept these bolts. A slot must be cut in each bracket to allow for adjustment in mounting. This can be done in a fashion similar to cutting the slot in the base. A 1/2-inch section of the bracket must be bent back on itself and flattened. It then should be drilled and tapped to mount the contact points. I found some brass screws (no. 6-32) with a knurled head at a hamfest for 10 cents each. A nut and lockwasher, put on the screw before threading it through, will lock the contact point in place when set.

Assembly

Final assembly is relatively simple. Install the 1/4- × 2-inch bolt and the two 6-32 × 1-1/2 inch bolts on the base. These are held in place with a nut above the base. Use a star washer and a nut below. The no. 6-32 bolts have solder-lug star washers to simplify the electrical connections.

The paddles are bolted to the mounting brackets, and the brackets are bolted to the armature pieces. A piece of copper braid was used to make the common connection between the paddle mounting brackets and the keyer ground. This was attached by forming a hole in the braid and putting one of the paddle mounting screws through it. The photograph shows this wire.

A rubber band is used to hold the armature on the armature support. Your choice will determine the amount of tension on the paddles. I found a nice heavy one about 3 inches long. The ends are looped around the paddle mounting brackets before bolting them to the armature pieces. The middle of the rubber

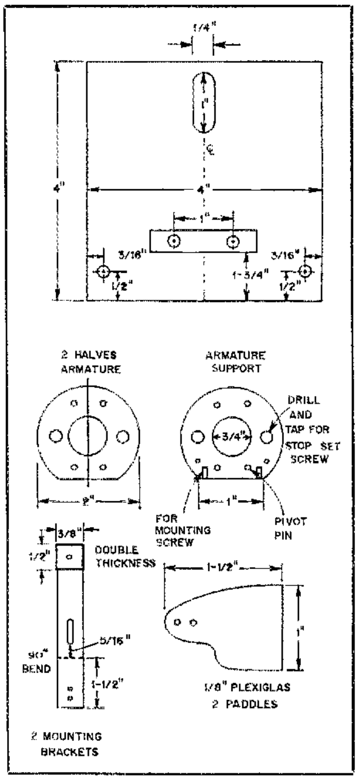


Fig. 1 — Drawings show the dimensions and shapes of the parts needed to build a CHIP.

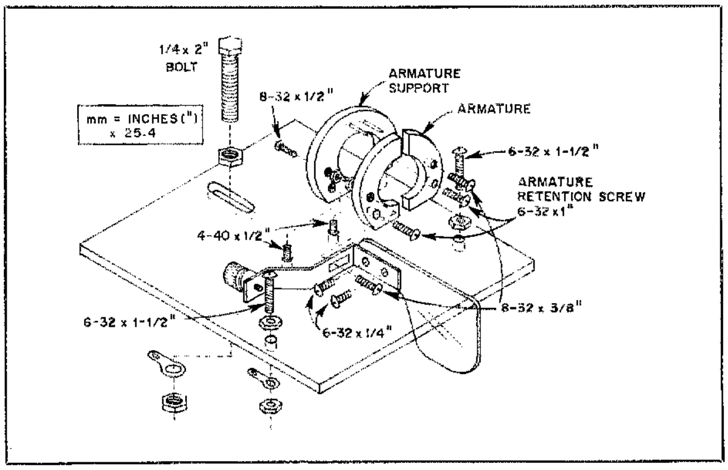


Fig. 2 — Exploded view of the CHIP assembly details.

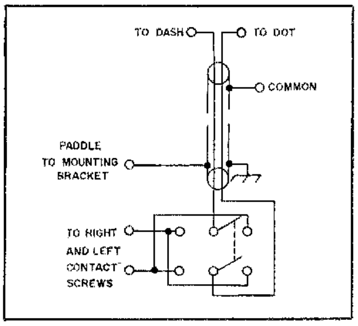


Fig. 3 — Electrical connections for the CHIP. A dpdt switch reverses the dot and dash lead to the keyer.

band is pulled through the center hole in the armature and armature support, then put around the tension-adjust bolt. Fig. 2 shows assembly details.

Final Adjustment

Position the armature-stop screws so that both sides of the armature are parallel to the armature support. Some bending of the paddle mounting brackets will position the contact screws in line with the heads of the no. 10 bolts. Adjust the spacing to suit your taste, and adjust the tension to give the "feel" you like.

I included a switch so I could reverse the leads for left- or right-hand operation (Fig. 3). I used a dpdt switch in a small box, which is mounted on the back corner of the base. You could attach a small piece of plastic on the back or side of your unit and mount the switch horizontally. I normally use the paddle with my left hand (I'm right handed), but I occasionally use my right hand. If another person wants to use the paddle, the switch can be set for his or her preference.

Operation

I am very pleased with the smooth operation of this paddle. The only problem is when my 2-year-old "harmonic" plays with it. He squeezes the paddles together hard, and this tends to bend the aluminum mounting brackets. Then I have to readjust the contact spacing. I will probably replace the aluminum with steel strap.

Rubber feet on the bottom of the base provide clearance for the mounting hardware. A couple of chunks of Plasti-Tak® under the front feet hold the paddle in place. This material prevents the paddle from sliding around, but allows it to be moved easily when necessary. It leaves no marks or residue on the desk.

One of the best features of the "CHIP" is its cost: 20 cents for the contact screws! Everything else came from material I had on hand.

New Products

ARCHER® VOLTAGE SPIKE PROTECTOR

☐ Radio Shack, a division of Tandy Corporation, has introduced the Archer® Voltage Spike Protector (61-2790). This device absorbs voltage transients associated with power-line surges. These surges are caused typically by load switching and lightning strikes. The surges usually last for only microseconds, but may produce peaks of 5000 V or more. Modern electronics equipment is especially vulnerable to these voltage spikes.

Delicate components in an amateur transceiver, a TV set, a stereo or a computer can be protected from most transients by the use of a Voltage Spike Protector. The VSP plugs into any 117-V outlet, and the equipment to be protected plugs into it. A metal-oxide varistor is wired across the ac line in the VSP. The GE MOV® used in the VSP can dissipate up to 10 joules of energy, and has a rated maximum clamping voltage of 435 for a 50-A surge of 8-μs rise time and 20-μs pulse duration. As an added safety feature, the VSP includes an 18-A thermal-cutout device that acts like a fuse should the MOV surface temperature exceed 75° C (167° F) because of excessive transient energy.

Although the VSP will not protect your expensive electronic equipment from a high-energy transient caused by a nearby direct lightning strike, it is a simple first step to take. You won't need an electrician to install one, and it is very inexpensive compared to the cost of repairing your radio or computer. The Archer® Voltage Spike Protector is available at Radio Shack stores and participating dealers. Price is $9.95. — *Larry Wolfgang, WA3VIL*

TEN-TEC ENCLOSURES

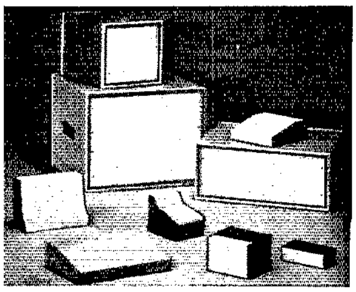
☐ Ten-Tec, Inc., has announced a newly expanded enclosure line. New models include high-style concepts in metal and metal/plastic combinations in larger bench and portable sizes.

The series 9 and 19 metal cabinets accept panel heights of 3.5 inches up to 17.5 inches, and widths of 9.5 and 19 inches.[1] Cabinet depths are 14.4 and 18.4 inches. There are 13 standard sizes. Welded aluminum construction is used. Standard rack panel mounting rails are provided at both front and back with interior racks for guide rails. Recessed side handles are provided in larger cabinets; smaller sizes are equipped with collapsible top handles. The styling features extruded aluminum front- and rear-edge bezels with walnut or black trim inserts. Standard textured finishes include blue, orange, black and dark brown. Optional front panels are offered in a variety of sizes with custom finishes. Special sizes, finishes and panel punching are available.

The series S, H and V use both metal and metal/plastic combinations, featuring sloping front panels for keyboard and switch-cluster configurations. Series S has 3-inch heights and four widths from 6.5 to 14 inches, with depths of 9 inches. The all-aluminum cabinets are available in standard textured finishes of blue or black with satin-aluminum or beige panels. Series H and V have metal chassis and plastic sides in walnut or black textured finishes. All three in this group have sloped and upright front panels.

For more information, contact Ten-Tec, Inc., Highway 411 East, Sevierville, TN 37862, tel. 1-800-251-9350. — *Paul K. Pagel, N1FB*

[1]mm = in. × 25.4.



Product Review

Conducted By Paul K. Pagel,* N1FB

Collins KWM-380 HF Transceiver

☐ For some amateurs, Collins radio equipment is a ham radio tradition. Over the years, the 75A series receivers, the S-line and the KWM-2 have helped establish Collins's reputation for high quality and performance. The latest Collins entry in the amateur market, the KWM-380, is in many ways different from the previous Collins products, but the Collins tradition is still present. It is a functional rig, incorporating the important operating features without a lot of "bells and whistles."

Receiver

One of the most prominent '380 features is the general-coverage receiver. An upconverting design, with the first i-f near 39 MHz, is used to provide continuous tuning from 1.6 to 30 MHz. There are provisions for five i-f crystal filters, any one of which can be selected independently of the operating mode. Two filters, an 8.0-kHz (a-m) and a 2.1-kHz (ssb) unit, are supplied as standard equipment. Our '380 review unit was equipped with 1.7-kHz, 360-Hz and 140-Hz filter options. There is also an optional 6.0-kHz filter for use in place of the standard 8.0-kHz a-m filter.

A feature most operators will find useful is the passband tuning. It allows the operator to move the receiver passband relative to the received signal (without changing the pitch of the signal). Passband-tuning operation in the '380 is similar to that found in other receivers, except that the passband tuning in the '380 also determines which sideband will be received. The MODE switch controls only the transmitter sideband selection.

Other receiver features include a hang type of agc with selectable decay rate (slow/fast/off) and an optional noise blanker. A built-in *front-panel* speaker is provided, along with headphones and external-speaker connectors. A line output provides an audio take-off that is independent of the AF GAIN control setting. This output is not disabled when headphones are used. Located on the rear panel are connectors for a second receiver (ANT RLY) and a separate receive antenna (RCV IN). Receive modes are usb/lsb, a-m and cw. During cw reception, an active af low-pass filter is switched into the audio chain to limit high-frequency hiss.

An interesting receiver feature is the SPOT button. When this button is pressed, a tone, equal in frequency to the transmit/receive frequency offset, is heard in the headphones or speaker. Tuning the receiver so that a cw signal produces the same frequency as the spot tone places the '380 transmit frequency within a few hertz of the received-signal frequency. The offset used in the '380 is 800 Hz.

Transmitter

The '380 transmitter section is all solid-state, has an output of 100 W (PEP), and provides 160- though 10-m band coverage. Additional frequency coverage is included for the MARS operator. The only transmit modes included in the '380 are cw and ssb. Automatic power turn-down protects the solid-state final amplifier from high SWR and excessive key-down time. During cw and RTTY operation, the output is reduced automatically to 50 W after a key-down time of 10 seconds. If the optional blower kit is installed, the full-power key-down time is extended up to one hour. A transmission-line SWR greater than 2:1 also causes an automatic power reduction.

The multifunction panel meter serves as an alc indicator, a forward and reflected power meter, and as a final amplifier dc voltmeter. Other standard features are the front-panel VOX controls and the manual transmit switch. Separate cw and ssb VOX-delay controls eliminate the need to change VOX adjustments when switching modes. Included on the rear panel are connectors for amplifier control and alc lines, a transverter output and an audio line input. An optional speech processor, employing a unique type of audio processing, is available for the '380. In the processor, the audio signal is split into two channels of equal amplitude, but differing in phase by 180°. Each channel is full-wave rectified (without filtering), and then the amplitude of the rectified signals is squared. By summing the two squared signals and taking the square root of the result, a dc signal, equal in amplitude to the peak amplitude of the audio signal, is produced. This dc signal is compared to the preset compression-threshold level to produce an agc voltage. By using this agc voltage to vary the gain of the audio amplifiers, an audio signal of constant *peak* amplitude is produced. The advantages of this patented approach are low harmonic distortion (because clipping is not used) and instantaneous response. All processing is done at af; therefore, mixers and rf filters are not needed.

A combination ac/dc power supply is contained in the '380. The supply can be connected to operate with input voltages ranging from 105- to 250-V ac. Dc operation requires 12 to 15 V at a current of approximately 20 A (3 A during receive). A large, aluminum heat sink is used to cool the power-supply devices and the final amplifier transistors.

Frequency Control

A fully synthesized local oscillator and digital control system perform the tuning functions in the '380. Push-button switches, located directly above the tuning knob, are used to select the desired tuning rate (1 MHz, 1 kHz, 100 Hz or 10 Hz per step). The 1-MHz and 1-kHz per-step rates are used as a "band switch," while normal tuning is done with the 100-Hz and 10-Hz per-step rates. The tuning knob provides 200 steps per revolution in all except the 1-MHz per-step rate. This translates to tuning rates of 2, 20 and 200-kHz per revolution. The 1-MHz per-step rate yields a 10-MHz-per-revolution tuning speed. A LOCK button electrically disables the tuning knob, thus preventing accidental frequency changes. The remaining VFO push button, SYNC, is used in conjunction with the A and B VFO memories.

To provide the equivalent of dual VFOs, the '380 has two VFO memories, or registers. A VFO switch enables the operator to select register A or B to control the VFO frequency. The contents of the selected register are displayed on the seven-digit LED display. Split-frequency operation, is also provided. Either register can be selected to control the receive frequency while the other register controls the transmit frequency. The transmit and receive frequencies don't have to be in the same band. It is necessary only that the transmit frequency is in an allowed range. The SYNC button mentioned earlier is used to load the frequency in the selected register (the displayed frequency) into the other register. This can be used to set up the '380 for split-frequency operation, or to use the second register as a frequency memory.

For example, if you want to work a station that is operating "split," you simply tune in the station using, say, VFO A, and then press SYNC. Now the transmit frequency of the other station (your receive frequency) is stored in register B. All that is necessary now is to tune

*Assistant Technical Editor

to the listening frequency of the station, set the VFO switch to RB-TA (receive B, transmit A), and call the station.

The frequency control story doesn't end with dual VFOs — enter the AC-3803 Control Interface. This '380 option expands on the flexibility offered by the digital VFO. When used with a user-supplied 16-button (two-out-of-eight) keypad, the control interface provides the operator with 11 frequency memories. These memories can be loaded from the selected VFO register (by pressing the ENTer key), or a different frequency can be keyed in and stored without disturbing the current VFO frequency (by using the STOre key). Any stored frequency can be recalled simply by pressing the recall (RCL) key and the desired memory number. A step (STP) key enables the operator to scan the memories manually, automatically skipping any unprogrammed locations. The clear (CLR) key allows you to remove incorrectly entered digits.

Limited operating-frequency information (tens and ones of MHz) is also available at the control-interface connector. This output data is intended for automatic control of external band-switched equipment, such as an amplifier or a Transmatch. The interface also allows the use of a home computer for transceiver frequency control. Although it is pointed out in Collins literature that specific computer programming information is not available, the necessary programs should be straightforward.

Receiver-Circuit Highlights

Amateurs with a curiosity about high-performance receivers will find the design used in the '380 interesting. Collins has applied proven techniques and devices carefully, rather than use radically new approaches to achieve a high level of receiver performance. In fact, the devices and circuits used in the receiver rf, i-f and audio sections will be familiar to most receiver enthusiasts.

Front-end filtering is provided by a combination of a broadcast-band rejection filter, a diode-switched high-pass filter and a 30-MHz low-pass filter. The correct high-pass filter is selected automatically as the operator tunes the receiver. After front-end filtering, the incoming signals are applied to a high-level (+17 dBm LO) diode-ring mixer. Following the mixer is the first i-f amplifier. A U322 JFET is used in the common-gate configuration in this stage. After this stage of amplification, the signals pass through a 4-pole crystal filter and then to a dual-gate MOSFET amplifier. Agc is applied to this amplifier and also to a pin-diode attenuator that proceeds the first mixer.

The noise blanker (optional) is located between the MOSFET amplifier and the second mixer. This mixer is also a diode ring type (+7 dBm LO). In it, the signals are converted to the 455-kHz second i-f. A broadband bipolar amplifier follows the second mixer. Output signals from this amplifier are applied to the passband tuning (PBT) unit. Another pin-diode agc attenuator is used between the PBT section and the last i-f amplifier.

The i-f crystal filters are contained in the PBT unit. Although this assembly is in the 455-kHz second i-f chain, the crystal-filter center frequencies are near 6 MHz. Received signals are heterodyned to the filter frequency, filtered and then converted back to 455 kHz. Use of the same variable oscillator for both conversions allows the passband to be shifted.

On-the-Air Performance

Operating the '380 was a pleasure. The front-panel controls are well-placed and easy to use. Becoming familiar with them took only a short time. Most of the controls are similar to those on other rigs, and their functions are straightforward. Selecting the receive sideband (using the PBT control) and changing bands with the selectable-rate tuning controls took some time to get used to. The control interface and key pad eliminated the latter problem. In fact, all of the control-interface features were very useful.

A "must have" option for dedicated cw ops is a narrow-bandwidth i-f filter. While narrower than the standard 600- or 500-Hz filters supplied for many transceivers, the 360-Hz filter in the '380 seemed optimum for general operating. Under certain conditions, having the option of switching to the very narrow 140-Hz filter greatly increased my operating enjoyment. The excellent frequency stability and the selectable slow-tuning rate of the '380 made using the narrow filter easy. Both cw filters have good skirt selectivity, and the '380 does not suffer from poor ultimate attenuation or "filter blowby."

I found the 1.7-kHz RTTY filter to be useful in fighting QRM during ssb operation. The extra selectivity can be a benefit, and the reduction in voice quality is minimal. Under better conditions, the 2.1-kHz filter provided good selectivity and excellent audio quality.

Having a general-coverage receiver in the shack opened the way to many hours of interesting SWLing and some broadcast-band DXing. While the '380 tuning range is specified as having a lower limit of 1.6 MHz, the receiver does tune to lower frequencies with reduced

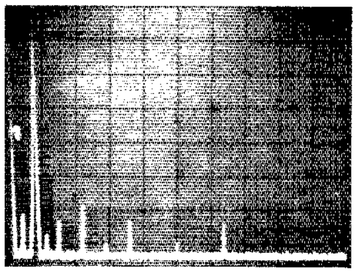


Fig. 1 — Worst-case spectral display of the KWM-380. Vertical divisions are each 10 dB; horizontal divisions are each 10 MHz. Output power is 100 W at 7 MHz. All spurious emissions are at least 58 dB below the fundamental output. The KWM-380 complies with current FCC specifications for spectral purity.

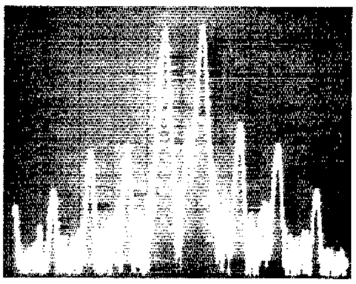


Fig. 2 — Spectral display of the KWM-380 during transmitter two-tone IMD test. Third-order products are 33 dB below PEP output, and the fifth-order products are 40 dB down. Vertical divisions are each 10 dB; horizontal divisions are each 1 kHz. The transceiver was being operated at rated output power on the 20-m band.

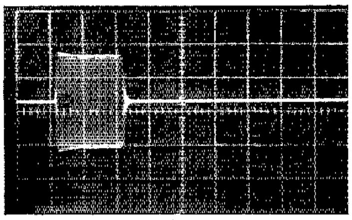
Collins KWM-380 HF Transceiver, Serial No. 1600

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: Receive — 1.6-29.999 MHz in 10-Hz steps; transmit — 1.8-1.999, 3.25-4.25, 6.75-7.55, 10.1-10.149, 13.75-14.6, 18.068-18.169, 20.75-21.7, 24.64-25.239, 27.75-29.949 MHz in 10-Hz steps.	As specified.
Modes of operation: Receive — a-m, ssb, cw; transmit — ssb, cw.	As specified.
Readout: 7 digit.	1/2 inch high, 7-digit red LED.
kHz/turn of knob: Not specified.	10 MHz/200/20/2.
Frequency resolution: 10 Hz.	As specified.
Backlash: Not specified.	Nil.
S-meter sensitivity (µV/S9 reading): Not specified.	160 m, 23; 80 m, 23; 40 m, 23; 30 m, 18; 20 m, 14; 17 m, 28; 15 m, 25; 12 m, 28; 10 m, 25.
Transmitter output: 100-W PEP.	As specified.
Harmonic suppression: Better than 40 dB.	−59 dB (see photo).
Third-order IMD: 31 dB below PEP.	−34 dB (see photo).
Spurious suppression: Better than 50 dB.	Better than 60 dB.
Receiver sensitivity: Less than 0.5 µV for 10-dB S+N/N.	Receiver dynamics measured with optional 360-Hz filter installed.

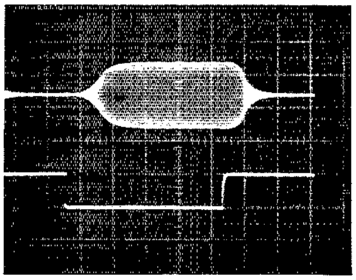
	80 m	*20 m*
Noise floor (MDS) dBm:	−131	−131
Blocking DR (dB):	noise limited	
Two-tone 3rd-order IMD DR (dB):	noise limited	
Third-order intercept:	noise limited	

Size (HWD): 6-1/2 × 15-1/2 × 18 inches.†	As specified.
Weight: 48 lb.††	As specified.

†mm = in. × 25.4 ††kg = lb × 0.454.



(A)



(B)

Fig. 3 — KWM-380 cw keying waveforms. First dot sent after VOX switching has a sharper rising edge because of alc setup time. It is also delayed approximately 20 ms, to allow external-amplifier changeover relays to switch and settle (A). The second, and all following dots, show normal rise and fall times of approximately 4 ms, and a delay of approximately 2 ms. This keying waveform should not cause key clicks (B). Horizontal divisions in A are each 20 ms; in B they are 5 ms.

sensitivity. The sensitivity reduction is a result of the broadcast-band roll-off filter used in the receiver front end. This filter is included to protect the receiver from overload by the strong broadcast-band signals found at some locations. It is possible to defeat this filter if a-m broadcast-band reception is desired. The high audio quality of the '380 was evident especially while listening to a-m broadcast stations.

I found the sensitivity of the '380 well suited to amateur-band operation, although some amateurs may prefer a slightly lower noise figure on the higher frequencies.

The weak point in the '380 receiver is the synthesized local oscillator. While it provides excellent frequency stability and tuning versatility, it also provides a relatively high level of LO sideband noise. This made it impossible to measure the IMD and blocking dynamic ranges using the current ARRL lab test methods. This is not a problem unique to the '380; LO noise problems of some degree are found in most synthesized transceivers. The '380 compares well with other synthesized receivers I have listened to. During routine operating, the LO noise is not readily apparent; only when a strong signal was within 10 or 20 kHz of the operating frequency did the effects of the LO noise become noticeable. The '380 LO also appears quite free of the spurs (removed from the LO frequency) found in some receivers.

Transmit performance was smooth and reliable. Reports on the cw and ssb signal quality were good, and the speech processor was effective. The only transmitter "glitch" was observed during cw operation. When the VOX circuit switched from receive to transmit, at the first key closure, an output transient could be seen on the station monitor scope. The transient lasted approximately 1 ms, and the peak amplitude was nearly equal to the normal full output power. It occurred just before the beginning of the normal output envelope. The people at Collins were advised of the problem, and we soon received a diode and instructions for installing it. Apparently, the diode had been omitted when a Service Bulletin modification was installed in the review unit. The keying waveforms shown in the photos were obtained after installation of the missing diode.

The owner's manual supplied with the '380 contains all the information necessary for transceiver operation. It also contains limited service information. The Collins service manual, a nearly 2-inch-thick volume, contains detailed information on how each transceiver section functions, complete parts specifications and numerous fold-out schematic diagrams. The modular construction used in many parts of the '380 should be a benefit if service is required. I was not surprised to find the overall component and construction quality to be high. In terms of reliability and good performance, the KWM-380 should continue the tradition established by the Collins equipment that preceded it. Price class: $4500. — *George Collins, KC1V*

TEN-TEC ARGOSY HF TRANSCEIVER

□ There is a trend in North America these days toward conservation and simplicity. Many Amateur Radio operators have discovered the joy and satisfaction of low-power (QRP) operation with simple equipment. Some grew tired or bored by the ease of establishing DX QSOs while running their super stations. Others never succumbed to the siren song of the "super snorter, signal-sender" syndrome. If you are one of that number, or if you are looking for a second or standby radio, consider the Ten-Tec Argosy.

Ten-Tec literally started a new era in the history of QRP when they introduced the Argonaut many years ago. This popular rig has ssb, as well as cw capability. Patience is a way of life for the QRPer (required to maintain one's sanity), but sometimes it is desirable to run a bit more power so that a contact can be made quickly and easily. While the Argonaut has only a 5-W input level, the 405 (a companion amplifier to the Argonaut) input level is 100 watts. The pair make a nice combination, but the FCC amplifier rules brought an end to production of the 405 in 1978. Grieve not: The Argosy has come, bringing the choice of low or medium power with it.

Features

A switch on the back panel selects either 10-or 100-W input. By adjusting the DRIVE control on the front panel, lower-power operation is possible. I found the power-select switch easy to operate; with my hand on the right rear of the top cover, my finger found and operated the switch easily.

The Argosy covers the current U.S. and Canadian amateur bands from 3.5 to 30 MHz. In addition, the 10-MHz WARC band is included, making a total of six hf bands in nine 500-kHz segments (four segments for 10 meters). Approximately 40 kHz of overrun is provided by the VFO on each band edge.

The analog frequency readout works quite well. The band-switch position tells the MHz increments. A linear scale with a lighted, red bar pointer (LED) indicates the hundreds of kHz. The kHz figures are read from the tuning-knob skirt; calibration is 1 kHz per division. Band changes are a dream with this all solid-state radio. There are no receiver front-end or final amplifier adjustments to make; just switch bands, change antennas, dial the desired frequency, and then transmit (after listening first, of course). Even the sideband selection is automatic.

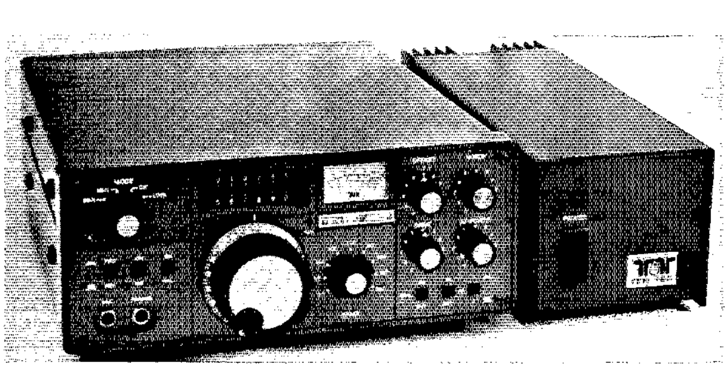
The front panel is clean and well laid out. The mode switch is located in the upper left corner; it has positions for sideband-normal (SB-N), reverse (SB-R), CW and LOCK. On the right side are the receiver OFFSET (RIT), the i-f NOTCH filter, the receiver AF-POWER and the transmitter DRIVE controls. Three push buttons are on the left panel switch: the wattmeter/SWR meter from FWD to REV, the optional noise blanker ON/OFF and the optional calibrator ON/OFF. Another set of three push buttons, these located in the lower right portion, control selectivity. One switches an optional i-f filter IN/OUT. (There are four optional crystal ladder filters available — 2.4- and 1.8-kHz 8-pole filters for SSB, and 500-Hz (8-pole) and 250-Hz (6-pole) for cw.) Two other switches are used for the optional audio cw filter — one for IN/OUT, the other for bandwidth. Position ONE is 450-Hz bandwidth; position TWO is 150 Hz. Center frequency is 750 Hz. A pair of 1/4-in. phone jacks[1] are used for connecting a microphone and a pair of headphones.

On the rear panel, located below the HIGH/LOW power switch, is the SO-239 antenna connector. On the other side of the rear panel is the four-pin power connector and ground post. Above these there are six phono jacks; they are for: KEY, + 12-V dc, AUX and three SPARES.

Operation

Full break-in (QSK) cw and push-to-talk

[1]mm = in. × 25.4; kg = lb × 0.454.



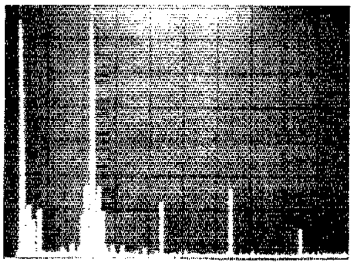


Fig. 4 — Spectral display of the Ten-Tec Argosy. Vertical divisions are each 10 dB; horizontal divisions are each 10 MHz. Output power is approximately 5 watts at 15 meters. The worst-case spurious emission is approximately 53 dB down from the fundamental.

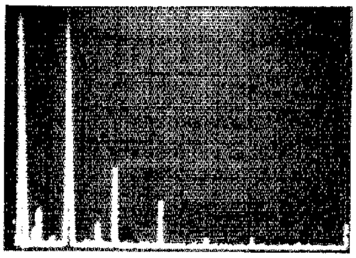


Fig. 5 — Spectral display of the Argosy. Vertical divisions are each 10 dB; horizontal divisions are each 10 MHz. Output power is approximately 40 watts at 20 meters. The worst-case spurious emission is approximately 48 dB down from the fundamental. The Argosy complies with current FCC specifications for spectral purity.

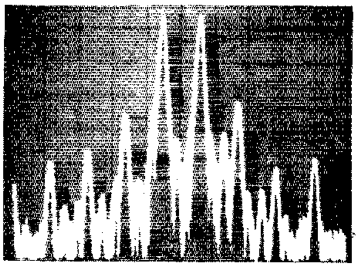


Fig. 6 — Spectral display of the Argosy during transmitter two-tone third-order IMD test. The third-order products are approximately 31 dB below PEP, and fifth-order products are about 46 dB down. Vertical divisions are each 10 dB; horizontal divisions are each 1 kHz. The transmitter was being operated at 100 watts of input power on the 20-meter band.

Ten-Tec Argosy HF Transceiver, Serial No. 00026

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: 3.5 to 30 MHz, including 10 MHz.	As specified, plus a minimum of 40 kHz additional at each band edge.
Modes of operation: Ssb, cw.	As specified.
Frequency display: Analog dial.	As specified.
Resolution: 1 kHz.	As specified.
kHz/turn of tuning knob: 18.	18.
Backlash: Not specified.	Nil.
RIT range: ±3 kHz.	±3 kHz.
Audio power output: 1 watt (8 ohms).	As specified.
Power consumption: Transmit, 122 watts; receive, 6.75 watts.	Not measured.
Transmitter rf-power output: 40-50 watts in high-power position; 4-5 watts in low-power position.	As specified.
Spurious suppression: Better than 45 dB.	54 dB worst case (5 W out); 60 dB worst case (40 W out).
Harmonic suppression: Better than 45 dB.	48 dB.
Carrier suppression: Better than 40 dB.	68 dB.
Transmitter third-order IMD: Not specified.	31 dB below PEP (see photo).
Frequency stability: Less than 20-Hz change per °F, averaged over a 40° change from 70° to 110° after a 30-minute warmup. Less than 15-Hz change from 105- to 125- V ac when using a Ten-Tec power supply.	620 Hz from cold start to one hour later.
S-meter sensitivity (μV/S9: Not specified.	Ranging from 21 to 27 μV.
Receiver sensitivity: 0.3 μV for 10 dB S + N/N typical.	Receiver dynamics measured with model 217 500-Hz i-f filter:

	80 m	*20 m*
MDS (dBm)	−133	−133
Blocking DR (dB)	99	98
Two-tone third-order IMD DR (dB)	64	64

Size (HWD): 4 × 9.5 × 12 in.
Weight: 8 lb.
Color: Gray.

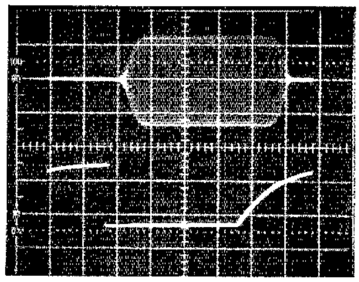


Fig. 7 — Cw keying waveform of the Argosy. Upper trace is the rf envelope; lower trace is the dc level at the key jack. Each horizontal division is 5 ms. The carrier level was adjusted until the alc indicator LED just showed full brilliance. Higher amounts of drive tend to sharpen the wavefront.

(PTT) operation on ssb are standard features of the Argosy. The built-in cw sidetone can be adjusted in pitch and volume to suit individual preference. To operate high power (100-W input), set the HI/LO switch to HI, and the mode switch to LOCK. Increase drive until the red ALC LED lights fully. Return the mode switch to the desired position and you are ready to transmit.

One of my first QSOs using the Argosy was with HZ1AB on 7-MHz cw. Later, while running QRP on the higher bands, many countries were contacted, including 3B8 and 9K2. I have used it in several contests with satisfactory results. Only the agc disappointed me. When the background noise level is low and signal levels are high, the first code element or voice syllable comes through with a loud "pop." This is caused by a too-slow agc attack time — a result of audio-derived agc. Most of the time this is no problem, but it can be particularly bothersome if one is wearing headphones. An rf gain control would help.

The second time the Argosy was turned on, the protective circuitry immediately shut it off. I turned the rig off and back on, and everything was fine. It still does that occasionally, but I find it no particular problem.

Output from the optional calibrator is pulsed. That makes it a lot easier to identify. I found that particularly useful amid the cacophony of the 40-meter band.

Clean audio characterizes the receive and transmit modes. Cw reception is enhanced by the addition of the 500-Hz i-f and audio cw filters. Yes, the Argosy has the stability to go with that kind of selectivity.

W1FB put the Argosy through its paces during a two-week "hamcation" on Barbados in April of 1982, operating 8P6EU. The transceiver performed admirably with sloping dipoles over the seashore. Worldwide DX contacts yielded reports ranging from RST 559 to 599.

Owing to the 85 to 95° F temperatures that prevailed during the daylight hours, and because of the 50-Hz line current on the island, the power transformer overheated. Operating with the top cover of the power-supply case removed solved the problem.

W1CKK, operating as 8P6FJ, had good results while using the unit on ssb. Reports indicated that the phone and cw signals from the Argosy were very clean — excellent audio quality and nice cw-note shaping. Certainly the transceiver is sized ideally for travel by airplane, and the weight is light with respect to comparable rigs.

You can buy the basic transceiver today and add the options later, if you desire. The optional features all mount easily inside the compact, metal cabinet. The Argosy is available from Ten-Tec, Inc., Sevierville, TN 37862. Price class: Argosy, $549; 225 power supply, $129; 226 calibrator, $39; 217 500-Hz filter, $55; 220 2.4-kHz filter, $55; 223 noise blanker, $34; 224 audio cw filter, $34. — *Chuck Hutchinson, K8CH*

Conducted By
Dennis J. Lusis,* W1LJ

GAIN OF VERTICAL COLLINEAR ANTENNAS

□ My friend employs a vertical antenna commonly used for 2-m fm communications, which is comprised of two λ/2 dipoles in phase, side mounted and spaced λ/4 from the supporting mast. The vertical spacing "S" is λ/2, providing maximum gain (see Fig. 1A). His neighbor employs a homemade antenna — two 5/8-λ vertical elements in phase, placed end-to-end, fed and matched by means of a λ/8 stub. His antenna is also side mounted on a supporting mast (see Fig. 1B). Which antenna has the most gain? The 5/8-λ collinear array would appear to, but actually my friend's antenna has a bit more gain!

The gain of a collinear antenna depends on the individual element lengths, the spacing between the elements and, if side mounted, the spacing between the elements and the mast. The gain is also critically dependent on the current phase in the dipoles. For maximum gain on the horizon, all elements must be fed in phase, and the current in each dipole element must be equal and balanced (i.e., symmetrical and in phase on each side of center). The gain of two end-to-end, 5/8-λ elements (better described as 5/4-λ dipoles) is 3 dBd. Two λ/2 dipoles spaced so that S = λ/2 provides 3.3 dBd of gain. Both antenna arrays are spaced λ/4 from the supporting mast, so the reflected wave from the mast combines with the direct wave from the dipole in the direction away

*Assistant Technical Editor

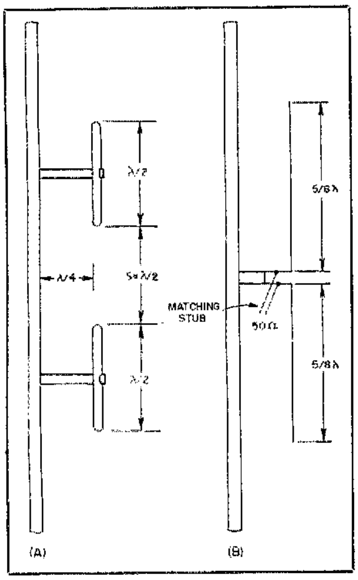


Fig. 1 — Collinear vertical antennas compared by author Belrose.

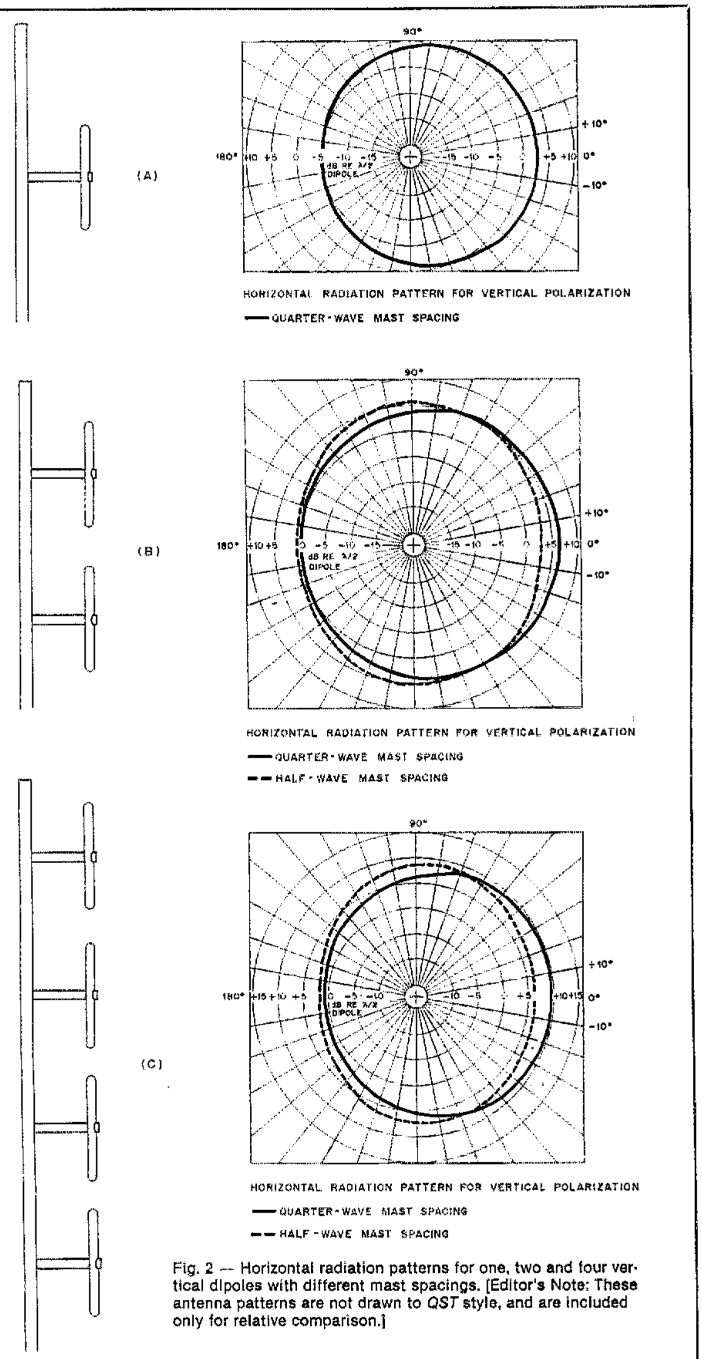


Fig. 2 — Horizontal radiation patterns for one, two and four vertical dipoles with different mast spacings. [Editor's Note: These antenna patterns are not drawn to *QST* style, and are included only for relative comparison.]

Table 1
Theoretical Gain When S = 0

Element Length		Number of Elements						
	1	2	3	4	5	6	7	8
	Gain (dBd)							
λ/2	0	1.7	3.2	4.3	5.2	5.9	6.5	7.1
	Gain (dBd)							
5/4λ	3	5.1	6.5	7.6	8.5	9.2	9.9	10.4

Table 2
Maximum Theoretical Gain

Element Length		Number of Elements						
	1	2	3	4	5	6	7	8
	Gain (dBd)							
λ/2 (S = λ/2)	0	3.3	5.2	6.2	7.5	8.3	9.0	9.6
	Gain (dBd)							
5/4λ (S = 5/8 λ)	3	6.2	8.1	9.4	10.3	11.1	11.8	12.4

from the mast. This increases gain by 3 dB. Hence the theoretical maximum gain for the two collinear arrays is 6 dBd and 6.3 dBd, respectively.

Table 1 shows the theoretical gains for stacked λ/2 dipoles, where spacings S = 0 and λ/2, and for 5/4-λ dipoles, where S = 0 and 5/8 λ. The spacings found in Table 2 are those that provide maximum gain. My calculations are rigorous, based on the assumption of cosinusoidal current in the elements. A computer program that performed a numerical integration over all radiation angles (0 to 90°) was employed.[1]

It is clear that optimally spaced dipoles provide significantly more gain than dipoles that are closely spaced (end-to-end). A simple estimate of which antenna has the most gain can be made by comparing the total length of the collinear antenna arrays (measured in wavelengths from the bottom end of the lowest element to the top end of the highest element). The collinear antenna that is the *longest* has the *most* gain. There is nothing magical about the use of 5/8-λ elements, except that individual elements must not exceed this length; otherwise, gain on the horizon will be less than the maximum obtainable.

The shape of the radiation pattern and the gain of the antenna depend on the spacing of the element(s) from the supporting mast. With a mast spacing of λ/4, the antenna has maximum gain in the direction of the element(s). The increase in gain is 3 dB. If the element(s) are spaced λ/2 from the mast, the pattern becomes bidirectional, with maximum gain (about 2 dB additional) in the plane perpendicular to that containing the element(s) and the mast.

Fig. 2 shows the horizontal patterns for one, two and four λ/2 dipoles, where S = λ/2 for λ/4 and λ/2 mast spacings. These patterns are for antennas of commercial manufacture. If an omnidirectional azimuthal pattern is desired, λ/4-mast spacing should be employed, with the elements arranged symmetrically around the mast. At least four elements are required to achieve an omnidirectional pattern.

There are almost as many methods of constructing and feeding collinear arrays as there are manufacturers of them. Many antennas made for amateur, as well as for commercial applications are end fed. In this arrangement, it is important that the antenna not be too long; otherwise, the upper dipoles will be fed with progressively smaller currents as compared to the bottom element. Also, careful design and construction is necessary to achieve in-phase currents in the elements. It is always necessary to choke off current flow on the braid of the coaxial feed line. When purchasing an end-fed collinear antenna, be sure that the manufacturer has measured the vertical radiation pattern, since the vertical patterns for some commercial (and homemade) antennas are tilted upward. The pattern maximum should be aimed toward the horizon. — *John S. Belrose, VE2CV, ARRL TA, Aylmer, Quebec, Canada.*

[1]The calculations were made employing a program available for the Hewlett-Packard model HP-41CV calculator.

References

Belrose, J. S. "The 300-Ohm Ribbon J Antenna for 2 Meters: A Critical Analysis." *QST,* April 1982.
O'Dell, P. "Decouple VHF Verticals." Technical Correspondence, *QST,* April 1982.
Tilston, W. V. and A. H. Secord. "The Radiation Patterns of Ground Rod Antennas." *Electronics and Communications,* Aug. 1967.

VIDEO "HUM" IN AUDIO AMPLIFIERS AND DIRECT-CONVERSION RECEIVERS

☐ Have you been frustrated by a persistent, somewhat raw-sounding "hum" in an audio amplifier or a direct-conversion receiver? Do all your attempts to filter, decouple and shield fail to eliminate it? If so, you may be listening to the video being transmitted by your local TV station. Although TV video has a bandwidth of several megahertz, it contains strong components very close to the line frequency and its harmonics.

Video can be distinguished from power-line hum by its rather "buzzy" nature, and the fact that its sound characteristic changes with the TV picture. The latter characteristic can be particularly misleading, since it often seems to change just as you're jiggling components, adding a bypass, or moving the rig. You can positively identify detected video by listening to the offending noise while watching each local TV station in turn. If the sound changes when the picture does, you're hearing video. On an oscilloscope connected to the audio output of the amplifier or receiver, and triggered by the power-line frequency, ac hum won't move. But video will slowly drift horizontally, taking about 20 seconds for the pattern to repeat.

Some direct-conversion receivers are susceptible to envelope detection. These can detect video, which amplitude-modulates the TV carrier. After identifying the noise as detected video, remove the receiving antenna. If the noise disappears, envelope detection is probably the culprit. Curing the problem involves using a mixer that is less susceptible to envelope detection, adding a low-pass filter in front of the mixer, or modifying existing circuits between the antenna and mixer to provide good attenuation at vhf.

A less obvious way for video to be demodulated and amplified is through the earphone or speaker lead into an audio output stage. Such a stage is frequently configured as shown in Fig. 3, in which gain is provided by an IC or a discrete operational amplifier. When a TV signal is picked up by the speaker or earphone leads, it's coupled through C_F (which has a low impedance at vhf) and into the inverting (−) input of the amplifier. There it's detected, and the resulting video is amplified and delivered to the speaker or earphones as the hum described earlier. This source of pickup can generally be cured by bypassing the earphone or speaker jack with a 0.001-μF capacitor — larger values may cause amplifier instability. Stubborn cases might require using shielded cable to the speaker or earphones. It's also possible that other strong a-m signals can be detected this way too, but vhf sources such as TV are most likely to cause problems. This is because typical earphone or speaker leads make a relatively effective antenna at vhf. — *Roy W. Lewallen, W7EL, Beaverton, Oregon*

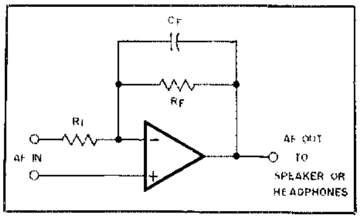


Fig. 3 — Basic audio-amplifier configuration.

Feedback

☐ Frank Noble, W3MT, informs us that there was an error on the schematic diagram for his L-C audio oscillator (Fig. 1, page 25, June 1982 *QST*). The capacitor at position B under S3 should be 0.1 μF. If you are building this oscillator and cannot find any of the scarce 44-mH toroids, Frank is redesigning the circuit to use all unpotted 88-mH units. He will send a revised schematic diagram to anyone who writes and includes an s.a.s.e. Frank Noble, W3MT, 10004 Belhaven Rd., Bethesda, MD 20817.

☐ Please note this correction to the i-f amplifier schematic diagram of the "Progressive Communications Receiver," Nov. 1981 *QST*, p. 17, Fig. 8. A 2.2-kΩ resistor should be placed in parallel with the primary (drain) winding of T4. Author Hayward notes that this resistor was omitted on the submitted diagram, and its absence could lead to severe i-f system oscillation.

☐ The colorful photo of the hot-air balloons on the cover of September *QST* was taken by Gerald Bowling of Visalia, California. Our apologies for inadvertently failing to give him credit in the issue.

Hints and Kinks

Conducted By Larry D. Wolfgang,* WA3VIL

MOBILE MOUNT AND DESK

☐ I needed a secure mount for my mobile station. The plastic dashboard of my new car did not seem strong enough for a conventional under-the-dash mount. An installation in a police cruiser gave me the idea for a desk-on-the-seat mount, as shown in Fig. 1. The front panel extends from the seat to the floor, and supports the box. A mobile mounting bracket fastened to the front piece places the rig in a convenient position. An extra bracket even allows two radios to be stacked piggy-back style. The box is used to store extra paper, pencils and other small items. A clipboard is attached to the top for writing.

Construction details are given in Fig. 2. You may have to vary the dimensions to fit your car and rig. My car has a bench seat in the front, and I use the center seat belt to hold the unit in place. This mounting method does not affect the comfort of the driver or one passenger. The rig does not block the heater vent, and with the radio mounted vertically the controls are easy to see and operate. — *Albert Keyworth, K1TKI, Mansfield, Massachusetts*

*Assistant Technical Editor

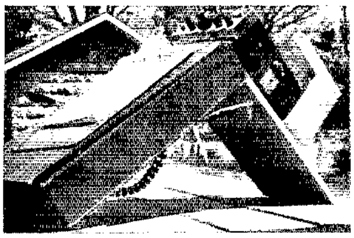


Fig. 1 — This photo shows the completed mount, with one radio attached. Note the extra mounting bracket for a second rig. You may have to shape the front piece to fit the transmission hump in your car.

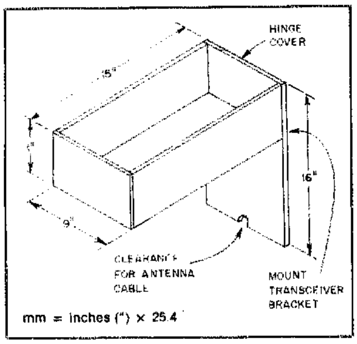


Fig. 2 — Construction details of the mobile desk. The dimensions should be adjusted to suit your car and rig.

EXPANDED RIT RANGE FOR THE ASTRO-150

☐ A drawback of the Swan Astro-150 transceiver is the limited RIT and FINE tuning ranges.[1] Here's a simple "no-holes" mod to extend the range of these controls.

Remove the bottom cover and the five screws that secure the band switch and VCO board. Disconnect the ribbon cable at connector P114, three RG-174/U cable plugs and the voltage-regulator socket. The board now can be removed. Locate R110 and R127, two 18-kΩ resistors to the left of the ribbon-cable connector. On the underside of the board, solder a piece of wire to short each resistor.

I operate only on 10, 15 and 20 meters, so my objective was to increase the RIT/FINE range on these bands. There is no effect on 40 or 80 meters. You will find that the tuning range increases with the frequency band. On 10 meters, the range is just over ± 1 kHz.

If you want even more tuning range, and an increase in range on 40 and 80 meters, you might consider replacing R111 and R126, two 8.2-kΩ resistors, with lower-value units. Because there is no way to turn off the RIT/FINE controls, and no detent or other way to be sure the controls are exactly centered, you should be extra careful when working near the band edges. — *Lance Holt, N9CDD, Biloxi, Mississippi*

RF CHOKE AND FUSE FOR IGNITION-NOISE SUPPRESSION

☐ The standard in-line fuses used with most mobile radio equipment measure 1-1/4 inches long by 1/4 inch in diameter.[2] By replacing this fuse with a smaller one (3/4 or 5/8 inch in length) having the same current rating, you will have room inside the fuse holder for an rf choke. One or two small ferrite beads and a piece of wire can be fashioned into an rf choke that will contact the bottom of the fuse holder and the fuse. Two Amidon[3] FB73-101 (or one FB73-1801) beads with no. 18 wire should work fine. Simply pass the wire through the bead and bend it over to form a contact on the end. A loop in the wire and a solder blob may help fill out the space. You may also have to wrap the small beads in a strip of electrical tape to increase the diameter. — *Cliff Buttschardt, W6HDO, Los Osos, California*

SWAN 45 MOBILE-ANTENNA REPAIRS

☐ I have had good results with my Swan 45 Mobile Antenna. One problem has developed, however, after many miles of high-speed travel and hot temperatures. The plastic coil supports became brittle, then broke. This allowed the coil and whip assembly to bend from the lower mast, causing erratic operation while moving.

To repair the antenna, disassemble the whip and whip quick-disconnect piece from the coil. Remove the two Phillips-head screws located just above the tuning scale on the mast. Loosen the Allen screw in the ring below the bottom coil support. Unsolder the two wires found at the top of the mast, and pull gently. The coil assembly should separate. You may have to put a flat screwdriver blade in the slots in the top of the lower mast to help separate the pieces. Replace the plastic coil supports, and reassemble your antenna.

I purchased replacement pieces from Cubic Communications,[4] but an alternative would be to make coil-support pieces from the tops of a couple of spray-paint-can lids. Use a razor blade or hobby knife to cut holes for the mast and the quick-disconnect unit. Silicone sealant can be used to weatherproof the new assembly. — *John Webb, KO5D, Vernon, Texas*

THE SNEAKY KNEE KEY FOR MOBILE CW

☐ I am as happy as a clam when I have keyer paddles between my fingers, but feel frustrated when I must use a mike instead. Therefore, I found mobile operation less and less delightful. I resolved to do something about it. My finely tuned Bencher paddles tended to lose the feather-like touch after bouncing off the firewall several times. None of the tie-down schemes I dreamed up seemed to protect my paddles and still keep them in a convenient operating position.

I decided to attack the problem from a different angle: to start from scratch, and to design a set of iambic keyer paddles that were inexpensive, rugged, convenient and easy to use. About this time, I happened across an old Army Signal Corps version of a mobile cw key at a swapfest. It consisted of a straight key fastened to a steel clamp that fit around the operator's thigh, just above the knee. It was *only* a straight key, and the big clamp was uncomfortable. The basic idea seemed like a good one, though.

My friend Tom Speed, K6WI, made a suggestion I liked. Instead of making a set of squeeze keys, why not build a pair of push keys? Rather than squeezing two switches toward a central point with my thumb and index finger, why not push two switches down with my index and middle fingers? I hooked up two microswitches and tried keying in this unorthodox style. To my surprise, it was very easy, and I was able to key reliably at around 30 wpm after a few minutes of practice.

Thus heartened, I built the model shown in Fig. 3. My wife suggested attaching it to my knee with a broad band of elastic and some Velcro® strips, and this has proven to be extremely comfortable. The whole thing cost me less than $10, and went together in an evening. I got the two switches at Radio Shack, and mounted them on a piece of single-sided pc-board material. Rather than etch the pattern onto the board, I gouged out the excess copper with a small hand drill. The placement of parts

[1] J. Pelham, "The Swan Astro-150 Transceiver," Product Review, July 1980 *QST*, p. 41.
[2] mm = in. × 25.4.
[3] Amidon Associates, 12033 Otsego St., North Hollywood, CA 91607.
[4] Cubic Communications, Inc., 304 Airport Rd., Oceanside, CA 92054.

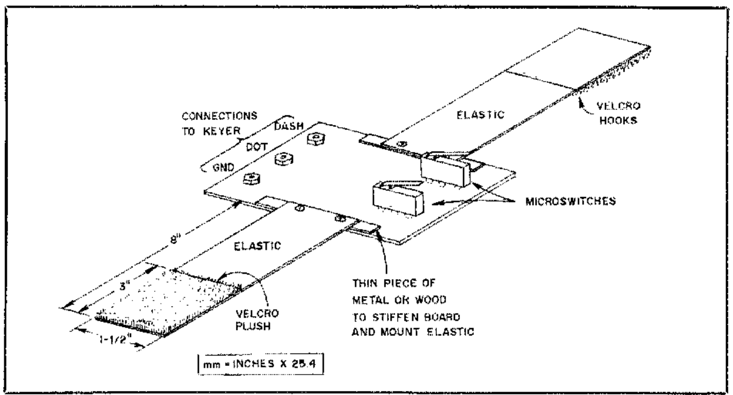


Fig. 3 — Sketch of the basic design of the Sneaky Knee Key. The two microswitches are spaced to be operated conveniently by your fingers.

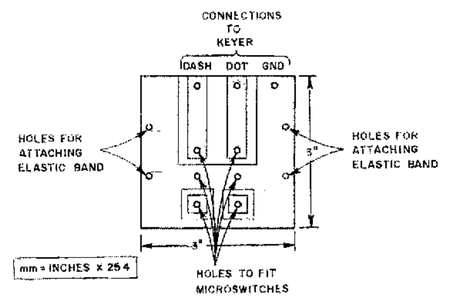


Fig. 4 — A pc-board pattern for the Sneaky Knee Key. Black represents copper. The pattern can be formed by cutting the copper with a hobby knife and removing unwanted strips by heating with a soldering iron. Alternatively, the author used a drill bit to gouge the copper off.

in this project is not critical (Fig. 4). All of the components are inexpensive and easy to replace.

The paddles have been in almost constant use on my mobile cw expeditions, and have held up extremely well. My right hand is never far from the steering wheel or gear shift. When trouble arises on the road, I send a quick little AS, and the other station stands by until I am clear of danger. It helps to have full break-in at both ends of the conversation. I use a Ten-Tec Argonaut, which has this feature, as well as RIT. To help keep the amount of hardware flopping around on my front seat to a minimum, I built a CMOS version of the Accukeyer inside the base of my Argonaut.

A basic requirement of mobile cw is being able to copy in your head. If you have not mastered this skill, please don't operate mobile cw while driving. Try copying someone else's cw in your head, and you will gain the skill quickly. To me there is something extremely fascinating about a mobile cw QSO that makes the miles roll swiftly by. I always get a little lift when I hear the other station reply, "You're a *mobile* station?" — *Mike Richardson, N5MR, Orangevale, California*

EASY NO-HOLES BUMPER MOUNT FOR YOUR ANTENNA

☐ When I bought a Datsun B-210, I needed a way to attach an antenna mount without drilling holes in the car or bumper. My solution was to fabricate a steel plate that fastens to the car by means of two existing bolts on the bottom of the bumper. The plate extends beyond the back of the car far enough to hold the ball mount. A right-angle connector is used on the bottom of the plate to connect the coaxial cable.

Depending on how the bumper is bolted to your car, you may have to bend the bracket to achieve the best position. If there is enough room it may be better to route the bracket over the top of the bumper in order to obtain more grounded clearance than I have. — *Bill Gardner, W8WG, Athens, Ohio*

IMPROVED CARRIER SUPPRESSION FOR THE HW-101

☐ I improved the carrier suppression and rf output of my Heath HW-101 in the ssb mode. I replaced the diodes CR1, CR2, CR3 and CR4 in the balanced modulator with Schottky diodes. HPA-2800 devices should work well. The diodes must be matched for forward and reverse resistances.

After replacing the diodes, I connected a wattmeter and a dummy load to the transceiver and adjusted the carrier-balance potentiometer and the carrier-null capacitor for minimum output in both the upper and lower sideband positions. I injected a 1000-Hz signal at the mike input and keyed the transmitter on 3.700-MHz lsb. Then T1 was adjusted for maximum output. Finally, I adjusted both slugs in T102 for maximum output on lsb and usb. — *John Dolan, KE4IK, Greenville, Tennessee*

KENWOOD TR-2400 TONE-PAD INTERMITTENT

☐ While operating my Kenwood TR-2400, I had difficulty using the autopatch, and was getting reports of intermittent tones and audio. The problem was getting worse, but the solution was elusive. After removing the rear case half, I discovered that the screws that hold the circuit board in place were loose. I tightened them, and the problem disappeared. Installing lock washers under the heads of these screws has prevented the problem from recurring. — *Charles Rabley, WA8RUO, Arcanum, Ohio*

HINTS FROM ABROAD

Rejuvenation of Nickel-Cadmium Batteries

☐ It is sometimes possible to overcome the problem of NiCd cells that have developed short circuits; however, this is not the only problem that can arise with old cells. David Foster, G3KQR, carried out some rewarding experiments on a large batch of secondhand NiCds.

He writes: "The most important finding was that old cells had lost weight. For C cells, the loss was as much as 1.4 oz (40 g). This appeared to be caused by pressure venting and loss of fluid. I reasoned that the weight loss was most probably due to water loss, and not so much from loss of hydroxide. These 'sealed' cells have a pressure-relief vent, which seems to allow blow-off at a pressure of about 2 atmospheres.

"The vent is under the positive terminal, sometimes obscured by a brass soldering terminal. This terminal can be drilled by shallow penetration with, say, a no. 55 drill. Pressure venting is made possible by the synthetic-rubber plug that is placed between the top of the positive terminal and the top disc during manufacture. The two metal pieces are spot-welded together.

"Access to the cell can be gained with a hypodermic needle and syringe thrust vertically through the hole in the top, through the rubber and into the cell. The needle track will heal itself when the needle is withdrawn. Top up the cell with distilled water. I found that old cells required about 3 ml (0.1 oz) of water.

"This procedure is simple and safe. There is no contact with the hydroxide. Hundreds of cells seem to have been given a new lease on life using this technique."

David recognizes that the venting, which is the basic cause of the weight loss, probably results also in some hydroxide loss. There may be no practical way to replace this lost hydroxide (in *Rad Com* "technical topics," Jan. 1977, it was noted that any attempt to use potassium hydroxide, even on the large screw-on-cap cells, could more easily result in a medical emergency than a revitalized battery).

For those wishing to use the G3KQR water-replacement technique, there may be the problem of acquiring hypodermic needles and syringes. Your pharmacist may wonder whether it really is a NiCd you want to "fix"! But that should hardly deter a real Amateur Radio "addict." — *Reprinted from* Radio Communication, *June/July 1980, "technical topics," Pat Hawker, G3VA, p. 636.*

OLD TIMERS' NOTEBOOK

Wire Device Protects MOS Transistors from Damage

☐ Destructive damage can be done to metal oxide silicon (MOS) transistors when an electrostatic potential is applied even momentarily to the transistor leads. Sufficient electrostatic potential to be damaging can be generated by simple handling. Adequate protection during storage and shipping is provided by either soldering the leads together or by wrapping foil around the leads. Neither method is suitable, however, when the MOS transistor is to be placed in a circuit where the leads must be separated for assembly.

The solution is shown in Fig. 5. A loop of flexible, small-diameter, nickel wire, attached to a music-wire spring, can be slipped over the MOS transistor case and released, so that the music-wire spring tensions the loop of nickel wire around all the transistor leads, shorting them together. This permits the leads to be handled without damage to the transistor and makes it possible to safely connect the transistor in the circuit.

In constructing the device, a length of 0.033-inch diameter wire is bent to form a spring. A piece of 0.007-inch diameter nickel wire, long enough to form a single loop near the center of its length, is then fastened to the two outer loops of the music wire and soldered.

To attach the device to a MOS transistor, squeeze the spring so that the nickel-wire loop can be slipped over the transistor case. Once beyond the case, the spring can be released; all the leads of the transistor will be shorted together by the taut nickel wire. The protective means provided by the manufacturer, e.g., twisting the leads, wrapping foil around the leads, or soldering all the leads together, may then be removed without damage to the transistor. A transpad, which is a small disk having holes in it spaced to suit the transistor leads, can be slipped over the leads to serve as a retaining disk.

The nickel-wire protected transistor can be soldered into a printed circuit board or into circuits using other types of construction techniques. If the circuit configuration allows, the protective device may be removed without cutting the nickel wire and thus used over again. It can be employed on MOS transistors having any number of leads, since the leads always lie in a circle. Should it be necessary to take the MOS transistor out of the circuit, reattach the protective device to the transistor being removed. — *NASA Tech Brief 66-10419 (Reprinted from* Hints and Kinks for the Radio Amateur, *8th ed., 1968, p. 119)* QST

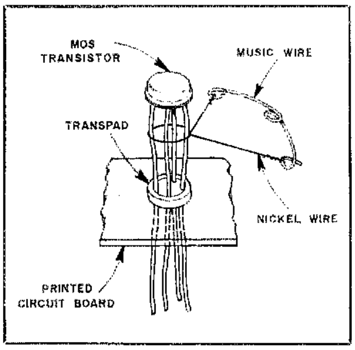
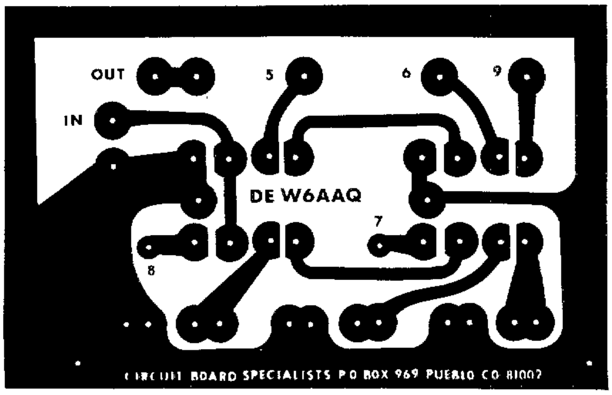
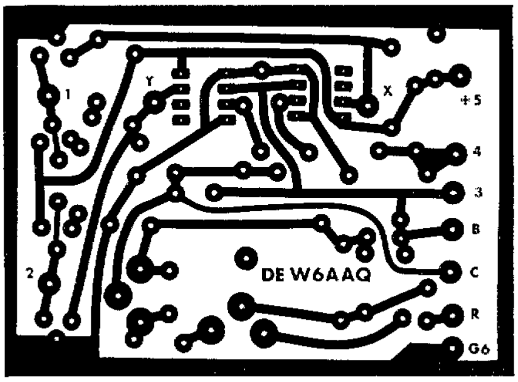


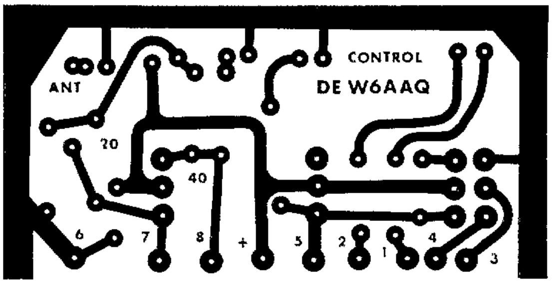
Fig. 5 — Metal oxide silicon (MOS) transistor protected from destructive static electricity during installation by wire device.



(A)



(B)



(C)

Circuit-board etching patterns for the mobile antenna-matching network. Black represents copper. Patterns are shown full-size from the foil side of the boards. At A is the input network board; at B, the main board; at C, the control-head board. Parts-placement guides appear on page 19.

Correspondence

Conducted By Peter R. O'Dell,* KB1N

All letters will be considered carefully. We reserve the right to shorten letters selected in order to have more members' views represented. The publishers of *QST* assume no responsibility for statements made herein by correspondents.

WHERE HAVE ALL THE ELMERS GONE?

☐ I am a potential ham who has read of many "Elmers" who give a helping hand. I would like to know where they are. I have recently contacted three Advanced class hams with a request for a Novice exam. Here are the results:

1) Was sorry he could not be of any help — he had dropped out and lost interest.

2) Was kind of begrudging about the idea. He was at the call of his employer. Might not be convenient to do what was necessary or be able to spare the short space of time.

3) Said he would do it for me. That was over six weeks ago. He has been reminded since then, but still no Novice test.

If all amateurs who are licensed extend a helping hand like this, then all I can say is "God help Amateur Radio!" Once I get to the point where I can be of assistance to an up-and-coming amateur, I will be willing to do whatever I can to advance his enthusiasm. — *Peter Thomas, Ferndale, Washington*

RTTY AND THE CONSIDERATE OPERATOR

☐ The "Considerate Operator's Frequency Guide" (*QST*, Jan. 1982, p. 85) fails to recognize two RTTY frequencies that have great significance to the North American RTTY stations who regularly work DX with that mode on the 40- and 80-meter bands. Due to the limited allocations of these bands in other countries, particularly European nations, it is necessary for W/VE stations to work RTTY DX on these frequencies:

80 meters	± 3590 kHz
40 meters	± 7040 kHz

Whether participating in contests or in casual QSOs with DX via RTTY, it is amazing to note the number of cw operators who either do not recognize RTTY as such, or who do not understand the necessity for use of these frequencies. Zero-beat carriers and cw obscenities do little to impede us, but they do say something about the "considerate operator" with whom we share the bands. — *James C. Edgerton, W1XG (MIT Radio Society), Cambridge, Massachusetts*

MORE GENTLEMEN'S AGREEMENTS

☐ During the recent meeting of the IARU Region 1 HF Working Group in Copenhagen, the question of the future band planning of the 1.8-MHz band was discussed. Although the final allocations resulting from the WARC-1979 decisions are not yet known in many countries, one fact of importance did emerge. A number of countries — already known to include Sweden, Denmark, Greenland and the Faeroe Islands — have a lower band limit of 1830 kHz. This means, of course, that they are unable to transmit in the 1825- to 1830-kHz section, which has for many years been recognized as the "DX window."

On page 51 of Jan. 1982 *QST*, it is suggested that 1825 to 1830 kHz should continue to be set aside for non-USA signals. With this in mind, the Working Group asked me to write and to ask you to perhaps reconsider the position, and to move the "DX window" higher in the band to the 1830- to 1835-kHz slot. We would appreciate your consideration of this matter. — *Dr. John Allaway, G3FKM, Chairman, IARU Region 1 HF Working Group*

I'M OKAY, BUT WHO ARE YOU?

☐ For a long time, a sizable segment of the ham community sought to get a relaxation of the call sign-identification rules. We finally got it, and what happened? Too many operators still insist on using the call signs of both stations in contact, both at the start and finish of a QSO. This practice is particularly wasteful of time on vhf/uhf repeaters, where everyone can hear all the stations in contact.

So many times we hear someone say to a new contact on 2 meters, "Well, I've forgotten your call, John . . ." And then a long exchange of apologies and repeats of call signs! Under the new rules it is so much simpler to say, "73, John, from KH6IO."

If we don't start using the new rules intelligently, the FCC may begin to wonder why we ask for rule changes in the first place. — *Richard C. Rhodes, KH6IO, Dallas, Texas*

GOLDWATER AND THE AVERAGE HAM

☐ The Goldwater interview in August *QST* made generally good reading. However, it might have been better still if the senator had further qualified or modified, or otherwise specified, what he means by "the average ham," as reported about halfway down column 3 on page 12: ". . .the average ham today never touches a key." There's just no way that phrase can be taken out of context. — *Robert Smeltzer, W4NZR, Greenville, South Carolina*

PRAISE

☐ I want to respond to W1BNN's letter in the August issue. I have recently returned to the ranks of licensed radio amateurs after an absence of more than 20 years. I find *QST* to be most helpful and informative in every area.

All hams don't think alike or operate the same; that is one of the great benefits of the Amateur Radio Service. We can all learn from each other. Mr. Murray should not forget that if we all thought alike, it would be a dull world, indeed! Accuracy is important, I agree; but who among us has not made any mistakes? So I say "thanks" to *QST* and to all hams striving to make ham radio better through positive contributions! — *Jack L. Fisher, N9DEF, Wheaton, Illinois*

PHONE-BAND EXPANSION

☐ Please put me on record as favoring the ARRL-sponsored phone-band frequency changes. Though 99% of my operations are on cw, the ARRL proposals are the best of those put forward, and take into consideration an expansion of 20-meter phone to Extras, an added incentive to upgrade. Though there are always dissenters, we are fortunate to have an organization as capable as the ARRL representing Amateur Radio. — *Paul A. Zavislak, KQ8X, Martins Ferry, Ohio*

☐ Most of the comments published in our media seem to ignore the rest of the world's amateur population. Indeed, the majority of U.S. operators have never been out of this country. Of those who have, very few have had the experience of operating from overseas. One comment was that there are very few stations operating in the 14.100- to 14.200-MHz section; this is absolute nonsense to any amateur who has operated from the "outside." Here it is often not possible to hear the stations using only a dipole and 50-W output power, and there are thousands active. U.S. stations with high power and beam antennas can only play havoc with those amateurs who cannot afford these luxuries. — *Hugh Rylands, VE2AKQ/W6, Oakland, California*

CODE WARS

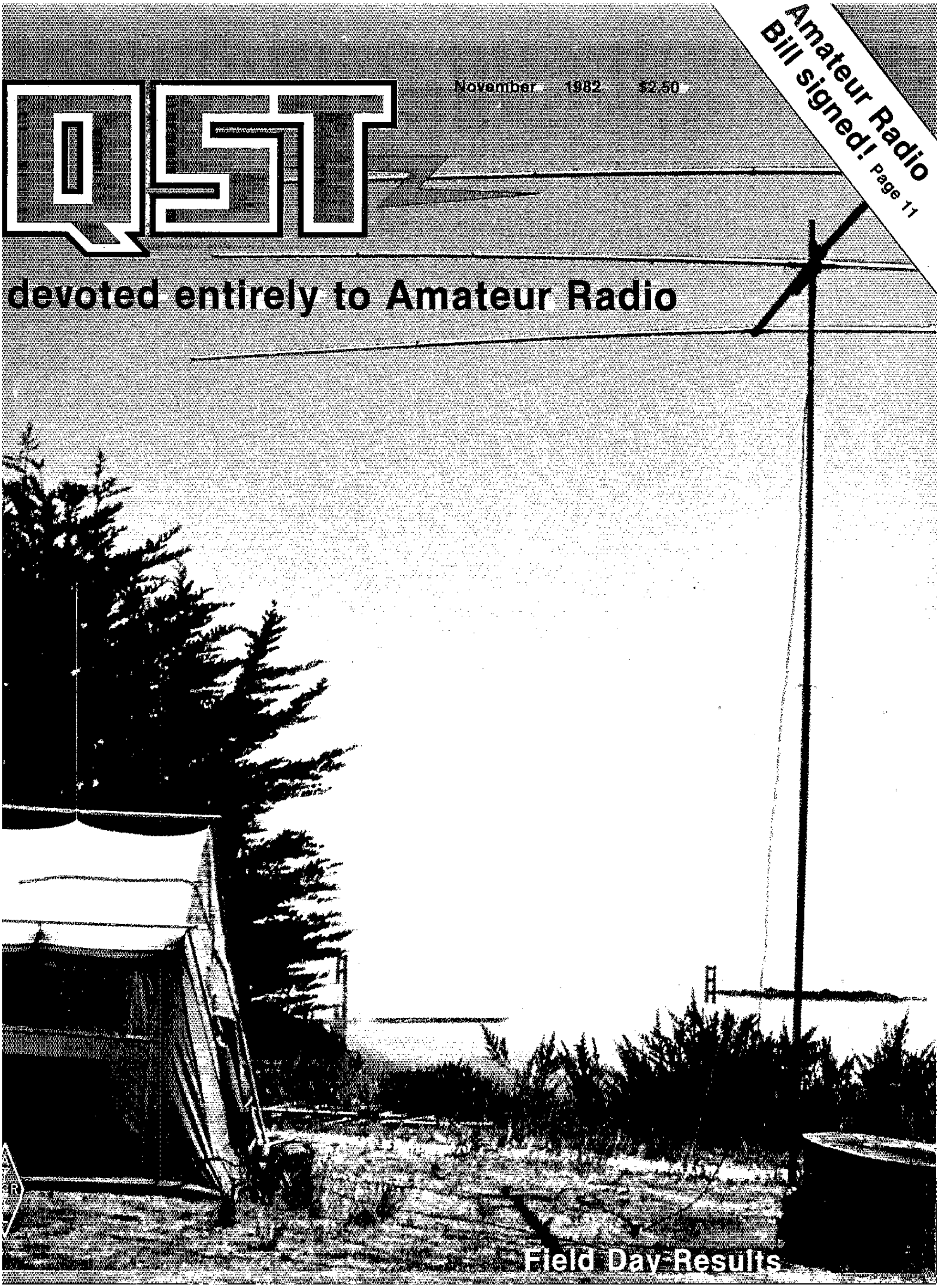
☐ I wish to go on record as being strongly opposed to any type of code-free amateur license. Cw is the common bond between all amateurs that sets us apart from other people. I am quite proud to be a ham, and love cw. My 13-year-old son is also a ham (Technician class). After being a ham only seven weeks, his code speed is up to 15 wpm, and he is waiting to take the cw test.

The 2-meter band would be just another *corn ball* band with a code-free license. Any idiot can talk over a mike, e.g., TV, Broadcast radio, CB, Business Band, etc. Cw was not easy for me, but I did it. I think that real ham radio is cw. — *Bill Diamond, WA0AOJ, Hannibal, Missouri*

☐ Let those persons who want a "no code" license suffer. If they want into Amateur Radio, let 'em learn the code. Let those lazy people quit trying to take a free ride at the expense of those who worked for a license. No sir, don't give them anything. Let 'em earn the privilege of operating an amateur station. It's a good lesson. — *Joe Keith, WB5NQU, Dougherty, Oklahoma*

☐ Amateurs who are operators with the capability of international contact must know cw. Amateurs who operate above 144 MHz are, for the most part, voice operators (minus EME and AMSAT ops). Amateurs who mainly experiment are using digital, computers and packet systems — not voice or cw. It seems to me, therefore, the possibility of a no-code license exists in the upper portion of the 440-MHz band, and above. My proposal is to keep all the license classifications as they are, and add the Experimenter Class on 440 MHz and up, with the theory test comparable to the General. Amateur Radio is alive, cw is alive and computer technology is alive. Now let's get it all together. — *Charles H. Johansen, Jr., KB2KW (SEC, Eastern NY), Holmes, New York*

*Public Information Officer, ARRL



QST
November 1982 $2.50
devoted entirely to Amateur Radio
Amateur Radio Bill signed! Page 11
Field Day Results

QST

November 1982 *Volume LXVI Number 11*

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OUR COVER
It's always nice to have a magnificent view, but Field Day means a great deal more. The group that operated from Angel Island in San Francisco Bay won't hesitate to tell you all about it. *(photo by N6BLN)*

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NEWS AND FEATURES

OPERATING

DEPARTMENTS

"RFI Bill" Becomes Law; Amateur Radio Benefits!

Intended primarily as an RFI problem-solver, P.L. 97-259 is much, much more. A decade of effort by hams and their supporters means a brighter future for Amateur Radio.

By W. Dale Clift,* WA3NLO

If you're an Amateur Radio operator, odds are that you'll get more out of your hobby because of a new law called P.L. 97-259. For example, you may be concerned about unqualified people becoming licensed. This law will help keep standards high. If you've wondered why the FCC doesn't issue licenses for more than five-year terms to cut down on its paperwork, stop wondering. This law will permit licenses to run for 10 years. If you've ever had an RFI problem, you'll be relieved to know that the FCC now has authority to require that home electronics equipment will have to meet RFI-susceptibility standards. If you're upset about the damage done to our good name by the tiny but disruptive minority within Amateur Radio, the FCC will now be able to seek out and punish offenders more swiftly. If you've been forced to wait patiently for some sort of action from an understaffed FCC office, a change is in the wind: FCC will at last be able to use the services of volunteers. If you've signed up to take an amateur exam, only to find that you'll have to drive 150 miles to get to it, you'll be glad to hear that there will be many more exam opportunities — in every state, Puerto Rico, overseas territories and even in some foreign countries.

All of this won't come to pass overnight, of course, but neither did the law that makes these improvements possible. Getting P.L. 97-259 on the books took perseverance and a concerted effort by many people. It took resolve in the face of setbacks — and there were plenty! The making of a law is a story of people, places and politics.

President Reagan shown here with Senator Goldwater, K7UGA, promptly signed the Goldwater-Wirth Amateur Radio legislation into law. *(Official White House photo by Karl H. Schumacher)*

How It Came to Pass

Amending the Communications Act of 1934 is no easy task. Many powerful individuals and groups have tried and failed to overcome the inertia of nearly 50 years, the length of time this law has governed wire and radio communications in the United States. Ten years ago, Amateur Radio leaders resolved to bring it up to date. The growing problem of radio-frequency interference (RFI) continued to seriously threaten the well-being of the Amateur Radio Service. Incidences of RFI to home electronic equipment were on the upswing, as were incidences of radio amateurs being blamed for causing the interference.

The 1960s and 1970s had brought an RFI problem of huge proportions. The fact that consumers were buying more electronic devices for their homes, plus the boom in the sales of Citizens Band (CB) transceivers, increased the probability that a home electronic device would be located near a transmitter. Nonetheless, amateur operators got the undeserved blame for many instances of RFI. The League tried to explain to disgruntled consumers that in typical RFI situations involving radio amateurs, RFI results from design deficiencies in the affected device. But consumers found it difficult to accept the concept that an apparently "passive" device, such as a TV or stereo, could be a "source" of interference. After all, when the ham was not transmitting, there was no problem!

The 1970s also brought a new concept

*Deputy Manager, Membership Services, ARRL in local and state government regulation. A few local governments began adopting ordinances that made it "illegal" to interfere with television or radio reception. These laws usually were based on a "causing a public nuisance" concept, and no one wanted to hear an Amateur Radio operator try to explain that an RFI problem was the fault of the affected device. If a ham living in one of these communities were operating his or her station and a neighbor experienced interference, the ham was breaking the law. It was an open and shut case, as far as these local governments were concerned.

Amateur Radio needed a solution to the problem of its being blamed for the inability of electronic devices to reject unwanted radio signals. ARRL leaders monitoring the political and technological trends knew that, with time, the RFI situation would only get worse. Amateur Radio operators would bear more and more of the undeserved blame for a growing RFI problem, and local and state governments would bow to local political pressure and enact laws that would hamstring amateur operation. The FCC, however, did not have the authority to set minimum RFI-rejection standards for home electronic devices. Amateur Radio needed a law that would amend the Communications Act to give the Commission this authority. Amateur Radio also needed a law that would make it clear, once and for all, that matters involving RFI are preempted by the Federal Government and are not subject to regulation by state or local governments.

The first RFI bill was introduced in 1972, during the 92nd Congress, by Representative Charles M. Teague (R-California). H.R. 16916 became known as the Teague "filter bill," because it would have required that "apparatus designed to receive broadcasts" shall meet FCC standards to be adopted so that "all interference from any amateur station operating on its assigned frequency [will] be filtered out." The 92nd Congress adjourned without taking any action on H.R. 16916, so in January of 1973 Rep. Teague reintroduced his filter bill into the 93rd Congress. The new bill was designated H.R. 3516, and *QST* published it, urging all League members to write to their congressmen in support of the measure.

Despite efforts from League members, Hq. staff and other amateur operators, the Teague filter bill remained bottled up in committee. The 93rd Congress adjourned, and the second RFI bill died. In a sad twist of fate, Rep. Teague also died. Amateur Radio had lost a stalwart friend who understood the problems facing radio amateurs.

The fallen baton was picked up in the 94th Congress by Representative Charles A. Vanik (D-Ohio). On May 15, 1975, Rep. Vanik, with the assistance and urging of Ted Cohen, W4UMF (now N4XX), of the ARRL RFI Task Group, introduced H.R. 7052. An improved version of the Teague filter bill, the Vanik Bill caught the attention of another congressman, Representative Gilbert Gude (R-Maryland). Rep. Gude asked to be listed as a cosponsor.

Storm Clouds Brewing

The new bill also drew the attention of some other people — people who did not share ARRL's enthusiasm for giving FCC

Consumers found it difficult to accept the concept that a TV or stereo could be a "source" of interference.

the authority to establish rf susceptibility standards for consumer electronic equipment. The first hint of an organized effort to defeat the foundling Amateur Radio legislation was reported to League members in the August 1975 issue of *QST*. On page 37 of that issue, Ted Cohen wrote:

> There are indications that manufacturers of home-entertainment equipment have begun to fight the legislation embodied in H.R. 7052. Their arguments are that RFI cases are too infrequent to call for such legislation, and further that the costs for reducing the susceptibility of their equipment (which they will, of course, pass on to the consumer) are too high and may jeopardize the marketability of some products.
>
> Both arguments are fallacious! . . . Further, with respect to the costs involved in susceptibility reduction, we estimate that even the inclusion of a high-quality, high-pass filter in a television receiver will cost the consumer no more than $5, *if the filter is installed at the time of manufacture.*

Thus began the League's fight with the Electronic Industries Association (EIA) over RFI legislation. The July, August, September and October 1975 issues of *QST* covered ARRL's efforts to get H.R. 7052 out of committee and on its way to becoming law. Members were urged to contact their congressmen and enlist their support of the Vanik Bill. The organized opposition from the well-financed EIA was disheartening, however.

Then, in February of 1976, Amateur Radio advocates of the Vanik Bill got a boost from Senator Barry Goldwater, K7UGA (R-Arizona), the only licensed radio amateur in the U.S. Senate. Sen. Goldwater introduced S. 3033 to be the companion legislation for the Vanik Bill. Now the 94th Congress had two RFI bills. Sen. Goldwater described the RFI situation eloquently when he introduced his bill on the floor of Senate:

> Mr. President, I am pleased to introduce today a companion bill to legislation proposed by Congressman Charles Vanik of Ohio to drastically reduce the amateur and CB radio bugaboos of television interference, hi-fi interference, and other radio frequency interference to home electronic equipment. Most consumers do not understand that when they may encounter interference with their home television or radio set after an amateur or citizens band radio operator moves next door, the source is not a defect in the equipment of their neighbor but with their own radio or television . . . (*Congressional Record*, February 25, 1976)

Still, support for the proposed RFI bills was not enough to overcome the organized lobbying efforts of the EIA. When the 94th Congress adjourned, the Vanik and Goldwater bills died.

Undaunted, Sen. Goldwater introduced an RFI bill in the 95th Congress: S. 684. May 1977 *QST* carried the complete text of the bill, and ARRL members were alerted that the RFI bill had been resurrected. Shortly after Sen. Goldwater introduced S. 684, Representative Adam Benjamin, Jr., (D-Indiana), introduced H.R. 8079. The Benjamin bill served as the House counterpart to S.684; the two bills were identical.

EIA opposition continued, but another influential organization, the Society of Broadcast Engineers (SBE), threw its support behind the League. Explaining its support, SBE noted:

> The quality of the broadcast signal is worthless if it is interfered with. This is particularly true of television, where SBE technicians strive for the state of the art in transmission of both picture and sound, only to have their work bollixed up by receivers which were not properly designed to begin with and which cannot discriminate between the desired and undesired.

Rep. Vanik, who was by this time no stranger to radio amateurs, introduced a new, improved bill into the 95th Congress, H.R. 8496. *QST* continued to urge League members to write to their congressmen. The Vanik bill, the Benjamin bill and the Goldwater bill — it was becoming confusing! And still *another* RFI bill was introduced! Representative Joseph L. Fisher (D-Virginia) introduced H.R. 11812. According to his legislative assistant, Adele Faber, the congressman introduced the bill as a *direct result* of the number of letters that his office had received regarding the problem of RFI. Radio amateurs' voices were being heard, but they were not being focused.

Finally: A First Congressional Hearing

For the first time there was a congressional hearing on RFI. The Senate Subcommittee on Communications, obviously taking note of the lobbying activity over RFI, decided that it wanted to hear about the RFI problem. On June 14, 1978, an ARRL delegation led by President Harry Dannals, W2HD, testified in support of S.684. Sen. Goldwater chaired the session held before a standing-room-only crowd. FCC Chairman Charles D. Ferris was the first to testify, and it soon became apparent that the FCC commissioners, themselves, were sharply divided on the issue of RFI-rejection standards for consumer devices. President Dannals made the League's position clear: Hams wanted

RFI-rejection standards for consumer equipment because they were tired of being scapegoats for radio-frequency-interference problems. Diametrically opposed to the League's position was the EIA spokesman, J. Edward Day, a former postmaster general of the United States. Mr. Day disputed the League's characterization of the RFI problem. Figures of RFI cases presented by the League were too high, RFI legislation simply was not needed, and imposition of such legislation might wreak havoc in the electronics industry, according to Mr. Day. The 95th Congress adjourned, and the RFI bills died.

Picking Up the Pieces

Sen. Goldwater called for representatives of the three main groups — industry, hams and FCC — to meet to help him pick up the pieces from the 95th Congress and decide what should be done in the 96th. There were no compromises. ARRL *still* wanted legislation. The EIA was dead set against it. The FCC, however, reported that it would be issuing a Notice of Inquiry on RFI. "Not enough," commented Hal Steinman, K1FHN, of the ARRL staff. "We know what the problem is; it's just a matter of *doing* something about it."

The struggle for RFI legislation continued. Representative Lionel Van Deerlin (D-California) introduced a bill, H.R. 3333, designed to rewrite the Communications Act completely. His bill proposed to give the "Communications Regulatory Commission" the authority to regulate the RFI susceptibility of home electronic equipment, but the rest of the bill was a hotbed of political controversy. Senators Goldwater and Ernest F. Hollings (D-South Carolina) also introduced S. 622 and S. 611, respectively. In the short space of one year, an ARRL delegation testified before Congressional committees three times in support of provisions for Amateur Radio. The League took every opportunity to get RFI legislation added to other measures, and even tried to get RFI provisons added to another Van Deerlin bill, H.R. 13015.

In the meantime, the ugly specter of local RFI legislation continued to rear its head. Texas State Representative Sam Hudson introduced Texas House Bill 75, which would have allowed civil actions to be brought against anyone "interrupting the transmission or reception of radio or television [signals]." An overwhelming response by Texas radio amateurs writing to Rep. Hudson resulted in the withdrawal of the bill, but the experience showed that a clear statement of federal preemption of RFI matters was needed more than ever. There were also smaller "brush fires" of local governments adopting restrictive antenna ordinances for the stated purpose of legislating RFI problems out of existence. Other amateurs were facing private lawsuits filed by neighbors, under a nuisance theory, because the amateurs allegedly caused RFI.

Going For Broke

ARRL efforts to amend the Communications Act were further complicated by the fact that amateurs needed legislation to cope with other problems. By 1980, Amateur Radio was facing the serious problem of FCC staff cutbacks amid a growing need for FCC services in administering and preparing amateur examinations and in monitoring the airwaves for rules violators. Representative William E. Dannemeyer (R-California) introduced H.R. 8445, designed to permit the FCC to use volunteers for the purpose of monitoring rules violators, but the bill died in committee when the 96th Congress adjourned. Not discouraged, he introduced H.R. 2203 into the 97th Congress. However, it, too, was limited to providing statutory authority for the FCC to use volunteers in the preparation and administration of amateur exams, and in monitoring the amateur airwaves for rules violators.

It soon became apparent to ARRL leaders that Amateur Radio needed one unified effort encompassing all the needed amendments to the Communications Act: FCC authority to adopt RFI-rejection standards, to use volunteers in the administration and preparation of amateur exams, and to enlist volunteers for monitoring the airwaves for rules violators.

Amateur Radio also needed legislation to exempt amateur transmissions from Section 605 of the Communications Act, the "secrecy provisions," to prevent a legal technicality from getting in the way of reporting rules violations efficiently. Also, getting the FCC the statutory authority to grant licenses for 10-year terms instead of the five-year maximum would free FCC resources for these other, higher-priority activities.

ARRL members went into action and let their congressmen know that they wanted them to support S. 929 and H.R. 5008.

Perry Williams, W1UED, ARRL Washington Area Coordinator, and Robert M. Booth, W3PS, ARRL General Counsel, asked Sen. Goldwater if he would be willing to sponsor yet another bill. Yes, the Senator was willing, and he suggested that the League's staff work with the staff on the Senate Subcommittee on Communications to prepare the bill.

ARRL's "wish list" made its appearance early in 1981 as Senate Bill 929. The only thing S. 929 did not contain when it passed the Senate in September was ARRL's hope for giving the FCC the authority to require a license at the point of sale for transmitters, to deal with the growing problem of "bootleggers" on the airwaves. That, the Senate staff decided, had best be left for another time; it was so controversial, it could have sunk the whole bill, ARRL was told.

Soon after the Senate adopted S. 929, Representative Timothy Wirth (D-Colorado) introduced H.R. 5008, a companion bill that contained essentially the same provisions as S. 929, along with FCC's "Track 1" (non-controversial) legislative requests. League staff identified weak areas in House support of the bills and made urgent, direct appeals to League members in certain congressional districts. ARRL members let their congressmen know that they wanted them to support S. 929 and H.R. 5008. League field officials, such as assistant directors and public information assistants, conducted their own grass roots campaigns among League members. Other League members went into action across the country.

Victory in the Final Round

In the fall of 1981, *QST* reported that S. 929 had passed the full Senate unanimously. On June 2, 1982, its counterpart in the House, H.R. 5008, sailed through the House Committee on Energy and Commerce. This Committee action was seen as the last major political hurdle; now, League and Congressional staffers had to watch for technical delays and the danger that the Congressional session might end before there was final action on the legislation.

Finally, on August 19, 1982, the U.S. Congress gave its approval to the Amateur Radio legislation. S. 929 and H.R. 5008 were passed as part of an authorization bill, H.R. 3239. The final hurdle would be the President, himself. On September 13, 1982, President Reagan signed H.R. 3239 into law. Amateur Radio and the League had won the final round.

The many years of effort and disappointment have given way to one large feeling of accomplishment and hope. It is not possible to list all those who helped in meeting this goal — it would be far too long. If *you* were one of those who helped, however, even if it was only to write a letter to your congressman, you can be proud. Thank you for the service you have given. It's not an exaggeration to say that the enactment of P.L. 97-259 begins a new age for the Amateur Radio Service in the U.S. QST

A High-Power Cavity Amplifier for the New 900-MHz Band

Be ready for the new 900-MHz amateur band when it's ours to use! The road to QRO is paved with resonant cavities and other forms of uhf plumbing.

By Robert I. Sutherland,* W6PO and William I. Orr,* W6SAI

The 1979 WARC (World Administrative Radio Conference) assigned a portion of the 900-MHz region to the Amateur Service in Region 2, which includes the United States, Mexico, Canada and the Central and South American countries. As of this writing, the band has not yet been positioned in the spectrum nor authorized for amateur use in the U.S. Even so, knowing that it will eventually be available raises questions of interest to vhf-minded amateurs.

What will the propagation characteristics of the new band be? Will it resemble 432 MHz or 1296 MHz, the companion bands? Or neither? What circuit techniques apply to the new band? How can power be generated at this frequency to make "tropo" and "moonbounce" (earth-moon-earth) communications practical?

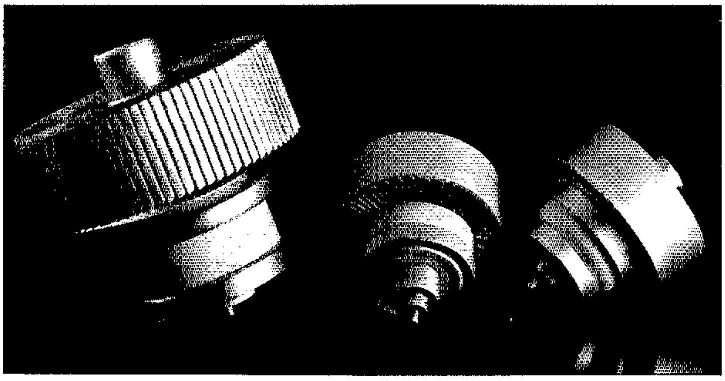


Fig. 1 — Uhf tubes, left to right: 8938 triode with a plate dissipation of 1500 W and rated for more than 1500 W of output at 400 MHz; the 3CX400U7, used in the CV-2805 cavity at 900 MHz; and a 3CX600U7, for over 380 W of output at 800 MHz (rated to 1000 MHz).

The 900-MHz Band Looks Good!

At first glance, the proposed 900-MHz band has a lot going for it. A given antenna type is about half as large as it would be at 432 MHz. That's good news for the enthusiast with the small back yard. Receiver noise figure can be as good at 900 MHz as it is at 432 MHz. Coaxial lines are less lossy at 900 MHz than they are at 1296 MHz. Standard antenna designs work well at 900 MHz, whereas some of them become "squirrely" at 1296 MHz. As every 1296-MHz enthusiast knows, generation of appreciable transmitter power at that frequency is a formidable task. Not so at 900 MHz.Several uhf transmitting tubes will deliver the goods at 900 MHz (Fig. 1), and circuit design is straightforward.

Taking everything into consideration, it seems as if the forthcoming 900-MHz assignment is a "natural" for radio amateurs, since the equipment required to make use of this portion of the rf spectrum is available now. All amateurs require is the *authority* to use this new, interesting band.

A 900-MHz Power Amplifier

Described in this article is a simple power amplifier that is intended for moonbounce communication at 900 MHz. In fm or cw service it provides over 200-W output, and in ssb service it provides over 300-W PEP output. Drive power is about 20 W peak in either case. For those interested, a block diagram of the complete EME station is given in Fig. 2.

The amplifier is essentially a quarter-wave rectangular resonator used in conjunction with a 3CX400U7 high-mu power triode. The tube operates at 1500 to 2000 V. A three-quarter-wave coaxial line assembly is used for the input circuit. Drive power is obtained from a solid-state circuit and a 3CX100A5 cavity amplifier. This is a basic uhf cavity amplifier design that was pioneered by EIMAC and used with success at frequencies above and below the forthcoming amateur band.[1]

The general operating characteristics of the 3CX400U7 tube are listed in Table 1. A combination of high amplification factor and minimum grid interception provide good power gain in cathode-driven service. Coaxial terminals and continuous cone-shaped internal supports for the grid

[1]Notes appear on page 16.

Table 1

Operating Characteristics of 3CX400U7 at 900 MHz

Tube Parameters	*Ssb*	*Fm/Cw*
Plate voltage	2000-V dc	1500-V dc
Cathode bias†	12.0-V dc	12.0-V dc
Filament voltage	6.3-V ac	5.0-V ac
Plate current	400-mA dc	400-mA dc
Grid current††	– 10 mA dc	– 10 mA dc
Useful power output	320 W	230 W

†Varies with class of service
††Approximate

*Varian/EIMAC Division, San Carlos, CA 94070

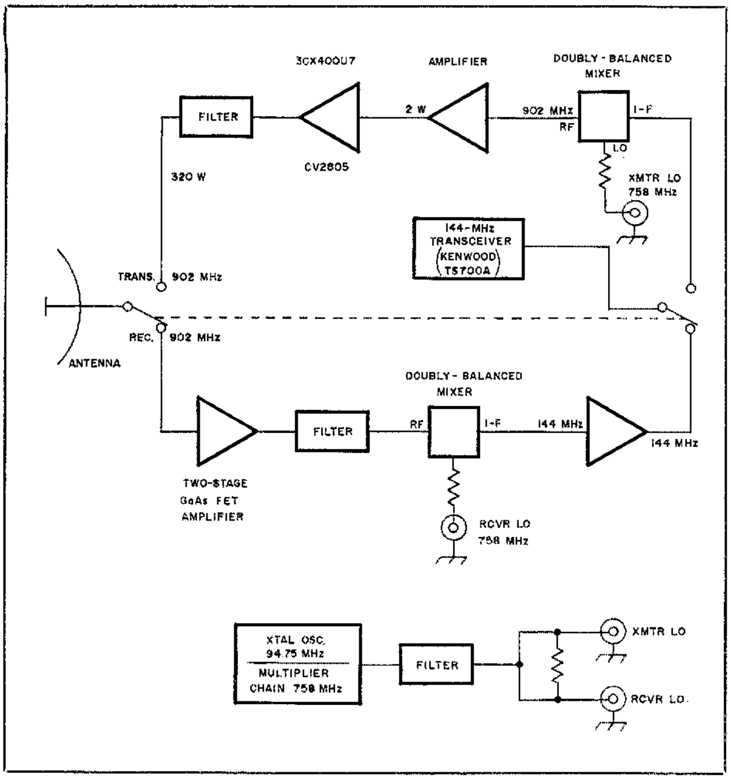


Fig. 2 — Block diagram of the planned EME station at W6PO. A 144-MHz transceiver is used as the station control unit.

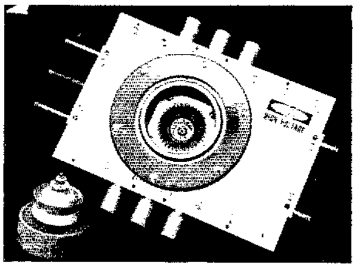


Fig. 3 — Top view of the CV-2805 cavity for 900 MHz. A 3CX400U7 provides more than 300 W of ssb output power. A phenolic ring surrounds the tube-anode collet and holds the circular plate-bypass capacitor (see text).

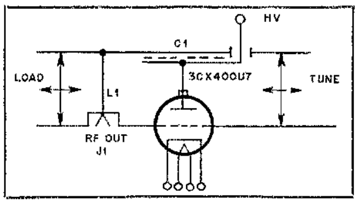


Fig. 4 — Plate circuit of the 1/4-wavelength rectangular resonator. Tuning is by means of sliding walls. The left wall (marked *load*) varies the output coupling by changing the cavity area between L1 and the wall. Resonance is obtained by moving the right wall *(tune)*, which varies the volume of the cavity. The two walls are adjusted in unison, much like the tuning and loading controls of an hf-band amplifier. A large plate is separated from the top of the resonator by means of a thin insulating sheet. It serves as a plate bypass capacitor.

and cathode elements of the 3CX400U7 provide the lowest possible inductance between tube elements and the external circuitry.

The Cavity Plate Circuit

The plate circuit of the CV-2805 amplifier (Fig. 3) is a quarter-wave adjustable cavity. Output coupling is magnetic. A loop is formed between the cavity walls and a post that terminates in the coaxial output connector. Coupling between the output loop and the cavity is varied by moving a wall of the cavity. A simple threaded drive shaft does the job. The degree of coupling is determined by the cavity area enclosed by the post and the cavity walls (Fig. 4). Plate-circuit resonance is established by changing the volume of the cavity by means of a second sliding wall. Contact between the movable walls and the cavity is maintained by preformed finger stock. The two walls are adjusted in unison, much like the conventional loading and tuning controls of an hf amplifier.

The Input Circuit

A simplified drawing of the input circuit is shown in Fig. 5. As shown at A, the circuit is a 3/4-wavelength-long coaxial line. Nearly a quarter wavelength of the circuit is inside the tube, loaded by the tube input capacitance, so that the use of a quarter-wave line is out of the question; insufficient line exists outside the tube to couple to or to effectively tune. An additional half wavelength of line is added to provide room for the tuning capacitor (C1) and the coupling capacitor (C2), which are both placed near the high-impedance portion of the line. The rf short at the bottom of the line is reflected one-half-wavelength up the line, placing the cathode and grid of the tube at a high-impedance point, with the proper 180° phase difference between the elements. Since the outside of the assembly is at dc ground potential (Fig. 6), the rf short at the bottom end of the line is made up of a very-low-impedance bypass capacitor, which provides dc isolation for the cathode-return circuit. Fig. 5B shows the same circuit folded back upon itself to conserve length. This is the configuration used in the CV-2805 cavity. The filament leads are brought out through concentric tubes at the center of the assembly; the tubes act as rf chokes to isolate the filament circuit.

Cooling The Cavity

Air for anode cooling is introduced from a cowl or chamber through the three short tubes on each side of the output cavity. The air then exhausts through the finned anode. The short tubes are dimensioned to serve as a "waveguide beyond cutoff" rf filter in the air openings. This prevents the loss of rf power through these ports. Approximately 11.5 cfm of air is required when the tube is operating at sea level and at the full anode dissipation rating of 400 W. The pressure drop across the anode cooler at this flow rate is about 0.2 inch of water. These figures are based on an incoming air temperature of 50° C and a maximum tube-anode temperature of 225° C.

Heater-Cathode Operation

The nominal heater voltage for the 3CX400U7 is 6.3. For operation above 300 MHz and at full power or key-down cw service, the voltage should be reduced as the cathode receives additional heat from rf charging currents and transit-time effects. In this cavity, operating heater voltage is 5.0 for continuous service. During warmup and standby periods, heater voltage is held at 6.3. Nominal heater voltage is applied for a minimum of 60 seconds before plate voltage is applied and operation commences. For best life expectancy and the most stable performance, it is suggested that the heater voltage be held to the final desired value with ±2%. For ssb service and low duty cycle cw, heater voltage is maintained at 6.3.

The Metering Circuits

Conventional grid- and plate-metering circuits are used, with protection provided for the meters by means of reverse-parallel shunt diodes. A zero-center meter is used in the grid circuit because a normal grid-current indication can be negative, depending on plate-circuit loading. This negative current is the result of tube characteristics and transit-time effects at the frequency of operation. A simplified metering diagram is shown in Fig. 7.

Amplifier Adjustment

Before operation is attempted, the cavity-amplifier controls should be set by means of a preturning chart. The cavity frequency rises as the tuning wall is moved inward toward the tube. During tuneup, an rf directional coupler should be placed in the drive line from the exciter. A Thruline® wattmeter, or equivalent monitor, is placed in the output line to the dummy load. Filament and bias voltages, and cooling air, are applied to the cavity. A filament voltage of 6.3 is applied for 60 seconds, followed by the anode voltage of 2000, maximum. Plate current with no drive signal will be approximately 50 mA. When about 10 W of drive is applied, the plate current should rise to 300 to 400 mA. There should be an indication of output power on the Thruline® wattmeter. Under no circumstances should there be rf drive with no plate voltage, as the full drive power will be dissipated in the grid. The tuning and loading controls are now adjusted for maximum output, and both of them are varied until maximum output is achieved. The filament voltage is now dropped to 5.0 for continuous duty or fm operation. It is held at 6.3 for ssb service.

The next step is to adjust the input tuning and matching controls under full-power conditions. The input probe capacitor and the tuning control are adjusted for minimum reflected power. These adjustments are interlocking, so they must be done alternately, tuning for minimum power reflection in the drive line. When this is achieved, the output tuning control should be reset for best power output.

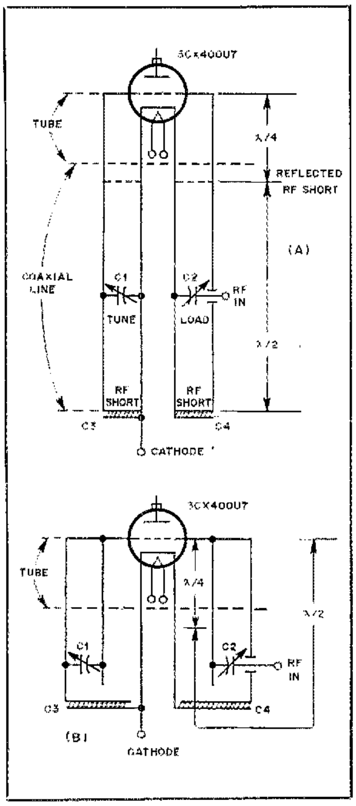


Fig. 5 — At A, the circuit is a 3/4-wavelength coaxial line. Nearly a quarter wavelength of the line is inside the tube — loaded by the tube input capacitance. It is difficult to couple to the short line section, which is external to the tube, so an additional half wavelength of line is added to provide room for tuning capacitor C1 and coupling capacitor C2. The rf short at the bottom of the line (C3, C4) is reflected a half wavelength up the line. This places the cathode and the grid at high impedance, with the proper phase difference between the elements. At B, the same circuit is folded back on itself to conserve length.

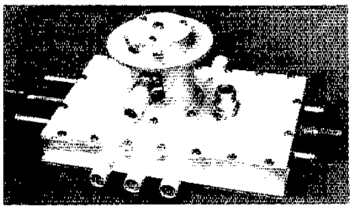


Fig. 6 — View below the CV-2805 cavity. Input-loading capacitor C2 is adjusted by sliding the coaxial fitting in and out of a sleeve. A clamp around the joint locks the adjustment. The plate rf connector is at the side of the input cavity. Filament and cathode connections are made at the end of the input cavity. The assembly is made from heavy silver-plated brass stock to limit thermal expansion.

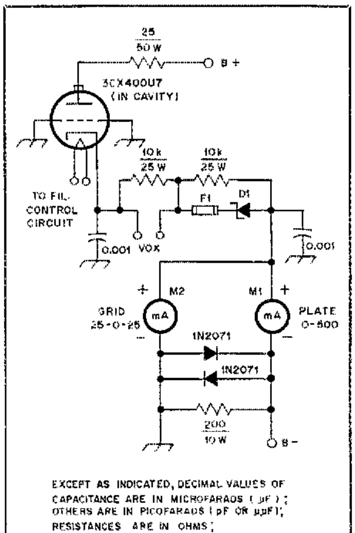


Fig. 7 — Amplifier metering circuit. Metering is done in the power supply return lead. The high-voltage negative line is a few mV above ground to allow insertion of the meters. Reverse-connected diodes protect the meters from overload.

Operation Notes

The tube anode is bypassed effectively in the cavity, so no special precautions are required for application of high voltage to the tube. Connection is made most easily to the center cap of the anode, and it is recommended that a 25-ohm, 50-W current-limiting resistor be used in the high-voltage lead to protect the tube in the cause of a fault condition.

Application of plate voltage should be interlocked with the rf drive in a suitable manner so that the drive signal cannot be applied to the cavity in the absence of plate voltage. It is suggested also that the equipment include an air interlock, so no voltages can be applied to the cavity unless there is an adequate flow of cooling air. For ssb service, the bias should be a fixed value and may be obtained with Zener diode(s) in the cathode circuit.

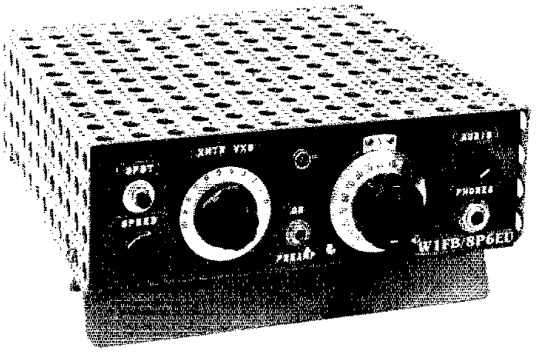
Finally, it must not be forgotten that absorption of rf energy by human tissue is dependent on frequency. Under 300 MHz, most of the energy will pass completely through the human body with little attenuation or heating effect. At 900 MHz, however, a noticeable heating effect exists, and a prudent operator will stay clear of the antenna field. More information on rf effects on the human body can be found in note 2. QST

Notes

[1]The brochure entitled "EIMAC Cavity Amplifiers," and data sheets for the CV-2805 and the 3CX400U7 are available at no cost by writing to: Application Engineering Dept., Varian/EIMAC Division, 301 Industrial Way, San Carlos, CA 94070.

[2]The following references should be helpful to those seeking further information:
ANSI C95.1-(1982). *Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields (300 kHz to 100 GHz)*. (New York: American National Standards Institute, 1982).
"ARRL Comments on the Biological Effects of RF Energy," Oct. 1982 *QST*, p. 53.
"How Dangerous is RF Radiation?" Technical Correspondence, Sept. 1978, p. 31.
Proceedings of the IEEE, Special issue on Biological Effects and Medical Applications of Electromagnetic Energy, Jan. 1980 (New York: IEEE, 1980).

The 8P6 Special — "Hamcation" Backup Rig



Campers, travelers, vacationers and DXpeditioners require compact, lightweight gear. This trans-receiver for 20 meters fits the description and is not difficult to build.

By Doug DeMaw,* W1FB

Worried about a breakdown with your primary station on a "hamcation" (ham radio vacation)? Need a small rig for a business trip or a weekend holiday? Or how about that camping trip you've been planning? No doubt a trans-receiver that can be operated from a 12- to 14-V dc power source, and which can deliver 6 to 8 W of properly shaped cw into a 50-ohm load, would appeal to you. By way of added features, how about including a single-signal superheterodyne receiver with a 250-Hz i-f filter and rock-stable frequency control of the transmitter and receiver sections?

Some Features

I've carried all manner of QRP transceivers and "separates" on junkets to various West Indies islands over the years, mainly as a backup to the primary equipment. Most of them have worked well in a pinch — when the commercially made transceiver failed. But, most of the homemade units contained direct-conversion (D-C) receivers, which did not provide the cw selectivity I desired. Futhermore, single-signal reception was not possible, which compounded the QRM problem — especially in pileups! Since a bare-bones superheterodyne receiver is scarcely more expensive or complicated to build than is a high-performance D-C receiver, the former was my choice for this project. The receiver section of the trans-receiver was described earlier in *QST*[1]; therefore, I will key this article to the remainder of the circuit in the portable unit.

Long-term frequency stability is of the utmost importance to dependable dial calibration and effective operating. Large changes in temperature are prevalent from day to night in the tropics and when camping. Some simple L-C VFOs fail to "measure up" in the presence of radical shifts in ambient temperature, sometimes drifting more than 5 kHz over a 20° F temperature change. I chose VXO (variable crystal oscillator) control for the receiver and transmitter sections of this QRP station and could detect no discernible drift in either circuit during two weeks on Barbados as 8P6EU. Chirp-free cw was obtained from the transmitter, and one operator I contacted remarked, "Boy, it sounds like you're keying a frequency standard." A tape recording of my 8P6EU signal (courtesy of N1FB) verified the "sanitary" sound of the signal.

The portable package contains a Curtis Lil' Bugger keyer ($29.95, from Curtis, minus case and speed control); a twin-T sidetone oscillator, break-in delay module for T-R switching; and a switchable 15-dB preamplifier for use ahead of the receiver, as desired. A block diagram of the composite circuit is given in Fig. 1.

Transmitter Circuit

An excellent 20-meter transmitter was designed by former Hq. staff member W1VD for use in the Project Goodwill program.[2] It was chosen for use in my trans-receiver, and some modifications were made to (1) increase the VXO frequency swing; (2) shape the cw waveform; (3) provide diode switching for T-R control; and (4) add decoupling networks to ensure unconditional stability of the low-level stages. A bipolar dc switch was also added for keying control, as were heat sinks on Q3, Q4 and Q5.

All of the modifications are included with the original circuit on a new pc board that is the same size as the original one.[3] The circuit performance is otherwise unchanged from that of the original W1VD design. Circuit details are given in Fig. 2.

The Curtis keyer has a sidetone circuit, which can be used in place of the twin-T audio oscillator in this design. The duplication of sidetone availability resulted from the Curtis unit being added as a last minute convenience before the Barbados trip.

A spotting switch has been included to permit zero beating the receiver to the transmitter frequency, or vice versa. When spotting is done, the operator should tune for a pitch of approximately

*Senior *QST* Technical Editor

[1]Notes appear on page 21.

700 Hz to ensure that the transmitter frequency closely approximates that of the station being worked. Because of the twin VXO feature of this trans-receiver, no RIT is required, and wide transmitter-receiver frequency splits are possible.

The VXO Circuits

Greater frequency coverage is available per single crystal as the crystal frequency is increased. Hence, the receiver provides roughly 30 kHz of coverage at 14 MHz, owing to the 17.6-MHz crystal frequency. The transmitter covers approximately 19 kHz with the 14-MHz crystal. I set my frequencies to cover the lower portion of the Extra Class cw segment, but crystals can be chosen to yield coverage in any part of the band. I have a second crystal pair that provides operation in the General class part of the 20-meter cw band. The four crystals enable me to receive from 13.999 to 14.060 MHz. I can transmit from 14.000 to approximately 14.038 MHz.

The crystals are cut for a load capacitance of 30 pF and should be of the fundamental-mode type. Although overtone crystals can be used on the fundamental mode, they do not provide as great a frequency swing as fundamental-cut crystals do. An AT-cut crystal in an HC-6/U style of holder is recommended for VXO use. FT-243 crystals are not suggested for these circuits.

The innovator may wish to experiment with the VXOs to extend the tuning range. This can be done by increasing the inductance placed in series with the crystals. But, a point will be reached where the oscillator becomes a VFO rather than a VXO (with swings in excess of 100 kHz). The rock-stable quality will be lost, however.

The upper range of crystal oscillation with these circuits will always be higher than the marked frequency of the crystal — approximately 15 kHz higher for the receiver and about 8 kHz for the transmitter. This should be considered when ordering crystals. Furthermore, no two crystals ground for a given frequency will yield exactly the same operating characteristics in terms of frequency limits and range.

The VXO tuning response is nonlinear. The low-frequency end of the range is spread out, but the high-frequency part of the range is bunched up, so to speak. A vernier drive is recommended for the receiver VXO, but direct drive is adequate for adjusting the transmitter VXO.

Receiver Preamplifier

Although the basic receiver is not a monument to sensitivity and dynamic range, it is satisfactory for most 20-meter operation. I added a MOSFET preamplifier for use during weak-signal reception (Fig. 3). The primary advantage is an increase in overall receiver gain, with a noticeable improvement in noise figure. The preamplifier can be switched out of the antenna line for routine operation. I used a circuit kit that is available from Circuit Board Specialists (see note 3).

T-R Break-In Circuit

Break-in delay is provided by means of the circuit in Fig. 4. The module was developed by WAØUZO for use as a COR (carrier-operated relay) in repeaters. It has the advantage of not "hot switching" the PA stage of the transmitter. Hence, the antenna is connected to the PA before drive reaches the MRF476s. Hot switching can destroy the PA transistors over a period of time, and it can send out a momentary transient or "blurp" that may cause interference to other amateurs who are sharing the band.

Variable time delay has been provided by virtue of a pc-board control. The drop-out period can be lengthened by changing the 22-µF capacitor at pins 7 and 8 of the IC to a larger value. The components specified in Fig. 4 will permit a maximum delay of roughly 2 seconds. Minimum delay is 0.2 second.

A CD4093 quad, two-input Schmitt-trigger IC is the heart of the T-R circuit. As configured, the circuit permits the relay to close (transmit initiate) and the receiver to turn off instantly. Roughly 5 ms later, the transmitter is actuated, preventing unwanted hot switching. When the cw key is left up beyond the delay period, the relay opens and the receiver is actuated 5 ms later.

A 2N2222 serves as a relay driver, and two bipolar pnp switches are used for additional T-R control. The foregoing transistors are driven by the Schmitt trigger.

K1A in Fig. 4 is a surplus 12-V dc relay (135-ohm coil) from my junk box. Any similar dpdt relay can be used with the T-R circuit. For full QSK, the timing capacitor (22-µF) can be deleted and a reed relay (dpdt) or pair of reed relays (spdt each) substituted for K1. The reed relays will follow high-speed keying; standard relays won't. Various methods for full QSK are discussed in *Solid State Design for the Radio Amateur.*[4] The T-R circuit also keys the sidetone oscillator.

Sidetone Oscillator

Fig. 5 shows the circuit of the sidetone oscillator. The values given provide a frequency of 700 Hz with a clean wave. Out-

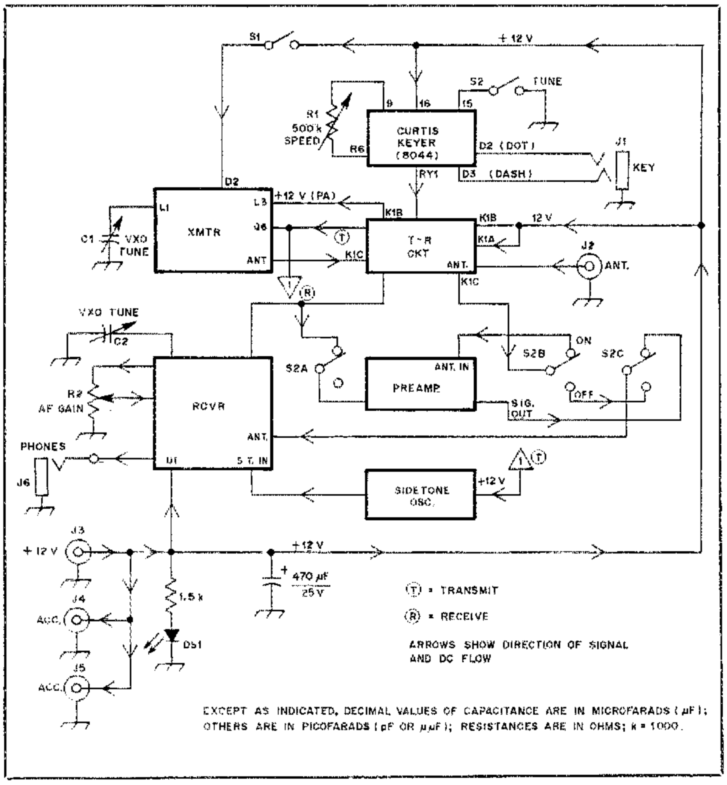


Fig. 1 — Block diagram of the trans-receiver showing how the modules are associated with one another. DS1 is a green panel-mount LED from Radio Shack. It serves as an on-off indicator. R1 and R2 are located on the front panel of the unit. The VXO tuning controls (C1 and C2) are available from the front panel.

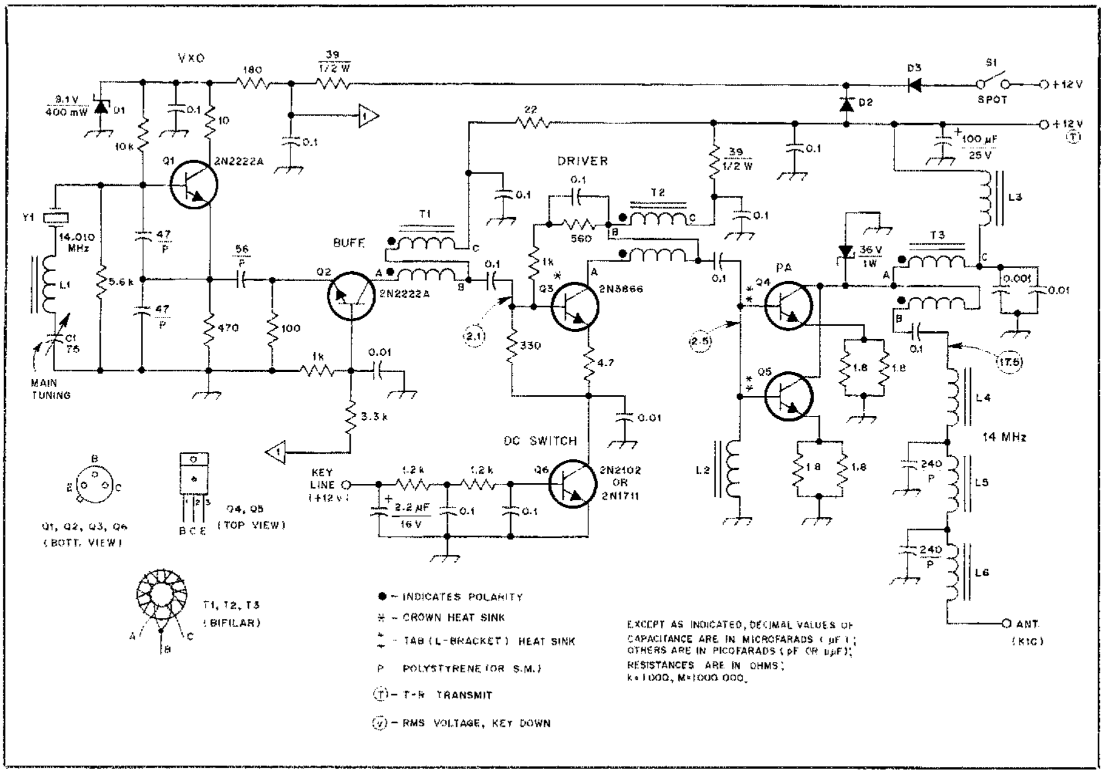


Fig. 2 — Schematic diagram of the modified W1VD 20-meter transmitter. Fixed-value capacitors are disc ceramic, unless otherwise noted. Polarized capacitors are tantalum or electrolytic. Fixed-value resistors are 1/4- or 1/2-W carbon-composition types, unless indicated differently.

C1 — Miniature 75-pF air variable.
D1, D4 — Zener diode regulator.
D2, D3 — 50-PRV, 1-A rectifier diode.
L1 — 43 turns no. 26 enam. wire on T50-6 toroid core (Amidon or Palomar Engineers), 7.5 µH.
L2 — Ferrite choke, 8 turns no. 26 enam. wire on an Amidon FB-73-801 jumbo bead.
L3 — Ferrite choke, 10 turns no. 24 enam. wire on an Amidon FT50-43 toroid.
L4, L6 — Toroidal inductor, 16 turns no. 24 enam wire on a T50-6 core.
L5 — Toroidal inductor, 19 turns no. 24 enam. wire on a T50-6 core.
Q4, Q5 — Motorola citizens band MRF476 transistor. Replaces discontinued MRF472 used in original W1VD circuit. Use homemade aluminum heat sink (small L bracket).
S1 — Push-button, momentary-on, panel-mount switch.
T1, T2 — Toroidal 4:1 broadband transformer. Use 11 bifilar turns no. 26 enam. wire on Amidon FT37-61 core.
T3 — Toroidal 4:1 broadband transformer. Use 11 bifilar turns no. 26 enam. wire on Amidon FT50-61 core.
Y1 — Fundamental 14-MHz range crystal, 30-pF load capacitance (see text). International Crystal Mfg. Co. type 434110, 10 N. Lee St., Oklahoma City, OK 73102.

put from the oscillator is routed to the op-amp audio-output stage of the receiver through a level control on the sidetone module. The audio-output amplifier is operational at all times, thereby permitting the sidetone to be heard during transmit periods.

Construction

There is plenty of latitude for packaging the trans-receiver. I chose a homemade cabinet that measures (HWD) 2-1/2 × 8 × 7 inches.[5,6] The cabinet bottom is a U-shaped piece of 16-gauge aluminum stock. The top cover is fashioned from a piece of aluminum cane metal that I bought at a hardware store. L brackets (two) are affixed to the inner edges (left and right) of the bottom half of the case. They provide anchor points for

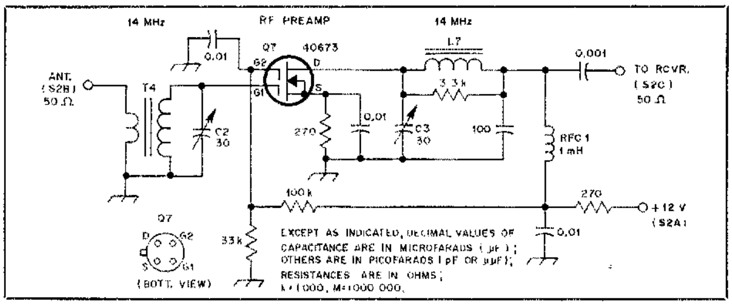


Fig. 3 — Schematic diagram of the 20-meter receiver preamplifier. Fixed-value capacitors are disc ceramic. Resistors are 1/4- or 1/2-W carbon composition.

C2, C3 — Miniature 30-pF Mylar or mica trimmer, pc-board mount.
L7 — Toroidal inductor, 30 turns no. 28 enam. wire on a T37-2 core.
RFC1 — Miniature rf choke, 1 mH.
T4 — Toroidal rf transformer. Primary, 2 turns no. 28 enam. wire over ground end of secondary winding. Secondary contains 28 turns no. 28 enam. wire on a T37-2 core.

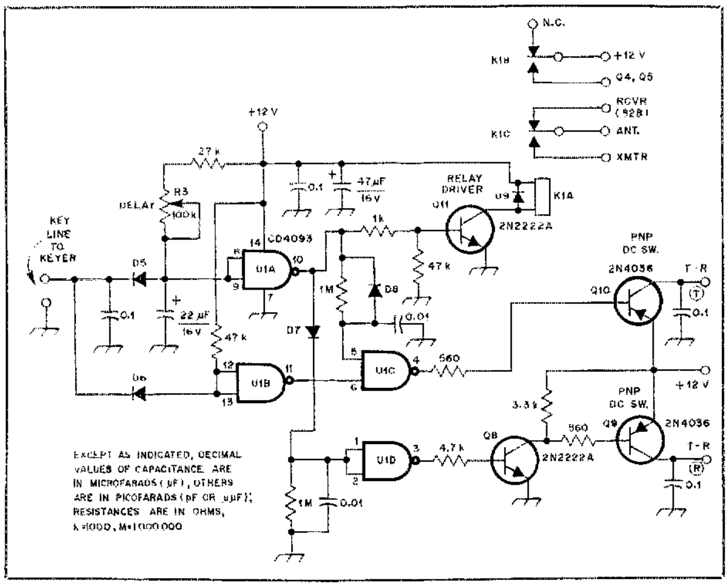


Fig. 4 — Schematic diagram of the break-in delay T-R circuit. Fixed-value capacitors are disc ceramic. The polarized capacitor can be tantalum or electrolytic. All diodes are small-signal silicon types, such as 1N914. K1 is a Magnecraft W67-RPC-X2 with a coil resistance of 135 ohms (see text). R3 is a pc-board mount trimmer control.

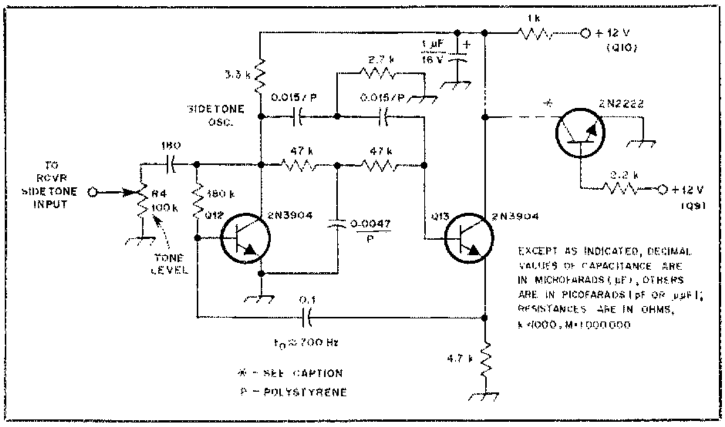


Fig. 5 — Schematic diagram of the twin-T sidetone oscillator for 700 Hz. Mylar or polystyrene style capacitors are suggested for best stability and Q. The polarized capacitor is tantalum or electrolytic. R4 is a pc-board mount trimmer control. The 2N2222 switch (optional) may be required to ensure fast turn off of the oscillator.

the lid, which is attached by means of two no. 6 sheet-metal screws per side.

The transmitter and receiver pc boards are supported above the chassis on 3/8-inch metal standoff spacers. All of the smaller boards are mounted on no. 4-40 screws, with two no. 4-40 nuts between the boards and the chassis to serve as standoff posts. A lock washer should be used at each mounting point to ensure good ground contact between the boards and the chassis. A view of the transreceiver innards is provided in Fig. 6. The revised transmitter is shown in Fig. 7.

RG-174/U miniature coaxial cable is used for all rf and audio wiring between the pc boards and the related panel jacks and controls. The shield braid of each cable should be grounded at each end. The dc connections are made with hookup wire that has been routed under the pc boards in bundles after being bound with lacing cord. A 470-µF, 25-V capacitor (see Fig. 1) is connected from the 12-V input jack to ground at the rear apron of the case. This helps to ensure a low-impedance 12-V bus and aids stability.

I painted the front and rear panels dark green. The top cover is painted gray. Both painted sections were given two coats of polyurethane clear spray after the paint had dried for 48 hours. This was done to provide a tough outer coating, which is practically impervious to damage from bumps and scratches. Green 1/4-inch Dymo® tape labels were added to identify the jacks and controls.

Adhesive-backed plastic feet (four) are attached to the bottom of the unit. I bent a length of aluminum sheeting to a 30° angle and placed it under the front of the box to elevate the panel during operation (see title-page photograph).

A set of pc-board templates and parts-layout data can be obtained from ARRL by sending $2 and a large s.a.s.e. Pc-board details for the receiver section were published in June 1982 *QST*.

Setup and Operation

It is best to assemble and test each module before mounting the circuits in the cabinet and wiring them together. "Murphy," should he be lurking in the background, can be unmasked early by this means. A scope or earphones will suffice when testing the sidetone oscillator. The T-R module can be checked by grounding the key line and observing the action of K1A.

Transmitter evaluation is accomplished by placing an output indicator (VSWR meter or wattmeter) between the PA and a 50-ohm dummy load. VXO range can be monitored on a station receiver, as can the quality of the keying. The approximate power output is determined by attaching a 2-W, 51-ohm resistor at the transmitter output terminal, closing the key (momentarily!) and measuring the rms voltage across the resistor by means of a scope or rf probe and VTVM. Power output should be between 6 and 8 W, depending on the supply voltage used. The power can be determined from

$$W = \frac{E^2}{R} \qquad \text{(Eq. 1)}$$

where E is in rms volts, and R is in ohms. Hence, if the load was 51 ohms and the developed voltage across the load was 19, the output power would be 7 W. Key-down current drain should be under 1.5 A. My unit draws roughly 1.3A.

The rf preamplifier can be tested and tuned by connecting it temporarily to the main station receiver. The gain, as noted on the S meter (relative) should be between 10 and 15 dB if all is as it should be. There must be no popping or blank carriers heard in the receiver as the amplifier is peaked. If there are some spurious responses, the preamplifier is unstable. If so, make sure the bypass capacitors are not defective and that all wiring is correct.

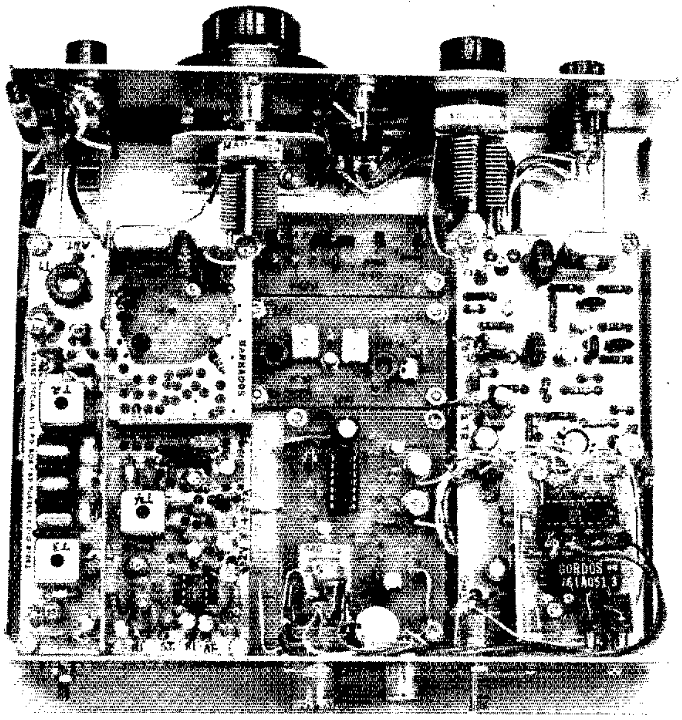


Fig. 6 — Interior view of the assembled trans-receiver. The receiver is at the far left. In descending order from the top center are the sidetone oscillator, the rf preamplifier and the break-in delay modules. At the lower right is the Curtis keyer, mounted on an L bracket above the transmitter pc board. The transmitter shown in this view is an original W1VD unit to which the modifications described in the text have been added. Fig. 7 shows the new transmitter board with a revised pattern and layout. The carrier-lock (tune) switch is located on the rear panel of the rig.

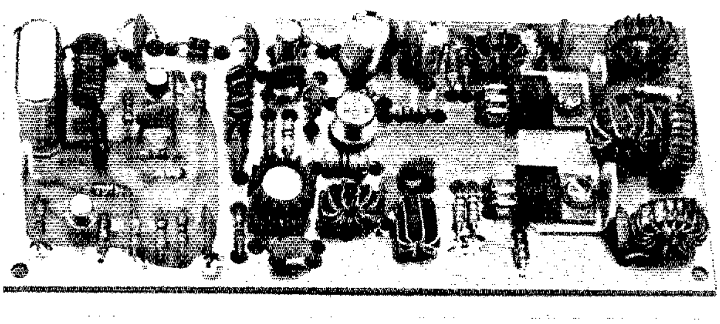


Fig. 7 — Photograph of the revised transmitter. Homemade heat sinking is provided for the PA transistors (far right). A crown heat sink should be placed on the driver transistor (board center). The ground foil has been etched away from the immediate area of the VXO to minimize stray capacitance and increase the crystal range.

Spurious responses will indicate self-oscillation. Only a smooth peak in received signal should be noted.

Results

Early-on testing was carried out at W1FB while using a Cushcraft A4 triband Yagi antenna at 50 feet. Countless stations answered my CQs and gave reports ranging from RST 569 to 599. Frankly, I could discern no difference in my success from that obtained with the FT-101ZD station transceiver (100-W output). I worked numerous European stations, and the JAs were easy to work too, when band conditions provided a good path. I was pleased when some operators asked what brand of gear I was using; they were interested because the cw note sounded so good! Many were amazed to learn the unit was homemade and that it put out only 7 W! This points out the value of proper cw waveform shaping, a trick that has not been learned by all of the commercial manufacturers. A 5-ms rise-and-fall time is the target value to shoot for.

On April 2, 1982, the little rig was packed and taken to St. James, Barbados, W.I., for a two-week holiday. The primary rig was a Ten-Tec Argosy, which operated at approximately 50 W during the 8P6EU, 8P6FJ, WB1FSB/8P6 operation. The 20-meter antenna was a sloping dipole over the seashore, the top end of which was some 35 feet above the beach. Excellent results, worldwide, were obtained with both rigs, and no operator could detect a signal difference in transmitters when I made unannounced switches during QSOs. Fortunately, we did not have to rely on the QRP trans-receiver as a backup, for the Argosy percolated nicely from 80 through 10 meters. But, I had a lot of fun with the small rig while testing its effectiveness from a DX location.

Tag Ends

It is entirely possible that the trans-receiver could be modified easily for use on 15 meters and, probably, for 40 meters. The shortfall on 7 MHz would be limited frequency shift with the VXO, but on 15 meters it should match that for 20 meters. I have not explored these possibilities and have no practical data to offer. A skilled experimenter should have no trouble with such a project.

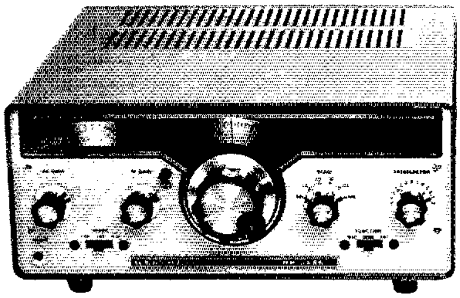
The packaged unit could be made much smaller than the example in this paper. If the pc boards were mounted on end (vertically), that would be a step in the right direction. Or, some of the boards could be stacked atop one another. One might even include an SWR indicator and Transmatch in the cabinet.

If you're a traveling ham, this may be the rig you need. It will accompany me on many business trips, vacations and camping trips in the future. The unit may be little — but it's *loud!* [QST]

Notes

[1]D. DeMaw, "Build a Bare-Bones CW 'Superhet,'" *QST*, June 1982.
[2]J. Rusgrove, "A 20-Meter, VXO-Controlled, 6-Watt Transmitter," *QST*, Dec. 1978.
[3]Negatives, circuit boards and complete parts kits for this trans-receiver are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002, tel. 303-542-5083.
[4]W. Hayward and D. DeMaw. Published by ARRL, Inc., Newington, CT 06111.
[5]See title-page photograph. A case made from double-sided pc-board material would serve nicely in place of the aluminum one shown.
[6]mm = in. × 25.4.

HR-1680 Receiver Modifications — Try Them!



Is your '1680 as "sharp" as you would like it to be? These "fixes" will let you enjoy all-around improved performance.

By H. L. "Herb" Ley, Jr.,* N3CDR

I needed a good 12-V portable receiver for operation in emergencies. A used Heath HR-1680 was located, then put through its paces. It proved to be an excellent unit, but the selectivity and signal-to-noise ratio were not up to par with my other station equipment, and the vernier-dial mechanism was erratic in operation. So, recognizing that the HR-1680 improvement project involved circuit and mechanical changes, I set to work.

Improving the Crystal Filter

The i-f amplifier section of the receiver is straightforward. The second mixer on the front-end circuit board feeds the first i-f amplifier on the audio/regulator (A/R) board. That stage is connected to the second i-f amplifier through a cascaded half-lattice crystal filter, made up of four crystals. Unfortunately, the part of the A/R board containing the crystal filter is packed tightly with components, offering little room for modifications. A better location for additions is near the output of the second i-f amplifier, in the area containing capacitor C235 and the 13.9 µH toroid (L201) (see Fig. 1). Thus, the problem of improving the i-f amplifier selectivity and noise characteristics became one of choosing a suitable addition for the space available.

An ARRL publication, *Solid State Design for the Radio Amateur*,[1] provided some excellent leads. The authors point out a useful approach to improving the signal-to-noise ratio of a receiver: the addition of a "tail-end" crystal filter at the i-f output. My approach to improve the input filter selectivity was to measure the frequencies of several sets of matched filter crystals and to pair the crystals as closely as possible in frequency so that the filter response would be as sharp as possible.[2] This permits the extra crystals with the outlying frequencies to be used in a half-lattice tail-end i-f filter, which replaces the original A/R board i-f output circuit. This circuit concept worked out better than expected, so read on!

How to "Do It"

First remove the four filter crystals and the two BFO crystals from the A/R circuit board. Use as little soldering iron heat as possible. Flow excess solder from the crystal pins so they are smooth. Remove excess solder from the circuit board. Next, build the test oscillator in Fig. 2, so that the exact crystal frequencies can be measured. I built the oscillator on a 12-squared, hacksawed circuit board that is patterned after the method described by Leslie,[3] but any other method may be used. The circuit must be an exact electronic duplicate of the BFO oscillators in the HR-1680, even to the point of matching the load capacitance.

Measure the frequency of each crystal removed from the receiver, as well as the new crystals, and mark them. I use 1/2 × 1-inch self-adhesive labels.[4] The measurements should be made to the highest resolution possible, preferably hertz. You will find that the BFO crystals will be reasonably close to the frequencies marked on the holders, but don't be disturbed if the filter crystal frquencies are different from the holder markings. This is because they are used as filter elements, not oscillators. It is important to do all measurements at one sitting, with the frequency counter warmed up. Next, tabulate each of the crystal frequencies on a worksheet in descending frequency order. A sample of my tabulation involving four sets of four filter crystals and two BFO cyrstal sets is given in Table 1. The more crystals you have to work with the better the final results will be.

The next step is to separate the crystals into sets. The objective is to come up with two filter crystal pairs, with each pair being as closely matched in frequency as possible. The average frequency for each of the pairs should differ by about 1.25 to 1.5 kHz to give a resulting passband that will accommodate both cw and ssb signals. Depending on how closely each pair of crystals is matched, and the filter termination, the passband of a cascade lattice filter is about 1 to 1.5 times the frequency separation. In three HR-1680s (in which there was no change in the termination resistor originally used), a frequency separation of 1.25 to 1.325 kHz gave completely satisfactory results. In addition, it will be necessary to select two crystals for the tail-end filter. This filter may, and usually does, have a greater bandwidth that the input filter. It is definitely *not* necessary that the average frequency of the four input filter crystals equal the nominal 3395.000-kHz HR-1680 i-f; a small deviation from that figure will not be noticeable.

The final step is picking the most suitable BFO crystal for each input-filter set. Tabulate the average frequency of the four crystals in each of the input-filter sets in descending order. Against these figures set the corresponding frequencies of the usb/cw crystals (nominally 3396.4 kHz) and the lsb crystals (nominally 3393.6 kHz), also in descending order. The BFO crystals with the highest frequencies

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[1]Notes appear on page 25.

should be used with the input filter of the highest average frequency, and so on. An example is provided in Table 2. Once this step is completed, immediately bag the crystals for replacement on the A/R circuit board. Once you've put this amount of effort into the project, you don't want to get the crystals mixed up! When you replace the filter and the BFO crystals on the A/R board (using the construction manual and the frequencies marked on the holders as a placement guide), place the crystal-frequency labels on a sheet of paper and file them in the HR-1680 manual.

Once the crystals are on the board, the receiver should be checked to make certain it is operational before adding the tail-end i-f filter. A noticeable improvement in signal-to-noise ratio should be apparent. Through the courtesy of the staff of the local Heathkit® store a comparison was made with my modified set and their shelf demonstrator, with the same antenna switched between receivers. A worthwhile improvement, as a result of crystal selection, was observed. But don't rest yet! The improvement resulting from the addition of the tail-end filter will be truly remarkable.

The Tail-End Filter

The tail-end filter is contructed on an etched single-sided circuit board that is 1-1/4 × 3/4 inches in size. The etching pattern and component placement for the board are given in Fig. 3, and the circuit diagram is shown in Fig. 4. The tuned circuit in the drain lead of Q205 is a direct copy of the crystal-filter components in the "Mini-Miser's Dream Receiver,"[5] designed by W1FB, for the same i-f. Components are placed on the unclad side of the board. Of particular importance are the holes in the circuit board, labeled A through D, which are used to connect the filter board to the main A/R board by using short lengths of No. 22 bare wire, so that the filter board just clears the components on the A/R board.

Before the tail-end filter can be installed in the HR-1680, several components must be removed from that board (L201 [13.9-μH toroid — yellow dot], C235 [150-pF mica] and C231 [10-pF disc]). The wire from hole A on the tail-end filter goes to the hole for C235 (originally attached to the drain of Q205), and the wire from hole B goes to the mounting hole for C235 (originally connected to the 13-V supply at the junction of C234 and R235). Also, the wire from hole C goes over the top edge of the A/R board to the ground foil at the edge of the board (scrape the protective coating from the foil before

Table 1
Crystal Frequency List

Filter Type Measured Freq. (kHz)	
Higher	*Lower*
3395.665	3394.331
3395.645	3394.328
3395.610	3394.313
3395.564	3394.285
3395.554	3394.283
3395.549	3394.277
3395.538	3394.260
3395.520	3394.234
BFO Type Measured Freq. (kHz)†	
usb/cw	*lsb*
6.589	3.768
6.554	3.752
6.493	3.637

†See text and Table 3 for method of selection.

Table 2
BFO Crystal Selection List

Rcvr No.	*Av. Filter Freq. (kHz)*	*BFO Xtal Frequency usb/cw*	*lsb*
3	3394.993	3396.589	3393.768
2	3394.923	3396.554	3393.752
1	3394.905	3396.493	3393.637

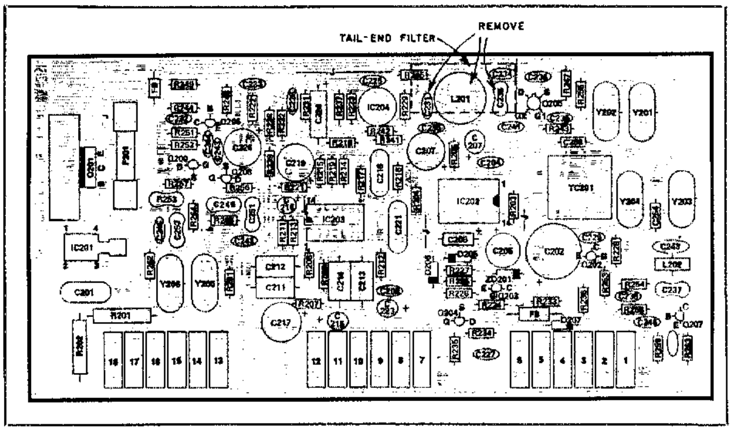


Fig. 1 — Component-side view of the HR-1680 audio/regulator board. The tail-end filter sits on top of this board.

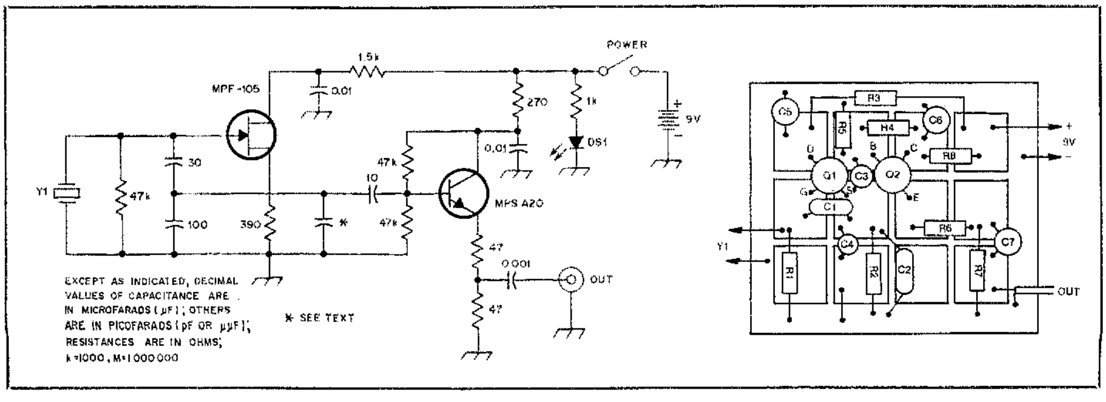


Fig. 2 — Test oscillator schematic diagram and parts-placement diagram. Y1 is the crystal under test. Black areas represent copper.

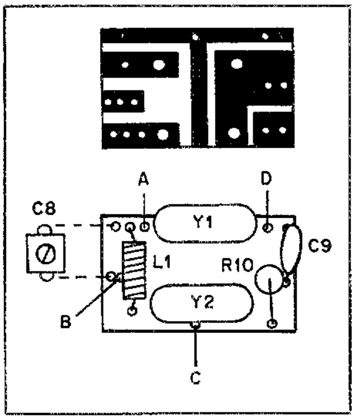


Fig. 3 — Tail-end filter circuit-board etching pattern and parts-placement diagram. The etching pattern is shown full size with black areas representing copper.

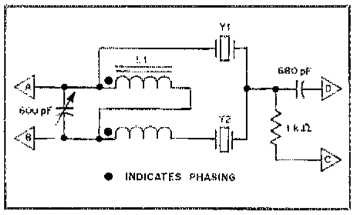


Fig. 4 — Tail-end filter schematic diagram. Y1 and Y2 are 3.3938 and 3.39505 MHz, respectively. L1 is 8 bifilar turns on an FT37-61 core.

soldering) and the wire from hole D goes to the counting hole for C231 (10-pF disc), originally connected to the junction of R242 and pin 4 of IC204.

The tail-end filter addition will reduce the receiver gain significantly because of insertion loss, causing a reduction in signal volume and a lower S meter reading. These anomalies can be returned to their original state by making two circuit board changes. The first is the replacement of R235 (4.7 kΩ) with a new resistor of 2.2 kΩ. This resistor is located in the bottom center of the circuit board and controls the S meter action. The second change is the addition of a 330-pF disc-ceramic capacitor as the emitter bypass element on Q207. Heath apparently considered adding such a capacitor, because holes and foil pads are present but not used. The position for the capacitor is adjacent to the 270-Ω emitter resistor (R263) at the bottom right-hand corner of the board. Its location is identified in construction manual pictorial 4-6 with the comment, "Do not install a capacitor at this location." It is important that a capacitor no larger than the one specified be used. Larger values will give greater gain, but they also cause intermittent stage oscillation.

Another addition is recommended for cw buffs — the installation of a 7-25 pF ceramic trimmer directly across Y206, the usb/cw BFO crystal. It can be added to the rear side of the board, positioned so that it can be adjusted from the top of the receiver. This trimmer permits adjusting the BFO beat note on cw so that maximum S meter response falls in the center of the active audio filter passband. This addition results in one disadvantage: It makes the BFO difficult to start if the set is exposed to cold temperatures. For the ssb operator there is no need to make this modification.

Once these changes have been completed, the usb/cw BFO crystal frequency can be adjusted for cw reception and the tail-end filter aligned. The A/R board is inserted in the receiver by means of three circuit-board extenders. With the calibration oscillator turned on and the BFO set to usb, tune the receiver to the calibrator signal at a convenient 100-kHz dial marker. The 600-pF trimmer on the tail-end filter board is tuned for maximum signal (if it has been added for cw operation), and the new usb/cw padding capacitor is adjusted for the lowest calibrator signal beat note. Now the receiver is tuned to produce a beat note that is approximately 750 Hz (the af filter center frequency). The 600-pF trimmer is adjusted carefully to peak the calibrator signal. If the receiver is tuned from one side of the signal to the other, the receiver should demonstrate excellent single-signal cw response. Some readjustment of the 600-pF trimmer may be necessary. If a sweep generator is available, it can be used to set the trimmer to the proper value. Its use is not necessary because excellent performance can be obtained using the alignment procedure described above.

Tail-end filter alignment of ssb operation is considerably simpler because of the broader passband required in that mode. Tune in an ssb signal with the BFO set to the proper sideband and the 600-pF trimmer set to produce the clearest received signal.

Table 3
Crystal and Filter Data for Three Modified Receivers

Receiver No./ Crystal Type	*Input I-F Filter Frequency (kHz) Each Unit*	*Mean*	*Tail-End Filter Frequency (kHz) Single Crystal Only*
1) Hi Pair	3395.538		3395.564
		3395.529	
	3395.520		
Lo Pair	3394.283		3394.234
		3394.280	
	3394.277		
Filter Avg. Freq.	—	3394.905	3394.899
Spacing	—	3391.249	3391.330
2) Hi Pair	3395.554		3395.610
		3395.552	
	3395.549		
Lo Pair	3394.313		3394.260
		3394.299	
	3394.285		
Filter Avg. Freq.	—	3394.923	3394.935
Spacing	—	3391.253	3391.350
3) Hi Pair	3395.665		N/A†
		3395.655	
	3395.645		
Lo Pair	3394.331		N/A
		3394.330	
	3394.328		
Filter Avg. Freq.	—	3394.993	N/A
Spacing	—	3391.326	N/A

†There was no tail-end filter added to receiver no. 3.

Curing Dial-Drive Problems

Some HR-1680s exhibit unnecessary problems with the vernier-dial drives. My receivers have been no exception, so I'd like to offer some suggestions for making the system work the way it was designed to.

If you are correcting drive alignment in an already constructed set, it is necessary to remove the VFO tuning capacitor for proper realignment. Removal is a simple process. First, unsolder the heavy wire from the VFO capacitor terminal. Remove the nuts holding the dial lamps and push the lamps to one side so the dial pointer plate may be taken out, thereby permitting tilting of dial and capacitor. Loosen the front vernier drive screws and remove the four VFO capacitor mounting-bracket screws. Carefully push the capacitor toward the rear to disengage the front vernier drive; then tilt and lift out the dial and capacitor. Loosen the bracket, vernier and capacitor screws so you can begin the realignment process from scratch.

In addition to following the manual instructions *exactly*, I recommend the use of all four mounting screws in the step shown in the manual pictorial, 5-8. These four screws must be turned down *tightly* before securing the other screws of the capacitor mounting brackets and vernier drives; care in this procedure pays big dividends. In the final mounting of the VFO capacitor to the chassis, tighten one set of screws in diagonally opposite positions before securing the last two. If the drive is still not smooth when you finish, repeat the vernier alignment until it is.

If you prefer a lighter touch to the drive, additional work is required. Only the front vernier drive requires attention in such situations, so you may complete the task by removing the tuning knob and the front drive (on its mounting plate) without removing the VFO capacitor and dial. Once the front vernier drive is free, a portion of the lubricant from the ball-bearing drive is removed by flowing a small amount of lighter fluid through the mechanism. When this is done, the lubricant must be replaced by adding petroleum jelly to the ball bearing races on the front, the back and the inside of the hollow shaft. Use a small screwdriver and work the drive until the lubricant is taken up. Replace the mounting plate and front drive, then tighten the shaft setscrews and mounting-plate screws. Treated this way, the drive can be spun easily with a single finger, and it still retains the smooth action.

If the dial has too much backlash, the grease in the front vernier drive can be replaced with automotive cup grease. Fill the hollow rear shaft of the drive about half-full with cup grease, insert a spare piece of 1/4-inch shafting in the rear of the drive, then press it into the drive. The cup grease will be forced into the drive races, expelling the old grease, which must be carefully wiped away before the vernier drive and mounting plate are replaced.

This project has produced a modified HR-1680 receiver having much better single-signal and signal-to-noise characteristics than the original kit receiver. In this sense, the project was highly productive. In addition, it has been an educational exercise in receiver modification and design that has been most informative. I highly recommend the project to current or future Heath HR-1680 owners.

Notes

[1]W. Hayward and D. DeMaw, *Solid State Design for the Radio Amateur* (Newington: ARRL, 1977), pp. 85-88 and 217.

[2]Heath sells a matched set of four HR-1680 filter crystals for $36.20. The part number is 404-331. At least one set of crystals is required to complete the project.

[3]S. B. Leslie, "Breadboards Revisited," *QST*, Feb. 1974, p. 30.

[4]mm = in. × 25.4.

[5]D. DeMaw, "The Mini-Miser's Dream Receiver," *QST*, Sept. 1976, p. 20.

Strays

UoSAT-OSCAR 9 LIVES!

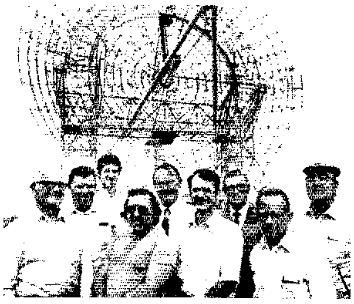
☐ When UoSAT-OSCAR 9 was launched in October 1981, satellite enthusiasts around the world had high expectations that it would serve as a valuable educational and experimental tool. (See related article beginning on page 53.) Those hopes suffered a serious setback in April 1982, however, when a command system glitch sidetracked final in-orbit checkout and stabilization. The glitch caused both telemetry beacons to be gated on — a major disaster, since at least one beacon had to be off for the satellite to "hear" ground commands on the band of the inactive beacon. With the 2-meter beacon desensing the 2-meter command receiver, and the 70-cm beacon desensing the 70-cm command receiver, UO-9 had, in effect, QRMed itself to "deaf"!

The UoSAT team at Surrey tried in vain to execute further commands; UO-9 simply would not respond. If nothing were done, UO-9 would be useless thereafter. The only hope lay in finding a ground station sufficiently powerful to overcome the local beacon and capture the command receiver. This would not be easy, since the satellite would be no closer than 330 miles (530 km) — its orbital altitude — from the ground station.

G3YJO contacted Dave Olean, K1WHS. Dave made a valiant effort with his powerful 2-meter EME array (*QST* cover, Sept. 1981). With 26-dBd gain, Dave zapped UO-9 with about 250-kW effective radiated power (erp), but could not break through.

Later in July, a team of amateurs at SRI International, Menlo Park, California, took up the challenge. Under the leadership of Dr. Robert Leonard, KD6DG, director of the Radio Physics Laboratory of SRI, an ad hoc UoSAT Salvage Team set to work rehabilitating the 150-foot (46-meter) SRI dish antenna. Occasionally used for EME work, the big dish had been out of service for years and had fallen into disrepair. Overcoming failed azimuth drive motors, leaky hydraulics and obsolete or missing computers, the team put the big dish on the air in August.

After several disappointments, the breakthrough occurred on September 20, when, according to KD6DG, "All the right pieces fell into place." With its 42-dBd gain pointed skyward, the big "rig" was keyed at 2235 UTC. About 10 MW of 70-cm erp blasted toward the "deaf" bird. UO-9 would either respond by turning its beacons off or by incandescing in the 70-cm flux! The beacons fell silent, and the jubilant Salvage Team knew at that instant that UO-9 had been saved. Awakened from his bed at midnight, G3YJO, at Surrey, soon was to confirm that, indeed, UoSAT was now responding to commands and that telemetry indicated the spacecraft's health as "nominal" (read FB). Operations will resume soon.



The team at SRI International that zapped UoSAT-OSCAR 9 back to life, from the left: W6YBL, KD6DG, KB6LZ, W6MXI, K6TDR, W6IRA, KE6D, W6WMC and W6GXN. *(photo courtesy SRI International)*

The dramatic salvage mission at SRI caps a singular episode in amateur satellite annals. However, the beneficial effects will be shared by all of Amateur Radio. The perseverance and professionalism of K1WHS, and the teams of G3YJO and KD6DG reflect enormous credit on all. While Amateur Radio history is replete with splendid examples of self-policing in regulatory issues, here we may have seen the best example of the flipside: The Amateur Service is also self-healing in cases of complex *technical* maladies!

It is a very proud day indeed! — *Vern "Rip" Riportella, WA2LQQ, Executive Vice President, AMSAT*

Next Month in QST

December *QST* will put you in a holiday mood with a host of enjoyable reading. Highlights are

- the first of a two-part article on the first kW, 2-30 MHz, linear broadband amplifier using power MOSFETs — an outstanding achievement.
- a Beginner's Bench workshop project (using readily available parts) that yields a versatile station accessory.
- articles on two timely subjects of general interest: cable-TV interference and the new League programs that can bring your affiliated club the recognition it has so richly earned.

The JF Array

You don't have a "green thumb" for antennas? This multiband "antenna farm" is easy to grow!

By Richard R. Schellenbach,* W1JF

It is purely accidental that the name of this antenna and my call sign are identical. However, it is no accident that the JF Array is a relatively simple but highly effective antenna system. It covers the 80-, 40- and 15-meter bands from a single transmission line. This antenna provides significant gain on the 40- and 15-meter bands, while acting as a standard $\lambda/2$ dipole on 80 meters. In fact, the array may be used on all hf amateur bands, without the gain and directional characteristics found on 40 and 15 meters.

The initials "JF" describe the physical configuration of this array. On 15 meters, the antenna consists of two back-to-back "J" type radiators; hence the name "J Flat-Top," which is shortened to JF.

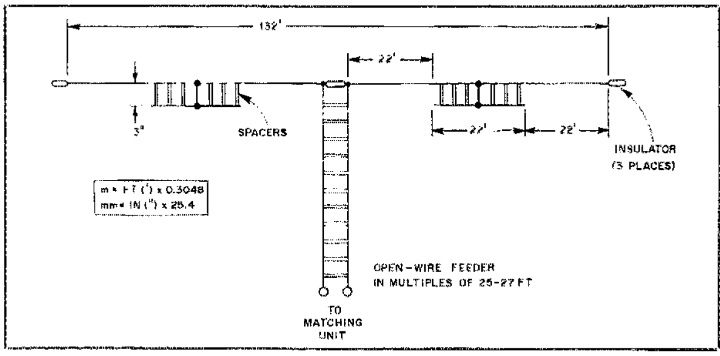


Fig. 1 — A dimensional drawing of the JF Array.

Theory of Operation

In essence, the JF Array operates as four $1/2$-λ elements in phase on 15 meters, and two $1/2$-λ elements in phase on the 40-meter band. On both bands, the feed impedance is extremely high. Therefore, an open-wire feed line (300 to 600 ohms) is recommended between this antenna and your Transmatch. Remember that this is a balanced antenna system, so it is desirable to maintain current balance from the antenna all the way back to your matching network.

Under some circumstances you may find it necessary to experiment with the length of your open-wire feeder. This is because some operating frequencies and line-length combinations present a load impedance beyond the capability of your matching network. The use of a nonharmonic-length feeder is the usual prevention or cure for this condition. Feeder lengths in multiples of 25 to 27 feet should allow all-band operation without any problems.[1]

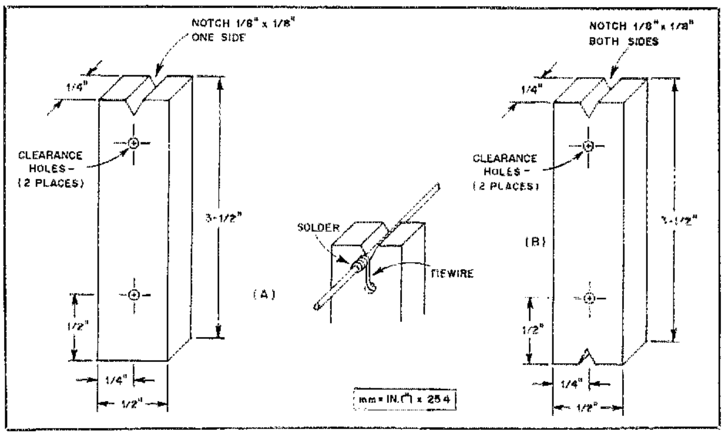


Fig. 2 — Spacer construction details for antenna sections are shown at A. Details of a spacer used for constructing the open-wire line are shown at B.

Construction

The flat-top section of the antenna is made from no. 14 copperweld, or no. 12 hard-drawn copper wire (Fig. 1). Heavy-gauge wire is necessary to support the considerable weight of the array. The two stub sections should be made from no. 14 or 16 hard-drawn copper wire, and are held apart from the flat top by means of homemade spreaders. These are fabricated from 1/4-inch-thick plastic or Plexiglas sheet (Fig. 2A). The length of individual spreaders is not critical, but it should not be longer than 4 inches to prevent the wires from becoming unwieldly during installation. A spreader should be placed every foot, or less, along the stub to provide support and to prevent undue movement during windy periods. The spreaders are held to the main antenna wire by small lengths (4 inches) of no. 14 or 16 copper wire. This tie wire should be passed through the clearance hole at the "V" groove end and wrapped tightly on both sides (Fig. 2). The stub wires then are passed through the opposite clearance hole, and *not* tied, allowing freedom of

[1] m = ft × 0.3048.

*12 Whitehall La., Reading, MA 01867

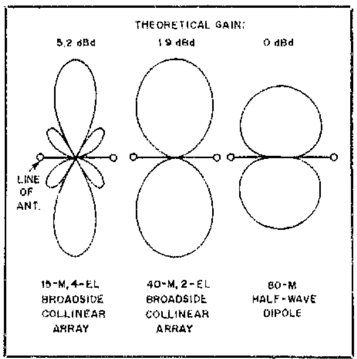


Fig. 3 — Radiation patterns and theoretical gain figures for the JF Array on different bands (for comparison only).

movement for stress-free support. After attaching the stubs, solder a jumper wire between the center-tap of each stub and the main antenna wire (Fig. 1). Ensure good electrical connections by first scraping off any enamel insulation or oxidation, and by wrapping the wires tightly before soldering.

Balanced feeders may be purchased, or constructed from no. 14 or 16 copper wire spaced apart by the spreaders shown in Fig. 2B. Various types of commercial open-wire transmission line offer the builder a lightweight, already-built option. Any of the popular 300- to 600-ohm lines will do.

Performance

It is worth noting that the JF Array radiates the main power lobe *broadside* to the wire and not off the ends as a conventional, harmonically operated antenna does (Fig. 3). With a properly balanced feed line, you will observe that the array has an extremely clean radiation pattern. Installed at the 30- to 45-foot level, the antenna provides good DX performance. There is yet another desirable advantage to be found: the JF Array provides an inherent diversity effect on the higher frequencies because of the large capture area. This effect greatly reduces fading that may occur during certain propagation conditions. Give this simple antenna a try. You shall be pleasantly surprised!

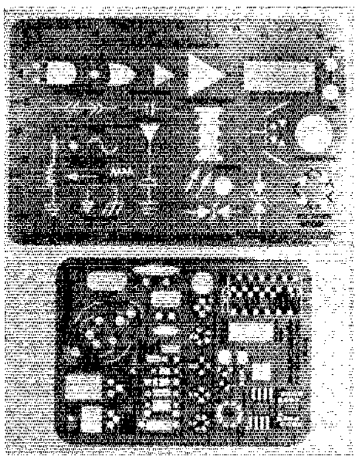
Dick, W1JF, a native of Southern California, was first licensed as W6TKX in the late 1930s. He is a 9-year veteran of both the U.S. Army and Navy, and has served as a communications specialist for nearly 40 years. Currently, Dick is a consulting scientist with Support Systems Associates, Inc., of Burlington, Massachusetts. In addition to his extensive communications experience, Dick holds a BSEE degree, and has completed post-graduate work in Business Management and Industrial Engineering.

New Products

ARCHER CIRCUIT SYMBOLS AND PC-BOARD-LAYOUT TEMPLATES

☐ Radio Shack offers two new tools geared to help students and amateur or professional circuit designers and builders achieve accurate, high-quality schematics and designs. A circuit-symbols template (276-180) and a pc-board-layout template (276-179) are available for $3.95 each.

The circuit-symbols template offers a large selection of component and logic symbols. There are also two ruled edges with 0.1-inch graduations. A pc-board-layout template eliminates guesswork in pc-board design. It supplies exact-size (× 1) stencils for most commonly used active and passive components, including ICs and discrete devices. Look for these offerings at your nearest Radio Shack store. — *Paul K. Pagel, N1FB*



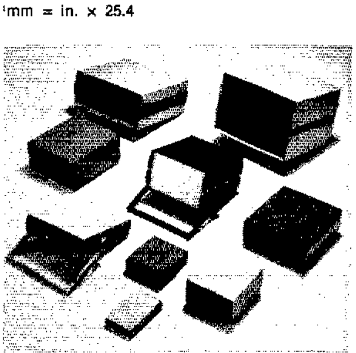
PAC-TEC ENCLOSURE KITS

☐ PAC-TEC Corporation offers 28 different plastic enclosure kits to aid in the construction of attractive and durable custom enclosures for a variety of items including power supplies, digital clocks, specialized test equipment, junction boxes and equipment interfaces. By using either the fixed-size units or the expandable units that allow the user to construct cases with several heights from a single kit, the designer can build the enclosure right on the workbench.

The kits, which come in four standard colors, include top and bottom covers, filler panels, front and rear panels (adjustable in expandable height models) and an assortment of necessary spacers and hardware. Available options include handles and tilt stands. Interior mounting bosses for securing components are standard, and detailed assembly and modification instructions are included with each kit. Front and rear panels can be drilled, cut, punched and silk-screened for displays and controls.

Available sizes range from the handheld Series HP, which measures 3.6 × 5.75 × 1.12 inches, to the substantial Series CL, which measures as large as 12.5 × 11.63 × 8.76 inches.[1] For more information, contact PAC-TEC Corporation, a subsidiary of LaFrance Corp., Enterprise & Executive Ave., Philadelphia, PA 19153, tel. 215-365-8400. — *Paul K. Pagel, N1FB*

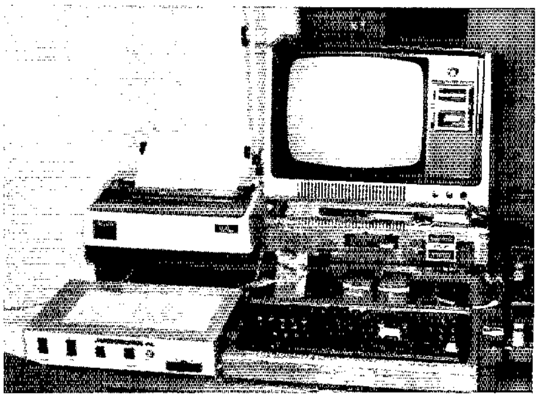
[1]mm = in. × 25.4



The Copper "80" Kettle

Are you "steaming" mad because of computer RFI? Try this unique fix for your TRS-80® microcomputer and enjoy QRM-free contacts.

By Hubert H. Wheeler,* W4IBU



It was in March of 1980, immediately after my retirement, that I became interested in RTTY and began investigating several of the methods to get on the air using this mode. At the time, I thought a computer and an interface would be the most appropriate setup, since it would give me two alternatives: the ability to interface with my Collins S-Line for RTTY and cw, and to have a personal computer as well. After looking at several computers, I elected to go with the TRS-80® Model I Level II and the Macrotronics RTTY/cw interface, even though I had been told of an RFI problem.

The problem with RFI was serious enough to make me wonder if I had made a big mistake. I read what I could on the subject, including an article from *QST.*[1] Following some of the suggestions from the article, I installed a new grounding system, shielded cables between the Macrotronics interface and the ham gear, and used Tube-koat on the inside surfaces of both the computer and the expansion interface.[2] The application of the Tube-Koat was not noticeably effective.

During a trip to Atlanta, I visited a craft shop that specializes in products for the fabrication of stained-glass windows and Tiffany-style lighting fixtures. It was there I discovered an adhesive copper foil. If this type of foil were available in sheets rather than narrow tapes, it could possibly be the answer to the RFI problems. Correspondence proved that it is available in rolls, 24 inches in width and 36 yards long.[3] If there were a sufficient demand, shorter lengths could probably be purchased.[4] The amount required is approximately 5 yards.

Installation

The adhesive copper foil comes in three sizes: 0.001, 0.00125 and 0.0015 inch. I suggest the 0.0015-inch size, since it seems to be best suited for the wear and tear of continuous use. Also, it is the best size to solder to. About 15 feet of the 24-inch foil is required to cover the keyboard and the expansion interface, to install the ground planes, and to shield the flat cables.

Fortunately, the foil acts as its own jumper between individual sections when there is an overlap of about 2 inches. The foil can be soldered once it is applied to the TRS-80® microcomputer, but be careful because the foil is thin. If you plan to solder the joints, practice on a spare cover first. The use of a small iron, applied quickly, will do the job nicely, with no damage to the plastic beneath.

My machine is no longer in warranty, so I began by opening the keyboard and installing a 20-gauge copper sheet between the keys and the printed-circuit board in the keyboard. The ALPS keyboard, installed in my computer, is the successor to the keyboard with keybounce. I can't be sure that this installation will work with the earlier keyboard. I drilled 1/4-inch and 3/8-inch holes in the copper sheet to match the stand-off supports, and installed the copper sheet between the keys and stand-offs. Be sure to clean the sheet thoroughly before final installation, for it takes only a minute particle of copper in the wrong place to cause havoc. Also, cover the printed-circuit board with a towel or other soft cloth to protect it from scratches. This copper sheet should not be grounded; rather, let it act as an electrostatic shield. To eliminate contact with the flat cable that connects the printed-circuit board with the keyboard, the copper sheet was cut to the size of the keyboard, measuring front to back, and was cut diagonally from back to front on the left side.

The foil will be applied to all surfaces of the keyboard and the interface, except the keyboard proper and the ventilation holes. At the ventilation holes, let the foil come up to, but not cover, the slots. Trim the foil that covers the screw holes and the interface switch, and test with an ohmmeter for continuity from the cables to the keyboard and the interface. If there is no continuity, use solder to bridge the foil junctions.

Copper screen wire is used for covering the ventilation openings. It is 16 × 16 mesh, wire diameter of 18 mills. I had considerable trouble in finding a vendor for copper screen wire. It seems that it is not available at the corner hardware store anymore.[5]

The screen is applied after the foil is in place, by being cut to size, tinned around the outside edges to prevent raveling, shaped to fit and soldered in place. I would recommend using a *hot* iron. Be quick!

Install a ground lug on the Macro-

¹Notes appear on page 29.

*2100 Buckingham Dr., Huntsville, AL 35803

tronics cabinet. This will serve the following purposes: (a) a connecting point for the shields of the interconnecting cables; (b) a connection from the earth ground to the Macrotronics and the printed-circuit boards (through the interconnecting cables); and (c) a point to which a connection may be made from the copper foil to the earth ground.

I removed the power supplies from the expansion interface, covered them with foil, and shielded the cables. A brute-force filter that serves just these two power supplies was installed. This brute-force filter is connected in series with the Radio Shack line filter.

Testing

All testing during and after the installation was done in the following manner: The tests were made by first connecting to a dummy load, and then to an antenna for each of the hf bands.

I learned that the printed-circuit boards in both the computer/keyboard and the expansion interface are grounded from one to another through the interconnecting cable. This same ground is also through the connecting cable to the Macrotronics cabinet. There is, therefore, no need to worry about bringing a ground out of the TRS-80 unit, for it is already there. The following items had no effect on the amount of RFI when these were disconnected: (1) the cassettes and their cables; (2) the printer and its cabled connection; and (3) the video display and its cabling.

With the Macrotronics interface connected directly to the computer, the RFI was reduced considerably. This did not permit the use of my printer, so I elected to leave the interface connected during the installation and during all tests.

Results

Is it all worth the effort, you ask? Well, I'm going to tell you how it is! Before I started on this modification, I could not use the 80-, 40-, 15- or 10-meter bands because of RFI, and 20 meters was barely usable. Since the modification, the video is very clean during transmission, even when the kW amplifier is activated. During receive, I can barely hear the RFI on 40 meters, but it is not enough to deflect the S meter — except at one spot near 7092 kHz.

Covering the exterior in the manner described above should not void the warranty if it is still in effect, unless, of course, you did install the copper sheet in the keyboard. Since my warranty had expired, this did not present a problem. Further, I suspect that the fact that the units have been opened will not deter the company from repairing them, though a charge may be involved. [Please check with Radio Shack before modifying machines that are still under warranty. — Ed.]

Observations

I found the solution to be extremely effective. If only the manufacturer would provide a kit! I am told that the Model II machines have been modified in compliance with FCC regulations, but I am not aware of the effectiveness of this modification. (See FCC Part 15.25 for details.)

In working on this project other ideas have occurred to me concerning the use of the copper foil. It would be possible to enclose any plastic case used for making electronic equipment. It might even be possible to use this foil for the construction of copper-coated printed-circuit boards, though I will leave this for others to investigate.

I believe that clock modifications are available for the TRS-80 microcomputer. This might have some effect on reducing the RFI by changing the clock frequency. It might be possible to install a small capacitor in parallel with the crystal to reduce the 10.6-MHz frequency to about 10.48 MHz and thereby eliminate the second harmonic now present at 21.289 MHz. This would move it out of the band rather than eliminate it!

I will be happy to respond to any and all inquiries. Please send an s.a.s.e with your questions. If you are active on RTTY, I hope we can have a QSO one day. Good luck!

Notes

[1]P. E. Cooper, "Microcomputers and Radio Interference," *QST*, March 1980, pp. 17-20.
[2]Tube-Koat is a conductive aerosol spray sold by G. C. Electronics, 400 South Wyman St., Rockford, IL 61101.
[3]mm = in. × 25.4.
[4]Rolls of copper foil may be obtained from Edco Supply Corp., 323 36th St., Brooklyn, NY 11232, tel. 800-221-0918, ext. 19.
[5]Copper screen is available in strips, 36 inches wide × 1 foot long, from McMaster-Carr Supply Co., 600 Country Line Rd., Elmhurst, IL 60726.

Strays

E.T. "PHONES HOME" WITH HELP FROM A HAM

☐ What do a Hollywood producer/director and a radio amateur have in common? The answer is the summer 1982 smash-hit motion picture *E.T. The Extra-Terrestrial.* Steven Spielberg may have produced and directed the movie to instant success, but it was the ingenuity of Henry Feinberg, K2SSQ, of New York City, that provided the movie's main character, an alien from a distant galaxy, with the means to communicate with its home planet.

The project started about a year and a half ago when one of Spielberg's aides called K2SSQ, then an exhibits and science demonstrations coordinator for Bell Labs in Murray Hill, New Jersey, and asked him if he would devise a "communicator" that could be used in the film. Since designing items along these lines is something Feinberg has done much of his life, he agreed to take on the E.T. communicator as a part-time project.

Henry Feinberg, K2SSQ, displays the "communicator" he created using a clothes hanger, a child's phonograph, an umbrella lined with aluminum foil and other household items that enabled E.T. to call long-distance — at intergalactic rates, of course. *(Roger Tully photo)*

Using articles commonly found around the average American home — such as a child's toy, a knife and a fork, a circular saw blade, a coffee can, a TV tuner and an umbrella — K2SSQ designed a "plausible" beacon transmitter that could operate unattended, yet be capable of directing a pinpoint signal (microwave) into space. While in real life the communicator really does not transmit any rf, moviegoers will be delighted to know that the device does have a "special effect" on E.T., who is able to "phone home" with it. — *Bill Pasternak, WA6ITF, Panorama City, California*

HQ. LAB RECEIVES EQUIPMENT DONATION

☐ The Yaesu Electronics Corp. recently donated an FT-680R 6-meter multimode transceiver and companion FP-80 power supply to the ARRL lab. This unit will serve to complement the lab's test equipment. ARRL expresses its gratitude for this gift.

Amateur Use of Solar Electric Power†

Part 2: For emergency use, collected solar energy must be stored. This is the description of the method and mechanics used with the PV modules discussed last month.

By C. Philip Chapman,* W6HCS, Paul D. Chapman and Alvin H. Lewison

Simply connecting a photovoltaic (PV) array to the equipment to be powered is not the most efficient means of using solar energy, especially for emergency use. Power would then be available only during periods of sunlight, and emergencies can occur at any time of day — or night. To provide the power required during no-sun periods, the collected solar energy must be stored. This may be accomplished by means of batteries.

A battery box (see Fig. 6), constructed on a concrete pad, is used to house the batteries and a shunt regulator. A floorboard provides an air gap and lifts the six batteries off the concrete. Water entering the battery box will not collect around the base of the battery pack, but will run out of the enclosure. The front, sides and sloping roof of the box are constructed from marine-grade plywood that is waterproofed and painted before assembly. To prevent water from entering into ventilation areas, the roof has an overhang along the front edge and a tight seal around the mating edges.

During battery charge, considerable amounts of hydrogen and oxygen can be produced. It is important not to allow an accumulation of these gases, particularly if electromechanical devices are used for inverter actuation and power distribution and management. Vents are placed in the front section of the box and on the one exposed side to provide ventilation. In the roof assembly, holes are added around the front and sides to allow any gases that may collect against the inside top of the roof to escape. Holes are located also in the back side in an area immediately above the heat-sink area. Finally, all the rectangular vents are covered with aluminum vent mesh to prevent animals from entering the box.

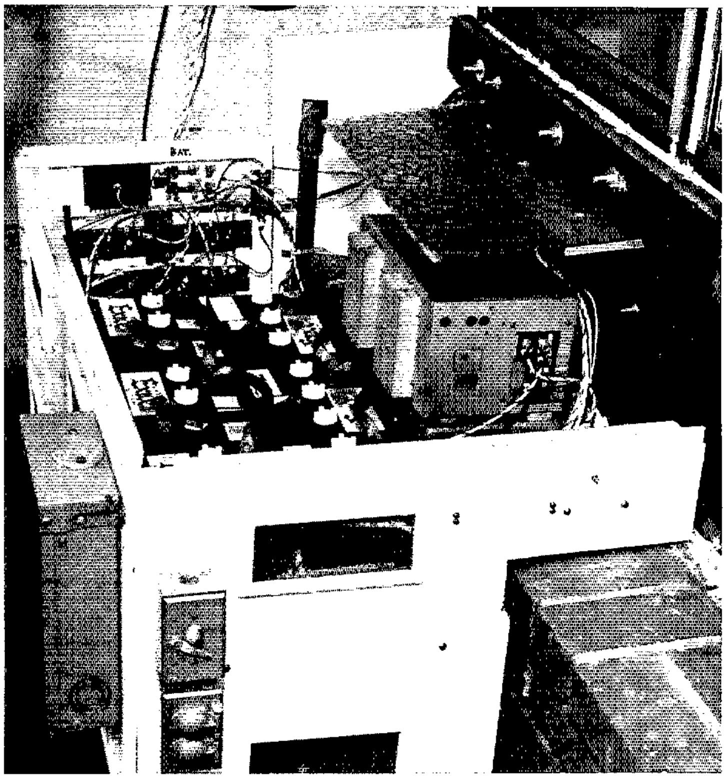


Fig. 6 — A view of the battery box showing the batteries, inverter and the breaker panel.

System Highlights

Fig. 7 is a conceptual diagram of this system. Extensive metering and the use of circuit breakers and isolation diodes are shown. The first isolation diode after the array protective diodes is used to isolate the PV panel-voltage meter from the rest of the system. This diode and the second isolation diode are Shottky devices.

Shunt Regulator: As shown in Fig. 8, a μA723 IC is used as the active device for the shunt regulator; it drives a pair of Darlington power transistors. These tran-

†Adapted from Jet Propulsion Laboratory publication 82-2, "A Low-Power Photovoltaic System With Energy Storage for Radio Communications," Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91103.

*2922 Alta Ter., La Crescenta, CA 91214

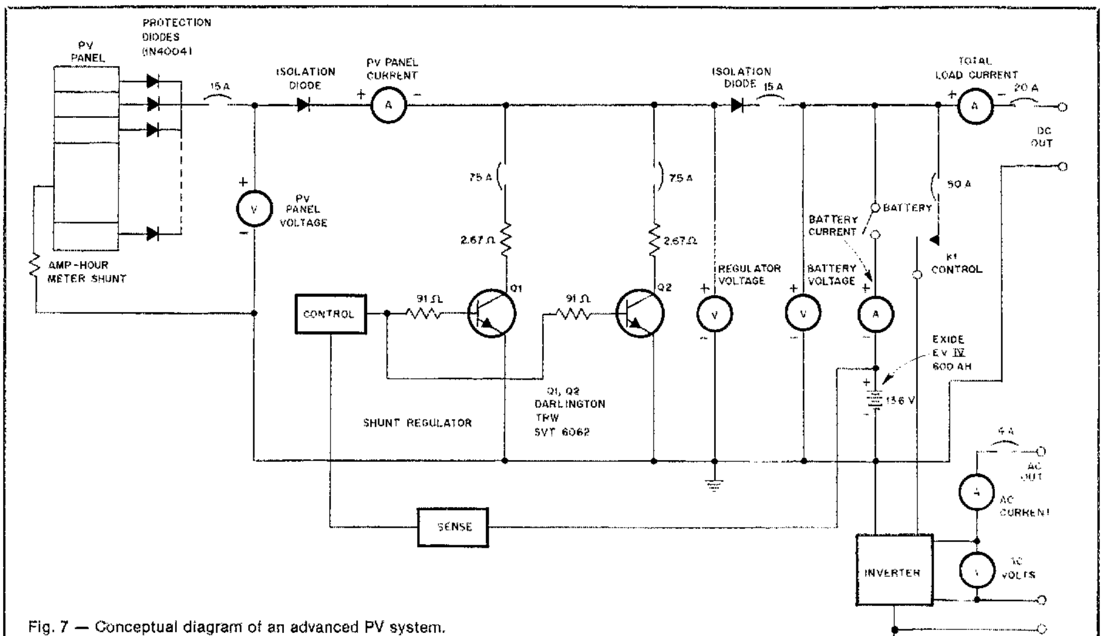


Fig. 7 — Conceptual diagram of an advanced PV system.

sistors are in series with the shunt resistors and regulate the current being diverted from the battery pack and load. It is because of their particular dc current gain versus collector-current characteristics that these transistors were selected. The current gain of these devices peaks when the collector current is between 4 and 6 A and is about 175 at 77°F. About 23 mA of base current is required to conduct 4 A through each device; the IC is capable of supplying at least 60 mA of drive current. At no time are the transistors driven into saturation, and the drive current is limited by the 130-ohm resistor and the 91-ohm resistors in each base lead.

As more array current is required to operate the equipment or charge the battery pack, drive current is reduced accordingly. If all of the array current is required by the load and battery pack, the shunt regulator turns off completely. Regulator control is accomplished by a feedback loop that senses battery voltage. The battery pack is maintained at a potential of 14.1 V during sun periods.

The 2.2-μF capacitor between the output and the inverting input of the 723 IC, and the 33-μF capacitor from the noninverting input to ground, stabilize the IC. These steps are necessary because of the high gain and wide bandwidth of the IC, which makes them highly sensitive when used in PV systems. The voltage regulator circuit board is heavily bypassed with 0.1-μF capacitors to bleed off any rf that might ride into the regulator box on the cable harness. Three parallel-connected, 8-ohm, 100-W, wire-wound resistors act as collector (shunt) resistors for each power transistor. These values were selected to allow at least 4 A of collector current for each device. About two-thirds of the shunt power is dissipated in the resistors, allowing the transistors to be operated conservatively. The resistors are mounted by means of stand-off brackets on the outside of the metal box containing the regulator. The transistors are mounted on heat sinks at the bottom of the battery

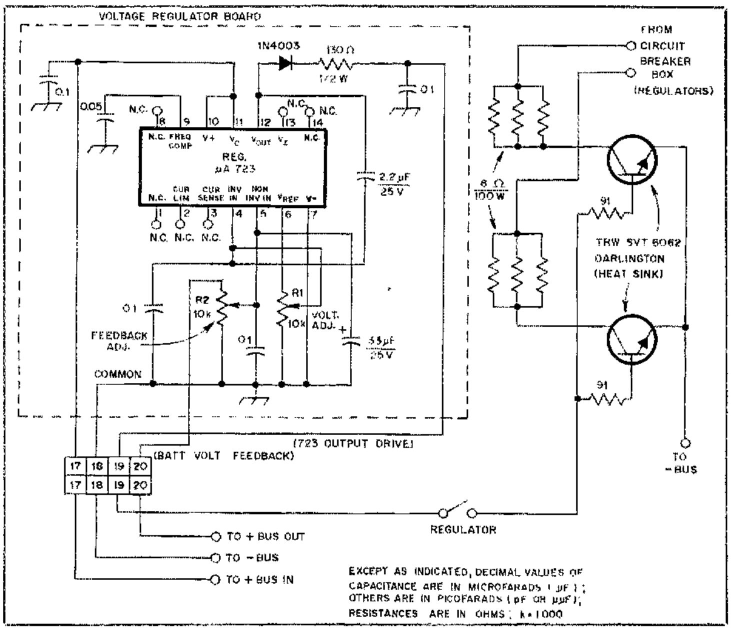


Fig. 8 — Schematic diagram of the shunt regulator. Refer to the text for more details.

box, where air is available for convective cooling.

Battery Pack and Power Conversion: The six batteries are connected in series-parallel to give a nominal 12.7-V open-circuit potential. This battery pack has a rating of about 400 Ah at a 225-A rate.

Power dissipated in the battery pack is not simply the charge current times the float (charge) voltage. It can be determined by the following:

$$q_W = (E_H - E_I)I \qquad \text{(Eq. 1)}$$

where

q_W = dissipated power in watts
E_H = thermal-neutral voltage (2.07 V per cell for any lead-acid battery)
E_I = battery potential with I amperes flowing
I = charge current in amperes

The aging factor for deep-discharge lead-acid batteries is a function of the number of deep discharges experienced by the battery pack and the depth of the discharges. It is electrolyte-temperature dependent.[4]

In general, it is advisable not to allow the battery pack to drop below 50% of full charge. This will extend the pack life by perhaps 40% in normal temperature environments when compared with discharges down to 80% of full charge. For lead-acid batteries, Ah out of the battery is nearly equal to Ah into the battery. A conservative rule of thumb is

$$Ah_{charge} = Ah_{discharge} \times 1.1 \qquad \text{(Eq. 2)}$$

Power-conversion equipment is used to convert the 12-V dc to 117-V ac, and 12-V dc to 700-V dc. While the communications equipment will work on 117-V ac as well as on 12-V dc, the 117-V ac is required to rotate the antenna arrays. Also, the low-band equipment can run higher power output using 117-V ac rather than 12- and 700-V dc.

A Nova 5060-12 fixed-frequency, sine-wave, single-phase inverter is used to produce 117-V ac from the system dc voltage. It has a maximum continuous output rating of 500 VA and is voltage and frequency regulated. Inverter efficiency is about 60%. The inverter can be actuated from the battery box or the radio room by means of a relay mounted in the battery box.

A dc-to-dc converter supplies high voltage to the final-amplifier tubes in the low-band gear when this equipment is used on dc. This converter will produce between 600 and 700 V and is not voltage regulated. Therefore, the input power of the low-band equipment is a function of the battery-pack status. This converter is located in the radio room and is actuated by a switch on the low-band transceiver.

Metering: During the time the station is not being used, engineering and scientific data are acquired. This is accomplished by a complement of meters (see Fig. 10) measuring various currents and voltages throughout the system. The Simpson dc voltmeters used incorporate self-shielding annular, 1-mA movements and provide 24-hour-per-day monitoring with minimal power consumption by the meters themselves. Diodes are used where needed to provide the necessary isolation and to ensure each meter display is restricted to a specified measurement task.

A dc voltmeter is located at the station operating position, where the operator can monitor the dc voltage level at the equipment location at all times and under varying loads. The reading can be compared with the battery voltage level meter to determine exact losses on the supply line to the station.

An Ah meter (Fig. 9) using the IMC model 520 digital ampere-hour integrator monitors the PV array output.[5] The IMC module consists of a voltage-to-frequency

[4]Notes appear on page 34.

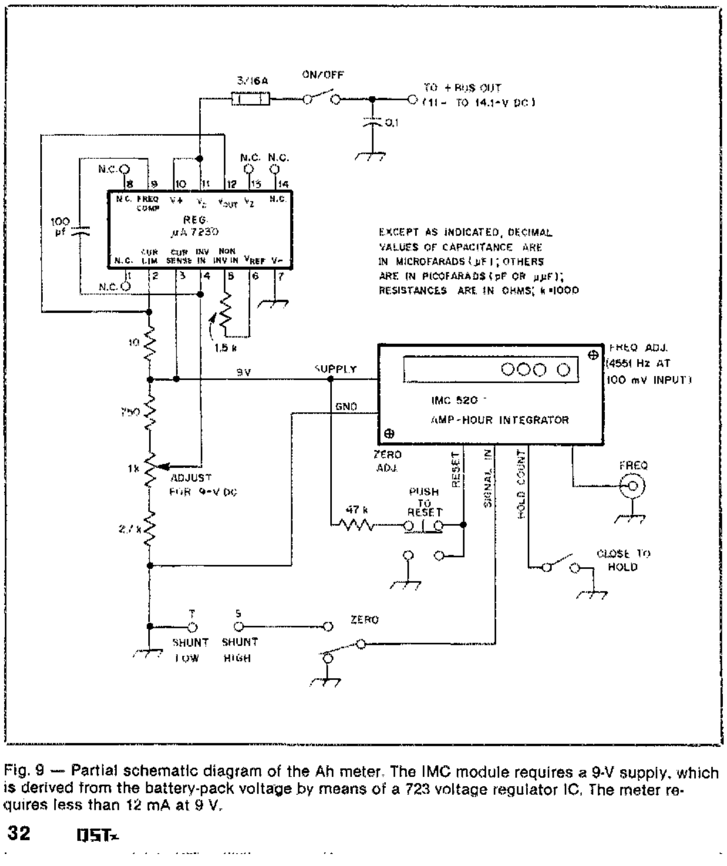
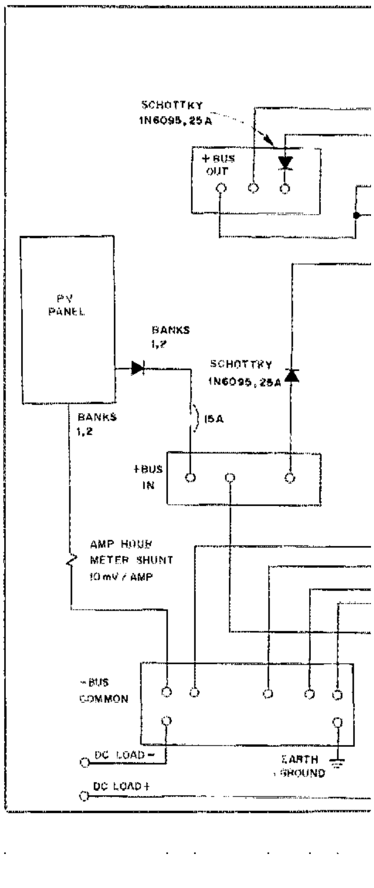


Fig. 9 — Partial schematic diagram of the Ah meter. The IMC module requires a 9-V supply, which is derived from the battery-pack voltage by means of a 723 voltage regulator IC. The meter requires less than 12 mA at 9 V.



converter (VFC), a 4-1/2 digit event counter and an LCD. A highly stable op-amp amplifies the input signal and sends it to the VFC. The VFC output is a train of pulses that is frequency proportional to the current present. A 10-mV-per-ampere, 0.25% precision current shunt located in the return lead to the PV array acts as the input signal source.

Some Considerations

The number of Ah per day of charge capacity available from an array on a cloudless day is a function of in-system PV module current characteristics, ambient temperature and atmospheric haze, site elevation and latitude, array wall and tilt angles, and time of year (sun declination angle).

Use of the PV module manufacturer's I-V characteristics may mislead the user. For example, on a warm (75° F), mildly hazy day at high sun, this system generates about 9.5 A with 22 modules in parallel, which would indicate perhaps about 0.43 A per module. Allowing 2 V more above the float voltage of 14.1, the curves in Fig. 3 (see Oct. 1982 *QST*, p. 14) indicate that the module current should be about 0.57 A, or 12.5 A total for 100 mW/cm² of sun radiation, at the normal operating cell temperature. This may occur under special or ideal conditions; however, 80 mW/cm² probably would be more realistic. In most instances where the SOC of the PV module is specified at 100 mW/cm² only, the actual performance most likely will be less than the I-V curves indicate. In addition, the shunt regulator constrains the array to 1 or 2 V above the float voltage, depending on the voltage drops between the array and the regulator. Therefore, the curves at 100 mW/cm² may not reflect the expectations of the actual system performance.[6]

Temperature and atmospheric haze affect the daily Ah totals, but not significantly over several days. Overcast or cloudy days swamp out the minor changes of temperature and haze. As the ambient temperature increases so does the cell temperature. The short-circuit cell current increases less than 0.1% per degree Celsius with increasing cell temperature, but the open-circuit cell voltage decreases more significantly (2.2 to 2.3 mV/C°). The net result is a reduction in cell power between 0.3 and 0.5%/C°.

Haze affects the array output more than temperature (at least in temperate climates). Comparisons of actual direct-beam-radiation measurements at the station site with three atmospheric haze models produced measurements of 82 mW/cm² for direct radiation and variations of between 65 and 96 mW/cm² for the haze models.

This system has a fixed tilt angle of about 36° and a wall angle close to 0°. The wall azimuth angle is the angle between true south and the array surface normal as projected down to the horizontal plane. Wall angles east of south are positive, west of south negative. The tilt angle is positive for surfaces tilted generally upward and facing generally south, and is zero for horizontal surfaces. Neither angle appears to be critical at nominal latitudes, particularly where a significant amount of the total irradiance falling on the array comes from reflections and diffuse reflections. If only direct-beam radiation were available, the tilt angle would be more important. A tilt angle about equal to the site latitude appears reasonable for fixed tilt-angle installations, such as this system.

The sun declination angle or time of year is important to the extent of establishing the number of hours the sun is available to irradiate the array. This is implicit in what is called the solar hour

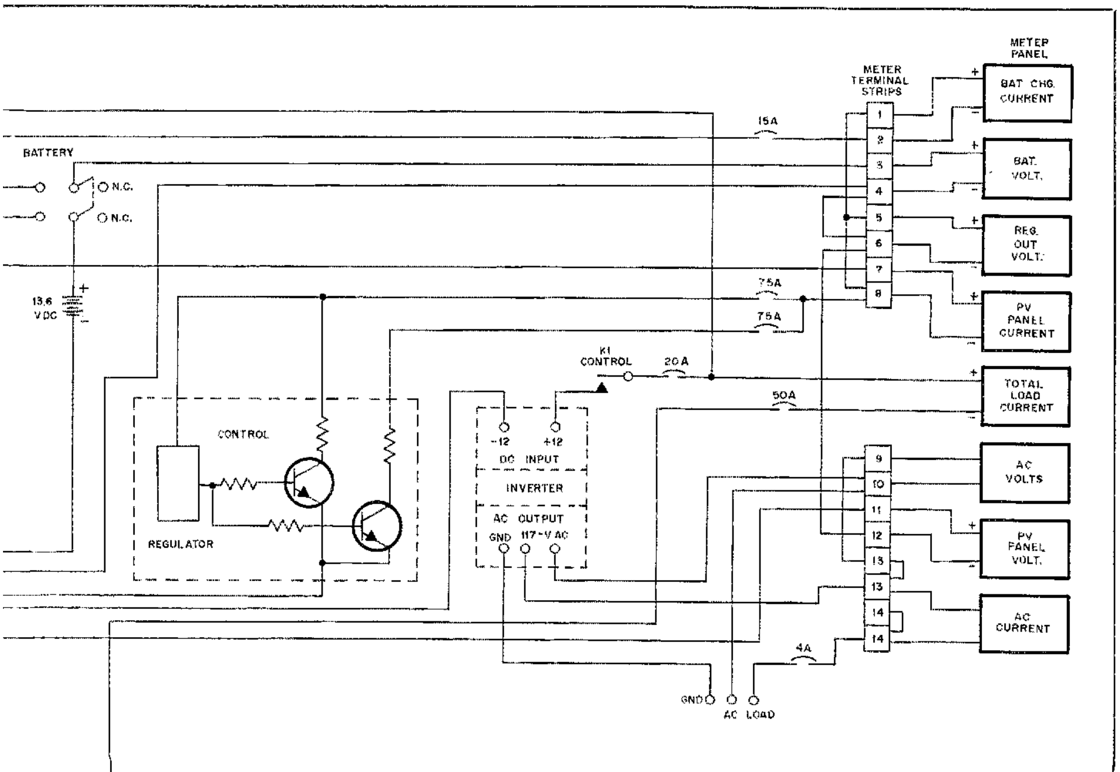


Fig. 10 — Wiring diagram of the metering system.

angle, which is equal to 15° times the number of hours from local solar noon. In the summer, the array will produce more daily Ah simply because the days are longer, and fewer Ah in the winter. This must be considered in specifying the array required to recharge the battery pack in a given number of hours or days.

Fig. 11 indicates the nominal voltages and currents from the PV array and within the battery box at high sun. The battery pack is assumed to be fully charged with no current being drawn by the radio equipment. The radio room is connected electrically to the system illustrated by two no. 4 stranded-copper cables for the dc loads, two no. 12 stranded-copper cables for the ac loads, and no. 14 wire for the inverter control.

System ground is established at the battery box where the negative side of the battery pack is connected directly to the utility company ground. However, this is not a single-point ground since the radio tower and antenna systems are grounded by means of the tower base, which is 5 feet in the ground. The outer coaxial cable shields connecting the radios to the antennas are at ground potential because of a radio room ground system used when operating the equipment from utility company power. This ground is the same one used at the battery box, but not the same ground point. This three-point ground configuration was initially of some concern. However, with all the equipment operating from solar power, less than 2 mA of ground-loop current has been measured. It is important to keep the dc-current meters in the current-source side of the equipment, rather than what is believed to be the current-return side when single-point grounding cannot be used. Otherwise, the meters may not read correctly. The station has been operated with some equipment simultaneously on utility power, dc solar power and inverter solar power with no ill effects.

The 50-foot run of cable between the radio room and the battery box exhibits a measured round trip dc resistance of 0.11 ohm. This impedance creates a problem when the dc-to-dc converter is used. This unit, located in the radio room, produces the heater current for the final-amplifier tubes and the plate voltage for the low-band transceiver when operating from dc (inverter off). It produces a 100-Hz square wave, which appears on the 12-V line. Any other equipment connected to this line will see this pulse train. This problem was partially eliminated by placing 86,000 µF of capacitance across the 12-V line. The capacitors are removed automatically from the line when the equipment is operated with the inverter or from utility power.

Control and Safety

Inverter control, emergency lighting control and radio room systems-voltage monitoring are performed in the radio room. The inverter is actuated by closing a 200-A, hermetically-sealed control relay. Because the input current to the inverter could be as much as 50 A, it is necessary to have a heavy-duty contactor. Also, the contactor is in a potentially hydrogen-rich environment; therefore, it is important to have a hermetically sealed device. All electromechanical switching devices are kept below the upper surface of the battery pack.

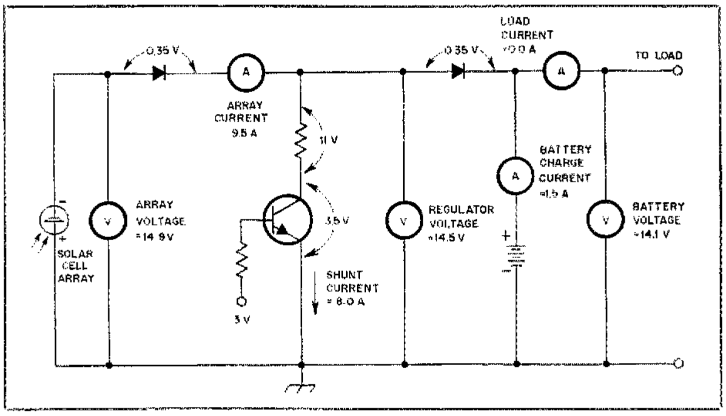


Fig. 11 — Nominal high-sun system voltages and currents.

The inverter input and output are floating. In this system the inverter chassis, the −12 V return and the 117-V ac low side are made common so mixed modes of utility, inverter and battery-powered operation can be used safely.

A breaker box using seven aircraft-type breakers is provided for safety. Although 12-V systems appear to be relatively safe from shock hazard, the results of getting a watchband, ring or wrench caught between +12 V and −12 V can be dangerous and quite painful. All equipment is fused, and all inverter ac distribution is wired according to the National Electrical Code with a third-wire ground carried through to all ac outlets. Finally, the array framework is grounded, and all antennas can be disconnected during electrical storms.

Summary

It is amazing how inefficient low-voltage (12-V) inverters are. Techniques and new semiconductor devices are available to improve this performance. Much of the available commercial communications equipment is designed for 12-V dc and 117-V ac, so 12-V sine-wave or pseudo sine-wave inverters are desirable for these systems.

Emphasis has been placed on increasing the efficiency of solar cells. Perhaps equally important areas of improvement are in battery development and complete characterization of these batteries for PV energy-storage use. Battery temperature coefficients, Peukert constants and constant power-discharge coefficients are required to design cost-effective energy storage PV systems.[7]

PV manufacturers should present their I-V curves in decrements of 10 mW/cm^2, from 80 or 100 mW/cm^2 and indicate that the curves translate linearly along the ordinate axis with irradiance. A few days of using a radiometer will convince most people that a 100-mW/cm^2 day happens only occasionally — at least in and near metropolitan areas. An 80-mW/cm^2 day is perhaps more realistic.

Since there is an abundance of 12-V communications equipment being manufactured, it would be helpful if the PV-module manufacturers would provide units specifically designed for 12-V energy-storage systems. This would assume 14.1-V float voltages, shunt-type regulators and two diode drops. A system then could be operated at an optimum point on the I-V curves.

It is definitely impressive to sit at the radio room console and talk to someone across town or halfway around the planet using a no-noise, nonpolluting energy source. We think small systems patterned after the one described here will appear in greater numbers as the cost of photovoltaics and inverters becomes more attractive.

Notes

[4] *Handbook for Battery Energy in Photovoltaic Power Systems*, SAND 89-702Z, Bechtel National, Inc., Final Report, Nov. 1979, pp. 2-5, 2-6, 3-23, 3-24, 3-25. Available from National Technical Information Service, U.S. Dept. of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.

[5] International Microtronics Corporation, 4016 East Tennessee St., Tucson, AZ 85714.

[6] R. G. Ross and C. C. Gonzales, "Reference Conditions for Reporting Terrestrial Photovoltaic Performance," *Proceedings of the AS/ISES 1980 Annual Meeting*, Phoenix, Arizona, June 1980.

[7] W. Peukert, "On the Dependence of the Capacity of Lead-Accumulators on the Discharge Current," *Elektro-Technische Z.* (ETZ), 18, 1897, pp. 287-288.

Antenna Gain Measurements

Part 1: Technique — the fine points of making accurate gain measurements without access to a professional antenna range.

By Fred Brown,* W6HPH

The field of antennas is one in which the amateur can make significant technical contributions to the state of the art; this has been well demonstrated in the past. In probably no other area of electronics does pure empiricism yield greater results.

Unfortunately, the myth has become widespread that gain measurements are beyond the acumen or ability of the intelligent amateur. This dilemma is further clouded by many antenna articles that have appeared in the amateur (and sometimes even in the professional) literature with exaggerated gain figures. Unfortunately, some antenna manufacturers have been dishonest about gain, so much so that *QST* has refused (rightfully) to accept advertising in which gain figures are mentioned.[1]

Transmission-line SWR measurements and even antenna impedance measurements are well covered in the amateur literature, but the parameter of most interest to amateurs — antenna gain — is largely neglected. There is no question that gain measurements are not as easy to make as impedance measurements, but this is not to say that gain cannot be determined accurately with fairly simple equipment and straightforward procedures. The techniques outlined here will permit the experimenter to determine the true gain of a manufactured or homemade antenna to an accuracy of within 1/2 dB or better.

This article deals with gain measurements at uhf, where antenna dimensions are small enough for convenient handling. Lower-frequency antennas can be measured by the use of scale models. In antenna work, scaling is based on the principle that when *all* dimensions are scaled by the same factor as the wavelength the scale model will perform exactly the same as its full-scale counterpart.[2] For instance, if we wanted a 432-MHz scale model of a 7.2-MHz antenna, all dimensions, including element and boom diameters, insulator size and so forth, would be scaled by a factor of exactly 60. The free-space performance of the scale model then would be precisely the same as the 40-meter version.

[1]Notes appear on page 37.

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Comparison and Reciprocity

The straightforward way to measure gain is to compare the performance of the antenna under test directly with that of a reference antenna of known gain.[3,4,5] Other techniques have been used to determine gain but, in terms of simplicity, practicality and accuracy, the comparison method is best for amateur purposes.

The reciprocity principle is that the gain, impedance and radiation patterns of any antenna are the same whether the antenna is used for transmitting or receiving. Comparison could be carried out at either end of the antenna range, but usually it is easier and more practical to compare antennas at the receiving end.

The Distance Requirement

At the very close range of only a few wavelengths, an antenna will perform differently than it will at large distances. The performance on an antenna range will be the same as the long-distance performance, provided that a certain minimum-distance requirement is met. Of course there is no *maximum* distance requirement; however, very long-distance antenna ranges give rise to fading signals, ground reflections and weak signal levels.

Primarily because of the ground reflection problem, the most practical antenna test-range distance is usually from 1 to 5 times the minimum distance requirement. This minimum range depends on the largest antenna dimension and the wavelength; the generally accepted value is

$$S_{min} = \frac{2D^2}{\lambda} \qquad \text{(Eq. 1)}$$

where the minimum distance (S_{min}) is measured in the same units as the largest antenna dimension (D) and the wavelength (λ).

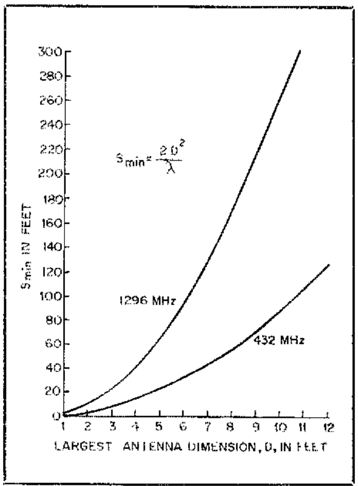

Fig. 1 — The minimum distance at which antenna gain can be measured accurately depends on the size of the antenna and the wavelength. Notice that for a given antenna size the minimum distance is three times as far for 1296 MHz as it is for 432 MHz.

A plot of S_{min} versus antenna size is given in Fig. 1 for 432 and 1296 MHz. Note that for a given antenna size, S_{min} is greater at the higher frequency.

The Reference Antenna

The simplest reference antenna is a dipole, and since gain is customarily expressed in decibels referred to a half-wave dipole (dBd), the dipole has the advantage of being a zero-dB reference. In some respects a dipole is the best, and in other respects it is the worst, of reference antennas. On the plus side is simplicity and reliability. You almost have to *try* in order to make a bad dipole. About the only thing that can go wrong is the impedance match, and this will show up readily with a simple SWR check.

The main shortcoming of the dipole is its lack of directivity: It offers little or no rejection of unwanted reflected signals that come from wrong directions. Nevertheless, if a good deal of care is exercised, accurate gain measurements are possible with a half-wave dipole reference antenna.

A better reference antenna has been developed by the Electronic Industries Association (EIA); dimensions are given in *The ARRL Antenna Book.*[6] A number of these 7.7-dBd gain antennas have been built by various amateurs, and it is worth noting that, even though different construction and impedance-matching methods were used, the gains have always measured within 1/10 dB of each other.

Another reference antenna design, easier to construct than the EIA antenna, is shown in Fig. 2. This antenna has the further advantage of being a good match to 50-ohm coax without any external matching devices. Its gain is 6.8 dB over a half-wave dipole.

Impedance Match

To measure gain accurately by substituting one antenna for another, both antennas should have the same impedance. This condition will be met if the SWR on both is low. But the match is not nearly as critical as is generally believed. For instance, an SWR as high as 2.0 results in a mismatch loss of only 0.51 dB. Fig. 3 gives the mismatch loss for SWR values between 1.0 and 2.0.

For best results, the receiver used for comparison should have an input impedance that is a match to the transmission lines used on the antenna, which will usually be 50-ohm coax. Sometimes attenuator pads are used ahead of the receiver to ensure that the antenna "sees" a 50-ohm load. Uhf attenuator pads, however, are expensive and not always available. Furthermore, they are not really needed at uhf, where the high attenuation of small-diameter coaxial cable can be utilized to do the same job. For instance, at 432 MHz, 37 feet of RG-174/U provides 7 dB of loss, and at 1296 it takes only 26 feet of RG-58/U for the same attenuation. A cable loss of 7 dB means a return loss of 14 dB, and this is enough to ensure that the input SWR will be less than 1.5, no matter how bad a mismatch the receiver is.

Reflections

Reflections are the main bugaboo of antenna measurements. An accurate determination of gain requires that the antenna be illuminated by a uniform-plane wave front from just *one* source. Any reflecting object constitutes an additional source. Unless the reflected signal is weak compared to the direct signal, substantial error can result. Practically any object larger than a quarter wavelength, conducting or nonconducting, can cause a reflection. Generally, two types of countermeasures can be taken against reflections: directivity and distance.

The most obvious way to avoid reflections is to get away from all reflecting objects (distance) by carefully choosing a test site. Fig. 4 shows the geometry of the reflection problem. Obviously, the reflected signal will be weak compared with the direct signal if d is large compared with S. For instance, if d is 5 times S, the reflected signal will need to travel more than 10 times as far as the direct signal. Assuming the worst case of a perfect specular reflection from a large object, a reflected-path distance 10 times as great would make the reflected wave at least 20 dB weaker than the direct wave. That might seem like enough attenuation, but reflected signals even 20 dB down can cause worst-case measurement errors as large as 1.7 dB.

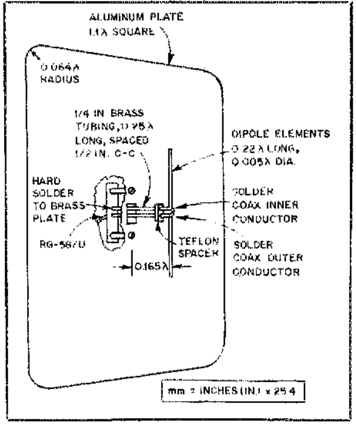

Fig. 2 — A half-wave dipole feed-point impedance can be reduced from 73 to 50 ohms by spacing it 0.165 wavelength above a conducting plane, as shown. The dipole-reflector combination makes a useful reference antenna with a forward gain of 6.8 dB.

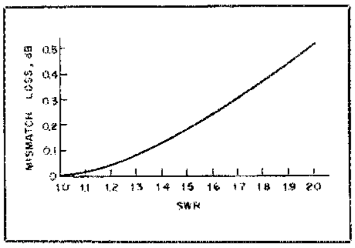

Fig. 3 — Decibel loss resulting from mismatch.

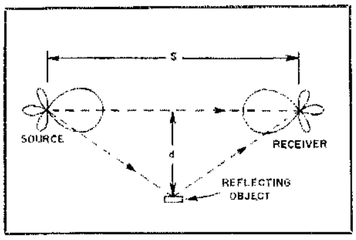

Fig. 4 — The signal can travel from the source antenna to the receiving antenna directly, or along a "bounce" path if a reflecting object is present. The magnitude of the reflected signal will depend on the ratio of d to S, the "scattering cross-section" of the object and on the radiation patterns of the two antennas.

Fig. 4 also illustrates how antenna directivity can be utilized to reduce errors arising from reflections. If the reflecting object lies in a direction that is near a null in the pattern of the source antenna, the reflected signal can be attenuated to an insignificant level.

It also can be understood from Fig. 4 why an antenna range intended for pattern measurements must be much more reflection-free than a gain-measurement range. When the antenna under test is rotated so that its main lobe is pointed at the reflecting object, the reflected signal is magnified by the gain of the antenna, whereas the direct signal may be greatly attenuated by a null of the receiving antenna.

Generally speaking, the ideal test site is an open field, far from houses, trees, cars, cows and all other objects. Such a site leaves us with only one large reflecting object to deal with: the planet Earth. This problem will be dealt with in detail later. The equipment and body of the experimenter can cause reflections, but usually these objects will be below or behind the source or receiving antenna where the directivity of these antennas will discriminate against reflected signals. In professional work, the personnel and equipment are sometimes placed in a hole below the antenna to "hide" them from the electromagnetic environment. The hole is covered with perforated sheet metal to simulate a smooth ground.

Open fields are plentiful and accessible in all parts of the country. (If the one you find is private property, be sure to get the owner's permission.) The field should be smooth to within a quarter wavelength, which is only 2-1/4 inches at 1296 MHz. Grass can be expected to absorb some of the ground-reflected wave, but heavy brush should be avoided. Where the field is furrowed, it is best to choose a signal path that is perpendicular to the furrows.

Any antenna range can easily be tested for reflections by means of a dipole or a similar probe held aloft on a stick. Observe the signal as the probe is moved a few wavelengths up and down, and sideways, across the wave front. A good test site will yield a constant signal strength as this is done. With vertical polarization, the dipole should be held above the experimenter's head so that his body will be in the direction of the dipole null. See Fig. 5. For horizontal polarization, the probe should be something more directive than a dipole. Two horizontal half waves fed in phase and spaced a half wave apart vertically will also provide a null in the downward direction. Closer to the ground, the reference antenna of Fig. 2 makes a good probe, as the experimenter can stand behind the reflector and thereby shield himself or herself from the source.

The ground-reflection problem will be dealt with in two parts since the case for vertical polarization requires a somewhat different treatment than that for horizontal polarization.

Vertical Polarization

It is not generally appreciated that at a certain angle of incidence a vertically polarized wave will not be reflected appreciably from the earth. Instead, it is simply refracted into the soil and absorbed. the angle at which this occurs is called the Brewster angle.[7] Its exact value depends somewhat on the soil conductivity, the soil dielectric constant and the frequency, but for typical soil at uhf the Brewster angle is usually quite close to 15°.

If, then, our antenna range is set up so the transmitted signal strikes the earth at an angle of 15° at the point on the ground at which it would be reflected to the receiving antenna, it will be possible to avoid virtually all of the ground-reflected signal. The geometry is shown in Fig. 6. Where transmitting and receiving antennas are of equal heights, an incidence angle of 15° requires that the range distance (S) be 7.5 times the height above ground (h).[8] Of course, S will also have to meet the minimum distance requirement (S_{min}) discussed previously.

Horizontal Polarization

With horizontal polarization there is no Brewster angle to absorb the ground reflection; instead, the reflection coefficient is nearly 100% for all angles of incidence of concern at the test range. Accordingly, we must employ a different strategy to avoid earth reflections, and a number of techniques have been devised to deal with this problem. Probably the most practical for the amateur is to utilize vertical-plane directivity at the source. If the transmitting antenna has a directive-pattern null in the direction at which the ground-reflected signal is transmitted, the ground reflection can be diminished to a negligible level.

It's not hard to make an antenna with a null at a given angle with respect to the main lobe. Two identical antennas (they could be Yagis or simple dipoles), fed in phase, will produce nulls that are a function of the spacing between the two antennas. Fig. 7 gives the relationship between spacing in wavelengths and the angle of the first null measured from the main lobe. For instance, if we want a null at 15° below horizontal, we space the two antennas 1.932 wavelengths apart vertically. Then, if we make the range geometry such that the angle of incidence for the ground-reflected signal is 15°, we will be able to avoid practically all of the ground reflection. It is essential that the two antennas be identical and be fed in phase with equal amplitudes. The latter requirement will be met if the two identical antennas are fed through equal lengths of transmission line of identical impedance. The lower antenna should be at least a few wavelengths above ground so that its feed-point impedance will not be affected significantly by the earth's proximity.

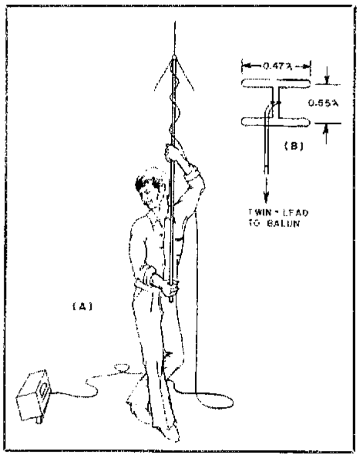

Fig. 5 — At A, if vertical polarization is used, a drooping ground plane makes a good test probe to check the antenna range for reflections. If the range is reflection-free, the received signal will remain constant as the probe is scanned across the wave front. A suitable probe for horizontal polarization is shown at B.

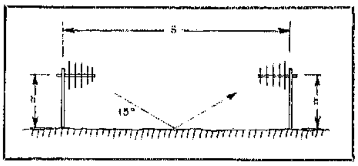

Fig. 6 — The ground-reflection problem can be avoided largely by using vertical polarization and making the range geometry such that the reflection signal will strike the ground at the Brewster angle of 15° (S = 7.5h). See text.

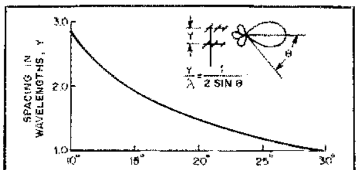

Fig. 7 — Two identical antennas spaced at distance y and fed in phase will produce a null at an angle θ, as shown. This null can be used to circumvent the ground-reflection problem.

Instrumentation

Fig. 8 shows home-constructed equipment suitable for making accurate gain comparisons in the field. This will be described in detail in Part 2, the conclusion of this article.

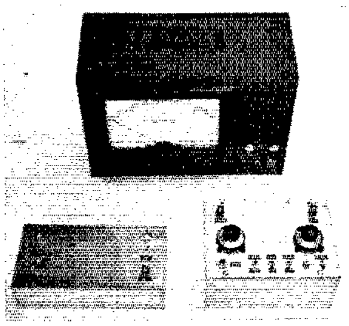

Fig. 8 — Shown here is complete instrumentation for battery-powered 432- and 1296-MHz antenna measurements. The equipment can be used also as a short-range mcw communications set. Details in Part 2 of this article.

Fred Brown was licensed at age 16 as W6HPH. He has held this call continuously since 1949, upgrading to Extra Class in 1967.

Electronics has been Fred's career as well as hobby. He received a BS from California State Polytechnic University in 1955 and an MSEE from the University of Illinois in 1956. He has worked as an electronics engineer for the U.S. Navy and Raytheon Mfg. Co., and has taught electronics at Mt. San Jacinto College and Cal Poly. Fred has authored more than 50 technical articles in amateur and professional journals. During the summer he can sometimes be heard operating in England as G5AWT.

Notes

[1][Editor's Note: Different measuring techniques may produce different gain figures for the same antenna, yielding inconsistent and thereby misleading results. (The antenna environment, or "test-range" facilities, are of primary significance.) No industry standard for gain measurements of amateur antennas has been recognized by the ARRL.]

[2]There are a few factors that do not scale perfectly, such as antenna losses, dielectric constants and so on, but seldom are these of any practical consequence.

[3]W. Overbeck, "Measuring Antenna Gain With Amateur Methods," *QST*, Oct. 1977, p. 11.

[4]B. Clark, "Direct Methods for Measuring Antenna Gain," *Ham Radio*, July 1969, p. 26.

[5]F. W. Brown, "How to Measure Antenna Gain," *CQ*, Nov. 1962, p. 40.

[6]*The ARRL Antenna Book*, 14th edition (Newington: ARRL, 1982), p. 15-25 (p. 320 in the 13th edition).

[7]E. C. Jordan, *Electromagnetic Waves and Radiating Systems* (Englewood Cliffs, NJ: Prentice-Hall, 1950).

[8]In this article, "angle of incidence" is measured from the reflecting surface, rather than from the normal to that surface, as is customary in physics texts.

An Ohmmeter With a Linear Scale

Build this simple, useful device during a weekend and enjoy the convenience of a linear readout scale.

By Harry M. Neben,* W9QB

Amateurs who experiment usually have a VOM (volt-ohm-milliammeter), which can be used to measure resistance. However, the scale of most VOMs is nonlinear, being cramped at the high-resistance end, which makes measurement little more than a guess. This resistance-measuring device has a linear scale and a range of 100 ohms to 10 megohms, can be calibrated by a single measurement, and is easy to build. The circuit is very simple, consisting of an operational amplifier, a Zener diode, a meter and a series of switched reference resistors.

This ohmmeter operates by comparing the voltages at the inputs of an operational amplifier, then translating this voltage differential into a meter reading (Fig. 1). For explanation purposes, we will make the reference and unknown resistors equal in value. In that case, the voltage at the inverting input will be equal to half the output voltage. Feedback through the unknown resistor will cause the output voltage to swing until there is no input-voltage differential. This 2:1 divider will cause the output voltage to swing to 2 V_Z, which causes the meter to read full scale.[1] An unknown resistance of less than the reference resistance will unbalance the operational amplifier input and cause the meter to indicate less than full scale. The user must select a reference resistance (or scale) of higher value to keep within the meter range. Note that the meter circuit includes a clamping diode. This diode is desirable to protect the meter against overload when the unknown resistor value approaches infinity (open circuit).

Construction

All components were purchased as stock items from a local parts store. There are no specialty components to frustrate the builder. The meter is built into a 6-1/4 × 3-3/4 × 2 inch experimenter box. The local store had a 6.2-V Zener diode, so this was used. Any Zener diode of less than 9 V can be used. Other parts were right from the rack. A 1-mA meter was selected as the most practical one to use, because the scale is easily multiplied by factors of 10.

Front-panel layout is conventional, with the meter, the selector switch and the measuring terminals in line from top to

[1]For a theoretical analysis of op-amp operation see G. Woodward, "A Beginner's Look at Op-Amps," *QST*, April 1980, pp. 15-18, and June 1980, pp. 25-31.

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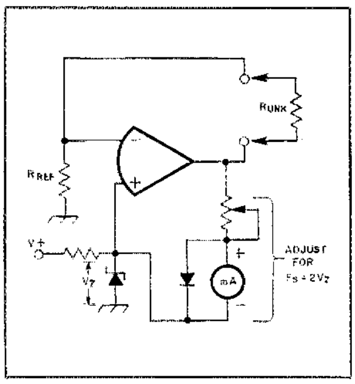


Fig. 1 — Basic circuit for the linear-scale ohmmeter. See text for details.

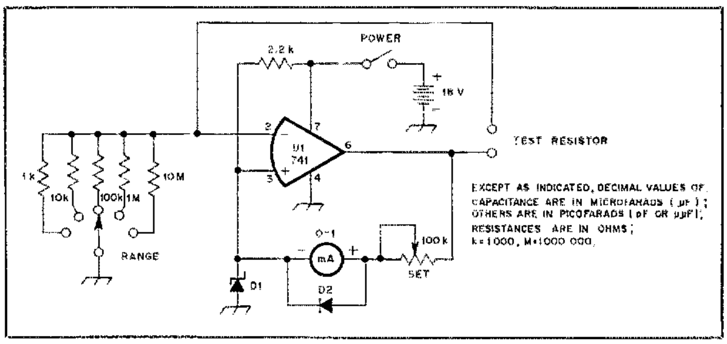


Fig. 2 — Linear-scale ohmmeter schematic diagram. Fixed-value resistors are carbon composition, 1/4 or 1/2 W.

D1 — 9 V or less, 200-mW Zener diode.

D2 — 1N914 silicon diode.

U1 — 741 operational amplifier.

bottom. The reference resistors are mounted on the selector switch. A small piece of perf board is used to mount the operational-amplifier socket and to provide space to mount the Zener diode, the limiting resistor and the meter-calibration potentiometer. The meter-clamping diode is mounted on the back of the meter. Two 9-V batteries are mounted within the case.

Calibration

After the Zener diode and meter are selected, the first step should be to calibrate the meter against the Zener diode voltage. This is done by using the auxiliary circuit (Fig. 3). Connect the Zener diode in series with a suitable resistor to a 9-V battery. Connect the meter and the 100-kΩ series potentiometer (R_s) across the Zener diode. Adjust R_s until the meter reads full scale. The meter circuit is now calibrated and no further adjustment is necessary. However, the accuracy of the readings of the meter will depend on the tolerance of the reference resistors.

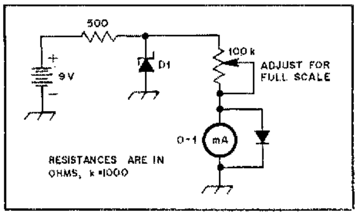


Fig. 3 — Calibration circuit for the ohmmeter. The meter series resistor is adjusted until the meter indicates full-scale.

Strays

WORKED ALL STATES, BICYCLE MOBILE

☐ There I was, a college professor who had been granted a nine-month sabbatical, with loads of spare time to improve myself. All that hamming was settling to my midsection. Some sort of exercise program to keep in shape was in order. Jogging was out because of a knee injury, so I decided on bicycling. This was fine for a while, but quickly became a little dull. What could be done to make exercise more enjoyable?

I remembered seeing an article about a fellow who put his rig on a bicycle and operated from it. That was it! I reconditioned my son's old Sears 10-speed by adding a luggage carrier and two metal saddle baskets on the back. Several power sources for my rig, an Atlas 210X, were investigated. My transceiver draws between 4 and 8 A at 12 V, so something hefty was needed. A car battery would be far too heavy, and $90 for a gel cell was too expensive. It was also a little large, although the one I saw had a shoulder strap. I decided to use a motorcycle battery (a Sears 12N9-4B-1) that had a 9-Ah rating. It weighed only 8 lb and measured 5-1/4 × 3 × 5-1/2 in. The best part was that it cost only $25 on sale.

Now for the antenna. It was a choice between my Swan M-34 mobile antenna with traps for 10, 15 and 40 meters or my single-band Hi-Gain Hamcat mobile. Here again size was the deciding factor. The Swan was heavier, but was only 66 in. tall without the extension for the 40-meter band. It would also provide multiband capability without having to switch traps. An old, flexible, metal-strap mobile mount from my junk box was secured to the back of the luggage carrier. The baskets, the luggage carrier and the bicycle frame were strapped together with antenna wire to create a ground plane.

The motorcycle battery was placed in one of the baskets. The rig, which consists of the Atlas 210X and a Ten-Tec 277 antenna tuner, was tied to the top of the luggage carrier. The tuner was needed to reduce the effects of the next-to-no ground plane that the antenna normally required.

I was ready to make my first radio-equipped ride. I was a little self-conscious, to say the least, knowing that the neighbors already had some reservations about me because of the antenna farm on my roof. What would they think when they saw me with my 66-in. antenna on the bike calling "CQ" as I rode down the street? Too late for that now; I was committed to the attempt. The first major problem encountered was getting on the bike. It is very hard to swing a leg over the rig and in front of the antenna. The next problem was learning to get control over the somewhat unstable vehicle. Then came getting off, which is also a tricky affair.

Having mastered the riding problems, it was time to operate the rig. I tuned it up on 15 meters, with an SWR of only 2.5 to 1. I called "CQ" and, after a short while, had my first QSO with Harry, W2ECP, of Rahway, New Jersey. After he stopped laughing when I announced myself as Bicycle Mobile 4, he gave me a 5 × 5 report. On the first ride, I also worked Colorado, New York, Wisconsin and Idaho (with a 5 × 2). The reaction of the people on the streets varied from interested to dumbfounded.

Even since he combined bicycling with Amateur Radio, Elliot Kleiman, WA4YDK, has found out how much fun exercising can be. In fact, he's already received WAS (with a bicycle-mobile endorsement) and WAC awards, and is well on the way to DXCC.

The best bands to work were 10 and 15 meters, although I also made some contacts on 20 and 40. The antenna seemed to work better with the 3-ft extension on the top, even though the 40-meter trap isn't supposed to pass much through it on 10 and 15 meters. The battery supplied enough power to operate up to an hour and a half. It would die in a manner similar to a NiCd — almost without warning. After a year of use in this manner, the battery still operates, but now it holds a charge for less than an hour. Because of the relatively weak transmitted signal, trying to break into a QSO in progress was more effective than calling CQ. A note of caution about motor-powered vehicles and curbs on streets: They have very little respect for an operating amateur. Care must be made in the selection of bike paths, in order to preserve both life and dignity.

After a year of operating, I applied for and received a Worked All States award, which has a very highly prized "bicycle-mobile" endorsement. Then there's the added thrill of working DX. Yes, I've worked ZS3, ZS4, 4X4, VK3, G3, JA and HC2. That's enough for WAC, but there are no special-category endorsements. DXCC must be the next goal. It turns out to be a very enjoyable way to ride a bike, and the QSOs that you have are a little bit more memorable than those from a fixed station. I even have a QSL with a picture of me and the bike.

I don't know if it's for everyone, but it is certainly a novel operating mode. I hope I can turn on the rig some day and hear someone else calling "CQ CQ" from a bicycle. A bike-to-bike QSO would really be something! — *Elliot B. Kleiman, WA4YDK, Hollywood, Florida*

Build the Timeless J Antenna

Need an inexpensive, simple antenna for use in hotels? Put this on your 2-meter rig — it's not a pipe dream.

By Lee Aurick,* W1SE

Some ideas never die: They seem to disappear, only to reemerge when we have a need for what they have to offer. The J, or J-Pole, antenna is one of these perennial concepts. I built one for 5 meters in the mid-'30s. Now I have revived it for use on 2-meter fm.

The antenna derives its name from its similarity to the letter J. A half-wave length antenna, it is fed at one end through a quarter-wavelength matching section. It may be fed by open-wire line or coaxial cable. (Some builders like to use a balun with the coaxial feed. I believe that a balun makes little difference in performance, and is only an unnecessary complication.)

My interest in reviving the J came from the inadequate performance of a quarter-wave antenna I used in a hotel room. I needed something that could easily be folded to carry within my luggage or the car. The J appeared to be a "natural" for this need. It operates independently of ground. You can match coaxial cable to it easily. Finally, the antenna may be constructed in sections that simply bolt together and mount on a plastic base.

Construction

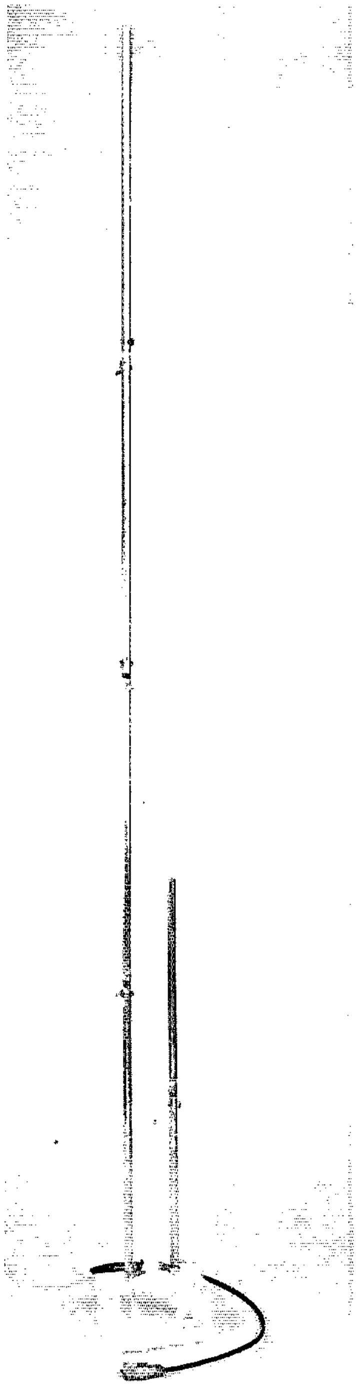
The radiating part of the antenna is 38 inches (mm = in. × 25.4) long and has a matching section that is 19 inches long (Fig. 1). Both are made from 3/8-inch diameter aluminum tubing. One side of the matching section must be added to the antenna section for a total of 57 inches. From this length is subtracted the length of one side of the "U" mounted within the plastic. In this instance, the length of the matching section within the plastic is 2-1/4 inches long. On the other side of the matching section this length is, similarly, subtracted from the 19-inch length. Therefore, each side is shortened by the length within the plastic and is, respectively, 54-3/4 inches and 16-3/4 inches long. The U-shaped base of the antenna within the plastic is made from 1/4-inch-diameter aluminum tubing and spaced 2-1/8 inches, center-to-center. The U projects 1-7/8 inches above the plastic (total length: 4-1/8 inches).

The lengths of the larger-size tubing mounted above the plastic base are divided into four pieces on the longer side, and into two pieces on the shorter side. This results in four pieces approximately 13-11/16 inches long and two pieces approximately 8-3/8 inches long.

Four lengths of 1/4-inch-diameter tubing are cut to 2 inches. These are inserted 1 inch into the larger tubing and are held with no. 6 screws, 1/2 inch long. One end is fastened in place with hex nuts, but the other end is secured with wing nuts for "no-tools" assembly and disassembly. A dab of different colored paint helps to identify mating parts — I have difficulty drilling holes in different pieces that will always match! With the paint identifier, you may always be certain of a correct match-up of sections, the first time, when assembling the antenna.

The base is made from a scrap piece of polystyrene. Just about any insulating material may be used. Care and patience must be exercised while drilling the plastic. The plastic must be worked slowly with frequent rests to permit the drill bit to cool. If not, a sloppy hole and charred or melted plastic, will meet your efforts.

The plastic base I used had a groove that ran the width of the block. I placed the bottom of the U in this groove. Rubber feet, attached to the bottom, should provide adequate clearance for blocks not having a built-in groove.



Matching

To make the connector clips, I cut two narrow strips of aluminum from scraps. I bent them to fit tightly around the aluminum sections and fastened them with no. 6 hardware. The center conductor is connected to one clip, and the shield

*Advertising Manager, *QST*

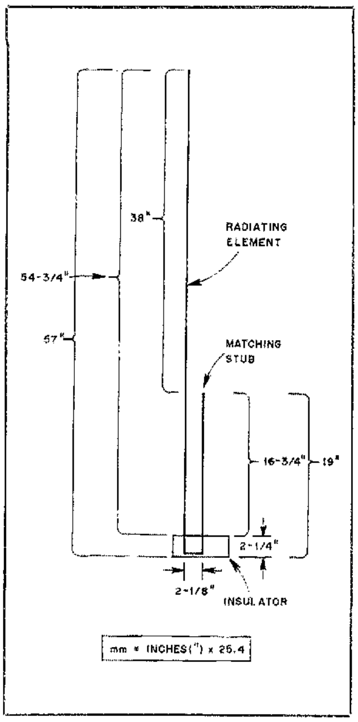


Fig. 1 — Construction details for the J. See text for discussion.

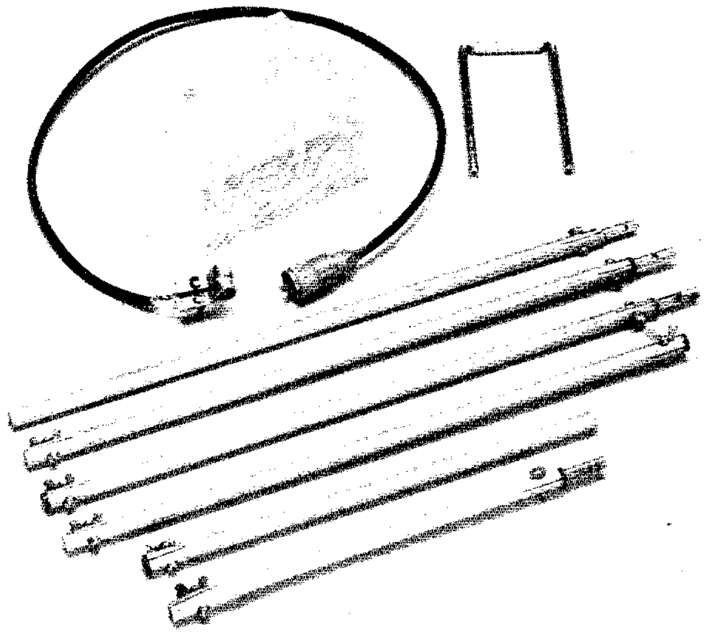
to the other. It doesn't seem to make much difference which is connected to which. I tried it both ways, and neither seemed superior.

Connect an SWR indicator in the line to indicate the point of match. Alternately, slide the connectors up and down and check the SWR until the match point is located. With the antenna matched to 1:1 at 146 MHz, the SWR remained below 1.2:1 throughout the band. Pivoting the connectors toward or away from each other has a slight effect on the SWR, and may be used for "fine tuning" the match. The antenna shown happened to achieve unity SWR at the point where the large tubing met the plastic base.

How Does it Perform?

Initial testing was done in the ARRL lab. The ARRL Hq. building is constructed with steel girders, which provide a degree of shielding. In addition, the lab is mostly underground. Despite these limitations, repeaters 15 miles away were "full quieting," and were raised easily with 10 watts of power.

The J is a simple antenna to build and adjust. It will provide a worthwhile improvement over most 1/4-wavelength antennas, and will beat a "rubber duckie" hands down. When you are a bit more fixed than mobile with your hand-held or other rig, you will find the J can add miles to your enjoyment.



The completed "J" antenna, ready for assembly.

Strays

MOVING? UPGRADING?

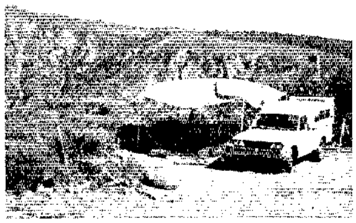
☐ When you change your address or call sign, be sure to notify the Circulation Department at ARRL Hq. Enclose a recent address label from a *QST* wrapper if at all possible. Address your letter to Circulation Department, ARRL, 225 Main St., Newington, CT 06111. Please allow six weeks for the change to take effect. Once we have the information, we'll make sure your records are kept up-to-date so you'll be sure to receive *QST* without interruption. If you're writing to Hq. about something else, please use a separate piece of paper for each request.

FIELD DAY IN THE REAL "BOONIES"

☐ Some of us dream of "getting away from it all" during Field Day, and the photograph illustrates the perfect spot to realize that fantasy. The setup was used by ARRL TA Dan Petersen (WA6OIL) and Roger Colbath (N6FMR) during their QRP Field Day operation in 1982. The spot is located 55 miles northeast of San Diego and is close to Garnet Peak.

The station was a Heath HW-8 (2-W output) and some homemade accessory gear. Dan says they didn't try to kill themselves setting any records, but they worked 61 stations in 26 states with their low-power station. They also copied the W1AW Field Day message, as topping for the cake.

WA6OIL also mentioned that when the photograph was taken they had a *mild* breeze (note the position of the flag!). Later in the day, "The wind came up"! Apart from that, the only difficulty was Murphy-related. Someone forgot to pack the roll of coaxial cable for the antenna, so several short lengths of line with connectors were joined, and the show was on the road. Well, why not? After all, Field Day is meant to simulate emergency conditions! — *Doug DeMaw, W1FB*



This site near Garnet Peak in southern California proved to be a gem of a place for WA6OIL and N6FMR during their 1982 ARP Field Day operation.

BEGINNER'S BENCH

Station Set Up — How to Make It Simple!

Buying equipment is only part of putting together an amateur station. Here are some hints that will make setting up your station and getting it on the air easy.

By George Collins,* KC1V

I remember watching a ham friend setting up his station. I was a newly licensed Novice at the time, and seeing this OT (old-timer) sort through the maze of wires, equipment and cables made me think that his middle name had to be Merlin! He never looked at a diagram, scratched his head, or made a false move. He *knew* where every wire belonged. How could anyone remember it all? I wondered if I would ever be able to do the same.

I'm sure many newcomers to Amateur Radio have similar experiences. Over the years, I have learned the old-timer's secret. He knew where everything belonged because he understood the purpose of each piece of equipment and how it had to be connected in order to function properly. If we use this approach when setting up our stations, what might seem to be a complicated puzzle will become a simple and logical arrangement.

There are two parts to setting up your station. First, the desired equipment is obtained and a suitable station location is chosen. This part of the process was covered by Doug DeMaw in an earlier article.[1] Along with tips on selecting equipment and accessories, he gave hints on how to lay out a comfortable and safe station. You would be wise to review that article before plugging in your transmitter and "throwing the switch."

After you have selected your equipment and have arranged the operating position, we come to the second part of station setup. We must connect the various pieces of equipment so they will function efficiently. Let's look at some station setups and see if we can understand how they are connected by first understanding what each piece of gear does. We'll also discuss how to use some of the accessory equipment to make our operating more enjoyable.

The simplest amateur station may consist of a transceiver and a single antenna. Many "first contact" QSOs have been made with such stations, but most amateurs soon want more versatility. A more typical station is shown in Fig. 1. Included in this arrangement is all the equipment a beginning amateur is likely to need. A transceiver is shown in the figure, but a transmitter and receiver combination could be used instead. Later, we'll discuss the transmit-receive (T-R) switching necessary when a separate transmitter and receiver are used.

SWR Indicator

Some type of standing-wave-ratio (SWR) indicator should be part of every amateur station. This piece of equipment serves many functions. It's useful as a relative power indicator during transmitter tune-up, and as an antenna-system "monitor" during operation. Should anything go wrong with the antenna or transmission line (such as a broken wire or a loose connector), the SWR indicator will reveal the problem by indicating a higher than normal SWR.

When a Transmatch is part of your station equipment, the SWR indicator really gets a workout! If it isn't a necessity for adjusting the Transmatch, it certainly makes the job much easier. You will also need an SWR indicator when trimming wire antennas to the correct length, or when making other antenna adjustments. Numerous commercially manufactured SWR meters and power meters are available, or you may choose to build one. Construction details for an SWR/power meter can be found in *The Radio Amateur's Handbook.*[2]

Although the SWR indicator has many uses, all the applications have one thing in common: We use the indicator to determine the SWR at the transmitter output. This tells us that the SWR indicator should be the first piece of equipment in the transmission line from the transmitter. We don't want it, for example, on the output side of the Transmatch. If it were located at the point, we could measure the antenna feed-line SWR, but we couldn't determine when the Transmatch was adjusted correctly. Remember, the purpose of the Transmatch is to provide a low SWR at the *transmitter output*. By placing the SWR meter between the antenna switch and the rig, we can use it to monitor the feed-line SWR of any of the antennas. It also allows us to use it as an output-power indicator when tuning the transmitter into the dummy load.

Low-pass Filter

Following the SWR meter is the low-pass filter. It helps attenuate transmitter harmonics that, if radiated, might cause television interference (TVI). We want it in the transmission line at all times, so it must be located between the transceiver and the antenna switch. It is recommended that the low-pass filter be placed directly at the transmitter output (between the rig and the SWR indicator in our

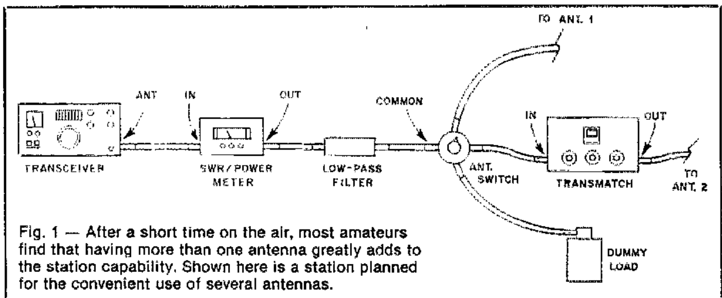


Fig. 1 — After a short time on the air, most amateurs find that having more than one antenna greatly adds to the station capability. Shown here is a station planned for the convenient use of several antennas.

[1]Notes appear on page 44.
*Basic Radio Editor

example). Generally this is a satisfactory location, but some SWR meters (because of rectifying diodes) have been found to generate harmonics of the transmitted signal. With such meters, we want the low-pass filter between them and the antenna! If you should experience a TVI problem, try both filter locations, and use the one that results in the least interference. It is important that the low-pass filter be used in a transmission line with a low SWR. For this reason, the filter should be located between the rig and your Transmatch.

Antenna Switch

Although it is a simple device, few accessories add more convenience to station operation than the antenna switch. Even in stations with only a single feed line (those that use a single multiband antenna), a switch is still convenient for selecting the dummy load during tune-up and while testing your transmitter. Five-position switches are commonly available, and most provide for grounding of all unused antennas. Building an antenna switch is also a great weekend project.[3]

Often, two antenna switches are useful. If you use your Transmatch with more than one antenna, a second switch can be placed at the Transmatch output to select the desired antenna.

Transmatch

A variety of Transmatch circuits are available, both in commercially manufactured units and for home construction. The operational details will vary depending on the circuit used, but generally the Transmatch can be connected to your station as shown in Fig. 1. Most commercial Transmatches are designed for use with antennas fed with coaxial cable. The most popular circuits used are the T-network and the modified T-network, or Ultimate Transmatch circuit. These circuits are also useful with end-fed wire antennas.

In addition to the basic function of providing a low SWR at the transmitter output, many Transmatches have other features. Some include antenna switching, and others contain an SWR or power meter. One feature that can be important is a bypass switch. It allows you to switch the Transmatch out of the transmission line when it is not needed. If your Transmatch contains antenna and bypass switches, you can eliminate the external switch. Be sure you have some means of connecting your transmitter output (after it passes through the SWR indicator) to the dummy load without it going through the matching circuit. You'll want to be able to do so during transmitter tune-up.

Amplifiers

When the General class ticket arrives, many hams begin thinking about adding an amplifier to their stations. Typically, it will be a linear amplifier designed for use with a transceiver in the 100-W-output class. These amplifiers normally have built-in T-R relays to handle the antenna switching. A control line between the amplifier and the transceiver allows the transceiver T-R switch to control the amplifier relay. During receive, the relay connects the amplifier input jack directly to the output connector. This connects the transceiver to the rest of the system just as if the amplifier were not present. While the transceiver is transmitting, the amplifier relay is closed, connecting the transceiver to the amplifier input circuit. It also connects the amplifier output to the feed line that goes to the antenna. When the amplifier is turned off (or is in standby), the transceiver is connected directly to the antenna feed line during transmit and receive.

Connecting this type of amplifier to the rest of your station equipment is easy. It simply goes between the transceiver and everything else! In effect, the amplifier is part of the station transmitter. All other station equipment is connected to it the same way it was connected to the transceiver. This is shown in Fig. 2.

Some older amplifiers found on the used-equipment market do not contain a T-R relay. Using these units with a transceiver requires the addition of a relay and some control wiring. You should not rule out these older amplifiers simply because they lack a T-R relay. Many of them are well-made, and can be obtained at bargain prices. The needed modification should not be difficult or expensive.

T-R Switching for "Separates"

Many new hams choose a separate transmitter and receiver combination for their first station. It's a good choice; some older units will provide excellent service at a minimum cost. Most of these transmitters require an external T-R relay (Fig. 3). The relay switches the antenna feed line from the receiver to the transmitter during transmit periods. A transmit/standby switch in the transmitter is used to control the relay. Some transmitters provide a switched voltage to operate the relay, while others allow you to connect directly to the control-switch contacts. In the latter case, you must provide a source of power for the relay coil. If the transmitter supplies the control voltage, be sure you choose a relay designed to operate at the *same* voltage. Many transmitters that contain only vacuum tubes supply only 117-V ac for relay operation. If your transmitter is of this type, be sure to exercise caution when wiring the relay. All 117-V lines must be well-insulated, and all "hot" terminals need to be covered. Check the schematic diagram in your transmitter owner's manual to determine how your equipment is wired.

In addition to transferring the antenna from the receiver to the transmitter, we must also "mute" the receiver by placing it in the standby mode while transmitting. In any well-planned amateur station we should be able to go from receive to transmit by operating a single switch. This means that the switch used to control the transmitter and the antenna relay must also control receiver muting. Often, the receiver mute line must be grounded in order to place the receiver in standby. If the transmitter has a second set of contacts available on the transmit switch, these can be used to ground the mute line. Normally, you can't use the same conacts to control the T-R relay and to mute the receiver. If only one contact set is provided in the transmitter, you can use a second or auxiliary contact set on the T-R relay for receiver muting. If this is done, the RCVR MUTE line in Fig. 3 would be connected to the antenna-relay auxiliary contacts.

Most recently manufactured transmitters were designed for use with a matching receiver. These units contain an antenna relay and receiver-control circuits, so you don't need an external relay. The receiver antenna input is connected to a receiver-output connector on the transmitter through a short length of coaxial cable. A control cable for connecting the units carries the receiver muting signal. Most receiver/transmitter pairs provide for transceiver-style operation with the variable-frequency oscillator (VFO) of one unit controlling the transmit and the receive frequency. While there is no reason a particular receiver or transmitter must be used only with "its twin," transceiver operation may not be practical with other than matching units.

Fig. 1 is only one of a number of possible equipment arrangements. The exact equipment being used and the type of operating you prefer will determine the details of your particular setup. By keeping in mind the function of each piece

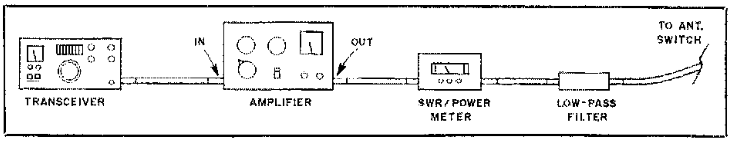


Fig. 2 — For medium-power operation (less than 300 W), RG-58/U coaxial cable is satisfactory. When a high-power amplifier is added to the station, as shown here, RG-8/U cable is recommended, especially if a high SWR may be encountered. RG-58/U cable can be used between the transceiver and the amplifier.

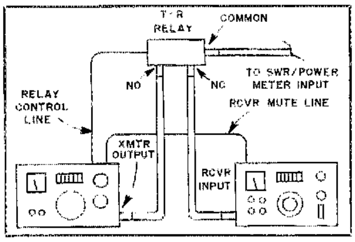


Fig. 3 — For convenient operation, a separate transmitter and receiver can be used with an external T-R relay. The common relay line is connected to the rest of the station in the manner used for the transceiver in Fig. 1.

of equipment you'll be able to plan your station to best fill your needs.

Tune Up

With your station setup completed, it's time to put it on the air and begin making contacts. Right? Almost, but before you begin filling the pages of that logbook let's look at some ways we can use our station equipment to best advantage.

The first step in putting your station on the air is transmitter "tune-up." One objective you should always have in mind is minimizing on-the-air tuning. This is when the antenna switch and dummy load shown in Fig. 1 really "shine." Always start your tune-up by selecting the dummy load by means of the antenna switch. Follow the instructions in your transmitter or transceiver owner's manual, and tune the rig for normal output into the dummy load.

Tuning procedures vary from one rig to another, but most modern ssb/cw transceivers are similar. If your rig has a vacuum-tube power amplifier (PA), you'll probably need to adjust the driver tuning, the amplifier tuning and loading, and the carrier- or drive-level controls. Most rigs are equipped with a TUNE position on the mode switch. It allows you to make the initial transmitter adjustments at reduced power (saving wear and tear on the output tubes!). Normally, the TUNE position is used while peaking the driver tuning control. With rigs that produce some output in the tune mode, you also can adjust the PA tuning control at reduced power. I use my SWR indicator as an output meter, and adjust the PA tuning for maximum output. This ensures that when the rig is placed in the cw mode the PA will be tuned approximately to resonance. Generally, the PA load control should be set at minimum loading for these initial adjustments.

Now you are ready to switch to the cw mode and complete the tuning procedure. Because you have preset the controls, closing the key should produce some output, and the plate current shouldn't be excessively high. The output power will be fairly low at this point because of the light amplifier loading. Increase the loading until the output reaches a peak, and then readjust the tuning control for maximum output. The two controls interact, so you will need to adjust one and then the other a few times to obtain maximum output. Keep in mind that your objective is to adjust the loading control for maximum output power. If you need to reduce the plate current (to keep it at the recommended level), do so by using the carrier- or drive-level control rather than by reducing the amplifier loading. Be sure to readjust the loading and tuning controls if large changes in drive level are made. After you have gone through this procedure a few times, you should find it easy to tune your rig in a matter of seconds.

If your antenna feed-line SWR is fairly low (less than about 2:1), you're ready to switch from the dummy load to the antenna and to start making contacts. At most, you may need to check the PA tuning adjustment. At higher SWR conditions, the loading control also will require some readjustment. If the SWR is higher than, say, 3 or 4, you probably will want to use the Transmatch.

Transmatch Adjustments

To minimize on-the-air Transmatch tuning, you need to be able to preset the Transmatch controls for the operating frequency and the antenna you are using. That means the controls must have dial scales of some kind. A T-network or an Ultimate Transmatch, for example, will have three controls: two capacitors and an inductor. The capacitor dials should have at least 20 scale divisions. If a rotary inductor is used, it should be equipped with a turns-counting dial. Pieces of paper or notecard taped behind the knobs can be used to make dial scales on units that don't have them. With the Transmatch controls preset, little (if any) on-the-air adjustment should be needed. The exception to this is when you are operating on the lower-frequency bands. Transmatch settings become more critical, or "sharper," as the frequency is lowered. On the 80- or the 160-m band, you'll need several sets of dial readings to cover the entire range.

"Presetting the Transmatch controls sounds like a good idea, but how do I know where to set the controls the first time?" That's a good question. To determine when the Transmatch is adjusted correctly you must have the antenna connected and the power applied. That means on-the-air tuning — something *we would rather not do*. In this case it may be unavoidable, but by doing it properly we can minimize interference to others.

First, become familiar with the operation of your Transmatch by using the dummy load as an antenna. Tune your rig directly into the dummy load. Then, connect the load to the Transmatch output. Using reduced power (no more than 10 watts or so), you now can get the "feel" of the controls without causing QRM. Also, the control settings you find in this manner will serve as good starting points when you adjust the unit with the antenna attached. When you are adjusting a T-network or an Ultimate Transmatch, a good method is to first set both capacitors to maximum capacitance and the inductance to minimum. Then, key the transmitter and adjust the inductor until the reflected power dips to a minimum. Next, adjust the *input* capacitor. Often, you will be able to obtain a match by using just these controls. If a match can't be obtained, decrease the output capacitance slightly and readjust the other controls. You want to use the largest value of output capacitance possible to obtain a match. This will yield the highest circuit efficiency. It also allows the greatest change in operating frequency without a need for Transmatch readjustment.

Once you can tune the Transmatch into the dummy load with ease, you're ready to attach the antenna. Place the controls in the positions you found to be correct for the dummy load, and then key the transmitter. If your feed-line SWR is not extremely high, you should need to make only small changes in the settings to obtain a match. When you're using an end-fed wire antenna, the impedance at the feed point can differ greatly from 50 ohms. In this case, the control setting may not be close to those found for the dummy load, and you will need to start from scratch.

When making on-the-air adjustments (on a clear frequency), never use more power than is necessary to obtain an adequate forward-power reading. A few watts should be more than enough. As you adjust the Transmatch for a dip in the reflected power, don't forget to check the forward-power reading from time to time. Transmatch mistuning can cause the transmitter output to drop. This, of course, makes the reflected power reading fall, even though the SWR is still high. Remember: The SWR is related to the *ratio* of the forward and reflected powers. Should the forward power decrease too much, you will need to readjust the PA tuning control.

There is (almost) always more than one way to do something, and operating an amateur station is no exception. Hopefully, some of the methods and equipment discussed here will help you develop your own techniques — techniques that will add to your operating pleasure and to the enjoyment of those who share the bands with you. QST

Notes

[1] D. DeMaw, "That First Ham Station — How to Choose It and Set It Up," *QST*, Nov. 1981, pp. 37-40.

[2] G. Woodward, ed., *The Radio Amateur's Handbook*, 59th ed. Newington: ARRL, 1981), pp. 16-31, 16-32.

[3] P. O'Dell, "Julie's Custom Antenna Switch," *QST*, June 1981, pp. 30-33.

Product Review

Conducted By Paul K. Pagel,* N1FB

Japan Radio Company Model NSD-515 HF Transmitter

I recently reviewed the JRC NRD-515 all-wave receiver.[1] So, I was also anxious to review the NSD-515 (matching transmitter in the "515" series). It covers all the amateur bands from 1.8 to 30 MHz, including the WARC bands at 10, 18 and 24 MHz. Featuring the latest technology, the '515 uses digital techniques to control the VFO system, to switch the internal filter networks and even to control an optional built-in antenna tuner!

Features

Ssb, cw and fsk are the operating modes of the transmitter. During ssb operation, an internal speech processor (which uses an rf compressor, a peak limiter and crystal filtering), can be activated to increase the effective "talk power." On fsk, the transmitter can be frequency-shifted directly by a teleprinter or by a set of dry contacts.

The front panel of the transmitter contains all the frequently used controls — VOX GAIN, ANTI TRIP and DELAY; the speech processor COMPressor control, an F-CAL/PTT/XMIT switch (used to key the transmitter manually and to spot a receiver), a multifunction VSWR/REL. POWER/IC/VC meter and switch, and the MODE switch. Both the mike and key jacks are on the front panel. Several controls on the '515 are not too common — a VFO LOCK knob prevents the unit from changing frequency. There is also a power output control knob, which works in *all* modes.

If the NSD-515 transmitter is mated with the NRD-515 receiver, the VFO of either unit can be used to control the pair as a transceiver, or the units may be operated "split" with independent VFO control. One multiconductor cable carries all the VFO signals and T-R switching lines between the receiver and transmitter.

A unique option offered with the unit is a preset, digitally controlled antenna tuner, which fits *inside* the transmitter cabinet! The circuitry consists of a series of L networks, with the amount of inductance controlled by relays, and the capacitance preset by means of trimmer capacitors. The relays are controlled by digital information sent from the BAND switch.

Circuit Features

The MHZ control, in conjunction with the main tuning dial, drives a series of TTL encoders that generate BCD data for each significant portion of the operating frequency — 0.1, 1, 10, 100 kHz, 1 MHz and 10 MHz. The 1- and 10-MHz information is decoded to switch the band-pass and low-pass filter networks, and to latch the various relays in the optional antenna tuner.

[1]"Japan Radio Company Model NRD-515 All-Wave Receiver," *QST*, Nov. 1981, pp. 42-43.

*Assistant Technical Editor

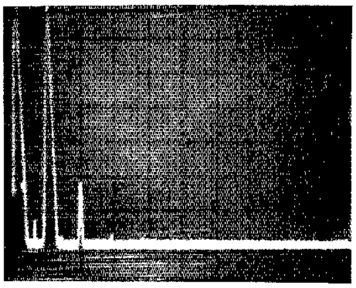


Fig. 1 — Spectral display of the NSD-515. Vertical divisions are 10 dB; horizontal divisions are each 2 MHz. Output power is approximately 100 W at 160 m. The worst-case spurious emission is approximately 52 dB down from the fundamental.

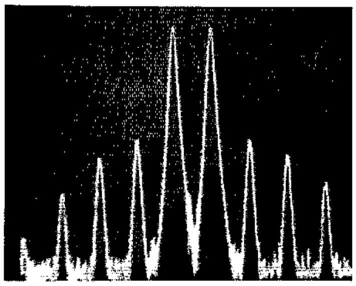


Fig. 2 — Spectral display of the NSD-515 during two-tone third-order IMD testing. The third-order products are 39 dB below PEP, and fifth-order products are about 43 dB down. Vertical divisions are each 10 dB; horizontal divisions are each 1 kHz. The transmitter was being operated at rated input power in the 20-meter band.

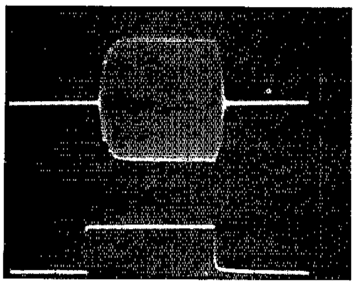


Fig. 3 — Cw keying waveform of the NSD-515. Upper trace is the rf envelope; lower trace is the actual key closure. Each horizontal division is 5 ms. Carrier level adjusted to rated input. Higher amounts of drive caused the wavefront to sharpen.

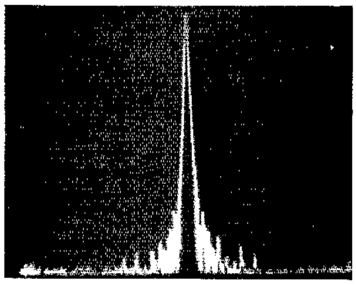


Fig. 4 — Narrow-band spectrum of the NSD-515. Vertical divisions are 10 dB; horizontal divisions are each 500 Hz. Power output is 100 W on 14 MHz. The noise at the base of the carrier is generated in the frequency synthesizer.

Signal generation in the '515 is by means of a combination of analog and digital technologies. The VFO system is entirely digital, using a shaft encoder to drive an up/down counter, which in turn determines the output frequency of the VCO. JRC engineers have done their homework in this synthesizer design: By using a high reference frequency and dividing the final output of the VCO in half, the noise sidebands of the synthesizer are reduced dramatically! The high-frequency oscillator (HFO) uses a bank of crystal oscillators. The frequency is varied by means of a Varicap® diode and the Δ-F (XIT) control. An SN76514 mixer IC is used to combine the VCO and HFO signals — a strange choice, since the '76514 is no longer available in the U.S. (something to think about when considering service).

A solid-state final amplifier is protected by control circuits that "watch" for over-temperature, excessive collector current and high VSWR. The final amplifier heat sink covers a major portion of the rear panel.

Options

Several options are available for the transmitter. These include the internal antenna tuner, an ac power supply, several types of microphones and a hand key. All of the optional items were included with the review unit.

The CFG-515 antenna coupler has a maximum tuning range of 12.5 to 150 ohms, or a 3:1 VSWR in a 50-ohm system. Maximum power rating is 150 W.

Dc power for the review unit came from the NBD-515 ac supply. This unit has a strapping bar that permits the use of 110, 117, 220 or 240-V ac. Dc output voltage is 13.8 at 15 A, *continuous duty*! A very large heat sink covers the entire rear panel of the supply.

Perhaps the most interesting option offered

Japan Radio Company Model NSD-515 HF Transmitter

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: Amateur bands — 160-10 meters, including WARC assignments.	As specified.
XIT range: Not specified.	± 600 Hz.
Modes of operation: Ssb, cw and RTTY.	As specified.
Frequency display: Six 1/2" red LEDS.	As specified.
kHz/turn of tuning knob: Not specified.	10 kHz.
Power output: 100 W.	Greater than 100 W.
Spurious suppression: 50 dB or more.	Worst case: 52 dB (160 m).
Third-order IMD: Less than − 31 dB, relative to PEP.	− 39 dB relative to PEP.
Frequency stability: Within ± 500 Hz 5 to 60 min. from power on, ± 50 Hz every hour after warmup.	150-Hz drift from a cold start to 1 hour later.
Power requirements: 13.8-V dc, 20 A.	As specified.
Size (HWD): 5.5 × 13.4 X 11.8 inches.†	
Color: Gray and black.	

†mm = in. × 25.4.

with the transmitter is the KY-3A cw hand key. The base of the key weighs almost 1 lb![4] A rubber base on the key prevents slippage on the desk top.

On-the-Air Operation

Through the good graces of the people at JRC, I was able to borrow an NRD-515 receiver to mate with the unit. The package is very neat; only two cables are required to interface the units. One carries T-R control and VFO signals, the other is the receive antenna line. Once the connections are completed, the operator has the pleasure of "twiddling" the 40 switches and knobs on the transceiver!

As with most of my product reviews, I tested the pair in several contests. Contests seem to present the most demanding amateur application for receivers or transmitters. Receivers are subjected to strong local and DX signals, and filtering systems are put through the paces because of very close channel spacing. Transmitters are operated for periods of 24 or 48 hours at a time, which tests their reliability; signal-processing systems for ssb are tested by the amount of "punch" they have in a pileup.

In every contest each piece of gear performed flawlessly. Comments about the transmit audio were nothing but "great," except when the compressor control was adjusted too high. On cw, the waveform is quite hard, but no comments about key clicks were heard (even at a multi-multi effort).

One problem arose on cw — zero beating. The delta-F control on the transmitter is for vernier adjustment of the transmit frequency. The digital display in the transmitter does not reflect the change in frequency for the delta-F control, which makes exact zero beating difficult.

Those of us looking for a new rig would probably pass right over the JRC twins; after all, the product is new, and JRC is new to the U.S. Well, after talking with a few JA stations, I found out that JRC is a very old and respected manufacturer of marine communications equipment. The quality of the equipment speaks for itself. It will be hard to return the review unit to the manufacturer! Equipment prices were not available. — *Gerry Hull, AK4L*

[4]kg = lb × 0.454.

WESTERN ELECTRONICS 998BUA TRAP DIPOLE

□ Most amateurs are willing to take a small trade-off in antenna efficiency for the convenience of multiband operation with a single antenna and feed line. Trap-style dipoles, verticals and hf-band Yagi beams are found worldwide, and many of them serve well as compromise antennas. The urban dweller or one-tower ham is a typical candidate for some form of multiband hf antenna. If a single feeder (coaxial line) is desired, then a trap (sometimes called a "trapped") type of radiator is of interest. Others prefer a center-fed or an end-fed Zepp antenna, which can be used with tuned feeders and a Transmatch. The inconvenience of a tuned feed line is the need to readjust the Transmatch each time the operator changes bands. Generally, this is not necessary when using a trap antenna.

I needed a multiband dipole for a two-week operation as 8P6EU at Barbados, W.I. Being mindful of the aesthetic quality of the beach area at Coconut Creek Club Hotel on the island, a clutter of antenna wires and feed lines was ruled out. An acceptable approach to the matter evolved from the use of a Western Electronics 998BUA trap dipole for use from 80 through 10 meters. The hotel manager had no objections to the use of the antenna when it was erected in the clear to protect the guests from accidental contact with the legs of the dipole and the feeder cable. It was erected as a sloping dipole over the seashore, with the high end approximately 40 feet above ground and the lower end about 10 feet above the sand.[3] The feed line was brought away from the antenna at a right angle, then routed to the station (a Ten-Tec Argosy).

The Antenna

Western Electronics was kind enough to ship a review unit of the 998 dipole in time for the West Indies trip. It arrived the day before our departure, which provided no time to check the system for performance. A cursory examination was carried out, however, and it became apparent that a serious problem would have to be resolved. Fig. 5 clearly illustrates the potential threat to proper operation: There is no firm electrical connection between the wire sections of the antenna and the traps. Rather, the no. 18 copper-clad steel wire terminates at each end of

[3]m = 0.3048 × ft.

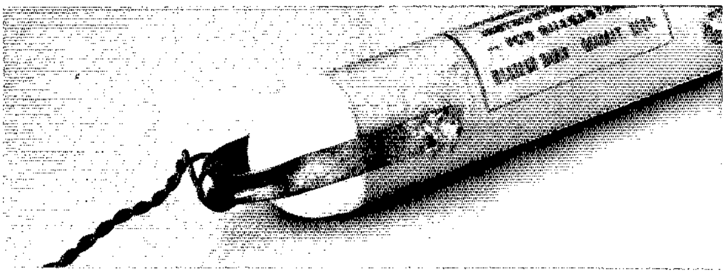


Fig. 5 — Close-up of the unmodified trap. Note the wire ring over the trap yoke, which serves as the electrical connection.

Western Electronics 998BUA Trap Dipole

Manufacturer's Claimed Specifications	*ARRL Test Results*
Antenna length: 104 feet.	Confirmed.
Feeder length: 90 feet.	Confirmed.
Power rating: 1000 W cw, 2000 W ssb.	Tested at 600 W only. No problems noted.
VSWR: 2:1 or less, all bands.	Does not conform on 80 meters (see Table 1).
Feed line: RG-58/U.	Confirmed.
Frequency range: 80 through 6 meters.	80-10 meters confirmed. Not tested on 50 MHz.
Electrical integrity: No claims.	Substandard (see text).
Physical characteristics: No claims.	Good.

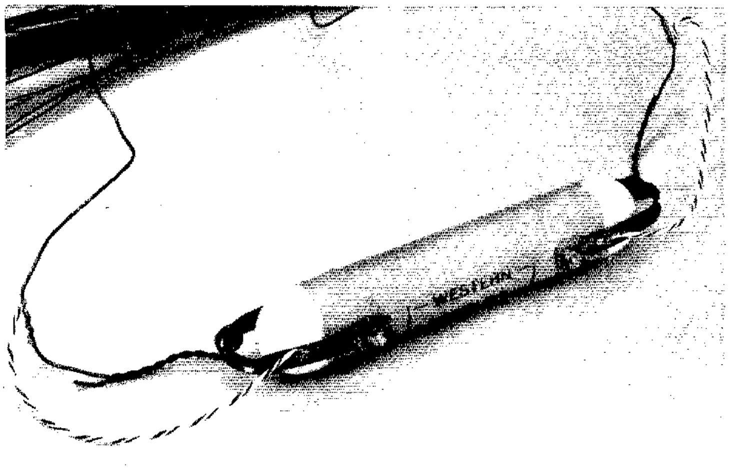


Fig. 6 — Modification of the traps to ensure proper electrical connections between the traps and the wire sections of the dipole. Lock washers have been added to the trap bolts. A coating of clear sealant was added to prevent corrosion where the yokes are mounted to the traps.

the traps in a preformed loop, which encircles the metal yoke of the trap. The instructions specify a need to ensure tension of the dipole in order to maintain electrical contact. This is in sharp contrast to fundamental procedures for electrical connections, especially those used in an outdoor environment! I observed also that the no. 6 studs and nuts that held the yokes on the traps were loose and without lock washers — another potential problem in the presence of wind and corrosion. Something had to be done before the antenna was erected in a salt-air locale!

Fig. 6 illustrates the quick preventive measure taken at each of the two traps. A length of stranded hookup wire (no. 22) was used as a jumper connector soldered from the antenna wires to the yokes on the traps. I strongly recommend that the manufacturer adopt this change. It was deemed important also to install lock washers at each of the yoke attachment points, then coat the hardware with noncorrosive sealant (see Figs. 5 and 6). These changes were vital to reliable performance, as salt air (or acid in the smoke and smog of cities) will tarnish and corrode a copper surface in a few hours, causing poor electrical joints. The copper surfaces of the trap antenna turned green during the first 24 hours of use on Barbados!

The 988 has one trap in each leg of the dipole. The traps are resonant in the 40-meter band. The more elaborate Western Electronics dipoles contain traps for the discrete bands of operation, thereby permitting the antenna to function as a half-wavelength dipole on each band of interest. The 998 does not perform in this manner on 20, 15 and 10 meters. It does, however, seem to present a current node for those bands at the feed point.

A 90-ft length of RG-58/U coaxial cable is supplied with the dipole. No brand name could be found on the gray-colored cable, but it was quite flexible and soft, making it easy to route around corners and into the hotel room. I did not perform loss tests on the line (50-ohm load and wattmeter), so the quality of the line is unknown.

Dacron guy line (rated at 300 pounds test) is supplied in two 15-ft lengths — one for each end of the antenna. A built-in lightning arrestor and static-drain resistor is located at the center insulator of the dipole. I sealed the open end of the coaxial cable where it emerges from the center insulator and joins the legs of the antenna; this spot seemed vulnerable to weather effects also. The feed line is terminated at the station end in a PL-259 type of connector.

Western Electronics specifies band coverage from 80 through 6 meters with the 998BUA. I did not test the system on 6 meters. Also, it is rated (guaranteed) for 1000 W on cw and 2000 W on ssb. My strong preference for a feed line at those power levels would be RG-8/U, but I have "pumped" 600 W into RG-58/U and RG-59/U with no ill effects when my antennas had a VSWR below 2:1. But, I have also melted the smaller lines with a 600-W output-power level when a high VSWR existed. This happened during an ice storm in New England. Beware!

Antenna Literature

A large collection of tutorial and supporting literature was shipped with the antenna. Some of it made very interesting reading, but other parts caused me concern because of technical misinformation. The misspelled words did not create any problems in comprehending the instruction sheets. Some of the statements are worth quoting:

1) "We have made hundreds of tests and found that when a coaxial feedline is long enough so that it is over one-quarter wave length long electrically at the lowest frequency, the antenna used on the feedline acts as a balun, and the RF currents equalize BEFORE they get to the antenna itself."

2) Concerning how much voltage is on each side of a dipole, the manufacturer recommends ". . .or you may prove it yourself, by simply drawing an arc off of each end of the antenna and compairing [sic] both sides while the transmitter is operating and feeding the antenna power *(use a lead pencil)*." Emphasis has been added by the reviewer, for this type of practice can be very dangerous, and it is not recommended. Also, an arc of such magnitude can send a large transient down to the transmitter, thereby posing a serious threat to a solid-state final amplifier stage. It also can cause RFI and TVI.

3) "The traps have zero losses."

4) "Anything above 15 feet will work well." [*Concerning antenna height* — Ed.]

5) "The height above ground has nothing to do with matching the SWR to the feedline, or feedline to transmitter, and it will not increase radiation efficiency of the antenna."

There are a number of similarly "interesting" statements contained in the antenna literature provided by the manufacturer, but we'll save that reading for you when you purchase your dipole.

Performance

I was glad I took a Transmatch and VSWR indicator with me to 8P6 land, for the SWR-protected transceiver I used would not operate effectively into the dipole without my creating a 1:1 condition at the station end of the feed line. This is typical of any well-designed solid-state transmitter that contains a VSWR shut-down circuit for the protection of the PA transistors.

Excellent results were obtained on 80 and 40 meters while using the trap dipole. I was able to work the world on cw with approximately 40 W of output power. Performance on 20, 15 and 10 meters was not spectacular, owing in part to poor daytime band conditions. I solved the problem to some extent by building a 20-meter dipole with tuned feeders, which was also erected as a sloper. It worked quite well on 20, 15 and 10 meters. At times, both antennas

Table 1
Measured VSWR Bandwidths

Band (meters)	*Lowest VSWR (MHz)*	*Band Edge (MHz)*	*Band Edge (MHz)*
80	2.1:1 — 3.850	2.9:1 — 3.500	2.5:1 — 4.000
40	1:1 — 7.150	1.8:1 — 7.000	1.8:1 — 7.300
20	1.3:1 — 14.350	1.6:1 — 14.000	1.3:1 — 14.350
15	1.9:1 — 21.450	1.9:1 — 21.000	1.9:1 — 21.450
10	1.7:1 — 28.000	1.7:1 — 28.000	2:1 — 29.700

Measurements were made by means of a Bird Thruline wattmeter, courtesy of ARRL Laboratory Technician Mike Kaczynski, W1OD. Readings on 15 and 10 meters are "apparent VSWR" indications, owing to the effects of the 90-foot RG-58/U feed line. Tests were not performed on 6 meters, although the antenna is rated for use on that frequency.

yielded similar signal reports on the three upper bands, but at other times the 20-meter dipole exceeded the performance of the 998 by two or three S units. I attributed the difference to the effective angles of radiation of the two antennas, respective to the time of day and propagation conditions.

Upon my return to the USA, the trap dipole was erected high and clear at ARRL Hq. Table 1 shows the measured VSWR on the bands from 80 through 10 meters. Western claims a 2:1 VSWR (or less) on all bands. I found this to be true on the specified frequencies other than 80 meters. The antenna was exceptionally handy and easy to erect, and was well suited to air travel in terms of weight and bulk. I strongly suggest that prospective buyers of this and similar Western Electronics models of antenna give consideration to performing the same type of "surgery" that I applied. The procedure will negate the occasion for intermittent operation, stray rectification, TVI and RFI.

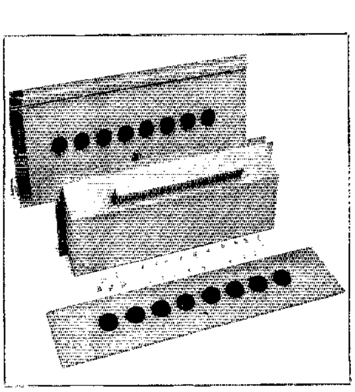
This antenna is distributed by Western Electronics, Kearney, NE 68847. Price class: $80. — *Doug DeMaw W1FB*

THE LAMBDA COAXIAL PORTAL UNIT

☐ Most amateurs have faced the problem of bringing their transmission lines through the outside wall of the house. With a single coaxial cable it's not difficult to do, but as the "antenna farm" grows, so does the problem. If you have five or six feed lines plus a rotator control cable or two, drilling holes through a window frame isn't likely to be a satisfactory solution.

The Lambda feedthrough panel is a *good* solution to the problem. With it you can bring up to eight cables through the wall without worrying about water leaks or drafts. Two 16-gauge aluminum panels, a protective cover and all the necessary hardware are supplied with the unit. The larger of the two panels, measuring 16-1/2 × 8 inches, mounts on the outside surface of the wall.[4] The smaller panel (16-1/2 × 4 inches) is attached to the inside wall surface. Both panels have eight holes, each fitted with a heavy rubber grommet that will accept cables up to 1/2 inch in diameter. The grommets prevent chafing of the feed-line insulation and also seal any unused holes. The protective cover attaches to the outside panel, shielding the holes from the elements. All the aluminum parts are painted with zinc-chromate primer. This produces a highly durable surface that readily accepts finish paints.

[4]mm = in. × 25.4



Installation

Installing the Lambda panel is easy. It is designed to mount between studs located 16 inches apart (center to center). After locating the studs, cut a rectangular hole in both wall surfaces, following the dimensions given in the instructions. Then fasten the outside panel over the hole with six woodscrews. A braided copper strap is supplied for connecting the panels together so that both can be effectively grounded. With the braid in place, pass the cables through both panels and attach the inside panel to the wall. Connecting a ground wire to the threaded stud provided on the outside panel and fastening the protective cover in place completes the installation.

If the cables do not have connectors attached to them, you will be able to pass them through the rubber grommets without removing the grommets from the panel. To install cables fitted with connectors, you must remove the grommets. They can then be carefully cut with a sharp knife and slipped over the cable. The holes in the panels are large enough (13/16-inch) to accept uhf (PL-259) or type-N (UG-21) connectors. With emphasis today on energy conservation, you will want to fill the space around the cables with fiberglass insulation to reduce heat loss.

When carefully installed and finished, the Lambda panel is an attractive, convenient solution to a sometimes difficult problem. The Lambda Coaxial Portal Unit is manufactured by Lambda Vector Corp., P.O. Box 35, Rte. 1, Monterey Rd., San Miguel, CA 93451. Price class: $50 — *George Collins, KC1V*

AVATAR MAGNETICS AV-357 POWER TRANSFORMER

☐ A popular construction project in *The Radio Amateur's Handbook* since the 1981 edition has been the 300- to 400-W 13.8-V power supply. The major stumbling block for would-be builders has been the lack of a commercially available transformer. Despite copious information in *QST* and the *Handbook* on rewinding transformers, many people are put off by the effort and uncertainty involved.

All that's changed with the introduction of the AV-357 by Avatar Magnetics. Ron Williams, W9JVF, designed the unit to the specifications given in the *Handbook* article. Taking special note of the critical requirement for precise rectifier voltage to maintain regulation and minimize dissipation, Ron tapped the primary winding in five places to provide optimum rectifier input. Another use for these taps is to compensate for line voltage variations.

Fig. 3 shows the AV-357, and the accompanying table lists the specifications. Anyone who's seen the photos in the *Handbook* will be impressed that the Avatar unit does the job of the *Handbook* transformers with less than half the volume. The obvious benefits of using a smaller, lighter transformer are enclosure compactness (easier to fit in the shack) and a lighter foundation (no need for expensive 1/8-in. aluminum plate!) The trade-off is that such a compact assembly must be designed to ventilate the transformer and prevent it from heating the already heavily taxed transistor heat sink. In the *Handbook* supply, the transformer ran practically cold at the rated load. The compact AV-357 unit naturally runs quite a bit warmer — not so hot as to take the skin off your fingers, but hot enough to affect any nearby sensitive regulator components. I tested the AV-357 in free air for eight hours using a 400-W load consisting of a parallel bank of five 5-Ω 225-W resistors (I knew they'd come in handy some day!). It's definitely a heavy-duty piece.

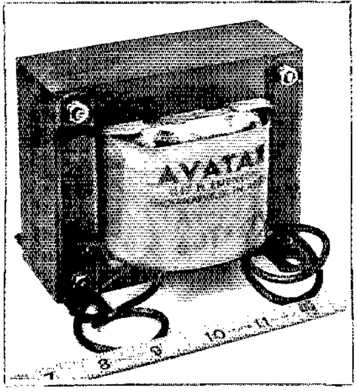


Fig. 3 — The Avatar Magnetics AV-357 transformer, designed for use in the *Handbook* 300- to 400-W power supply.

Avatar Magnetics AV-357 Power Transformer

***Manufacturer's Claimed Specifications*†**

Input excitation: 117 V, 60 Hz

Output voltage vs. load current:

		(100% duty)	*(25% duty)*
Primary tap	*Open*	*20 A*	*30 A*
1	21 V	20 V	19.5 V
2	20	19	18.5
3	19	18	17.5
4	18	17	16.5
5	17	16	15.5

Dimensions: 5-1/4 × 4 × 4-1/2 in.

Weight: 13 lb.

†Verified in the ARRL laboratory.

At 400 W of secondary output, the measured primary current at 117 V was 4.4 A for an efficiency of 77%. The primary magnetizing current was 330 mA, using the tap yielding the highest secondary voltage. All of these tests were performed at 60 Hz. No information is published for 50-Hz operation, and no power generator for that frequency exists in the ARRL lab. (I approached several of the staff audiophiles, but none was willing to subject his amplifier to so severe a test!) However, the designer suggests 20% as a reasonable current derating factor for 50-Hz applications.

The AV-357 removes a significant impediment to the home construction of 13.8-V power supplies for transmitting service. If you don't know why you should build your own supply instead of buying an "accessory" unit for your transceiver, see the *Handbook* article. Avatar Magnetics can custom-wind transformers for any load from 200 to 2000 W. Price of the AV-357 is $35 plus shipping. Avatar's address is 1147 North Emerson, Indianapolis, IN 46219. — *George Woodward, W1RN*

Hints and Kinks

Conducted By Larry D. Wolfgang,* WA3VIL

LOW-FREQUENCY SQUARE-WAVE PULSES

☐ When you are testing digital circuits the need occasionally arises for a source of low-frequency square-wave pulses. I have found that an electronic keyer and a voltage source connected in series make a suitable source of low-frequency pulses for some applications. Fig. 1A shows the general arrangement.

The dot lever of the keyer is held closed for as long as the pulses are needed. If a wider pulse is desired, the dash lever may be used. The speed control is used to vary the frequency of the pulses. The output of the voltage source is not specified because this will depend on the requirements of the circuit under test. For the TTL family, the pulse height usually needed is 5 V, so a 5-V source would be used if there is no voltage drop across the keyer output terminals. You will need to pay attention to the polarity of the source and of the keyer (if any) and the polarity of the circuit under test. Be sure that the grounds of these devices do not cause problems.

An alternate circuit is shown in Fig. 1B. As shown, the output will be low with the key open. To produce a high logic level with the key open, simply omit the inverter.

If the circuit under test must be pulled to ground potential, this circuit will not work. I did not require this, and the circuit worked well. Keyers that use a relay-switched output may not be suitable for this application because of contact bounce. — *James Herb, W3SHP, Selinsgrove, Pennsylvania*

REMOVING DIRT IN METER MOVEMENTS

☐ I read the item about removing dirt in meter movements by Dean Elkins, K4ADJ, in the June 1982 Hints and Kinks column with much interest. Some years ago I worked in the test-equipment lab of a large electronics firm. We used a method that I think was much simpler to free the many meter movements that became stuck with dirt. It does not require the removal of the armature or pole pieces of the meter.

Obtain some self-sticking paper labels from an office-supply store. These come with the adhesive side on a waxed-paper base. Using a sharp knife or scissors, cut some strips of this material about 1/16 inch wide, and an inch or more long.[1] The labels are a little stiffer than ordinary tape.

Remove the meter case and look through the movement to locate the metal "hairs" that are causing it to stick. Peel the backing strip from a piece of the label and work it carefully through the pole piece. The metal bits will adhere to the paper strip, and can be removed easily. Repeat the process with more label strips until the movement is free. You can test this by blowing gently on the pointer. Reassemble the meter case, and it will be just like new. — *Warren Laufer, K2FG, Buffalo, New York*

FILAMENT INRUSH-CURRENT LIMITER FOR LINEAR AMPLIFIERS

☐ I wanted to protect the 3-500Z tubes and the diodes in my Heath SB-220 linear amplifier from excess current when turning it on. Another goal was to accomplish this without changing the amplifier circuit. I designed and built an external unit housed in a surplus box with a perforated aluminum cover for good ventilation.

My amplifier is wired for 117-V ac operation, but I built the current limiter with possible 234-V operation in mind. Fig. 2 shows the circuit I used. The changes required for 234-V ac use are shown in Fig. 2B.

To use the device, you merely plug the ac line cord from the amplifier into the unit and then connect the line cord of the limiter into a wall outlet. Turn on the amplifier, then switch on the limiter. The amber pilot light comes on and the 3-500Z tubes warm up gradually to a slight glow. In five seconds, the relays close, the green pilot lamp comes on and the tubes reach full operating temperature. — *David Brown, W6NBM, Wildomar, California*

KENWOOD TS-120S CW FILTER

☐ When I installed the cw filter (Kenwood YK-88C) in my TS-120S, I discovered that I could not operate in the cw mode without the filter. Switching to the usb position to receive and back to cw for transmit was an inconvenience I would not tolerate.

[1]mm = inches × 25.4

*Assistant Technical Editor

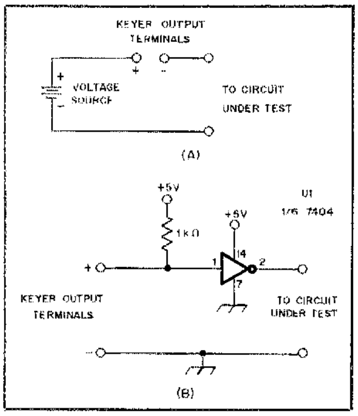


Fig. 1 — Shown at A is a simple method of obtaining low-frequency square-wave pulses. The voltage source should suit the circuit under test. An alternate circuit for use with TTL levels is shown at B. The inverter can be used or not, as appropriate.

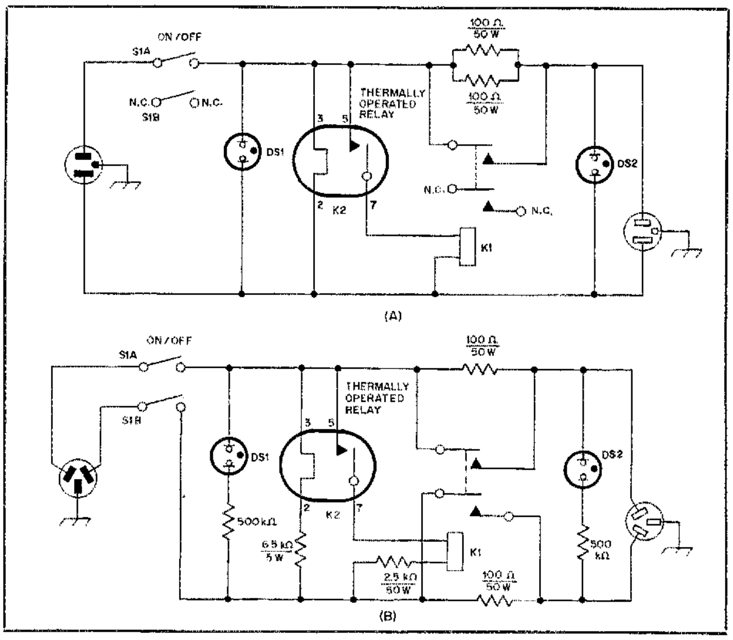


Fig. 2 — The schematic diagram of an inrush-current limiter used to protect the tubes of a linear amplifier is shown at A. A revised circuit for use with an amplifier wired for 234-V operation is shown at B.

DS1, DS2 — Neon pilot lamps: one amber, one green lens. Built-in resistor for 117-V ac operation, such as Radio Shack 272-707.
K1 — 117-ac relay, dpst, 25-A contacts, such as Potter & Brumfield type PR7 AY.
K2 — Amperite time-delay relay, no. 115NO5 (5-s delay); available from Allied Electronics, 401 E. 8th St., Fort Worth, TX 76102, or from the location nearest you.
S1 — Dpst switch; 25-A, 234-V contacts.
Octal tube socket for K2.

The problem could be solved by installing a dpdt switch, but I did not want to drill holes in my new radio. The noise-blanker switch is a dpdt unit. I never found the noise blanker to be effective, so I decided to use that switch.

A small plug, labeled no. 29 on the i-f board, must be removed. A pair of leads are soldered to the NB switch common positions and connected to this plug (Fig. 3). I forced scrap resistor leads into the plug terminals. A pair of leads should run from the outer (off) switch position to the SSB/SSB position on the noncomponent side of the pc board. A third pair of wires connect from the in (on) switch position to the SSB/CW position on the pc board. Now the NB switch stands for "narrow band." Owners of other rigs with similar shortcomings may benefit from my solution. — *Don Hayford, NØBPI, Aurora, Colorado*

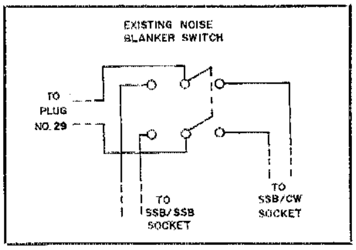


Fig. 3 — Switch-wiring diagram showing how to provide selectable wide- or narrow-bandwidth filters in the cw position.

BATTERY-PACK SAFETY FOR HAND-HELD RIGS

☐ I recently noticed a small rust spot under one of the screws on the top of my ICOM BP-3 battery pack. I was concerned about the possibility of battery leakage and deterioration. When I opened the case, I found damage to the insulation on the wires, and one wire was burned off. The open lead was between one of the screws on the bottom of the pack and an internal NiCd cell. Since I never use a drop-in charger, the problem had probably gone undetected for some time.

I believe this failure was caused by the two bottom contacts being shorted. This could occur if the unit is carried in a pocket with keys, or by contact with any conducting material. I modified my battery packs by placing a diode in the line between the screw and cell to prevent a recurrence of a short circuit. Alternatively, one or both contacts could be insulated with electrical tape or a dab of silicone sealer. — *John E. Noel, W4UGV, Huntsville, Alabama*

☐ I was concerned about shorting the contacts on the top of an extra battery pack for my ICOM IC-2AT. I solved the problem by cutting a credit-card-thick piece of plastic to fit into the slide connector. A 15/16 × 2-1/4 inch card fits nicely. Whenever I change batteries the plastic cover is transferred to the unused battery. This prevents the cover from being misplaced. I believe other radios use a similar battery-pack connection arrangement, so my idea may be adaptable to other hand-held rigs. — *Tom Karnauskas, N9BWY, Cary, Illinois*

LINE-VOLTAGE ADJUSTER

☐ A few years ago, I was living in a place where line-voltage regulation was not very good. In the evening, when there was time to operate, line voltage would sag. Frequently, the sag was bad enough to cause the power supplies in my equipment to lose regulation. That in turn caused VFO drift. I was, even at that, surprised by the first report of chirp on my signal; the second chirp report helped me decide to cure the problem. An autotransformer to control station voltage would have been nice, but I didn't have one that was suitable for 10 A. Some filament transformers and a 1.5-A autotransformer were all I could find for possible use.

I solved the problem by building a circuit similar to the one in Fig. 4. The secondary of a filament transformer, T2, is wired in series with the high side of the ac line. All current to the load flows through the T2 secondary; therefore, it must have a heavy enough rating to carry that current. Depending on phasing, the secondary voltage in T2 will either subtract from or add to (BUCK or BOOST) the line voltage. S1 reverses the phasing of T2. T1 allows smooth control of the amount of BUCK or BOOST. — *Chuck Hutchinson, K8CH, ARRL Hq.*

CLIPPERTON-L 60-Hz HUM

☐ The January 1982 Hints and Kinks column offered a solution to the problem of 60-Hz hum caused by the Clipperton-L power supply. That solution places an additional 1.6-A load on the filament winding. My solution to this problem reduces the filament-winding load.

I had a spare Hammond 166G6 filament transformer (with center tap). Fig. 5 shows how I connected this transformer in parallel and in phase with the original filament winding. D1 connects the center tap to ground, and C44 is used to bypass any rf. The primary winding is connected to terminals 3 and 4 on the power-network terminal board. — *W. H. Galpin, VE4AB, Winnipeg, Manitoba*

REWINDING AUDIO TRANSFORMERS FOR 60-Hz USE

☐ I needed a power supply for a transistorized project. Since I had a few "boat anchors" from the vacuum-tube era, I picked out a transformer to be rewound. After checking the cross-section and window area of the core, I used tables to select the primary and secondary wire sizes for the required power. *The Radio Amateur's Handbook* supplies information on rewinding transformers.

When the transformer was rewound, I connected a voltmeter to the secondary and plugged in the line cord. In 60 seconds it would have fried an egg! I tried rewinding twice the number of turns on both the primary and secondary, half the total turns, and doubling the wire size on both the primary and secondary. Nothing seemed to help. Finally, I discovered that I had rewound an audio-transformer core. The moral is: Don't try to use one of these for a 60-Hz power transformer. — *Glenn Knox, W7ERS, Kent, Washington*

KENWOOD TS-830S "TALKBACK"

☐ Some Kenwood TS-830S transceiver owners have experienced transmitter "talkback." This quirk may be manifested during transceiver operation, with or without an amplifier. It may be eliminated by adding an rf filter to the receiver audio power amplifier.

Cut the 12-V supply-line foil between R47 and C28 at IC Q4 on the af unit (X49-1140-00). A 1-µH choke is bridged across the gap. One lead of a 0.01-µF disc-ceramic capacitor is soldered to Q4, pin 1; the other lead is attached to a solder lug secured beneath the IC mounting screw on the heat sink. That's all there is to it! — *Paul K. Pagel, N1FB, ARRL Hq.*

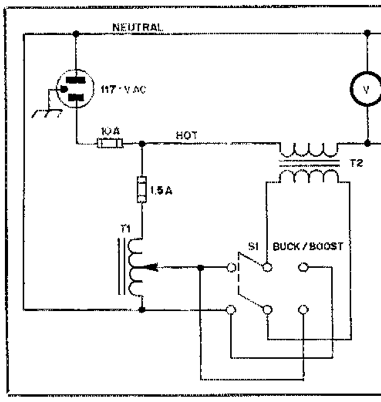


Fig. 4 — This circuit can be used to buck or boost line voltage by approximately 10%.
T1 — Autotransformer; 117-V ac, 1.5 A.
T2 — Filament transformer; 117-V primary, 12.6-V, 10-A secondary.

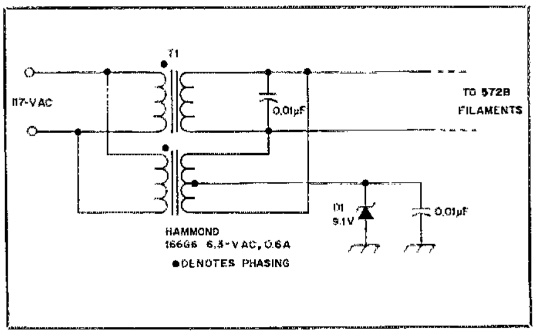


Fig. 5 — Schematic diagram showing how a center-tapped filament transformer can be connected in parallel with the one in a Clipperton-L to eliminate 60-Hz hum.

Technical Correspondence

Conducted By Dennis J. Lusis,* W1LJ

The publishers of QST assume no responsibility for statements made herein by correspondents.

ANTENNA CURRENT DISTRIBUTION

☐ McDonald's article, "An End-Fed Extended Double Zepp for 2 Meters" (June 1982 *QST*), is an excellent one. However, I believe the current distribution diagrams for the double Zepp and extended double Zepp (Fig. 1) are incorrect.

Since it is necessary for the current to reverse every 180° (or half wavelength) of its travel, currents in the transmission line of the double Zepp must be the reverse of that shown. Likewise, the current in the center sections of the extended double Zepp must be the reverse of that in the outer two sections of the antenna. Also, currents cannot flow in the same direction on opposite sides of the transmission line. Please refer to Fig. 1 for what I believe to be the proper representation of current flow in these antennas. — *Floyd X. Passmore, W7KLE, Beaverton, Oregon*

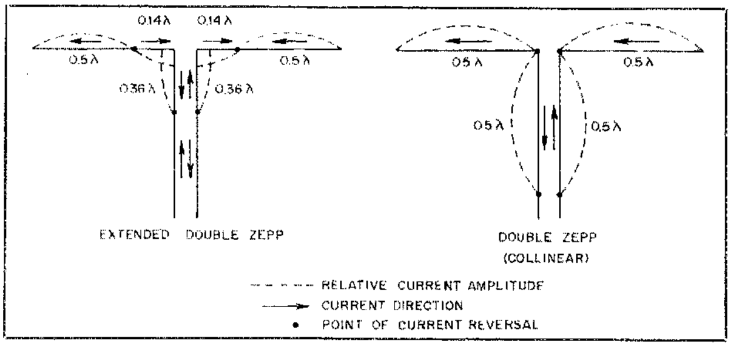


Fig. 1 — Corrected current distribution for the antennas described by Passmore.

PROBE POLARITY CONFUSION

☐ Doug DeMaw's article in December 1981 *QST* on the basics of equipment servicing raises a very important issue. In the OHMS position, the probe polarity is usually reversed between VOMs and VTVMs. In the VOM, the red terminal almost always has the negative voltage. In the VTVM, red is, indeed, positive.

Some VOMs have a polarity-reversing switch. My experience has been that these units do have positive voltage on the red jack when the unit is set for positive polarity. Your best bet is to follow Doug's advice: "Make certain that a positive potential does, in fact, exist at the positive output jack." — *Frank Dukat, K6NL, Los Altos, California*

HENTENNA, OR SKELETON SLOT?

☐ In the February 1982 issue of *QST*, Sugihara, JJ1UMS, describes the "Hentenna." After building one for 145 MHz, I noticed that it bore a striking similarity to a skeleton-slot radiator! Chapter 7 of the *RSGB VHF/UHF Manual* verified this. The skeleton-slot dimensions given there vary slightly from Sugihara's design. The height of the rectangular loop in inches is 6740/f(MHz),[1] and the width is 2250/f(MHz). As with the Hentenna, the feed point should be near the center of the vertical legs. Using the above formulas, feed-point impedance is given as 72 Ω, and a delta match is recommended.

In Europe, the skeleton slot (or Hentenna) is very popular as a driven element in stacked Yagi arrays. One set of parasitic elements is positioned parallel with the upper horizontal section of the loop, and one set with the lower. This configuration allows a pair of stacked Yagis to be fed with a single feed line, and eliminated the need for a phasing harness. Commercial versions of this antenna, utilizing stacked 8-over-8 element Yagis, produce a theoretical gain upwads of 13 dBd. Perhaps North American amateurs will recognize the Hentenna as an alternative to the driven-element systems they are presently using. — *Thomas D. Feise, DC6XT, Oberhausen, Federal Republic of Germany*

[1]mm = in. × 25.4.

*Assistant Technical Editor

W1VD FETVOM IMPROVEMENTS

☐ The FETVOM described by Jay Rusgrove, W1VD, in March 1978 *QST*, and subsequently included in the ARRL *Handbook* (1982, p. 16-5) is a terrific instrument. But I had some problems, and the solution of these, along with some modifications, may interest others.

In the original article, Rusgrove cautions against using anything except MPF102s. Since I live in the "boonies," access to these was restricted, so I had to be content with Radio Shack FETs, not all being suitable. The problem was twofold: poor matching and frequent failure. I came to the conclusion that the failures were because of possible design conditions in the ohms mode, which could provide higher voltage to the gate of Q1 than was furnished to its drain, particularly at turn on (S1). I believe the Zener diode, D1, was intended to prevent this, but in my case it did not.

I made two changes and one substitution. The latter was to use 2N3821 FETs (RS 276-2028), which are rated for 50 V_{dss} and also provided an acceptable match. The first of the changes was to move the voltage supply line from the high side of the 100-ohm resistor connected to the two drains, to the low side (or drain connection point). This makes it impossible to get more voltage on the gate of Q1 than on the drain. And second, by connecting an NC push-to-open switch across D1, the lead to the gate of Q1 (in the ohms function only) is grounded while the meter is idling in the OHMS position and/or while ranges are being changed. Then, when ready, push the switch and take the reading. After several months, no more failures.

As with many construction projects, one thing led to another, and when I discovered nonlinearity in the ohms readings, albeit small, a study of the problem led to several other changes. The first was to increase B1 to 12 V from a regulated supply, then to increase the values of all the resistor-bank arms substantially and thereby read a lower voltage across RX, which corrected the nonlinear hump in the middle area of the meter scale. The meter? I changed it also, from the 50-μA movement, to a 3-1/2 digit millivolt meter I had (it uses a 7107 with a ± 5-V regulated supply), and thus could accomplish two things: digital readout and increased sensitivity. This meter was buffered when used in the ohms mode by means of two 500-kΩ resistors, one in each lead with the meter positive terminal to the Q1 side. This made it possible to extend the range of the ohmmeter with excellent linearity for all measurements. Using the 200-mV range, the upper limit goes easily beyond 1 megohm, and a new lower range (by adding one switch position to S3) will read fractional ohms (in increments of tenths from 0.1 ohm) up through 10 ohms. The resistor-band arms are, starting with the lowest range: 8 k, 12 k, 120 k, 1 M, 7.5 M, 75.3 M, respectively. These values afford substantial range overlap. The range markings on S3 are: 10, 50, 500, 5 k, 50 k, 1.2 M, respectively. Use fixed-value resistors in series with the pc controls for calibration. To make operation of the zero set easier and less critical, I used a 5-kΩ potentiometer with a 22-kΩ fixed-value resistor on each side, in place of the R11 originally shown. Now, when the meter face reads 103 ohms, it is 103 ohms without any interpolation.

One little-stressed advantage of digital readout is freedom from upper and lower needle-swing limits, as experienced in analog meters. Where linearity of the instrument design (as in this case) extends reasonably outside the range markings, the reading is still possible and accurate, even though it may be 25% or more beyond the marked range limits.

Another addition uses a four-position function switch (S2) for added capability to the package. September 1978 *QST* carries a lead article by Douglas A. Blakeslee, N1RM, for the construction of a capacitance meter. His unit fits right into the package. The change here was the use of the digital readout, only this time the 3-1/2 digit meter is used in its 2-V range, and the regulated 12-V supply is switched over here. Again, the convenience and directness of digital readout is a big plus. Readings are directly in microfarads, and the range switch can show the appropriate left-hand zeros to add to the reading.

Obviously, there is a negative side to this meter change: a ± 5-V supply and a + 12-V supply, both regulated, are required. This adds to the combination instrument when used primarily as bench test gear. This is no handicap. I feel the greatly increased accuracy, range and ease of reading the four-function combination instrument outweighs any disadvantage. — *Gilbert Earle, Cool, California*

VERSATILE SWITCHED-CAPACITOR FILTER WITH AUTOMATIC LEVEL CONTROL

☐ Unless you are using an ultra-modern receiver with both i-f band-pass and "tail-ending" filter schemes,[1] maximum selectivity is not being achieved. A switched-capacitor filter (SCF) is an economical answer to analog active filters, which require op amps with critical supporting components. By comparison, the SCF cutoff frequency is simply determined by a digital type of clock generator that controls the sampling rate and, hence, the passband.

The SCF I'm describing is a 10th-order, elliptic type of low-pass filter, which exhibits a ripple in the passband of less than 0.6 dB pk-pk. The stopband attenuation is greater than 60 dB using a single, inexpensive IC as the filter element. Fig. 2 shows the typical "brick-wall" band-pass characteristics of an elliptic filter, and is representative of what to expect from the SCF.

Because the SCF is intended for use in radio communication applications, it must accomplish low-pass filtering from at least 400 to 2400 Hz, allowing coverage of both cw and ssb emissions. In addition to audio filtering, it was deemed worthwhile to provide an automatic level control (alc) feature to protect the operator from uncomfortable variations in audio volume. These may be caused by sudden and unpredictable changes in propagation, or the presence of interference. The filter and the alc sections provide a useful measure of circuit gain, which makes the system useful when it follows a product detector, in which audio levels are low. The SCF is shown in Fig. 3.

The alc circuit consists of a single NE570 IC, which is used as a high-dynamic-range compressor and sidetone monitor. This circuit provides a gain inversely proportional to the receiver input level, so that a 20-dB *decrease* in input level will produce a 20-dB *increase* in stage gain. The system will maintain an output level of ± 1 dBm for an input change of + 14 to − 43 dBm at 1 kHz. The alc also features a fast-response characteristic without the pumping usually associated with other types of audio compressor circuits. An additional feature: the NE570 is internally biased for a quiescent current of only a few milliamperes, which conserves power.

A single CD4047AE monostable multivibrator is used in the pulse-generator section of the circuit. R1 controls the sampling frequency, which in turn governs the band-pass characteristic. Using the R and C values shown, the pulse generator will cover a range of approximately 9.5 kHz to 60 kHz in pulse rate. When applied to the clock input of the MC14414-2, this pulse rate will produce a cutoff frequency range from 400 to 2400 Hz. If the reader wishes to develop his or her own band-pass range, the filter cutoff frequency can be determined by the following equation:

$$F_{co}\,(Hz) = \frac{F_{clock}\,(Hz)}{24.22}$$

Since only one frequency-control mechanism is required, the CD4047AE may be located away from the remainder of the circuit. The clock output from pin 13 can be routed via shielded cable to pins 10 and 11 of the MC14414-2. R1 can be mounted on a front panel.

Power-supply requirements for the SCF are minimal. Any well-filtered and regulated dual 6-V supply capable of delivering 100 mA will suffice. — *Richard Schellenbach, W1JF, Reading, Massachusetts*

[1]W. Hayward, "A Competition-Grade Receiver," *QST*, March and April 1974.

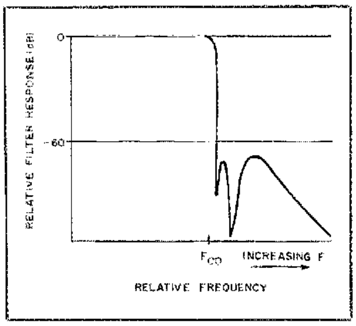


Fig. 2 — Relative frequency-response characteristic for the switched-capacitor filter (SCF).

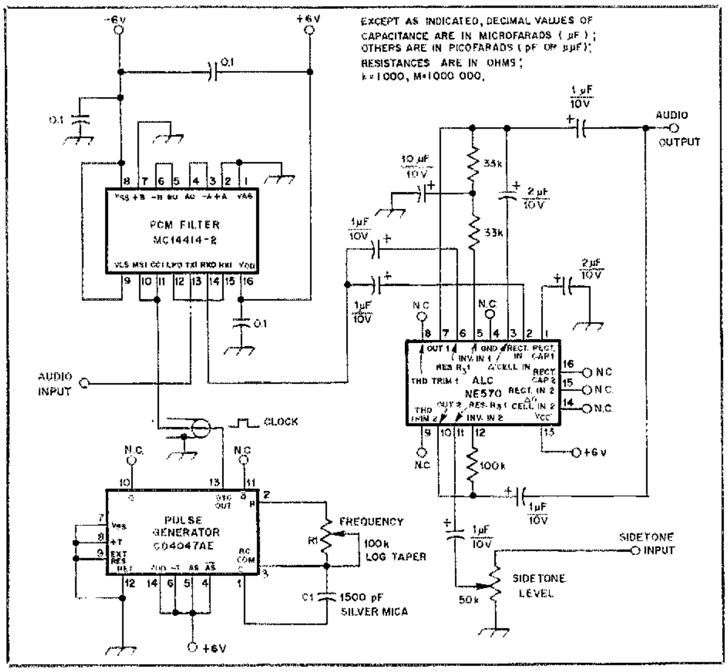


Fig. 3 — Schematic diagram of the SCF.

Feedback

☐ Greg McIntire, AA5C, has found an error in the 110-baud ASCII software for his "Microprocessor-Based RTTY Speed and Code Converter" (Jan. and Feb. 1982 *QST*). Line 175 of the listing should read: RXBTCNTLD = 8; /*# BITS FROM TTY*/

Author McIntire also informs us that etched circuit boards for the converter are now available from him. Contact him at the address given in the *QST* article for details.

☐ The price of the ICOM PS-15 power supply and the corporation address are shown incorrectly in the August 1982 Product Review of the ICOM IC-720A HF Transceiver. The correct price class of the PS-15 is $150, and the correct address is: ICOM America, Inc., 2112-116th Ave., N.E., Bellevue, WA 98004.

☐ The following corrections should be made to the information contained in "Build a Microprocessor-Controlled L-C Meter That Sends Morse Code," September *QST*. On page 15, Table 1, delete the second decimal point following the zero in both software versions of the character set. Add an apostrophe (') to the Standard Software set. In the first column, page 17, delete the overscore over ALE. In Fig. 3, delete the 1% P designation for C10. Also, the left side of R1 should be shown connected to U4, pin 3, not to the + 5-V line.

☐ Dick Stroud, W9SR, points out an error made in reproducing Fig. 3 of "Explore '220' with this State-of-the-Art Transverter," which appeared in August 1982 *QST* (p. 14). The 1.2-kΩ resistor just above U1 should not be connected to ground.

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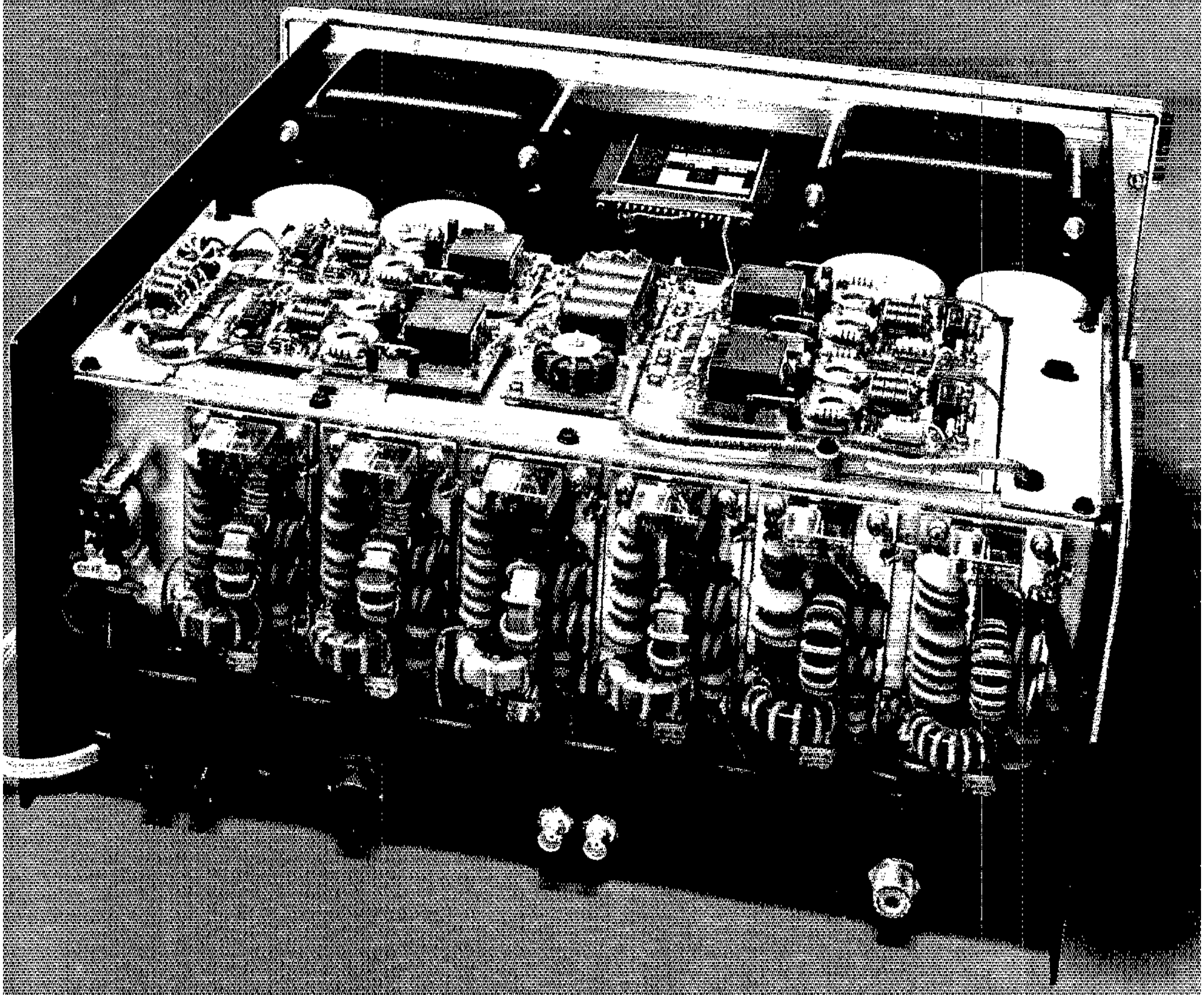

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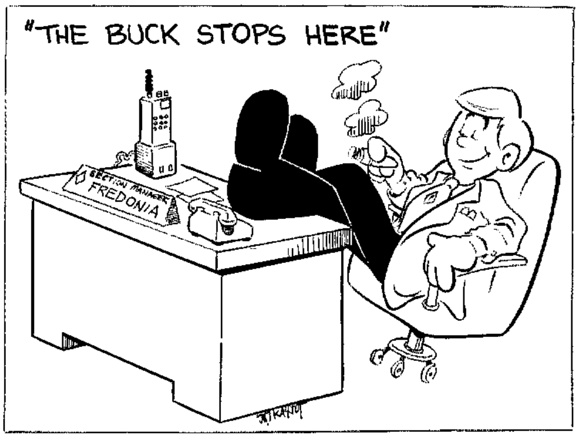


Larry Lunchbucket finds personal fulfillment in the League's expanded field-organization structure.

As told to Robert Halprin,* K1XA

Call me Lunchbucket.[1] I was born and raised in Fredonia City, USA, but I left the comfort and security of home to seek my fortune in the big city. Things didn't work out so well. I was fired from a prestigious job as a reporter on a major midwestern newspaper. Following that, I knocked around a bit. It's no secret; I had some problems. I don't mind admitting that I was seeing a psychiatrist. He helped me get over the disgrace that I felt as a result of losing my job. He also assisted me in getting rid of some paranoid notions I had about the ARRL.

My frame of mind was so improved that I came home to Fredonia City, caring not what people might say about my less-than-glorious return. I wasn't the conquering hero, but I vowed to start over again, to put my life back together. Things started looking up when, despite generally lackluster economic conditions in Fredonia City, I secured a good job — a management position at a sewage-treatment plant. At last, I was on my way. I had achieved some stability and tranquility in my life. Or so it seemed.

The Road Warrior

Fate was destined to change everything. One sub-zero winter evening, while driving home from work on a lonely country road, I hit a patch of ice and lost control of the car. I crashed through a guardrail and over into an embankment. Painfully, I dragged myself out of the ruined vehicle, and checked my vital statistics. They were still valid, but in a world of hurt.

Salvation was, it seemed, clipped onto my belt: my 2-meter fm hand-held. Luckily, it had a scanning feature, as it was a major effort just to flip the switch to the ON position. In any case, the rig locked into a busy frequency upon which, coincidentally enough, the Southern Fredonia Emergency Net was going full steam. I immediately felt a lot less isolated; moreover, both the Section Emergency Coordinator (SEC) and the Section Traffic Manager (STM) frequented that net, so I knew I was in good hands.

I had to stand by for a substantial amount of time, as it turned out, while numerous amateurs on the net expressed themselves in great detail about a variety of personal ailments (although my ailment had more immediacy). I eventually got the opportunity to check in, at which time I briefly explained my predicament and asked that someone notify the state police. Suddenly, the Section Emergency Coordinator broke in and instructed net control not to help me unless I slapped a number on my message and made it formal radiogram traffic.

I found this slightly unusual, in view of my condition — rapidly freezing to death in the snow, not so lightly sprinkled with large quantities of my own blood. But you can bet I composed a radiogram right quick. Shortly thereafter, I was permitted to pass the message to a station on the net. As soon as I finished, the Section Traffic Manager asked to be recognized and thereupon disagreed with my "check" (the number of words in the message). A lengthy discussion ensued, with each ham on the rollcall asked to render an opinion: Is *frostbite* one or two words? Finally, the STM told me he would write a letter to ARRL Headquarters for a "ruling," and that my rescue would commence as soon as a reply was received from Newington. At this point, I lost consciousness.

The Recovery Room

I awoke in Fredonia City General Hospital. The doctor told me I was okay, thanks to a passing REACT member who had radioed for help. I was certainly grateful for that. The doctor indicated that I would be in the hospital for at least two weeks while my wounds healed.

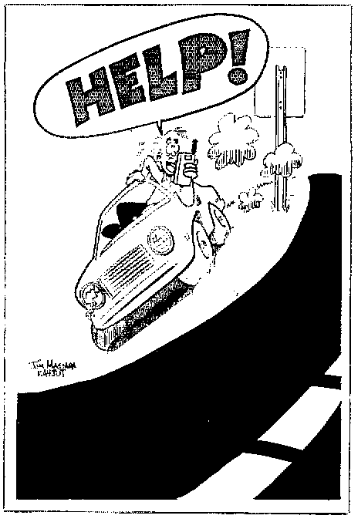
During this period of recuperation, I had an opportunity to catch up on my reading, primarily *QST*. I should mention first that my animosity toward ARRL had resurfaced; after all, "their" SEC and STM had practically "planned" me into oblivion. How, I wondered, could these feeble-minded bureaucrats in the Ivory Tower back East make those two guys leadership officials? I intended to write a scorching letter to Newington about it.

Well, I stumbled across an article in June 1982 *QST* called "New Life for ARRL Sections." Heck, if there was anything that needed new life, it was the ARRL Fredonia Section, which was in worse shape than I was.

In the article I found out that ARRL leadership appointments, such as STM and SEC, are *not* made by ARRL Hq., but by the ARRL Section Communications Manager. While our SCM was a nice chap, he was only accessible to the 50 or so hams that were regulars on the

[1][Editor's Note: The preceding three installments of the Larry Lunchbucket series appear in *QST* in June 1979, April 1980 and April 1981.]

*Deputy Communications Manager, ARRL



Fredonia cw net. The remaining 1500 League members in the section, and the hams who were *potential* ARRL members, had no contact with the SCM or the STM/SEC, and were left out in the cold, if you'll pardon the expression.

I had plenty of time on my hands, so I decided to revise my scorcher to Newington, severely chastising them for appointing our SCM. But as I got deeper into the article, I realized that SCMs aren't appointed at all; they are *elected* by the League members in each section. Every two years, the position is up for grabs, and all it takes is a nominating petition signed by five League Full members to get a new person in the running. Instead of complaining, all I would have to do is submit a petition for a candidate of my choice and let the democratic process prevail. But this was old information.

The real news of the article was that the ARRL Board of Directors had approved a revitalized section structure. A new position, Section Manager, with expanded responsibilities, will replace the SCM in each section over a two-year transition period.

The Section Manager will manage *all* League activities in the entire section. While National Traffic System and Amateur Radio Emergency Service functions will continue in full swing, the Section Manager will spearhead other section activities that are of major importance to Amateur Radio and the League. To be an effective mainstream field organization, the volunteer force will delve into RFI problem-solving, affiliated-club support, liaison to state government, encouragement of technical activities, and a stepped-up campaign of volunteer monitoring and bulletin dissemination. Not all of these goals are directly operational as such; hence the title of Section Manager.

Interestingly enough, I noticed that the Fredonia Section had an SM election coming up pretty soon. Since I was now up on all my reading, I figured, what the heck, they could do a lot worse than me. I'd run for it myself. (I cut down to two packs of cigarettes a day, so I was able to afford to maintain my ARRL membership continuity.)

The Real Campaign

My ham friends came to visit me in the hospital, and all of them signed my petition. Unfortunately, this left me three signatures short. I advertised my quest on 2 meters and eventually obtained the required number of signatures. Just as I was being discharged from the hospital, I fired off the petition to League Hq. Later, I was informed that the signatures were valid, and an election would be conducted.

I had some heavy-duty competition; my opponent was the vice president of the Fellowship of Wireless Aardvarks. The vote was close, but I managed to squeak into office. I credit my victory to a debate between him and me on 75 meters; there was a solar flare and no one could hear a thing! In any case, when I was informed that I had won the election, I thought to myself — in the words of the character played by Robert Redford in *The Candidate* — "What do I do now?"

The Roster Evolves

Clearly, the first major task was to assemble a team of lieutenants to get things happening in the Fredonia Section. I needed a hand-picked group of capable section leaders. In addition to personnel to modernize the traffic and emergency-preparedness end of things, other slots needed to be filled. Someone was needed to intensify the volunteer monitoring function, especially with respect to the Amateur Radio legislation recently passed by Congress and signed by President Reagan. An amateur was needed to keep a "receiver" on matters affecting Amateur Radio at the state government level; another to work with radio clubs in creating a more effective local presence of Amateur Radio. A League enthusiast was required to promote Amateur Radio aggressively in the media. An electronics whiz would be asked to encourage technical activities, while a section historian would be asked to supervise an on-the-air bulletin program containing news of both a local and national nature. Seek, it is written, and ye shall find:

For the post of *Official Observer/RFI Coordinator*, I appointed a no-nonsense, take-charge kind of guy, who most recently was a security guard for the U.S. tour of the Rolling Stones. He loves HBO.

The *State Government Liaison*, an attorney who works in the Capitol vicinity, is an avid ham and amateur photographer who installed a 250-foot tower on his property, which adjoins a nudist colony.

An *Affiliated Club Coordinator* was the hardest to place, but I eventually found a well-qualified person; he was the maitre d' and part owner of the Boom Boom Club in Fredonia's version of the Combat Zone.

A former broadcaster and p.r. man agreed to become *Public Information Officer;* he's a real image-maker who never wears shorts with black shoes and socks in public (or in private, as far as I know).

My *Technical Coordinator* was an amateur who won a *QST* cover plaque for his article on the differences in radio-wave propagation between imported and domestic beer-can verticals.

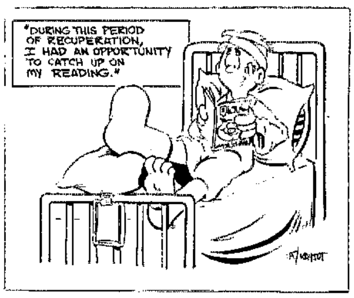
Of the 25 Official Bulletin Stations in Fredonia, only one was able to copy W1AW direct. Since this is essentially a broadcasting function, I was fortunate enough to find an amateur who committed George Carlin's Seven Dirty Words to memory. I appointed him *Bulletin Manager.*

Now you probably expect that I sacked the STM and SEC on day one. Wrong! I don't have a vengeful bone in my body (those that weren't shattered in the accident, anyway). Both these folks had good leadership skills and an extensive background in NTS and ARES activities that no ham in the section could match. When I asked them to continue in office, I recommended that they start thinking in terms of being mobilizers rather than *im*mobilizers. Thankfully, they agreed to stay on (besides, they had such nice, form-fitting jumpsuits).

The Right Stuff

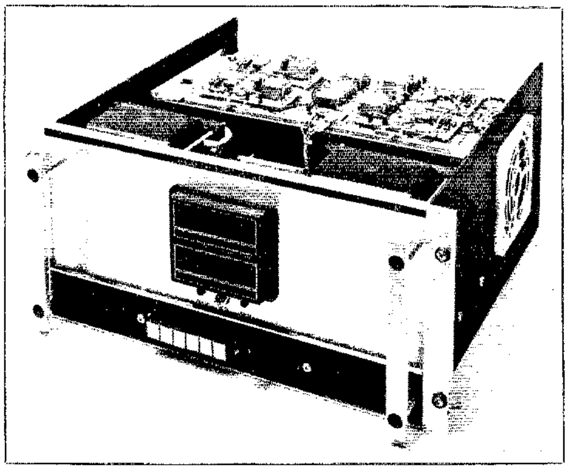
I really can't claim total credit for the Fredonia Section's running so smoothly. The credit goes to these highly motivated leadership officials; they deserve all the accolades. They have already distinguished themselves in the section. To wit, the State Government Liaison headed off an attempt to remove the lightning bolt from call letter plates; our Public Information Officer was interviewed on local television and didn't once use phonetics; our OO/RFI Coordinator solved a serious

Continued on page 58 . . .



MOSFET RF Power: An Update

Part 1: Power FETs are now practical for 2-30 MHz broadband-amplifier use at the kilowatt level. How do they compare with vacuum tubes and bipolar transistors? This report by ARRL TA Granberg provides some interesting answers.



By Helge Granberg,* K7ES/OH2ZE

Interested in power-FET technology? This paper combines a status report with some useful application notes for MOS power devices. It is intended to document the progress that has been made recently in power-FET development and deployment, but it is not meant as a construction article. The data presented are, however, suitable for amateur designers who wish to develop their own power-FET amplifiers.

Early power FETs were relatively low-level devices, but now these transistors can produce power amounts of 100 to 150 W. In contrast, we now have bipolar devices that yield up to 250 W of rf power (500-600 W in special water-cooled packages from at least one manufacturer). If we compare watts against dollars, using an 8877 tube as an example, a watt from a solid-state amplifier is about twice as expensive. If we include the necessary harmonic filters for broadband amplifiers, the price will be even higher.

Narrow-band solid-state amplifiers are considered feasible only for single-band use. This is because the low impedance levels (typical) make band switching the passive elements impractical. Also, losses will result.

Push-pull solid-state amplifiers aren't difficult to design, and they are desirable because the impedances are higher. Also, rf ground loops are easily eliminated. Other advantages are that the powers of the two devices are combined and the even harmonics are suppressed. Broadband-transformer matching is suitable up to vhf. Other techniques, such as coaxial or other transmission lines (to provide a 180° phase shift) are practical up to the microwave spectrum.

The output harmonic filters of amplifiers usually are designed for 50 ohms, which makes them easy to switch. One low-pass filter usually covers less than an octave, but the frequency can be varied within the filter response without tuning or switching in a new filter. Because the amateur bands are one octave apart (except for 10, 18, 21 and 24 MHz), a separate filter is required for each band. More on this later.

Amplifier Specifics

The components for the circuit of Fig. 1 are not available from a single source. Many are engineering samples that were obtained from various manufacturers. As stated earlier, this treatment is conceptual rather than practical.

This amplifier provides a power output of 1600-to 1800-W PEP or cw, inclusive of the 0.3- to 0.4-dB filter losses, depending on the operating frequency. A nominal 40 W of drive is needed for full output. The input line contains an attenuator (selectable for 1, 2, 3 or 6 dB) to make the amplifier compatible with various commercial exciters, and to comply with FCC regulations. Over 2 kW of output power is possible with the 16 Motorola MRF150 MOS field-effect transistors used, but the power supply is rated only for 2800 W — the limiting factor.

The main power supply, shown in Fig. 2 (60 V no load, 48 V full load), consists of two smaller supplies. Each operates one of the large power modules. A regulated supply would dissipate some 400 to 500 W in the regulating process and would greatly increase the total weight of the system. A switching-mode supply would be rather complex for this power level, and would require RFI shielding.

Why FETs?

Power FETs have these definite advantages over bipolar transistors in this application:

1) More tolerant to load mismatch.
2) Simplified circuit design and biasing.
3) Lower high-order IMD (comparable to vacuum tubes).
4) Easier to make broadband because of higher input Z.
5) Gain can be controlled by varying the bias voltage. This can be used for alc shut-down instead of PIN-diode switches in the rf input. Linear alc can be had for ssb, but excessive bias reduction will deteriorate the IMD.
6) Higher power gain. The increase at 30 MHz can be 3 to 6 dB.

Industrial interest in power FETs probably relates to item 3. High-order IMD (9th order and up) causes adjacent-channel "splattering." This would also happen with an over-driven or mistuned tube amplifier. Low-order IMD (3rd and 5th) can be as high as −20 dB, and the signal will sound good if the high-order products are absent. Thus, the FCC specification is for only −25 dB on the 3rd-order product, and −60 dB or more for the 9th-order product and above (Marine).

*Motorola Semiconductor Products, Inc., Phoenix, AZ 85062

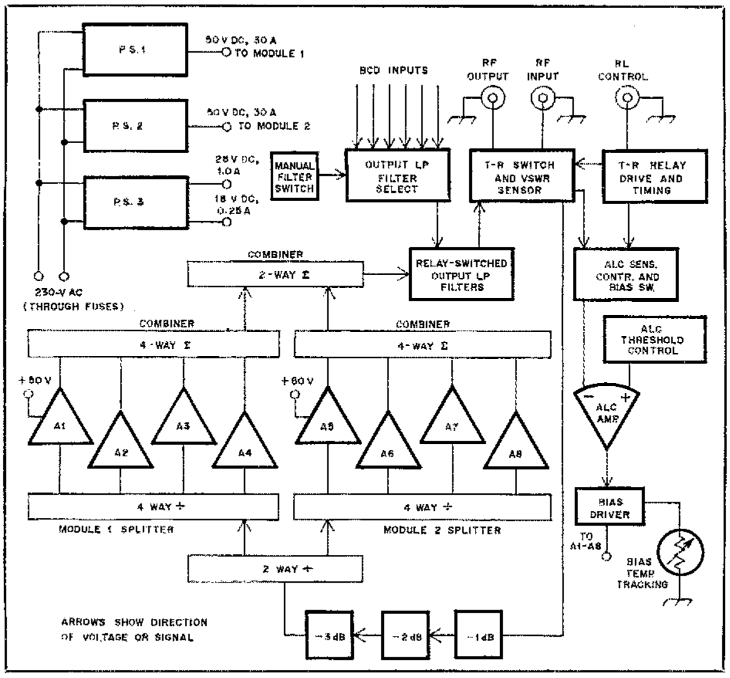


Fig. 1 — Block diagram of the 2-30 MHz power FET linear amplifier. A1-A8, inclusive, are individual FET amplifiers. See text for circuit description.

Bipolar transistors (depending on the type and internal structure) usually produce much more high-order IMD than is the case with FETs or tubes, unless the bipolar devices are biased to Class A and operated at reduced power.[1]

The power gain of a common-source FET amplifier can be varied 20 dB or more by adjusting the bias voltage. All present rf power FETs are enhancement-mode MOS types: If the gate and source are at the same potential, there is no current flow through the drain. The gate of an N-channel device must be positive with respect to the source in order to "turn on" the transistor. The gain-control range depends on the initial gate-threshold voltage (1 to 4 V typical) and the amplitude of the voltage swing at the gate. The transistor will be turned off completely and become an attenuator if reverse bias is applied.

In this amplifier, the bias is lowered only to near ground potential — a gain reduction of 8 to 10 dB. This can be sufficient in the event of a shorted or open load condition. Protective control voltage is obtained from a reflectometer at the amplifier output (Fig. 1). This amplifier also includes a self-contained linear alc system. Alc voltage is not fed back to the exciter as is done normally. The control range is limited to about 2 dB, beyond which it would degrade the IMD excessively. Bipolar-transistor amplifiers usually employ a variable voltage or current attenuator at the input port. PIN diodes are often used, but for linear alc an elaborate circuit is needed to prevent harmonics and distortion.

General Description

A block diagram of the total sytem (exclusive of the digital panel meters) is shown in Fig. 1. One meter reads 0-199.9 V and the other is for 0-199.9 mV. The latter one reads current and has 50-A and 50-mA shunts. The shunts (3) are shown in Fig. 2 as 0.001-ohm resistors. The shunts are used to read the individual currents of the rf modules, and one shunt is utilized to monitor the total current. The voltmeter monitors the nominal voltages of the main supplies, or about one half the voltage difference when switched to both supplies.[2,3] This metering system eliminates the need for heavy-duty wiring and prevents large currents from flowing through the switches.

There are two main rf modules (Fig. 1). Each contains four push-pull amplifiers. Combiners are used to produce a summed output of 1600 to 1800 W. Two pieces of Aavid Engineering heat-sink extrusion (no. 60140) support the amplifier boards, the combiners and other components of each module. Four copper heat spreaders (each 3/16 × 2 × 5-1/2 inches; mm = 25.4 × in.) are mounted individually on the flat surfaces of the heat sinks. The layout permits four MOSFETs (two boards) to be mounted on each of the heat spreaders. Copper is nearly twice as good as aluminum for heat conduction. Hence, it improves the instantaneous heat transfer by spreading the concentrated heat from the transistor flanges more efficiently along the aluminum heat sinks. The two heat sinks are supported by means of aluminum plates on each side. The plates also serve as mounting brackets for the whole structure. This technique provides a channel with the heat-sink fins inside. Two 5-inch fans (actuated by two 75° C thermostats — normally open) force air through the channel. The thermostats are attached to the heat sinks. During cw operation, the fans cycle about two minutes on and five minutes off.

Fig. 3 shows the component layout. Near the top is one of the power modules with four amplifier boards. The output combiner is shown at the center of the module. The lower part of the assembly contains the power supply. At the upper left are the two- and four-port splitters. The two-port main combiner is at the upper right.[4]

The transistor leads are pressed down (not soldered) against the pc boards and related contact areas. Teflon rings, then silicone-rubber rings, followed by aluminum rings, ensure firm contact when pressed in place by means of special standoffs. This method makes field service easier when replacing a transistor, since no soldering is required.

Filtering and T-R Circuit

The main combiner output is fed to a bank of low-pass filters. These are relay-switched for the desired band. The front-panel control switch operates when the BCD inputs to the filter-select circuit are open or high. When one or more of the BCD inputs are grounded, the manual switch is disabled and a light indicates the filter that has been selected by the code. This feature is useful for automatic band changing with transceivers that are designed for computer control.

Output from the filters goes to a T-R switch that consists of two Kilovac HC-1/530 vacuum relays. One is located at the amplifier input and the other is at the amplifier output. The relays are housed in separate shield enclosures (with BNC interconnect) to minimize unwanted crosstalk. T-R relay timing and drive signals must occur in a precise timing sequence to prevent "hot switching" in the amplifier output. Thus, the output relay must be energized first and released later than the input relay. For full QSK, the delays should be minimized. In this circuit the limit is about 8 ms, owing to the speed of the relays. Longer delays would hardly affect the QSK operation, but would shorten the marks for RTTY and cw, which would be apparent at high operating speeds. The control signal from the transceiver requires a key-to-ground

[1]Notes appear on page 16.

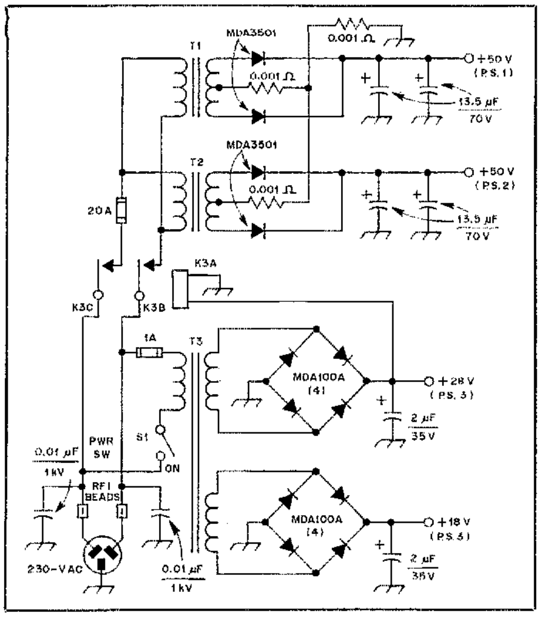


Fig. 2 — Schematic diagram of the FET amplifier power supply. Capacitors are disc ceramic, except those with polarity marked, which are electrolytic. Z1 and Z2 are ferrite beads for RFI suppression (Fair Rite no. 2673021801).

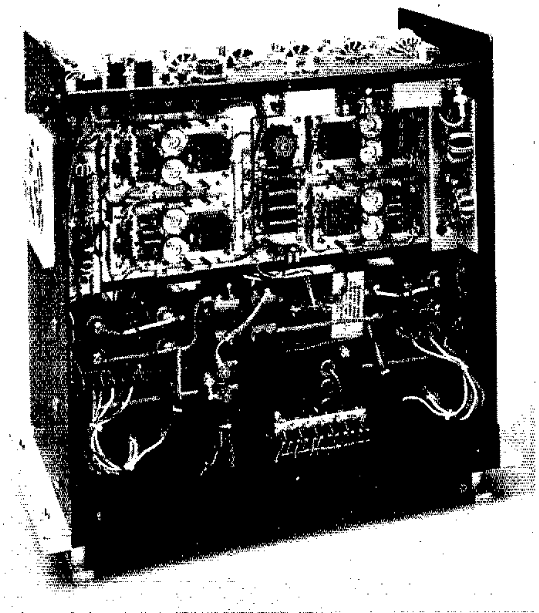


Fig. 3 — The inside of the solid-state amplifier. See text for discussion of module positioning.

polarity. The T-R, timing and drive-circuit module is visible at the upper right in Fig. 3 (just under the rear panel).

A reflectometer type of VSWR sensor is housed in the T-R circuit enclosure. Only the reflected power is measured. Output is routed to the circuit board that contains the alc, bias-temperature tracking and automatic filter-select circuits. Regulators for 12 and 24 V are also located on this board. Ferrite beads are used on the leads that enter this board. This prevents rf from getting into the alc amplifier and CMOS logic circuits.

The T-R output relay control voltage is routed also to the alc circuit. This turns off the transistor bias during standby, thereby preventing the 400-W standby dissipation (500 mA per transistor) of the 16 devices.

The bias-temperature tracking feature keeps the idling current constant with increasing heat-sink temperature. Normally, it would approximately double from 25° C to 75° C. This function is handled by a thermistor that is coupled to one of the heat sinks. Idle-current variation is 20% or less.

Circuit Details

Fig. 4 contains a schematic diagram of one of the push-pull amplifiers. The circuit is much simpler than one with bipolar transistors. The external resistor values

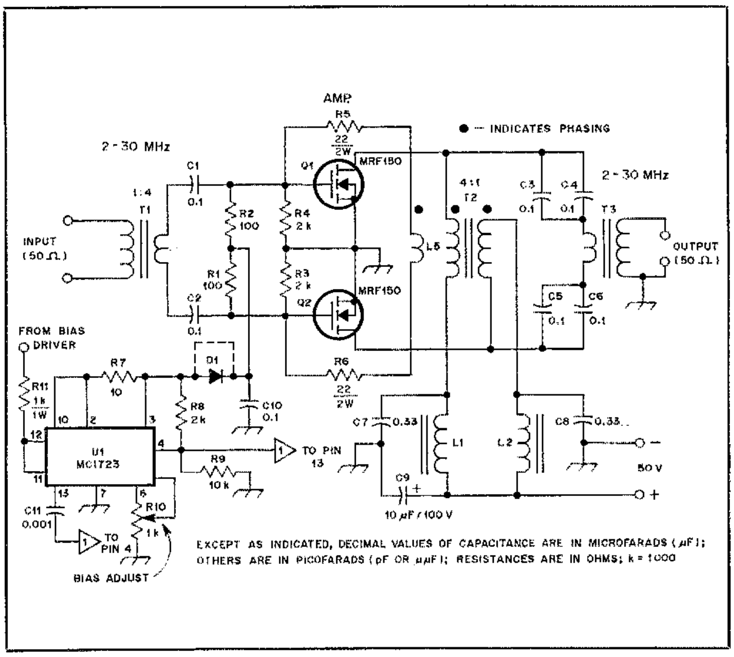


Fig. 4 — Schematic diagram of one of the power modules, inclusive of the bias regulator. C1, C2 and C10 are monolithic capacitors. C3-C8, inclusive, are ceramic chip capacitors. C9 is electrolytic and C11 is disc ceramic. Fixed-value resistors are carbon-composition, 1/2 W, unless noted otherwise. R10 is a Trimpot®. See text for discussion of the remaining components.

for the bias regulator permit regulation of the load but not the input voltage. The regulator serves three purposes: (1) Provides convenient bias adjustment (0.5 to 9 V) with R10; (2) provides a current sink for fast discharge of C10, for alc shutdown; (3) gives isolation between the bias circuits of each amplifer to the common-base driver. Hence, the adjustment of one amplifier does not affect the bias levels of the remaining amplifiers. D1 was used on the initial test board for protection of the regulator. It should be jumpered out for this application to prevent defeating the fast alc action. The regulator of Fig. 4 switches off in about 120 µs when the voltage from R11 drops from 24 to 2 or less. Considering all of the time constants and delays in the loop, the alc can still react in less than 0.5 ms.

The gates of Q1 and Q2 present an almost pure capacitance, respective to the sources, at 2-30 MHz. To ensure stability, the high input Q is lowered by means of R1, R2, C10 and negative feedback from T2. The source impedance and feedback are controlled by R5, R6 and L5. T2 is wound on a TV-antenna-balun style of core with a bifilar winding. L5 consists of one turn on the same core. The ferrite core should have a μ_e of at least 800 and a high Curie temperature for use down to 1.8 MHz. Teflon-insulated wire is recommended because T2 can reach temperatures in excess of 150° C. T1 and T2 are the common ferrite sleeve/metal tube style of transformers described in note 2. The transformation ratios are 4:1 and 1:4, respectively. A low-loss ferrite core (Stackpole C7/DB) is used for T3. It was chosen to prevent core overheating during extended periods of operation. It is available in a rectangular balun format (no. 55-7051) and has a larger cross-sectional area than the more common no. 57-3238 ferrite sleeves.

Most failures during initial testing occurred from overheating in the output blocking capacitors. Since they are ceramic chip capacitors, soldered rigidly to the pc board, cracks appeared in them. These capacitors must handle an average rf current of 4 to 5 A, but at relatively low voltage. Paralleled disc-ceramic capacitors were tried at C3-C6, inclusive. They worked fine, but were bulky for this board layout. They serve to dc-isolate T3 (unnecesary with this style of transformer) and to compensate for the frequency versus output-impedance slope of the transistors. Part 2 of this paper will appear in a subsequent issue of *QST*.

Notes

[1]"Power MOSFETs versus Bipolar Transistors," *AN-860*, Motorola Semiconductor Products, Inc.

[2]*The Radio Amateur's Handbook*, 59th edition (Newington: ARRL, 1982).

[3]*DC Power Supply Handbook* (Application Note 90A), Hewlett-Packard Co.

[4]"Broadband Transformers and Power Combining Techniques for RF," *AN-749*, Motorola Semiconductor Products, Inc.

SEASON'S GREETINGS FROM THE HAMS AT ARRL/IARU HQ.
(Listed in alphabetical order of call sign)

Joel Kleinman	N1BKE	Gerald L. Hall	K1TD
Richard "Bones" Palm	K1CE	Perry Williams	W1UED
Naoki Akiyama	N1CIX/JH1VRQ	George Collins	KC1V
Jeannie DeMaw	W1CKK	Arline Bender	WA1VMC
Laird Campbell	W1CUT	Bill Jennings	K1WJ
George Grammer	W1DF	Chuck Bender	W1WPR
Elizabeth H. Karpiej	KA1DTU	Bob Halprin	K1XA
Joan Merritt	KA1DTV	John Lindholm	W1XX
Maureen Thompson	KA1DYZ	Sandy Gerli	AC1Y
Stephen C. Place	WB1EYI	Steve Pink	KF1Y
Paul K. Pagel	N1FB	Ellen White	W1YL/4
Doug DeMaw	W1FB	David Sumner	K1ZZ
Hal Steinman	K1FHN	Edward C. Raso	WA2FTC
Marian Anderson	WB1FSB	Carol L. Smith	AJ2I
Marge Tenney	WB1FSN	Leo D. Kluger	WB2TRN
John Nelson	W1GNC	Mark J. Wilson	AA2Z
Bill Webb	WB1GOO	Christopher Imlay	N3AKD
Bob Atkins	KA1GT	Donald B. Search	W3AZD
Ed Tilton	W1HDQ	W. Dale Clift	WA3NLO
Steffie Nelson	KA1IFB	Larry Wolfgang	WA3VIL
Joan Becker	KA1IFO	William A. Tynan	W3XO
Jean Peacor	K1IJV	Steve Ewald	WA4CMS
Cheryl Sowers-Clift	KA1IXI	Gerry Hull	AK4L/VE1CER
Andrew Tripp	KA1JGG	Paul Rinaldo	W4RI
Brian Downey	WA1KSF	John Troster	W6ISQ
Dennis Lusis	W1LJ	Wayne Yoshida	KA6KGU
Stan Horzepa	WA1LOU	Chuck Chadwick	K8AXL/WB8MOB
Phil Accardi	AJ1N	Chuck Hutchinson	K8CH
Peter R. O'Dell	KB1N	Jim Clary	WB9IHH
Sally H. O'Dell	KB1O	Bernard D. Glassmeyer	W9KDR
Mike Kaczynski	W1OD	B. Robert Benson	VE2VW
Bruce Kampe	WA1POI	Harry MacLean	VE3GRO
George Woodward	W1RN	Maxim Memorial Station	W1AW
Richard L. Baldwin	W1RU	ARRL Hq. Station	W1INF
Lee Aurick	W1SE		

Strays

LISTEN UP

☐ According to Florida law, "No person shall operate a motor vehicle while wearing a headset, headphone, or other listening device, other than a hearing aid. . ." I gather this would include the single earpieces used by some hams to copy above road noise level. Some Florida hams are using this method, and I wonder if they know about the law. [Editor's Note: This law is not unique to Florida. Massachusetts, for example, has a similar law. It's a good idea to check it out with your state's Motor Vehicle Department.] — *Otto Freytag, K4QFM, Riviera Beach, Florida*

I would like to get in touch with . . .

☐ any New York amateurs who are interested in starting a Big Apple Novice net. Tony Sparacio, KA2HJP, 2 Stuyvesant Oval, New York, NY 10009.

☐ hams who would like to form a national net for lovers of cw QRS for the purpose of formal and/or informal traffic and ragchewing at a speed not to exceed 16 wpm. Gerald Smith, KL7FX/4, P.O. Box 7592, Fort Gordon, GA 30905.

Next Month in QST

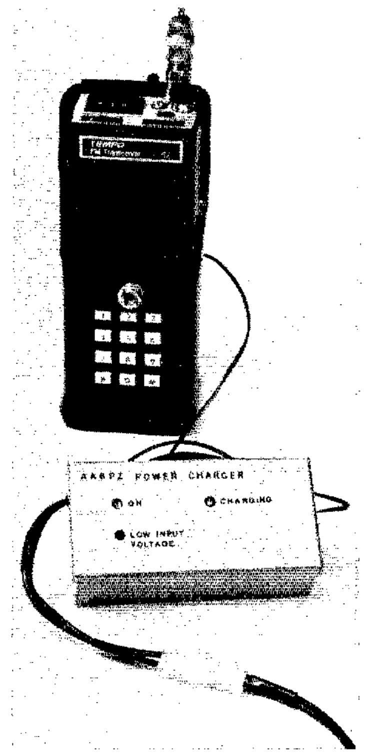
To begin the new year, which promises to be another exciting one for Amateur Radio, we'll bring you something old and something new, in the form of

- two well-respected antenna systems, and why they're just as useful in the 1980s as they were in years gone by.
- a spanking new vhf-uhf awards program based on grid squares. Who'll be first to qualify for VUCC?

Build the AA6PZ Power Charger

How many NiCd packs have you "fried" by leaving them on a fast charger too long? This rapid charger will take the nuisance out of NiCds.

By Paul Zander,* AA6PZ



It was only a few hours after I purchased my TR-2400 transceiver when I discovered that the life of the NiCd batteries was limited. The batteries always seemed to "go dead" in the middle of a QSO. This prompted me to undertake a research program. Here is what I found.

When your batteries go dead, you have three choices. The first is to accept your fate and QRT while the batteries charge. Your second choice is to substitute another charged battery, which requires opening the transceiver and reprogramming the memory after the new battery is in place. The remaining alternative is to connect the transceiver to an external power source. This is the direction I chose in developing a power-charger circuit that can operate the transceiver and charge the batteries at the same time.

Voltage and Current of NiCd Batteries

Let us consider the voltage and current characteristics of NiCd batteries. The battery pack used in a typical hand-held transceiver consists of several cells connected in series to give the desired voltage. Usually there are 8 cells, but some rigs use 7, 9 or even 10. For simplicity, the rest of this article assumes that the battery has 8 cells. If your rig requires a different quantity of cells, remember to scale the voltages to the correct number. Table 1 lists the number of cells in several transceivers.

The battery voltage is determined primarily by the state of charge, and by any current that may be charging or discharging the battery. A battery at rest (neither being charged nor discharged) will produce approximately 9.6 volts (1.2 volts per cell). When the battery is fully charged, the voltage is near 11 volts, and when the battery is discharged, it falls to 8 volts (Fig. 1).

When current is being drawn from the battery the voltage drops slightly, as shown by the bottom line in Fig. 1. When the current stops, the voltage recovers to the resting value over a period of several seconds. This explains why the receiver works well enough to hear, "Negative copy on your last transmission. Better check your batteries."

When the battery is being charged, the voltage is higher than if the battery were just resting, as shown by the top line in Fig. 1. This implies that a battery charger must be capable of supplying a voltage greater than the battery voltage if charging current is to flow.

This fluctuation in voltage (with current) points out a problem with chargers that supply current pulses or unfiltered ac to the battery. Charger-current ripple can cause ripple on the battery voltage. The voltage ripple may, in turn, affect the transmitted signal.

Table 1
Batteries Used in Popular Transceivers

Model	Number of Cells	Diode
Kenwood TR-2400	8	No
Tempo S1	8	Yes
Yaesu FT-207R	9	Yes
Santec	8	

So much for the battery voltage. How much current can the battery deliver and how fast can it be charged? The batteries in most hand-held transceivers are AA cells rated at 450 milliamp-hours (mAh). This figure is the battery capacity; it means that a fully charged battery can delivery 450 mA for one hour before it will be discharged. A transmitter that draws 500 mA will discharge the battery in less than one hour of continuous transmission.

Some manufacturers inflate their ratings slightly by stating that the same cell can deliver 50 mA for 10 hours, thus rating the cell at 500 mAh. The significant point here is not so much the creative specification, but the fact that NiCd batteries can be discharged at high rates of current with only a small sacrifice in total efficiency. This property of NiCds overwhelms all of their disadvantages, making them a popular choice for use in portable transceivers.

A typical transceiver draws 500 mA or more from the battery during transmit. The same battery can also be charged at similar rates, provided it is not overcharged. When a battery is fully charged the incoming electrical energy can no longer be converted to chemical energy. Instead, the energy is converted to internal heat and pressure. Most NiCds are

*86 Pine La., Los Altos, CA 94022

designed to handle overcharging at rates no greater than one tenth the capacity, or 45 mA. Higher rates of overcharging lead to venting of gases and a permanent reduction in battery capacity.

The problem is to determine when the battery is almost charged, and then reduce the current to a safe level for "topping off" the battery. A low-current topping charge is desirable to allow each cell to be fully charged, despite variations between individual cells.

Constant-Current Charging

Now that we better understand the NiCd battery, how can it be charged? Even more importantly, can it be charged while the transceiver is being used? The simplest device is the trickle charger, which contains a circuit that provides a steady 45-mA current at any battery voltage. This is shown by curve A in Fig. 2. A practical circuit may have some finite voltage limit, but as long as it is at least 1.5 volts per cell, the battery can be fully charged. There are two problems with the trickle charger. First, it takes 12 to 16 hours to deliver a full charge. Second, a transceiver draws between 20 and 100 mA on receive, and much more during transmit. With a trickle charger supplying 45 mA there is no current left to charge the battery. In fact, you are still discharging the battery while you are operating.

Constant-Voltage Charging

A different approach is to use a constant voltage source with adequate current available to power the transmitter. Curve B of Fig. 2 shows the output characteristics of a constant-voltage source. The problem here is determining the correct voltage, as the battery voltage varies slightly with internal construction and temperature. If the charger voltage is too high the battery can be damaged by being overcharged. If the charger voltage is reduced to, say, 10 or 11 V, the battery can only be partially charged. As a result, the constant-voltage circuit is more properly used as a power supply.

The Power Charger

After considering the constant-voltage and the constant-current chargers, we can see that it would be desirable to combine the best features of each. The Power Charger that I have designed does just that. As shown in Fig. 3, when the battery voltage is low, the current available from the charger is high enough to keep the transmitter on the air. As the battery voltage increases, the charging current decreases in order to avoid overcharging the battery. Finally, as the battery approaches full charge the current tapers off more slowly with increasing voltage. This action provides a topping-off charge with some latitude for variations in battery voltage.

Sounds good, but does it work? It sure does! Fig. 4 shows what happens when a discharged battery is connected to the Power Charger. The initial current is high, charging the battery to 25 to 30% of its capacity in the first hour. The current drops off as the battery is charged. After approximately 6 hours the battery is fully charged. Then, as continued charging pushes the battery voltage higher, the current decreases to a few milliamperes. If you forget to disconnect the Power Charger after the battery is charged, the final charge rate is actually less stressful to the battery than if you were using a constant-current trickle charger.

What happens if you operate with the Power Charger connected? When the transmitter draws current from the battery the battery voltage drops, and more current is available from the power charger. When the battery is less than three quarters charged the charger supplies most, if not all, of the transmitter current.

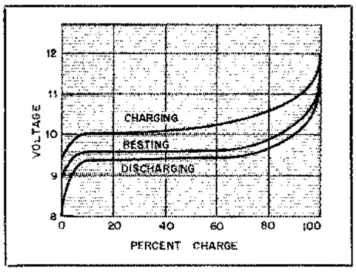


Fig. 1 — Voltage of a NiCd battery as a function of the state of charge.

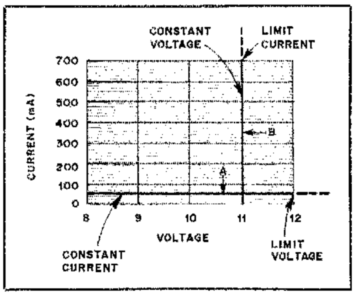


Fig. 2 — Output characteristics of a constant-current (curve A) and a constant-voltage (curve B) charger.

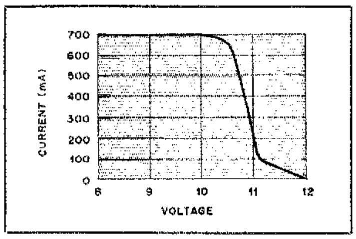


Fig. 3 — Output characteristics of the Power Charger circuit.

Rapid-charging capability, by itself, is of limited utility if the charger must be plugged into a wall outlet. The Power Charger can be operated with a wide variety of sources that supply from 12 to 30 volts. For mobile operation the car battery can supply the power from the cigarette lighter. For extended portable or emergency operation, storage batteries may be useful. For fixed-station use, a simple ac operated supply can be used.

Circuit Description

A simplified schematic of the Power Charger is shown in Fig. 5. A full schematic is shown in Fig. 6. A pnp series-pass transistor, Q1 is used to control the charging current, and a 1-Ω resistor (R1) is used to monitor that current. When Q1 has enough base drive it will have 0.2 V or less between collector and emitter. This, combined with the voltage drop across R1, allows this circuit to have a minimal difference between the input and output voltages. Although it might be possible to use an IC voltage regulator in place of Q1 and some of the other parts, most IC regulators have a minimum of 2 or 3 V between the input and output. This makes them unsuited for mobile and portable operation where there is not much voltage to spare.

Q2 and Q3 control the base drive to Q1. Q3 receives input from Q4 if the charging current is too high — and from Q5 if the output voltage is too high. In response to either of these inputs Q3 reduces the Q2 base current. This, in turn, reduces the base drive to Q1 so that the proper output voltage and current are maintained.

Q4 and the associated components monitor the output current. The base-emitter junction of Q4 is connected across R1. When the current is more than 700 mA, Q4 is turned on. This sends a signal through the other transistors to reduce the base drive to Q1 so the current cannot go higher. In practice, this much current will only be drawn by the transceiver if you are transmitting while the battery is discharged. If the 700-mA current limit is not high enough for your transmitter it can be increased by connecting R5 between the emitter and base of Q4. The formula

$$R5 = \frac{70}{(R1 \times I_{max} - 0.7)} \qquad \text{(Eq. 1)}$$

can be used to determine the correct value. For example, a 680-Ω resistor would increase the current limit to 800 mA.

During most of the charging cycle Q5 and the 4.7-V Zener diode act as a voltage-sensing circuit. The combination of Q1, Q2, Q3 and Q5 regulate the collector voltage of Q1 at 11.2 V. There is, however, a resistor (R1) between that point and the battery. When the output

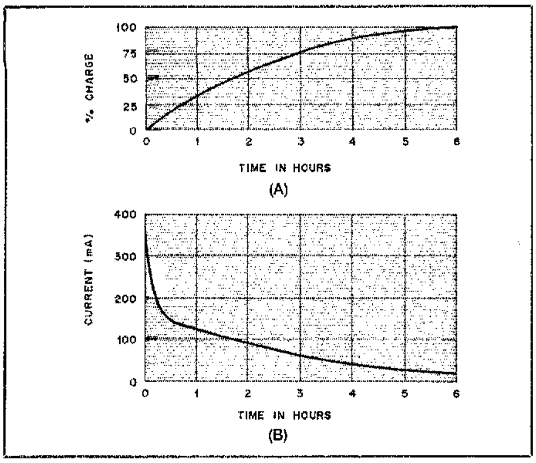


Fig. 4 — Typical charging performance of the Power Charger. Shown at A is the percentage of full charge obtained as a function of charging time. The charging current, as a function of time, is shown at B.

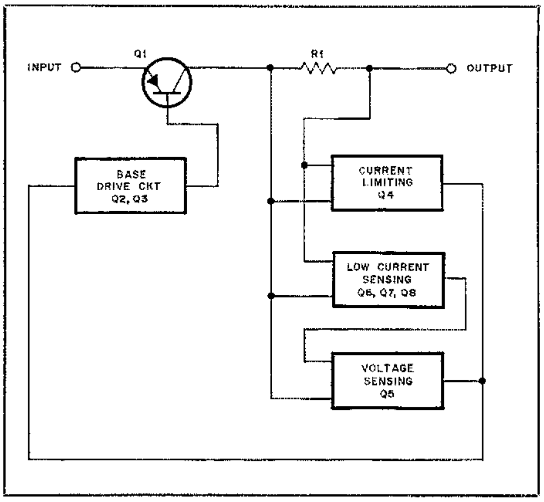


Fig. 5 — Block diagram of the Power Charger.

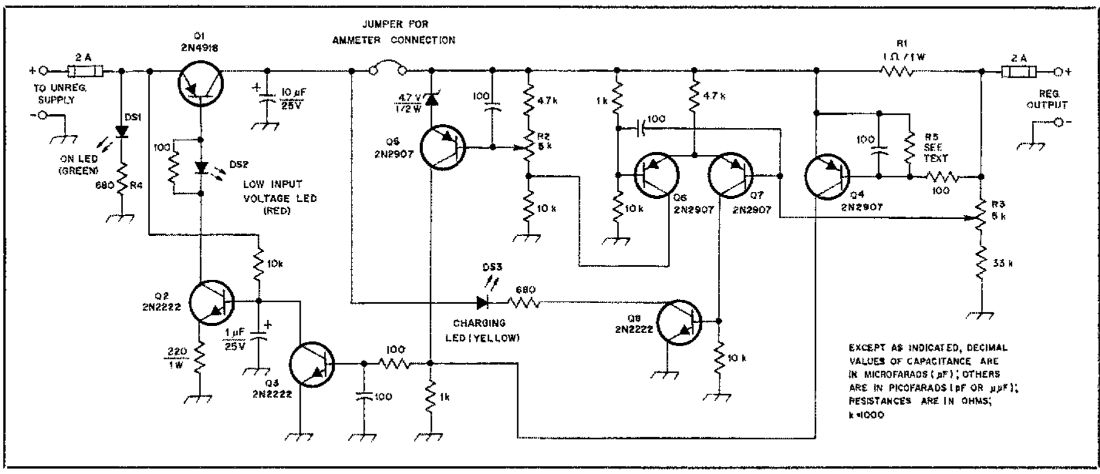


Fig. 6 — Schematic diagram of the Power Charger. Except as indicated all resistors are 1/4-W, 5% carbon types. Capacitors are disc ceramic units rated at 50 V or greater. Polarized capacitors are 25-V electrolytic types.

current is 500 mA there is 0.5 V across R1, so the output is only 10.7 volts. At 200 mA, the drop across R1 is 0.2 volt and the output is 11.0 volts. Viewed from the battery terminals, as the voltage increases the charging current decreases.

As we have just seen, R1 determines the slope of the voltage-current relation shown in Fig. 3. A value of 1 Ω works well with NiCd batteries having a capacity of 450 mAh. For batteries having a smaller capacity, the value of R1 should be increased. For example, when one is charging 250-mAh batteries, R1 should be 1.8 Ω. Using a 330-Ω resistor for R5 would give a maximum current of 500 mA.

The remainder of the circuit is used to provide the topping-off part of the charging cycle. Q6 and Q7 form an amplifier that senses the voltage drop caused by charging current flowing through R1. When the current approaches 100 mA, Q7 starts to turn off and Q6 begins to turn on. The collector output of Q6 is connected to the base circuit of Q5. This causes the charger voltage to rise slightly. The output voltage is allowed to increase more as the current drops further. Eventually, a point of equilibrium is reached at which the current is only a few milliamperes. This current is unable to push the battery voltage higher. With this method, the battery can be fully charged safely and quickly.

As the output voltage increases at the end of the charging cycle, the base drive to Q8 is reduced. This causes the CHARGING LED to dim and eventually go out when charging is complete.

If the input voltage is too low the LOW-VOLTAGE LED turns on to signal that you will be unable to fully charge the battery. This is most likely to occur when using an external storage battery to supply the Power Charger. A similar situation can occur when using the Power Charger with the Kenwood TR-2400 and other rigs that do not have an internal diode in series with the battery. If the power-charger input is accidentally disconnected, Q1 might conduct some current in the reverse direction. The LOW VOLTAGE LED will light as a warning. If, under these circumstances, the input terminals should be accidentally short-circuited, Q2 and Q1 turn off as a safety measure to avoid damaging the radio. The residual current drain on the

NiCd battery will be only a few milliamperes.

The last items in the schematic diagram are the input and output fuses. As we have just seen, the power-charger circuit has current limiting, so perhaps the fuses are not necessary. However, consider that a fully charged NiCd battery can delivery many amperes to a short circuit, and that an automobile battery is designed to deliver peak currents of 200 A or more. In this environment a couple of 20-cent fuses seem like a good idea to prevent unwanted fireworks!

Construction

In designing the Power Charger circuit, consideration was given to using parts that are readily available. The only critical part is Q1, which should be a 2N4918. The fuse clips are Littlefuse no. 102071 or a similar part by another manufacturer. Alternatively, fuses with wire leads can be soldered directly to the board.

All of the components can be mounted on a 1.9- × 3.9-inch etched circuit board.[2] This size fits comfortably inside a 2 × 4 × 1-inch aluminum box. A parts-placement diagram is shown in Fig. 8. Fig. 9 contains front-panel drilling template. Q1 is mounted with an insulating washer between it and the box. The mounting provides heat sinking for Q1 and mechanical support for one end of the circuit board. The other end of the board is supported by a no. 4-40 machine screw and three nuts. The first nut holds the screw securely to the box. The remaining nuts go above and below the board to hold it level in the box. The head of the same screw can be used to mount a rubber foot on the outside of the box.

Probably the only construction difficulty you will encounter is determining the proper charging connector for your transceiver. The Yaesu FT-207R has a subminiature phone plug; the Tempo S-1 contains a miniature phone plug. The Kenwood TR-2400 and the ICOM IC 2A have the same coaxial power plug, but the plus and minus connections are reversed.[3] Then there are several transceivers that are intended for use with a drop-in charger. A mating connector can be made from pieces of plastic and screws for the contacts. The challenge with the drop-in connector is to maintain contact when you transmit. Otherwise, the Power Charger cannot supply power directly to the transmitter, but can only recharge the battery when you set the transceiver back in the charger.

Another concern arises when you try to use one Power Charger with two transceivers. If the transceivers have a different number of cells in their battery packs, then the charging voltage must be different for each transceiver. It might be possible to build the Power Charger for the transceiver with the greater number of cells, and use an adapter containing two series silicon diodes for the other transceiver. The pair of diodes has a drop of approximately 1.4 V, which is similar to that of one charged NiCd cell. A compromise adjustment of the output voltage would then allow use of the Power Charger with either transceiver.

Adjustment

There are two variable resistors to adjust for proper operation of the Power Charger. Make sure that the input voltage is high enough that the LOW INPUT VOLTAGE LED remains off while these adjustments are being performed. The initial adjustment procedure is based on voltage measurements. The final adjustment procedure measures the specific charging current.

For the initial adjustment, turn R2 fully counterclockwise and R3 fully clockwise. Connect the Power Charger input to a convenient dc supply and the output to a dc voltmeter. Both the ON LED and the CHARGING LED should be lit. Adjust R2 for 11.2 volts (1.4 volts per cell). If your transceiver is the FT-207, a Tempo, or other model with an internal diode, increase the voltage by 0.7 volt to compensate for the voltage drop in the diode. If you are unsure about the accuracy of your voltmeter it is advisable to adjust R2 for a voltage reading that is a little on the low side. Next, slowly turn R3 counterclockwise. The CHARGING LED should become dim and go out. Adjust R3 to the point where the CHARGING LED is so dim you can barely see it. Then turn R3 a quarter turn counterclockwise. The output should increase by about 1 volt as R3 is adjusted.

The final adjustment takes care of small errors in setting the voltage, and adjusts the Power Charger to compensate for a diode or other components that may be between the transceiver charging connector and the battery.

Fully charge the battery with a trickle charger, then remove it from the charger for at least a half hour, but for not more than a day. This will allow the battery to recover from being charged.

Next, connect a milliammeter in place of the circuit board jumper between the CHARGING LED and R1. This is the best place to measure the charging current accurately. If, instead, the meter were connected directly to the output of the Power Charger, it is likely that the voltage drop caused by the internal resistance of the meter would adversely affect the adjustment. A meter connected in place of the jumper will measure the current drawn by Q5, Q6, Q7 and the associated parts. This current, which is about 10 mA, can be measured when the Power Charger output is disconnected. When the battery is connected the true charging current can be found by subtracting the transistor cur-

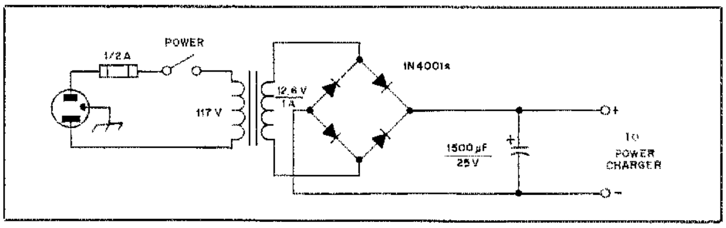


Fig. 7 — A simple ac adapter, such as the one shown here, can be used to power the charger for fixed-station use.

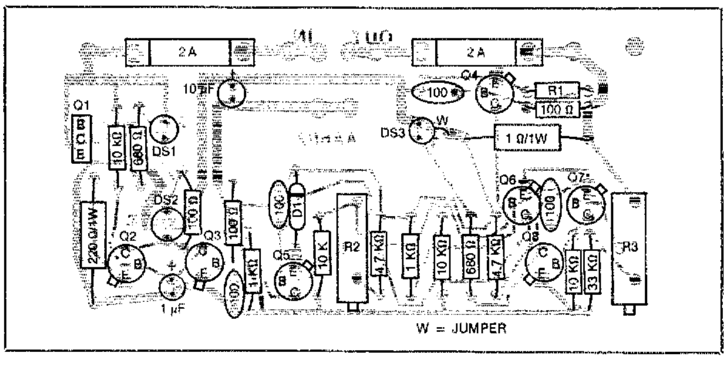
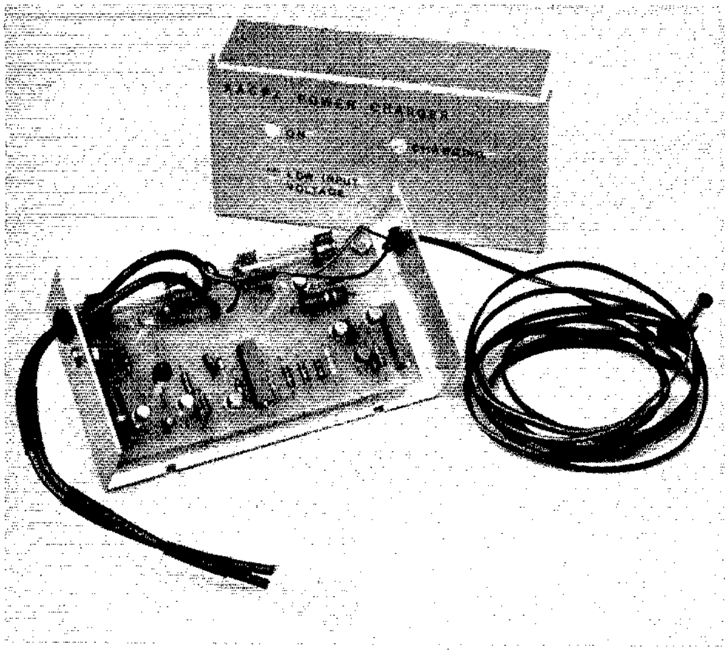


Fig. 8 — Parts-placement guide for the Power Charger. This view is from the component side of the board. Gray areas represent an X-ray view of the unetched foil. The etching pattern appears on p. 51.

[1]Notes appear on page 21.



Interior view of the Power Charger. The three LEDs are mounted on long leads so that they protrude through the top cover.

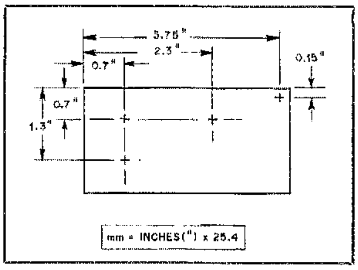


Fig. 9 — If the circuit-board pattern shown in Fig. 8 is followed this drilling template can be used to locate the mounting hole and holes for the LED indicators.

rent from the meter reading.

It may be tempting to measure the Power Charger input current instead, but an ammeter connected at the input would read the current drawn by the ON LED, the CHARGING LED and the base of Q1. This current could be from 20 to 100 mA, thus making an accurate determination of the charging current impossible.

Now, with the ammeter connected and the Power Charger turned on, it is time for the big moment. Connect the transceiver containing the charged NiCd battery to the Power Charger. The initial current surge may be 100 mA or more, but the current should fall quickly to less than 45 mA, which is the trickle-charge rate. Adjust R2 for a charging current between 20 and 30 mA. Adjust R3 until the CHARGING LED is so dim you can barely see it. Some interaction between these adjustments is normal, so you will probably have to repeat them several times until the current and the brightness of the CHARGING LED are correct. Since continued charging will cause the current to decrease slowly with time, the adjustments should be completed within a minute or two of connecting the battery. If this can't be done disconnect the transceiver for a few minutes to allow the battery to recover, then try again. If you plan to use your Power Charger with more than one battery, a compromise adjustment of R2 may be necessary to compensate for construction differences in the batteries.

If you encounter difficulty with this adjustment it is possible that you have a bad component or a wiring error. Power resistors in values from 10 to 200 Ω may be used as loads to verify that your Power Charger has an output similar to that shown in Fig. 3.

If you have an FT-207, it may be desirable to reduce the voltage slightly. It may take a little longer to charge the battery. However, you can avoid the problem of not having the transceiver work properly because of high battery voltage attributable to having left it on the charger too long.

Operation

Operation of the Power Charger is simple. Connect it to a convenient power source between 12- and 30-V dc. If the polarity is correct, the ON LED will light. If the voltage is high enough, the LOW INPUT VOLTAGE LED will be off. Connect the transceiver and the CHARGING LED will come on. When charging is complete the CHARGING LED will go out. Disconnect the Power Charger first from the transceiver and then from the power source. Fig. 7 shows a suggested supply if you don't have a suitable ac power supply. It has some ac ripple, but that is no problem since the charger acts as an electronic voltage regulator.

If a supply of 20 V or more is used to power the charger, an external 10- or 20-Ω power resistor should be used to reduce the power dissipation in Q1. The value of R4 should also be increased to keep the current through the ON LED below 20 mA.

The Power Charger can be used to charge the battery or to maintain the charge in the battery while the transceiver is being used. It is recommended that the latter mode of operation not be used on an exclusive basis, however. If the NiCd batteries are not allowed to cycle occasionally between a fully discharged and fully charged condition, they will suffer a temporary reduction in capacity. Although it is not necessary, a good procedure is to let the battery run down before connecting the Power Charger. This will maintain maximum battery capacity.

The last consideration is temperature. NiCd batteries are not designed for wide temperature extremes. With the exception of some special cells, most NiCds vent if they are allowed to exceed 45° C (113° F). Especially avoid leaving them in a closed car on a sunny day. Also, at low temperatures the chemical activity in the battery slows down. NiCds can be used below freezing, but the capacity is reduced. For these reasons, charging of any type should be minimized when the battery is very warm or very cold.

Conclusions

The Power Charger reduces the low battery indication on the transceiver from a crisis to a minor inconvenience. I have not used the trickle charger with my TR-2400 since getting the prototype of the Power Charger working many months ago. The trickle charger is now resting in the junk box between some Novice crystals and spare vacuum tubes.

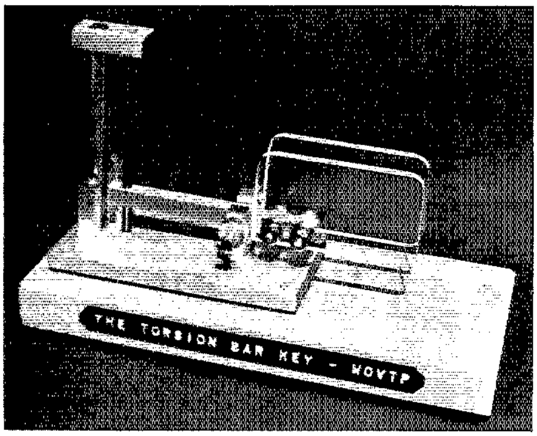
Notes

[1]Etched, drilled and soldered-plated circuit boards for this project are available from the author for $12 and an s.a.s.e. with postage for 2 ounces. The ARRL and *QST* in no way warrant this offer.
[2]mm = inches × 25.4.
[3]The standard ICOM battery pack has an internal series resistor that must be removed for fast charging.

Reference

Nickel Cadmium Battery Application Engineering Handbook, no. GET-3148A, General Electric Co., Gainesville, FL 32602.

The Torsion Bar Key



Build this paddle and add a twist to your cw operating.

By Thomas P. Leary,* WØVTP

A number of articles have appeared in *QST* and elsewhere describing mechanical devices required to operate electronic keyers. After studying these and the many complex schemes employed in commercial paddles, I realized that a simpler recipe for such a key was possible.

To avoid complexity, I decided to construct a paddle that could be fabricated almost entirely with homemade parts. The torsion-bar key described here uses relatively few components, most of which can be built at home in a modestly equipped shop.

The torsion bar concept is a simple one to demonstrate. When a tree branch is twisted and released, it flexes, then returns to its natural position. In this design, the torsion bar functions as the lever-return spring. When the lever arm is moved, the bar twists, offering tension. When the paddle is released, the tension forces the lever back to center (neutral) position.

Construction

Aside from the parts shown in Fig. 1, you will need the following no. 4-40 plated flat-head screws: three 1/4-inch, five 1/2-inch, two 3/4-inch and two 1-inch.[1] In addition, two no. 8-32 1/4-inch and two no. 4-40 1/4-inch steel set screws are needed. You will also need some small wood screws to secure the brass base to the wooden one.

This key can be made with hand tools, but an electric drill or drill press is recommended. If both tools are available, the drill press is the better choice. The brass and steel parts may be found as scrap in some machine shops. Plan on obtaining plenty of extra pieces in case you "goof."

Make sure to mark all pieces carefully and center punch the holes before drilling. Drill the two holes in the top support fixture and the base simultaneously by clamping or gluing them together to ensure proper alignment. The knurled finger nuts, used to tighten the contact screws, may be difficult to locate; mine were found in a box of surplus parts.

Rigid support for the torsion bar is provided by the thicker vertical rod (1/4-inch-diameter steel or brass). This rod is attached to the base and to the rectangular fixture with set screws. The torsion bar (1/8-inch round steel drill rod) is mounted parallel to the support rod and is attached to the rectangular fixture. A simple sleeve bearing (a hole in the brass base) allows the torsion bar to rotate at the bottom, while the rectangular fixture holds the top of the bar firmly.

The lever arm is fabricated from 1/4-inch brass, and is attached to the flat on the torsion bar. This arm is operated by the paddles; pushing it either way "makes" the corresponding contact. The outside surfaces of the paddles should be separated by about 3/4-inch. Thin washers on each side of the lever serve as spacers. The wooden base measures 6-3/8 × 3 × 5/8 inches. The brass base is centered on the wood, and moved 1/4-inch forward. Small wood screws are used to attach the brass base to the wood. Thin rubber feet can be attached to the bottom of the wood to prevent it from sliding on the operating table.

The lever arm is grounded, and is connected to one of the binding posts. The contact points are connected to the other two binding posts by means of thin brass shim strips underneath the base.

I used 10-mil Teflon sheet to insulate the two contact points and their corresponding binding posts from the base. Hold the Teflon sheet over the holes in the base, and punch through it with a sharp pencil; this expands the material into the holes and prevents the 4-40 screws from shorting to the base. If Teflon sheet is not available, any thin insulator (such as a rubber gasket) will do.

Tighten the no. 4-40 set screw in the top fixture last, making sure that the lever is centered between the contact posts. Adjust the contact gap by turning the 3/4-inch no. 4-40 screws and lock them with the knurled finger nuts. The final adjustment is lever tension. With the untreated drill rod, the action is medium. Tension may be increased by lowering the rectangular fixture toward the base. For a lighter touch, the torsion bar can be made of a piece of 1/8-inch brass or brazing rod.

Garnet (not sand) paper will give the brass parts a "brushed" finish. In the old days, hams made almost everything they used in their shacks. Be an old-time ham and become a keymaker!

[1] mm = inches × 25.4.

*218 South 95th St., Omaha, NE 68114.

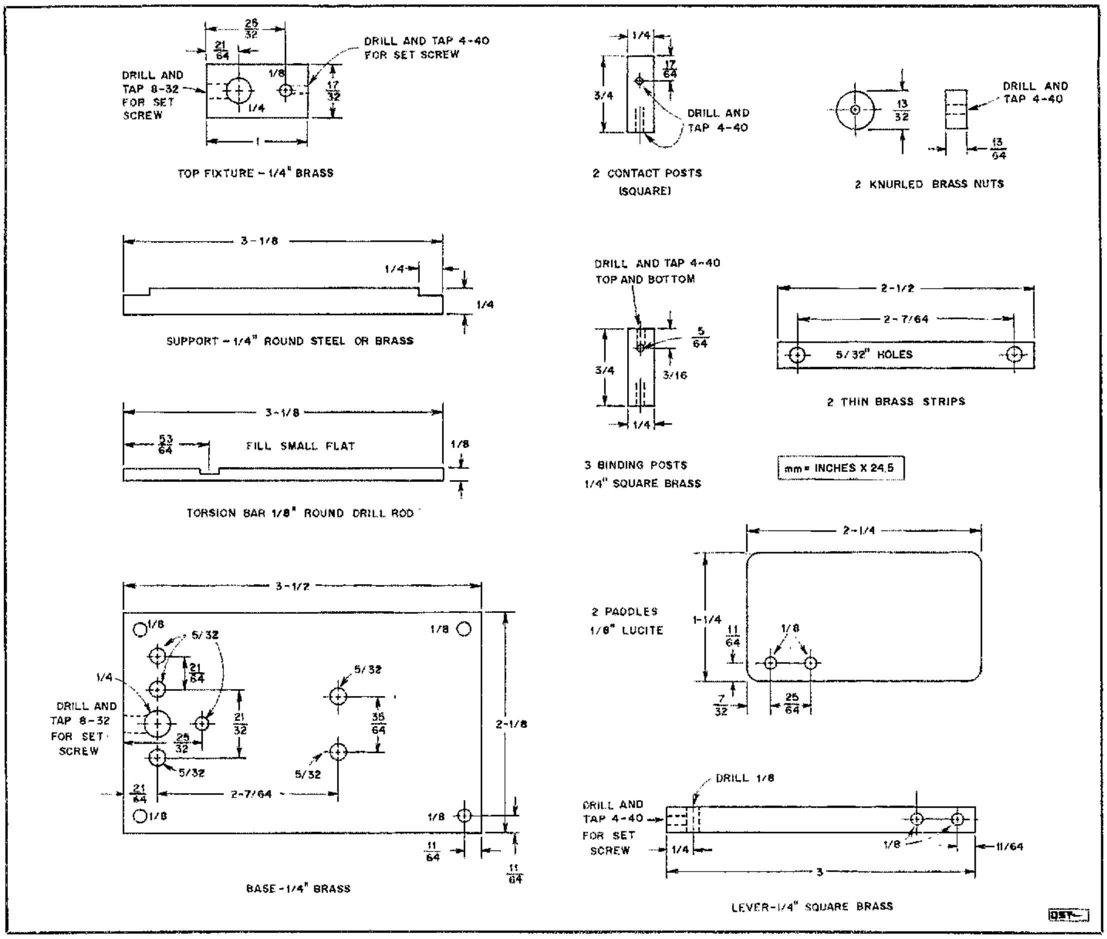


Fig. 1 — Parts for the Torsion Bar Key. Dimensions given are in inches (mm = inches × 25.4).

Strays

TIS DO'S AND DON'TS

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For us to respond promptly to your inquiries we must have:

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(2) your amateur call and license class (tell us if you're not licensed)

(3) your membership expiration date

(4) a stamped, *business-size* envelope bearing your mailing address for our reply (IRCs acceptable from outside the U.S.).

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2) Please do not ask for comparisons among commercial products. Choice of equipment is largely a matter of personal preference. Consult Product Review information in *QST;* compare manufacturers' specifications in their brochures.

Do not ask for information on articles published in other magazines. Write to the editor or author of that article.

Do not request custom designs for amateur gear.

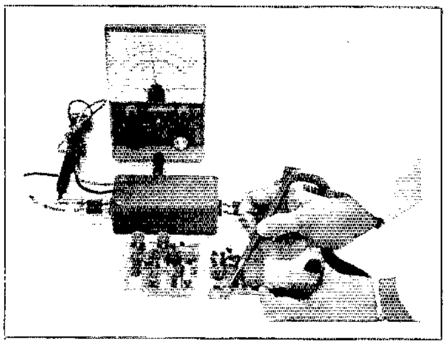
Do not ask advice on nonamateur matters. We cannot respond to questions about CB, marine radio, hi-fi, etc. (unless they concern interference caused by amateur gear).

3) Use a typewriter when possible; otherwise, write or print *clearly.* Please be reasonable in the number of questions you ask; try to limit your questions to three per letter.

4) When writing, please come right to the point, and be sure to share with us whatever experience you have had with the problem in question. This will avoid our reply covering ground you've already been over.

5) Address all technical questions to: Technical Information Service, American Radio Relay League, 225 Main St., Newington, CT 06111.

Semiconductor Testing — in or out of the Circuit



Take a tip from the manufacturers of digital multimeters that offer in-circuit semiconductor testing, and build a pn junction tester. A battery, a resistor and your trusty old VTVM are all you need!

By Clifford J. Appel,* WB6AWM/7

Can a semiconductor be tested easily with an analog ohmmeter? Yes! The technique has been pointed out in *QST* many times. A fine discussion of the method appears in the December 1981 issue.[1] I have used it for years and it works, for sure.

Measuring the resistance in the forward direction and the reverse direction through a semiconductor certainly makes sense, doesn't it? In the forward direction we would expect to see a low resistance. Simple, no?

Yes, if the semiconductor is all by itself. If the semiconductor is on a printed-circuit board, with the components connected to the semiconductor in the intended circuitry, the resistance-measuring technique may be confusing. The reason for the confusion is that the ohmmeter is not only reading across the semiconductor, but also across all circuit components in parallel with the semiconductor. These parallel components can make the "low" resistance in the forward direction look like a short, or at least lower than the resistance we expected. Likewise, the very high resistance in the reverse direction might not be what we thought it should be, although it still may not look low or look like a short. When confronted with this confusing circumstance, there's only one way to put one's mind at rest. Break out the soldering iron, pull the semiconductor off the circuit board, and check it again!

That would be fine if we had only one semiconductor to test. But what if we had to test every semiconductor on the circuit board? Now we are facing a real chore, and what at first seemed like fun has quickly turned into a nightmare. There must be a better way.

There is — or I should say, there are! Two alternative techniques are available. The first is the less satisfactory of the two, in my opinion, but I will describe it briefly since being aware of it increases one's electronic troubleshooting knowledge. The second technique is the best method I have seen to date for semiconductor testing. It is used commercially with some digital multimeters, but there is no reason we can't use it with our less-sophisticated analog voltmeter.

The Low-Voltage AC Tester

The first technique incorporates a clever gadget that has been named printed-circuit board tester, dynamic transistor checker and octopus. Basically, it puts low-voltage 60-Hz ac (about 3 V peak-to-peak) across the semiconductor. The voltage across the semiconductor is viewed with an oscilloscope. Because alternating current is used, the semiconductor is tested in the forward direction during part of the ac cycle, and in the reverse direction during the rest of the cycle. A printed-circuit-board tester I built several years ago is shown in Figs. 1 and 2. References listed at the end of this article provide slightly different schematics and offer a more detailed description of the tester, but the idea is the same.[2,3]

Be aware that one connection from the tester goes to the horizontal input of the oscilloscope. Therefore, the scope must not sweep as it would during normal operation. Disable the sweep, place the "horizontal" control in the "external" mode, and use the horizontal amplifier in the scope just as the vertical amplifier is used to view a signal. I make this point because I have seen people struggle unsuccessfully to make the tester provide patterns, and they soon give up in frustration, thinking this little gadget was a hoax. They merely had the scope adjusted improperly.

The printed-circuit-board tester will display patterns on the scope in accordance with the impedance it sees. If the probes in Figs. 1 and 2 are not touching anything, they see an open circuit and thus show a horizontal line on the scope (Fig. 3A). If the probes touch each other, they see a short circuit and thus show a vertical line on the scope (Fig. 3B). Since ac is used in the tester, it is possible to check inductors and capacitors, within reason, for shorts or opens, in addition to testing semiconductors. Figs. 4 and 5 show the oscilloscope presentation when the tester probes are placed across a diode and a 5-μF capacitor, respectively. Note that in Fig. 4 we see a combination of a horizontal line and a vertical line. This is an open and a short. Isn't this what we would expect to see across a diode? In one part of the ac cycle we see a short through the diode. In the remaining part of the ac cycle we seen an open across the diode. Fig. 5 is not quite so obvious, but if the capacitor value is much higher than 5 μF, the circle will be more of a vertical line (a short, right?). If the capacitor value is lower than 5 μF, the circle will flatten out to a horizontal line (an open, since the low capacitance at 60 Hz yields a high reac-

[1]Notes appear on page 26.

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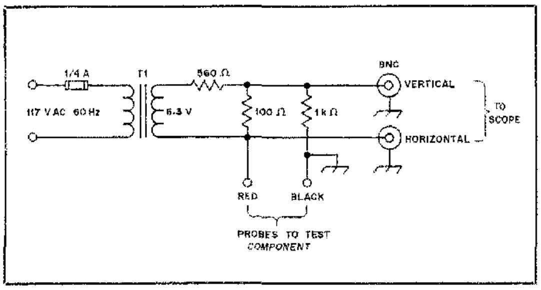

Fig. 1 — Schematic diagram of the printed-circuit-board tester used in conjunction with an oscilloscope for testing semiconductors "in circuit." T1 can be a filament transformer.

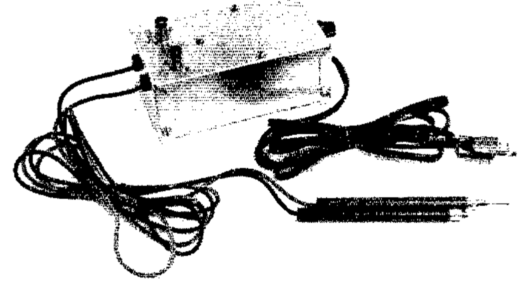

Fig. 2 — The printed-circuit-board tester constructed by the author. The BNC connectors permit coupling to an oscilloscope with RG-58/U cable.

tance). We could apply similar logic to testing inductors. And, of course, we test transistors just as if the base-emitter combination and base-collector combination were the same as the anode-cathode combination of a diode. The collector-emitter combination is tested to ensure there is no short or low resistance.

The Drawbacks

"Tell me no more," you say. "This device is just what I've been waiting for." Well, let me break the bubble, or at least deflate it a bit. Most of the time when checking semiconductors in a circuit with the tester, we get the pattern shown in Fig. 4. Sometimes, though, we get strange patterns because of the components that may be in parallel with the semiconductor. With experience (and maybe intuition), we can decipher these strange patterns. At other times, the only thing to do is pull the device off the printed-circuit board and test it out of circuit. On occasion, the pattern can be downright deceiving. A clear example is Fig. 5. True, the pattern comes from a 5-μF capacitor, but I also had a diode across the capacitor. The diode characteristic did not show up at all on the scope presentation.

Of course, the other drawback to the printed-circuit-board tester is that it is inconveniently pseudo-portable. You have to drag it around and set up the scope; 117-V ac has to be available for the tester and probably for the scope, too. For the reasons stated above and in the previous paragraph, I do not consider the printed-circuit-board tester the better of the two techniques for checking semiconductors in circuit.

The PN Junction Tester

The second technique — the only way to "fly," in my opinion — is the pn junction tester. This method is used by Beckman, Fluke and a few other manufacturers of digital multimeters.

When a direct current passes through a pn junction (that is, an anode-cathode junction of a diode, a base-emitter junc-

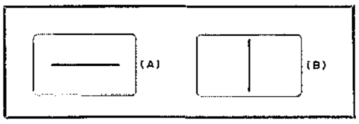

Fig. 3 — At A the tester presents a horizontal line on the scope when looking across an open circuit. At B, it presents a vertical line when looking across a short circuit.

tion or a base-collector junction of a transistor), there is a voltage drop in the forward direction. For a silicon semiconductor this voltage drop is 0.6 to 0.7 V. For a germanium semiconductor, the voltage drop is 0.25 to 0.35 V. In the reverse direction, current will not pass through the junction; therefore, the junction is an open circuit. So, if we push current through the junction (the diode or transistor) and measure the voltage drop across the junction with a voltmeter, we have the pn junction tester.

As mentioned earlier, pn-junction testing is the technique used by Beckman and Fluke in their digital multimeters. Fig. 6 shows a typical pn-junction test on a silicon diode using the Beckman multimeter. On the left, the junction is being tested in the forward direction. Note the drop is 0.625 V, above what we expected. On the right, the leads from the multimeter are reversed across the diode and the result is a reading of OL on the multimeter. Loosely translated, this means the multimeter sees an open circuit across its leads. Thus, these tests show the diode is good. An open in both directions (an OL on the meter) would tell us the diode is defective. Similarly, a shorted diode would present no voltage drop and the meter would read zero.

When the Beckman meter displays OL, it is telling you that the voltage it sees across the leads is more than 1.999. When used as a pn junction tester the 2.0-V scale on the voltmeter is switched in automatically. The voltage inside the Beckman meter that is placed across the meter leads

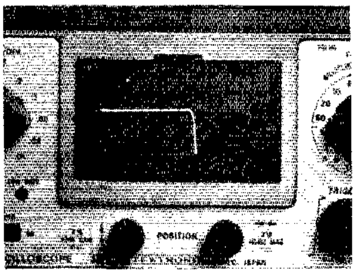

Fig. 4 — The tester shows an open and a short when placed across a diode.

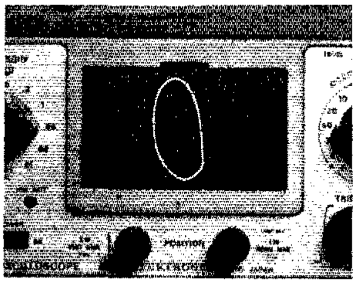

Fig. 5 — The tester shows a circle when connected across a 5-μF capacitor.

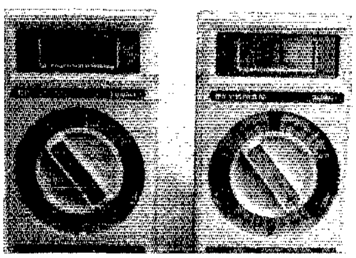

Fig. 6 — Beckman multimeter reading forward voltage drop (left) and reverse voltage drop (right) across a diode.

is about 5 V. Thus, OL means overload or overrange, because you are trying to read 5 V on the 2-V scale. It doesn't harm the meter, and the OL feature is a nice touch to let you know what's going on. Also, the current being pushed through the pn junction comes from a constant-current source of about 5 mA. The Fluke multimeter pn-junction tester operates about the same way, except that it does not use a constant-current source and has no OL feature. In addition, the current pushed through the pn junction is about 1 mA.

A Circuit for Home Construction

So now you're probably thinking that you already have a digital meter, a VOM and a VTVM, and now someone is suggesting that you spend another $180 or so on a new instrument just so you can check semiconductors in circuit. Not so. We can build our own pn junction tester and use our existing voltmeter.

I don't want the electrical engineers in our Amateur Radio ranks to laugh too loudly at me, but the sophisticated circuit shown in Fig. 7 is what I use as a pn-junction tester with my ancient Heath VTVM. Let's look at how this thing works so you can "design" your own to suit your particular meter. I am going to assume the meter used is an analog meter, but the idea is the same for a digital meter.

Let's assume your low-range voltage scale is zero to 1.5, as it is on my Heath VTVM. If you use the 1.5-V scale, then the battery used in the pn junction tester should be 1.5 V. If your meter has a zero-to 3-V scale, use two batteries in series to get 3 V. If your meter has a scale that is not convenient for use with carbon-zinc dry cells, you may choose to use some inexpensive NiCd batteries. Example: Full scale is 2.5 V, so use two NiCd batteries in series to get 2.4 V. Whatever you do, the battery voltage should not exceed the maximum voltage on the range scale you select if you are using an analog meter. Why? Because during the time the probes in Fig. 7 are open-circuited you are reading the battery voltage, and you'll slam the meter needle into the stops if you use a battery voltage higher than the maximum value of that range.

If we take a lesson from the Fluke and Beckman pn junction testers, the current we push through the pn junction needs to be between 1 and 5 mA. Let's assume that our nominal silicon pn junction will drop 0.65 V. If we use a 1.5-V battery, the resistor will drop the difference, or 0.85 V. Resistor values between 850 and 170 Ω will yield currents from 1 to 5 mA. I used a 330-Ω resistor in my pn junction tester. If you use a 3-V battery, any resistor between 2.2 kΩ and 470 Ω would be suitable. If you use 2.4 V from NiCd cells, any resistor between 1.8 kΩ and 390 Ω will be suitable.

Fig. 8 shows the exotic packaging and construction technique I used for my pn junction tester. Three drops of super glue fix the battery holder to the plastic enclosure. All parts are obtained from Radio Shack. The photo at the beginning of this article shows the pn junction tester and the Heath VTVM being used to test a transistor on a printed-circuit board.

Testing Procedure

The approach used to test semiconductors in or out of a circuit is the same as if we were using the Beckman or Fluke. If the drop in the forward direction reads somewhat close to the 0.6 V or 0.7 V we expect to see, and the drop in the reverse direction is the full battery voltage (1.5, 3 or 2.4, depending on the battery you selected), the pn junction is good. Remember when testing transistors to check the base-emitter junction, the base-collector junction, and the collector-to-emitter, in forward and reverse directions (six checks). The collector-to-emitter test should always show an open (full battery voltage, both directions). And if you ever test a pn junction that yields zero potential across it, you have a shorted junction. You need test no further — the semiconductor is dead.

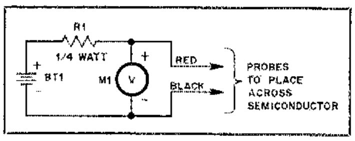

Fig. 7 — Schematic diagram of the pn junction tester. See text regarding BT1 and R1. M1, as used by the author, is an old Heath VTVM, but could be any VTVM or FETVOM, or high-impedance digital voltmeter.

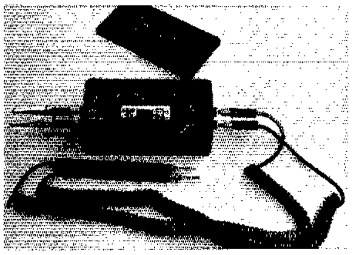

Fig. 8 — The layout of the pn junction tester. The meter is connected to the jacks on the left; the probes on the right are placed across the semiconductor. The enclosure is Radio Shack part no. 270-222. The battery is a size C dry cell.

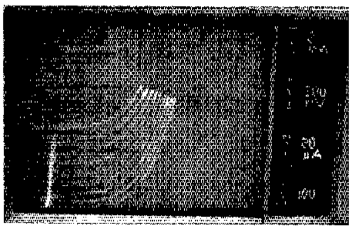

Fig. 9 — The Tektronix curve tracer shows a transistor to be defective even though the pn junction tester showed that it was good. The lines should remain essentially horizontal in sweeping from left to right, rather than curving upward significantly. The vertical traces at the right indicate that the transistor breaks down at a potential from collector to emitter of approximately 3.5 V.

More Drawbacks?

I have described the pn junction tester and have shown how you can make one for use with your meter. Now you think that the ultimate, perfect, foolproof semiconductor tester will solve all problems, for certain. You will never have to remove a semiconductor from the circuit to test it. Well, not quite. There will be times when a good semiconductor will appear defective (such as Darlington configurations), and it will have to be removed to conduct an accurate test. No tester is foolproof in those situations, but they are few and far between.

And one final caveat: If we test a semiconductor with the pn junction tester and it checks okay, are we *certain* it is good? Nothing is certain except, as the saying goes, death and taxes. The pn-junction test is reliable 99% of the time, but one of my colleagues has found that rare occasion when the pn-junction test showed a transistor to be good when the Tektronix curve tracer showed it to be defective. See Fig. 9. But the printed-circuit-board tester described earlier also showed the transistor to be good, as did the resistance checks with an analog ohmmeter that were outlined in the article referenced in note 1. Fortunately, events such as that are statistical rarities.

If you noticed something strange about the Heath VTVM in the photograph at the beginning of this article, you are observant. There is a toggle switch on the front, and the 117-V ac umbilical cord is missing. A 1974 article by Mike Kaufman outlines a modification to the Heath VTVM that can be applied to any VTVM.[4] The change removes the two vacuum tubes and replaces them with an LM310 voltage-follower op amp. It is a modification that is well worth the time to perform, as it makes your electronic meter truly portable.

Any question a reader has will be answered to the best of my ability. Please enclose an s.a.s.e. with the correspondence. Thank you! QST

Notes

[1] D. DeMaw, "Some Basics for Equipment Servicing," *QST*, Dec. 1981.
[2] V. Epp, "Dynamic Transistor Tester," *Ham Radio*, Oct. 1971.
[3] D. Ludlow, "The Octopus," *QST*, Jan. 1975.
[4] M. Kaufman, "How to Convert Your VTVM to an IC Voltmeter," *Ham Radio*, Dec. 1974.

Clifford J. Appel was first licensed as KN4NKF in October 1960, graduating to WA4EBX a year later. An Extra Class amateur since May 1978, he is a Communications and Instrumentation Mechanic at Grand Coulee Dam, the nation's largest hydroelectric power-generating facility.

Antenna Gain Measurements

Part 2: Instrumentation — simple, easily constructed instruments permit a precise determination of antenna gain.†

By Fred Brown,* W6HPH

Part 1 of this article dealt with the techniques of measuring antenna gain accurately. This concluding part is devoted to the equipment needed for such measurements. Comparison of two antennas obviously requires (1) a signal source and (2) some kind of receiver capable of giving a quantitative indication of received signal strength.

Station receivers and transmitters are often pressed into service as antenna-range instruments, but such make-shift arrangements usually leave much to be desired. The equipment described here is designed specifically for accurate gain measurements on the two amateur bands most likely to be used for antenna experiments: 432 and 1296 MHz. Antenna size and height-above-ground requirements make gain measurements awkward on bands below 420 MHz, and antennas become especially unwieldy below 144 MHz. Bands above 1300 MHz, on the other hand, require microwave sources that are not easy for the average amateur to construct. And antennas for these higher bands, rather than being too large, shrink to a size that is sometimes too diminuitive to work with conveniently.

A Signal Source

On-the-air signals are used sometimes for antenna measurements, but they are generally not satisfactory, for a number of reasons. They are often intermittent in nature, and frequently they are in a wrong direction or not close enough to the desired frequency. On-the-air signals will nearly always meet the distance requirement, but sometimes they are so far away that fading becomes a problem.

†Part 1 of this article appeared in November 1982 *QST*.

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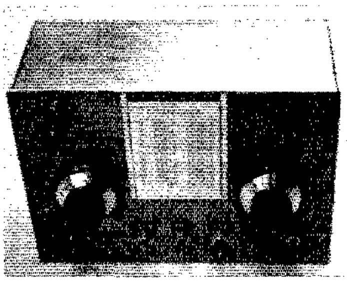
For these and other reasons, it is preferable to have a completely portable source that can be taken into the field. Fortunately, since only a very low power level is needed (in the milliwatt region), battery requirements are minimal.

For antenna work, a crystal-controlled source is not really necessary. A frequency stability on the order of ± 1/2% is usually adequate, and this degree of stability can be attained easily with an ordinary L-C oscillator. A self-excited oscillator is considerably simpler to construct than a crystal-controlled source, and has the further advantage of being adjustable in frequency — a feature often useful to the experimenter.

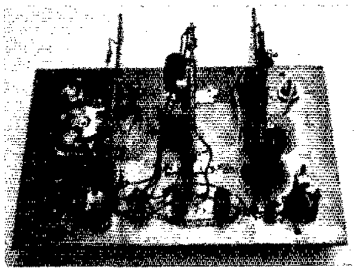
Most measurements at microwave frequencies are done with 1000-Hz, amplitude-modulated sources. This is because laboratory-type microwave detectors are usually either bolometers or point-contact silicon diodes. These detectors feed an amplifier-meter combination; if the source were unmodulated, it would be necessary to use a high-gain dc amplifier with attendant drift problems. High-gain audio amplifiers are easy to construct and do not suffer the notorious drift problems of dc amplifiers. The audio amplifier is usually tuned sharply to 1000 Hz to improve the signal-to-noise ratio, and to help reject stray signals modulated by other frequencies.

In keeping with this tradition, the source described here is 1000-Hz modulated, and is therefore compatible with most laboratory-type microwave instruments. Square-wave modulation is used because it simplifies the modulator (only a switching transistor is needed) and also because it avoids fm problems.

In Fig. 9, Q1 is the 432-MHz oscillator and Q2 is the 1296-MHz oscillator. If only one band is of interest, the unneeded oscillator could be omitted, of course.



A frequency-calibration chart is fixed to the front panel of the 432- and 1296-MHz signal source. The vernier dials are Archer catalog no. 274-605, sold by Radio Shack.



Inside view of the signal source shows the 1000-Hz modulator board between the 432-MHz oscillator (left), and the 1296-MHz oscillator.

Both Q1 and Q2 are inexpensive and readily available 2N5179 transistors. Q3 and Q4 form a 1000-Hz multivibrator, and Q5 acts as a switch to modulate either oscillator. The modulation frequency can be set to exactly 1000 Hz by means of R1.

Dielectric tuning (C3) is used on the 1296-MHz oscillator because ordinary variable capacitors are almost unusable at

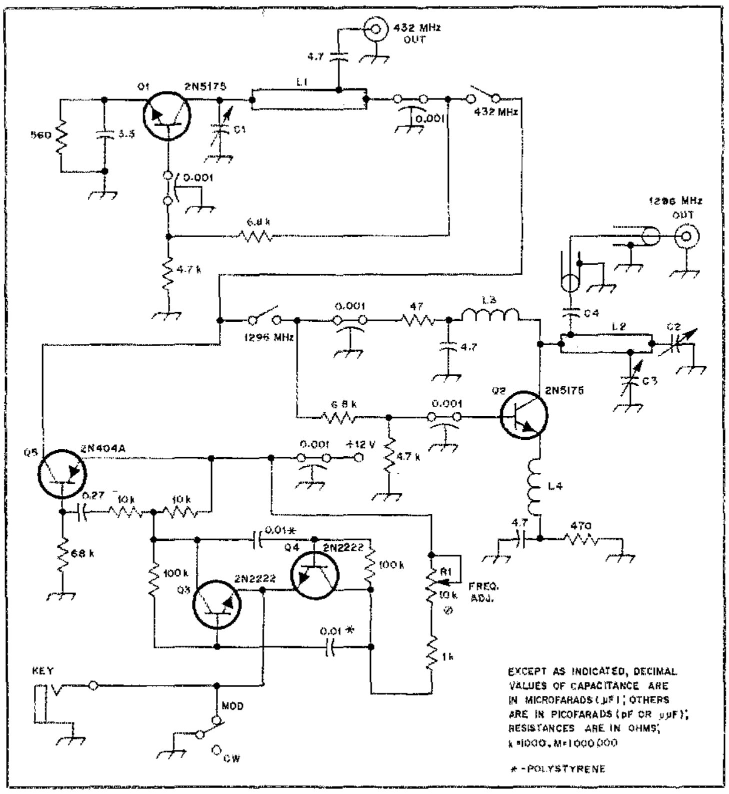


Fig. 9 — This battery-powered combination 432- and 1296-MHz signal source permits antenna measurements at sites remote from ac power. Construction details of the 432-MHz oscillator, Q1, and the 1296-MHz oscillator, Q2, are given in Figs. 10 and 11, respectively. Adjust the modulation frequency to 1000 Hz by means of R1.

C1 — Two-plate APC-type variable, 4-pF maximum capacity.
C2 — 0.5-3 pF ceramic piston trimmer, Triko 201-01M suitable (Alaska Microwave part no. 55100, Alaska Microwave Lab, Box 2049, Palmer, AK 99645.
C3 — See Fig. 11 and text.
C4 — Rectangular tab of 24-gauge copper, 5/8 inch long, 0.22 inch wide, spaced 0.065 inch above L2. See Fig. 11.
L1 — 1.75-inch length of no. 12 solid copper wire, spaced 0.3 inch from circuit board. See Fig. 10.
L2 — Rectangle of sheet copper, 1.33 inches long, 0.43 inch wide, spaced 0.24 inch from circuit board. See Fig. 11.
L3 — 9 turns no. 22 bare wire, 0.13-inch ID, 0.35 inch long.
L4 — 4 turns no. 22 bare wire, 0.13-inch ID, 0.23 inch long.

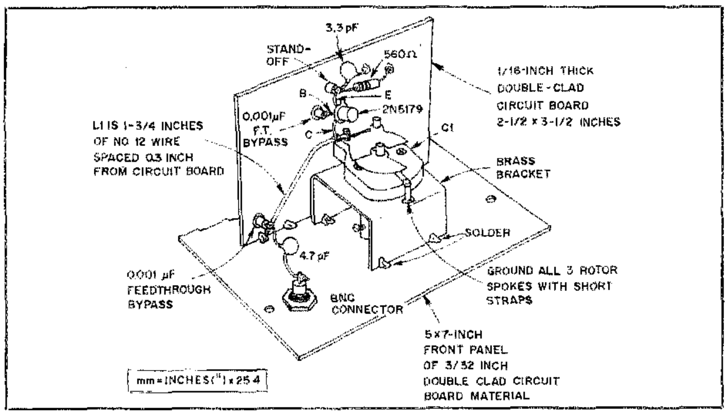


Fig. 10 — The 432-MHz oscillator is tuned by a two-plate APC-type capacitor, C1, which has a maximum capacity of 4 pF. Tuning range is roughly 390 to 450 MHz.

this frequency. The tuning range turned out to be only 6 MHz — barely enough to compensate for frequency shift caused by ambient temperature changes. The range could have been made greater if the plastic tuning vane had been made of metal sandwiched between two layers of plastic.

The signal source is built on a 5 × 7-inch panel of 3/32-inch double-clad circuit board. A standard 5 × 7 × 3-inch aluminum chassis serves as the cabinet. Complete shielding is mandatory, of course; stray radiation from the source would be detrimental in antenna work. Most of the construction details should be evident from the photographs and Figs. 10 and 11. Each oscillator is built on a separate 2-1/2 by 3-1/2 inch rectangle of 1/16-inch double-clad circuit-board material. The modulator is built on a piece of perf board of the same dimensions.

The usual caveat with respect to shortest possible uhf lead lengths apply to these oscillators, especially Q2. Ordinary TO-18 transistors seldom are used at a frequency as high as 1300 MHz, but they can be made to work if care is taken. To minimize inductance, the feedthrough bypass capacitor on the base of Q2 should be of a type that has a low profile; it should protrude no more than 1/16 inch above the circuit board.

The source is powered by an external 12-V battery, and current drain is about 6 mA. Power enters the box through a feedthrough bypass capacitor to avoid radiation from the power lead.

The Detectors

There are a number of reasons to justify choice of a detector and amplifier combination in preference to a superheterodyne receiver. In addition to being much simpler, direct detection avoids the frequency-drift problems common to self-excited oscillators and tunable "superhets." Furthermore, a superhet normally would terminate in a linear detector, which would have a mathematically predictable response over less dynamic range than the square-law detector used here.[5]

The term *square law* means that the detector output voltage is proportional to the *square* of the rf input voltage. If the output is amplified and indicated on a linear meter, the meter reading will be proportional to received *power*, rather than voltage. Any diode detector with output of less than 10 mV will have a nearly perfect square-law response over a wide dynamic range — in fact, from 10 mV all the way down to the noise level.

Another reason the square-law detector is preferable is that it improves resolution. Small changes in signal level are doubled over what they would be with a linear

[5]Notes appear on page 31.

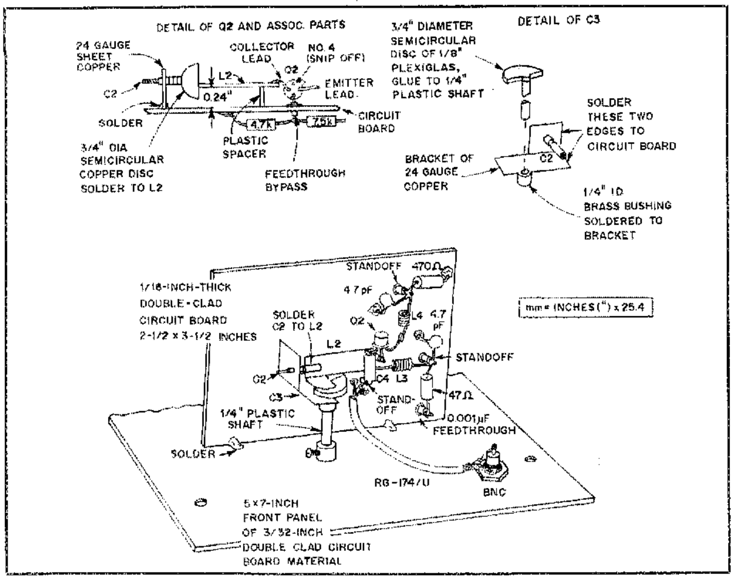


Fig. 11 — The 1296-MHz oscillator uses C3, a semi-circular plastic vane, for fine tuning. L2 is supported at one end by the piston trimmer, C2, and at the other end by a plastic spacer, which is glued in place with epoxy cement. With C3 at half capacitance, the frequency is set to 1296 MHz by means of the coarse frequency adjustment, C2. Very short base and collector leads on Q2 are mandatory if the oscillator is to reach 1296 MHz.

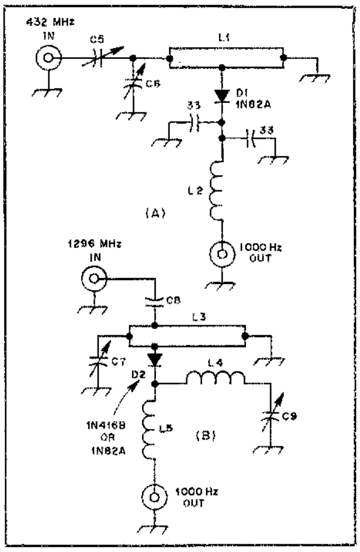


Fig. 12 — The 432-MHz detector (at A) and the 1296-MHz detector (at B) both use point-contact silicon diodes to rectify the uhf signal. Construction details are given in Fig. 13.

C5, C6, C7, C9 — 0.5-3 pF ceramic piston trimmer, Triko 201-01M suitable. (Same as C2 in Fig. 9; see that caption.)
C8 — 0.31-inch-wide strip of 22-gauge copper, 0.78 inch long, spaced 0.12 inch from L3. See Fig. 13.
L1 — 2.75 inches no. 12 solid bare wire bent to L shape, spaced 0.38 inch above circuit board, tapped 3/4 inch from C6. See Fig. 13.
L2 — 19 turns no. 22 bare wire, 0.15-inch ID, 1.5 inches long, air wound.
L3 — 0.38-inch-wide strip of 22-gauge copper, 1.5 inches long. Bend as shown in Fig. 13.
L4 — 3/4 inch of no. 22 wire connecting D2 to C9.
L5 — 12 turns no. 22 bare wire, 0.15-inch ID, 0.45 inch long.

detector: A 1-dB rf-level change results in a 2-dB change in output, and so on. In contrast with an S meter, in which a 3-dB change is barely noticeable, a square-law detector spreads 3 dB out over the entire upper half of the meter scale, from mid- to full-scale. As a result, changes as small as 0.05 dB are quite discernible.

Untuned detectors often are used for antenna work, but a tuned detector has the advantage of providing at least some rejection of RFI, and the further advantage of better sensitivity. Separate tuned detectors were made for 432 and 1296 MHz (Fig. 12), although both are housed in the same box. As with the source, complete shielding is mandatory. The detectors are built on a 4 × 8-inch rectangle of 3/32-inch-thick double-clad circuit board. This forms the cover plate for a standard 4 × 8 × 2-inch aluminum chassis. Construction details are shown in Fig. 13.

As can be seen from Fig. 12, a commonplace 1N82 diode is used as the 432-MHz detector. At 1296 MHz, the 1N416B proved slightly superior, although a 1N82 could have been used for this band with only a small sacrifice in sensitivity. Input coupling of both detectors should be adjusted for maximum output when driven from a 50-ohm weak-signal source. The coupling and tuning adjustments interact to some degree, and so will need repeaking several times. The combination of L4 and C9 on the 1296-MHz detector is a series-tuned bypass network, and should be tuned for maximum response.

The Indicator Unit

Ultimately, the gain measurement will depend on a meter reading of some sort, and it is important that the meter indication truly reflect the gain difference between the antenna under test and the reference antenna. Since the detectors are operating in their square-law region, the indicator unit must sometimes work with

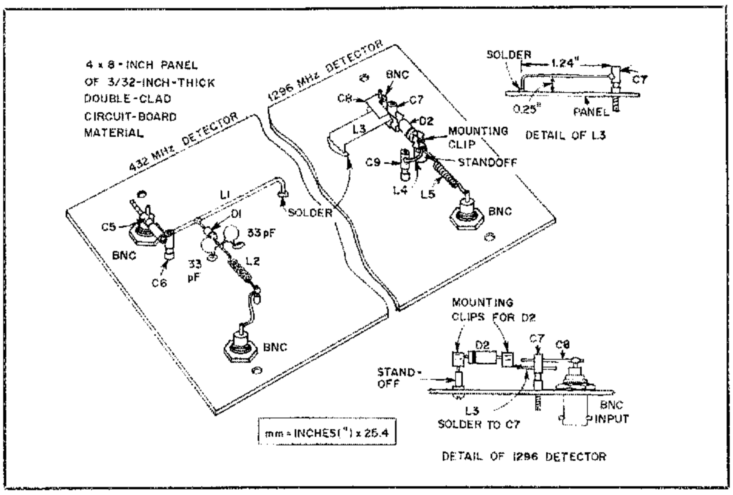


Fig. 13 — Both detectors are built on a single 4 × 8-inch panel of copper-clad circuit-board material. The 432-MHz input coupling capacitor, C5, is soldered directly to the BNC connector center pin and capacitor C6. Similarly, C8 is soldered directly to the 1296-MHz-input BNC. The panel fits on an inverted 4 × 8 × 2-inch aluminum chassis. Complete shielding is important.

inputs of only a few microvolts, and in no case more than 10 millivolts. A high order of amplification is therefore needed to boost the 1000-Hz signal to a level at which it can drive the meter. Also essential is a large dynamic range, which calls for a low noise figure and narrow bandwidth.

The circuit shown in Fig. 14 was designed to meet these requirements. Starting at the input, the 1000-Hz audio signal is amplified by FET Q6 and filtered by the two-pole filter, L6-C10 and L7-C11. A one-pole filter would have been adequate from a strictly signal-to-noise-ratio standpoint, but a two-pole filter was used for reasons that will be apparent later. Output of the filter is adjusted in level by the attenuator switch, S1, and delivered to the source follower, Q7.

You may notice that the resistance values in the attenuator will result in steps of 10 dB, whereas the front panel is calibrated in 5-dB steps. This is because the front-panel calibration refers to the rf level at the *input* of the detector. Since the detector is square-law, its output will be double the number of decibels change at its input.

After passing through the gain control, R2, the 1000-Hz signal is further amplified by Q8 and Q9. The meter is driven by a rectifier circuit consisting of op-amp U1 and diodes D3 and D4. An exceptionally linear response results from placing the rectifier in the op-amp negative-feedback loop.[10] The 2200-µF capacitor and the 47-ohm resistor across the meter are for nothing more than meter damping. These components will not be needed if a well-damped meter is used.

The output of U1 is also amplified by U2 and the two transistors, Q10 and Q11. These transistors drive a 2-inch speaker mounted on the sidewall of the cabinet. If used strictly for antenna measurements, the speaker and its driver could be omitted, but its inclusion makes it easier to identify interfering signals, such as radar; it is also sometimes helpful for making adjustments by ear when the meter is not in view. The main reasons for including the speaker, however, will be made clear later.

Since only audio frequencies are involved, construction of the indicator unit is not especially critical. Precautions must be taken to prevent feedback around the extremely high-gain amplifier, however. The preamplifier components (inside the

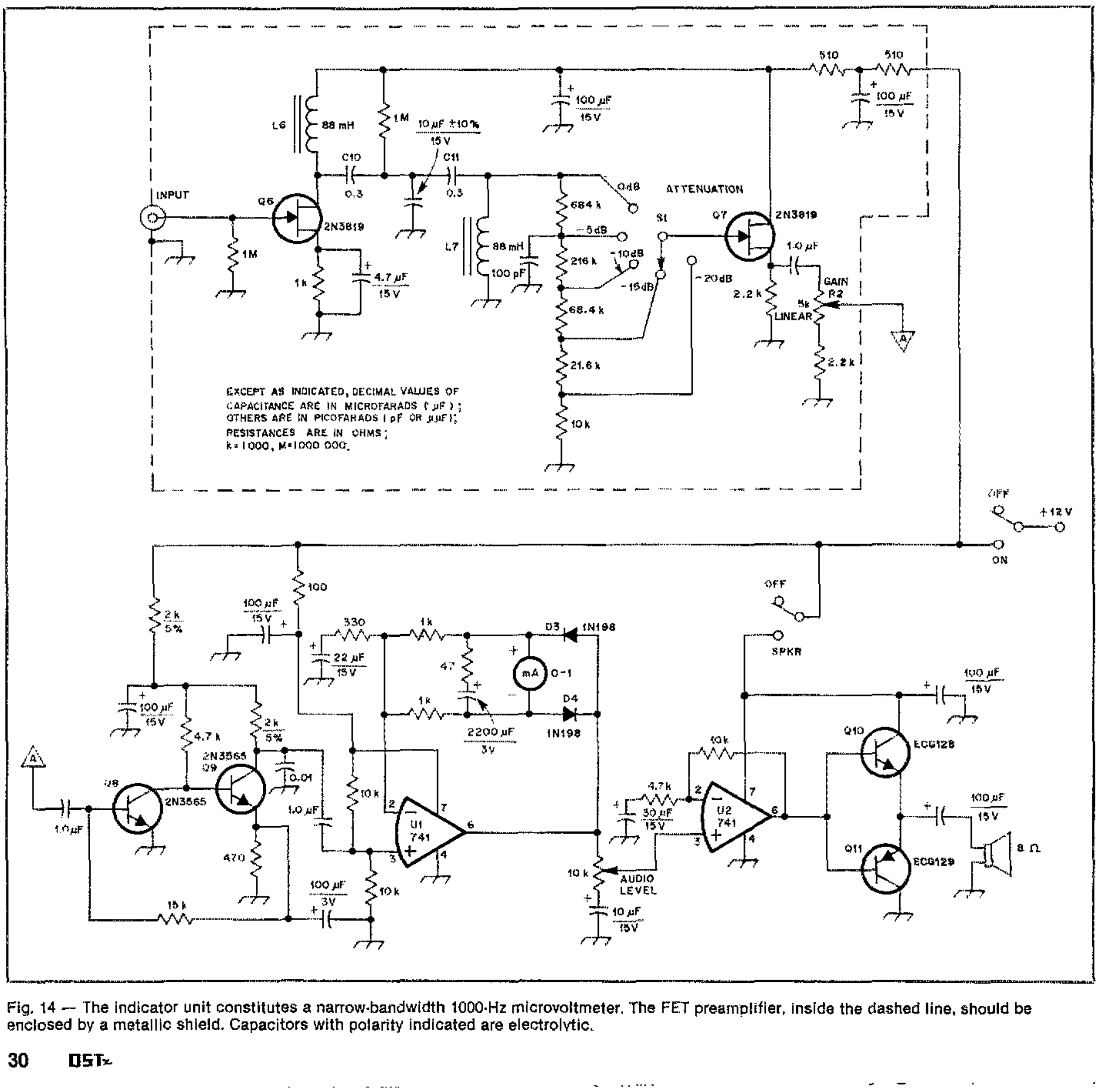
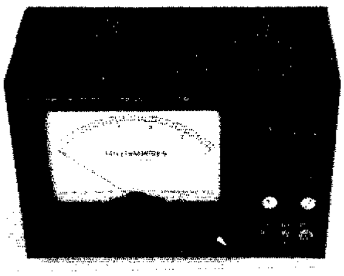


Fig. 14 — The indicator unit constitutes a narrow-bandwidth 1000-Hz microvoltmeter. The FET preamplifier, inside the dashed line, should be enclosed by a metallic shield. Capacitors with polarity indicated are electrolytic.



The indicator unit incorporates a rechargeable 12-V NiCd battery. A 2-inch speaker is mounted on the left side panel. Front-panel dimensions are 8-1/2 × 12 inches, and the cabinet is 5-1/2 inches deep. The base is made of 1/2-inch plywood; top and sides are 1/4-inch Masonite.

dashed line in Fig. 14) should be shielded from the rest of the circuitry. The 1-MΩ input resistor at the gate of Q6 should be a film type — composition resistors are too noisy. Film resistors also should be used for the switchable attenuator, and these latter resistors should all be 1% values. Since the values are not standard, it may be necessary to use series or parallel combinations of available resistors to make up the correct values.

The 1000-Hz band-pass filter is made from ordinary 88-mH toroids (advertised frequently in *QST*) and 0.3-μF resonating capacitors. These components should be adjusted for resonance at exactly 1000 Hz. Fine tuning can be accomplished by substituting slightly different values, by paralleling capacitors, or by removing a few turns from the toroids.

Although an average-size meter could have been used, the large 7-inch meter was chosen because it is easy to read from a distance. When converting into decibels, remember that the meter reading is proportional to received *power*, not voltage. Second-hand microwave instruments called *standing wave indicators* sometimes can be purchased very reasonably at flea markets; these instruments have a meter with a decibel scale calibrated for a square-law detector. If one of these meters is used for the indicator unit, the instrument will be direct-reading in decibels. Another possibility is a meter from an old ac VTVM, but it will always be necessary to divide the decibel readings by a factor of two.

In any event, for best accuracy, all measurements should be done in the upper 7/10 of the meter scale. If the meter reading is below 0.3, the attenuator switch should be turned to a higher gain position.

As mentioned earlier, the diode detectors can be expected to maintain their square-law response up to an output level of about 10 mV. Above that level, their response increasingly becomes less square law and more linear until, above 100 mV, they are almost perfectly linear. For this reason, it is advisable to make note of the gain-control setting at which full-scale deflection occurs at 10-mV input (on the lowest attenuator-switch position). Remember to stay below that signal level when making quantitative measurements. The full-deflection sensitivity of the indicator unit is 25 μV at maximum gain, so there is ample dynamic range below 10 mV.

Other Uses

CW Processor: Usually when we go to the trouble of building something, we want the end result to be as versatile as possible. This is especially true if extra functions can be included by adding only a few more parts.

As mentioned before, the speaker and its driver circuit are not absolutely necessary for antenna measurements. But their addition allows the indicator unit to be used in the shack as an audio processor for cw reception. The audio bandwidth of the unit is 59 Hz at 6 dB down, and 148 Hz at 20 dB down. When the audio output from an ordinary 3-kHz-bandwidth receiver is run through the indicator unit, improvement in cw reception is phenomenal.

It will be noticed that there is no forward bias on Q10 and Q11. This causes the audio output stage to function as a threshold gate — another feature intended for cw reception.[11] If linear operation is preferred, it can be made so by disconnecting the 10-kΩ resistor from the base of Q10 and Q11, and connecting it to their emitters instead.[12]

MCW Communications Set: Note that a key jack was included in the source unit. This permits the antenna instrumentation to be used as a short-range mcw communications set. As such, it will clearly not meet the needs of a serious uhf operator. But it is plenty good enough for something like sending code practice to the kid across the street, or for indoor transmitter hunts.[13] Keying capability is needed, in any event, to comply with FCC requirements of call sign identification every 10 minutes.

With a total of 18-dB antenna gain (receiving plus transmitting), the maximum range of this instrumentation was measured as about 1/2 mile on 1296 MHz. The range is so short mainly because of the receiver insensitivity; about 50 μV of rf is needed to produce an audible output. A superhet a-m receiver would extend the line-of-sight range to more than 50 miles.

Notes

[9] F. W. Brown, "How to Measure Antenna Gain," *CQ*, Nov. 1962, p. 40
[10] National Semiconductor Corp., *Linear Applications*, 1973, p. LB-8.
[11] J. J. Duda, "Noise Reduction for CW Reception," *Ham Radio*, Sept. 1973, p. 52.
[12] A. G. Evans, "The Two-Hour Audio Amp," *73*, Sept. 1980, p. 118.
[13] A. E. Hudson, "Hidden-Transmitter Hunts for Everyone," *QST*, Sept. 1948, p. 40.

Strays

TA PROFILES

We had the pleasure recently of welcoming Richard M. Jansson, WD4FAB, into our official TA family. His professional expertise in thermal design (especially in the area of solid-state rf amplifiers) will be of value to all radio amateurs. He is a Life Member of the ARRL, and holds appointments in the VHF/UHF Advisory Committee and as an Official Emergency Station.

First licensed in 1972 as WA1QLI, Dick currently holds an Advanced class license. He has received amateur awards for WAC, DXCC, 600 Club, Satellite DX Achievement, WAS, WAS-6 meter and WAS-satellite. He is a Life Member of SMIRK, SWOT and AMSAT, and holds a membership in the Academy of Model Aeronautics (AMA). He is also a member and past president of the University of Maryland Amateur Radio Club.

Dick resides in Maitland, Florida, and is the senior staff engineer for Martin Marietta Aerospace. There he is engaged in cryogenic thermal design and thermodynamics of closed-cyle cryogenic refrigerators. He is also avocationally employed as a member of the AMSAT Phase III spacecraft engineering team, providing thermal-design engineering needed for the complex craft. (An excellent report on WD4FAB's achievements for the AMSAT team appears in *AMSAT Satellite Report*, No. 28, March 8, 1982.) Dick was previously a member of the AMA Frequency Committee (advising the AMA on frequency usage for radio-controlled [R/C] modeling). The most recent AMA activities involved action with FCC on 80 new R/C frequencies in the 4-meter band, and a new 6-meter band plan for amateur modelers.

Dick is a registered professional engineer with the Commonwealth of Massachusetts. He earned his BS degree in mechanical engineering from the University of Maryland. When his busy schedule allows, Dick enjoys R/C sailplane modeling and flying, R/C model yacht racing and photography. — *Marian Anderson, WB1FSB*

TA Dick Jansson, WD4FAB, busy at work in his office.

The Effect of Supporting Structures on Simple Wire Antennas

Your tower does more than just support your antennas. You may be surprised at the results!

By John S. Belrose,* VE2CV

Wire antennas, such as dipoles, inverted Vs and Delta Loops, are the most commonly used antennas for Amateur Radio communications on the lower hf bands (160, 80, and 40 m). Theoretical vertical-plane patterns for dipoles and inverted Vs at various heights above ground have been well documented.[1,2] Mayhead[3] has measured the vertical-plane patterns of dipoles, quads and Delta Loops on an improvised antenna pattern range. While his results are not in perfect accord with my measurements performed on a commercial antenna test range, the patterns he provided gave me the stimulus to begin my study.

Amateur wire antennas are typically supported by grounded metal towers between 50 and 60 feet high.[4] The supporting towers are therefore about the right height to be resonant (h~λ/4) at 80 m, and could affect the antenna radiation pattern markedly. Yet this fact has been ignored by the radio amateur; he usually takes no account of the fact that dipoles and Delta Loops radiate vertically polarized fields off their ends. The amateur normally is concerned only with the field that lies broadside to the antenna. Since this field is horizontally polarized and the towers are vertical, this may be the reason the influence of metal towers has been overlooked.

This article describes experimental measurements and theoretical model calculations for various wire antennas over a perfectly conducting ground plane, with and without the influence of metal support towers. The experimental testing was done at 200 MHz, employing a ground-level antenna-pattern range that has been described in *QST*.[5] Reradiation effects from the supporting towers are at a maximum, since the towers were approximately λ/4 high at the model frequency. A summary of the results given here has been published previously.[6]

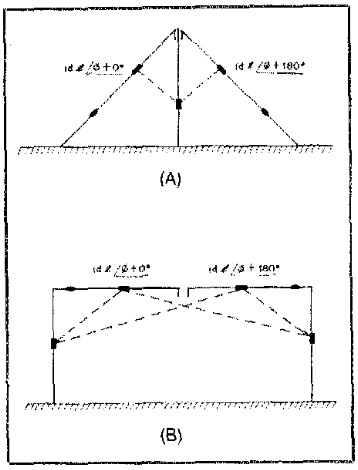


Fig. 1 — Drawings illustrating how antenna-current elements (idℓ) induce currents on conducting support tower(s). An inverted V (A) and a horizontal dipole (B) are shown.

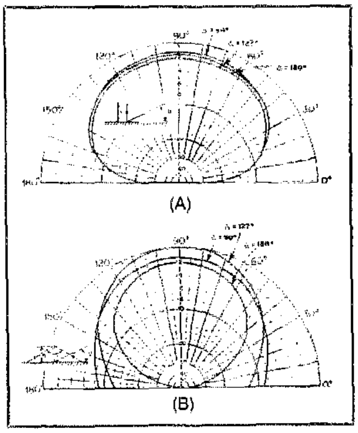


Fig. 2 — Vertical-plane, polar diagrams of an inverted-V antenna for two orthogonal planes and polarizations. A is for horizontal polarization in the plane broadside to the antenna, and B is for vertical polarization in the plane of the antenna.

The 1/2-λ Inverted V

The 1/2-λ inverted V is a resonant dipole with drooping ends. It is a very practical antenna, requiring only one support. Provided that the feed is balanced, the effect of a metal supporting tower on the radiation pattern is minimal. This can be seen in Fig. 1A. The current elements (idℓ) on each arm of the dipole will be in opposite phase, so currents that each induces on the tower will cancel. The vertically polarized pattern of the antenna is very sensitive to any imbalance, and a balun should be employed to provide balanced feed if a true bidirectional pattern is desired.

Vertical-plane patterns for various configurations of 1/2-λ inverted-V dipoles are shown in Fig. 2. The azimuthal patterns (not shown) are typical figure eights with maxima in the respective orthogonal directions for each polarization. When the included angle Δ between the two arms of a dipole is equal to 180°, this is the configuration of a horizontal dipole. For this pattern measurement, the antenna was supported by nonconducting towers.

The height (h) in Fig. 2, and others to

[1]Notes appear on page 35.

*3 Tadoussac Dr., Aylmer, PQ J9J 1G1, Canada

follow, is λ/4. While no attempt was made to measure absolute gain, all patterns were taken at a constant power level employing a 50-Ω signal generator. With reference to the 1/2-λ dipole (Fig. 3), 0 dB corresponds to an overhead power gain ($\theta = 90°$) of 6 dBd. The gain differences measured for $\Delta = 127°$ and 90° are opposite to those that would be expected; this is because an inverted V with $\Delta = 90°$ is a better match to the 50-Ω feeder cable. The input impedance of a horizontal dipole is approximately 72 Ω.

For radio amateurs, the configuration $\Delta = 90°$ is optimum. This antenna provides high-angle radiation for short- to medium-distance communications, but the polarization is dependent on the azimuth; low-angle vertical polarization, for communication to distant stations, is maximum in the plane containing the antenna.

The 1/2-λ Dipole

The vertical plane radiation patterns for the 1/2-λ dipole are shown in Fig. 3. These are tracings of the observed patterns, with no smoothing. The "wiggles" on the curves are a range imperfection. Note that the conducting towers have little effect on the horizontally polarized field in the plane broadside to the dipole (Fig. 3A); the conducting towers have a significant effect on the low-angle ($\theta<20°$) vertically polarized field in the plane of the dipole (Fig. 3B). In fact, the tower effect results in a significant field directed toward the horizon. The azimuthal patterns, not shown, were again typical figure eights, orthogonally directed for each polarization.

A qualitative explanation for these differences can be inferred from the sketch in Fig. 1B. The current elements ($id\ell$), which are located the same distance each side of the feed point, are of equal but opposite phase. Each element will induce a current on each supporting tower, and the resulting currents on the towers will not cancel. Therefore, a marked effect would be expected — particularly in the plane of the antenna and in the direction of the horizon, since this is the direction of maximum field strength from a vertical radiator.

The 1-λ, Apex-Down, Apex-Feed Delta Loop

A 1-λ, apex-down, apex-feed Delta Loop radiates essentially like a horizontal 1/2-λ dipole, and the resulting patterns, with and without metal supporting towers, should be similar to those found in Fig. 3. This expectation was confirmed by measurement (Fig. 4).

The measured patterns for the apex-down, apex-feed Delta Loop are replotted in Figs. 5 and 6 on a rectilinear format, and for comparison with theoretical calculations. A geometrical representation is shown in Fig. 7A. The theoretical gains (in dBi) G_ϕ and G_θ are the horizontally

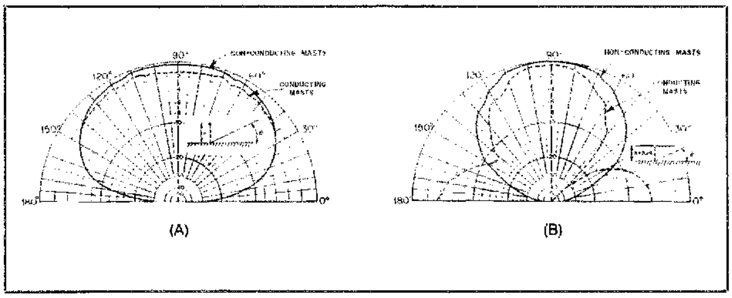


Fig. 3 — Vertical-plane polar diagram of a horizontal dipole antenna for two orthogonal planes and polarizations. A is for horizontal polarization in the plane broadside to the antenna, and B is for vertical polarization in the plane of the antenna. The continuous and broken curves are for nonconducting and conducting support towers, respectively.

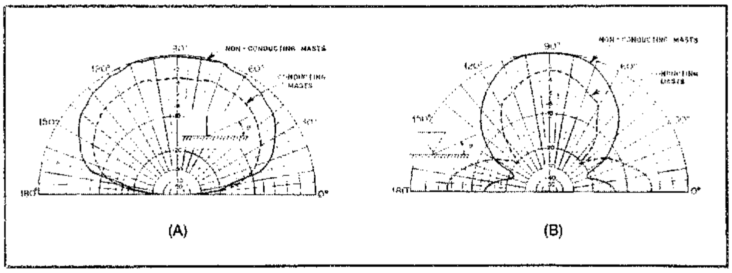


Fig. 4 — Vertical-plane polar diagrams of a 1-λ, apex-down, apex-feed Delta Loop for two orthogonal planes and polarizations. A is for horizontal polarization in the plane broadside to the antenna, and B is for vertical polarization in the plane of the antenna.

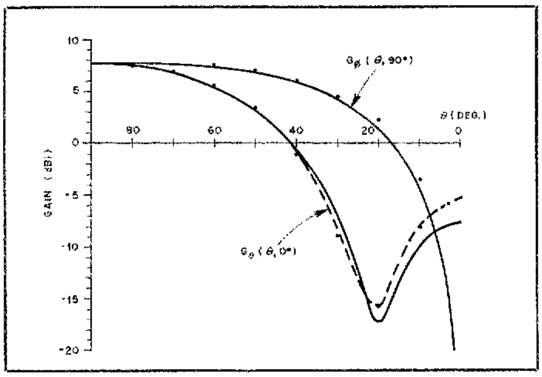


Fig. 5 — Calculated gain curves for the apex-down, Delta-Loop antenna shown in Fig. 7A, where the support towers are nonconducting. The dots and broken line represent measured values.

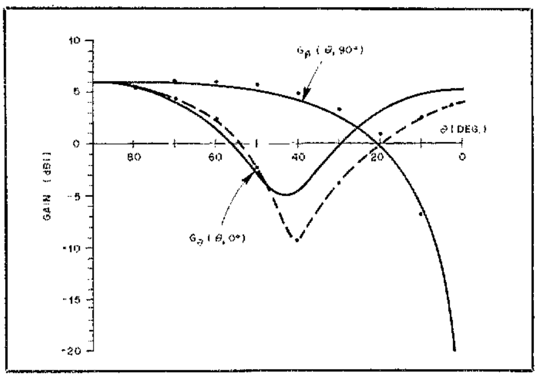


Fig. 6 — Calculated gain curves for the apex-down, Delta-Loop antenna shown in Fig. 7A, where the support towers are conducting. The dots and broken line represent measured values.

and vertically polarized power gains, respectively. The theoretical results (shown by the solid lines) were calculated by a modern numerical electromagnetic code (NEC) developed by Burke and others.[7] The broken lines have been plotted from data obtained through measurement. While an exact agreement between prediction and measurement does not exist, it is clear that the effect of the conducting tower is well predicted by the NEC. While no attempt was made to ensure that the numerically modeled 1-λ Delta Loop was exactly resonant, it is interesting to note that a marked change in input impedance was predicted when metal towers are employed. With nonconducting towers, the input impedance of a 1-λ loop (in free space) was calculated to be $157\ \Omega \angle -35^\circ$, which changed to $293\ \Omega \angle -49^\circ$ when conducting towers were modeled.

The 1-λ, Apex Down, Top-Corner-Feed Delta Loop

Figs. 8 and 9 are patterns for the 1-λ, apex-down, top-corner-feed Delta Loop. With nonconducting towers, the radiation is predominantly vertically polarized (see Fig. 8), with maximum field strength in the plane broadside to the antenna (Fig. 9). Gain in this broadside direction is about 1 dBd. With conducting towers, the bidirectional nature of the vertical polarization pattern (in the plane of the antenna) is modified (Fig. 8B). The ellipsoidal azimuth pattern is distorted into a weak cordiodal pattern (Fig. 9), with a slight field-strength maximum in the direction of the feed point.

The 1-λ, Apex Up, Lower Corner-Feed Delta Loop

This antenna is a practical one, since only a single supporting tower is needed. The arrangement is shown in Fig. 7B. Theoretically derived gain patterns are shown in Figs. 10 and 11. While a conducting tower noticeably modifies the pattern, the effect is minimal and, from a practical standpoint, can be ignored. The gain pattern in Fig. 11 (where a conducting tower is present) shows that the radiation is predominantly vertically polarized, with maximum field strength toward the

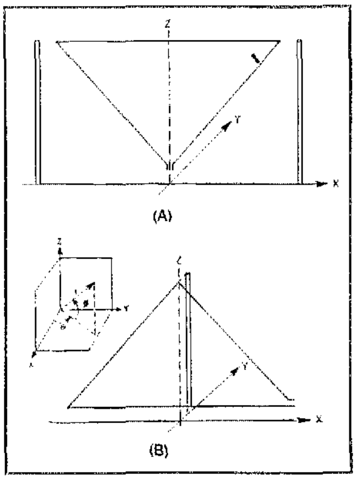


Fig. 7 — Geometry for (A) an apex-down, Delta-Loop antenna and (B) an apex-up, Delta-Loop antenna. Insert provides text coordinate reference.

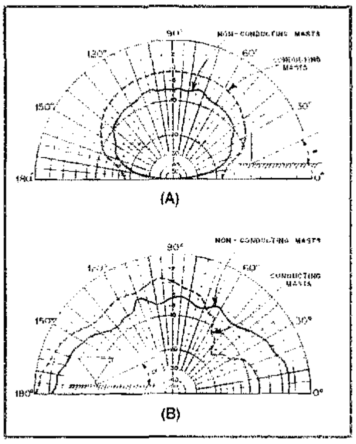


Fig. 8 — Vertical-plane, polar diagrams for a 1-λ, apex-down, top-corner-feed Delta Loop for two orthogonal planes and polarizations, measured (A) for horizontal polarization in the plane broadside to the antenna and (B) for vertical polarization in the plane of the antenna.

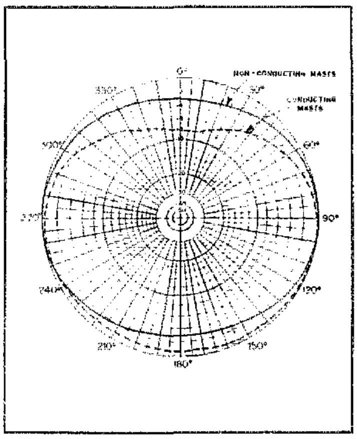


Fig. 9 — Azimuth polar diagram for vertically polarized radiation of a 1-λ, apex-down, top-corner-feed Delta Loop, measured at an elevation angle θ = 10°. The antenna was in the 0° - 180° plane, with the feed point on the 0° side.

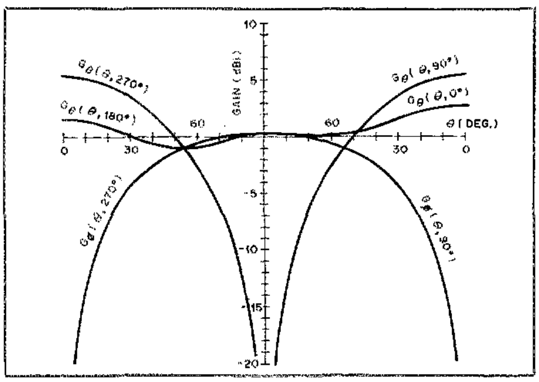


Fig. 10 — Calculated gain curves for the apex-up, Delta-Loop antenna shown in Fig. 7B, where the support tower is nonconducting.

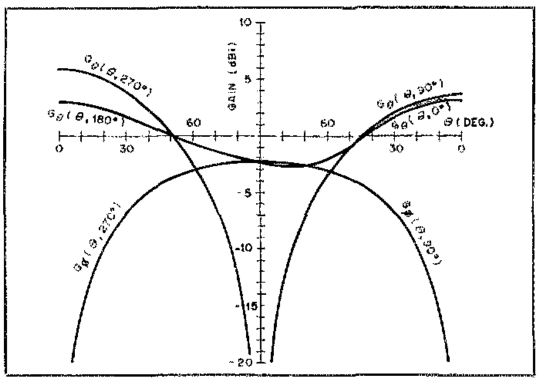


Fig. 11 — Calculated gain curves for the apex-up, Delta-Loop antenna shown in Fig. 7B, where the support tower is conducting.

horizon. Gain is greater than 3 dBi at all azimuths. It should be noted that the gain of a 1/4-λ monopole over a perfectly conducting earth is 5.16 dBi (3 dBd); therefore, the 1-λ Delta Loop has not provided increased "gain." However, it provides a means to obtain, with a single supporting tower, an efficient antenna without the need for a radial ground system. Like all 1-λ loops, it also can be used on its harmonic frequencies. Dipoles and monopoles are resonant on odd harmonic frequencies, whereas the 1-λ loop is resonant on all its harmonic frequencies.

Effect of Varying Tower Height

A grounded, conducting tower reradiates strongly when it is either 1/4- or 3/4 long, and less when it is of any other height. Fig. 12 illustrates how the relative scattering effect for grounded metal towers of various thickness varies with tower height.[8] While this parameter cannot be used to simply predict the radiation patterns for wire antennas suspended on towers of different heights, it does provide some insight into the magnitude of the effect. For example: If towers that were approximately λ/4 long at 80 m were used to support a 160-m antenna (h ~ λ/8), the magnitude of the reradiated fields on 160 m would be 22 dB less than on 80 m; at 40 m (h ~ λ/2), the effects would be 5-9 dB less (dependent on the thickness of the tower).

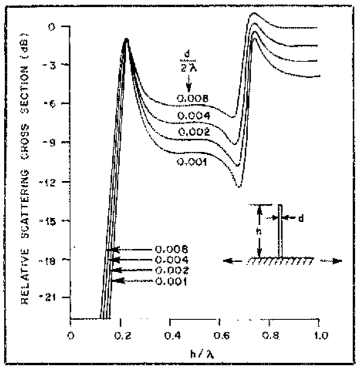


Fig. 12 — Normalized scattering cross section (along the ground plane) for a grounded, conducting tower. The scattering cross section is a quantitative measure of the reradiated signal power density, with respect to the plane wave incident on the scatterer.

Acknowledgments

The author wishes to express his thanks to L. R. Bode, who built the model antennas, and to Max Royer, of the Communications Research Center, who carried out the numerical modeling. Thanks also to J. G. Dunn, of the National Research Council, who measured the antenna patterns on their test range.

Notes

[1] *The ARRL Antenna Book*, 13th ed. (Newington: ARRL, 1974), pp. 55-56.

[2] D. Covington, "Radiation Patterns of Dipoles Over Perfect Ground, *QST*, April 1970, pp. 46-50.

[3] L. Mayhead, "Loop Aerials Close to Ground," *Radio Communication*, May 1974, pp. 298-301.

[4] m = feet × 0.3048.

[5] J. Belrose, "The Half Sloper — Successful Deployment is an Enigma," *QST*, May 1980, pp. 31-33.

[6] J. Belrose, "The Effects of Metal Supporting Towers on the Radiation Pattern of Simple Wire Antennas," *1981 IEEE Second International Conference on Antennas and Propagation*, Conf. Proc. No. 195, Vol. 1, April 1981, pp. 84-87.

[7] J. Burke, A. Poggion, J. Logan and J. W. Rockway, "NEC — Numerical Electromagnetic Code for Antennas and Scattering," *1979 IEEE International Symposium on Antennas and Propagation*, Seattle, WA, Vol. 1, June 1979, pp. 147-150.

[8] G. Royer, "The Effects of Re-radiation from High-rise Buildings and Towers Upon the Antenna Patterns for AM Broadcast Arrays," *1981 IEEE International Symposium on EMC*, Boulder, CO, August 1981.

New Books

☐ *The Complete Handbook of Amplifiers, Oscillators, and Multivibrators,* by Joseph J. Carr. Published by Tab Books, Inc., Blue Ridge Summit, PA 17214. Softcover, 364 pages, Tab book no. 1230. First edition 1981, 5-1/2 × 8 inches, $8.95.

From the opening pages of this book dealing with basic semiconductor theory, until the closing chapter on microwave devices, the ham and nonham alike will find a wealth of information dealing with electronic fundamentals and basic solid-state devices, along with devices such as oscillators and multivibrators.

Filling the book with practical working examples, author Carr has managed to cover quite a broad area of electronics in a comprehensive manner. In fact, he discusses some topics in this book that are not treated in very many other books. For example, entire chapters are devoted to designing FET circuits, utilizing isolation amplifiers, tackling operational amplifier problems, explaining the CDA (current difference amplifier) and OTA (operational transconductance amplifier), voltage-to-current converters, choppers, carrier and lock-in amplifiers. The chapter on microwave devices (Gunn devices, IMPATT devices and TRAPATT diodes) is especially valuable for the above 1-GHz experimenter.

Math is used where needed but is not overdone. The only problem with the book is an occasional erroneous reference in the text, mostly to figure and graph numbers, but this problem is not overtaxing. All in all, the book serves as interesting reading for any ham as well as a useful addition to the reference shelf. *— Al Gordon, WD6HAK*

☐ *Practical RF Design Manual,* by Doug DeMaw. Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. First edition, 1982. Hard-bound, 6 × 9 inches, 246 pp., including index, $24.95.

The title of this textbook says it all! It is a practical, down-to-earth manual for those of us in the ham fraternity who like to "roll their own." Even if you are not interested in building your own equipment, the vast amount of information presented in this book will give you a better understanding of how and why circuits behave as they do. The text is very readable, so even if your electronic knowledge is not "extra class," you should be able to gain a wealth of information. The professional electronics engineer should also find this book valuable.

Chapter 1 leads you through transmitter and receiver fundamentals, delving into frequency stability, spectral purity, SWR protection circuits, etc. The section on receiver dynamic range and how to measure it is very worthwhile. If your understanding of this much-talked-about subject is fuzzy, it may be worth the price of the book for this information alone. Sensitivity, selectivity and noise limiting are also covered.

Chapter 2 is all about frequency control. Crystal oscillators, L-C rf oscillators and heterodyne frequency generators are covered, and many practical circuits are given.

Chapters 3 and 4 deal with small and large rf amplifiers, including design criteria and many explanatory circuits. Particular emphasis is placed on amplifier stability, biasing, broadbanding techniques. In addition, there is a lot of material on VMOS power FETs.

The final chapters will fill you in on frequency multipliers, mixers, balanced modulators, detectors, i-f amplifiers, filters and agc systems.

One worthwhile and handy feature of this book is that the formulas, and results, are entered on the diagram so you do not have to go searching through the text for them. I found some errors in the diagrams that I can only assume crept in when the draftsperson copied the originals to the Prentice-Hall format. The proofreaders also missed them!

I have been building ham gear for over 30 years, and I found many new and useful ideas in the pages of this book that may be applied to almost any project. It is a worthwhile addition to any technical library. *— Norm Bradshaw, W8EEF*

MINIMUF: A Simplified MUF-Prediction Program for Microcomputers

On which band and at what time should you expect propagation to Pakistan or Pennsylvania? Use this computer model of muf and prepare your own up-to-the-minute predictions.

By Robert B. Rose,* K6GKU

In the mid 1970s, Navy engineers were working to utilize the explosion in microprocessor computing technology to improve the timeliness and accuracy of hf-propagation predictions. The primary emphasis was directed toward allowing hf users in the field to assess current propagation conditions. Up to that time, hf-prediction codes were long, complex programs requiring large computers. The user in the field depended on long-term predictions based on years of historical observations. This method often lacked the ability to reflect current solar activity and any changes in the operating scenario. The Navy work was directed toward developing a simplified hf-prediction system that was adaptable to almost any micro or minicomputer using the BASIC language. Further, it was desired that the user be able to enter current solar/geophysical parameters, such as solar flux. This provided more accurate predictions.

The hf sky-wave channel, shown in Fig. 1, is generally described as being bounded by the maximum usable frequency (muf) and by the lowest usable frequency (luf). The luf is an absorptive function, and is controlled by power, signal-to-noise requirements and other such system gain functions. It is a fuzzy boundary, and, as far as amateur operation is concerned, frequencies near the luf are the least efficient part of the spectrum. Most hf users know that the closer to the muf one operates, the more efficient the communications channel becomes. DXers are particularly interested in the muf characteristics of certain paths. The muf is a physical boundary that is controlled by the level of solar activity and solar illumination on the path. It is a concise constraint that the hf user cannot overcome with power, antenna or other mechanical means. Because it does vary on a day-to-day basis, and because sometimes it is vastly different than long-term predictions would show, it seemed that a simplified muf-prediction algorithm would be a very useful tool. In the mid 1970s, scientists at the Naval Ocean System Center predicted that the peak of solar cycle 21, 1978 to 1982, would be higher than initially expected, further motivating the project.[1]

Traditionally, the prediction of muf was done by a large, complex computer model, nominally consisting of 150,000 to 200,000 bytes of computer code. In 1977, a simple model was developed to show the dynamics of the muf and how its sensitivity to solar activity varies.[2] "Simple" is an understatement; the new model consisted of 80 BASIC program steps! Many military, industrial and commercial hf users have implemented and tested MINIMUF.

The initial verification was done by comparing the predictions with oblique-incidence-sounder data, which is the only way to observe the actual muf boundary. The original sounder data base encompassed 196 path months (4704 test points) of observed maximum usable frequencies measured over 23 different hf-sounder paths. MINIMUF was found to have an rms error of ± 3.8 MHz. Current users find it useful from 2 to 50 MHz for muf predictions out to 6000 miles.[3] However, accuracy degrades for ranges of less than 250 miles.

As one can imagine, anything as simple as MINIMUF invites "tinkering." Over the past three years, numerous experimenters have made attempts to improve the model with such features as adding an E and F_1 region (MINIMUF is a single-layer F-region model), changing constants to reflect local conditions and giving it more diurnal variation. All of these revisions, when compared against oblique-sounder data, degraded the accuracy and made the program more complicated. These exercises only served to prove the old adage, "If it works, don't fix it." The ver-

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[1]Notes appear on page 38.

sion of MINIMUF described in this article was first published in 1978,[4] and is still the principal version in use.

Application Tips

With increasing solar activity, user interest in updating MINIMUF to reflect current conditions also increased. The updating method found to be most effective was to vary the sunspot-number input parameter as a function of the 10.7-cm solar flux. Because of the lag in F-region response to a rapid increase in solar activity, it is best to use either a 5-day, 15-day or 90-day running average of the 10.7-cm flux. The type of application will determine which is best. The 5-day mean is a short-term, more dynamic input, while the 90-day mean is more applicable for long-term planning. These flux values can be acquired from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Boulder, CO 80303 or from WWV transmissions at 18 minutes after each hour. The conversion from 10.7-cm flux to sunspot number is accomplished by the graph shown in Fig. 2.

Two other points are borne out by field testing. First, MINIMUF is an F-region approximation. Any intervention by E-region modes of propagation, either as multiple E or EF complex modes, is not predictable by MINIMUF. Such operational situations, however, are proving to represent only a small percentage of the total. Second, MINIMUF has the greatest accuracy within the one- and three-hop ranges, between about 250 and 6000 miles. Predictions for transmission paths longer than this should be used with some caution. Fig. 3 is a sample output listing that users may find helpful in getting their version of MINIMUF working.

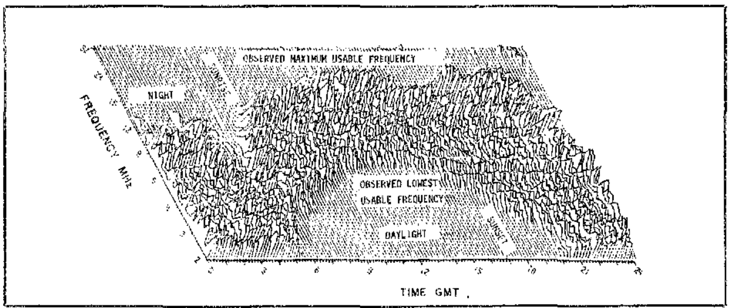


Fig. 1 — A typical 24-hour plot of the hf sky wave channel.

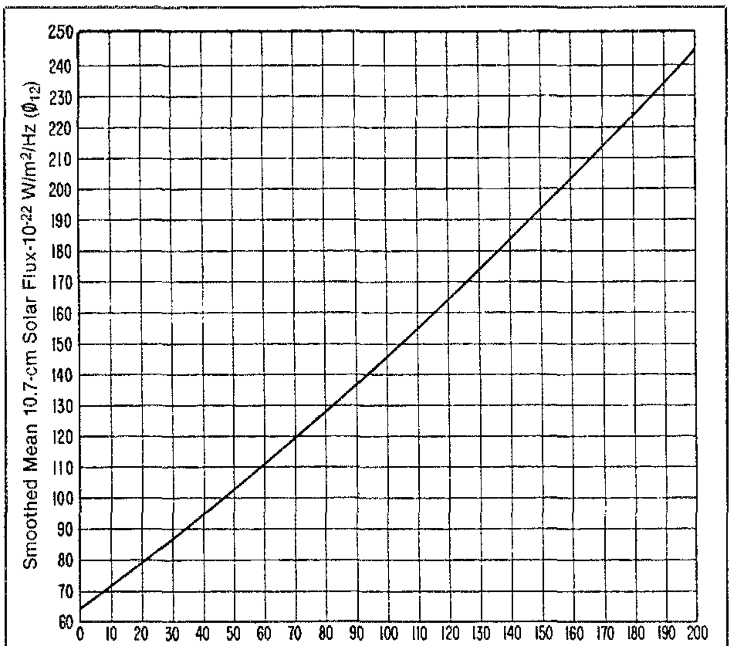


Fig. 2 — Relationship between the smoothed International Sunspot Number and the smoothed mean 10.7-cm Solar Flux.

Conclusion

MINIMUF is simple, and it works. It is expected to be particularly useful during the next solar-minimum period, in the mid 1980s, for operation in the new WARC bands.

It is emphasized that MINIMUF is not designed to replace the current large-scale numerical codes such as IONCAP, ITS-78, SKYWAVE, and the like. If you have ready access to a large computer, use the large codes. If you are limited to a Texas Instruments TI-59® calculator, Radio Shack TRS-80® microcomputer, or similar micro-based systems, MINIMUF was designed for you. It is conceivable that in the future MINIMUF will be resident in a read-only memory (ROM) in a microprocessor controlled transceiver. If the operator enters the desired end points, date, time and solar flux, he or she could quickly determine whether a frequency band was open in the desired direction. Technically, it is feasible now.

The author wishes to acknowledge the contributions of Dr. Paul Levine of Megatek Corporation, who produced the original MINIMUF concept, and Messrs. J. N. Martin and D. B. Sailors of the

```
DATE: 17 OCT
TRANSMITTER LOCATION:
  LATITUDE 21.00,  LONGITUDE 156.00
RECEIVER LOCATION:
  LATITUDE 38.00,  LONGITUDE 122.00
SUNSPOT NUMBER = 110

        HOUR          MUF (MHZ)
        -----         ---------
          0             36.3
          1             35.0
          2             33.0
          3             29.9
          4             25.0
          5             22.8
          6             20.9
          7             19.3
          8             18.0
          9             16.9
         10             16.0
         11             15.2
         12             14.6
         13             14.1
         14             13.7
         15             21.0
         16             27.6
         17             31.5
         18             34.0
         19             35.6
         20             36.7
         21             37.3
         22             37.5
         23             37.1

  PRESS RETURN TO PERFORM NEXT CASE.
```

Fig. 3 — Example of a 24-hour muf listing from MINIMUF-3.5. Times given are in UTC.

Naval Ocean Systems Center, San Diego, California, for their work in the mathematical and software development of MINIMUF, and also for the extensive accuracy verifications they performed.

APPENDIX — MINIMUF BASIC PROGRAM

A listing of the MINIMUF-3.5 program is included. Lines 100 through 720 contain a small driver, which allows the model to be exercised. The actual MINIMUF program starts at line 1000.

The input variables for the MINIMUF program are as follows:

L1 — Transmitter latitude ($-90° \leq$ L1 $\leq 90°$)
W1 — Transmitter west longitude ($-360° \leq$ W1 $\leq 360°$)
L2 — Receiver latitude ($-90° \leq$ L2 $\leq 90°$)
W2 — Receiver west longitude ($-360° \leq$ W2 $\leq 360°$)
MØ — Month ($1 \leq$ MØ ≤ 12)
D6 — Day ($1 \leq$ D6 ≤ 31)
T5 — Time (UT), hours (Ø.Ø $\leq$ T5 $\leq$ 24.0)
J9 — Output muf, MHz
S9 — Sunspot number
PI — 3.141593
PØ — 1.570796

[Editor's Note: This program listing is from a Tektronix computer. You may have to change some statements for the version of BASIC used by your computer. For example, this computer has a function, PI, which returns the value for π. Some versions of BASIC do not have the ACS (arc cosine) function, and it must be derived. The statement – ATN(X/SQR (– X * X + 1)) + 1.5708 will work in place of ACS(X).]

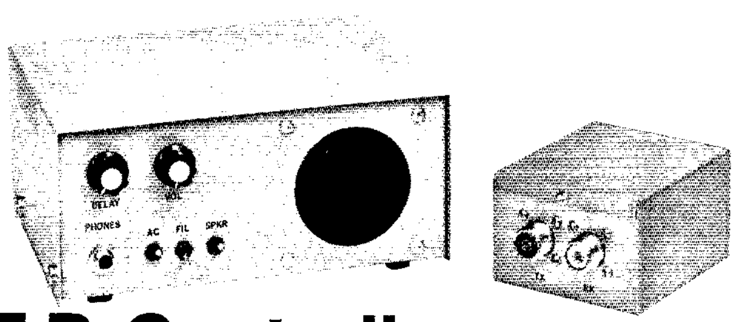
Notes

[1]P. E. Argo, J. R. Hill, R. B. Rose and M. P. Gannis, "Radio Propagation and Solar Activity," *QST*, Feb. 1977, pp. 24-27.
[2]R. B. Rose, J. N. Martin and P. H. Levine, "MINIMUF-3: A Simplified HF MUF Prediction Algorithm," Naval Oceam Systems Center Technical Report TR-186, Feb. 1, 1978.
[3]km = miles × 1.6093.
[4]R. B. Rose and J. N. Martin, "MINIMUF-3.5: An Improved Version of MINIMUF-3," Naval Ocean Systems Center Technical Document TD-201, Oct. 26, 1978.


```
1 REM - SAMPLE DRIVER FOR MINIMUF 3.5
100 INIT
110 DIM M$(37),A$(4),M(12)
120 DATA 31,28,31,30,31,30,31,31,30,31,30,31
130 READ M
140 M$="JANFEBMARAPRMAYJUNJULAUGSEPOCTNOVDEC"
150 RØ=PI/180
155 P1=2*PI
160 R1=180/PI
170 PØ=PI/2
180 PAGE
190 PRINT "TRANSMITTER LAT, LON = ";
200 INPUT L1,W1
210 IF L1=>-90 AND L1<=90 THEN 240
220 PRINT "INVALID LATITUDE.  MUST BE IN RANGE (-90,+90)."
230 GO TO 190
240 IF -360<=W1 AND W1<=360 THEN 270
250 PRINT "INVALID LONGITUDE.  MUST BE IN RANGE (-360,+360)."
260 GO TO 190
270 PRINT "RECEIVER LAT, LON = ";
280 INPUT L2,W2
290 IF -90<=L2 AND L2<=90 THEN 320
300 PRINT "INVALID LATITUDE.  MUST BE IN RANGE (-90,+90)."
310 GO TO 270
320 IF -360<=W2 AND W2<=360 THEN 350
330 PRINT "INVALID LONGITUDE.  MUST BE IN RANGE (-360,+360)."
340 GO TO 270
350 PRINT "DATE (DAY,MONTH) = ";
360 INPUT D6,MØ
370 IF 1<=MØ AND MØ<=12 THEN 400
380 PRINT "INVALID MONTH.  MUST BE IN RANGE (1,12)."
390 GO TO 350
400 IF 1<=D6 AND D6<=M(MØ) THEN 430
410 PRINT USING 420:M(MØ)
420 IMAGE "INVALID DAY.  MUST BE IN RANGE (1,",FD,")."
425 GO TO 350
430 PRINT "SUNSPOT NUMBER = ";
440 INPUT S9
450 IF S9>Ø THEN 480
460 PRINT "INVALID SUNSPOT NUMBER.  MUST BE NON-NEGATIVE."
470 GO TO 430
480 PAGE
490 A$=SEG(M$,3*MØ-2,3)
500 PRINT USING """DATE: "",FD,1X,FA":D6,A$
510 PRINT "TRANSMITTER LOCATION:  ";
520 PRINT USING 530:L1,W1
530 IMAGE"LATITUDE ",FD.2D,", LONGITUDE ",FD.2D
540 PRINT "RECEIVER LOCATION:     ";
550 PRINT USING 530:L2,W2
560 PRINT USING """SUNSPOT NUMBER = "",FD":S9
570 PRINT
580 PRINT "    HOUR       MUF(MHZ)"
590 PRINT
600 L1=L1*RØ
610 W1=W1*RØ
620 L2=L2*RØ
630 W2=W2*RØ
640 FOR T5=Ø TO 23
650 GOSUB 1000
660 PRINT USING 670:T5,J9
670 IMAGE 5X,2D,7X,2D.D
680 NEXT T5
690 PRINT
700 PRINT "PRESS RETURN TO PERFORM NEXT CASE.";
710 INPUT A$
720 GO TO 180
1000 REM - MINIMUF 3.5
1010 K7=SIN(L1)*SIN(L2)+COS(L1)*COS(L2)*COS(W2-W1)
1020 IF K7=>-1 THEN 1050
1030 K7=-1
1040 GO TO 1070
1050 IF K7<=1 THEN 1070
1060 K7=1
1070 G1=ACS(K7)
1080 K6=1.59*G1
1090 IF K6>=1 THEN 1110
1100 K6=1
1110 K5=1/K6
1120 J9=100
1130 FOR K1=1/(2*K6) TO 1-1/(2*K6) STEP Ø.9999-1/K6
1140 IF K5=1 THEN 1160
1150 K5=Ø.5
1160 P=SIN(L2)
1170 Q=COS(L2)
1180 A=(SIN(L1)-P*COS(G1))/(Q*SIN(G1))
1190 B=G1*K1
1200 C=P*COS(B)+Q*SIN(B)*A
1210 D=(COS(B)-C*P)/(Q*SOR(1-C↑2))
1220 IF D=>-1 THEN 1250
1230 D=-1
1240 GO TO 1270
1250 IF D<=1 THEN 1270
1260 D=1
1270 D=ACS(D)
1280 WØ=W2+SGN(SIN(V1-W2))*D
1290 IF WØ=>Ø THEN 1310
1300 WØ=WØ+P1
1310 IF WØ<P1 THEN 1330
1320 WØ=WØ-P1
1330 IF C=>-1 THEN 1360
1340 C=-1
1350 GO TO 1380
1360 IF C<=1 THEN 1380
1370 C=1
1380 LØ=PØ-ACS(C)
1390 Y1=Ø.Ø172*(1Ø+(MØ-1)*3Ø.4+D6)
1400 Y2=Ø.4Ø9*COS(Y1)
1410 K8=3.82*WØ+12+Ø.13*(SIN(Y1)+1.2*SIN(2*Y1))
1420 K8=K8-12*(1+SGN(K8-24))*SGN(ABS(K8-24))
1430 IF COS(LØ+Y2)>-Ø.26 THEN 1520
1440 K9=Ø
1450 GØ=Ø
1460 M9=2.5*G1*K5
1470 IF M9<=PØ THEN 1490
1480 M9=PØ
1490 M9=SIN(M9)
1500 M9=1+2.5*M9*SOR(M9)
1510 GO TO 1770
1520 K9=(-Ø.26+SIN(Y2)*SIN(LØ))/(COS(Y2)*COS(LØ)+1.ØE-3)
1530 K9=12-ATN(K9/SOR(ABS(1-K9*K9)))*7.639437
1540 T=K8-K9/2+12*(1-SGN(K8-K9/2))*SGN(ABS(K8-K9/2))
1550 T4=K8+K9/2-12*(1+SGN(K8+K9/2-24))*SGN(ABS(K8+K9/2-24))
1560 CØ=ABS(COS(LØ+Y2))
1570 T9=9.7*CØ↑9.6
1580 IF T9>Ø.1 THEN 1600
1590 T9=Ø.1
1600 M9=2.5*G1*K5
1610 IF M9<=PØ THEN 1630
1620 M9=PØ
1630 M9=SIN(M9)
1640 M9=1+2.5*M9*SOR(M9)
1650 IF T4<T THEN 1680
1660 IF (T5-T)*(T4-T5)>Ø THEN 1690
1670 GO TO 1820
1680 IF (T5-T4)*(T-T5)>Ø THEN 1820
1690 T6=T5+12*(1+SGN(T-T5))*SGN(ABS(T-T5))
1700 G9=PI*(T6-T)/K9
1710 G8=PI*T9/K9
1720 U=(T-T6)/T9
1730 GØ=CØ*(SIN(G9)+G8*(EXP(U)-COS(G9)))/(1+G8*G8)
1740 G7=CØ*(G8*(EXP(-K9/T9)+1))*EXP((K9-24)/2)/(1+G8*G8)
1750 IF GØ=>G7 THEN 1770
1760 GØ=G7
1770 G2=(1+S9/250)*M9*SOR(6+58*SOR(GØ))
1780 G2=G2*(1-Ø.1*EXP((K9-24)/3))
1790 G2=G2*(1+(1-SGN(L1)*SGN(L2))*Ø.1)
1800 G2=G2*(1-Ø.1*(1+SGN(ABS(SIN(LØ))-COS(LØ))))
1810 GO TO 1880
1820 T6=T5+12*(1+SGN(T4-T5))*SGN(ABS(T4-T5))
1830 G8=PI*T9/K9
1840 U=(T4-T6)/2
1850 U1=-K9/T9
1860 GØ=CØ*(G8*(EXP(U1)+1))*EXP(U)/(1+G8*G8)
1870 GO TO 1770
1880 IF G2>J9 THEN 1900
1890 J9=G2
1900 NEXT K1
1910 RETURN
```

BEGINNER'S BENCH

Build a Universal T-R Controller



Are you missing out on semi-break-in cw? Do you have to change control circuits to try out a new rig? If so, this easy-to-build T-R controller is for you.

By George Collins,* KC1V

A feature of modern ssb transceivers that many cw operators enjoy is key-activated T-R (transmit-receive) switching, or semi-break-in cw, as it is often called. With semi-break-in cw, the station equipment is switched automatically from receive to transmit when the operator closes the cw key. After the key has been open for a preset time period, the station is switched back to receive.

If you are using an older transmitter and receiver, or a homemade QRP (low power) rig, chances are semi-break-in cw is a feature you have been without. Another problem with this type of gear is that the required control circuits (transmitter keying, receiver muting, etc.) differ from one piece of equipment to another. Generally, it's not too difficult to find suitable control circuits for a given transmitter and receiver, but if you have more than one rig, or you enjoy trying out different equipment, the problem becomes more complex. To add to the difficulty, many transmitters require an external antenna relay.

How can we solve these problems? By building the Universal T-R Controller! This workshop project should eliminate most (if not all) of the problems you may encounter when interconnecting your equipment. As a "plus feature," you get semi-break-in cw, a good sidetone and an audio filter — all in the same package.

Features

Before we discuss the construction and operation of the T-R controller, let's see exactly what it will do. First, it provides semi-break-in operation. The time period from key opening until the station is switched to receive (the hold-in delay) has been made adjustable. This allows you to set the delay according to your sending speed and personal preference. Normally, the delay time is set so that the station remains in the transmit mode between words, but switches to the receive status when there is a pause in the sending.

An important function of the T-R controller is the keying delay. When the key is closed, the antenna relay is actuated immediately. Typically, it takes 15 to 25 ms for the relay to move from one position to the other. If the transmitter were keyed at the same time the relay coil was energized, the output would very likely reach full power before the relay had closed. This undesirable opening or closing of the relay with voltage applied to the contacts is called "hot switching." It can result in a "clicky," interference-producing signal and burned relay contacts. A keying delay built into the T-R controller eliminates this problem by preventing the transmitter from being keyed until the key has been closed for approximately 25 ms. This delay occurs only during the first key closure. Once the relay is closed, the delay is unnecessary and the transmitter keying follows the opening and closing of the key, exactly.

In order to provide for keying of a variety of transmitters, two transistor keying switches are used. One switch will key negative voltages (grid-block keying), while the second switch is used to key positive voltages (found in many solid-state rigs).

Transistor switches also are used for receiver muting. Three switches are provided for this purpose: one for negative muting lines, and two for positive lines. One of the positive switches is closed during transmit, while the other is open. These switching circuits enable you to use the T-R controller with just about any transmitter and receiver combination.

A requirement for good cw operating is a sidetone monitor. Unfortunately, many older commercial transmitters and some homemade rigs don't contain a sidetone circuit. For this reason, I included a sidetone oscillator in the T-R controller. The tone generated by the controller is a clean, pleasant-sounding sine wave. An audio amplifier and a speaker are provided for direct monitoring, or the sidetone signal can be fed to the audio amplifier in your receiver. If the receiver is not capable of driving a speaker, the low-level audio from the receiver can be fed to the amplifier in the T-R controller for speaker operation. An active audio filter is used as part of the sidetone generator. It can also be used during cw reception to improve the overall selectivity. It can be switched out of the receiver audio line if it is not needed or if you are copying a voice signal. A built-in power supply allows the unit to be operated from the 117-V ac line. You can also operate it from a 12-V dc supply if one is available.

The antenna relay is mounted remotely. This avoids having to run coaxial cables to the front of your operating position. It also helps in keeping rf energy out of the logic and audio circuits! The relay specified can be used at power levels up to 150 W.

Construction

To make construction of the T-R controller as simple as possible, etched circuit boards have been used.[1] One board contains the semi-break-in logic and switching

*Basic Radio Editor

[1]Notes appear on page 43.

circuits (Fig. 1). A second board is used for the sidetone oscillator, the active filter and the audio-amplifier circuits (Fig. 2). Most of the ac power-supply components (Fig. 3A) are mounted on the sidetone board. If you wish to power the circuit from only a 12-V dc supply, these components can be omitted. Alternative wiring for 12-V dc operation is shown in Fig. 3B. Parts-placement diagrams for the circuit boards are shown in Fig. 4. While etched circuit boards make for rapid assembly, they are not a necessity. You can use almost any construction method you like for this project, with good results.

As is the case with most construction projects, the T-R controller should be assembled one section at a time. Test each section before assembling the next. This makes testing and troubleshooting much

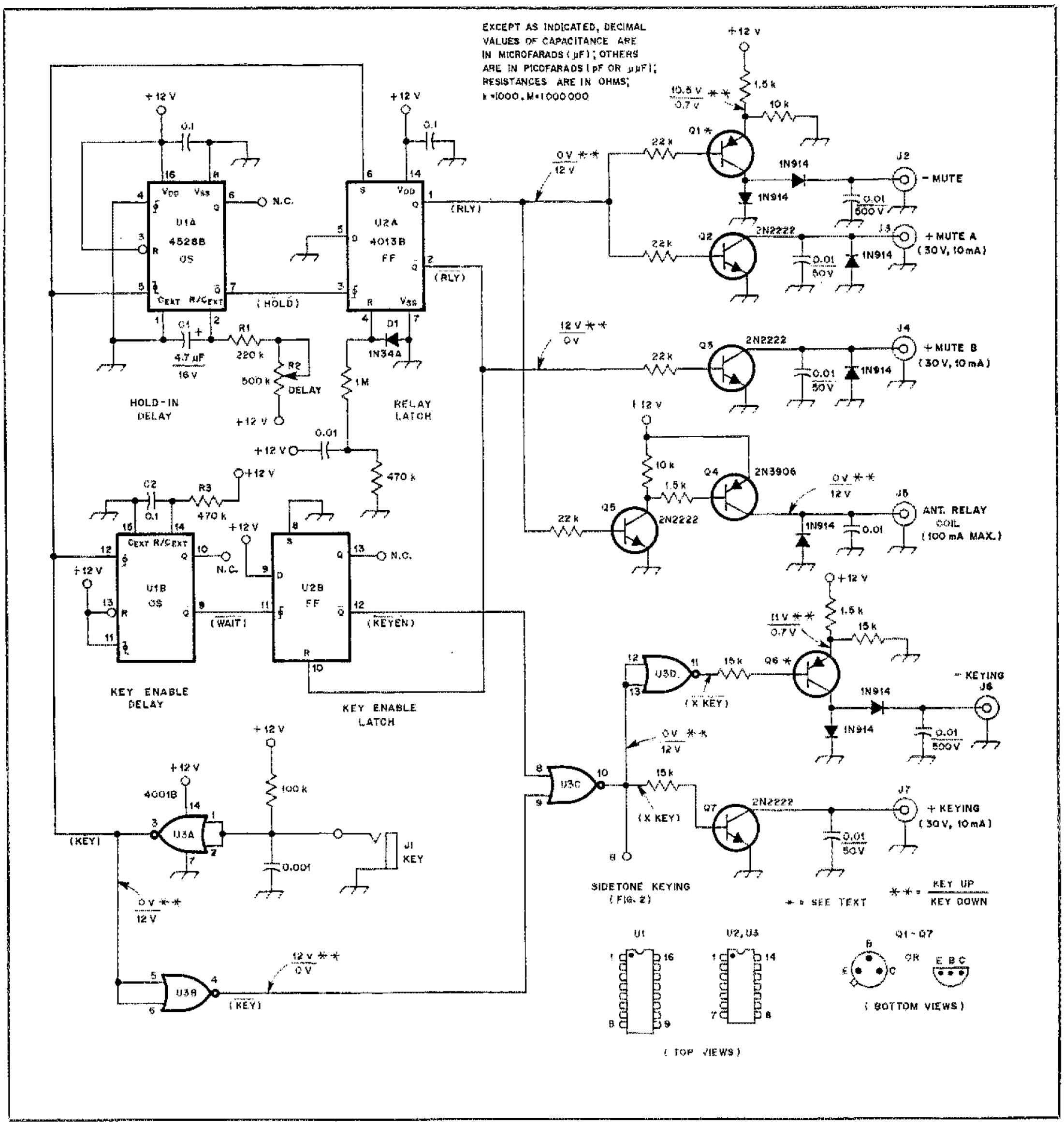


Fig. 1 — T-R controller-logic and switching-section schematic diagram. Unless otherwise specified, resistors are 1/4-W, 5% carbon types, and capacitors are 16-V disc ceramics. Polarized capacitors are electrolytic. Numbered components not listed below are for text reference only. Radio Shack part numbers are shown in parentheses.

C2 — 0.1-µF, 25-V Mylar.
D1 — 1N34A germanium diode (276-1123); type 1N270 also suitable.
J1 — 1/4-inch phone jack (274-252).
J2-7, incl. — RCA type of phone jack (274-346).
Q1, Q6 — High-voltage pnp switching transistor, ECG 288 or equiv.
Q2, Q3, Q5, Q7 — Npn switching transistors, 2N2222 (276-1617) or equiv.
Q4 — Pnp switching transistor, 2N3906 (276-1004) or equiv.
R2 — 500-kΩ, linear-taper, panel-mount control (271-210).
U1 — 4528B CMOS dual monostable (276-2496).
U2 — 4013B CMOS dual D-type flip-flop (276-2413).
U3 — 4001B CMOS quad two-input NOR gate (276-2401).

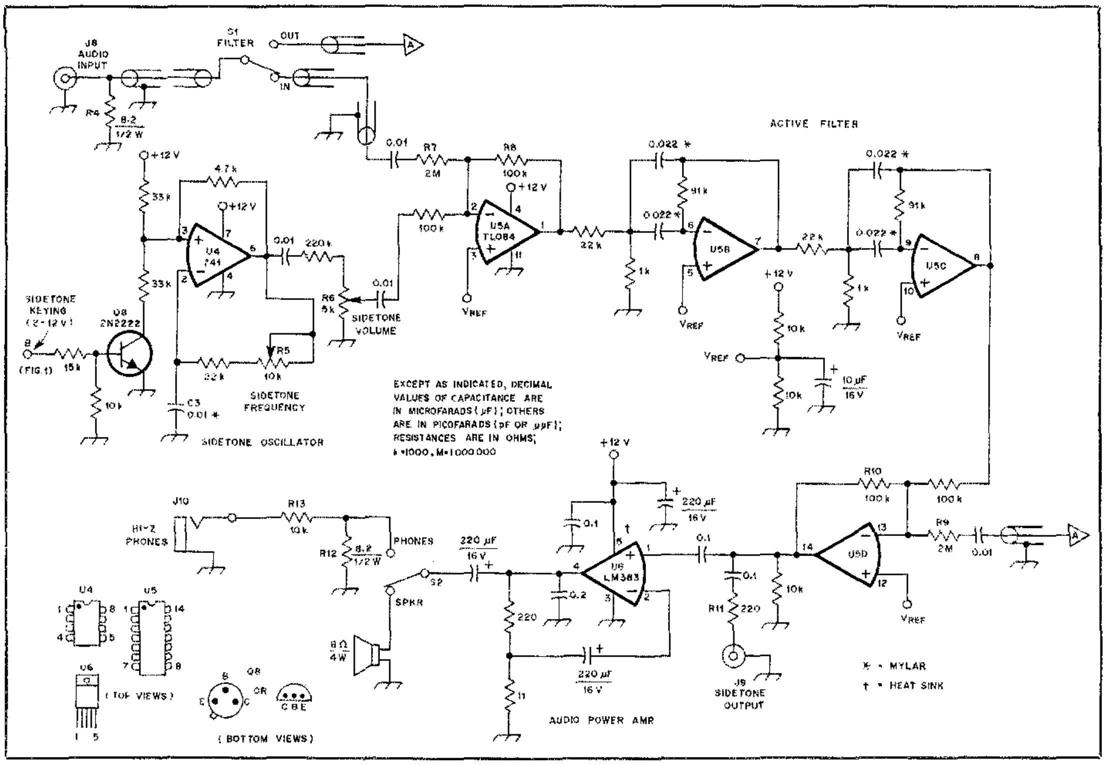


Fig. 2 — T-R controller-sidetone and audio-section schematic diagram. Unless otherwise specified, resistors are 1/4-W, 5% carbon types, and capacitors are 16-V disc ceramics. Polarized capacitors are electrolytic. Numbered components not listed below are for text reference only. Radio Shack part numbers are shown in parentheses.

C3 — 0.01-µF, 25-V Mylar.
J8, J9 — RCA type of phono jack (274-346).
J10 — 1/4-inch phone jack (274-252).
R5 — 10-kΩ, 1/4-W, pc-mount control (271-1720).
R6 — 5-kΩ, audio-taper, panel-mount control (271-1720).
S1, S2 — Miniature spdt toggle switch (275-613).
U4 — 741 op amp, 8-pin DIP (276-007).
U5 — TL084 quad op amp (276-1714).
U6 — LM383 audio amp (276-703).

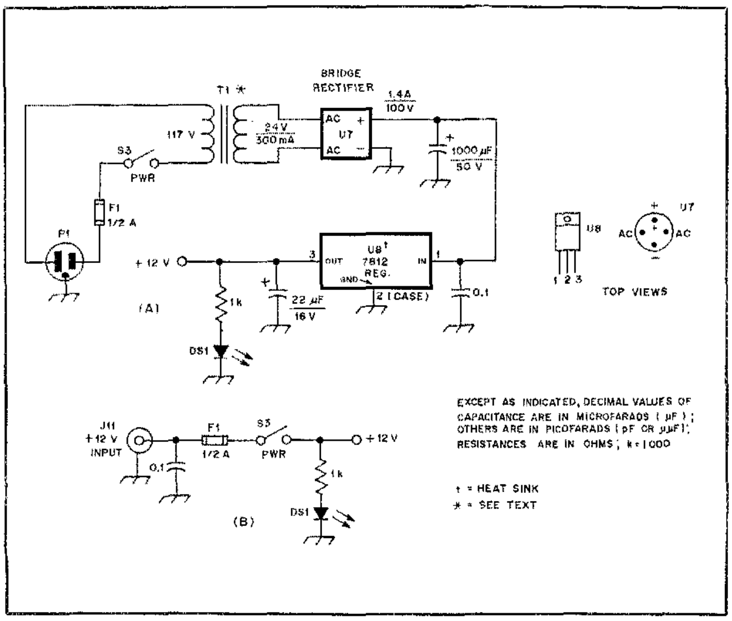


Fig. 3 — T-R controller ac power-supply schematic diagram (A). Alternative wiring for operation from an external 12-V dc supply is shown at B. Unless otherwise specified, resistors are 1/4-W, 5% carbon types, and capacitors are 50-V disc ceramics. Polarized capacitors are electrolytic. Numbered components not listed below are for text reference only. Radio Shack part numbers are shown in parentheses.

DS1 — Red LED (276-041).
P1 — Three-wire line cord with plug.
T1 — 24-V, 300-mA transformer (273-1386). See text.
U7 — 1.4-A, 100-V bridge rectifier (276-1152).
U8 — 12-V, 1-A, three-terminal voltage regulator (276-1771).
J11 — RCA type of phono jack (274-346).

easier. Start by mounting the power-supply components on the sidetone board. For safety, mount the circuit board, the power switch (S3) and the fuse (F1) in the cabinet before testing. Plug in the unit and close S3. DS1 should light, and the voltage at the output of U8 (pin 3) should be between 11 and 13 V. The input voltage to U8 (pin 1) will be approximately 35. This is higher than necessary and results from the use of a readily available 24-V transformer. If you can obtain an 18-V transformer, it can be used in place of the specified unit. I modified a 24-V transformer by removing turns from the secondary winding until the ac voltage measured approximately 18. This is relatively easy to do, and the lower voltage reduces the amount of heat generated by the regulator IC (integrated circuit).

After testing the power supply, you can assemble the remainder of the sidetone board. Be sure to use sockets for mounting U4 and U5. U6 is soldered directly to the circuit board (as are U7 and U8). You may need to bend the leads of U6 slightly to match the circuit-board pads. Before applying power to the circuit, check the orientation of Q8 and that of each IC. Make sure the wiring is correct, and check the value of each resistor and capacitor. Place S1 in the OUT position, set R6 at midrange and switch S2 to SPKR. Now apply power and connect the sidetone keying input (point B, Fig. 2) to the 12-V supply. You should hear a tone in the speaker. If you don't, turn off the power (unplug the line cord!), then recheck the wiring and the placement of each component. With R6 set for a moderate audio level, adjust R5 for maximum volume. Adjusting R5 in this way sets the sidetone signal to the center frequency of the active filter. This is necessary if we are to obtain a pure tone and good keying characteristics.

The next step is to assemble the logic board. Sockets should be used for all the ICs on this board. These ICs are CMOS (complementary-symmetry metal-oxide semiconductor) devices and can be damaged by static discharges. CMOS ICs should always be stored with the pins inserted in conductive foam or wrapped in aluminum foil. Touch a grounded conductor before handling the ICs, and don't place them in the sockets until all the wiring has been completed and the board is ready for testing. Never insert or remove a CMOS device while power is applied to the circuit! If you follow these rules, you shouldn't have difficulty working with CMOS ICs.

To test the logic board, connect the remote antenna relay (Fig. 5) to J5, and a key to J1. When power is applied, key closure will cause the relay to switch to the transmit position. When the key is opened, the relay should remain closed for a short time (the hold-in delay period). The length of time the relay remains closed depends on the setting of R2. The maximum hold-in delay is approximately 2 seconds.

The keying delay is so short that you won't be able to observe it without using a dc oscilloscope. If a scope is available, connect it to pin 9 of U1. Attach an electronic keyer (set the speed for 20 to 30 wpm) to J1 and close the dot lever. The scope should display a square wave that switches from 12 V to ground. The signal should remain at ground for approximately 25 ms. As a final check, measure the key-up and key-down voltages shown in Fig. 1. Be sure to wait until the hold-in delay has "timed out" before measuring the key-up voltages.

The controller and the antenna relay should be housed in metal enclosures for shielding. I used commercially available boxes for both enclosures, but homemade units constructed of circuit-board material will serve as well. Don't mount the sidetone board too close to T1. Also, keep the audio leads away from the ac wiring. Shielded wire should be used for all the audio wiring, and the shields should be grounded as shown in Fig. 2. I like to use shielded wire for the external leads to the relay, the transmitter and the receiver, as well. This avoids problems

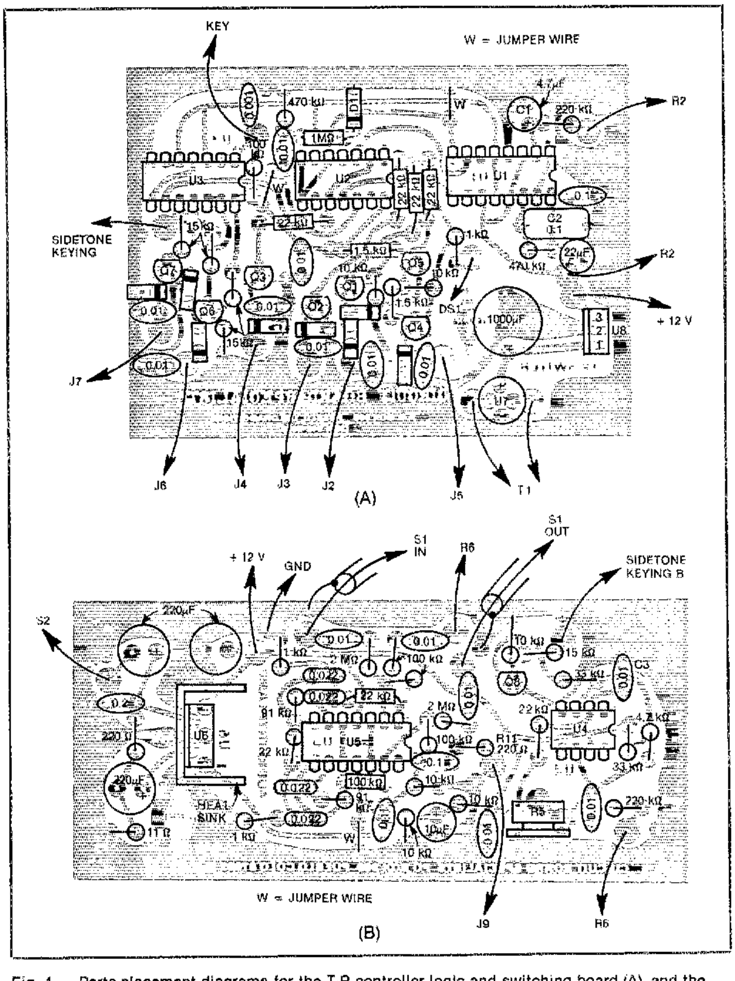


Fig. 4 — Parts-placement diagrams for the T-R controller logic and switching board (A), and the sidetone and audio board (B). The boards are shown from the component side. Gray areas represent an x-ray view of the unetched copper. Etching patterns for these boards appear in the Hints and Kinks section of this issue.

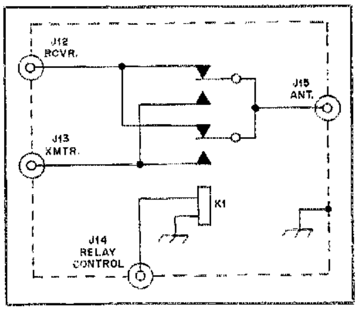
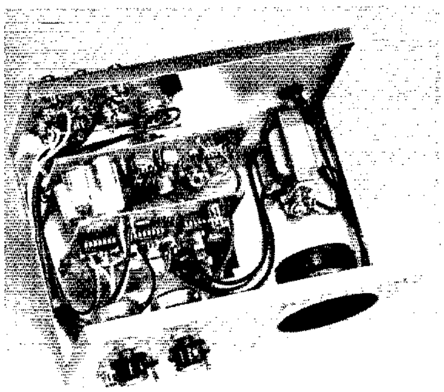


Fig. 5 — Remote antenna relay schematic diagram.

J12, J13, J15 — SO-239 coaxial-cable connector (278-201).

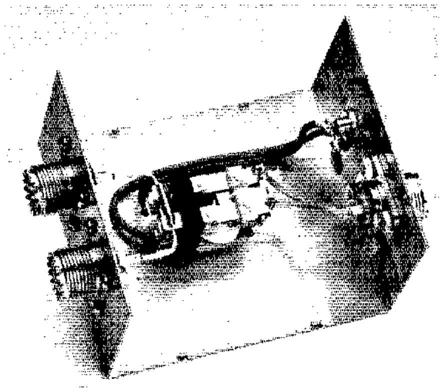
J14 — RCA type of phono jack (276-346).

K1 — Dpdt relay, 10-A, 125-V ac contacts, 12-V, 160-Ω coil (275-218).



This version of the controller was constructed in a metal cabinet available from Radio Shack (270-269). A larger-than-necessary cabinet was used to allow other station accessories to be added later.

The remote antenna relay is housed in a 3 × 2-1/2 × 2-inch aluminum box.[2] Leads to the moving contacts are removed from the relay terminals and connected directly to the ANT connector. The relay is held in place by silicon adhesive applied to the relay frame and the box.



that might be caused by rf being picked up on the leads.

A few of the components in the controller must be selected with care. In particular, the capacitors used in the keying-delay circuit (C2) and the active filter should be low-leakage types (such as Mylar). They should have a tolerance of 10% or better. Q1 and Q6 are high-voltage pnp switching transistors. The critical parameter of these transistors is the collector-to-emitter breakdown voltage (V_{ceo}). Almost any pnp device rated at 150 V or more can be used. The other transistors are not critical.

Using the T-R Controller

Connecting the controller to your gear doesn't require much more than plugging the receiver muting line and the transmiter keying line into the correct switching-circuit jack. After that, all that remains is to connect the sidetone and audio amplifier/filter section. This can be done in a number of ways, depending on your particular needs. To use the amplifier in the controller, you connect the receiver audio output to J8. If the receiver output has a high impedance characteristic, you'll need to change the value of R4 to 47 kΩ. You can adjust the gain of the amplifier to suit the output level of the receiver by changing the value of R7 and R9. Increasing the resistance will lower the gain.

If you do not wish to use the amplifier in the controller, J9 can be used to feed the sidetone signal to your receiver audio section. With some receiver sidetone inputs, it may be necessary to increase the value of R11 to between 10 kΩ and 47 kΩ. Use the value that provides the best signal level with your receiver. The values shown for R12 and R13 were selected for use with high-impedance (2-kΩ) headphones. If you are using low-impedance phones, R12 should be omitted and R13 changed to 10 Ω.

How It Works

There are two parts to the T-R controller logic section. One part (U1B and U2B) produces the keying delay, and the other (U1A and U2A) generates the hold-in delay. U1 is a dual monostable multivibrator, or one-shot device. This device produces an output pulse each time a trigger signal is applied to the input. The length of the pulse is determined by the R-C network connected to the timing inputs C_{ext} and R/C_{ext}.

U2 is a dual flip-flop; it acts as a memory device. When a transition from a logic Ø (0 V) to a logic 1 (12 V) occurs at the clock input (pin 3 or 11), the logic level at the data, or D, input is transferred to the output (Q). After the clock transition has occurred, the logic level at the D input can change, but the Q output state will remain the same — the flip-flop will "remember" what level the input was at when the last clock transition occurred. This flip-flop is clocked only by a Ø-to-1 transition; the reverse transition will not affect the output state. Flip-flops of this type are referred to as being positive-edge triggered.

When the key is closed, the output of U3A (which is connected as a simple inverter) changes from a logic Ø to a logic 1. This Ø-to-1 transition triggers one-shot U1B. As soon as U1B is triggered, the $\overline{Q}$ output goes to logic Ø. $\overline{Q}$ will remain a Ø for the keying delay period. When U1B times out, $\overline{Q}$ changes from a Ø to a 1. This positive transition triggers flip-flop U2B. Because the D input of U2B is at +12 V, the triggering causes the Q output to go high (a logic 1). The $\overline{Q}$ output is always in the state opposite that of the Q output, so it goes low. The logic Ø from $\overline{Q}$ is used to control the gating of the key signal, through U3C, to the transmitter keying switches (Q6 and Q7). This prevents the transmitter from being keyed until the keying delay one-shot function has completed the timing cycle (25 ms). The keying will remain enabled until flip-flop U2B is reset.

U2A, the relay-latch flip-flop, also is actuated when the key is closed and the Q output immediately goes to a 1. This turns on the antenna relay circuit. It remains on until U2A is reset by U1A (the hold-in delay one-shot). This one-shot is triggered by a *negative* (1-to-Ø) transition; thus, it does not begin timing until the key is opened. When U1A times out, the $\overline{Q}$ output goes from a Ø to a 1. This clocks the relay-latch flip-flop, turning off the antenna relay circuit. Resetting the relay-latch flip-flop ($\overline{Q}$ = 1) causes the keying-enable flip-flop to be reset, making it ready for the next cycle of events.

Because the one-shots are retriggerable, the timing cycle starts over at every active transition. Thus, the hold-in delay is timed from the *last* key opening. The R-C network connected to the U2A reset input causes the flip-flop to be reset when power is applied. This ensures that the logic circuit will "come up" in the correct state when turned on.

Most of the signal lines in the logic section have been named. The names were chosen to indicate the function of the line. A bar over the name indicates that the function is active when the line is at a logic Ø. For example, the line labeled $\overline{\text{KEYEN}}$ is the keying-enable line. When it is at a logic Ø, the transmitter keying is enabled. The RLY line controls the antenna relay switch. It does not have a bar over it, so the relay is turned on when RLY is a logic 1. $\overline{\text{KEYEN}}$ is referred to as an active low signal, while RLY would be called an active high signal.

Conclusion

Versatility was a major consideration in the planning of the T-R controller. The logic and switching section will control just about any receiver and transmitter combination. By simply adjusting a few resistor values, the sidetone and audio section is tailored easily to a wide variety of receivers. I think you'll find that the Universal T-R Controller will simplify your station setup and increase your operating enjoyment.

Notes

[1]Etched circuit boards, parts and parts kits for the Universal T-R Controller are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002.

[2]mm = in. × 25.4.

Product Review

Conducted By Paul K. Pagel,* N1FB

ICOM IC-730 HF Transceiver

☐ My excitement ran high as I took the IC-730 home just in time for the November Sweepstakes phone weekend. I found the instruction manual easy to read, and logically organized. Noticeably missing was much of the literally translated Japanese that seems to plague some imported equipment manuals. A few minutes of reading the manual and checking the controls was all I needed to feel ready for a contact. Front-panel controls are clearly labeled and positioned for ease of operation.

The '730 comes with most of the features now considered standard on an hf transceiver. It covers the ham bands from 80 through 10 meters, including the three WARC bands. Modes of operation are a-m, lsb, usb and cw, with PTT, VOX or semi-break-in operation possible. Controls are provided for mike gain, rf power, af and rf gain, and band selection. An agc circuit with two selectable time constants is provided, but there is no way to turn it off completely. The noise blanker can be turned on or off using a push-button switch on the front panel. (Blanking pulse width is selected as wide or narrow with a control hidden under a removable panel on the case top.) Other features include an rf speech processor, receiver incremental tuning and a digital readout for the two VFOs. There is a built-in receiver preamplifier that is helpful for pulling in weak stations. A band-pass shift control (i-f shift) helps reduce interference from strong stations on nearby frequencies. This control also changes the tone of a received signal, which results in a decrease in the intelligibility of an ssb station.

The review unit was equipped with an optional crystal calibrator and the IC-EX203 150-Hz cw audio filter. An IC-PS15 ac-operated power supply provided the necessary 13.8-V dc at 20 A. This supply is controlled by the power switch on the '730. Other matching accessories available from ICOM include an external speaker, headphones, a mounting bracket for mobile operation, a desk microphone and a hand-held scanning microphone. Additional filters are the FL-45 (500-Hz) cw crystal filter and the FL-44 ssb crystal filter. The FL-30 crystal filter will also convert the i-f shift control to a true pass-band tuning system.

Special Features

Several features of the '730 deserve special attention. A four-bit microcomputer is used to control the phase-locked-loop local oscillator. This allows selection of three tuning rates, determined by push-button switches. You can change the VFO frequency in steps of 1 kHz, 100 Hz or 10 Hz. The faster rate is ideal for tuning from one end of the band to another, and the slower rate is convenient for "fine tuning" a station. The 100-Hz rate is about right for normal tuning, but you will hear the distinct incremental frequency changes as you tune through a signal. Don't be confused, as was one mystified '730 owner that I talked to. The tuning rate refers to the digital tuning jumps, not kilohertz per turn of the knob. A LOCK button prevents changing the operating frequency — a good idea for those of us who are prone to bumping the tuning knob!

Push buttons are used to select VFO A or B, and NORMAL/SPLIT operation. Either VFO can be used independently for transceive, or they can be used in tandem for split-frequency (same band) operation. The frequency of either VFO can be written instantly into the other by using the WRITE button, but be careful. To write the frequency of VFO B into VFO A, you first select VFO A, then push the WRITE button. More than once I tried to do it the other way and found myself with two VFOs at the opposite end of the band! The frequency of VFO A can be written into memory (one frequency per band) and, if the MEMO button is engaged later, it is like having three VFOs. On "power up," both VFOs and the memory will be 100 kHz up from the bottom of the selected band. A rear-panel jack is provided for the connection of +9- to +12-V dc source, such as the optional BC-10A ac-operated supply or the car battery in a mobile installation. This will retain the operating frequency of both VFOs and the memory on each band while the rig is switched off.

The RIT function is activated with a push button; an LED near the control indicates when it is in operation. I expected the digital frequency display to change as I turned the RIT control knob, but found that, as with my analog-readout rig, the displayed frequency remains the same.

A multifunction front-panel meter serves as an S meter on receive, but can indicate a variety of information on transmit. This will depend on the setting of the front-panel meter control and the SWR/SET switch under the top-cover access panel. The front-panel button can be set to indicate ALC or RF output. With this control set for RF output, the top switch can be used to indicate relative output power or SWR.

Also found under the top cover access panel are the VOX GAIN, VOX DELAY, and ANTI-VOX controls. The cw monitor level can be adjusted here, the noise blanker pulse width selected, and the speech processor switched on or off. The crystal calibrator is turned on and the 25- or 100-kHz marker frequency is selected by means of small slide switches. Operating any of these controls will require you to study the underside of the access panel for identification of the tiny controls. You will have to peek through the opening to see which switch you are pushing.

Rear-panel jacks are provided for connection of an antenna, a power cable, a key, an external speaker, a memory back-up supply and an accessory plug. The alc voltage from an external amplifier can be input through a jack provided for that purpose. There is a spring-type ground connector that aids fast connect and disconnect of the ground wire.

Receiver

An incoming signal is routed through a low-pass filter selected by the BAND switch. A preamplifier can be activated to provide about 10 dB of gain, if needed. Next, the signal proceeds to the band-pass filter as selected by the BAND switch. A high-level doubly balanced mixer combines the received signal with the first LO signal to provide the 39.7315-MHz first i-f. A signal from the second LO is combined with the first i-f signal in another high-level doubly balanced mixer to produce a second i-f at 9.0115 MHz. The MODE switch selects an a-m crystal filter only, or the additional ssb or cw crystal filters. With the FL-45 (500-Hz) cw filter installed, the CW-N position selects this filter, while the CW position selects the ssb filter. The signal now is converted to 455 kHz and is fed to either a ceramic filter in the a-m mode or a mechanical filter in the ssb or cw modes. The optional FL-44 ssb crystal

*Assistant Technical Editor

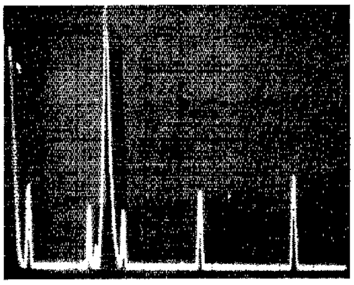


Fig. 1 — Worst-case spectral display of the IC-730. Vertical divisions are each 10 dB and horizontal divisons are each 5 MHz. Output power is approximately 90 W on 20 meters. All spurious emissions are at least 50 dB below peak fundamental output. The IC-730 complies with current FCC specifications for spectral purity.

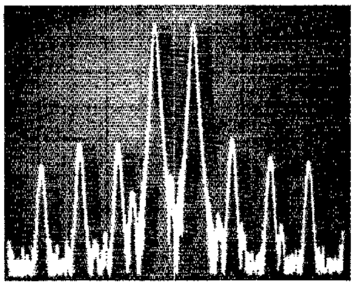


Fig. 2 — Spectral display of the IC-730 during the transmitter two-tone IMD test. Third- and fifth-order products are down 40 dB, and the seventh-order products are down 46 dB. Vertical divisions are each 10 dB, and horizontal divisions are each 10 kHz. The rig was being operated at 80-W PEP output on 20 meters.

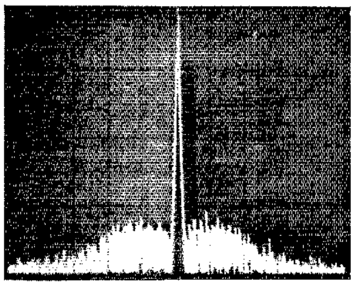


Fig. 3 — Synthesizer noise is shown in this photo. The IC-730 was producing 80 W of output power on 20 meters. Vertical divisions are each 10 dB, and horizontal divisions are each 10 kHz.

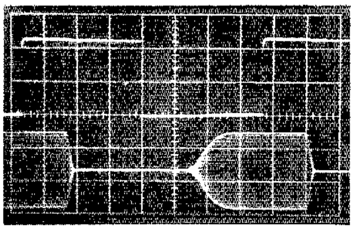


Fig. 4 — The keyed cw waveform of the IC-730 is shown. The upper trace shows actual key closure, while the lower trace shows the rf output envelope. Horizontal divisions are each 10 ms.

ICOM IC-730 HF Transceiver, Serial No. 01519

Manufacturer's Claim Specifications	*Measured in ARRL Lab*
Frequency coverage: 80 through 10 meters; WARC bands included.	As specified, plus 100 kHz above and below each band edge.
Modes of operation: lsb, usb, cw, a-m.	As specified.
Frequency readout: 6-digit blue luminescent display.	3/8-in.-high digits. Also analog marks on tuning knob, every 2 Hz in 10-Hz tuning position.
kHz/turn of knob: Not specified.	100 kHz/10 kHz/1 kHz for 1 kHz/100 Hz/10 Hz tuning.
Backlash: Not specified.	Nil.
RIT range: ± 800 Hz.	As specified.
S-meter sensitivity (μV/S 9): Not specified.	80 m, 150; 40 m, 150; 30 m, 140; 20 m, 160; 17 m, 160; 15 m, 180; 12 m, 190; 10 m, 180.
Receiver sensitivity: ssb/cw 0.3 μV for 10 dB S + N/N	Receiver dynamics measured with optional IC-EX203 150-Hz audio filter installed. The first number is with the internal preamp on.

	80 m	*20 m*
Noise floor (MDS) dBm:	− 140	− 140
	− 134	− 133
Blocking DR (dB):	N.L.†	
Two-tone 3rd order IMD DR (dB):	N.L.	96
	95	95
Third-order intercept:	N.L.	+ 4.0
	+ 6.5	+ 9.5

Audio power output (8-ohm load): 2 W.	As specified.
Power requirements: 13.8-V dc ± 15%, negative ground. Current drain 20 A max. (at 200-W input).	Not measured.
Transmitter rf output power: ssb, 200-W PEP input; cw, 200-W input; a-m, 40-W output maximum.	80- to 100-W output on all bands in cw mode.
Harmonic suppression: Better than 50 dB.	Second harmonic, − 54 dB; third harmonic, − 50 dB (Fig. 1).
Spurious suppression: Better than 50 dB.	− 60 dB (Fig. 1).
Third-order IMD: Not specified.	− 40 dB (Fig. 2).
Color: Black.	
Size (HWD): 3.7 × 9.5 × 10.8 in.††	As specified.
Weight: 14.1 lb.	As specified.

†N.L. means noise limited
††mm = in. × 25.4; m = ft X 0.3048; kg = lb × 0.454.

filter can be used to replace this mechanical filter if you desire greater ultimate rejection at the − 60 dB points and a better i-f shape factor. A 9.4665-MHz LO can be shifted ± 1.5 kHz by sliding the IF SHIFT control. This oscillator provides the fourth conversion in the receiver circuit, back to the second i-f of 9.0115 MHz before sending the signal on to the detector and af amplifier.

The review unit also had the 150-Hz audio filter installed. This filter is activated in either CW position, providing a very narrow passband. If you like tuning the band with a wider filter, you will have to switch to the USB mode. But this causes the operating frequency to shift 1.5 kHz. When you find a station you want to copy, and switch to the CW mode, you will have to retune the rig. I found this somewhat annoying.

The receiver proved to be quite sensitive, and displayed good dynamic range. The front end was not "crunched" by most strong, locally generated signals.

Transmitter

The '730 has a solid-state, broad-band transmitter that provides between 80 and 100 W of maximum output power into a 50-ohm load. There is no tune-up required, and the final-amplifier transistors are SWR-protected. I found that the output started to be cut back as the SWR approached 2:1. Most of the time I used a random-length wire antenna (a no. 30 wire out the window and attached to the rain gutter) and a Transmatch in a "no outside antennas" apartment. The Transmatch provided a 50-ohm load on all bands to keep the final transistors "happy."

The MIC GAIN control adjusts the level of modulation, and should be adjusted until the alc meter is moving within the bottom half of the scale. An RF POWER control adjusts the output from about 10 to 100 W. With the speech processor switched on, the MIC GAIN sets the clipping limits while the RF POWER control sets the rf drive level.

There is only one VOX DELAY circuit, so if you like to use VOX on phone and work semi-break-in cw, you will have to readjust the delay each time you change modes. This is not difficult, but can be a nuisance.

The final-amplifier transistors are cooled by a fan that runs only during transmit. A temperature-sensing circuit will switch the fan to a faster speed and keep it on continuously if the transistors reach a temperature of 167° F (75° C). The operating manual warns you to stop transmitting and investigate the cause of the overheating. The fan is fairly quiet, but I found it annoying to have it turning on and off with each cw character being sent.

The cw keying waveform exhibits an excessive delay after key up. The changes suggested in the article by Don McClure, KB2Z, "Keying Improvements to the ICOM IC-730," July 1982 *QST*, pp. 23-27, would make it a better cw rig.

Operating Impressions

I first operated the '730 during the November SS Contest. It didn't take long to really appreciate the ease of operating this rig. With low power and "no antenna," I use the "hunt and pounce" method of contesting. The two VFOs plus memory made it easy to keep tuning and working stations, while jumping back to a pileup and seeking a chance to work a particular station.

The receiver has several "birdies" on each band. Most are just noticeable with no antenna connected, and do not move the S meter. There are three birdies that cause the S-meter needle to move just perceptibly, but these are outside the band edges. One signal at 17.9460 MHz reads S4.

Initially, the review unit seemed to have low audio output, with severe distortion at high volume levels. This was noticeable with the built-in speaker or an external speaker, but not with headphones. In this condition, the rig was totally unacceptable for mobile operation. The high ambient noise level in my car requires lots of audio from the radio, and the '730 just couldn't supply it without distorting the signals to an unintelligible level. Later on, the audio amplifier failed completely and the rig was shipped back to the factory for repair. It was returned promptly, and the audio problems were cured. The rig is now a pleasure to operate while mobile.

Doug DeMaw, W1FB, tested the '730 in anticipation of taking it on a hamcation trip to Barbados. When Doug reported to several stations that their frequency was jumping during the QSO, they replied that *his* frequency was *also* changing. What could this problem be? The rig went back to ICOM instead of to Barbados. This repair took about three weeks, with a report that an intermittent had developed in the VFO power supply.

What don't I like about the '730? I would prefer to have separate VOX DELAY controls for ssb and cw operation, and I would like these and other controls to be located on the front panel instead of under the top cover. I would also like to be able to select the 150-Hz audio filter when needed for cw reception. I wonder why no 160-meter position was included. These concerns may be minor when compared with the many good features of the rig.

In conclusion, the IC-730 is a pleasure to operate. It has almost every feature you could ask for, either built-in or available as an accessory. Small size makes it ideal for a mobile installation or traveling, but it will serve nicely in the fixed-station operating position also.

Price class: IC-730, $829 (including mike); IC-PS15, $149; FL-45, $60; IC-EX203, $39. Available from: ICOM America, Inc., 2112 116th Ave., N.E., Bellevue, WA 98004 — *Larry Wolfgang, WA3VIL*

HEATH COMPANY GU-1820 AC POWER SYSTEM

☐ Solar-electric power has yet to negate the utility of gasoline-powered ac generators. The latter can provide plenty of watts for operating electrical items, even when the sun is not shining! They are noisy, and they consume gasoline, but they're ideal for emergency and Field Day use by amateurs. The Heath GU-1820 is no exception.

I was surprised to learn that the Heath power system was supplied in kit form. I didn't fancy myself as a mechanic or engine specialist, nor do I at present. Therefore, I was relieved to find that the engine was preassembled and adjusted. A 5-hp Briggs and Stratton engine (3600 rpm) tended to "ice the cake," since that brand has such an outstanding reputation. It was all shiny and black, just waiting to be activated by a mighty pull of the starting rope!

The manufacturer rates the alternator at 2200 W maximum. It is a single-phase, 2-pole, revolving-field, self-excited mechanism. The power factor is 1.0, and regulation is ± 5%, no load to full load. The output is 120-V ac at 60 Hz. Running time is 1.75 hours per tank of fuel at one-half load (1100 W).

Assembly

An assembler commences by putting the frame together. You need some tools a bit more rugged than those designed for most radio work, so plan to have a 6- or 8-inch crescent wrench, a pair of pliers, a heavy-duty screwdriver and a socket-wrench set (if available). Watch out for skinned knuckles, for there are some sharp edges on the metal parts of the system.

The engine attaches next, then comes installation of the adaptor housing, followed by insertion of the alternator rotor. So far so good — and no confusing instructions of the kind found with kits for those swing sets, etc., that you've built for your children! If you've ever agonized over the poor language and vagaries of instruction sheets for toys and household items, you'll be delighted with the clarity of the Heath instruction manual.

Assembly of the end-bell parts (mostly electrical) is the next step. But first, the end bearing must be driven into the housing by means of a hammer and wooden rod (supplied). Do this step with care, lest the bearing not start correctly in the hole. Tap and inspect, tap and inspect, until you're sure the bearing is well into the hole and that it has gone into the housing correctly. If it becomes cocked during this step, damage (and frustration) will surely result.

Installation of the electrical wiring and parts comes next. The end bell contains nearly all of the wiring, an electrolytic capacitor, the brushes, a rectifier, a circuit breaker and ac outlet plugs. Once these components are in place you can install the stator for the alternator. Then, some final wiring is done. It consists of connecting the leads from the stator to the appropriate terminals in the end bell. It is necessary also at this juncture to polarize the alternator. The task is a simple one, consisting of attaching a 6- to 15-V dc source to the brushes while observing the proper polarity. This job takes about 15 seconds.

Finally, the end bell is bolted in place and some adhesive-backed labels are affixed to specific parts of the system. My, what a pretty sight the completed power system presented as I stood back and admired my work (and gingerly touched my skinned knuckles). I was anxious to "gas up" and pour in some oil so I could see if it actually would function. More on that later.

Some Problems

The first two alternator rotors had to be sent back to the factory because of damage. The end of the rotor that contains the slip rings for the brushes to contact is made of plastic. The first two units had broken plastic face plates, owing to improper packaging for shipment. The third and final rotor was packed very well, and it was in perfect condition. I assume that Heath has corrected the packaging problem after receiving our recommendations.

I experienced difficulty with the plastic insert (item B5) that mounts in the end bell to secure the brushes. The electrical terminals are affixed to the insert piece by means of sheet-metal screws. The latter must be inserted with great care (and I was careful), for as they develop threads in the plastic the insulating block can become chewed up by the screw. This will result in poor electrical joints; the sheet metal screw may vibrate loose in time. I stripped one of the holes and had to use the next larger size sheet-metal screw to ensure integrity in that part of the system. Use caution when doing this step! I think a better technique would be for the supplier to tap the holes in the plastic insert for, say, a no. 8-32 thread. Then, no. 8-32 bolts could be used to secure the brushes. If there is a weak link in the chain, I'd say this part of the system is it.

My final difficulty came during initial testing of the system. Upon starting the engine, my pulse hastened in anticipation of having ac

Heath Company GU-1820 Portable AC Power System

Manufacturer's Claimed Specifications	*ARRL Evaluations*
Engine type and rating: 5 hp, 4 cycle, Briggs & Stratton.	As specified.
Output voltage: 120 ac (nominal) at 60 Hz.	As specified.
Circuit voltage: 20-A reset circuit breaker.	As specified.
Frequency regulation: 4 Hz max., no load to full load.	As specified.
Voltage regulation: ± 5%, no load to full load at rated 3600 rpm.	No rpm check made, but regulation as stated.
RFI: Contains RJ-8 resistive spark plug.	No RFI noted when frame of unit grounded and generator operated 100 ft from radio antenna.
Running time: 1.75 hours per tank of fuel at half load (1100 W).	Not tested
Carrying method: Half-cradle handles.	As specified.
Weight: 84 pounds (38 kg) with oil and fuel in unit.	Not checked.
Dimensions (HWD): 15 × 16 × 31 in. (380 × 410 × 790 mm).	As specified

voltage available for my soldering gun, my test appliance. What ho? No power was available! A check of the output receptacle showed "zero volts." I removed the end bell, started the generator again and found that the missing voltage had appeared. Back went the end bell into position; no output voltage again! After removing the end bell once more, I spotted a damaged wire that had been squeezed between two metal surfaces. The insulation was punctured, and a short circuit resulted. The manufacturer warns against pinching the leads, but it's hard to ensure they're in the clear when the end bell is bolted on. I recommend considerable care when attaching the end bell.

The instruction booklet for the gasoline engine does not specify how much oil is required. It instructs the user to fill the chamber with oil, so I assumed I was supposed to bring the oil level up to the top of the filler hole, or nearly so. That's what I did. The system seems to run nicely, and there's no splatter of oil on the garage walls to indicate that I erred in my decision.

Final Coments

The last step in making the system ready to use is to set the governor for the proper speed to ensure the correct line frequency. This requires an electric clock and a watch with a sweep second hand. The process is a simple one and can be accomplished in a short period. Assembly time for me was approximately five hours. A person with better mechanical aptitude than I could doubtless do the job much faster.

The unit runs smoothly and starts easily.[1] It appears to be excellent for use during camping trips and Field Day exercise, and when emergency power is needed for communications during storms and other acts of God. Proof of field performance came when AK4L/VE1CER of the ARRL staff borrowed the generator for a DXpedition to St. Paul Island (VE1SPI operation, July 1982). The plan was to use two 1200-W gasoline generators borrowed from the Nova Scotia government, plus the GU-1820. Some of the crew doubted that the Heath unit — though rated at 2200 W — would do the job, owing to the small size.

During the five-day operation, the operators had just over 12,000 QSOs, and the GU-1820 provided power for most of the contacts. The other power plants were old and hard to start, but from the first pull of the starter rope, the '1820 provided excellent service. The usual load for the Heath generator was two 100-W hf-band transceivers and a linear amplifier running at 400 W of output power (plus some table lamps).

If you've been considering a power plant, this may be the one to consider. Manufactured by the Heath Company, Benton Harbor, MI 49022. Price class: $480. — *Doug DeMaw, W1FB*

[1]Initial starting of the engine is difficult, owing to the lack of fuel in the carburetor and supply lines. After several yanks on the starting cord, I decided to remove the spark plug and drip about 6 drops of gasoline into the cylinder head. The plug was replaced, and the engine started on the first pull of the rope.

TET HB-35T TRIBAND ANTENNA

☐ This review has been delayed for a considerable time in an effort to resolve what, in my opinion, appeared to be mechanical problems with the antenna. During this period of evaluation (about seven months), the antenna has been raised and lowered at least six times; on two occasions, twice in one day. I am now quite familiar with and I like the antenna. It really performs. If you're thinking of purchasing one, there are some things you should know about it.

The HB-35T offers five elements on 10 and 15 meters, and four elements on 20 meters, on a 24-foot 7-inch boom. The first director functions only on the two higher frequency bands. Driven out of phase, the two rearmost elements are connected by phasing rods to a small piece of plastic midway between the two elements. Supplied originally, this was a piece of circuit board with the crossover etched into it. The manufacturer reports that this was not well received by some amateurs, though I saw nothing wrong with it, and it served its purpose. However, a replacement is being offered to all HB-35T owners, and the new crossover is now made by means of metal links crossing over and under the plastic. The two driven elements are responsible for the generous bandwidth offered by this antenna.

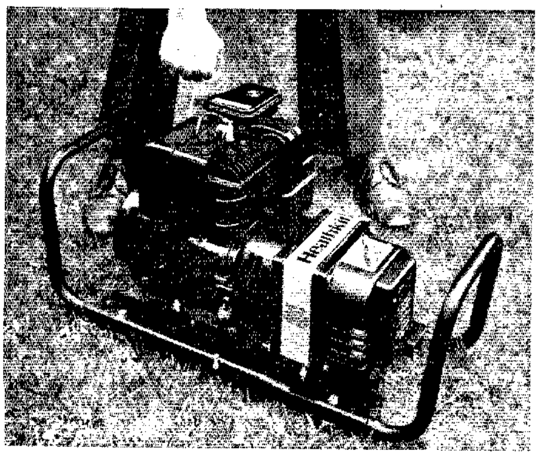
The manufacturer initially supplied triangular plastic wedges to fit between the boom and the U bolts at each element, and at the boom-to-mast mounting point. Apparently these were not entirely satisfactory, as replacements have been supplied to all purchasers, and present production has been updated to include wedges made of aluminum stock.

Disappointment

When first erected on the tower, the HB-35T showed a dismal and disappointing SWR of about 7:1 across each band. The tower was lowered, and the antenna was thoroughly inspected. I suspected that the coaxial balun supplied by the manufacturer might be defective, but, before replacing it, I decided to try something else first. When installed initially, the balun was strapped securely to the boom with nylon electrician's straps in front of the forward driven element. Could this balun somehow be coupled capacitively to the boom? The straps were removed, and the balun was stood on end, with only one strap holding the balun to the boom. The resultant SWR curves are shown in Fig. 5. A telephone conference with the manufacturer disclosed that 25% of the HB-35T antennas sold have evidenced the same problem.

Why not all of them? I don't know. Perhaps some other method of securing the balun to the boom was used. On a subsequent raising, the elements were mounted below the boom, and the balun was permitted to hang down slightly below the boom. This situation produced an SWR response almost identical to the one shown. The manufacturer says nothing about this potential problem in the instructions, and has not acted on my suggestion that the problem could be eliminated by a change in the instructions to indicate that the elements should be mounted below the boom. Apparently, the manufacturer intends to handle such problems on a case-by-case basis. Should you purchase this antenna, you now know what to do. The suggestion has been made to the manufacturer that a truss be provided to support the boom so that all the elements might be in a direct line. While this is not a serious matter, there is some sag in the boom. The manufacturer has indicated that there are no plans to provide a truss at this time.

It is recognized that an early model of this antenna was made available for review. However, Figs. 2, 4 and 5 of the instruction



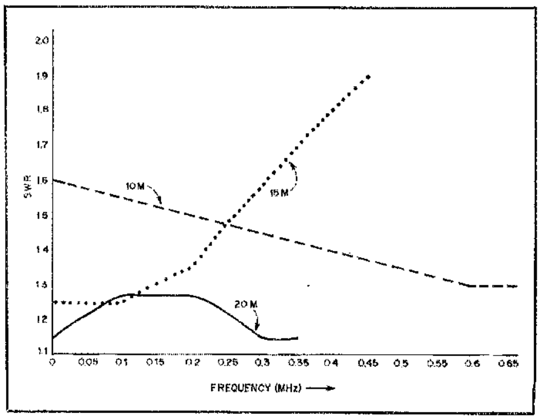


Fig. 5 — SWR curves of the TET HB-35T.

TET HB-35T Triband Antenna

Manufacturer's Specifications

Power capability:	3 kW
Nominal feed impedance:	50 ohms
Maximum element length:	27 ft 6 in.
Turning radius:	18 ft 10 in.
Suitable mast size:	1-1/2 to 2 in.
Weight:	49.5 lb.
Wind surface area:	8.1 square ft.
Wind load at 80 mi/h:	162 lb.

sheets were missing, and were not supplied until sometime later, well after the antenna was installed. I can feel for the inexperienced amateur who may be putting together his first triband array, and who runs into such a situation. It is frustrating and completely avoidable. (Simple household accessories frequently come with better instructions than those accompanying complex amateur antennas costing hundreds of dollars.) It is a general failing of most antenna manufacturers. The manufacturer advises that the HB-35T instructions are now complete.

So much for the gripes. It is impossible to make an element-dimension error. The tubing is drilled just where you are to insert a self-tapping screw to pin the sections together. Metric socket or open-end wrenches are a big help. Short of these, a small adjustable wrench may be used. The hardware is stainless steel, including the U bolts, and should be trouble-free for many years.

Comments

What do I like about the antenna? Just about everything else. The antenna exhibits excellent bandwidth. It has a rugged construction, and has survived a severe New England winter with no apparent deterioration in physical integrity or electrical performance. In the final analysis, it is an excellent DX antenna with countless foreign stations commenting favorably on the signal from W1SE while operating "barefoot," as well as at the legal power limit. The HB-35T is available from: TET Antenna Systems, 1309 Simpson Way, Suite F, Escondido, CA 92025. Price class: $330. — *Lee Aurick, W1SE*

INSTANT SOFTWARE ELECTRONIC BREADBOARD PROGRAM

☐ No one knows for sure who first came up with the idea. It was during the early days of Amateur Radio; an enterprising young ham with more enthusiasm than dollars wanted to test a new circuit. His bankroll would not stand the price of a metal chassis just to test an idea. What would serve as a substitute? Of course! A few minutes later, he was securing the major components of his project to his mother's breadboard. A couple of hours later, when terminal strips, wires, resistors and capacitors had been carefully connected in place, the unit was ready to test. History does not record the name of this brilliant young man, nor do we know the results he obtained. But the concept of using a breadboard for circuit prototyping was born.

In recent years, a number of manufacturers have introduced products that make circuit prototyping easy. All you need are the components and some hookup wires — no solder needed! What could be easier?

Now you can prototype linear circuits without solder or hookup wire. You don't even need the components! The Electronic Breadboard allows the user to design and simulate linear electronic circuits on a computer, and to evaluate voltages, currents, impedance and frequency response of the circuits. To run the program, you need a Radio Shack TRS-80® microcomputer, Model I or III, level II, with at least 16 K of memory. This program was not intended to analyze digital circuits, or ones that include reverse-biased transistors. Using this program you can: add or remove components, determine the voltage at a particular point in the circuit or at all points in the circuit, set the operating frequency for ac or dc operation, analyze circuit operation while using linear or logarithmic frequency sweeps, calculate the impedance at a particular point in the circuit, save and load circuit designs via cassette tape, and calculate the current through all voltage sources.

No matter what your level of electronics expertise, you can use The Electronic Breadboard. The beginner can practice Ohm's law problems, while the more advanced user may design a matching network for use in a new amplifier.

Capability

Resistors, inductors and capacitors, as well as current and voltage sources, can be simulated by the program. Page 18 of the program documentation booklet says, "By definition, a current source is considered to have infinite resistance so the current will not affect the resistance. On the other hand, an ideal voltage source, which the program is working with, has zero resistance." For active components you can choose operational amplifiers or bipolar transistors. Transistors must operate in their linear range — that is, never in cutoff or saturation.

Before you run the program, you should make a sketch of your circuit, numbering all nodes. The procedure for doing this is explained clearly.

It takes quite a while to load a complicated circuit. It is nice to be able to save a circuit on cassette for further analysis at a later time. When a circuit is loaded from a cassette, you have the option of increasing the number of nodes or voltage sources.

A simple command calls to the screen a list of all components in the circuit under evaluation. Working with 16 K of memory will allow solution of circuits in which the sum of nodes and voltage sources is less than 16. You could consider, for example, a 14-node circuit with one voltage source. There will be sufficient memory remaining for the circuit to contain 40 components. If your computer has more memory, you can add more nodes, voltage sources and components.

Current and voltage sources can be defined as dc or ac generators. Response tests can be run at a single frequency or in one of two sweep modes. In a linear sweep, the difference between test points is always the same; in a logarithmic sweep, the difference gets larger as the frequency increases.

When you call for a linear frequency sweep, you will have to define the minimum and maximum frequencies and the increment (step size) between test points within those limits. You will then select the node you want to examine during the sweep. Next, you select a graphic or tabular output of the results. Tabular results indicate frequency, voltage and phase at the selected node. Graphic results will show data for either voltage or phase at the selected node. While in the graphic mode, if you wish to return to the command mode, simply hold down the "S" key until you return. You will want to know that! I tried a graphic display of output from a cw audio filter; it took 53 minutes to compute and display the results. I should have read the documentation first!

Documentation

Just nine short pages give you all the information you need to run the program. Don't stop when you get to page 10! Beginning at that point, there is a section entitled "An Introduction to Electronics." It looks pretty simple at the start, and it is; but hidden throughout that part is some pretty important information.

A word of caution is in order. The documentation is not well written and there are errors. On page 14, the equivalent resistance for a pair of resistors is given as

$$R_{EQ} = \frac{R_1 R_2}{R_1 R_2} \qquad \text{(Eq. 1)}$$

The correct formula is

$$R_{EQ} = \frac{R_1 + R_2}{R_1 R_2} \qquad \text{(Eq. 2)}$$

The formula for resonant frequency is given on page 22 as

$$f = \frac{1}{2\pi}\sqrt{LC} \qquad \text{(Eq. 3)}$$

The proper formula is

$$f = \frac{1}{2\pi\sqrt{LC}} \qquad \text{(Eq. 4)}$$

In a discussion of imaginary impedance, the documentation says, "This is the mathematical 'imaginary,' where the impedance still exists but is just not directly observable." The word "imaginary" does not refer to the observability of the impedance at all; rather, it refers to the number scale that is used to represent it mathematically. Confusing? Read on!

Fig. 21 in the booklet shows an operational amplifier application. A plus sign is placed near the inverting input of the op amp. For those of us who are used to electronic terminology, this can be confusing! This is either mathematical terminology or an error. In the former case, the plus indicates the summing input; the inversion is ignored.

I ran into a program output that is not explained in the documentation. Under some conditions during ac circuit analysis, the program gave an ADMITTANCE UNDERFLOW error message and returned to the command mode. Evidently, the situation had the possibility of significant computational error. For that reason, you may not be able to run a frequency response on some circuits.

You could go to the public library and find the formulas necessary to perform the calculations that this program does. For less than the cost of the program, you could buy a scientific calculator to help you with the mathematics. If you already have your own computer, the calculator would not be necessary. While research and step-by-step problem solving would make you smarter, using The Electronic Breadboard is easier. It also leaves less chance for you to make an error.

The Electronic Breadboard is available on cassette for the Radio Shack TRS-80® Model I and Model III from Instant Software, Inc., Peterborough, NH 03458. Price class: $50. — *C. L. "Chuck" Hutchinson, K8CH*

Hints and Kinks

Conducted By Larry D. Wolfgang,* WA3VIL

AFSK SYSTEM FOR FAX

☐ A recent change in FCC regulations to permit the use of FAX on the lower ham bands encouraged me to develop this AFSK circuit for a Telefax machine that had not been used for a few years. The variable light intensity reflected from a FAX picture is converted to a variable audio-frequency-modulation source (AFSK). The circuit uses a Radio Shack 9400 voltage-to-frequency or frequency-to-voltage converter, and a Radio Shack IC Experimenter's PC Board. With all new parts, the system costs about $30, is easy to build and produces pictures with good resolution. Fig. 1 shows the schematic diagram of the modulator circuit.

Before assembling the photo-diode in the light tube, as shown in Fig. 2, you should check the alignment of the optical system. Put some printed matter on the drum and you should be able to see a clear image projected on the pin-hole plate. The brightest area should be centered around the pin hole. Readjust the position of the image-lens focus tube and light-focusing tube to meet these conditions, if necessary.

After installing the photo-diode, move the picture to a white area on the paper. Adjust the position of the photo-diode closer to or farther from the pin hole, so the light-to-frequency converter gives an output signal near 2300 Hz, as measured at pin 10. Now rotate the drum to a black area of the picture and check the output frequency. It should be about 1500 Hz. R1 should be preset for 2.75 V between the center pin and ground with a white spot on the picture, and 2.63 V with a black spot. R2 should be preset for 3.26 V between the center pin and ground. Adjust R1 and R2 until the output frequency varies between these values, as you rotate the drum from white to black areas. A word of caution: What appears to be black to your eye may not appear to be black on the photo-diode. For example, a soft lead-pencil mark is more black than that of a felt pen. This system is immune to any light except that which comes through the pin hole, but extraneous light falling on the transmitted picture, or shining through the pin hole, will reduce the contrast, and should be avoided.

A power supply for the AFSK modulator is shown in Fig. 3A. This is a 5-V Zener-diode-

*Assistant Technical Editor

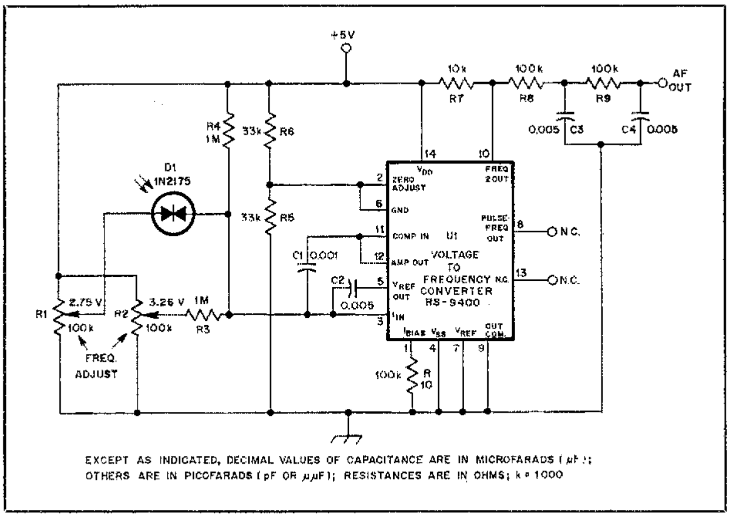


Fig. 1 — Diagram of an AFSK modulator for use with a FAX machine. U1 is mounted in an IC socket. Numbers in parentheses are Radio Shack part numbers.

D1 — 1N2175 Diffused Silicon Photo-Duo-Diode. (276-1790).
R1, R2 — 100-kΩ linear-taper potentiometer.
U1 — 9400 voltage-to-frequency converter
Circuit board — IC Experimenters Board (276-024) or Universal DIP Board (276-159).

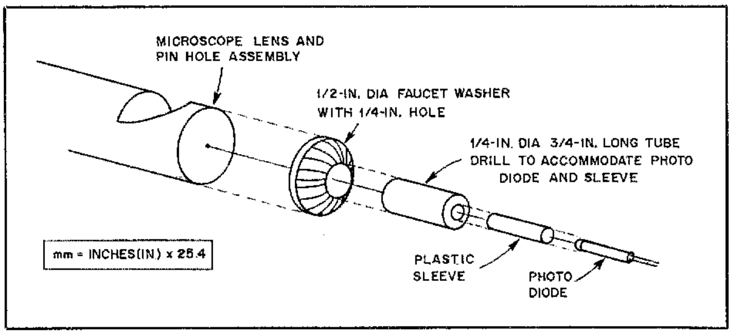


Fig. 2 — Mounting details for the photo-diode. The faucet washer is epoxied to the pin-hole plate. Be careful not to get any epoxy in the pin hole!

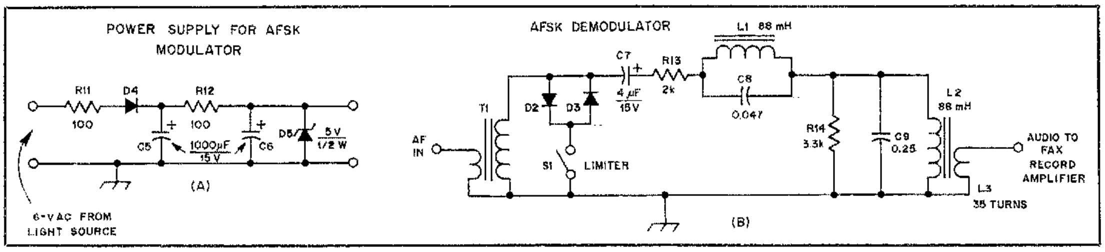


Fig. 3 — Schematic diagram of a power supply for the AFSK modulator is shown at A. An AFSK demodulator circuit is shown at B.

D2, D3, D4 — Silicon-rectifier diodes, 100 PIV, 1 A.
D5 — 1/2-W, 5-V Zener diode.
L1, L2 — 88-mH toroid.
L3 — 35-turn secondary wound over L2.
T1 — Audio-output transformer, 10 kΩ to 8 Ω, wired as a step-up transformer.

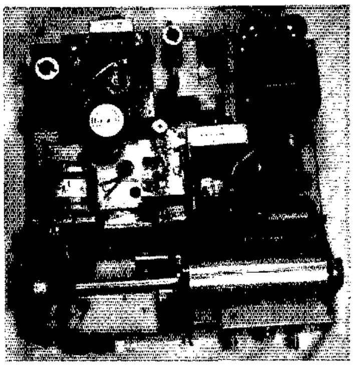


Fig. 4 — The completed FAX system.

regulated supply, with the ac voltage taken from the exciter-lamp supply. All components for the supply are mounted on a five-lug terminal strip, which is substituted for the single-lug stand-off terminal on the lamp supply.

A demodulator for receiving FAX signals is shown in Fig. 3B. A passive discrimination circuit adapted from a slow-scan TV circuit is used. A 35-turn secondary is wound on L2 for impedance matching. S1 allows selection of the limiter action provided by the diodes. The audio signal is fed into this circuit directly from the receiver speaker line. Fig. 4 shows a FAX unit with the modulator and demodulator circuits added. The modulator board is in the center, and the demodulator is mounted on the left-rear corner of the unit.

You must be able to tune in FAX signals accurately to receive proper pictures. This can be done by using an oscilloscope to look at the signals on the grid of the 6V6 stylus-driver tube (pin 5). The strongest pulses are the signals toward the black range.

You will find FAX operation near the popular SSTV frequencies. You should be able to identify this mode by the sound of the sync signals. — *Wally Lamb, WØPHD, Warren, Minnesota*

CIRCUIT LAYOUT PATTERN FOR RADIO SHACK UNIVERSAL DIP BOARD

☐ We have found the Radio Shack Universal DIP Board (276-159) to be versatile for wiring projects, without the need for a pc board. We made a copy of the board pattern on an 8-1/2 × 11-inch sheet of graph paper.[1] Copies of this sheet can be used to draw the components and wiring for the project, as was described in May 1982 *CQ*. This serves as a parts-placement diagram. A layout for the AFSK modulator circuit described in the previous Hint is given in Fig. 5.

We have built many small projects on these boards, and sometimes they come out smaller than if we used a published pc-board pattern. The circuit is laid out component side up, so be sure the ICs and transistors are shown as seen from above. — *Harold (NØARQ) and Todd (NØART) Mitchell, New Brighton, Minnesota*

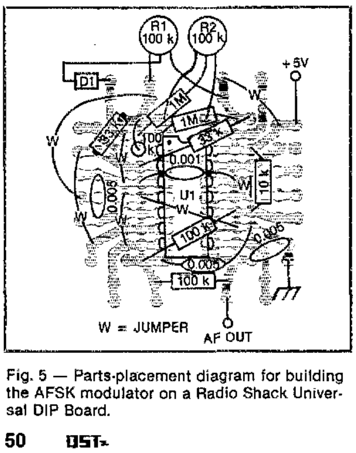


Fig. 5 — Parts-placement diagram for building the AFSK modulator on a Radio Shack Universal DIP Board.

WEATHERPROOFING ANTENNA CONNECTIONS

☐ Plumber's Putty, a nonhardening waterproof material, is available in tape form. It may be used to cover soldered connections, coaxial fittings and other outdoor, corrosion-prone connections. After applying the tape it should be kneaded to remove air bubbles and to provide a smooth surface. A small piece of this putty on the end of a screwdriver blade is handy for inserting screws in hard-to-reach locations. This tape comes in rolls 53 inches long by 1/2 inch wide, and is available in the plumbing section of K-Mart and other department stores. — *Harry Burhans, W3FM, Malvern, Pennsylvania*

SOLDERING STATION HINTS

Soldering-Iron Temperature Control

☐ When my 30-W soldering element burned out, I pressed an extra 50-W element into service. As expected, it was too hot for most work. An incandescent-light dimmer worked well for controlling the working temperature of the tip. You can purchase a ready-made unit, or the circuit of Fig. 6 can be built.[2] The dimmer should be wired in an electrical box that has a receptacle to plug in the soldering iron. This would be ideal for the construction of a soldering station for the workbench. The unit of Fig. 6 could also be used as a variable-speed control for your electric drill or other motor-operated devices. — *Wayne Hester, KD4QP, Mobile, Alabama*

[1] mm = in. × 25.4.

[2] J. Hall, "Motor-Speed Control for Power Tools," *QST*, June 1971, p. 34.

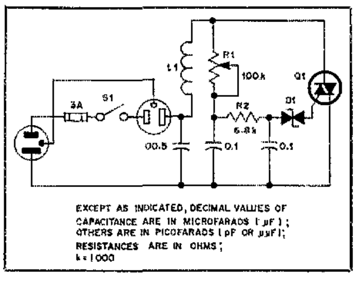


Fig. 6 — Schematic diagram of a light-dimmer circuit that can be built to control your soldering-iron temperature.

D1 — Diac, 2 A, 300 mW (Motorola MPT28, HEP 311 or equiv.).

L1 — 70 µH, approx. 18 ft of no. 18 enam. wire on a 1-1/2-in. long, 1/2-in. dia form.

Q1 — Triac, 8 A, 200 V (Motorola MAC2-4, HEP 340 or equiv.).

R1 — Linear-taper control, 100 kΩ.

Soldering-Iron Idler

☐ Two things frustrate me when I am soldering. The first is having to wait for the iron to heat up, and the other is replacing tips that have become inoperative because of overheating. What is needed is a soldering iron with two temperature settings: one for regular use, the other an "idle" setting that keeps the iron warm, but won't allow it to overheat.

My solution is to wire a diode (1N5404, 400 PIV, 3 A, such as Radio Shack 276-1144) in parallel with an spst switch. This assembly can be connected in series with a line cord and a receptacle in a box. With the switch open, pulsating dc is sent to the soldering iron, keeping it warm. When the switch is closed, the diode is bypassed and full line voltage reaches the iron. The tip heats to operating temperature in a matter of seconds. A similar circuit is used in the deluxe soldering station shown on page 17-2 of the 1982 edition of *The Radio Amateur's Handbook*. — *Timothy Garrity, WD9DZV, Chicago, Illinois*

Soldering-Iron Stand

☐ I purchased a soldering-iron holder at a Radio Shack store (catalogue no. 64-2078). This stand comes with a built-in sponge tray for tip cleaning. The stand is not heavy enough by itself, and will tip over easily. I removed the sponge tray to gain access to the hollow metal base. The base was filled with lead bird shot; then the sponge tray was replaced. Now I have a good soldering iron stand that stays where I put it, and it won't tip over. — *Dana Junkins, WA1YRE, Kittery, Maine*

Soldering-Iron On Indicator

☐ Here is an idea that I am sure has prevented a fire in my "shack" many times. I always plug my soldering iron into a "cube tap," and plug this into the wall outlet. Also, I plug a neon pilot light, or night light, into the cube tap. As I leave the room, the neon lamp warns that the soldering iron is on. I simply pull the cube tap to turn it off. I also have a metal L-bracket fastened to the wall. A hole in the free side holds the iron and keeps it safely off the table, but within easy reach. — *Russel Alexander, W7JWH, Sequim, Washington*

FREEZE DAMAGE TO COAXIAL CABLE

☐ A badly damaged length of aluminum hardline coaxial cable was brought to my attention by Fran Ziobro, K2BRF. Fran was checking a run of the cable in a water-filled conduit. A considerable length of cable was deformed,

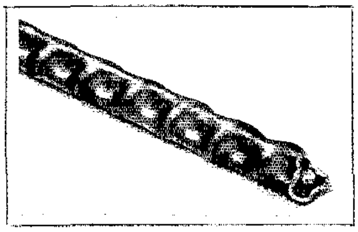


Fig. 7 — Damage to a piece of hardline cable caused by repeated freezing and thawing in a water-filled conduit.

as shown at Fig. 7. Over the years, this conduit had been exposed to below-freezing temperatures. Fran proposes that the hydraulic pressure from repeated freezing and thawing formed the relatively soft aluminum sheath around the center conductor and the webbed plastic support. The regularity of the depressions, spiraled along the cable, supports this assumption.

This failure emphasizes the necessity to provide a dry environment for coaxial cable, and to avoid freezing temperatures if possible. Cold temperatures and immersion in water appear to be required for this damage, but neither of these is good for any kind of coaxial cable. — *David Geiser, WA2ANU, New Hartford, New York*

AZDEN PCS-4000 TRANSMITTED-AUDIO SHAPING

☐ Having enjoyed using an Azden PCS-3000 for a year, I decided to trade it for the newer model, PCS-4000. This rig is also a pleasure to use, but the transmitted audio had too much bass response. This was not like my old PCS-3000.

I decided to do some audio shaping, and experimented with different capacitor values in series with the positive mike lead. (Capacitors in series will roll off the low-frequency response.) When I put a capacitor in series with the lead, a low-frequency oscillation modulated the rig. It sounded like an old-fashioned power-supply vibrator. Using a mylar capacitor instead of a disc-ceramic unit helped resolve the problem, but did not eliminate it. I decided to use a 0.02-μF mylar capacitor because a 0.01-μF unit cut off too much bass, and a 0.047-μF capacitor did not appreciably affect the audio.

Originally, the 700-ohm mike element shunted the audio-IC chip to ground. When the capacitor was placed in series with the mike element, the clip was lifted above ground potential and the circuit began to oscillate. I added a 2.7-kΩ resistor from the rig side of the capacitor to ground, and this completely stopped the oscillation. The resistor and capacitor were added inside the microphone case. These changes provide good transmitted audio from my rig.

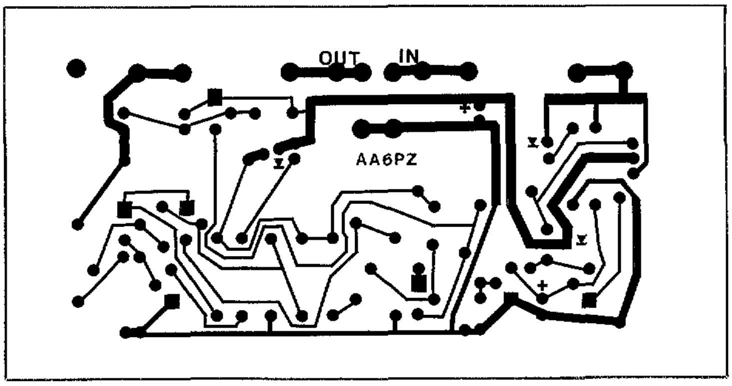
I had to turn the deviation control, VR404, counterclockwise approximately 3 degrees to bring the deviation back to 5 kHz after this modification. — *Lee Bahr, WØVT, Shawnee, Kansas*

OLD TIMER'S NOTEBOOK

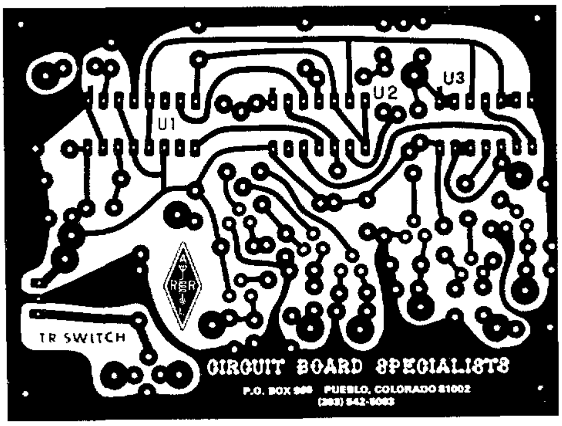
Window Feedthrough

☐ The problem of bringing transmission lines into the shack can be a sticky one, especially if one does not wish to drill window frames or walls, or to replace the panes of glass with plastic sheets.

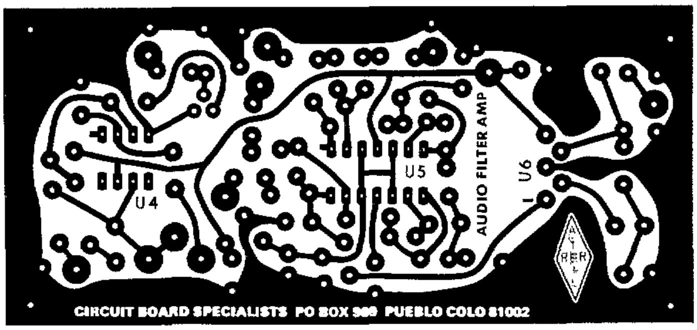
My method is to make a sandwich out of any one of the foam materials used by upholsterers, and to bring the antenna feeders into the shack between two sheets of foam that have been cut to sufficient width, about an inch or so wider than the window opening. The other dimension should be great enough to provide a closure base for the window and screen or storm window. I have found this method to provide excellent weather protection if the windows are closed firmly and held down with a wedge or tack against the window frame. — *A. W. Smith, K3ZMS (Reprinted from* Hints and Kinks for the Radio Amateur, *7th ed., 1965, p. 89)* QST



Etching pattern for the Power Charger. Black areas represent unetched copper viewed from the foil side of the board. Pattern is shown actual size; parts-placement diagram appears on p. 20.



(A)



(B)

Etching pattern for the Universal T-R Controller logic and switching board (A), and the sidetone and audio board (B). Patterns are shown from the foil side of the board. Black areas represent unetched copper. The parts-placement diagrams for these boards appear on p. 42.

Technical Correspondence

Conducted By
Dennis J. Lusis,* W1LJ

The publishers of QST assume no responsibility for statements made herein by correspondents.

MORE PROPAGATION NOTES

☐ Referring to Mackenzie's notes on long-range propagation,[1] I have shared similar thoughts since 1959. At that time, I was amazed by some of my 10-meter signal reports while using low power and poor antennas. I believed this very efficient propagation could be explained in ways similar to certain acoustics or sound-wave phenomena. While sound waves are not exactly the same as electromagnetic radio waves, there are similarities in their behavior.

In the acoustics field, there is a rather common phenomenon called "the whispering gallery effect." It occurs when low-level sound waves (i.e., someone whispering) are easily propagated from one side of a large room to another. Such rooms have either curved ceilings or walls. In the former case, the ceiling approximates an ellipse, and the whisperer and listener are at focal points. However, the latter case (the curved wall) is what suggested the idea of efficient ionospheric radio propagation without lossy earth reflections. In this case, the whisperer is located very close to the curved wall (typically spherical) as is the listener, who is a considerable distance away. The low-level sound waves are projected at very small angles to the wall and, through a series of efficient reflections, eventually arrive at the listener. This type of "whispering gallery effect" is not as intense as the focused ceiling variety, but can be startling when experienced.

The curved-wall sound-wave phenomenon has been studied for many decades — perhaps first in a truly scientific manner by Lord Rayleigh, who reported the findings in his 19th century acoustics masterpiece.[2] He described this propagation mode as "creeping and clinging," because of his belief that the sound energy creeps along in short steps and clings close to the wall. It is conceivable that the same thing could happen to radio waves in the ionosphere. If so, the Rayleigh type of ionospheric propagation mode would eliminate inefficient earth reflections.

The major difference between Rayleigh's and Mackenzie's theory is that the latter suggests a minimum number of reflections along paths that just miss hitting the earth. The Rayleigh-type mode generally would be composed of many reflections at very small angles, with relatively short distances between reflections. Mackenzie also believes that local wavestream dispersion from each ionospheric reflection is responsible for the signal returning to earth. While it may be true in some cases (more discussion later), I think a little differently about this. I believe that a wave propagated by the creeping-clinging mode (let's call it cc) could travel for thousands of miles with essentially *no* dispersion to earth until some major ionospheric discontinuity is encountered. Such discontinuity could be an ionospheric-storm effect, local ionospheric turbulence, low- or high-density ionized clouds, or the day/night F_2 layer discontinuity. When the main F_{2cc} wave front encounters the discontinuity, it is refracted/reflected to earth in the somewhat usual manner, resulting in relatively strong signal reception. These may also explain some sudden fadeout phenomena, which would occur when a cc mode loses its receiving-end discontinuity. Such phenomena could occur as the daylight/darkness boundary moves and the wavestream, formerly refracted down through the F_1 layer, has suddenly just exceeded the critical angle and is then reflected back upwards.

There are several possible variations on the cc mode idea. One possibility is that this type of propagation could occur in the E layer alone under certain conditions. This might explain some of the longer-distance sporadic E or E_s mode behavior. Another variation is the long-hop limiting case where the main wavestream just misses the earth (this is the example cited by Mackenzie). In actuality, there could be an infinite number of short- to long-bounce variations between the cc mode and the latter example. Questioning the number of reflections and reflection efficiency is appropriate here. Numerous cc-mode reflections along the F_2 layer would be more efficient than fewer, larger-angle reflections. Waves that reflect at large angles, particularly those that come close to the earth each time, must penetrate the F_1 and E layers twice between each reflection — resulting in further absorption loss. — *J. S. Gibson, W4SVH, Smyrna, Georgia*

[1] S. B. Mackenzie, "Theory for Long-Range Propagation," *QST*, May 1982, p. 42.
[2] J. S. Rayleigh, *The Theory of Sound*, Vol. 2 (New York: Dover Reprint, 1945), pp. 126-129.

*Assistant Technical Editor

MORE STATE-OF-THE-ART RTTY†

☐ Auto-start and anti-space are highly desirable features for today's RTTY operator. These may be obtained in a much simpler way than described by Witmer in November 1981 *QST*.

Fig. 1 shows an RTTY demodulator circuit that I developed for our local Navy MARS unit. It uses three transistors and an XR2211 PLL IC. Pins 5 and 6 of the XR2211 are complementary, lock-detect outputs. Pin 6 is used for the auto-start function and pin 5 provides the mark-hold action. Although the a-s circuitry is derived from the same IC that does the detection, sensitivity and bandwidth of both sections are identical, and the auto-start is positive and reliable. The a-s will trigger only if the signal is good enough to print, and it will not false on voice or noise signals.

Most operators prefer a short delay of a second or two for a-s turn on, and between 10 and 30 seconds for turn off. Both delays can be achieved by connecting an R-C combination from the base of Q3 to ground. Suggested values are 330 kΩ and 10 μF. Longer turn-on delays also can be achieved by increasing the size of the capacitor at pin 3 to 10-25 μF.

No tuning indicator has been included. The value of such devices is questionable. They don't truly indicate or aid in tuning, but merely show that the phase-locked loop has achieved lock — something we know anyway by the fact that the auto-start has turned on and the machine is printing.

It should be pointed out that this unit is state of the art in terms of its components, and will give a good account of itself on vhf, and, to a

†Adapted with permission from the Navy MARS publication *Kilowatt World-Wide*.

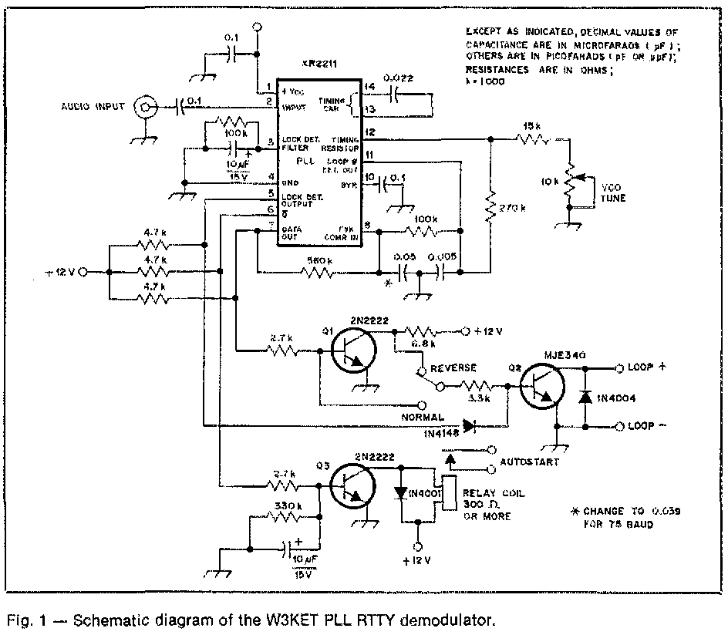


Fig. 1 — Schematic diagram of the W3KET PLL RTTY demodulator.

lesser extent, on hf. For hf applications, there are considerably better, though much more complicated, circuits available. — *Melvin Leibowitz, W3KET, Wilmington, Delaware*

STUB-MATCHING TABLES

☐ I have provided Tables 1, 2 and 3 to make it simpler and less expensive for amateurs to build their own stub-matching networks, as shown in Fig. 2. The tables are useful for three reasons: (1) The classic shorted-stub matching system suffers from mathematical, but not physical, complexity. (2) Most hams have access to 50-ohm coaxial cable and 300-ohm TV twin-lead. (3) Antenna tuners are made to operate into these two types of line.

By using these tables, it is possible to match coaxial cable directly to a balanced load if the lineup to the stub is rolled into a 3- or 4-turn coil, forming a balun. TV twin-lead cable can also be used to feed conventional beams or wire dipoles by using the information found in Tables 2 and 3.

When you are using these tables, it is necessary to multiply the length given by the velocity factor of the transmission line actually used. This value may be obtained from the ARRL *Handbook*. Table dimensions show the length from the load point to the tap, and the length of the shorted stub in air, rather than in a transmission line. — *Robert C. Wilson, KL7ISA, Bethesda, Maryland.*

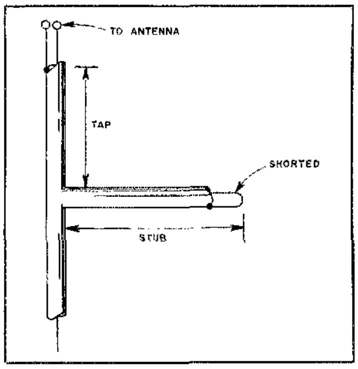


Fig. 2 — Physical configuration of a stub-matching network. Stubs should be made of the same type of cable used for the transmission line.

Shorted-Stub Matching Tables

Table 1

Frequency (MHz)	*Tap (in.)*	*Stub (in.)*
7.2	117	672
10.1	83	479
14.2	59	341
18.0	47	269
21.3	40	227
24.5	34	198
28.6	29	169
52	16	93
147	5.7	32.9
222	3.80	21.80
432	1.95	11.20
1296	0.651	3.73
2350	0.359	2.06
3400	0.248	1.42

52 to 12 ohms; coaxial cable to 4-way split, coaxial cable to beam, etc.
mm = in. × 25.4

Table 2

Frequency (MHz)	*Tap (in.)*	*Stub (in.)*
7.2	102	698
10.1	73	497
14.2	52	354
18.0	41	279
21.3	35	236
24.5	30	205
28.6	26	176
52	14	97
147	5.0	34.2

300 to 52 ohms; twin-lead to 52-Ω antennas, lines, etc.

Table 3

Frequency (MHz)	*Tap (in.)*	*Stub (in.)*
7.2	119	669
10.1	85	477
14.2	60	339
18.0	47	268
21.3	40	226
24.5	35	197
28.6	30	168

300 to 72 ohms; twin-lead to dipoles, etc.

PAL SSTV?

☐ In June 1982 *QST*, Miller, W9NTP, proposes a compatible slow-scan color-television system patterned after the U.S. and Canadian NTSC fast-scan system. I believe that, in practice, his proposed system is unsatisfactory, primarily because of the NTSC technical limitations. I will compare briefly the Miller system with the Royle (G3NOX) system, which is featured in November 1980 *QST*.

Royle transmits color SSTV images by the field-sequential system; he sends three successive black-and-white SSTV images, each taken through one of the three primary-color filters — red, blue and green. As shown by the cover photo on the 1981 *Radio Amateur's Handbook*, the Royle system works quite well. It suffers from only two minor disadvantages when compared with the Miller system — a color image takes three times as long to transmit as does a black-and-white image, and the system is not compatible with existing equipment. Color images *cannot* be received in black-and-white on an unmodified black-and-white receiver.

The Miller system, however, suffers from two major disadvantages when compared with the Royle system. The Miller color-image quality will be much poorer than Royle's, and is actually more susceptible to interference and distortion. Miller's system will produce undesirable color fringes on the edges of objects (owing to limited color bandwidth), and chroma errors (caused by phase shifts in the color channel), resulting in performance that is less than acceptable.

To get an idea of what a Miller color SSTV image is like, look at the mediocre image produced by a computer on a home color-TV receiver. The image created in the computer is excellent — the color errors you see are caused mostly by the limitations of NTSC color transmission. Now take the RGB (separate unencoded red, blue and green) outputs from the same computer, drive an RGB color monitor, and enjoy an improved image! This is the essential difference in quality between the Miller and the Royle systems.

Phase errors and differential phase errors (amplitude-dependent phase shifts) are a constant problem in NTSC equipment. Multipath transmission, which is unavoidable on the hf bands, produces phase (and hence color) errors that are annoying. An entire industry has developed circuitry designed to alleviate these problems in the NTSC system — but has found little success. When European countries adopted color-TV standards in 1961, not one country adopted NTSC, but either PAL or SECAM — both of which reduce or eliminate the phase-error problems.

In conclusion, I feel that Miller's system is sacrificing to the image quality. The primary strength of his system is in compatability, which is much less vital in the amateur service than in a commercial context. — *Peter Traneus Anderson, KA1ETG, Burlington, Vermont*

Feedback

☐ In "Phase III with a Tetrode UHF Amplifier" (Aug. 1982 *QST*), plug and jack designations in Figs. 2 and 3 do not always agree between the drawing and the caption. In most cases, the reader should be able to identify the correct part reference number. Cinch connector part numbers are divided into three parts: a letter (P for plug, S for socket), followed by three numbers (the last indicates the number of pins), and some letters (AB for panel mount, CCT for use on cable).

The meter (Fig. 3) used by author Merry is calibrated with 0 to 1 and 0 to 3 scales. With resistor values shown, full-scale readings are: I_g and I_s 30 mA, E_p 3 kV and I_p 300 mA. If the 3-kΩ resistor connected to P3, pin 8 in Fig. 3 is changed to 10 k-Ω full-scale reading for I_p will be 1 A.

In Fig. 4, the anode of the bottom Zener diode should show a connection to the negative side of C6. The 100 μF filter capacitor in the bias supply is shown with reversed polarity.

A complete set of detailed drawings and photos is available from the author for a nominal charge. [This offer is not warranted by ARRL — Ed.]

☐ Please note these corrections to Fig. 1 of "Mobile Antenna Matching — Automatically," *QST*, Oct. 1982, p. 16. A ground symbol should be placed at the junction of pins 1 and 4 of U1 and the anode of D3. Test points B and C are located at pin 2 of U2 and the junction of R7 and R8, respectively.

☐ Jack Althouse, K6NY, correctly points out (see the W1FB Technical Correspondence item on baluns in Aug. 1982 *QST*) that the balun leads or internal inductance can shift the beam-antenna resonance lower in frequency. If this happens, the driven element sections will need to be readjusted for proper resonance with the balun in the circuit.

☐ Please refer to the ARRL International DX Contest results in Oct. *QST*, pages 76 and 77, for the following correction. The N5AU multi-multi and the N5CMI multi-single phone scores were inadvertently omitted from the North Texas Contest Club aggregate entry in the Medium Class. With the addition of these scores, the club totals rise from 12,265,540 points and 32 entries to 18,983,830 points and 34 entries. The overall standing of the NTCC does not change; however, their corrected score is within 8% of the winning total, not a "distant" second as indicated in the text.

New Products

MYERS ELECTRONIC RESEARCH AMS MODULE

☐ Myers Electronic Research has developed a wide-band synchronous detection radio module (dubbed the AMS), which may be of interest to Amateur Radio experimenters and builders. The AMS uses seven ICs, counting the on-board voltage regulator. Among these ICs is a Plessey SL624, which is used as a synchronous a-m detector and provides signal-level information to a Plessey SL1621, which acts as the agc system for the module.

The manufacturer specifies the AMS to have a usable frequency range of 200 kHz to 20 MHz, a 5-MHz sensitivity of 5 μV for a 10 dB S + N/N ratio with a 50%-modulated 1-kHz signal, a maximum input signal-handling capability of 265 mV, and an audio output level of 1 V rms into a 47-kΩ load. The power requirements are 9- to 15-V dc, with a current drain of 60 mA at 12 V. These specifications were checked in the ARRL lab and the AMS module passed with flying colors.

The AMS module is flexible. By placing a suitable crystal or mechanical filter ahead of the rf input to the module, it becomes an i-f amplifier operating at the filter frequency. A ferrite-rod antenna and a suitable tuning capacitor, substituted for the filter, transform the module into a broadcast receiver with built-in muting capabilities. An AMS direct-conversion (D-C) receiver can be made by using a tuned circuit at the front end and injecting a VFO signal (at the proper frequency) of a few millivolts in amplitude. Voltage present at the S/N pin may be measured with a high-impedance voltmeter. Thus, an S meter can be included.

Muting is accomplished by grounding a single pc-board pin. By linking the COM and SIG pins, muting may be referenced to the incoming signal level. In this mode, the MUTE potentiometer setting is proportional to the S-meter reading necessary for unmuting.

Further information may be obtained from Myers Electronic Research, Customer Services Division, 145a Ashley Rd., Altrincham, Cheshire WA14 2UW, England. Price class: Wired and tested, £53; kit, £39. — *Paul K. Pagel, N1FB*

MOTOROLA PRECISION SUPER BETA OPERATIONAL AMPLIFIERS

☐ Motorola is producing, and offers immediate delivery of, precision low-drift op amps with exceptional specifications and increased package options. These devices were formerly available exclusively from National. The LM11 op-amp series combines the best features of existing bipolar and FET op amps with a precisely controlled, ion-implanted super beta process. The super beta design allows reduction of input bias currents by more than an order of magnitude over earlier precision bipolar devices, such as the popular LM108A. The LM11 bias currents equal those of precision BIFET op amps at room temperature. Unlike BIFETs, however, the LM11 bias currents do not double every 10° C.[1]

Although bandwidth and slew rates are less than in BIFET op amps, the LM11 excels with lower input-offset voltage, offset current and significantly lower temperature drifts. Substantially lower power consumption eliminates warm-up stabilization time in critical applications.

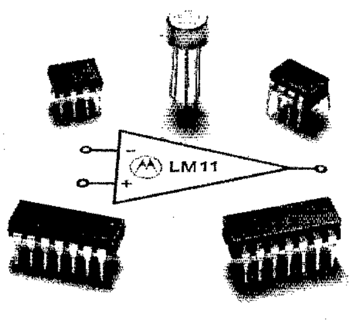
The LM11 is internally compensated, but external compensation can be added for improved stability when driving capacitive loads. The input offset voltage may be balanced with a single external potentiometer.

These Motorola devices exhibit improved bias and input offset currents at high temperatures, and bandwidth and bias current are consistent from device to device. In addition, the temperature coefficient of the input offset voltage (TCV_{IO}) follows a theoretical curve related to the offset voltage at 25° C. This means that the TCV_{IO} may be closely estimated from the V_{IO} at room temperature. For example: A V_{IO} of 100 μV will typically have a temperature coefficient of 0.35 μV/° C.

The precision characteristics of the LM11 make it ideal for applications in analog memories, temperature controllers, low-frequency active filters, light meters and logarithmic amplifiers. An LM11 can be substituted easily for other op amps in existing circuits to provide improved performance or to eliminate trimming operations.

The LM11 is offered in five packages, including 8-pin plastic and ceramic, 8-pin metal can, and 14-pin plastic and ceramic. It is available in two temperature ranges: −55 to +125° C and 0 to +70° C. The 0 to +70° C line (sufficient for Amateur Radio applications) can be obtained at a reduced price with somewhat relaxed electrical specifications. Prices range from $1.60 to $2.90 each in 100 to 999 quantities. According to the manufacturer, all devices are in stock and available from the factory and authorized Motorola distributors. For further information, contact Bob Benzer at Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036. — *Paul K. Pagel, N1FB*

[1] ° F = 9/5 °C + 32



SILICONIX HIGH-VOLTAGE MOSPOWER® FETS

☐ Siliconix is producing 10 DMOS power FETs with drain-to-source breakdown voltage (BV_{DSS}) ratings ranging from 350 V to 450 V. These devices come in the popular TO-3 package. Within this family are four high-power proprietary parts plus six second-source devices. The proprietary VN3500/4000 series specifies a power dissipation (P_{DISS}) of 125 W at 25° C, a 3-to 6-V threshold voltage for high noise immunity, and a -55° to +175° C operating and storage temperature range. The second-source IRF330/430 series offers a 75-W P_{DISS} rating, a 2- to 4-V threshold voltage, and a -55 to +150° C temperature range.

BV_{DSS} options for the VN3500/5000 series are 350 V and 400 V each with 5 A or 6 A I_D MAX, and 1-ohm or 1.5-ohm drain-to-source "on" resistance ($R_{DS(ON)}$) MAX measured at a high drain current of 3 A.

Devices comprising the IRF330/430 series are socket-compatible with power FETs from Motorola and International Rectifier. These devices have BV_{DSS} ratings ranging from 350 V to 450 V with I_DMAX specified from 3 A to 4 A. $R_{DS(ON)}$ MAX ratings, which range between 1 and 2 ohms, are specified at a 2-A drain current.

Proprietary Siliconix parts (VN4000A, VN4001A, VN3500A and VN3501A) range in price from $15.30 to $18.00 each in lots of 100 or more. The second-source parts are priced from $6.96 to $9.30 each in lots of 100 or more. For further information, contact Siliconix Marketing Services, P.O. Box 4777, Santa Clara, CA 95054. — *Paul K. Pagel, N1FB*