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SEPTEMBER 1973

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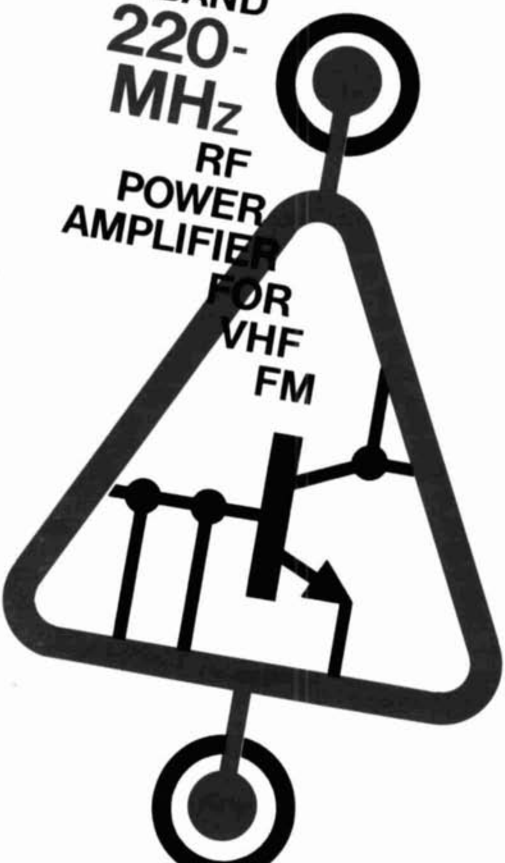

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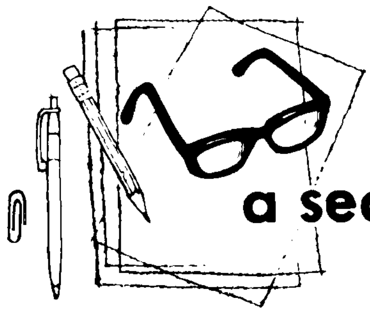


a second look by jim fisk

circuit design contest

Here is an opportunity for all you experimenters and amateur circuit designers to put your talents to work, and perhaps, to win some fabulous prizes. This contest which has the theme, "Quadzilla is coming", is sponsored by National Semiconductor and *EDN* magazine, and is for the best circuit design using all four devices in *any* linear quad IC. National Semiconductor will pick the 10 winners, while *EDN* will determine the placement of those winners.

Although anyone can enter the contest, the entry must be on a National Semiconductor entry blank or a facsimile thereof. National is offering a 32-page handbook on the contest which is half data sheets on National Semiconductor Quad ICs, and half application notes, and includes an official entry blank. Copies of this useful handbook are available, upon request, from *ham radio* magazine.

The grand prize winner will receive a Panasonic 4-Channel Entertainment system which includes a tape and record player, receiver and speakers. The next four winners will receive a Zenith portable color TV set. The last five winners will receive Garrett Incredible Time Machines – electronic digital calculators with a built-in digital alarm clock. Entries must be submitted by October 31st, so now is a good time to dust off your slide rule and put your ingenuity to work.

220-MHz repeater

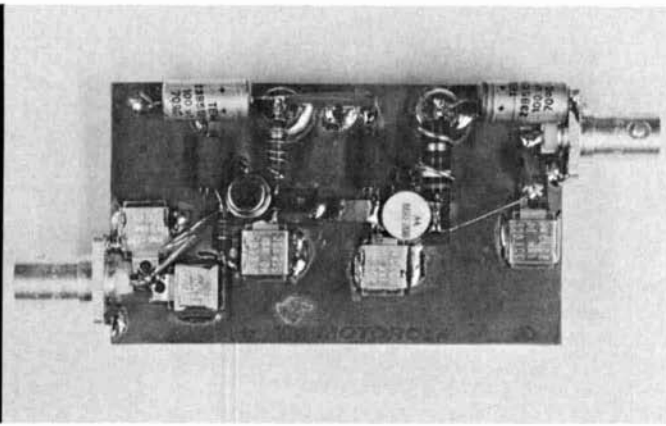
In an effort to bring vigorous 220-MHz activity to amateurs from coast to coast, Clegg has just announced a repeater-lease program, where a new Clegg 220-MHz repeater, valued at approximately $1200, will be leased to amateurs at special club rates of only $25 per month. Although FCC Docket 19759 proposes to convert the top 1-MHz of the 220-MHz amateur band into a new class-E Citizens Band, it may still be possible to prevent adoption of this proposal if it can be demonstrated that large numbers of amateurs are using the 220-MHz band. The new Clegg 220 repeater-lease system appears to provide just such an opportunity.

The 220 repeater is leased complete (except antenna and transmission line), with features that include automatic identification, all solid-state construction, and built-in timers. It operates at 10- to 15-watts output, uses a Phelps-Dodge duplexer, and has approximately 0.4-μV sensitivity. The repeater includes an ac power supply, local microphone input and metered signal strength.

All amateur radio clubs are invited to contact the Clegg Division if they are interested in getting their club into this repeater program. The low monthly rental fee can be further reduced with club member purchases of the Clegg FM-21 transceiver, a 220-MHz fm unit. Interested clubs should write to Phil Theis, K3TUF, Clegg Division, International Signal and Control Corporation, 3050 Hempland Road, Lancaster, Pennsylvania 17601, or telephone him at (717) 299-3671 for more information.

Jim Fisk, W1DTY
editor

More Details? CHECK—OFF Page 110



220-MHz rf power amplifier for vhf fm

Design and construction of a solid-state, 10-watt, class C rf power amplifier with an operating bandwidth of 40 MHz

Jerry DuBois, K7JUE, Motorola Semiconductor Products, Inc., Phoenix, Arizona

Designing high-gain, wide bandwidth, vhf power amplifiers has been a sticky problem in the past. However, by using a new approach, and standard rf semiconductors, you can now get improved performance at a lower cost. The particular rf amplifier described in this article was designed to operate at 220 MHz with an output power of 10 watts and a bandwidth of about 40 MHz.

Two members of a new high-gain family of Motorola vhf devices are used here to demonstrate their effectiveness as broadband amplifiers. The MRF207 and MRF208 rf power transistors, when used together, net greater than 100 times power gain at 220 MHz.*

The design goals included successful broadband vhf design – something which has often eluded rf designers. At the same time, a high-gain amplifier was needed which would supply 11-watts output with a reliable 20-dB of stable gain. With a low-pass filter at the output this would provide a solid, 10-watt radio. A block diagram of a transmitter using this amplifier is shown in **fig. 1.**

*The Motorola MRF207, MRF208 and MRF209 are available from franchised Motorola distributors. In small quantities the MRF207 is priced at $2.25, the MRF208 at $11.70, and the MRF209 at $14.25.

Recent developments in low-Q transistors have stimulated new approaches to wideband design. With the publication of complete data sheets, trial and error has been virtually eliminated from matching network design. In the following design, real life values are within a few percent of their calculated counterparts.

sider the transistor chip capacitance as the first element.

Referring to the Smith chart analysis shown in **fig. 2**, the input impedance of the MRF207 (10 - j11.5 ohms) falls in the upper lefthand corner of the chart. (This chart is normalized to 1, so all impedance values on the chart must be multiplied by 50, all admittance values must be multiplied by 20.) First, a *series* element is plotted which transforms 10 - j11.5 ohms to 10 + j20 ohms. The length of this series rotation is 0.61 ohms on the chart; multiplying by 50 yields 31.5 ohms. A reactance of +31.5 ohms at 220 MHz is provided by a 22-nH inductor.

To transform the 10 + j20 point to 50 + j0 requires a *parallel* element. Since parallel circuit elements are most easily

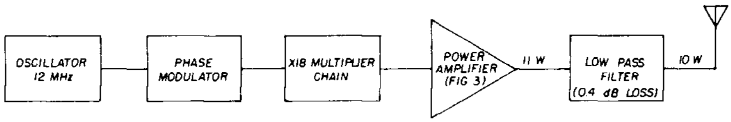
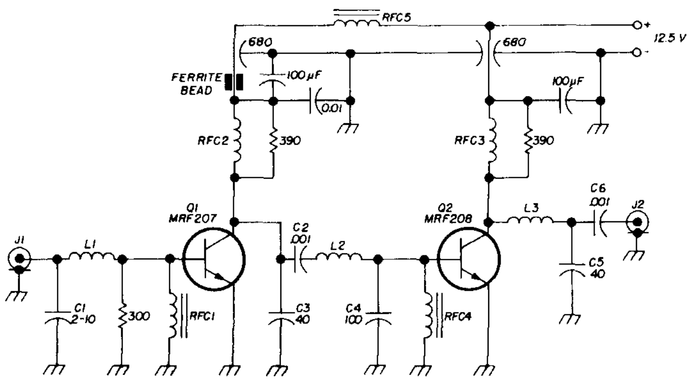


fig. 1. Typical 10-watt, 220-MHz fm transmitter using the rf power amplifier shown in fig. 3.

design

Achieving gain flatness, along with good efficiency, involves some trade-offs. The trick is to know when to stop. The amplifier described here displays good efficiency characteristics over the entire design bandwidth with a gain variation of about -0.8 dB. In this particular circuit, single step networks, which are broadband by nature, are used. Actually, they represent a pi configuration if you con-



C1	20-pF metal-clad mica capacitor (El Menco MCM 01/002/-CA200DO)
C2,C6	0.001-μF metal-clad mica capacitor (El Menco MCM 01/002/-CA103DO)
C3,C5	40-pF metal-clad mica capacitor (El Menco MCM 01/002/-CA400DO)
C6	100-pF metal-clad mica capacitor (El Menco MCM 01/002/-CA102DO)
L1	1 turn number 24 wire, 1/4" ID
L2	copper strap, 0.032" thick, 0.25" wide x 0.75" long
L3	0.8" lead of capacitor C6 (0.001-μF disc)
RFC1,RFC4 RFC5	low-Q rf choke (Ferroxcube VK200-20/4B)
RFC2	2 turns no. 24 wound around 390-ohm, 1/4-watt resistor
RFC3	2 turns no. 20 wound around 390-ohm, 1-watt resistor

fig. 3. Schematic for the 10-watt, 220-MHz rf amplifier. Capacitors C1, C2, C3, C4, C5 and C6 must be metal-clad mica types such as those manufactured by El Menco. Other types of capacitors will not result in proper circuit operation.

plotted when described in terms of admittance, first convert 10 + j20 ohms (0.2 + j0.4 on the chart) to 20 - j40 millimhos (1.0 - j2.0 on the chart). The length of the parallel rotation to the center 50-ohm point is 40 millimhos or 25 ohms, represented at 220 MHz by a 20-pF capacitor.

If you are able to use an immittance chart you can eliminate the impedance to admittance conversion step described above, since it is accomplished automatically by the immittance chart. However, the Smith chart is somewhat more familiar to amateurs, hence its use here.

This simple procedure completes the design of the input network. The other two networks are designed in the same fashion (see **fig. 3**). The interstage network is really a two-step network with the device input inductive reactance acting as one element. Series equivalent impedance data for both transistors is given in **table 1** so the designer can see how all network element values were arrived at.

It is obvious that this is a single-frequency design. Since the device characteristics vary gradually with frequency, these transistors will remain matched over a relatively large frequency range. Multifrequency data could be treated in the same manner, and a network which has flatter frequency response might be calculated. However, in this case, the 40-MHz bandwidth was considered to be more than adequate when the entire 220-MHz fm band is only 2-MHz wide. The additional work and increase in component count was deemed unnecessary.

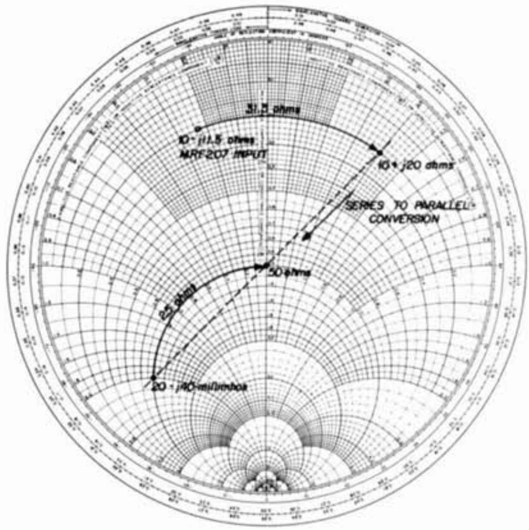


fig. 2. Smith chart analysis of the input network used to match 50 ohms to the series equivalent input impedance of the MRF207 transistor, 10 - j11.5 ohms.

construction

Construction of the 220-MHz power amplifier is generally straightforward, but some areas require care. The decoupling networks are important to stability.

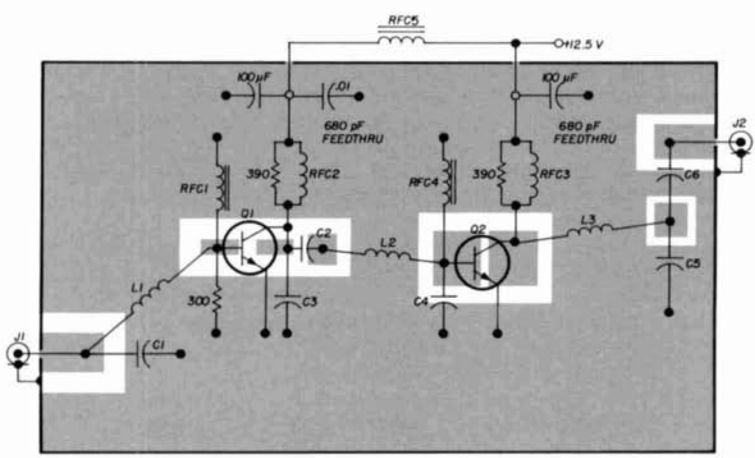


fig. 4. Full-sized printed-circuit layout for the 10-watt 220-MHz power amplifier.

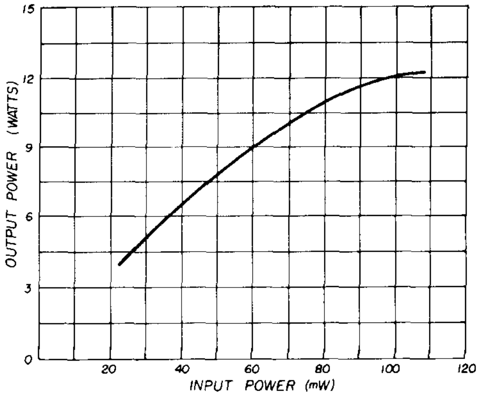


fig. 5. Power output vs drive for the 220-MHz power amplifier operating with a 12.5-volt power supply.

Feed-through type construction was found to be necessary. One matching element, L2, may require adjustment. Tweaking can be accomplished by varying the point on L2 where the 0.001-μF blocking capacitor is connected. This capacitor was purposely used as part of the network to allow adjustment. A good place to start is about 2/3 of the way out from the base of the MRF208 (see photograph). Inductor L2 must be soldered very close to the case of the MRF208. The 100-pF Unelco capacitor, C4, must also be mounted very close to the transistor as shown in the photo.

Inductor L3 can be increased in value slightly to give better efficiency at some sacrifice in bandwidth. As with any high-gain vhf circuit, minimum emitter lead length is required for maximum gain and bandwidth. Inductors L2 and L3 may be bent closer to or away from the printed-circuit board to tune the amplifier.

A clip-on heatsink should be used on the MRF207 driver transistor, and a heatsink approximately 2x2x0.5 inches should be used with the MRF208 output transistor. A full-size printed-circuit layout for the amplifier is shown in **fig. 4**.

A gain curve is included in **fig. 5** which shows that the amplifier has some considerable reserve at a specified power input of 100 mW and 10-watts output. The input vswr varies from 2:1 at the band edges to 1:1 at 220 MHz. Plots of worst-case amplifier performance show a total output variation of 0.8-dB over the frequency range, 200-240 MHz (see **fig. 6**). Efficiency runs approximately 55% and spurious outputs are down more than 35 dB.

table 1. Series equivalent impedance data for the Motorola MRF207, MRF208 and MRF209 rf power transistors at 220 MHz.

device	power rating (watts)	input impedance (ohms)	output impedance (ohms)	minimum gain at 220 MHz (dB)
MRF207	1.0	10 - j11.5	32 - j41	8.2
MRF208	10	1.4 + j1.4	5.7 - j1.25	10.0
MRF209	25	1.4 + j1.8	3.9 - j0.2	4.4

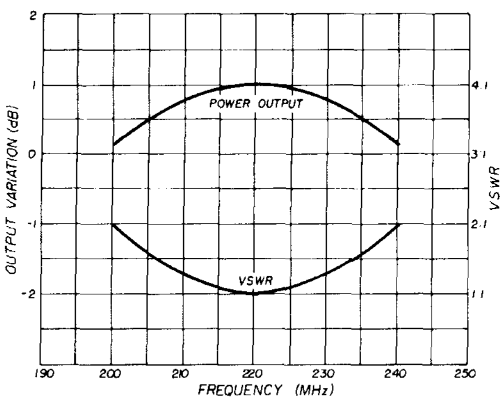


fig. 6. Power output and vswr characteristics (50-ohm load) for the wideband power amplifier. Gain varies less than 0.8 dB from 200 to 240 MHz.

This 220-MHz power amplifier shows that a wideband amplifier in the vhf region, built with currently available, non-internally matched transistors, is feasible. In this amplifier we have replaced an old design which had six tuning adjustments with a fixed-tuned power amplifier that has 10 times the bandwidth. At the same time, a reduction in both cost and component count has been accomplished.

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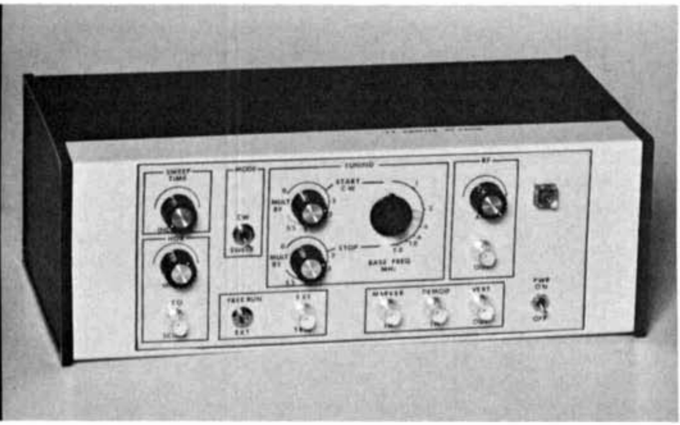


solid-state i-f sweep generator

Complete construction details for an i-f sweep generator that covers the frequency range from 100 kHz to 15 MHz

Ray Megirian, K4DHC, Box 580, Deerfield Beach, Florida

It has been said that the things we see are more believable than effects perceived by any of the other senses. Also, a picture can convey more information in a moment than other forms of measurement can over a much longer period of time. Undoubtedly, this reasoning is responsible for the wide range of sweeping-type electronic instruments in common use today.

The sweep generator described here is similar to one I discussed in a previous article.[1] While more simple and less costly to build, it boasts some worthwhile improvements over its predecessor and should not be relegated to the gadget category. Keep in mind that this design is quite flexible and lends itself to innovation. Some of the possible variations will become evident later in the article.

the vco

The heart of any sweeping instrument is generally a vco. In this case a Motorola MC4024P IC multivibrator (vcm) is used as the signal source. Square waves may not be ideal for rf but they do work, and this economical IC provides good sweep capability too. It also eliminates the need for alc circuits since the output amplitude is constant.

The MC4024P contains two identical oscillators and level translators but only one of them is needed in this application. The only external component required is a capacitor, which, in combination with a dc control voltage, determines the oscillator frequency. Thus, two methods for determining the frequency range of the oscillator suggest themselves. Use several fixed capacitors in conjunction with a range switch or a single high capacitance variable to cover the desired range, as I did here.

In either case, the selected capacitance determines what shall be referred to as the "base frequency." The dc control voltage will then establish the extent of the sweep excursion.

Voltage control of the oscillator frequency is accomplished by applying a voltage ramp to the proper pin on the IC. The dc levels at both ends of the ramp are set by front-panel controls, thus allowing independent selection of both the starting frequency and the stopping frequency.

Although the data sheet for the MC4024P IC claims that 3.5 to 1 variation in frequency is possible with control voltages ranging from 1.0 to 5.0 volts, all the devices I tried provided at least 5 to 1 change and as high as 6 to 1 if the control voltage was increased to about 6.0 volts.

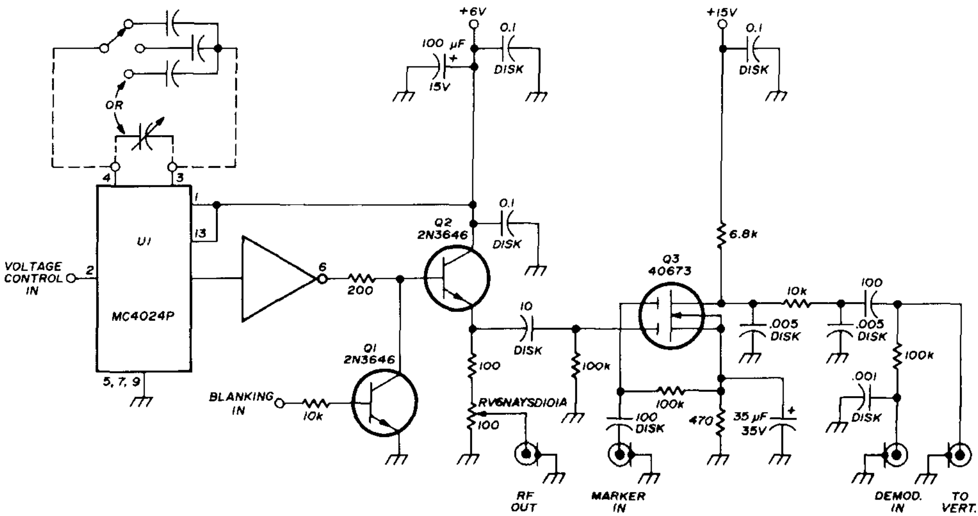


fig. 1. Rf oscillator and birdie marker schematic. Transistor substitutions may be made where those devices shown are not on hand.

The vco as well as a birdie marker system are combined on a single PC board. A schematic for this board appears in **fig. 1**. The mixer for the marker system is quite conventional and uses a dual-gate mosfet. This added feature is a practical necessity for most alignment operations and is complete except for the marker source. For precise measurements use a crystal oscillator to provide the marker signal; otherwise, an ordinary rf generator is quite adequate.

Transistor Q1 blanks the output during the retrace period and emitter-follower Q2 buffers the output from the vco. The output amplitude across a 50-ohm load is about 1.0 volt p-p maximum.

ramp generator

The improvements of which I spoke concerning an earlier design were made

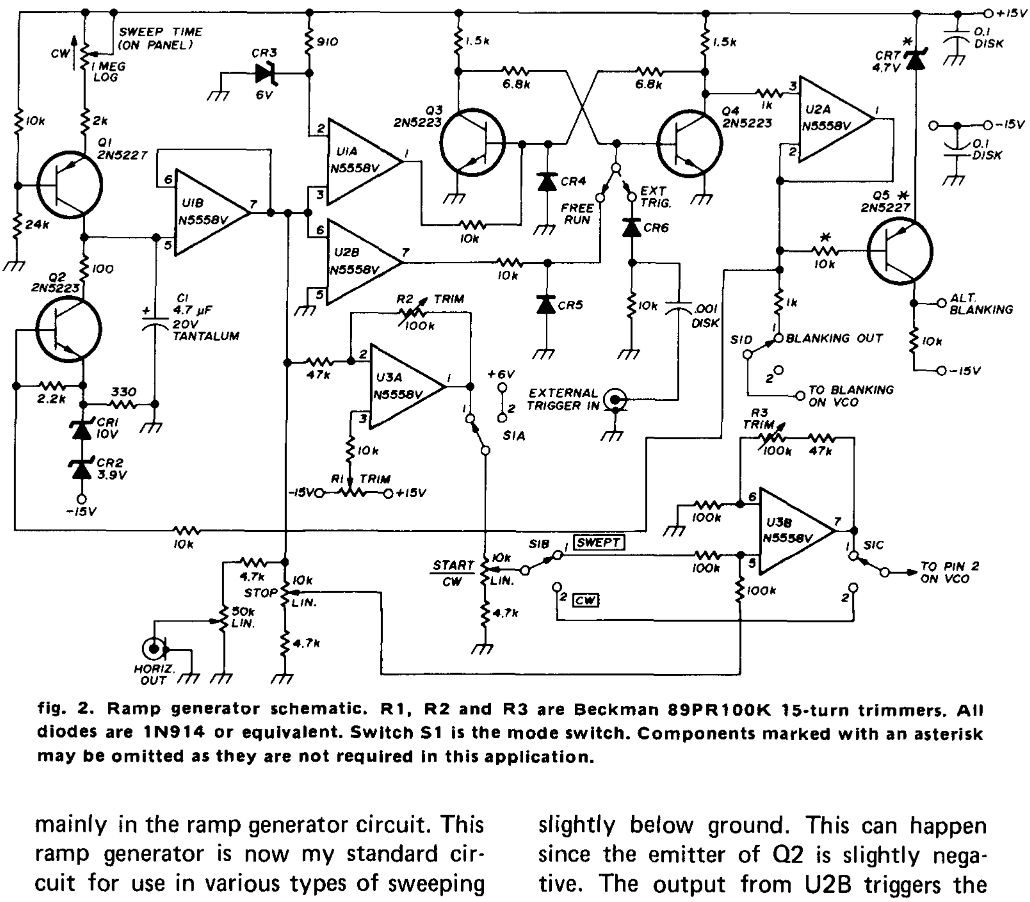


fig. 2. Ramp generator schematic. R1, R2 and R3 are Beckman 89PR100K 15-turn trimmers. All diodes are 1N914 or equivalent. Switch S1 is the mode switch. Components marked with an asterisk may be omitted as they are not required in this application.

mainly in the ramp generator circuit. This ramp generator is now my standard circuit for use in various types of sweeping instruments and is complete on its own PC board for that reason. A schematic of the ramp generator is shown in **fig. 2.**

A linear ramp is generated across capacitor C1 as it is charged by the constant-current source, Q1. This waveform, buffered by voltage-follower U1B, appears at the inputs to comparators U1A and U2B. U1A senses the positive peak and will flip when the level reaches a value just above that of zener diode CR3.

When the output of U1A goes positive, the flip-flop consisting of Q3 and Q4 changes state so that Q3 turns on and Q4 turns off. The collector of Q4 is now positive and this voltage is fed back to Q2 via the voltage-follower U2A. When Q2 turns on, it rapidly discharges C1.

Comparator U2B senses zero and will flip when the voltage across C1 goes slightly below ground. This can happen since the emitter of Q2 is slightly negative. The output from U2B triggers the flip-flop which shuts off Q2 and allows C1 to start charging again as the cycle repeats.

If it is desired to trigger the ramp generator rather than have it free-running, a positive-going external pulse may be applied to the base of Q4 instead of the output from U2B. This is shown in the drawing and provided for on the PC board. If this feature is not to be included, the unnecessary components may be omitted and a jumper installed from the base of Q4 to the output network of U2B.

In order to generate a voltage ramp whose end points can be set to any desired level, a positive-going ramp and a negative-going ramp are added together in a summing amplifier. As the amplitudes of the two input ramps are varied, the generate the resultant ramp applied to the vco.

This circuit also provides two different blanking pulses. The one present at the output of U2A is a ground-based pulse which goes positive during the capacitor discharge period and is used for retrace blanking. The second blanking pulse is positive during the sweep period and goes

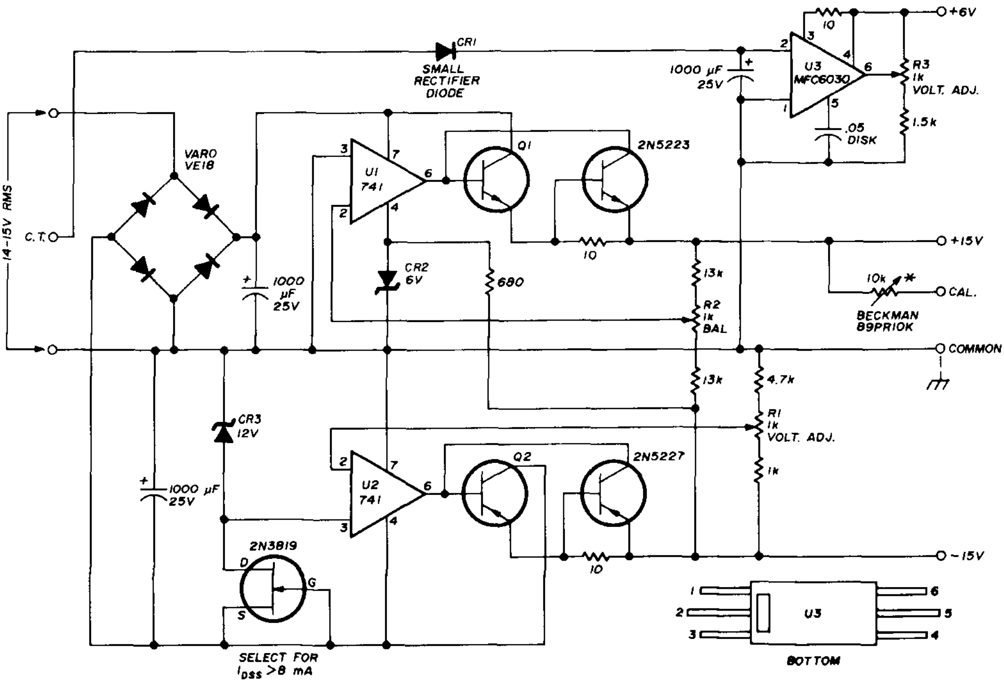


fig. 3. Power supply schematic. Transistors Q1 and Q2 should be silicon types with at least a 2-watt rating. U1 and U2 are 741 op-amps in TO5 cans; remove pins 1, 5 and 8. U3 is a Motorola MFC6030. Trimmers R1, R2 and R3 are 1-turn vertical-mounting units such as the Wescom RV301. The 10k Beckman pot may be omitted as it is not needed in this application.

output will assume the desired characteristics. A more detailed explanation is given in my previous article and will not be repeated here.

The output from U1B is the basic positive-going ramp which is used as both the *stop* signal and the horizontal sweep for the scope. It is also applied to the input of amplifier U3A which inverts it and provides the negative-going ramp required for the *start* signal. Controlled amounts of these two waveforms are applied to summing amplifier U3B to negative for the discharge portion of the cycle. This latter pulse is not used here and, once again, the unnecessary parts may be omitted from the board assembly.

One possible innovation which may be of interest was incorporated into the original unit. By means of appropriate switching, a dc control voltage may be applied to the vco in place of the ramp and is varied in amplitude by means of the *start* pot. This allows CW operation of the generator much as any other rf source.

Although not provided here, the output could also be fm modulated by capacitance coupling an audio signal into the vco in place of the ramp. At the same time, CW tuning could be maintained to allow adjusting to any desired center frequency.

boards used in the original instrument. The vco board was laid out to accommodate a film-dielectric variable capacitor having three gangs, 330-pF each. With all sections in parallel, this unit provides a range of 20 to 990 pF.

Since it is unlikely that prospective

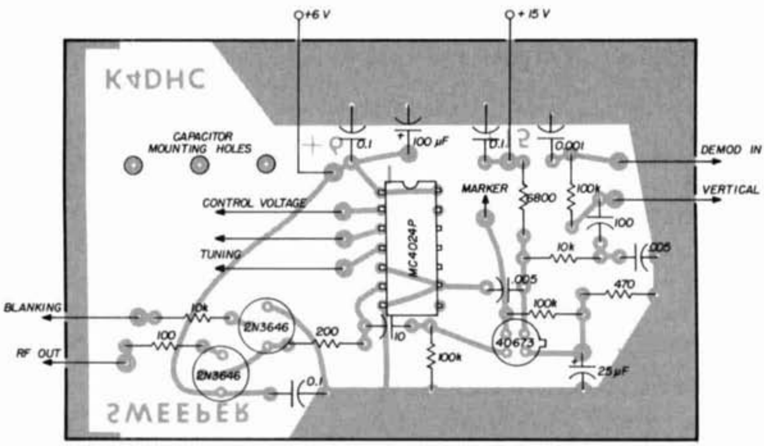


fig. 4. Component side of the vco board. Remove pins 10, 11 and 12 from the IC. Wide copper border on the left side is the common bus and should be grounded.

power supply

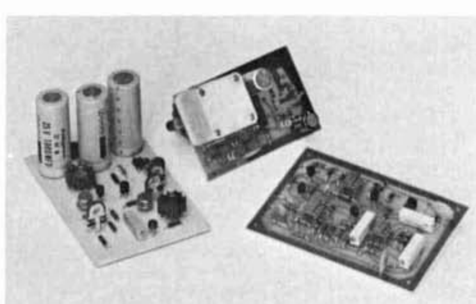
The power supply must furnish ±15.0 volts and +6.0 volts. Current requirements are quite moderate and no power transistors are needed in the regulators. **Fig. 3** is a schematic for the supply I used. It is assembled on a PC board and is another of my standardized circuits.

A tracking regulator is used in the ±15-volt section utilizing a pair of op-amps. Trimmer R1 will vary the voltage of both supplies simultaneously and trimmer R2 will vary only the +15-volt supply. Trimmer R2 is used to balance the two voltages and R1 is used to set the output level. The 6-volt section has its own regulator and trimmer.

Short-circuit protection is provided for all supplies. The 15-turn trimmer is not needed for the i-f sweep generator and may be omitted.

construction

Printed-circuit artwork and parts location drawings are shown for all three builders will be able to find any of these variables (Mitsumi PVC-3R), I suggest using fixed capacitors and a range selector switch. Approximate values for a three-band assembly would be 820, 150 and 20 pF to cover the range from 100 kHz to 15 MHz. The use of compression trimmers is recommended for ease of alignment. The board can be fastened directly to the rear of the bandswitch in the space allocated for the variable capacitor.



The power supply (left), the vco (center) and the ramp generator (right) printed-circuit assemblies before installation.

If you decide to use a substitute variable capacitor and mount it external to the board, don't forget to insulate it from ground! This capacitor is internally connected to two emitters in a balanced circuit and neither end can be grounded.

All external connections to the PC means of R2 and then set the level to 15.0 volts by adjusting R1.

The low voltage supply should be set to around 5.5 volts to start with as this may be adequate with some devices.

You may have wondered about the 4.7k resistors from the bottom end of

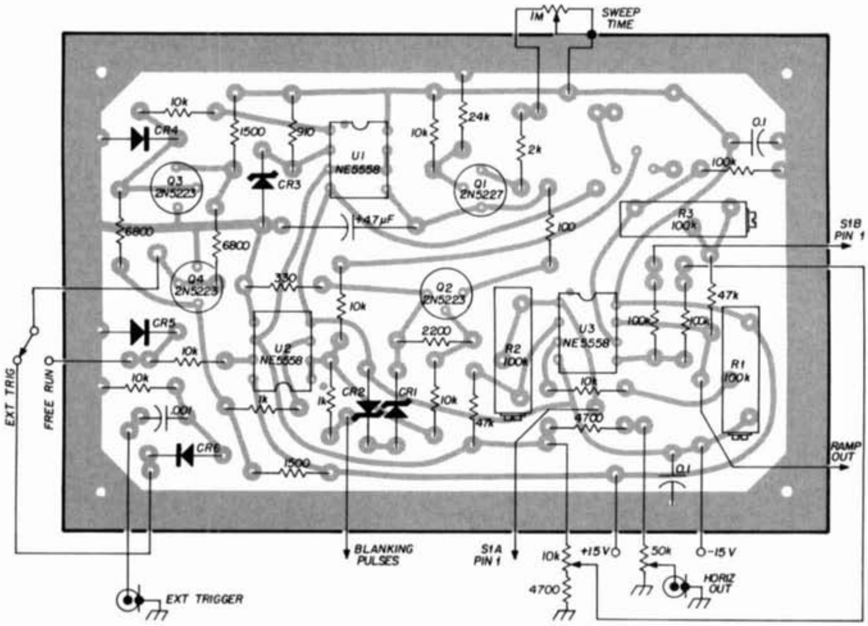


fig. 5. Component side of the ramp-generator board. The copper border is the common bus and should be grounded. If external triggering is not used, jumper points A and B on the board.

boards are made by wire leads connected to the appropriate pads provided on the boards. There is one exception to this on the vco board. The 100-pF capacitor which couples the marker signal to the mixer, Q3, is itself used to complete the connection between the board and the front-panel connector.

The photos show the three PC assemblies before installation as well as overall views of the interior and exterior of the completed unit. The cabinet is a Ten-Tec MW-12 which I happened to have on hand, but it is really larger than needed.

alignment

The power supply voltages should be set to the proper levels before anything else. Balance the two 15-volt supplies by each control pot to ground. These resistors overcome a 2-volt threshold in the vco control voltage response characteristic. Practically no frequency change occurs for the first 2 volts and a rather weird sweep would result if control was started from ground level.

When you are ready to start, set the mode switch to CW and the output frequency at the low end. With a scope or counter check the output frequency with the *start/cw* control at both minimum and maximum. If the tuning ratio is 5.5 to 1 or better, stop right there. If not, increase the supply voltage to around 5.8 volts and recheck to see if the ratio has increased. There will be a shift in output frequency due to the voltage change, but for now you are only interested in the actual range afforded by the control voltage. Set the supply level for the best ratio but do not exceed 6.0 volts.

Once this phase is complete, return the *start/cw* control to minimum and proceed with marking the "base frequencies" on the panel. If you used trimmer capacitors and a bandswitch, now is the time to set them to the desired frequencies. These changes will not alter the tuning ratio afforded by the control voltage. In the case of a variable capacitor, mark appropriate spots on the dial to suit your convenience.

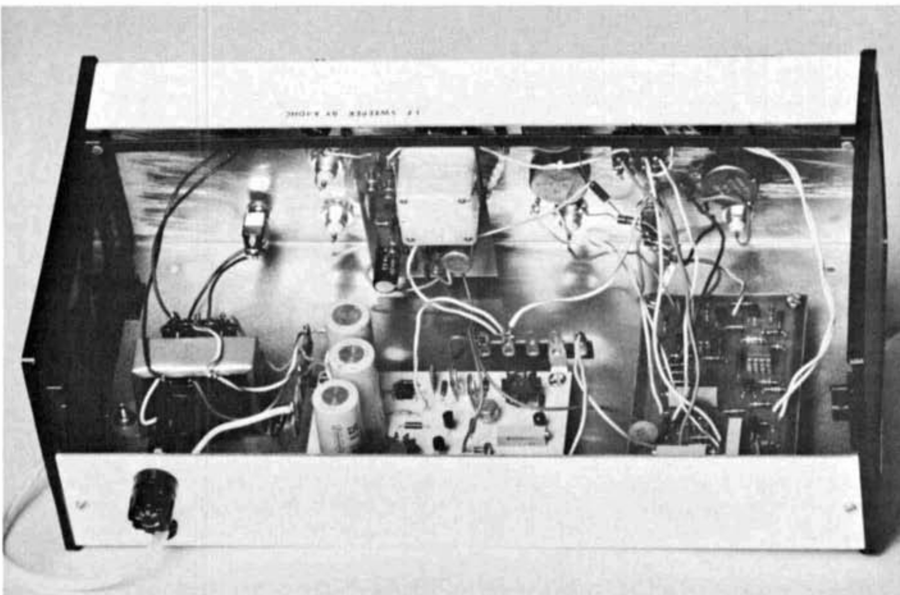
Next, the *start/cw* control should be marked off at points corresponding to multipliers of the base frequencies. These may be X2, X3 or whatever is suitable. Transfer these same points to the *stop* control and oscillator alignment is complete.

The adjustment proceedure for the ramp generator is next and will require the use of a dc oscilloscope. First, set the three 15-turn trimmers to mid-range, switch the mode switch to *swept* and turn the *sweep time* control to minimum resistance. Connect the scope probe to the top end of the *stop* pot. You should see a positive-going ramp of 6.0 volts amplitude and about 15 milliseconds duration with its base line at zero volts.

Switch the scope probe over to the high end of the *start/cw* control and observe a negative-going ramp. If all you see is a straight line, then it's likely the op-amp is latched up due to excess offset voltage. If the display is negative, start turning trimmer R1 in a counter-clockwise direction and reverse if the display is positive.

Once the ramp comes into view, adjust R1 so that the base line of the ramp is exactly zero. Next adjust R2 so that the amplitude of this ramp is the same as the first. You may have to readjust R1 since there is some interaction between these two trimmers. As soon as the two voltage ramps are set, connect the probe to a point on the mode switch where you can pick up the output ramp.

Turn the *start/cw* control to minimum



Interior view of the completed i-f sweep generator. The printed-circuit boards are mounted on metal spacers.

and the *stop* control to maximum. The result should be a positive-going ramp starting at approximately 2.0 volts and peaking at 6.0 volts. For tracking, adjust R3 so that the ramp peaks at the same voltage level as the maximum CW control voltage.

Turn the *start/cw* control towards maximum and observe the base line rising until, at maximum, there is a straight-line display. If any tilt still remains, it is due to summing error and may be corrected by readjusting R2 until the line straightens out.

Check for blanking pulses at the proper point on the mode switch and for the horizontal output ramp at the *width* control. Turn the *sweep time* control to maximum resistance. The sweep period should increase from the original 15 milliseconds to 5 or 6 seconds. That completes set-up and checkout of the ramp generator.

conclusion

Instruments such as the one I've described here can be extremely useful to the homebrew enthusiast and, even if constructed from all new parts, should cost only about fifty dollars.

Some portions of this device may be of interest even if the entire system is not. As I pointed out above, I have standardized the ramp generator and power supply for interchangeable use in several other designs. Incidentally, I normally use the full ramp capability of 12 volts in other applications and use a 12-volt zener for CR3. To maintain approximately the same sweep time range, a 2.2-μF capacitor is used at C1.

If anyone is interested in exchanging ideas regarding sweeping-type instruments, I would be pleased to hear from you. I will also try to help anyone having trouble locating any of the components or in duplicating the PC boards.

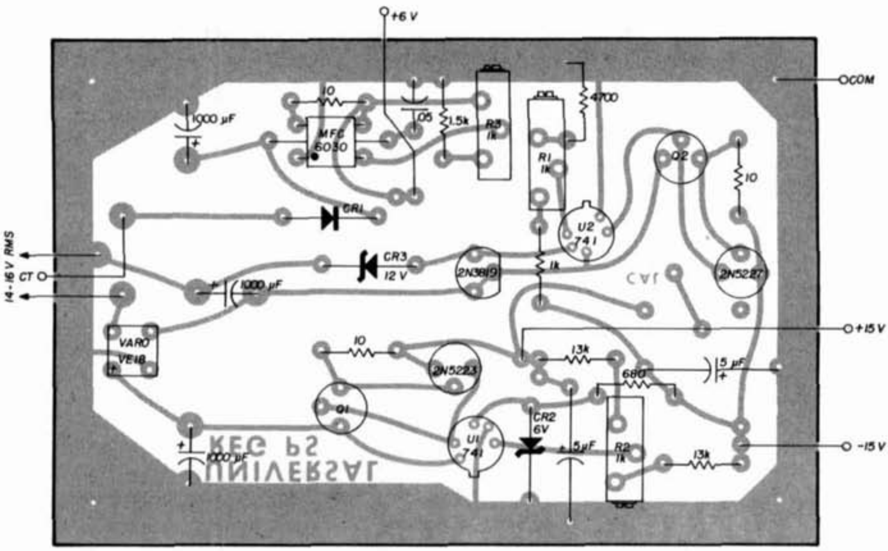


fig. 6. Component side of the power supply board. The copper border is the common bus and should be grounded.

reference

1. Ray Megirian, K4DHC, "Lab Type IF/RF Sweep Generator Using ICs," *73 Magazine,* November, 1972, page 226.

ham radio

rf speech processor for single sideband

High-performance rf speech processor for ssb offers 7 to 9 dB increase in effective audio output

Henry G. Elwell, Jr., W2MB, 392 Lafayette Avenue, Westwood, New Jersey 07675

Speech processing to improve communication capabilities has been discussed and developed for many years, and it covers both audio and radio frequency spectrums. Although audio clippers are simple to build and show effectiveness, they usually sound lousy. And, theoretically, they should.

Clipping produces square waves which are rich in harmonics. Thus, a 400-Hz tone includes 800 Hz, 1200 Hz, 1600 Hz, etc., up to the limit of the audio filter passband. Audio frequencies which do not produce harmonics in the audio passband, assuming a 3-kHz cutoff, are 1500 Hz and higher. The multiple audio harmonics produce the distortion in an audio-type clipper and give the high-pitched, tinny quality usually characteristic of such a device.

If the speech processor is used properly so that the transmitter presents a normal bandwidth signal, and if it truly enhances the communication capabilities of the station, it means little that your voice is high pitched and not recognizable to your friends — you are trying to improve your "get-through" ability.

However, some processors sound like "a one-man pile-up" and do little to improve communication effectiveness. An audio clipper I used improved my ability to get through the noise when signals were weak, but it sounded lousy. Studies and analyses indicate that processing at an rf level is the best way to go. During the 1972 ARRL DX Contest, a Comdel Speech Processor, which is based on rf clipping, was borrowed from W2JKN. Its effectiveness proved superior to the audio clipper, and, in addition, voice quality was almost as good as the output from my un-processed SB100 ssb transmitter.

A number of articles have been written on the subject of rf clippers. The simple fact that sells me is that the filter following the rf clipper attenuates all harmonics of the carrier. If proper design precautions have been taken to build a high-fidelity audio system, the final detected audio signal should be good.

all harmonics of the fundamental frequency and restores the modulation envelope to its fundamental characteristics.

The product detector, which uses the same local oscillator as the balanced modulator, produces the processed audio. A lowpass audio filter provides desired audio shaping of the signal to the transmitter microphone input. Two sideband filters are required for proper rf processing — the second filter is the one already existing in the station ssb transmitter.

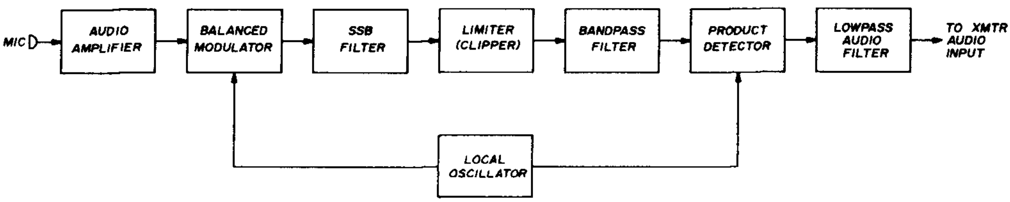


fig. 1. Block diagram of the rf speech processor.

My first attempt at rf clipping was in the intermediate frequency stages of the SB100, but it was unsuccessful. It's also awkward to modify a finished piece of equipment. The project lay dormant until my experience with the Comdel unit — then I had to have my own.

An rf clipper with audio in and audio out permits the construction of a black box which is put between the microphone and the audio input of the transmitter. It is actually a complete ssb transmitter-receiver, but its output is powerful (**fig. 1**).

operation

The audio amplifier amplifies the microphone signal to a level suitable to drive the balanced modulator. The balanced modulator, excited by a local oscillator, produces a double sideband signal with suppressed carrier. The ssb filter eliminates one of the sidebands, and the limiter provides the necessary gain to produce limiting or clipping at the carrier frequency. The bandpass filter attenuates

The nice part of the device shown in **fig. 1** is that it can be built without disturbing the station transmitter. For all practical purposes each stage can be tested as you go along. However, you must build the stages in the following order to permit "as you go" testing: power supply, audio amplifier, balanced modulator and local oscillator, sideband filter, limiter and passband filter, product detector and, finally, the lowpass filter (see **fig. 2**). When built in this sequence, each item can be tested and certified as being correct before proceeding further. With this approach I was surprised at how little "fooling around" was required to make the device work properly when I connected it to my transmitter.

Many of us, including myself, get overwhelmed with the rapid strides in electronics these days, and we approach some of the new microcircuits with doubts in our minds, because it isn't a vacuum tube. I've taken a stand, however, that no more vacuum tubes will be used in any of my new equipment. Further-

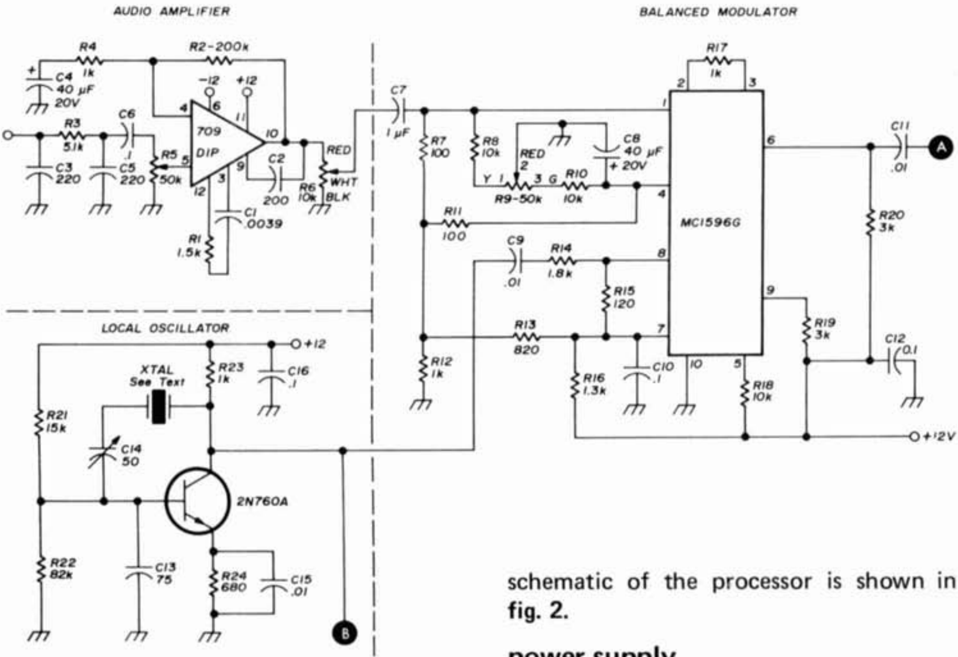
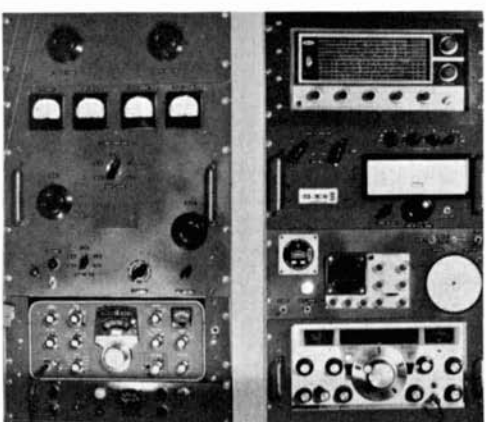


fig. 2. Circuit for the rf speech processor makes maximum use of integrated circuits. Power supply is shown in fig. 3.

more, if I can find a multifunction microcircuit to do the job, I will eliminate the transistors as well. Of course, this requires a lot of faith in the microcircuit application engineers. In building an rf speech processor the manufacturer's designs were followed by me explicitly, and the thing works great. A complete schematic of the processor is shown in **fig. 2.**



Station console used at W2MB.

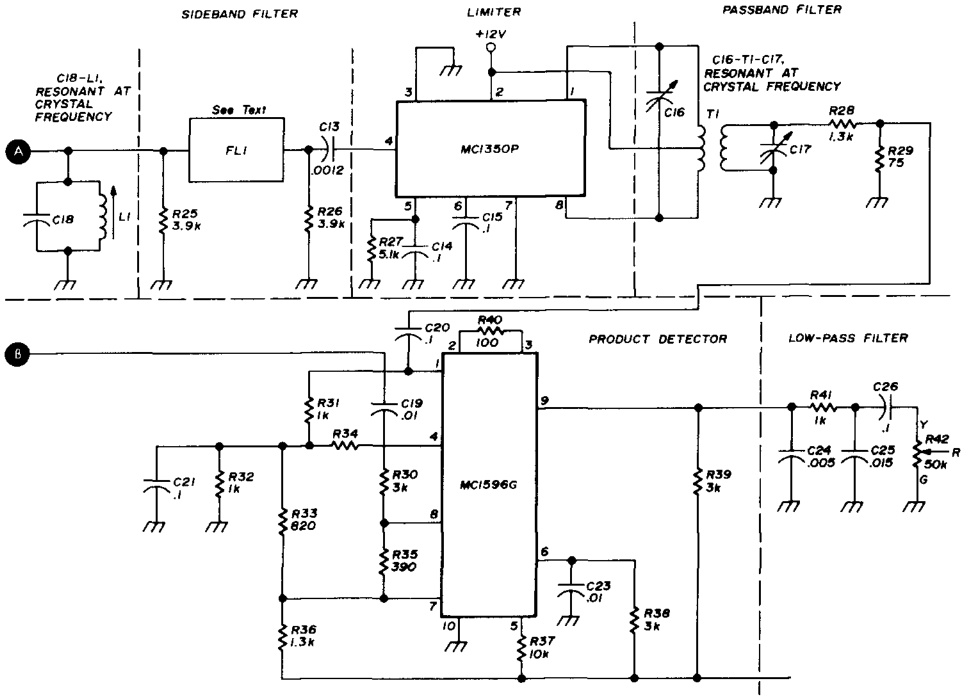
power supply

The processor circuitry requires both positive and a negative 12-volt supply. The negative 12 volts were required for the 709 audio amplifier; all other circuits require +12 volts only. To keep it simple, a transformer with a 24-volt center-tapped secondary was connected to a bridge rectifier and the center tap used as ground (see **fig. 3**).

To keep the output voltage within bounds, a 12-volt zener diode was used in each polarity leg. The selection of the series zener resistors was an experimental one, because the current requirements of the ICs were unknown at the time I built the power supply. Once the − 12-volt load was established, it remained constant because the 709 IC was the only load. However, as additional loads were placed on the +12-volt line, the output level dropped below 12 volts because of the drop across the series zener resistor. The value of that resistor was then lowered to permit the zener diode to regulate the output voltage. The ripple on the positive voltage is higher than the negative output, and a larger filtering capacitor is used.

audio amplifier

The design philosophy of the audio



oscillator was to obtain as flat a frequency response and low distortion as possible, relying on the sideband filter to provide the desired audio response. Just any old IC op-amp is not suitable as some of them have poor frequency response. The 709 was used because it has good response and is readily available. The circuit, as shown, is flat, within 2 dB, from 30 Hz to at least 10 kHz, with a gain of about 200. Maximum undistorted output is 7.5 volts.

The potentiometer, R5, is used for setting the clipping level, whereas potentiometer R6 is used to set a maximum permissible level to the balanced modulator. An rf suppression network, consisting of C3, R3 and C5, was included to minimize rf feedback problems. However, it was not entirely effective as will be discussed later.

local oscillator

The choice of the carrier frequency is your own. I had two crystal filters on hand; the original SB100 filter, 3.395 MHz, removed from the rig when I installed the Heath 400-Hz filter, and a Hermes model 2215KZ filter, centered on 2.215 MHz. The Heath filter has a nominal shape factor of 2.1 while the shape factor of the Hermes is 3.5. Since the 2.1 shape factor may be needed on some other, more critical, project, the Hermes filter was used in the speech processor. It makes little difference what frequency your filter is as long as it is not too high. The limiter stage should have as large a spectrum above its operating frequency as

table 1. Voltage readings at the pins of the μA796 balanced modulator.

pin number	dc reading (volts)
1	3.6
2	2.9
3	2.9
4	3.6
5	1.2
6	8.7
7	6.8
8	6.8
9	8.7
10	0

possible to permit it to generate the many harmonics that result in effective clipping action. Thus, the lower the better seems appropriate.

The Comdel speech processor uses an oscillator frequency below 500 kHz, which permits the use of an LC sideband filter. Some readers may wish to explore that area. However, since I had the crystal filter on hand I used it.

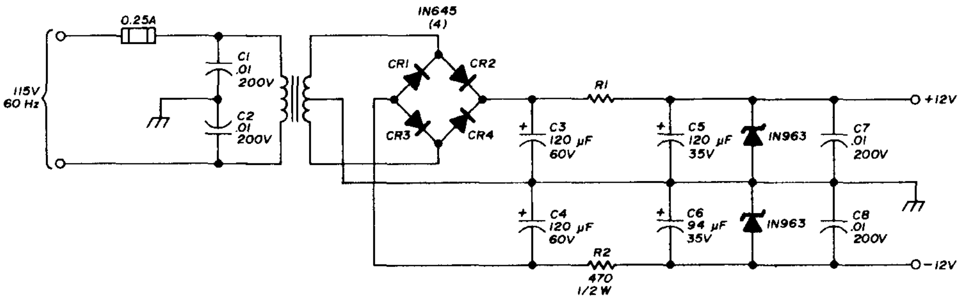


fig. 3. Power supply for the rf speech processor. For dropping resistor R1, start with 470 ohms (2 watts) and add 390-ohm resistors in parallel as more stages are added to the processor (see text).

I used a crystal oscillator of conventional design, but the use of a trimmer at C14 is essential to properly align the crystal frequency in the crystal filter passband. A total variation of about 1 kHz was possible with the trimmer shown in **fig. 2.** The oscillator has an output at the collector of 2.4 volts.

balanced modulator

A number of articles have been written using the Motorola MC15966 balanced modulator.* The IC I actually used, however, was the equivalent Fairchild µA796, because of its availability. The balanced-modulator circuit I used was described in an industrial electronics magazine, *EDN/EEE*.[1] The local-oscillator signal is recommended as being 60 mV. Adjustment of the local-oscillator signal is accomplished by varying R14 and R15 to prevent excessive loading of the oscillator while, at the same time, keeping R15 as low as possible; 50 ohms is recommended. It was a compromise, therefore, to end up with a local oscillator input of 85 to 90 mV with R15 at 120 ohms.

table 2. Dc operating voltages of the MC1350P IC under quiescent conditions.

pin number	dc reading (volts)
1	9.0
2	12.3
3	0
4	4.0
5	4.2
6	4.0
7	0
8	9.0

A dc check was run using three different µA796 ICs and they all have the same readings as shown in **table 1.** Measurements were made with a Heath Model V-7A-volt ohmmeter.

The recommended modulating signal voltage is 300 mV and R6 is used to set the proper level. The setting of R6 depends upon the microphone being used, and it is necessary to experimentally determine the microphone output. Then, with an audio signal input at the maximum expected level and with R5 at one-half range, R6 is adjusted to produce a µA796 pin 1 level of 300 mV. Output at pin 6 with C18-L1/ peaked is about 200 mV.

The null balancing potentiometer R9 with zero audio signal is adjusted to produce minimum output voltage. The best I could obtain was 30-dB attenuation.

*The National LM596, Signetics NE596 and Fairchild µA796 are equivalents.

sideband filter

After the sideband filter is wired in, and output is obtained from it, the frequency of the local oscillator must be adjusted for the desired passband. The setup shown in **fig. 4** is useful.

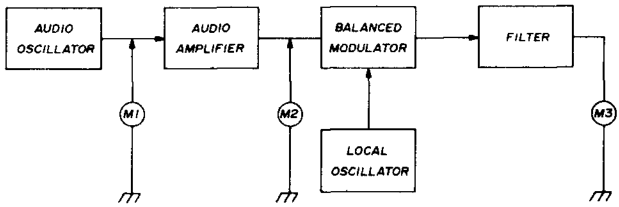


fig. 4. Test setup for setting the frequency of the local oscillator for the desired audio passband. Meters M1, M2 and M3 are voltmeters.

The voltmeter, M2, is not really necessary, but it provides information on the response of the audio stage. A frequency response curve from about 50 Hz to 4000 Hz should be run and plotted in dB vs frequency. The local oscillator capacitor, C14, should be adjusted to move the audio passband up or down, depending on the initial frequency plot. My initial attempt put the lower frequency roll-off at 600 Hz; this is much too high. Since my voice is normally high pitched, the oscillator frequency was adjusted so that the 6-dB down points occurred at 200 Hz and 2700 Hz.

limiter

I originally decided to use a μA709 IC op-amp for the limiting stage. However, after considerable attempts at high-frequency compensation with poor results, the idea was abandoned. The use of the μA709 op-amp was carried through, however, until the complete processor was finished and put on the air. It sounded raucous and was quickly removed.

An LM373 was tried as a combination clipper-filter-product detector stage, but it was also unsuccessful. The LM373 would be ideal if the input to the product detector was available for monitoring or filtering.

Finally, a limiter using an MC1350P was built. The MC1350 is a $1.15 item designated as an i-f amplifier. It has a typical power gain of 48 dB at 58 MHz and was put to work in a circuit recommended in the Circuit Specialists catalogue.

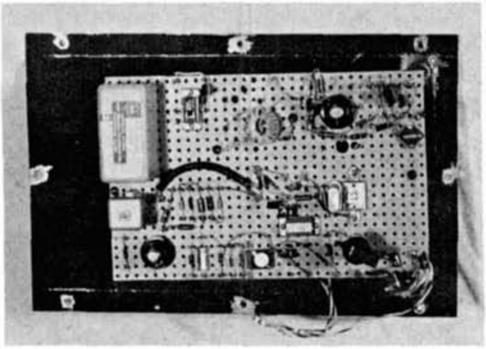
The device has one feature which I first felt to be a disadvantage – it requires a center-tapped primary for the output transformer. I felt it was desirable, for simplicity, to use a single-parallel tuned circuit for the passband filter as was done on the output of the balanced modulator. However, the MC1350 output requirement made it necessary to use a double-tuned transformer with much superior passband characteristics. The output from the filter is an exceptionally good sine wave, even at maximum limiting, indicating excellent harmonic attenuation. A conventional shielded, slug-tuned coil form was originally used but was replaced by a small toroid for physical size reasons only.

Tuning of the primary and secondary of the toroid coil is accomplished with trimmer capacitors. As oscillation occurred with the secondary open; a 1.3k ohm resistor across the secondary stopped the oscillation. Maximum voltage across the

table 3. Dc operating levels of the μA796 product detector under quiescent conditions.

pin number	dc reading (volts)
1	3.8
2	3.0
3	3.0
4	3.8
5	1.3
6	9.0
7	7.2
8	7.2
9	9.0
10	0

secondary is 2.4 volts. Limiting of this stage occurs at 80-mV audio voltage into the balanced modulator, but no distortion appears across the secondary winding of the transformer at 800-mV input to the balanced modulator. **Table 2** indicates the dc voltages to be expected under quiescent conditions.



Speech processor is built on a section of perforated board. Crystal filter is in upper left-hand corner with MC1350 limiter to the right. MC1596 product detector is in upper right, just above crystal-controlled local oscillator. MC1596 balanced modulator is in lower right-hand corner.

product detector

A μA796 IC is also used as a product detector to convert the rf signal back to audio. Again, the recommendations of the application engineers were followed and the circuit worked fine. **Table 3** indicates the dc voltages to be expected under normal quiescent conditions.

The designers' recommendations regarding ssb level to the product detector are to use up to 100 mV rms. Since the output from the limiter stage was excessive the resistive loading on the secondary of the rf transformer was made into a voltage divider to supply a maximum of 100 mV to the μA796. The carrier level was set at about 180 mV by means of the voltage divider feeding pin 8 of the IC.

lowpass filter

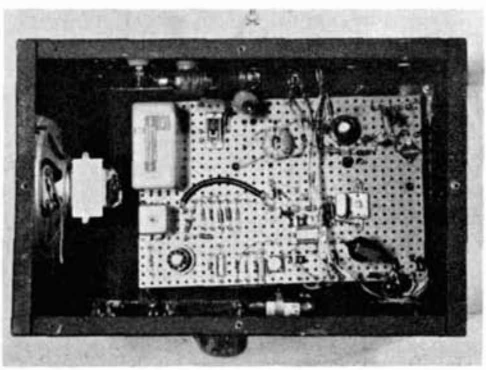
The lowpass filter eliminates all remaining rf energy and provides a little audio shaping. I used a 0.015-μF output capacitor to provide better balance between my normally high-pitched voice and the permissible frequency response of the system. The output potentiometer, R42, was adjusted so that the processor output voltage was the same as that delivered by the microphone directly. Thus, I can switch from normal to processor with no adjustment to the transmitter microphone gain control.

dummy load tests

Tests with the SB100 ssb exciter into a dummy load indicated that the audio with the new processor in the line sounded much like the un-processed SB100 signal, with one difference – the audio was very loud and full. To see what was happening, different limiting values were cranked in and measurements recorded from the SB100. The results are shown in **table 4.**

How was the dB limiting cranked in? W2LL and I discussed the meaning of "a given dB of limiting," and made the following conclusions. First, increase the audio input signal until limiting of the output occurs, call it **A.** Then, the ratio of a further increase in input audio to the A input signal, call it **B,** expressed in dB is the amount of limiting in dB.

This was done by measuring the audio voltage at pin 1 of the balanced modu-



Speech processor circuit board is mounted in an old portable receiver chassis (speaker on left is not used).

lator, while monitoring the audio level at the output of the processor. With an input signal equal to maximum mike level, increase R5 from zero output until a limiting output is obtained at the processor output. Just juggling R5 while watching the output meter will give a suitable answer. Call this measured input voltage to the balanced modulator **A**. If you double the **A** voltage by increasing R5 you have produced 6-dB of limiting. Of course, the processor output does not change.

If you increase the **A** voltage ten times, you have 20 dB of limiting or clipping. That is the way I did it and, having read no other description elsewhere, the procedure is assumed to be correct.

The tests of **table 4** were accomplished by talking into the microphone and noting the peak of the two meter indications; plate current and relative power. It was necessary to use a repeatable sound, and the word "three" was found to be the best of the usual "one, two, three, four, hello test," variety. The audio gain of the transmitter was adjusted so that grid current of the output stage would barely flicker. The adjustment was tricky with the microphone alone, but, with the processor, there was no problem. Once limiting occurs, no additional grid drive is experienced, regardless of how loud you talk. However, the test showed that increased limiting did produce higher plate currents and relative outputs.

on the air tests

W2KXD, who is my strongest critic in the speech processing area, said that my signal was 1000 times better (whatever that means) than my audio clippers or my earlier test with the 709 limiter and was acceptable for on-the-air use. Brief tests were made on 75 meters and without the processor my signal was S9 +29 to +34 dB. With the speech processor in the line my signal was S9 +38 to +41 dB. This is an improvement of 7 to 9 dB in signal strength.

table 4. Performance of the speech processor with different limiting levels.

limiting (dB)	plate current (mA)	relative power
none	100	4.0
8	140	5.5
14	160	6.5
17.5	170	7.5

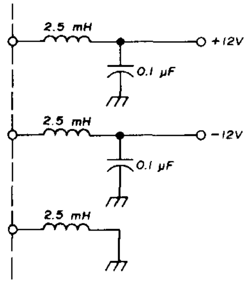


fig. 5. Filtering added to the power supply leads to prevent rf feedback within the speech processor.

Next, I went to 20 meters and got into a pileup for a UK2. He came back to me and we exchanged reports and names; before we could sign a UK3 called me so we moved up 5 kHz and talked for awhile.

Then I went to 15 meters and calamity hit – rf feedback galore. Ten meters and even 40 gave me problems. The processor was in a metal box, the power supply was in an external metal box and the interconnecting wires were plain hookup wire. The solution was to put a 2.5-mH rf choke between a feedthrough on the processor box and a 0.1-μF ceramic capacitor to ground for the +12 and -12 volt lines and the ground lead as shown in **fig. 5.** This completely cured the rf feedback. The microphone input cable and the cable from the processor are shielded.

ham radio

reference

1. Roy Hejhall, "For High-Frequency Communications Use Balanced Modulators," *EDN/EEE,* February 15, 1972.

coax dehumidifier

Here's a drier
for hard-line coax
that uses no motors,
no pumps,
no electricity,
no gas, and
practically no money

William L. Smith, K4RJ, Franklin, North Carolina 28734

It looks like RG-8/U coax is on the way out, and not a day too soon. Repeater operators, meteor chasers, aurora gazers, moonbouncers, microwave nuts, and even dc-band DXers are making more use of low-loss lines which use metal-tube outer conductors in place of that old braid.

There are two kinds of hard-lines in general use. In one type the cable is filled with foamed insulating material, which excludes air and moisture, and supports the inner conductor. In the second type, usually called "air dielectric" the inner conductor is supported by a minimum of insulating material, the rest of the space being filled with dry air or gas. This is the kind which has the lowest losses at all frequencies.

The big problem with air-dielectric cable is how to keep it dry inside. Commercial installations use tanks of dry nitrogen or other gas under pressure, air pumps equipped with dessicators, or mechanical dehumidifiers, and sometimes even include heaters for drying the dessicant. Most such installations cost between $100 and $1000; amateurs need a more simple and economical solution to the problem.

The cable I use at K4RJ (and formerly at W3GKP) is a 40-foot length of 1-5/8-inch Styroflex. The input to the cable is about 275 watts at 2304 MHz. The power is monitored with a directional coupler which gives a full-scale reflected-power reading (and automatic transmitter switch-off) at approximately 1.2:1 standing wave ratio. The loss in the line is about 2 watts per linear foot.

observations

Four years of operating produced the following observations:

1. If the cable is sealed at both ends while filled with ordinary air containing some moisture, the swr is excessive. If a tuner is inserted to lower the swr seen by the transmitter, the swr readings become unstable at full power. Each adjustment of the tuner to lower the swr results in another shift in impedance, the condition continuing for several hours, possibly without end. It seems that the power dissipated in the line is moving the moisture around from one place to another.

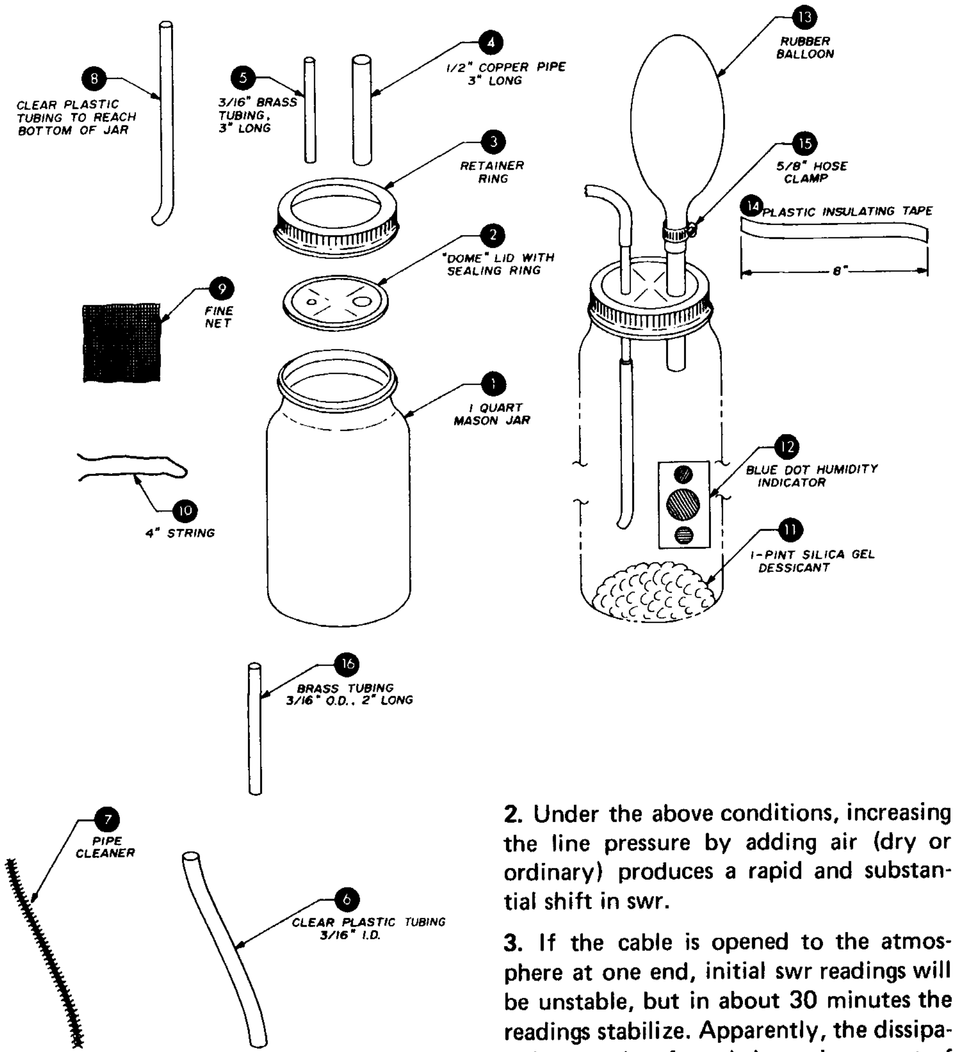


fig. 1. Construction details of the low-cost hard-line dehumidifier. See table 1 for complete list of parts.

2. Under the above conditions, increasing the line pressure by adding air (dry or ordinary) produces a rapid and substantial shift in swr.

3. If the cable is opened to the atmosphere at one end, initial swr readings will be unstable, but in about 30 minutes the readings stabilize. Apparently, the dissipated power has forced the moisture out of the cable. If the cable is left unsealed the whole job must be repeated the next day.

4. Opening the cable at both ends and flushing it with dry air (air from a small compressor pumped through a can of dessicant and into the cable) will result in stable readings. However, this air flushing takes longer than the rf flushing described in **3** above.

5. If one end of the cable is sealed, and the other end is attached by a short length of tubing to a closed can of dessicant, the cable can be flushed by rf in about 30 minutes, as in **3**. Thereafter, the swr will remain low for a week with no further operation of the transmitter.

objectives

The objectives for a home-made drying system would be to keep the line under a slight positive pressure (to insure there is no leakage from outside in), and should include a pressure indicator and an over-pressure release. It should also include a drying agent and a humidity indicator.

Maintenance, if required, should be simple and easy. Periodic operation of any of the apparatus should not be needed. Furthermore, the drying system should be safe, and both initial cost and operating expense should be minimized.

My system meets these objectives. One end of the cable is sealed; the other end is connected by tubing to a container of dessicant. Normal changes in temperature cause the cable to "breathe" through the dessicant. Air "exhaled" by the cable passes into an ordinary balloon, which serves as a constant-pressure variable-volume indicator, and safety valve. The dessicant is held in a glass container, through which the humidity indicator can be seen clearly.

construction

All the parts for the dehumidifier are shown in **fig. 1** and described in **table 1.** First, punch, drill or ream two holes in the dome lid to pass the 3/16-inch brass tubing and 1/2-inch copper pipe with a snug fit. Tin the edges of the holes with solder, insert the two pieces of tubing, leaving about a third of the length on the lower side of the lid, and solder them in place. Be careful when soldering not to damage the rubber seal around the edge of the lid.

Now, attach the clear plastic tubing to the 3/16-inch brass tubing, and assemble the lid to the Mason jar with the retaining ring. Submerge the jar in water, and while holding your thumb over the open end of the copper pipe, blow into the free end of the plastic tubing and look for air bubbles. If it leaks, re-solder the joints. If it's airtight, separate all the parts and dry them thoroughly.

table 1. Parts list for the coax dehumidifier.

1.	1 quart Mason jar
2.	1 Dome lid for Mason jar
3.	1 retaining ring for holding Dome lid on jar
4.	½" copper pipe, 3" long
5.	3/16" OD brass tubing, 3" long
6.	3/16" ID (5/16" OD) clear plastic tubing, length to reach from dehumidifier to coaxial cable
7.	pipe cleaner
8.	3/16" ID (5/16" OD) clear plastic tubing, length to reach bottom of jar
9.	2" square nylon stocking material or fine net
10.	4" string
11.	1 pint silica gel dessicant
12.	Blue-Spot humidity indicator
13.	rubber balloon, size and color optional
14.	8" length plastic insulating tape
15.	5/8" stainless hose clamp
16.	3/16" OD brass tubing, 2" long

Wrap the fine net (an old nylon stocking works fine) over one end of the short section of clear plastic tubing (part 8 in **fig. 1**) and tie it in place with the piece of string. Push the other end of the plastic tubing over the lower end of the 3/16-inch brass tubing which is soldered to the jar lid.

If the silica gel has been exposed to the air, dry it according to the instructions on the container (or spread it on a flat pan and bake it in an oven at 250° F for five hours). When the dessicant is completely dry, place the Blue-Spot humidity indicator inside the Mason jar so the spots are visible from the outside and pour the silica gel into the jar. Reassemble the lid and retainer ring on the jar and work the plastic tubing down through the silica gel until it's near the bottom of the jar.

Place the rubber balloon over the top of the 1/2-inch copper tubing, wrap it tightly with the plastic insulating tape, and secure it with the 5/8-inch hose clamp. Slip one end of the long section of plastic tubing (part 6, **fig. 1**) over the end of the 3/16-inch brass tubing. Place the pipe cleaner (a secondary dirt filter) in the free end of the plastic tubing.

Arrange the air fitting on the coaxial line to receive the free end of the plastic tubing. If necessary, drill or ream the air fitting to accept a 2-inch length of 3/16-inch brass tubing (part 16) and solder the tubing to the coaxial line. The plastic tubing can be attached to this brass tubing.

Now, blow into the free end of the plastic tubing until the rubber balloon is suitably inflated. Quickly push the free end of the plastic tubing over the brass tubing soldered to the coax line. This completes the dehumidifier system.

Obviously, there is nothing magic about the dimensions I used, but a few remarks may be in order. The flexible plastic tubing should be a snug push fit on the brass tubing so that clamps are not needed. The shorter the length of the tubing to the coaxial line, the better the system will work.

If the balloon is a snug fit on the copper tubing, it may be held tight enough just by the tape. In one case I found the balloon fit only loosely, so the hose clamp had to be used.

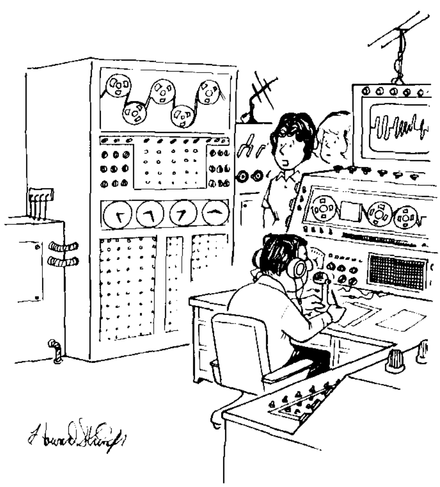
If the system is inflated by lung power, condensed moisture from the breath may be seen inside the plastic tubing, especially in cold weather. However, this will dissipate in a few days. It can be avoided by using a tire pump or football pump to pressurize the system. Initial drying of the air can be accelerated by running the line at full power for an hour or so.

Don't expect the size of the balloon to change dramatically unless you have a long, fat coaxial line. The actual change will depend on the temperature variations. Black-jacketed line exposed to the sun will heat up much more than line buried in the earth.

On a recent trip I described this system to several amateurs and one asked, "What happens when the balloon breaks?" I thought this was a joke until I returned home and found the balloon split and deflated (it was an old one). This is not a crisis because the cable continues to breathe through the dessicant, which traps any moisture which might otherwise enter. My system sat "open" like this for four days without any noticeable change in the dryness of the dessicant or the swr of the cable.

Now that we have gotten rid of that RG-8 – what about the PL-259?

ham radio



"It started out as a simple listening post. But that's how Arnold is. . . When he gets involved in something, he goes all out."

one-crystal frequency-synthesizer for two-meter fm

Design aspects of a frequency synthesizer for receiver and transmitter frequency control on two meters

Jack Cox, WØKMV, 13525 West 7th Drive, Golden, Colorado 80401

Integrated circuits have made it possible to build simple frequency synthesizers that heretofore had been complex to design and construct. As an added bonus, 7400-series TTL ICs have made even a large synthesizer inexpensive. Several articles describing synthesizers have appeared, but most of them are designed for a specific transmitter or receiver or transceiver. Modifying them to fit other frequency-multiplication and i-f schemes has called for a major redesign of the circuit. In addition to these problems, some frequency synthesizers have an extremely long lock-up time, making them unusable for transceive operation.

The heart of a digital synthesizer is the phase locked loop (PLL). Basically, the PLL is a circuit that compares the phase of two input signals and produces a dc voltage whose amplitude is relative to the difference in phase of the two signals. This dc voltage, after filtering, is used to change the frequency of a voltage-controlled oscillator (vco). When the vco frequency and phase reach a value equal to the reference frequency applied to the PLL, the dc voltage stops changing and the loop is said to be locked. A basic phase-locked loop is shown in **fig. 1.** From this circuit will be developed a frequency synthesizer that is flexible and can be adapted to almost any transceiver presently in use.

Although this article is not intended as a construction article, all of the circuits shown have been breadboarded and work. A synthesizer using these circuits is now under construction. This article is intended primarily to stimulate thought in the design of synthesizers in order to obtain the best possible circuitry.

basic phase-locked loop

Referring to **fig. 1,** it can be seen that the output frequency of the vco and the reference frequency must be the same to arrive at a locked condition. Although

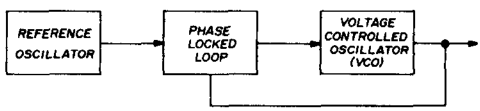


fig. 1. Basic phase-locked loop.

this is not practical for our purposes, it does bring to mind the possibility of using the PLL as a stable frequency reference by using a conditioned signal source.

Note also that the vco output frequency will be just as stable as the reference frequency input to the PLL. In any frequency synthesizer, stability is dependent upon the reference frequency and should be given serious thought. Since the circuit of **fig. 1** is unusable in a channelized system, it is expanded to include a counter or programmable divider, as shown in **fig. 2.**

By including the counter in the feedback loop, you can now produce N number of output frequencies with only one reference frequency input. This is achieved by programming the counter to always have a frequency output equal to the reference frequency, regardless of the vco output frequency.

For example, assume the reference is 1 MHz and the desired output frequency is 7 MHz. The programmable counter, in this case a down-counter, is preloaded with the number 7. The counter now counts down from 7 to 0 and reloads, and the count recycles again. The counter produces one output pulse for every seven input pulses. This is equal to 1 MHz output for 7 MHz input and the loop is locked, producing a stable output at 7 MHz. Lock is achieved by the PLL producing a dc output voltage that causes the vco to move frequency in the proper direction to achieve lock.

A phase-locked loop system has a basic property that must be taken into account when designing a frequency-synthesizer system. This is the amount of time required for the system to lock after a step in frequency. Generally, the lower the reference frequency, the longer the amount of time required to achieve lock. This is due primarily to the time constant of the components used to filter the dc output voltage. This explains the long time constant in some designs where the reference frequency is in the order of hundreds of hertz.

In one design the required output frequency was approximately 6 MHz for the transmitter and the desired channel spacing, at 144 MHz, was 10 kHz. In this design, the 6-MHz signal was divided by the counter to produce an output of 416.666 Hz, which is equal to the reference. After multiplying the vco output by 24, these 416.666-Hz steps produced a 10-kHz change in frequency at 144 MHz. Because of the very low reference frequency, lockup time was approximately 3 seconds. Of course, this is much too long to be useful in a transceiver. This design also required special switching functions to achieve the required divide ratio.

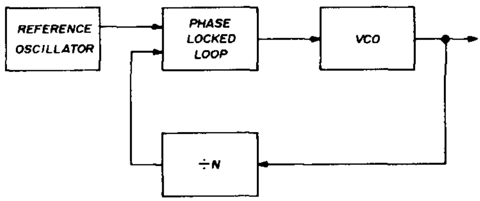


fig. 2. Phase-locked loop using a programmable frequency divider.

The frequency synthesizer shown in **fig. 3** is much the same as **fig. 2,** but an additional frequency divider has been added to the output of the vco and the reference frequency has been designated as 10 kHz. The variable counter is programmed so that each step in frequency produces a 10-kHz change in the vco output. This keeps the reference frequency high enough so it is easy to filter. It will also allow the use of easily available thumbwheel switches to provide direct readout.

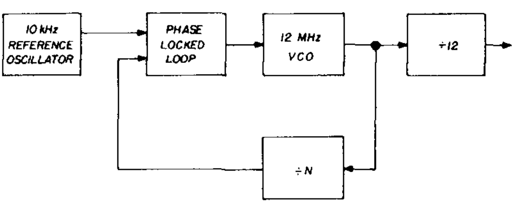


fig. 3. Phase-locked loop with an output frequency divider.

The added divider is used to divide the output of the vco by an amount equal to the multiplication factor of the trans-

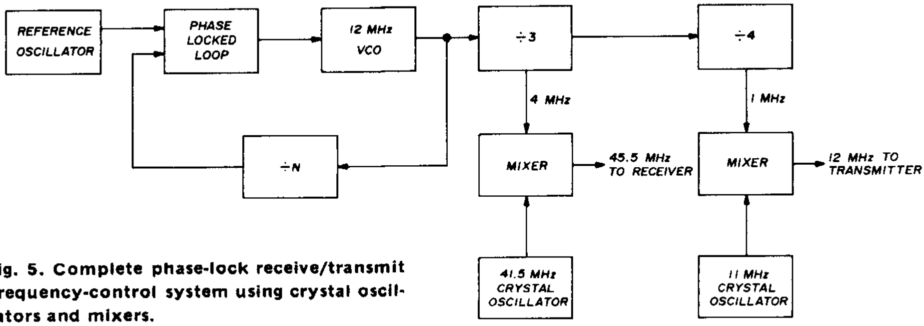


fig. 5. Complete phase-lock receive/transmit frequency-control system using crystal oscillators and mixers.

mitter. Assume the transmitter multiplies the crystal frequency by 12. Assuming a vco frequency of 12 MHz, the output is divided by 12, resulting in 1 MHz. This 1-MHz signal is mixed with 11 MHz, producing a frequency of 12 MHz. This is multiplied by 12 to 144 MHz.

If it is desired to transmit on 144.010 MHz, the programmable counter is stepped from the original 1200 to 1201. The vco frequency is now 12.010 MHz, divided by 12 to 1,000.833 Hz, mixed with 11 MHz to 12,000.833 Hz and multiplied by 12 in the transmitter to provide the final output at 144.010 MHz.

As can be seen from **fig. 4**, this system requires the use of a mixer and another crystal oscillator and doesn't provide for the receive function. However, a one-crystal system will be shown (the one crystal oscillator is that of the reference) that will provide both the transmit and receive frequency control and will be suitable for transceiver operation.

receiver control

The basic system shown in **figs. 3** and **4** is applicable to any transmitter multiplication factor. Normally, the vco frequency should equal that of that original transmitter crystal which is being replaced by the PLL. This system was developed for a General Electric TPL rig. Although the TPL originally used 6-MHz crystals in the transmitter with a multiplication of 24, 12-MHz crystals seemed to work just as well and produced adequate deviation.

However, to include receiver frequency control in the system requires the addition of another frequency divider (see **fig. 5**). The required divide-by-12 (for the transmitter) is replaced by divide-by-3 and divide-by-4 circuits connected in series. This technique provides a control frequency for the receiver. Using a first receiver i-f of 8.7 MHz, the required injection frequency for reception on 144 MHz is 135.3 MHz. This, divided by three (the multiplication factor in the receiver) is 45.1 MHz.

In **fig. 5** the basic 12-MHz vco frequency is divided by 3, providing an output at 4 MHz. This 4-MHz signal is mixed with a 41.1-MHz crystal oscillator to obtain the 45.1-MHz receiver injection frequency. The system of **fig. 5** provides complete frequency control for both transmit and receive with one programmable divider and three crystals. How-

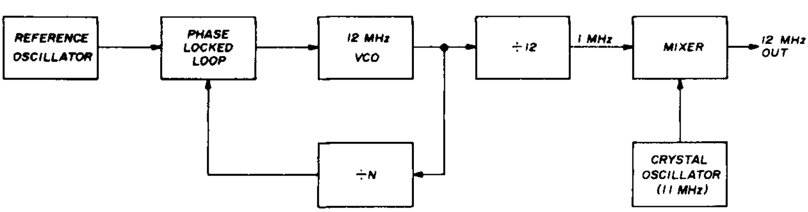


fig. 4. Phase-locked transmitter frequency-control system providing 10-kHz steps on two meters.

ever, it is possible to develop a one-crystal system that has the same stability as the reference oscillator. The system of **fig. 5** is as stable as the two crystal oscillators because their instabilities are additive. However, because of some of the odd intermediate frequencies in some receivers, it may be necessary to use this technique to avoid a complicated frequency-division system.

It is important, before proceeding, to choose the frequency of the reference reference oscillator will produce a frequency error in the output of the vco. The drift is a ratio between the divide program of the programmable counter and the reference error. By measuring the reference error, it is possible to predict the vco error. The often-used phrase, "good enough for ham use," is not good enough. Most amateur repeater and mobile installations are commercial quality, and we should strive to keep it that way.

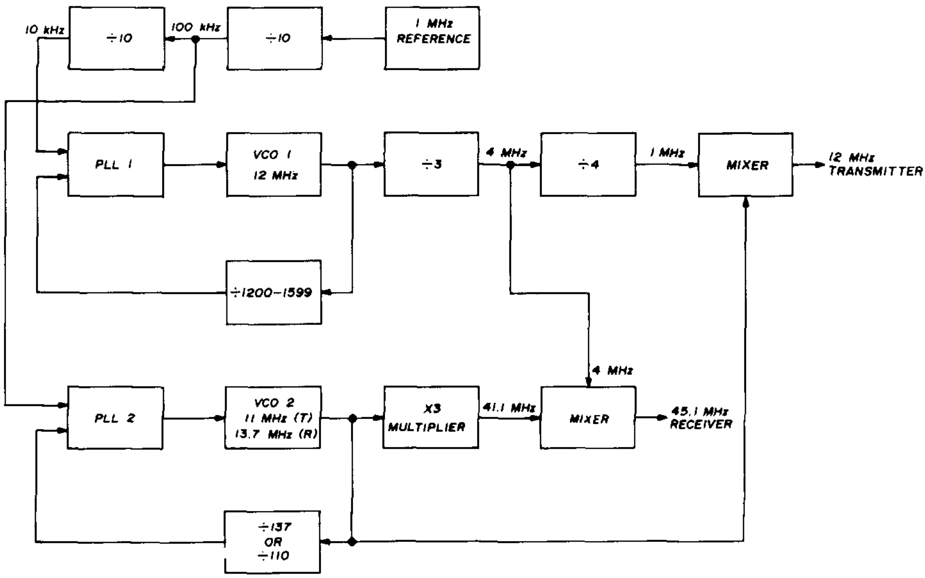


fig. 6. Transmit/receive frequency-control system using two phase-locked loops. Output frequency stability is equal to that of the reference oscillator.

oscillator. A 100-kHz crystal will provide adequate stability, especially if it's mounted in a proportional oven. Remember that, when choosing a reference oscillator frequency, to a point the higher the frequency of the crystal, the better the stability. Although it depends on the particular crystal and its characteristics, normally, if a 1-MHz crystal is used, its stability will be better than that of a 100-kHz crystal.

The utmost in stability should be sought because any frequency error in the synthesizer will be multiplied by the transmitter and receiver multiplier chains. Also, it can be shown that drift in the

one-crystal phase-lock system

The one-crystal phase-lock frequency-synthesis system in **fig. 6** provides complete receiver and transmitter frequency control. A 1-MHz reference oscillator has been chosen for this circuit with two divide-by-10 ICs. This provides outputs at 10 and 100 kHz. The 10-kHz signal is applied to the main synthesizer loop (loop 1); the 100-kHz signal is applied to a secondary loop (loop 2). The secondary loop replaces the added crystal oscillators shown in **fig. 5**. This means that the stability of the system is the same as that of the 1-MHz reference oscillator.

To understand the operation of the

two loops, start with the transmitter. The frequency of vco 1 is 12 MHz followed by a frequency division of 12. Loop 2 is programmed to 11 MHz and applied to a mixer along with the output of loop 1. The output to the transmitter is 12 MHz.

In the receive mode vco 2 has a frequency of 13.7 MHz which is multiplied by three to 41.1 MHz. This signal is mixed with the 4-MHz output from loop 1 to provide a receiver injection frequency at 45.1 MHz.

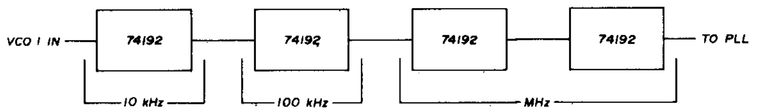


fig. 7. Programmable counters used in loop 1 of fig. 6 to divide by 1200 to 1599.

As was mentioned previously, this system was developed for the GE TPL rig. To adapt this frequency synthesis system to other frequency ranges, you will have to do a bit of pencil pushing, changing the basic frequencies and dividing/mixing schemes. This system can, however, be used as is with a receiver having a 10.7-MHz first i-f, although it will only cover 146 to 148 MHz.

programmable counters

The programmable counters used in loop 1 of **fig. 6** are programmed from 1200 to 1599, corresponding to a frequency range of 12.000 to 15.990 MHz. The 10- and 100-kHz counters in **fig. 7** are programmed with BCD-coded thumbwheel switches, providing direct frequency readout. The MHz counters are programmed by a rotary switch labeled 144, 145, 146 and 147 MHz. These four frequencies correspond to vco frequencies of 12, 13, 14 and 15 MHz.

The programmable counters in loop 2 (**fig. 8**) use the same arrangement. In this case, however, programming is controlled by internal gating and is not brought out to the front panel. The counters in loop 2 are programmed for 137 on receive and 110 on transmit, corresponding to 13.7 and 11.0 MHz, respectively, for vco 2.

When using these counter ICs remember that the input programming terminals will rise toward the supply voltage if they are unused or left open. To preserve the noise immunity of the counter, which is especially important for mobile operation, these inputs should not be left floating or open; tie them to V_{cc} or ground, depending on the requirements of the system.

The control system shown in **fig. 9** uses NAND gate switching and places all the counter inputs at the proper level. This control system also provides for transmit/receiver switching of the synthesizer oscillators for split-frequency operation.

The inputs to gates A1 through A4 and B1 through B4 in the control system are connected to V_{cc} through 4700-ohm resistors. The output of the BCD thumbwheel switches RX-S1, RX-S2, TX-S1 and TX-S2 are connected to the inputs of the A and B gates as shown in **fig. 9.** The wipers of the switches are connected to the C gates.

The push-to-talk circuit shown is for a grounded PTT system. That is, when you push the PTT switch to transmit, the PTT line is placed at ground. One input of gate

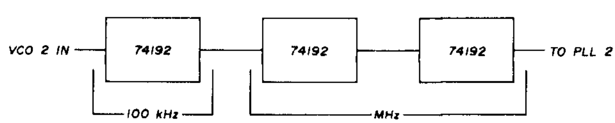


fig. 8. Programmable counters used in loop 2 of fig. 6 to provide divide by 137 (on receive) or divide by 110 (on transmit).

C1 is tied to the PTT line (V_{cc} on receive); the other C1 input is connected to V_{cc} through a 4700-ohm resistor. With both inputs high, the out is low, effectively grounding the wiper of the receiver thumbwheel switches.

One input to gate C2 is connected to the output of C1 and the other input is connected to V_{cc}. When the output of C1 is low, the output of C2 is high. Since the output of gate C2 is connected to the wipers of the transmit thumbwheel switches, their outputs are high during receive, regardless of their setting, and have no effect on gates A and B.

For example, assume you want to receive on 146.94 MHz. The receiver thumbwheel switches are set to read 94. Therefore, 1, 2 and 8 of RX-S1 are open and 4 is grounded through gate C1. In RX-S2, 2 and 4 are open and 1 and 8 are grounded through C1. With 4 grounded, gate A3-A is grounded, making its output high. All other A gates have both inputs high, making their outputs low. Programmable counter PC1 is now programmed for 4. Since 1 and 8 of RX-S2 are grounded, counter PC2 is programmed for 9.

The remaining counters in loop 1 (PC3 and PC4) are programmed to 144, 145, 146 and 147 MHz with a rotary switch mounted on the front panel. Gates C3 and C4 control programmable counters

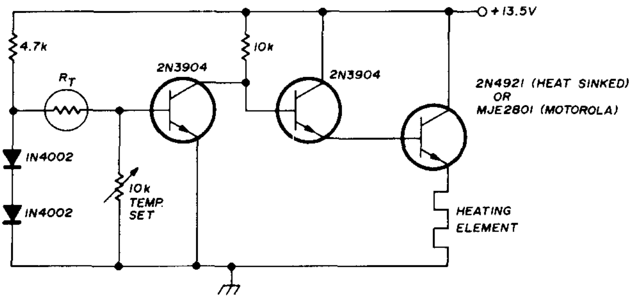


fig. 10. High-stability proportional oven control for the reference oscillator crystal. Thermistor R_T has 10k resistance at 25° C. Heating element is made from wire from an old crystal oven (see text).

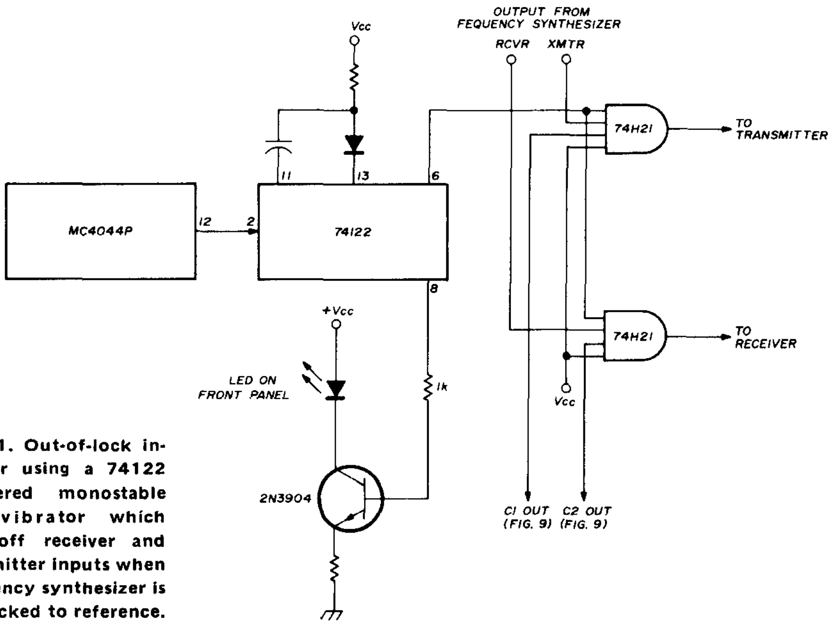


fig. 11. Out-of-lock indicator using a 74122 triggered monostable multivibrator which cuts off receiver and transmitter inputs when frequency synthesizer is not locked to reference.

PC5, PC6 and PC7 in loop 2 and program them for 137 on receive and 110 on transmit.

If the PTT applies a positive voltage to the system it is necessary to remove the 4700-ohm resistor at the input to C1 and install a 5-volt zener diode from this point to ground. It is also necessary to reverse the C1 and C2 wiper connections to the transmit and receive thumbwheel switches (receiver switches go to the output of gate C2 and the transmitter switches to the output of gate C1).

There are several programmable counter ICs that can be used in this system, but the least expensive of these is the 74192 up-down counter. This IC has the necessary frequency response and can be used in this circuit without additional gating.

proportional oven

For good frequency stability of the reference oscillator, a proportional oven is a must. Most thermostat-type items do not provide the close temperature regulation required for good frequency stability because they cycle with a 3- to 5-degree temperature differential.

The simple proportional oven control circuit shown in **fig. 10** has good temperature stability. The resistance element, R1, should be chosen to draw from 800 mA to 1 ampere when the oven is full on. I used the resistance wire from a 12-volt Motorola gold-type oven. The current through the heating element will be reduced to a much lower level when the oven has reached its operating temperature.

To reduce the sustaining current through the heating element a good layer of insulation should be installed around the oven. One way to do this is to use a small can to contain the crystal. The can can be wrapped with an insulating layer of fiberglass tape with the resistance wire wound on top of the tape.

The resistance wire should be non-inductively wound. To do this, fold the wire in half, and at the loop or fold-back end, attach a wire to the top of the can with a small piece of tape. Separate the two wire ends, and keeping them evenly spaced, wrap them around the can, working toward the bottom. After the resistance wire is in place, attach insulated

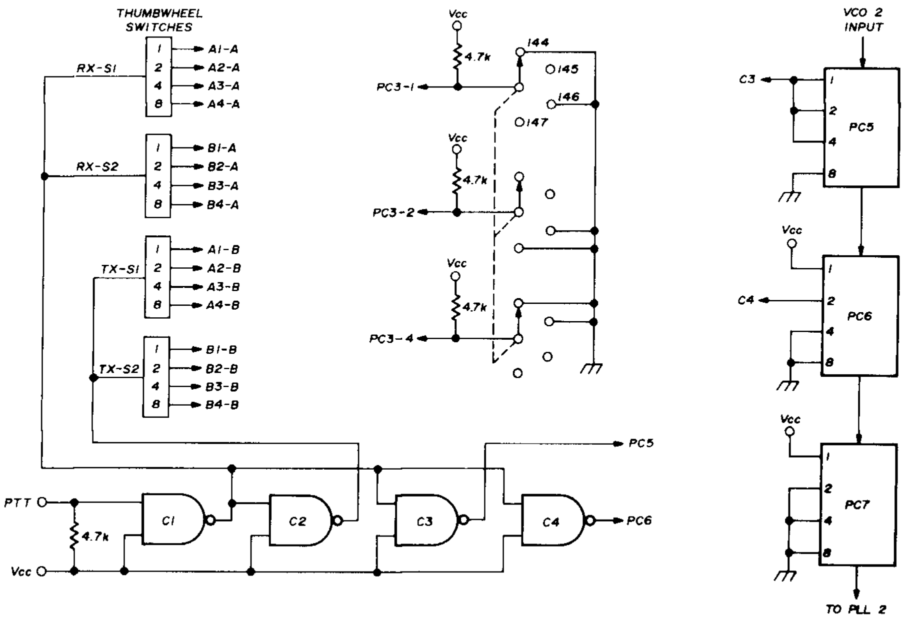
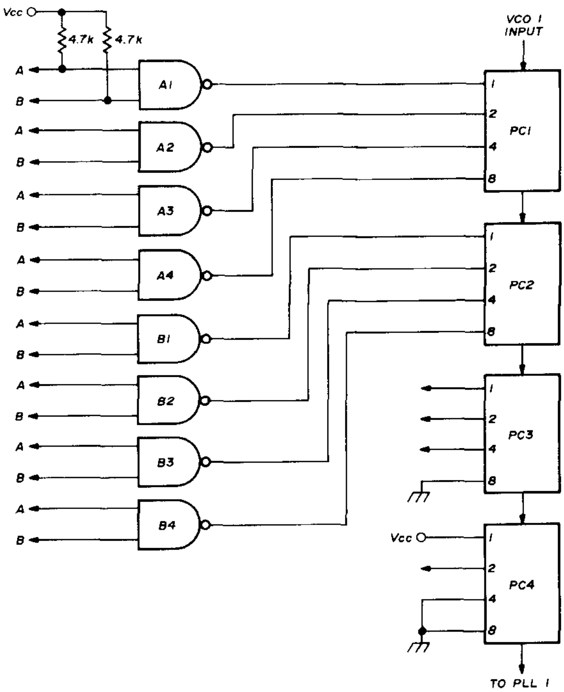


fig. 9. Control circuits for the programmable frequency dividers used in loops 1 and 2 (see fig. 6).

leads to the two ends and wrap the entire assembly with another layer of fiberglass tape.

This assembly is placed in a second, larger can. This second can should be big enough to contain from 1/8- to 1/4-inch of insulation such as sheet foam. The thicker the insulation, the better the oven and the lower the sustaining current.



The thermistor should be mounted inside the first can, as close as possible to the crystal. You may want to mount two crystal sockets in the can – one for the crystal and one for the thermistor. The thermistor can be installed on a base cannibalized from another crystal.

other circuits

The choice of a mixer circuit is left to the builder. I would prefer a dual-gate mosfet such as the Motorola MPF-121, followed by an amplifier with a drive control in the emitter circuit. The drive control is adjusted to the point of adequate drive across the desired frequency range; any overdriving of the circuit will result in undesired spurious output. The multiplier, mixer and amplifier should all have double-tuned tank circuits to help reduce spurious outputs and enhance broad-banding.

The phase-locked loop ICs I used for my breadboard experiments were Motorola MC4044Ps. These devices perform well, and with adequate filtering, the noise level was quite low as was any 10-kHz reference energy on the output. In addition, the MC4044P lends itself to building a simple out-of-lock indicator **(fig. 11)**.

Pin 12 of the MC4044P is always high when the loop is locked, but produces negative-going pulses when the loop is unlocked. If this output is applied to a triggered monostable multivibrator, such as the 74122 or 74123, and the time constant of the multivibrator is longer than time between pulses, the output can be used to control a gate that will cutoff the output of the synthesizer until the loop is locked.

I used a Motorola MC4024P IC for my vco. This is a dual voltage-controlled multivibrator with a typical maximum operating frequency of 30 MHz. Since the MC4024 is a dual unit, it can be used for both vco circuits required in the one-crystal frequency synthesizer. The maximum frequency I could obtain from the units was 24 MHz, but that may have been because the bread-board wiring capacitance limited the upper frequency. No interaction was observed between the two oscillators.

oscillator stability

Several times I have mentioned the importance of providing a very stable reference oscillator. One way to obtain excellent stability is to use WWVB as a reference. WWVB in Boulder, on 60 kHz, is stable to better than 1 part in 10^{12} per day and frequency accuracy is usually better than 2 parts in 10^{11}. Since vlf propagation is primarily ground wave, signal strength is adequate in most parts of the country for use as a reference.

The receiver for WWVB could be quite simple. The tuned rf amplifier could use IC amplifiers and tuned circuits made from toroid pot cores or old 50-kHz i-f cans retuned to 60 kHz. After amplification, the WWVB signal should be passed through a limiter circuit to remove amplitude variations and noise. The signal would then be squared up with a Schmitt trigger to be used as a reference with the phase-locked loops (see **fig. 12**).

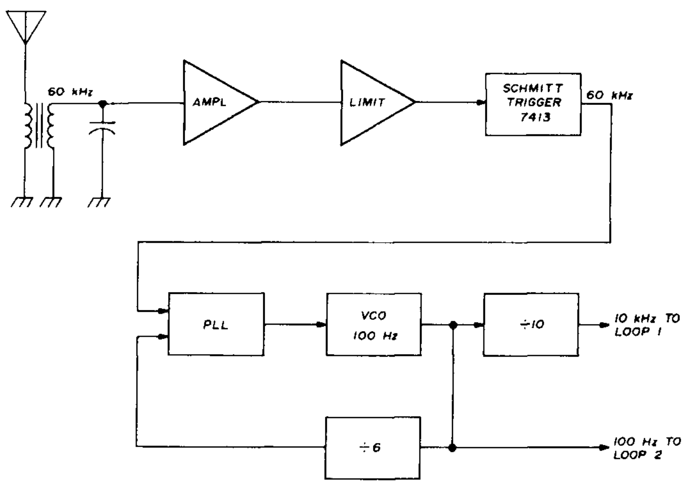


fig. 12. Using the received WWVB signal as the reference in a two-meter frequency synthesizer.

Because of the reference frequencies required for this synthesizer, a 60-kHz vco would not be usable. However, if the vco were at 100 kHz and divided down to 60 kHz for input to the PLL, the 100-kHz signal could be used for loop 2 and divided by 10 for loop 1. With the vco running at 100 kHz, it should be stable enough to withstand momentary losses of signal, such as might be encountered in mobile operation, without appreciably drifting off frequency.

Since WWVB goes off the air at specified times for maintenance, it would be necessary to provide a secondary oscillator that could be switched in, when necessary. The PLL is not perfect, nor can it maintain a perfect lock or phase relationship, so stability would not be as high as that of WWVB itself, but even so, it should surpass almost every commercial standard.

summary

I hope that this brief discussion of frequency synthesizers will stimulate interest in these very useful devices. I realize that this is not the ultimate synthesizer, but then, no one piece of equipment ever is. I would be happy to hear from anyone with similar ideas, or with suggestions for improving the basic design.

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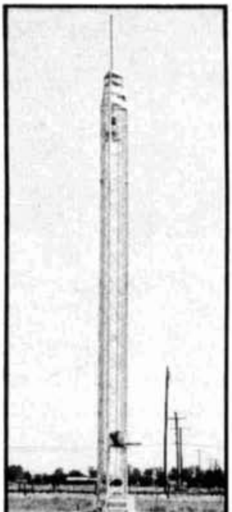
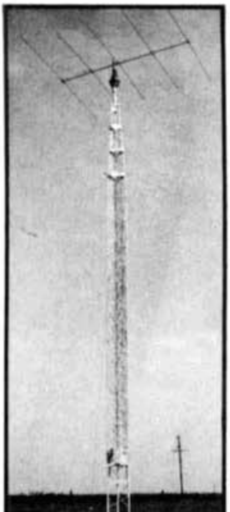
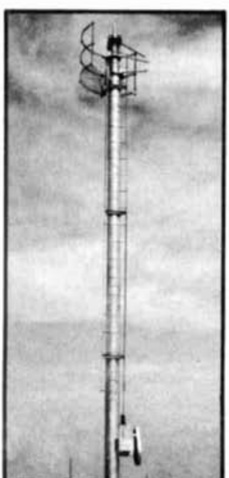


W-51

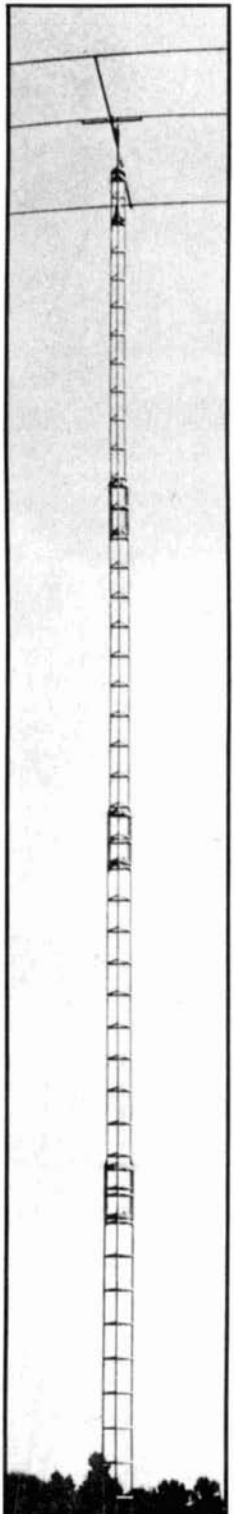


MW-65

LM-470D



TM-370



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low-power vhf dummy load

The tobacco load — a low-vswr dummy load that will handle 30 watts of rf

Dave Sprague, WB9DNI, 78 Paddock Street, Aurora, Illinois 60538

Here is a one-evening project that will provide a very useful accessory for your shack — a 50-ohm dummy load capable of dissipating more than 30 watts of continuous power with a vswr below 1.1:1 through 220 MHz and typically, below 1.5:1 at 450 MHz.

The rf load is neatly packaged in a 7-ounce pipe tobacco can, filled almost full with transformer oil. The load itself consists of ten 510-ohm (5%) 1-watt carbon resistors parallel-mounted between pieces of copper weatherstripping. An alternate design approach is to use 2-watt resistors for a 70-watt load. However, there is a tradeoff with this approach as the vswr at 220 MHz may be as high as 1.8:1.

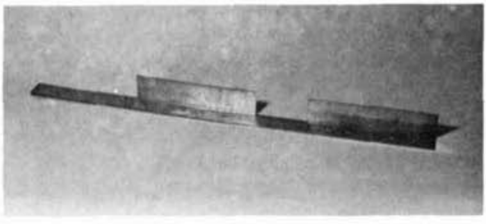


fig. 2. Copper strip used for mounting the 5% 1-watt resistors used in the rf load.

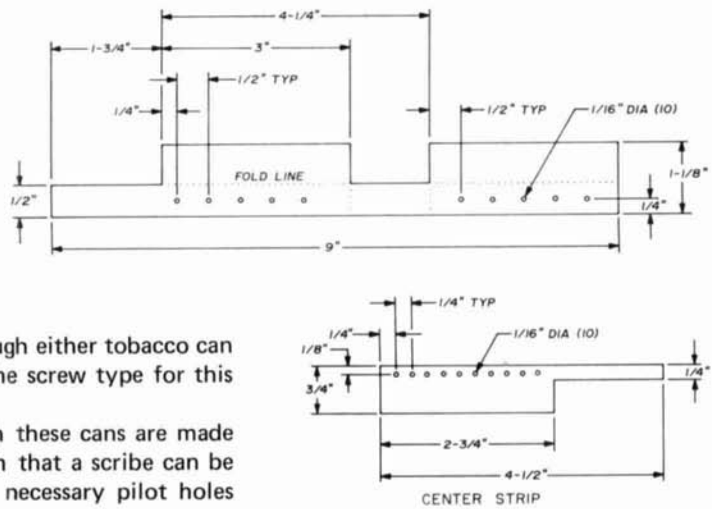
construction

Two types of 7-ounce tobacco cans are readily available from your pipe-smoking friends. They differ in the type of lid. The older type uses a paint can type lid; the second, and newer, type uses a screw-on lid. Although either tobacco can will work, I used the screw type for this project.

The metal which these cans are made from is soft enough that a scribe can be used to punch the necessary pilot holes when mounting the connector and vent tube in the lid. First, test the tobacco can for leaks by filling it with water. If any leaks are found, seal the seams of the can with a thin coat of RTV or similar oil-resistant sealer.

I tried several materials for the element mounting strips, but I found ordinary copper-clad weatherstripping to be electrically suitable, inexpensive and easy to form. Cut the strips to the specifications of **fig. 1.** Fold the larger strip as shown in **figs. 2** and **3.**

fig. 1. Layout of the copper strips used in the construction of the 30-watt rf load.



When the copper strips are completed, lay the smaller strip before you, as pictured in **fig. 1B.** Insert the first five resistors in alternate holes beginning with the hole closest to the right end. The end of the resistor body should be flat against the strip, but do not cut the soldered lead off at this time. A vise is a great help to keep the resistors properly aligned while soldering.

Next, turn the copper strip over and insert the remaining resistors in place with their bodies similarly aligned. Don't be stingy with the solder here — a good electrical connection is more important than looks. You should now have a unit which resembles **fig. 4.**

Cut the soldered lead of each resistor flush with the solder joint. Trim the free lead of each resistor to approximately ½ inch. Insert the center strip and resistors into the outer strip by carefully spreading the edges of the outer strip (see **fig. 5**) and guiding each resistor lead through the

Completed rf load. Small tube to the left of the coaxial connector allows heat expansion of the cooling oil.

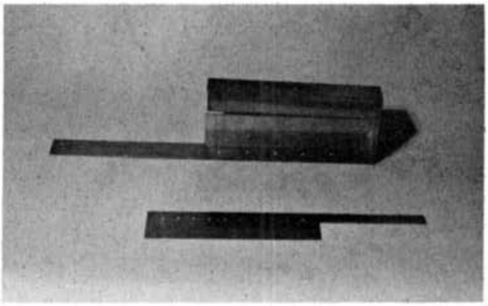


fig. 3. Copper strip is formed into a closed U-shaped box as shown here before installing the center strip and 1-watt resistors.

appropriate hole. Solder the free lead of each resistor to the outer copper strip, keeping the strip edge as close to the resistor body as possible. Trim the excess lead flush with the solder joint.

Solder the back and bottom edge of the outer copper strip as shown in **fig. 6.** When soldering, keep the center and outer strips separated. After verifying a resistance of 51 ohms between the strip tabs the load element is ready to mount in the tobacco can.

Mount a female SO-239 uhf coaxial connector through the lid of the can. I used pop-rivets to mount the connector but screws and nuts will work just as well if screw length is kept to a minimum.

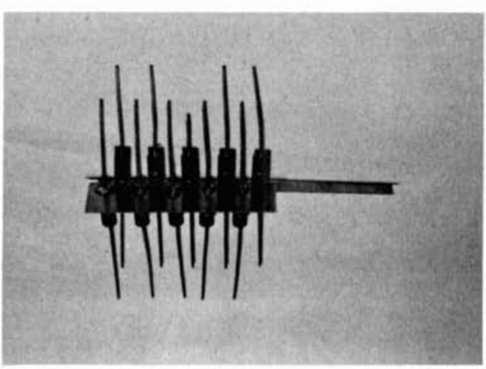


fig. 4. First, solder the resistors to the center strip. This center strip is then mounted in the U-shaped box as shown in fig. 5.

Solder a 3/4-inch piece of 1/8-inch OD copper tubing through the can lid so that the bottom of the tube extends to approximately 1/16-inch inside the lid. The load element should be mounted on the lid so that the bottom just touches the tobacco can bottom when the lid is secured (see **fig. 7**). There is sufficient tab length to fit almost any can type. Cut the excess from each tab, and solder the center tab to the SO-239 connector; solder the outer tab directly to the lid.

operation

Fill the tobacco can about two-thirds full of a transformer oil.* Insert the load

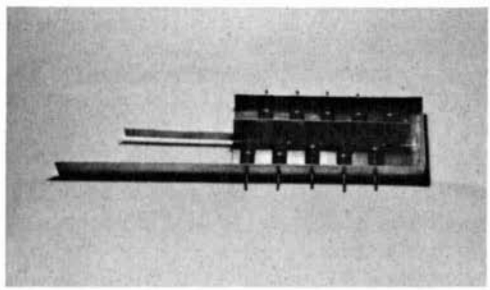


fig. 5. Install the center copper strip with resistors into the U-shaped box.

element and secure the lid. Remove the lid and note the highest point the oil reaches on the resistance element. Add enough oil to just cover the entire element. This leaves sufficient space for expansion as the oil heats. Secure the lid on the can tightly, and tape the seam.

Use a through-line type rf wattmeter when testing the tobacco load. Or, use a vhf reflectometer between the transmitter and the load. Keep the power low for the initial trial. There is nothing to tune or adjust. If the vswr is high, recheck the

*A small quantity of transformer oil can usually be obtained from your local, friendly, public utility company. Use caution if a substitute oil is used — the dielectric constant of vegetable oil, for example, is not consistent.

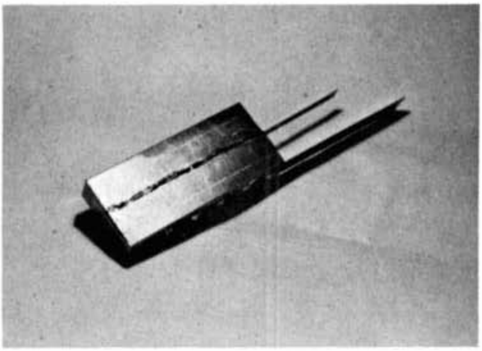


fig. 6. Solder the resistor leads and edges of the center copper strip to the U-shaped copper box.

dimensions of the load element and all solder joints.

I found that the tobacco load was able to withstand several rf overloads for short periods of time without damage to the load element. The thirty-watt rating is on the conservative side. With proper care this small load will pay for itself many times over.

ham radio

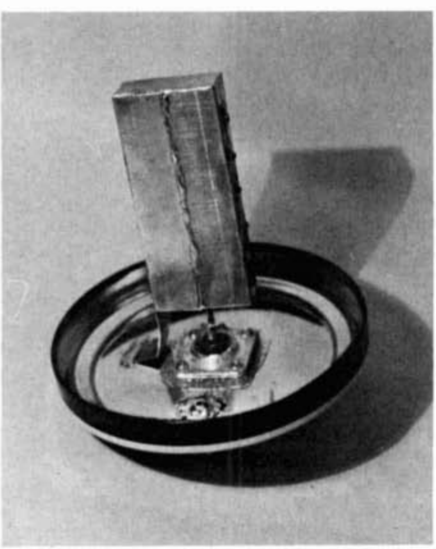


fig. 7. An SO-239 coaxial connector is soldered to the lid of the tobacco can and the load element is installed.

vertical monopole log-periodic antennas for 40 and 80 meters

How to build low-cost log-periodic antennas for complete coverage of the amateur 40- and 80-meter bands

George E. Smith, W4AEO 1816 Brevard Place, Camden, South Carolina 29020

In previous articles I have described some homebrew, dipole-type log-periodic antennas, including antennas for 20, 15 and 10 meters[1,3] and 40, 20 and 15.[2] The log periodics discussed in these articles have provided gain on the order of 8 to 13 dB, depending on their length, their height above ground, the number of elements and the apex angle.

While testing some log periodics for use on the 7-MHz band I decided to try to lower the vertical angle of radiation to obtain improved, long-range communications performance. One way this could be accomplished would be to raise the antenna to 1/2-wavelength above the ground (or better still, to raise the antenna to 140 feet, a full wavelength). However, this would require at least two, and preferably four, 70- or 140-foot masts, so the cost would be very high. My 40-meter log periodic, at 50-feet above the ground, was as high as I could go, since I was using pine trees as supports.

Another method of lowering the vertical angle of radiation would be to use a vertical log periodic. Although I had previously tried a 10-, 15- and 20-meter log periodic in the vertical configuration by suspending it from some tall pine trees, this would be impractical for the 40-meter antenna because the longest element is 70-feet long. However, it would be possible to do this with a single 75-foot mast.

A possible alternative would be to use quarter-wave vertical elements working *against ground* or a ground plane. This is similar to the vertical monopole log-periodic configurations used by some commercial stations for long-haul high-frequency circuits.

40-meter monopole log-periodic

I determined from a scale drawing that, by using only five elements, it would be possible to suspend a monopole 40-meter log periodic from a single catenary line strung between two high pine trees. With this construction, the horizontal radials would be about 20-feet off the ground (see **fig. 1**). A similar approach was used for a 75-meter log-periodic which I built later. The swr for both antennas was less than 1.5:1 over the entire design frequency range.

If this antenna could be installed a few feet above a salt marsh or a high-conductive ground, the radials could probably be eliminated. Some commercial monopole log-periodics use buried ground radials in place of the counterpose shown in **fig. 1.**

It should be noted that the ground radials become decreasingly shorter from the rear to the front of the antenna. They should be about the same length or slightly longer than their companion vertical elements.

Construction of the center insulators for this antenna is shown in **fig. 2**. These insulators are made from 1/4-inch thick lucite, 5/8-inch wide and 3-inches long. The two outside holes are for the radials; the holes on 1-1/2-inch centers are for the two-wire feeder. The center hole is for the quarter-wave vertical radiating element.

The vertical radiating elements and the ground-plane radials are fed by an open-wire feeder located at the bottom of vertical radiators. The transposed feed system required for log periodics is shown in **fig. 1.** A 4:1 balun is connected to the short-element end of the open wire feeder; a coaxial transmission line is used from the balun to the transmitter.

The driven or active element (element number 2) is approximately one quarter wave-length from the balun feed point. The quarter-wave line provides an impedance step-up. Since the impedance at the lower end of element number 2 is quite low, the quarter-wave transformer steps up the impedance to 200 to 300 ohms. The 4:1 balun provides a fairly good match to 50-ohm coax. The swr from 7.0 to 7.3 MHz is comparatively flat and less than 1.5:1 over the entire 40-meter band.

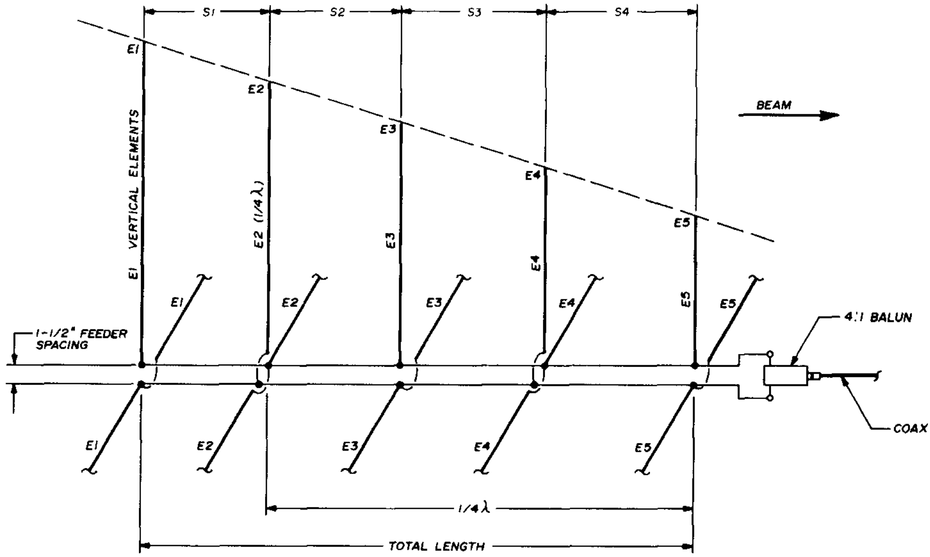
A 1/4-inch nylon line was used as the catenary to suspend the five vertical elements. This line was stretched between two supports as shown in **fig. 1.** The ground-plane radials were placed about 20-feet above the ground because clearance was necessary for some fruit trees which are located under the antenna. The outer ends of the radials are about 10-feet above the ground and are anchored to stakes or convenient posts or trees.

A total of 13 ground radials were used with this antenna: one to either side of the five vertical elements, plus two to the rear (element 1) and one to the front (element 5). Monofilament fish line (40-pound test) is used as guys and insulators for the radials.

performance

At distances greater than 400 miles, this antenna showed 8- to 10-dB gain over a commercial 40-20-15-10 trap vertical which works quite well for DX. The vertical is mounted on a roof 35-feet above ground and has all the radials, including four for 40 meters. The extra radial for 40 is necessary to lower the swr on that band.

Signals off the back of the log periodic



dimensions (feet)

	3.5-4.0	3.8-4.0	7.0-7.3	14.0-14.35
E1	70	65	35	17.5
E2	67	62	33	16.5
E3	58	55	28	14.0
E4	50	45	24.5	12.25
E5	43	40	20	10.0
S1	30	26	14	7.0
S2	27	24	13	6.5
S3	24	23	12	6.0
S4	19	18	9	4.5
total length	100	91	48	24
mast height	80	75	50	30
pole height	45	40	25	20

were just about the same as the trap vertical. As would be expected, stations just past the skip zone reported better signal strength from my half-wave doublet, 50-feet in the air (due to its higher angle of radiation). At distances greater than about 400 miles, however, the log periodic started paying off. This greatly enhances 40-meter operation during the daylight hours. It was difficult to do much testing after dark because of the heavy QRM from foreign broadcast stations.

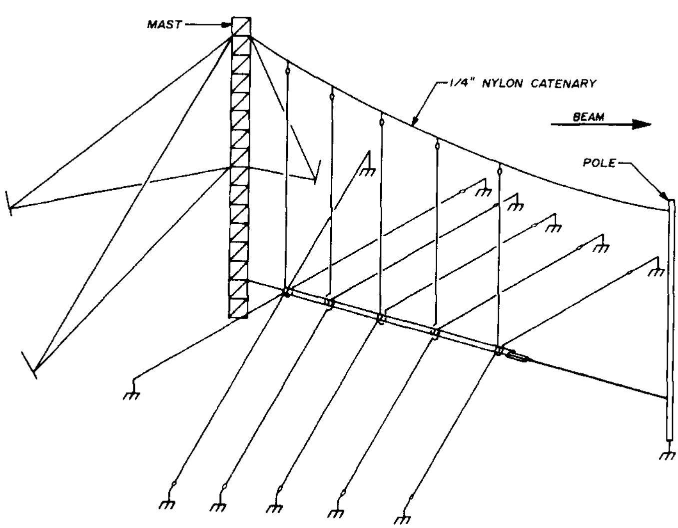


fig. 1. Five-element monopole log-periodic. Elements and radials are made from no. 15 aluminum wire. The 3.8-4.0 and 7.0-7.3 MHz designs (columns 2 and 3) have been built and tested. The swr was less than 1.5:1 over the entire frequency range. The designs for 3.5-4.0 and 14.0-14.35 (columns 1 and 4) have not been tested.

On reception, however, the vertically-polarized log periodic is much more susceptable to man-made noise than the horizontal doublet. As with any vertically-polarized, high-frequency antenna, it should be located as far as possible from industrial plants and busy streets. My antenna is about a block from the nearest street and is comparatively quiet except when cars come into my driveway.

80-meter log periodic

Since the 75-meter log periodic was erected only temporarily for test purposes, the ground radials and the open-wire feeder were only 3- to 4-feet above the ground. For a permanent installation this height should be increased to 10- to 15-feet. Since some of the radials have rf current circulating through them, the increased height above ground would prevent accidental contact with the radials. Also, this increased ground-to-radial height would increase the effective height of the antenna.

This antenna was originally designed to cover the entire 3.5- to 4.0-MHz band, but I discovered that there wasn't sufficient mast height for the rear element, which was 70-feet long. I decided to build a monopole log-periodic to cover only 3.8 to 4.0 MHz; this reduced the length of all elements by about 5 feet.

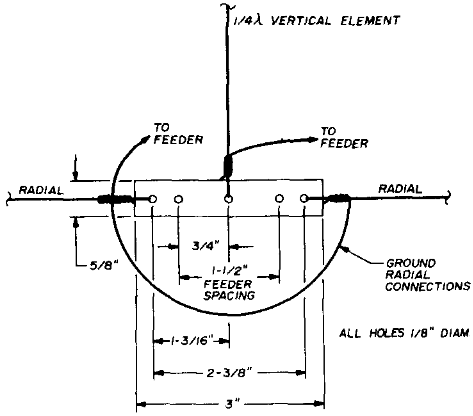


fig. 2. Construction of the center insulators. Material is 1/4" thick lucite. Connections to the open-wire feedline are shown in fig. 1.

The overall length from the rear to forward element is 91 feet. A minimum width of 135 feet is required at the rear and 80 feet at the front for installing the radial ground-plane system.

After the antenna was completed, I ran a series of vswr tests to determine if the swr was greater than 1.5:1 at any point in the band. The vswr readings were as follows:

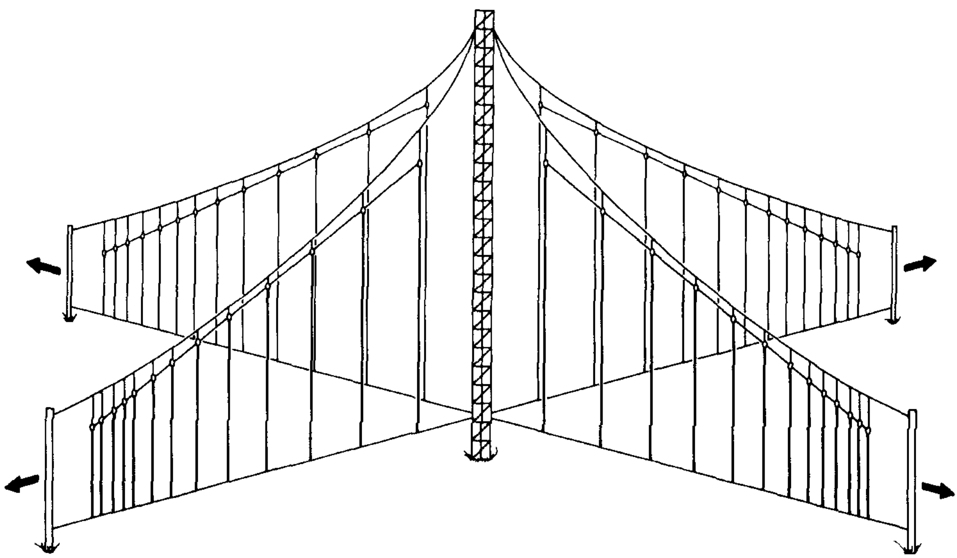


fig. 3. Suspending four vertical log-periodics from a single mast to obtain complete 360° coverage.

4.0 MHz	1.25:1	3.7 MHz	1.1:1
3.9 MHz	1.4:1	3.6 MHz	1.2:1
3.8 MHz	1.2:1	3.5 MHz	1.2:1

Although the swr is relatively flat over the entire 80-meter band, it is doubtful that the antenna has much directivity at the lower end of the band since it was designed to cover 3.8 to 4.0 MHz. On-the-air tests were confined to the upper 2 MHz of the band because the dipole I use for comparison purposes is limited to this meter bands, but further tests are needed to confirm this.

I was unable to obtain any data on front-to-back ratio as few stations were received off the back of the antenna. Side attenuation seems about the same as other log periodics I've used.

construction

The cost of assembling this antenna is quite reasonable, considering it will pro-

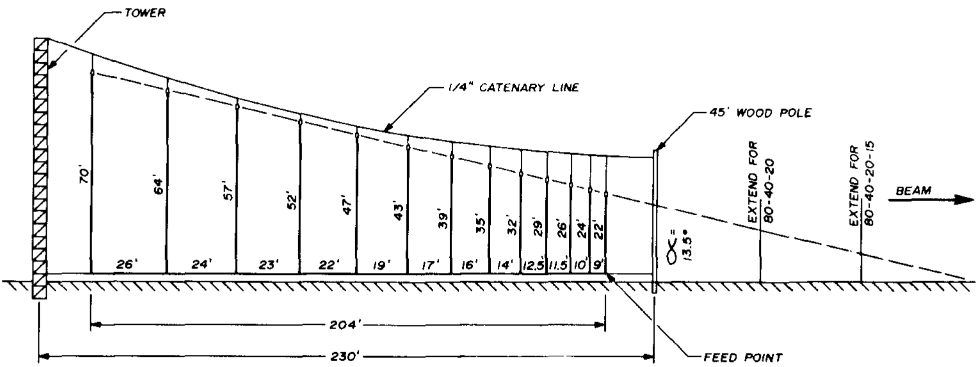


fig. 4. The vertical log-periodic can be extended to cover all frequencies from 3.5 to 7.3 MHz. This log-periodic uses 13 elements and requires a mast separation of 230 feet.

frequency range since the swr is greater than 1.5:1 below 3.8 MHz.

On-the-air tests indicated that the 80-meter monopole log periodic was best suited for distances greater than 500 to 600 miles during the daylight hours, and 1000 miles or more after dark. For shorter distances the horizontal dipole was usually one to three S-units better. However, at greater distances the lower radiation angle of the log periodic really began to do its stuff, and stations reported up to two S-units improvement with the log periodic.

For about one hour before and after sunrise and sunset, the log periodic is quite erratic, regardless of the distance. During these hours the dipole exhibited considerably less fading than the monopole log periodic. Also, the forward lobe of the log periodic appeared to be narrower than that experienced with log periodics on the 40-, 20-, 15- and 10- vide up to 10-dB gain for DX. About 850-feet of wire is required for the elements plus another 185 feet for the open-wire feeder. I used number-15 aluminum wire which is manufactured for electric fences and can be purchased in quarter-mile coils for $8.70. Costs are also cut by using homemade lucite insulators and 40-pound-test monofilament fish line. The most expensive item in the installation is the 4:1 balun, which retails for $8.95. Total cost is about $25.00 (the 40-meter monopole log periodic is somewhat less, costing about $17.00).

other configurations

If space permits, two of these antennas could be mounted back to back, the rear elements suspended from a single mast. For more complete coverage three, or even four, beams could be supported by the same mast (see **fig. 3**). If you have enough real estate, the 80-meter log periodic can be extended as shown in **fig. 4** to provide operation on both the 3.5- and 7.0-MHz bands. This two-band arrangement is about 205-feet long and would require a mast separation of 230 feet. A total of 13 elements are used in this antenna, about the minimum suggested for a log-periodic covering a 2:1 frequency range.

Since most amateurs aren't interested in the 3-MHz segment between the top end of 80 and the low end of 40, considerable space can be saved by breaking the antenna into two parts as shown in **fig. 5**. However, with this system two separate feedlines are required.

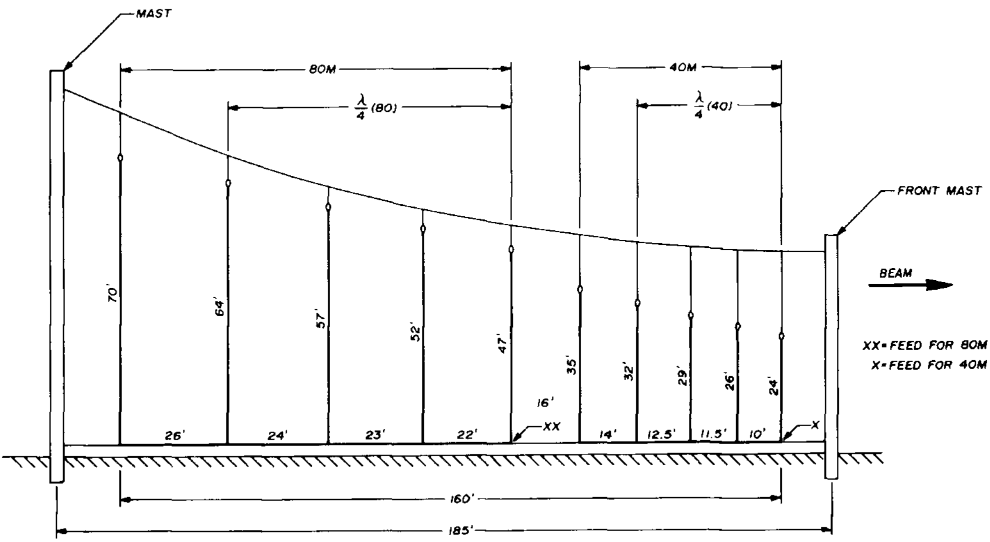


fig. 5. Breaking the log-periodic into two separate sections, one for 40 and one for 80, saves considerable space, but requires a separate feed system for each section. This antenna covers the frequency range, 3.5 to 4.0 MHz and 7.0 to 7.3 MHz.

inverted monopole log periodic

After I completed the tests on the 40-meter log periodic shown in **fig. 1**, as an experiment I decided to try this antenna inverted, with the radials at the top. By using several trees as supports, I was able to suspend two nylon catenary lines to support the radials. This allowed the radials and the center open-wire feeder to be suspended approximately 50-feet above the ground. The five quarter-wave monopole elements were suspended from the center feeder insulators. Since the rear element is 35-feet long, its lower end was about 15-feet above the ground (see **fig. 6**).

The object of this test was to elevate the current loop as high as possible, possibly lowering the vertical angle of radiation. Getting the current loop as high above ground as possible is similar to the old Bruce array which uses quarter-wave vertical elements in phase, spaced one-half wavelength.

Although time did not permit conclusive testing of this particular antenna, after a week of testing its gain seemed to be greater, or to increase, the more distant the station (over 500 or 600 miles). For stations just past the skip zone the horizontal dipole had the edge.

I had hoped to beam this experimental antenna to the west or northwest to run tests with W5s and W7s, since there seems to be a great deal of 40-meter activity there, but unfortunately, the trees I use for supports were all in the wrong places.

Therefore, I had to beam the experimental log periodic to the south. This limited the maximum distance to about 600 miles (Miami) as few stations further south were operating on 40 meters.

The forward lobe of this experimental antenna seemed to be narrower than that exhibited by the horizontal log periodic described in the previous article.[2] This is in line with other vertically polarized log-periodics I tried on the higher frequency bands which also had sharper forward lobes than their horizontal counterparts.

If the trees had allowed this "upside-down" monopole to be aimed to the northwest I'm sure I could have made some interesting tests. This configuration might also have possibilities as a low-angle beam for working DX on 80.

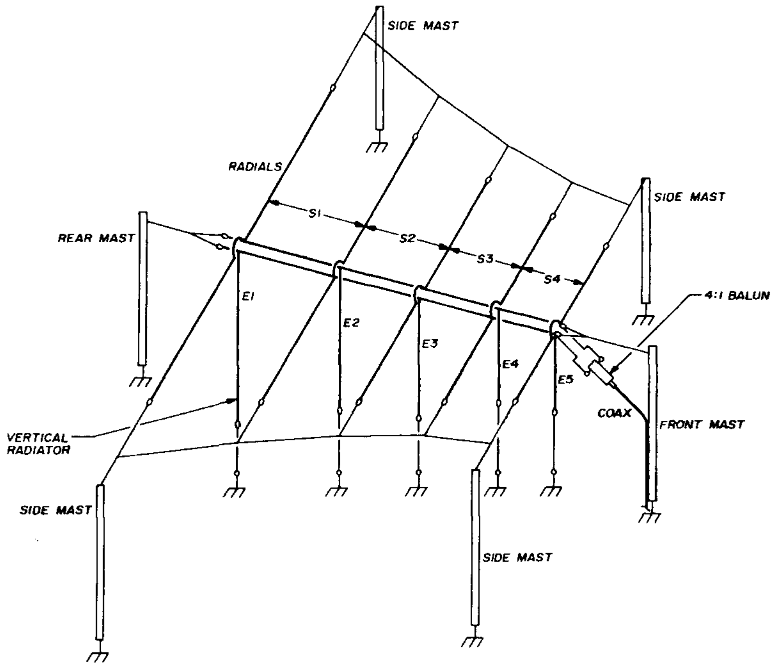


fig. 6. Inverted vertical monopole log periodic for 40 meters.

dimensions (feet) for 40 meters

E1	35	S1	14
E2	32	S2	13
E3	28	S3	12
E4	24.5	S4	9
E5	20		

summary

The 40-meter log-periodic antennas are capable of 8 to 10-dB gain in the forward direction. Compared to the 3- to 5-dB gain provided by most 40-meter beams, the log periodic is worth consideration. The horizontal or inverted-vee log-periodic is suited for normal operation and compares favorably with a doublet except for its higher gain in the forward direction. The vertical monopole log-periodic is better suited for working DX.

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1. G.E. Smith, W4AEO, "Three-Band High-Frequency Log-Periodic Antennas," *ham radio,* September, 1972, page 28.
2. G.E. Smith, W4AEO, "Log-Periodic Antennas for 40 Meters," *ham radio,* May, 1973, page 16.
3. G.E. Smith, W4AEO, "High-Gain Log-Periodic Antenna for 10, 15 and 20." *ham radio,* August, 1973, page 18.

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noise reduction for CW reception

How to use threshold-gate/limiting and energy-integration to reduce noise interference on CW

John J. Duda, W2ELV, 6 Tuscarora Avenue, Geneseo, New York 14454

Much of the noise encountered in CW reception can be markedly reduced, and in many cases entirely eliminated, by appropriate processing of the received signal. It is well known that noise is a function of the bandwidth of the receiving system. Therefore, a narrow bandpass filter is one way to reduce noise. It is also well known that high amplitude impulse noise may be reduced by signal limiting.

In addition, there are other noise reduction methods, including using an audio filter followed by a detector which is used to operate a relay, which in turn keys an audio oscillator.[1] This technique eliminates all noise, but is not immune from keying by high intensity static bursts or by undesired signals on nearby frequencies. In addition to false keying there is the difficulty encountered by loss of "feel" for the signal. If the signal or receiver drifts off frequency there is no cue as to what direction you must tune to repeak the signal.

threshold gating

There are other methods of noise reduction, and, in general, best results may be obtained by using a combination of the various methods. The techniques discussed here are based on the fact that noise may be classified as either background hiss and hum, or as impulse noise. Usually, background hiss and hum is of lower amplitude than the CW note and may be eliminated by threshold-gating.[2,3] The basic threshold-gating circuit is reproduced in **fig. 1.**

The post-gate filtering accomplished by the tuned circuit in series with the earphones not only reduces the distortion of the signal introduced by the gating process, it also reduces the amplitude of impulse noise which breaks through the gate. Thus, if the output signal at the earphones is fed through a second amplifier and subjected to a second threshold-gate, some of the impulse noise at the output of the first threshold-gate will not appear at the output of the second gate.

Noise is further reduced if the intermediate amplifier is frequency selective and peaked to the frequency of the post-gate filters. This process may be carried even further, through a third gate-filter, and beyond. The greater the number of stages, the greater the immunity to impulse noise.

The effectiveness of reiterative gate-filtering is a function of the gain settings of the intermediate amplifiers and the selectivity of the post-gate filters. Installation of a two-gate system is easily accomplished by substituting the headset in **fig. 1** with a 3.2:2000-ohm matching transformer and using this to drive a power amplifier with another gate-filter in its output.

The 3.2-ohm winding of the matching transformer (an audio output transformer is satisfactory) replaces the headset while the 2000-ohm winding is terminated with a 2.2k resistor. This output is fed into the high impedance input of the audio amplifier. The amplifier must have sufficient power to operate the second threshold-gate filter; a minimum of one to two watts is acceptable. With this setup there will be a noticeable improvement over the performance of a single threshold-gate filter. The gain setting of the amplifier between the threshold-gates is fairly critical.

energy gating

Impulse noise may also be discriminated on the basis of energy content if it is possible to make reception contingent upon the energy content of the received signal or noise. Impulse noise tends to have less energy per unit time than a CW signal, and this difference can be put to use. **Fig. 2** shows how an RC circuit can be used to integrate energy, providing a gate-control voltage to make signal passage dependent upon average energy content.

However, such a system appears to have two major weaknesses. First, it must truncate the received CW note, as passage of the note cannot occur until sufficient energy has accumulated. Secondly, it is vulnerable to post-signal impulse noise, as at the tail end of a note it is possible for impulse noise to integrate with the energy remaining from the CW note. **Fig. 2** shows this.

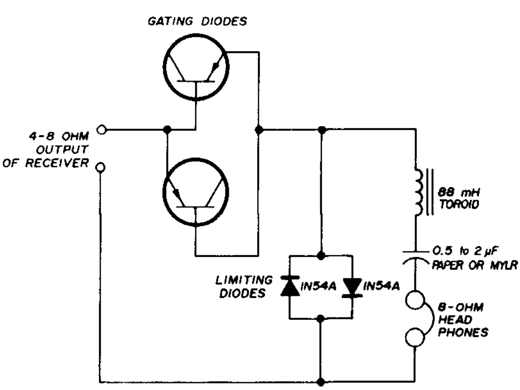

fig. 1. Basic threshold-gate/limiter circuit with post-gate filtering. The emitter-base junction of 2N414 transistors may be used for the gating diodes.

The truncated CW note is not very serious, because if the output of the energy gate is fed to a tuned circuit, the Q of the circuit will tend to lengthen the CW character. With appropriate circuit parameters the two effects will cancel one another. However, there is no immediate solution to post-signal vulnerability. Fortunately, in practical applications it does not seem to be a very serious problem.

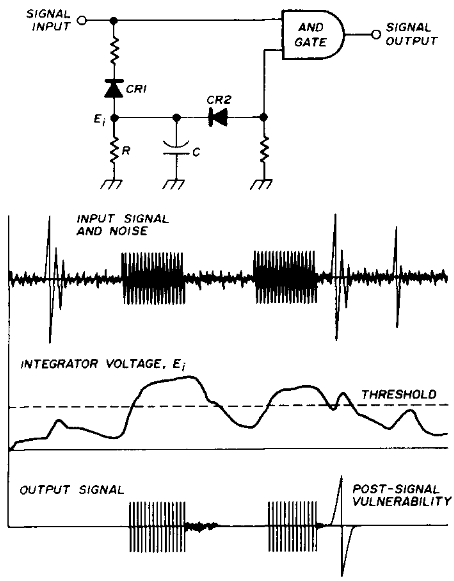

fig. 2. Energy-gating circuit. The RC integrator averages energy over time. The output of the integrator is used to operate an AND gate through a threshold device (CR2). Note the post-signal vulnerability.

As can be seen, the value of the RC integrating circuit is fairly critical — the higher the value of the integrating capacitor, the greater the immunity to impulse noise and the greater the truncation of CW notes, as well as a greater post-signal vulnerability. The lower the value of the integrating capacitor, the opposite is true. Nevertheless, there is a range of RC values which give satisfactory results.

Experiments with energy gating

evolved from further developments in the threshold-gating circuit. In an attempt to increase the amount of post-gate filtering I built the circuit in **fig. 3.** The two tuned circuits are brought into mutual resonance by placing an ac voltmeter (or dc milliameter with a diode and appropriate value of series resistance) across each capacitor and tuning the receiver through a carrier. Peak readings at each capacitor should occur at the same dial setting (same audio frequency). If there is a difference, mutual resonance can be established by adding padding capacitance *across the capacitor which gives the* peak reading at the higher audio frequency.

The circuits have sufficient Q to introduce a slight amount of ringing so a small amount of damping was introduced to reduce this. In the circuit in **fig. 3** there is a diode and variable resistor in series across the second tuned circuit. The variable resistor is set to give the most pleasing note. Once this setting is determined you can measure the resistance of the variable and replace it with a fixed resistor of the same value.

combining the systems

An improved circuit that incorporates threshold-gating, post-gate filtering, energy gating and tone characteristic control is shown in **fig. 4.** The Q of the first tuned circuit serves to multiply the driving signal to a level adequate for operating the integrating circuit (CR1, R1 and C1). Transistor Q1 serves a switching *function; diode CR2 and the emitter-base* characteristics of Q1 provide a threshold effect.

A variation of this circuit is given in **fig. 5.** Here, the resistor in series with the base connection of Q1 is eliminated and the keying voltage from the integrating circuit *is made variable. This adjustment* effects the keying characteristics of Q1 and there seems to be a critical setting at

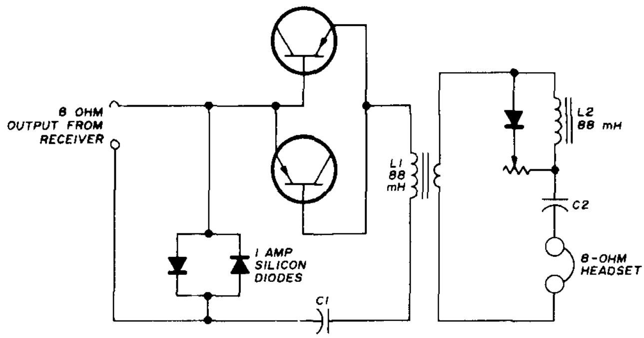

fig. 3. Threshold-gate/limiter with two-stage, post-gate filter. Tuned circuits L1-C1 and L2-C2 are resonated to the same frequency. Link on L1 is 32 turns no. 28. Value for C1 and C2 falls in the range 0.5 to 2.0 µF; exact value is a function of the desired peak frequency.

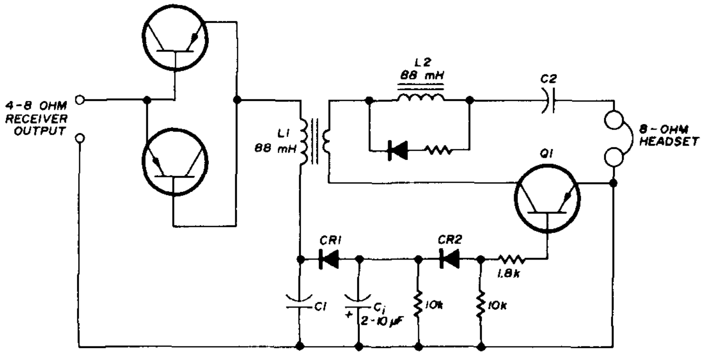

fig. 4. Threshold-gate circuit with both amplitude and average energy thresholds. C1 is the energy integrating capacitor; 2 to 10 µF provides satisfactory results. Diode CR2 provides threshold keying of Q1, which acts as a switch in the headset circuit. Link on L1 is 32 turns no. 28.

which the CW notes are more crisp, and hence, more readable than usual.

The circuits in **figs. 4** and **5** provide complete elimination of some forms and amplitudes of impulse noise. Total elimination of impulse noise is not possible, however, if the circuits are overdriven or if the impulse noise is very severe. There is some similarity between energy-gating and that method which uses the received signal to key an independent audio oscillator. In energy gating it is the signal itself which is keyed. Thus, it is possible to discriminate between impulse noise and signal, or from one signal to another, when these happen to key the output. In addition, some feel of the receiver tuning is maintained.

To evaluate reiterative-gating and energy-gating I put together a two-stage system. The first threshold-gate filter was followed by a ten-watt hi-fi amplifier which fed the circuit of **fig. 5**. The receiver I used had a Q multiplier and an internal audio filter, and I found it necessary to lower the Q of the receiver's audio filter to avoid ringing (all tuned audio circuits were set to the same frequency).

With this receiving system I found that signals as close as 250 Hz could be completely separated. Radioteletype signals were received as two distinct signals, with a zone of silence in between. Most interesting, however, was the immunity to sideband energy from radiotelephone signals. Apparently, there was insufficient average energy to operate the energy gate. It was possible to tune through the 40-meter band at night and not be bothered by the international shortwave stations which operate there. Each of these signals were reduced to a carrier which occupied about 200-Hz of dial space. Beyond that, there was no indication of their presence.

summary

There is much that can be done to achieve crystal clear CW reception. The CW signal is amenable to various types of signal processing, as all you have to preserve is its timing characteristics. The circuits presented here are perhaps the most simple ways of obtaining threshold- and energy-gating. With more sophisticated circuitry it should be possible to achieve superior results.

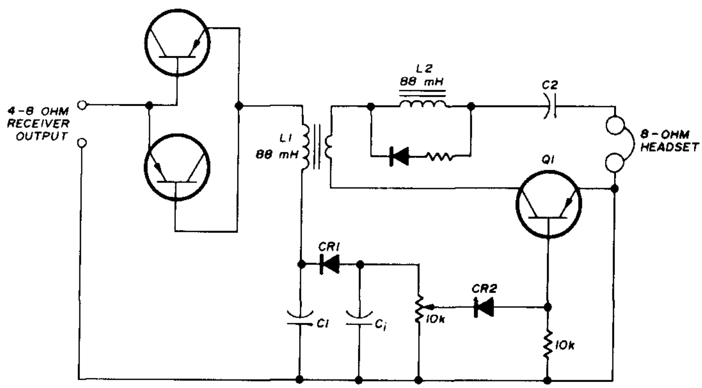

fig. 5. Alternate amplitude/energy gate circuit. Setting of the 10k variable resistor is critical for besting sounding CW note. Transistor Q1 and CR1 and CR2 are small-signal types. Link on L1 if 32 turns no. 28.

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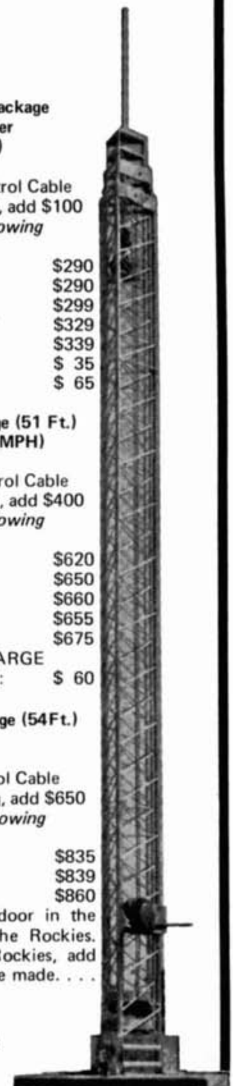

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two-capacitor transmission-line matching system

Eliminate antenna matching stubs with this simple two-capacitor matching system

Bill Johnson, W6MUR, Box 803, Ben Lomond, California 95005

It is often desired to match an open-wire transmission line to a resonant antenna whose resistance is different than the characteristic impedance of the line. There are many sources which adequately describe how this may be done using shorted or open stubs, but very little is available on doing this with a combination of lumped constants and a transmission-line section. This article describes a convenient matching system using fixed capacitors connected across the open-wire line a specific distance apart, and shows how to find that distance.

The use of capacitors, particularly the relatively inexpensive fixed vacuum types still available on the surplus market, is attractive in this application because it eliminates the need for line sections hanging down, and facilitates experimental adjustment. Vacuum capacitors are weatherproof, probably more so than feeder spreaders. The losses involved are certainly comparable, if not less than with lines.

matching system

The system is essentially that of the double-stub tuner, except that for flexibility in achieving a match to a wider range of load (antenna) resistances, and to enable the use of capacitance values specified in advance, it will be assumed that the transmission-line matching section has a Z_0 different than the main transmission line to be matched.

The circuit analyzed is shown in **fig. 1.** The matching section has electrical length, θ, and characteristic impedance, Z_0. The two capacitors are represented as reactances X1 and X2, respectively, with X2 nearest the load (antenna) and X1 nearest the transmitter. Resistance R_a is the antenna resistance and R is the characteristic impedance of the main transmission line to be matched. Antenna reactance can be compensated for by simply moving the two capacitors along the line so that there is a section of line between X2 and the antenna.

The analysis proceeds along conventional lines assuming image-impedance operation and treating the line section and two capacitors as a network. The image impedances are unequal and made the same as the resistances R and R_a. The short-circuit and open-circuit impedances at each end of the line are computed, from which you can obtain both the ratio R/R_a and the product RR_a. Manipulation of these relationships then permits the reactances to be found. The result, for capacitive X1 and X2, is

$$\frac{Z_o}{X1} = \frac{1}{T} \pm \sqrt{\frac{R}{R_a}} \sqrt{\frac{1}{T^2} + 1 - \frac{Z_o^2}{RR_a}} \quad (1)$$

$$\frac{Z_o}{X2} = \frac{1}{T} \pm \frac{1}{\sqrt{\frac{R}{R_a}}} \sqrt{\frac{1}{T^2} + 1 - \frac{Z_o^2}{RR_a}} \quad (2)$$

where $T = \tan\theta$. In these equations the same sign of the radical must be used in both equations. A necessary condition is that the quantity under the second radical be positive. For this to be true,

$$\sin\theta < \frac{\sqrt{RR_a}}{Z_o} \quad (3)$$

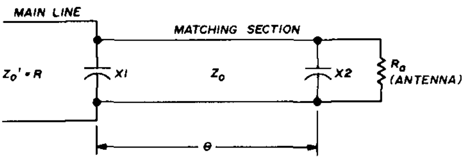


fig. 1. Basic two-capacitor line-matching system.

This places a limitation upon the length of line that can be used, or conversely, upon the range of impedances that can be matched. This is the same sort of limitation that applies in the case of conventional double-stub tuners where transmission line sections rather than capacitors are used. In this case, however, it was assumed that Z_0 can be established as something different than that of the main transmission line. If this were not done, $Z_o = R$, and $\sin\theta < \sqrt{Ra/R}$ (from **eq. 3**). In practical situations, such as matching a 73-ohm antenna to a 600-ohm transmission line, you would find that the line section might have to be rather short, about 20° in this example. Therefore, it is necessary to retain the option of changing the Z_0, and, as will be seen later, you *must* have this option if you are to use capacitors of predetermined values.

With two capacitors whose values are fixed in advance, Z_0 becomes a variable and it is necessary to solve **eqs. 1** and **2** simultaneously to find Z_0 and $T = \tan\theta$. Fortunately, this is not too difficult and the result is

$$Z_o = \frac{R_o}{\sqrt{\left(\frac{m-\rho}{a}\right)^2 + 1 - \rho^2}} \quad (4)$$

$$T = \frac{R_o}{\rho Z_o} = \tan\theta \quad (5)$$

where

$$R_o = \sqrt{RRa}$$

$$m = \frac{R_o}{X_1}$$

$$n = \frac{R_o}{X_2}$$

$$a = \sqrt{\frac{R}{R_a}}$$

$$\rho = \frac{m - a^2 n}{1 - a^2}$$

Both m and n are positive for capacitive reactance. If the quantity under the radical turns out to be negative, you must choose other capacitor values and try again.

example

Following is a step-by-step procedure for finding the required Z_0 and length of the line section. There are some general rules that should be followed, however, to avoid having to repeat the calculations because one of the values turns out to be imaginary. First, select the capacitance values so that their reactance is somewhere around the characteristic impedance of the line to be matched. Second, install the largest capacitor on the side having the lowest impedance.

In this example it is desired to match a 73-ohm antenna to a 460-ohm line. Three

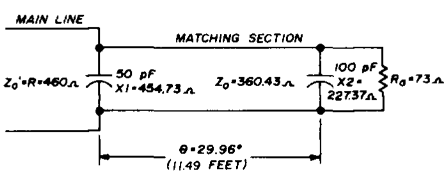


fig. 2. Two-capacitor system for matching a 73-ohm antenna to a 460-ohm line at 7.0 MHz.

50-pF vacuum capacitors are available. Since 50 pF has a reactance of 454.73 ohms at 7000 kHz, this would be a good value for the 40-meter band. In as much as three capacitors are available, two of them are placed in parallel and used for X2, nearest the low-impedance, or antenna side of the line. (If matching a higher impedance antenna, R_a greater than R, put the parallel capacitors on the line side, nearest the transmitter.)

To find the characteristic impedance of the matching section, Z_0, and the length of the matching section, it is necessary to go through the following calculations:

$$R_o = \sqrt{RR_a} = \sqrt{460 \times 73}$$

$$= 183.25 \text{ ohms}$$

$$a = \sqrt{R/R_a} = \sqrt{460/73} = 2.51$$

$$m = R_o/X_1 = 183.25/454.73 = .403$$

$$n = R_o/X_2 = 183.25/227.365 = .806$$

$$\rho = \frac{m - a^2 n}{1 - a^2}$$

$$= \frac{.403 - (2.51)^2 \times .806}{1 - 2.51^2} = .882$$

Now, using **eq. 4**, find the characteristic impedance of the matching section, Z_0

$$\frac{183.25}{\sqrt{\left(\frac{.403 - .882}{2.51}\right)^2 + 1 - (.882)^2}}$$

$$= 360.43 \text{ ohms}$$

Compute tan θ and find θ in the trignometric tables

$$\tan\theta = R_o/\rho Z_o$$

$$= 183.25/(.882 \times 360.43) = .576$$

$$\theta = 29.96^\circ$$

When θ has been determined, the length of the line section can be calculated with the following formula

$$L = \frac{2.73}{f_{MHz}}\theta = (2.73/7)29.96 = 11.49 \text{ feet}$$

The completed matching system consists of a 360.43-ohm open-wire line, 11.49-feet long, with three vacuum capacitors, as shown in **fig. 2.** The line section can be made up applying the usual formulas for characteristic impedance,

$$Z_o = 276 \log_{10} \frac{2S}{d}$$

where S is the center-to-center spacing and d the wire diameter, in the same units. A 360.43-ohm line made from number-12 wire requires a spacing of 0.82 inches. If this is considered too narrow, then use a four-wire line for which

$$Z_o = 138 \log_{10} \sqrt{2}\frac{S}{d}$$

if the wires are arranged on a square, or

$$Z_o = 138 \log_{10} \frac{2D_2}{d\sqrt{1 + (D_2/D_1)^2}}$$

if the wires are arranged on a rectangle of sides D_1 and D_2. Diagonally opposing wires are connected together in a four-wire line of these types.

To compensate for antenna reactance, the distance of X2 from the antenna can be varied, or else a variable capacitor can be connected in parallel with X2 (or with one of the two capacitors removed) and tuned for minimum vswr on the main line. The best approach, of course, is to have the antenna cut to length at the desired frequency so that it is resonant and nonreactive.

summary

The same principles can be applied to other cases, say where you want to use inductance rather than capacitance. The same relationships apply, but with the sign changed on X1 and X2 (and hence, on m and n). A matching system is, after all, equivalent to a pi-matching network where impedance transformation takes place due to unequal image impedances of the network. You might even use the same general analytical approach to design a *three-capacitor* matching system that would then allow a predetermined Z_0 to be used for the line section.

ham radio

vari-Q filter

Remember the shunt Q multiplier? Here's how to use it in series with a narrowband mechanical filter

Stirling M. Olberg, W1SNN, 19 Loretta Road, Waltham, Massachusetts 02154

An affliction of the QRP bug resulted in a receiver accessory that is compact and has many features found in high-power stations. Receiver selectivity is always important; in QRP operation it often means the difference between completing a contact or no contact at all.

My receiver for QRP work is a superhet that has a 1.2-kHz mechanical filter and a Q multiplier. This combination reduces the overpowering effect of nearby signals and improves the signal-to-noise ratio. Used with a narrowband mechanical filter, the Q multiplier can be used to peak or null a signal within the mechanical filter passband.

selectivity

The combination of a 1.2-kHz mechanical filter and a Q multiplier offers advantages not found in many commercially built amateur receivers. The narrow bandwidth provided by the mechanical filter, in combination with the Q multiplier, provides discrimination between strong and weak signals; the Q multiplier allows you to peak or attenuate a signal across the mechanical filter passband.

Parallel-resonant circuits that have a high Q also present a high resistance, and thus a high impedance, which is subject to a reduction to a lower value due to the circuit to which it's connected. It's impossible to prevent this effect, but it can be reduced. In a practical parallel-resonant circuit, the impedance can be expressed as:

$$Z_r = QX \qquad (1)$$

where

Z_r = impedance at resonance (ohms)

Q = quality factor

X = reactance of C or L (ohms)

The result of **eq. 1** is that Q is degraded due to changes of reflected impedances caused by the Miller effect. Such degradations adversely affect the operation of the Q multiplier due to its method of coupling to the receiver. It became clear that isolation of input and output circuits would offer some improvement. This isolation was achieved in the circuit of **fig. 1**.

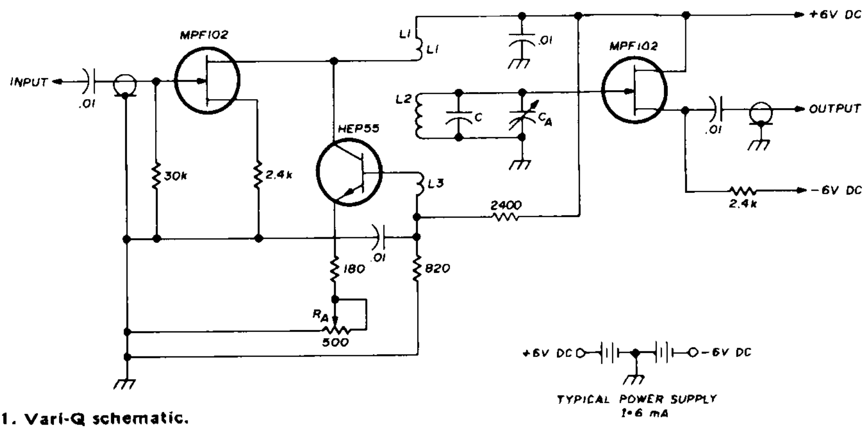


fig. 1. Vari-Q schematic.

The heart of the Q multiplier is an inductor with a high Q (typically of the order of 100). I found that the receiver circuitry associated with the Q multiplier degraded its Q so that full capability of the Q multiplier was not fully realized. A review of some basic theory will help to explain.

example. Let our inductor have an unloaded Q of 200. The inductive and capacitive reactance of the circuit are each 500 ohms. Thus Z_r = QX = 200 x 500 = 100k ohms, which is the impedance of the parallel-resonant circuit.

Another consideration, which will help to understand the problem, is the 3-dB bandwidth of our parallel-resonant circuit. The bandwidth at the 3-dB points is:

$$BW = f_o/Q \qquad (2)$$

where

f_o = resonant frequency (kHz)

Q = quality factor

For a Q of 200 at 455 kHz ±3 dB, f_o = 455/200 = 2.2 kHz. The loaded Q is:

$$Q = R/X \qquad (3)$$

where

Q = quality factor

R = parallel load resistance (ohms)

X = reactance (ohms)

From **eqs. 2** and **3** it can be seen that bandwidth is an inverse function of load impedance.

the Q multiplier

Now that we've reviewed the facts regarding inductors in parallel resonance, let's take a closer look at the Q multiplier. The Q multiplier is an amplifier that functions as a very high-Q circuit. It is connected in parallel with one of the receiver i-f stages. A parallel-resonant circuit has a very high impedance. Any signal passing through the i-f at the Q multiplier resonant frequency sees a very high shunt impedance and is not attenuated, whereas signals near the Q multiplier resonant frequency appear on the skirt of the Q multiplier response curve and are shunted to ground. As the regeneration control is advanced to a point just below oscillation, the effective Q of the circuit is increased. Thus the peaking action can be increased to any desired level.

It's possible to attenuate adjacent ssb signals in the same manner, but a much lower regeneration level is required. In CW operation, another interesting effect is the inability of the Q multiplier to respond to static or key clicks; this is because the Q will not build up fast enough to respond to such impulses.

the vari-Q circuit

The circuit acts like a variable filter with a bandwidth adjustment. For this reason "Vari Q Filter" is the name given to the circuit. Sufficient gain is available to compensate for any losses in its addition to most receivers.

A review of **fig. 1** shows that the input circuit impedance approximates the reactance of an i-f transformer. The input is coupled to the gate of a fet, which is directly coupled to the collector of an HEP55 or similar transistor. The HEP55 serves as the Q-multiplier regenerative amplifier.

The base of the HEP55 is connected to one of the secondary windings of the transformer (L3). Feedback is produced by coupling the output into the input of this amplifier via the tuned secondary, which has the high Q required. The input and output circuits are arranged to be completely isolated. Also, sufficient gain *is available to allow regeneration to* occur.

The usual Q multiplier circuit is coupled very loosely to the i-f input through a so-called gimmick capacitor (twisted lead). The gimmick must be connected between the output of the mixer and the first i-f input as shown in **fig. 2A**. The Vari-Q Filter differs in its installation — it is connected in series as shown in **fig. 2B**. When the Vari-Q Filter is added to the i-f strip, the loading effects are so small that it acts as a Q multiplier. Of more importance, the Vari-Q Filter retains these properties across the full passband of the mechanical filter.

It is rarely required to operate the Vari-Q circuit near the unstable level since extremely narrow passbands can't be used; so a lower level of regeneration is used, which offers greater stability.

It is possible to completely eliminate one of two CW signals by adjusting the

table 1. Coil and capacitor data. All coils are wound with no. 32 enamelled wire.

frequency (kHz)	L1 L2 L3 (no. turns)	core type	C CA (pF)
50	16 130 40	Ferroxcube 1811CA250-387	3600 10-75
455	12 115 24	Amidon T44-15	470 7-45
1800	6 100 18	Amidon T44-15	75 3-30

tuning capacitor, CA, to recenter the passband of the Vari-Q Filter. A very small loading effect is reflected into the LC combination. The output of the source follower is coupled through a small capacitor to the i-f transformer, which serves as an input. The 2.4k source follower load resistor can be changed to match any required load simply by substituting the desired value. It is important to use a balanced power supply. Current drain is 6 mA, which can be supplied from a battery.

Table 1 is included to allow the home brew artist to scale off his own frequency requirements. The toroids and pot cores indicated can be substituted with any inductor having a Q of the order of 100.

construction

The Vari-Q filter is built on a small piece of etched circuit board employing "circuit stiks." The variable tuning capacitor can be found in surplus bins. Its small size allows it to be mounted to the board directly, which reduces lead length and allows the unit to be mounted on the receiver front panel. Next to the capacitor a potentiometer, used as the regeneration control, was added to the front panel, giving full control to the filter circuit.

operation

For best results the regeneration control should be at a low setting, and the tuning capacitor should be at mid range. Tune in the desired signal. If interference is present, adjust the regeneration control until a slight "plop" is heard, but do not advance it further. Then tune in either the desired signal or null the interferring signal by adjusting the variable capacitor. If greater selectivity is desired, advance

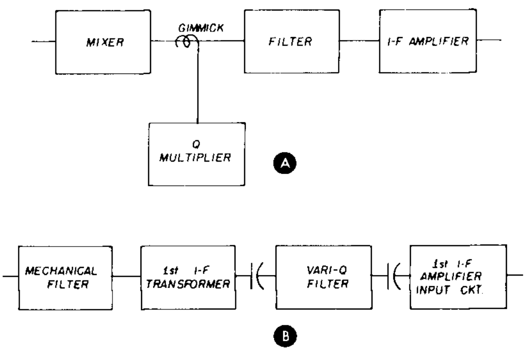
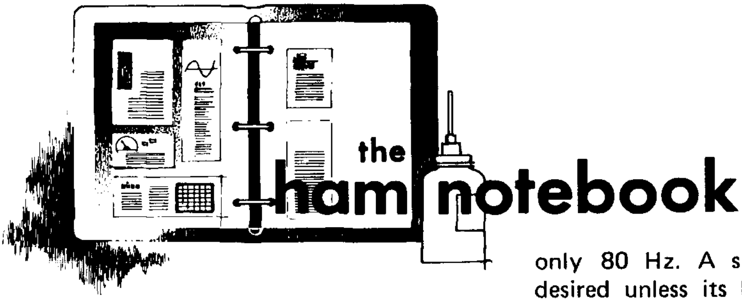


fig. 2. The usual Q multiplier is connected in parallel with the i-f as shown in (A). The Vari-Q Filter is connected in series as shown in (B).

the regeneration control until a ringing effect is heard. The amount of ringing that can be tolerated is a variable that depends on the operator. With experience and skill, it's possible to pull weak signals out of noise and interference even when background ringing occurs. The regeneration control has a fairly wide range and won't cause the unit to break into oscillation until the control is close to its maximum position.

Although the Vari Q was designed for a QRP receiver, it has also been incorporated into my 75A4 and UR388 receivers. Several others have also used it successfully in other receiver designs. The Vari Q will be manufactured either as a kit or as a complete unit. Details are available — send me a self-addressed stamped envelope.

ham radio



adding a cw filter

Many transceivers don't have sufficient selectivity for CW so a good audio filter must be added. Several good active filters are available, powered by a small battery. The filter should not be in the circuit while you scan the band or listen to ssb. Therefore, two switches may be needed; one for the filter and one for the battery. If wired as shown in **fig. 1**, a single dpst switch is all you need. In its *normal* position the filter is shorted out of the circuit and the battery circuit is open.

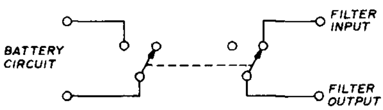


fig. 1. When installing a CW audio filter in your transceiver a single dpst switch may be used to turn off the power supply and by-pass the filter.

The filter may be added between the audio output of the receiver and an earpiece. If convenient, it is better to install it between audio stages, where the audio signal level is still low. In any case, make sure that shorting the filter input and output does not upset some dc circuit within the receiver or in the filter itself.

Because of the extreme selectivity of a good filter, an incoming beat frequency must be held to narrow limits. For example, a CWF-2 filter* has a center frequency of 750 Hz and a bandpass of only 80 Hz. A signal cannot peak as desired unless its beat note is near 750 Hz.

If your transceiver has *variable* offset control, the receiver can be tuned (for desired beat) without changing the transmitter tuning. My Swan 350C does not have such a control. Although adding the filter greatly improved CW reception, I decided to modify the set for maximum efficiency.

In the *receive* position a fixed 10-pF capacitor (C-140 on the schematic) is added across the carrier oscillator crystal. This creates a beat of 800 Hz. I replaced C-140 with a 25-pF variable. Now I can peak all signals, and can also chase a drifting signal without varying transmitter tuning.

Front-panel space is limited, so I removed the *rf gain* pot to make space for the 25-pF capacitor. Gain had always been left at maximum, anyway, so I didn't need the gain control. A fixed 10,000-ohm resistor replaced the pot.

The CWF-2 can be switched to several bandwidths, 180, 110 or 80 Hz. I prefer the latter at all times (except when scanning the band or listening to ssb).

I. Queen, W2OUX

*The CWF-2 CW audio filter is available from MFJ Enterprises, Box 494, State College, Mississippi 39762.

magnetic fields and the 7360

Having had occasion to work on several sideband transceivers using the 7360 magnetic-deflection mixer tube, I found these tubes much influenced by stray, external magnetic fields. The deflection plates inside the tube can also be permanently charged.

On one occasion I found the 7360 would not balance out the carrier in any position of the balance pot, while another tube worked as it should. I tried a homebrew degaussing coil about two inches in diameter, dropping the tube through it with 60 cycle ac on the coil, thinking the field would become progressively weaker as the tube passed through. However, results were unsatisfactory and the tube still refused to balance.

With the tube in its socket, I passed a permanent magnet along the glass envelope from bottom to top. Still no improvement. When the magnet was reversed, however, the tube came to life and a good balance was obtained about one-third of the way through the pot rotation.

Watch where you lay the 7360 when out of its socket. A screwdriver on the bench may be magnetized, and alongside the 7360, it will do its worst. Even when testing the tube, don't put it down on top of the tester, the transformer may be mounted right underneath and not magnetically shielded. Also, watch out for steel tube shields for the 7360, they may become magnetized.

Eugene A. Hubbell, W7DI

finding square roots

The small, hand-held digital electronic calculator is showing up in large quantities in the marketplace, and every large discount department store has several from which to choose. These calculators are great to have in your home for every-day calculations or even electronic circuit design. Although most of the consumer-oriented calculators are excellent for the standard mathematical functions of addition, subtraction, multiplication and division, the square root function is missing. However, by application of the Mechanic's Rule,* extracting square roots may be obtained with greater than slide-rule accuracy. Although the answer has a small amount of error, the result may be used for most applications.

*James and James, *Mathematics Dictionary,* D.Van Nostrand Company, New York, third edition, page 233.

The Mechanic's Rule is as follows:

$$\sqrt{N} \cong \frac{\left(\frac{N}{est\sqrt{N}}\right) + est\sqrt{N}}{2}$$

where N is the number you want the square root of, and est ON is the estimated square root.

For example, find the square root of 54. Since 54 falls between 49 and 64 (square roots 7 and 8, respectively), the square root of 54 will be between 7 and 8, and probably, by inspection, around 7.3. Plugging these numbers into the Mechanic's Rule:

$$\sqrt{54} \cong \frac{\frac{54}{7.3} + 7.3}{2} = 7.349$$

This answer, when squared, yields 54.008, which represents better than 0.02% accuracy.

John A. Sego, K9DHD

active microphone impedance match

It seems that fate, often perverse, always arranges for those high-quality microphones that show up in surplus outlets to be of the low-impedance type. As nearly all amateur radio transmitters are designed for high-impedance microphone input, you have to use some sort of an impedance-matching device to mate the two. An additional complication appears in the situation of high-quality microphones often having an output that's not quite large enough to satisfy the average transmitter, even with an impedance matching (and voltage) step-up transformer.

Since I had just such a situation, plus a desire to rectify it, I built a transistorized unit that solved both elements of the problem quite satisfactorily. The solution had the additional positive attraction of costing nothing. Nothing, that is, if you have purchased a few surplus (and well-loaded) PC boards. That was the source of the parts I used, and the circuit boards had been acquired long ago just for a few specific parts, with the excess going into my junkbox. (Perhaps I should be honest and state that *my* junkbox occupies an attic, an ex-garage and two backyard storage buildings!)

The transistor is an ideal impedance-matching device. In either the common-base or the common-emitter configuration it presents a low-impedance input circuit that will provide a reasonable impedance match for a 25-ohm microphone. Microphones, fortunately, are

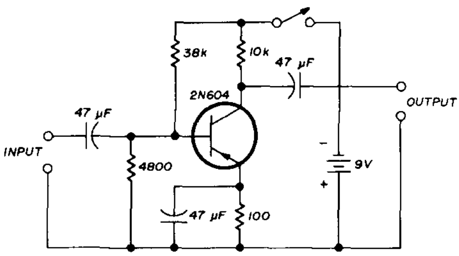


fig. 2. One-transistor microphone impedance-matching circuit matches low-impedance microphones to high-impedance inputs common with amateur ssb transceivers.

very tolerant of match. Just don't work them into too low a load impedance.

For my project, I selected the common-emitter configuration. The selection was not based upon any overweening factor; the common-base probably would have been just as satisfactory. Much the same attitude prevailed in the selection of component values. There is a very wide latitude of choice, within which the exercise of reasonable judgement determines what you'll use. The values given in the schematic diagram are ones that work and work well, being mutually compatible for desired gain and frequency range as well as low waveform distortion.

A PNP transistor was used, picked because of the high h_{fe} of the 2N604 lifted off a surplus circuit board. It must have been a good choice, for gain is more than ample. The output is appreciably greater than that from a transformer designed expressly for microphone impedance matching.

I built my unit on a piece of insulating board of uncertain origin and composition. Holes were drilled for flea clips and for the three leads of the transistor. These leads were bent over and soldered to adjacent flea clips. All components were mounted on flea clips, with the physical arrangement of parts almost exactly following the schematic diagram shown in **fig. 2.**

The completed unit enabled an Electro-Voice Model 637 microphone to provide all the audio input needed by my Drake TR-4 transceiver. On-the-air checks of audio quality have been quite pleasing, a compliment to both the microphone and the impedance-match/amplifier.

Carl Drumeller, W5JJ

using the Shure 401A microphone with the Drake TR-4

The audio passband of the Drake TR4 transceiver, when used with the recommended Electrovoice microphone, has insufficient gain if the operator has a deep, bass voice. This can be improved by using a Shure 401A microphone, but the original microphone circuit of the TR4, consisting of 1000-pF blocking capacitor and 6.8 megohm grid leak, is unsuitable for the Shure 401A.

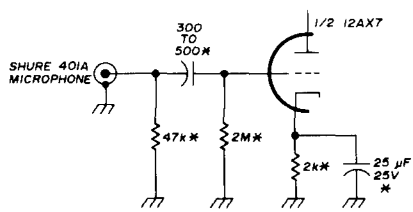


fig. 3. Modifications to the TR4 speech circuit for use with the Shure 401A microphone. This microphone is particularly suitable for operators with deep, bass voices.

The solution to this problem is shown in **fig. 3**. The new components are indicated by asterisks. In my rig the new components are clustered around the tube base. The existing printed-circuit board assembly is left intact except for the connection to the grid of the 12AX7.

Harry Manning, G3XOM

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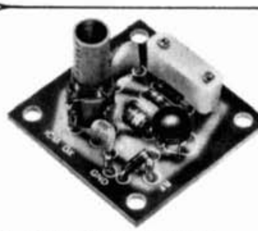

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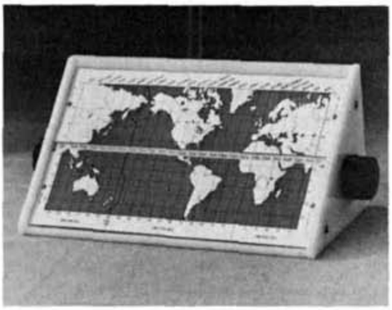
new products

graphic time-teller



An operating aid that will interest hams active in DX work, as well as foreign broadcast listeners, has been introduced by U-J Industries. By the turn of a knob the operator may position the drum dial, viewed through an opening in the map panel, so that his local time appears at the map line for his time zone. The standard time for all other time zones may then be read from the dial at those zone lines, and the GMT hours are shown in each margin of the map. If on daylight saving time, the operator simply positions his local daylight time at the meridian line to the east of his actual zone line. World standard times and GMT hours remain correct.

Schedule planning is greatly facilitated by the quickness with which the operator may turn to other times for his location for a look at other-country times at those other hours. This is a flexibility not realized through the use of tables or 24-hour clocks having countries listed around the dial.

The map panel features enamel on aluminum, with the ocean areas in blue and other features in black. In the top margin is shown, for each time zone, the name of one or two countries (or cities or other areas) that are within the zone. In the other margins latitude and longitude figures are shown. To add to the visual presentation, the hours of daylight are printed in red and the hours of darkness in black. This is an aid in determining conditions along the signal path. The cabinet is hand-crafted of acrylic sheet, and is slightly over nine inches long.

List price of the *Time-Teller* as illustrated is $18.50 plus postage. A complete kit is available at $14.75, and a basic kit is $11.75. The latter includes map panels, assembled drum dial with shaft and 2-color chart, angles and other hardware, but not cabinet (cabinet drawings are included) or knobs. Additional information is available from U-J Industries, 6605 Shoal Creek Boulevard, Austin, Texas 78757, or use *check-off* on page 110.

eye-ball QSL cards

These new eye-ball QSL cards are designed for the radio amateur who actively participates in hamfests, club meetings or eye-ball QSOs. Eye-Ball QSL Cards are simulated engraved business cards printed on deluxe citation card stock with a choice of three colors: black, blue and red. ARRL or club emblem cuts may also be included in your layout. There is no need to give away expensive QSL cards when you can give an Eye-Ball QSL Card for less than 1 cent each.

These eye-ball QSL cards are available at $7.95 per thousand for one color or $8.95 per thousand for two colors, postpaid (add $1.00 for ARRL or club emblem cuts). Available from Lecours Enterprises (KØOJW), 814 Riderwood Drive, Hazelwood, Missouri 63042.

More Details? CHECK–OFF Page 110

antenna noise bridge

Amateur radio antennas, including two-meter fm systems, can now be tested for resonant frequency and impedance with the Omega-t Systems Antenna Noise Bridge. The Antenna Noise Bridge, models TE7-01 and TE7-02, combine precision and measurement flexibility normally found only in a collection of expensive laboratory equipment.

Able to be used over the entire range from 1 to 300 MHz, the antenna noise bridge allows testing and tuning for optimum performance from an antenna and receiver without the use of additional equipment. It also replaces any other testing equipment, specifically vswr bridges, with a more accurate test system.

The antenna noise bridge can be used to test beams, whips, dipoles, quads or complete antenna systems by connecting the instrument between the antenna to be tested and the station receiver. For more information, write to Omega-t Systems, Inc., Box 1010, Richardson, Texas 75080, or use *check-off* on page 110.

veroboard kit

Vero has introduced their new Veroboard Kit DIP 24 for use with integrated circuits. Engineers, technicians and experimenters will enjoy using the DIP 24 Kit as it eliminates the need for etching, drilling and making terminals. The boards are used for mounting and interconnecting dual-in-line IC packages for development applications, as well as for production runs where variations of the basic design may be required.

Supply lines are positioned adjacent to all DIP locations and are connected to the outer edge contacts. The layout pattern permits the mounting of packages having any number of terminations provided they are on 0.1-inch centers. When fitted in horizontally mounted card frames the DIPs are positioned in parallel vertical rows. The boards are punched with a matrix of holes on 0.1" centers ready to accept dual-in-line packages or IC sockets. Plain holes off the copper tracks can be used for terminal pins.

The Vero DIP Kit consists of one 11824 board, which is 4.5 x 6.5 inches, with 22 contacts on two sides, a 44-pin edge connector, card extraction handle, design sheet and 10 14-pin DIP sockets. The DIP 24 Kit sells for $16.22. For more information, write to Vero Electronics Incorporated, 171 Bridge Road, Hauppauge, New York 11787, or use *check-off* on page 110.

tone burst encoder

Palomar Engineers has announced a new tone burst encoder for use with two-meter fm repeaters and in other remote-control applications. Using LC tuned circuits and an IC amplifier it features accurate tone frequency, low drift, and immunity to rf pickup and interference.

An important application is tone-burst entry to two-meter repeaters. Many repeaters require a short burst of an audio

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tone for turn-on. Each repeater in a local area and on the same or nearby frequency uses a different tone; this prevents accidental turn-on of other repeaters. Eleven tones, from 1650 to 3000 Hz, are in widespread use. The Palomar Engineers encoder produces all eleven tones as selected by a front-panel switch.

The Palomar encoder has a built-in half-second timer. The time is adjustable and can be wired to produce a continuous tone for other remote control applications.

The Encoder is housed in a compact 4x3x2-inch case with an anodized aluminum control panel. The required +12 Vdc power is normally taken from the associated transceiver. Outputs for both high and low impedance microphones are provided so the unit may be used with all the popular fm transceivers. Price is $37.50, postpaid. For a free descriptive brochure, write to Palomar Engineers, Box 455, Escondido, California 92025, or use *check-off* on page 110.

fast-scan/slow-scan tv camera

The Thomas Electronics and Engineering Company has recently announced the availability of their new, all solid-state, fast-scan/slow-scan television camera, the model HCV-1B. This new camera features a built-in ac power supply and rf output on fast scan for viewing on a standard tv set. There is a provision for the addition of an audio sub-carrier module for home entertainment and recording of fast-scan signals on video tape.

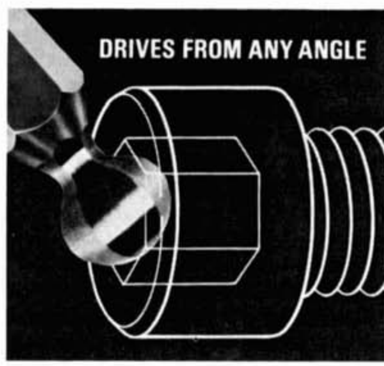
Slow-scan output meets FCC standards with white at 2300 Hz, black at 1500 Hz and sync at 1200 Hz. Amplitude is adjustable, zero to 3 volts p-p. Output impedance is 1000 ohms. The output spectrum also meets published Bell System tariffs for voice couplers.

The video output on fast-scan is 1.5 volts p-p. The rf output is 1.5 millivolts p-p, adjustable for channels 2 through 6. With this camera fast-scan video or rf may be monitored at the same time slow-scan is being televised.

The HCV-1B is furnished with a standard type-C lens mount and is available with or without a lens. The unit is covered by a standard 90-day warranty and a complete service department is available if service is ever required. A printed-circuit board exchange program is also in affect. All critical components are mounted in plug-in sockets to provide quick and easy change without a soldering iron.

Price, ready to operate with a Soligor 25mm, f1.9 lens or Cosmicar 2519 is $395.00. Price less lens is $365.00. For more information, write to Thomas Electronics and Engineering Company, Inc., Post Office Box 572, Hendersonville, Tennessee 37075, or use *check-off* on page 110.

unique hex-socket drivers



Xcelite is now manufacturing a line of Allen hex-type screwdrivers and interchangeable blades with an unusual "ball-point" tip design that achieves a speed and ease in engaging and turning that is unattainable with conventional drivers.

The tools work at any angle, thus being able to handle hex socket screws which, because of obstructions, cannot be reached straight-on. Because they slip into sockets more easily and faster than regular hex socket drivers, they simplify adjustments and speed up work, even in normal situations.

Nine sizes, from .050 through 3/16 inch, are available; fixed handle types,

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singly or a complete set in a handy roll kit with extra pockets for associated tools are available, as are interchangeable Series 99 blades singly or in a compact set that includes a regular detachable handle, extension, and a transparent plastic case. Complete information, specifications, and prices are contained in new Bulletin/Price List No. 273L which may be obtained by writing Xcelite Incorporated, Orchard Park, New York 14127, or by using *check-off* on page 110.

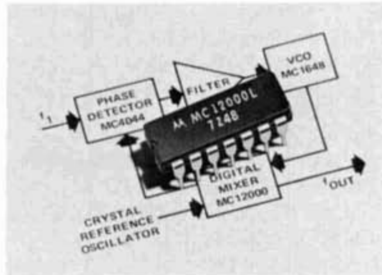
fm and repeaters for the radio amateur

The ARRL has recently introduced the latest in their long list of books for the radio amateur. This new book, "FM and Repeaters for the Radio Amateur" represents several years work on the part of the editor, Thomas McMullen, W1SL, and many members of the league staff as well as contributions from amateurs from all over the states. Although some of the material in this book was originally published in *QST,* the majority is new, including many new projects and circuits that haven't appeared in print before.

Chapters cover such topics as fm receivers, fm transmitters, mobile and portable equipment, antennas for base and mobile stations, repeaters, repeater controls and accessories, repeater technical problems and cures, testing fm gear, using surplus fm equipment, tips on buying used fm gear, repeater club organization, fm operating practices, suggestions for completing FCC repeater applications and the latest FCC regulations that pertain to repeater use.

For the amateur who is interested in vhf fm, this book is an essential addition to his library. If you are having a problem with your repeater system, chances are that you will find the answer in this excellent manual. Soft-bound, 232 pages, hundreds of photographs and drawings, $3.00 from your local dealer or from Comtec Books, Greenville, New Hampshire 03048.

digital mixer for phase-locked loops



Motorola Semiconductor Products has just announced introduction of a digital mixer for use in phase-locked loops (PLLs). Numbered the MC12000, the digital mixer generates an output frequency which is the difference between its two input frequencies.

The mixer consists of a D-type flip-flop, together with TTL to ECL and ECL to TTL translators. Using the MC12000 in a phase-locked loop, frequencies (one or more) up to 250 MHz can be generated economically and without the need for tuned circuits. The output frequency may be either a single fixed frequency or a series of programmable frequencies (using additional circuitry).

Phase-locked loops are electronic servo loops which cause an oscillator to follow exactly the phase of a reference signal. Either an analog or a digital approach may be taken toward the design of a phase-locked loop. The analog method is useful for *signal detection* (as in fm demodulation), while the digital approach is best suited for *signal generation* (as in multi-channel frequency synthesis and computer timing chains).

It is the latter application area, signal generation, for which the new Motorola digital circuit is intended. The mixer is expected to find use as a prescaler in phase-locked loop applications where the voltage-controlled oscillator operates above 10 MHz and a relatively narrow tuning range is required.

The MC12000 is available off-the-shelf in a 14-pin ceramic dual in-line package. Pricing in small quantities is $7.50. For

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more information, contact the Technical Information Center, Motorola Inc., Semiconductor Products Division, Box 20924, Phoenix, Arizona 85036, or use *check-off* on page 110.

touch-tone generator

Interface Technology has announced a small Touch-Tone generator for repeater keying or dialing through on a phone patch. The unit generates the standard 12 frequency pairs used for Touch-Tone dialing by the telephone companies. It is designed so that the output can be used in several ways. For one, a speaker included in the kit can be mounted internally and the unit simply held up to the microphone. The speaker can also be mounted in a small, remote case (optional) and connected by a cable to the generator; this allows the user to position the generator on a table or desk while the speaker is held up to the microphone. A third approach is to wire the unit directly into the microphone circuit, eliminating the speaker altogether.

There are no switches or controls on the unit other than the key pad, so no current is drawn from the standard 9-volt transistor battery until the operator touches a key to generate a tone. This feature insures long battery life and simplicity of use.

The unit is packaged in an attractive black molded plastic case and weighs only 8 ounces. It sells for $33.95 in kit form or $53.95 assembled and tested. Write to Interface Technology, Inc., Post Office Box 24565, St. Louis, Missouri 63141 for more information, or use *check-off* on page 110.

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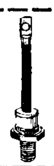

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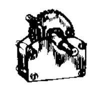
DX Callbooks .... $ 6.95
Radio Handbooks latest 19th edition .... $ 14.95
Lafayette Telsat-SSB 25, Sideband CB Rig Write
Heathkit HW-17 with Heath FM Adapter .... Write
Gonset 903A 2 meter amplifier, 5 watts in, 500 watts out all modes $375.00
HQ-180 with clock. Mint condition, professionally calibrated. Needs new RF gain control $275.00
Millen magnetic shields for 3" C.R. scope tubes with brackets. .... Brand new $ 6.95
TP-9 Similar to EE-8 field telephone with built-in amplifier. Up to 50 mi. Less easily obtained batteries .... Brand New $ 75.00
115 Volt AC Power Supply for BC-221, slips into battery compartment $29.50
ALUMINUM DIE CAST BOXES in many different sizes. Dosy boxes. Details in New Green Sheet No. 23. Write for latest prices.



Jackson G80 brass 50:1 anti-backlash dial drive ¼" to ¼". $19.00 value $5.50

2 METER VHF DUMMY LOAD/WATTMETER Good up to 15 watts — w/SO-239 CONNECTOR $15.95

BARKER & WILLIAMSON

Dummy Load - Wattmeters - 52Ω
333 DC - 300 MHz, 1000 watts int. $139.95
334A DC - 230 MHz, 1500 watt $169.95
374 DC - 300 MHz, 250 watt int. .... $ 79.95
850A, 852 Inductors .... $ 59.95
851 Inductor .... $ 29.95
425 Low Pass Filter, 10-80 meters .... $ 24.95
210 Audio Osc., ideal for lab & broadcast $329.95
410 Distortion Meter, ideal for lab & broadcast $369.95
AM-141 Amplifier, 2000 watts RF output, continuous 2-18 MHz, complete with coils and 833-A's. Built-in 115 VAC Supply, unused $950.00

STANDARD

SRC-146A 2 meter handheld transceiver $289.00

Tube Headquarters. Diversified Stock. Heavy inventory of Eimac tubes, chimneys, sockets, etc.

572B .... **$ 17.50**

Barry Now Stocks Bogen, Electrovoice & University. Call or Write.

CASH PAID . . . FAST! For your unused TUBES, Semiconductors, RECEIVERS, VAC. VARIABLES, Test Equipment, ETC. Write or call Now! Barry, W2LN1. We Buy!

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Send 10¢ plus 40¢ postage & handling (refund 1st order).

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DEPT. H-9

212-WA-5-7000 **ELECTRONICS**

See Page 112 for more from Barry

NEW!!

"Cloverleaf"...

SBE-450TRC TRANSCONVERTER

instant access to 450 from 144

Now . . . SBE opens up a new high speed route that leads to instant 450MHz operation from any 2 meter transceiver! Rev up—switch in the exclusive SBE, SB-450TRC "Cloverleaf"—arrive instantly on 450! Return at will!

Installation couldn't be more simple. Outwardly, "Cloverleaf" is a small black box that connects between your existing 144 MHz FM transceiver and its antenna, also to the microphone and car 12 volt battery. You plug the 450MHz antenna into another receptable provided. SB-450TRC has no external tuning, no controls other than a switch that allows instant shift between the 144 and 450MHz ranges. No mods are necessary. **Your existing 144MHz transceiver remains intact.**

Transmitter-wise, SBE "Cloverleaf" is entirely **passive—draws no DC power yet delivers 40% of the RF drive at three times the frequency.** Example: 4 watts out on 450 MHz for 10 watts drive on 2 meters. This high efficiency frequency multiplication is accomplished by a power varactor diode in conjunction with multiple high Q tuned circuits. The 450MHz output is of course frequency modulated; overswing, due to frequency multiplication, being compensated by a fixed pad in the microphone circuit within the unit.

Receiver-wise, "Cloverleaf" has a front end with unity conversion gain that converts 450MHz band signals to I-F frequencies corresponding to 144MHz channels. Limiter, discriminator, output audio and loud speaker in the 2 meter transceiver continue to function in the usual manner.

Mobile wise, this all-solid-state transceiver is ideal—a compact box that can mount wherever space is available. "Cloverleaf" current drain is negligible.

Price-wise, this SBE high value/performance breakthrough represents worthwhile savings over the cost of a complete 450MHz transceiver with comparable characteristics. Truly, SBE has done it again!

SBE

· Unit with covers removed

LINEAR SYSTEMS, INC. *220 Airport Boulevard, Watsonville, Calif. 95076*

YAESU

YOUR ASSURANCE OF PERFORMANCE & QUALITY

SP101-P $59.00
SP101 19.00

FV101 $99.00
160M THROUGH 10M

FT101 $649.00
TRANSCVR 260W PEP

FL2100 $339.00
80M THROUGH 10M
1200W PEP

The SP101-P Landliner provides phone patch operation as well as speaker. Front panel: Patch switch, meter, TX and RX gain controls. Rear apron: Receiver 4 ohm output, receiver 600 ohm output, monitor null switch, balance control, line jack, transmitter high Z jack.

The FV-101 permits split frequency operation and control from either the FT-101 or FTDX401.

The FT-101 exciter covers 160, 80, 40, 20, 15, (CB), and 10 meters and comes complete with microphone cable and plug, fused DC power cable and plug. AC cable with plugs and all necessary plugs are furnished. AC and DC supplies are internal.

The FL-2100 linear amplifier needs only 3 wire cable and coax cable. Connectors are furnished.

FTDX401 $599.00
TRANSCVR 560W PEP

FV401 $99.00
EXTERNAL VFO
80M THROUGH 10M

FL2000B $399.00
LINEAR AMP
1200W PEP

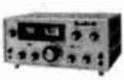
FRDX400 $299.00
RECEIVER
160M THROUGH 10M

FTdx401 features high power, super sensitivity and sharp selectivity. The FTdx401 includes: AC power supply, noise blanker, 100 KC and 25 KC calibrators. VOX break-in, phone patch terminal, cooling fan. Covers 3.5 through 10 MHz plus WWV. 560 watts PEP. All that is required to get on the air is a microphone and speaker.

The FV-401 permits split frequency operation for the DX chaser or net operator. Covers 80 through 10 meters.

FL 2000 B 1200 watts PEP, 1000 watts CW, 600 watts AM. Drive power required 100 watts. Has two cooling fans and uses two 572 B tubes.

FLDX400 $399.00
EXCITER
80M THROUGH 10M



FL2000B $399.00
LINEAR AMP
1200W PEP

SP401-P $59.00
SP401 19.00
SPEAKER/PATCH

FP-2
AC POWER SUPPLY

FRdx400 includes 2 mechanical filters plus "T" notch rejection tuning, and clarifier for easy zero set for SSB. Crystal control 1st mixer and tunable 1st I.F. provides stable operation and high spurious rejection. 100 KC and 25 KC calibrators. VFO can be used in transceive operation in conjunction with F series transmitter.

FLdx400 operates SSB, (USB LSB selectable), AM, CW and FSK. Circuitry can be built in for RTTY operation. 240 watts PEP. VOX, PTT, and break-in CW.

FL-2000B grounded grid linear uses a pair of 572 B tubes. Plate meter VSWR monitor, 2 fans, built-in power supply, 80 through 10 meters, 1200 watts PEP with distortion product in excess of 30 DB down.

FT2FB $239.00
144-148MHz
10W HIGH 1W LOW

FT2-AUTO $379.00
144-148MHz

FP-2 AC power supply specifications: Output - 13.5 volts, 2 amps. AC input - 100/117/220/234 volts. Speaker - 5" x 3-1/5". Portable or home base operation can be achieved with the addition of the optional FP-2 power pack. This AC power pack provides regulated DC power for the transceiver and charging voltage for optional leak proof rechargeable colloidal type batteries. In addition, a high fidelity elliptical style speaker is built into the pack.

The FT-2FB opens the door to noise free broadcast quality 2 meter operation, and thanks to the repeater stations throughout the country, the 2 meter band is no longer restricted to line of sight. General coverage 144 to 148 MHz, 12 channels (3 supplied). Push to talk. Receiver .3 amps, transmit 1.7 amps, power source 13.5 volts + 10%. Dimensions 6-3/8" w. x 2-1/2" h. x 10" d., weight 4 lbs. Comes with dynamic microphone, connector plug, DC cord, fuse and mobile mount.

YC355-D $289.00
DIGITAL COUNTER-BUILT IN PRESCALER

Complete with
A.C. Power Cord 6 Ft.
D.C. Power Cord 6 Ft.
Signal Test Lead with
BNC Connector 3 Ft.

The FT-2 auto is a compact base or mobile VHF/FM transceiver, covering 146 to 148 MHz, featuring electronic scanning up to 8 stations between 146-148 MHz with priority channel sampling while locked on another channel. Adjustable tone burst push-button lock on for repeater actuation. The FT-2 auto is self-contained. Two power cables are supplied with the transceiver, including all mounting hardware, cables, connectors, and accessories required for both mobile and base installation, as well as dynamic push to talk microphone. Operates from various AC voltages or 13.5 DC. Dimensions 8-3/4" w. x 4-1/4" h. x 11-5/8" d. Weight 9 lbs.

SPECIFICATIONS

	YC-355D
Frequency range	5Hz to 35MHz (50Hz to 200MHz)
Accuracy	±time base stability + 1 count
Display	5 Digit
Sampling time	1 milli-sec or 1 sec
Display time	0.1 sec 2 sec
Frequency Unit	KHz, MHz
Display	Display tube
Input Voltage	20mV—20Vp-p (0.15V ~ 5Vp-p)

		YC-355D
MAX Input Voltage		60Vp-p, less than 10 sec (5V p-p)
Input Impedance		HIGH: 1 M ohm, Low: 56 ohms
Input Capacity		Less than 20pF
Time base Frequency		1 MHz Crystal controlled
Stability		0.0005% at 25° C 0.0025% at 0° ~ 40° C
Power Requirements	A C	100/110/117/200/220/234V 50/60Hz 18V A
	D C	12 ~ 14.5V 1A

		YC-355D
		220(W)X80(H)X270(D) (8 3/4 W X 3 3/4 H 10 1/2 inches)
Weight		
Tube	Display tube	5
Semi-conductors	Silicon diode	12
	Silicon transistor	9
	FET	1
	IC	26

PRICES SUBJECT TO CHANGE WITHOUT NOTICE

FACTORY SERVICE IS AVAILABLE WHERE WARRANTY HAS EXPIRED. MODIFICATION KIT MK-160 (160M) $16.00 WITH XTAL- PLUS LABOR. MODERNIZATION KIT MIR-1 FOR OLDER MODEL FT101 $40.00 PLUS LABOR. BROCHURES WITH SPECIFICATIONS ARE AVAILABLE AT YOUR DEALERS LISTED BELOW:

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RACOM ELECTRONICS/206-255-6656
Renton, Wash.

WILSON ELECTRONICS/702-457-3596
Pittman, Nev.
ED JUGE ELECTRONICS/817-926-5221
Fort Worth, Tex.
AMATEUR ELECTRONICS SUPPLY/414-442-4200
Milwaukee, Wis.; Cleveland, Ohio

FRECK RADIO & SUPPLY/704-254-9551
Asheville, N.C.
HARRISON RADIO/516-293-7990
Farmingdale, L.I., Valley Stream, L.I., New York City, N.Y.
HAMTRONICS/215-357-1400
Trevose, Pa.
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What has feathers, a lot of class, and loves hams?

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hosted by **SOUTHERN NEVADA AMATEUR RADIO CLUB, INC.** at

FLAMINGO HOTEL CONVENTION CENTER, LAS VEGAS, NEV. 89109 – JANUARY 3-6, 1974

ADVANCE REGISTRATION — $10.50 per person includes:

1. Special room rate of $15.00 plus room tax per night single or double occupancy, effective January 3 through 10, 1974 while 500 rooms last at the Flamingo Hotel.
2. Advance Registration drawing ticket for Saturday.
3. Regular Registration drawing ticket for Saturday.
4. Complimentary cocktail at the Flamingo Hotel.
5. Complimentary KENO ticket at the Flamingo Hotel.
6. Admission to technical seminars, meetings and exhibit area, Friday and Saturday.
7. Ticket for admission to cocktail party hosted by SAROC and HAM RADIO MAGAZINE, Friday.
8. Ladies who register will receive admission ticket for their program on Saturday.
9. Ticket for admission to cocktail party hosted by SAROC and SWAN ELECTRONICS, Saturday.
10. Ticket for Flamingo Hotel Buffet Hunt Breakfast with Champagne, Sunday.
11. Tax and Gratuity on all items 1 through 10 except hotel accommodations.

ADVANCE REGISTRATION with midnight show — $17.50 per person:

Includes all items 1 through 11, plus Flamingo Hotel Midnight Show and two drinks, Sandler and Young are scheduled in the Flamingo Hotel Main Show Room.

ADVANCE REGISTRATION with dinner show — $21.50 per person:

Includes all items 1 through 11, plus Flamingo Hotel Dinner Show (Entree: Brisket of Beef) no cocktails, Sandler and Young are scheduled in the main show room.

Advance registration must be received in SAROC, P. O. Box 73, Boulder City, NV 89005 on or before December 15, 1973. Refunds will be made if request in writing received in P. O. Box 73 on or before January 3, 1974.

SEVENTH NATIONAL FM conference Friday and Saturday, FM Hospitality Room 16/76, 28/88 and 34/94 repeaters. WCARS-7255 and WPSS 3952 special events stations to assist mobile operators.

Mail accommodations request to Flamingo Hotel, Las Vega, Nevada 89109 — Do it now!

Mail Advance Registration fee to, SAROC, P. O. Box 73, Boulder City, NV 89005 — Before December 15

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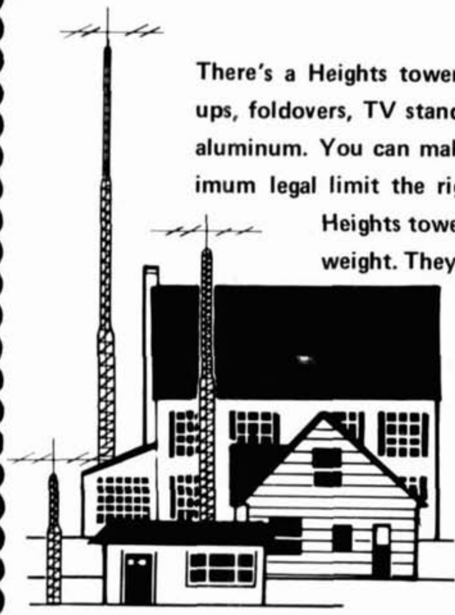
WE WILL PUT YOU AT ANY *HEIGHT* YOU NEED REGARDLESS OF WHAT THAT *HEIGHT* MIGHT BE!



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BROADBAND AMPLIFIERS, for amateur, MATV, CATV and commercial use

We offer a quality line of low noise, low IMD amplifiers covering the region from 2 MHz to 1.5 gHz. For communication use, simple filters at the input will yield coverage of the bands of your choice. Where remote location is necessary to offset line losses, coax powered versions are available with adapters or power supplies.

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Please write for information on our other products including RF Multimeters, VSWR Bridges, Detectors, L-C, Crystal and Tunable Active Peak-N-Notch Filters.

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Opto Electronics

LED GaAs INDICATORS

- ☐ 2-MV1*, Amber, visible jumbo epoxy lens upright $1.00
- ☐ 1-MV2*, TO-18, Dome, green, visible 1.19
- ☐ 3-MV3*, visible, "coax pin pak", red, mini dome lens 1.00
- ☐ 1-MV4*, stud, high power, red, 2-watts 3.95
- ☐ 1-MV4H*, stud, high power, hi-dome, red, 2-watts 3.95
- ☐ 3-MV10B, visible, red, clear, dome lens, TO-18 ..... 1.00
- ☐ 3-MV10C visible, red, diffused, dome lens, TO-18 ..... 1.00
- ☐ 3-MV50*, axial leads micro-mini dome, clear, red 1.00
- ☐ 3-MV5012*, visible, red, small dome lens 1.00
- ☐ 2-MV5022*, jumbo red dome, TO-18, visible 1.00
- ☐ 2-MV5020*, jumbo clear dome, TO-18, visible, red 1.00
- ☐ 1-MV5040*, 4-LED red array, with 5-lead pak 1.49
- ☐ 3-MV5054*, visible, red, jumbo dome lens, upright 1.00
- ☐ 2-MV5080*, TO-18, micro-mini, clear dome, red 1.00
- ☐ 4-MV5082, visible, red, clear flat lens, TO-18 ..... 1.00
- ☐ 1-MV5222*, jumbo dome, green, panel snap-in 1.98
- ☐ 1-MV5322*, jumbo dome, GaAsp, panel snap-in Yellow 1.98
- ☐ 1-MV9000*, cartridge panel lamp, sealed, red, clear lens 1.49
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- ☐ 1-ME-1*, infra-red, parabolic lens, pin type 1.19
- ☐ 2-ME-4*, infra-red, "invisible", TO-18, diff. dome 1.19
- ☐ 2-ME60*, infra-red, "invisible", axial, micro-mini 1.00

OPTO-COUPLERS *Monsanto Equivalent

- ☐ MCA2-30* 1500V Photo Darlington Relay $1.00
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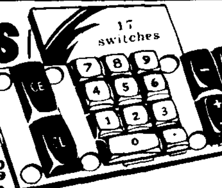
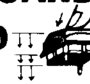
- ☐ MCD2* 1500V Isolation Photo Diode 1.00
- ☐ MCT1* 4000V Isolation Photo Transistor 4.95
- ☐ MCT2* 1500V Isolation Photo Transistor 1.00
- ☐ MCT2-D* 1500V Isolation Twin Photo Transistor 1.98
- ☐ MCT5-10* 10,000V Isolation Photo Transistor 4.95
- ☐ MCT5-25* 25,000V Isolation Photo Transistor 5.95

CALCULATOR KEYBOARD



☐ **$12.50**



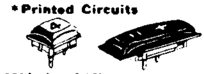
3 for $30

☐ Etched calculator board with holes, as above, less switches ..... $2.50 Board

Properly etched, drilled, "MULTIPLEXED," with proper diodes. Ready to go! Used with our own CAL TECH's 5001 chip advertised at $ 9.95 or equal to Cal Tech or Mostek chip. Keyboard uses the new manufactured by OAK, printed-circuit low-profile FEATHER TOUCH switches. 0-to-9 in white with black letters. Decimal white with black dot. CE, CL and the 4 function switches are in blue with white characters. Designed by top maker. Size: 6½ x 4½ x ½". All etched connections link to take a 12-pin edge connector.

OAK FEATHER-TOUCH SWITCHES

*For RTTY *For Unique Panel Switches
*Printed Circuits



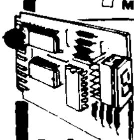
Mfd. by OAK (Ham's note, RTTY, too) data systems, same as used in Keyboard Calculator. SPST. Normally Open, 24V 1 amp contacts. Characters and letters easily changed. 3/8" high. Printed circuit.

No.	Sale	No.	Sale
☐ 0*	$.69	☐ 8*	.49
☐ 1*	.49	☐ 9*	.49
☐ 2*	.49	☐ CE†	.69
☐ 3*	.49	☐ CL†	.69
☐ 4*	.49	☐ −†	.69
☐ 5*	.49	☐ + =†	.69
☐ 6*	.49	☐ ÷†	.69
☐ 7*	.49	☐ ×†	.69
		☐ •*	.49

*White top, black numbers.
†Blue top, white characters.

☐ Kit of 17 above switches for keyboard $9.

LED MITY DIGITS "DCM'S"



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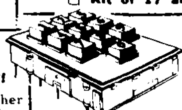
Digital Counting Modules ☐ **9.99**

INCLUDES P.C. EDGE CONNECTOR — FREE!

Kit includes: 3 x 2" printed ckt board, with fingers too! Side-mounting socket, MAN-4 resistors, 7448, 7475, 7490, booklet.

Will outperform any other DCM on the market today, not gaseous, not incandescent, but a device that will READ almost for life. MAN-4, Monsanto equal.

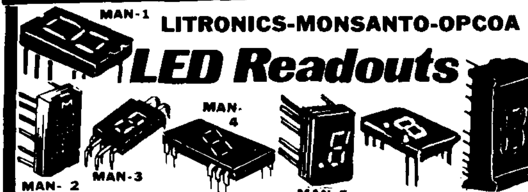
GENERAL TELEPHONE DATA ENTRY KEYBOARD



Only **$8.88** ☐

Used in calculators, touch-tone, encoding, programming devices. 10 PUSH BUTTONS (0 to 9) & 2 uncommitted. All switches have 2 separate poles & 6 separate busses — totalling 6 busses & 24 poles. . . . Any combination of which can be used! Size: 3x2½x1".

LITRONICS-MONSANTO-OPCOA LED Readouts



All fit 14-pin IC sockets, 5V 10 to 20 mils, 0-to-9 numerals, plus letters & decimal. With spec sheets.

*Monsanto Equal.
**MAN-1 Specs.
†35-Diode Array.

Type	Character Size:	Color Display:	Decimal	Driver	Each	Special
☐ MAN-1*	.27	Red	Yes	SN7447	4.50	3 for $12.
☐ MAN-2*	.32†	Red	Yes	2513	8.88	3 for $24.
☐ MAN-3*	.115	Red	Yes	SN7448	2.25	3 for $6.
☐ MAN-3*	.115	Red	No	SN7448	1.49	3 for $3.
☐ MAN-4*	.190	Red	Yes	SN7448	2.95	3 for $8.
☐ MAN-4*	.190	Red	No	SN7448	1.79	3 for $5.
☐ MAN-5*	.27	Green	Yes	SN7447	8.88	3 for $24.
☐ MAN-8*	.27	Yellow	Yes	SN7447	8.88	3 for $24.
☐ LITRONICS 707** (MAN-1)	.33	Red	Yes	SN7447	3.50	3 for $9.
☐ OPCOA** SLA-7 (MAN-1)	.33	Red	Yes	SN7447	3.50	3 for $9.
☐ OPCOA** SLA-7 (MAN-1)	.33	Red	No	SN7447	1.95	3 for $5.

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- ☐ 5-MAN-3* "The claw", some segments missing, hobby use. $1.00
- ☐ 1-MAN-*4 some segments missing, hobby use, readout 1.00
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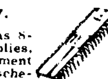
- ☐ 1-SLA-7 Opcoa's MAN-1, hobby, some segments missing 1.00
- ☐ 10-LED HOBBY SURPRIZE! asst. types, no-test 1.00
- ☐ 5-MONSANTO's Opto Coupler surprise, asst. no-test 1.00
- ☐ 3-PC. KIT, MAN-1, MAN-3, MAN-4, some segments missing 1.49

12-DIGIT 'CALCULATOR CHIP'

☐ CT5001 **$9.95** ☐ 3 for $27.

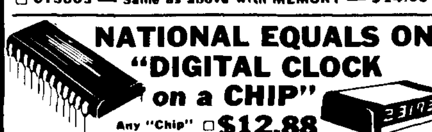


Similar to Mostek 5001. Outperforms Texas 8-digit TMS1802. A 40-pin DIP. Adds, multiplies, subtracts, and divides. Use with 7-segment readouts, Nixies, and LED's. We include schematics, instructions to build calculator. $9.95

☐ CT5002 — Same as above Operates on 9V battery

☐ CT5005 — Same as above with MEMORY — $14.95

NATIONAL EQUALS ON "DIGITAL CLOCK on a CHIP"



Any "Chip" ☐ **$12.88**

Mfrs #	Description	Sale
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☐ 5312	24-pin, ceramic, any readout, 4-digits: C-D	$12.88
☐ 5313	28-pin, ceramic, any readout, 6-digits: A-C	$12.88
☐ 5314	24-pin, plastic, LED and incandescent readouts, 6-digits: A-B	$12.88

*With Spec Sheet

Code: A—Hold Count. C—1 PPS Output.
B—Output Strobe. D—BCD

*Money Back Guarantee!

☐ **2.95**

☐ 6-DIGIT MAN-3A MUX'D PC BOARD

Clock DCMs, VTVM, DVM, calculators, multiplexed.

☐ 6-MAN-3A's for above board. $9.50.

STUD 'TRIACS'

PRV	15 amp	25 amp
50	☐ $.65	☐ $.85
100	☐ .85	☐ 1.05
200	☐ 1.25	☐ 1.45
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☐ 115 VAC 3PDT $2.98
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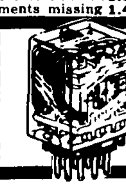

Excellent for "HAM" use as antenna switching, latching, transmit, receive, etc., and 100's of commercial or industrial uses. Includes plastic dust-cover with diagram and hookup info, 11-pin plug-in base. Contacts movable gold flashed silver, stationary overlay, with silver cadmium oxide movables. All contacts 10 amp 3PDT. Coil data, 115VAC 2250 ohms, 17.5 ma. 12 VDC 21 ma. 168 ohms. Size: 2¼" x 1 5/16". Wt. 4 ozs. Center pin missing. Comar Mfg. type equal too.

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☐ 15¢ CATALOG on Fiber Optics, 'ICs', Semi's, Parts

POLY PAKS

P.O. BOX 942H LYNNFIELD, MASS. 01940

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A COMPLETELY PORTABLE FREQUENCY COUNTER WITH . . .

* 10 HZ to 65 MHZ range
* Full six digit readout (L.E.D.)
* Sensitive front end (LESS THAN 10 MV.)
* Only $199

FEATURES

- High capacity rechargeable Ni Cd batteries
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- "Battery save" switch for spot checks
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Mail orders directly to:
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Midwest City, Okla. 73110

Model C-65 Freq. counter	$199.00
Battery charger	8.00
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Two stage preamps use KMC Bipolar and Mosfet Transistors. 20db gain, 20 MHz bandwidth. These are high quality preamps suitable for the most demanding applications. AC models have die cast case, others have metal enclosure.

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VHF DX OPS

MODEL 60 SPEECH PROCESSOR — QRO the average-to-peak ratio of the speech waveform as much as 8 db. using a logarithmic principle. Operates with FM, SSB and AM transmitters and transceivers. Low/High impedance Mic input. Two 9Vdc batteries provide a self-contained unit.

Model 60W	(Processor Assembled)	$26.50
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QRG ?

MODEL 20 DIGITAL DIAL — Available for Collins and Drake gear. Optional four digit readout and crystal time base. QSY your fixed or mobile transmitter, receiver or transceiver with 100 Hz accuracy and no last digit jitter. Simple one wire connects dial to rig and you're ready to go. **Specify your type of rig.**

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MODEL 11A PADDLE — Designed with reliability in mind. No mechanical switches or bearings to fail. Paddle contact spacing adjusts easily.

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SOFT TOUCH

A smooth rhythmic feel — a slight but definite "break" — these are among the highly desirable features that make the operation of a Ten-Tec keyer a delightful experience. The KR40 and KR20 paddle suspensions employ magnetic forces to achieve the unique "soft touch" that means smoother, more articulate and relaxing QSOs for you.

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Single paddle straight keyer. Self-completing characters. Pre-set weighting, alterable. Excellent "feel". For 6 or 12 volts, DC.
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Dual paddle straight keyer. Self-completing characters. Two position weight switch and monitor oscillator. AC operation.
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KR40
Top-of-the-line Squeeze keyer. Iambic sequence. Full dit and dah memories, weight control and monitor oscillator. AC operation.
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INCORPORATED
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ON LINE SWR & POWER METERS

PRICE — $29.95

FREQUENCY RANGE: 3 - 150 MHz
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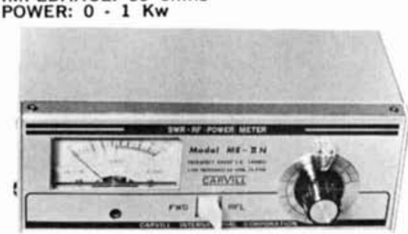
POWER: 0 - 1 Kw



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FREQUENCY RANGE: 3.5 - 150 MHz
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MFA-22 DUAL VERSION
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- **Transmit and Receive Operation:** All units have both **Simplex** and **Repeater Modes**
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- 1-2 WATTS IN 15 WATTS PLUS OUT
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- 12-14 VOLTS NEGATIVE GROUND
- LESS THAN 1dB LOSS ON RECEIVE

PA-1501 H

Wired and Tested

$49.95 **$39.95** *complete kit*

NEW — 10 CHANNEL SCANNER **$14.95**
works on any receiver — less crystal deck

NEW — 10 CHANNEL CRYSTAL DECK **$ 6.95**
with diode switching

NEW — COR **$19.95**
with 3 min, 3 sec timer

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with crystal filter

Also available:

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- RX 144/220 C w/Crystal filter $69.95
- TX-144 .... 1 Watt Exciter $29.95
- TX-220 .... 1 Watt Exciter $29.95
- PA 144/220 15 Watt Amp less cabinet connectors & switching $29.95
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Add $1.00 shipping per kit ordered. New York Residents add sales tax.

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flea market

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COPY No special layout or arrangements available. Material should be typewritten or clearly printed and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** can not check out each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue. Deadline is 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

WANTED: tubes, transistors, equipment, what have you? Bernard Goldstein, W2MNP, Box 257, Canal Station, New York, N. Y. 10013.

AIR FORCE MARS will hold its first annual Eastern Division Conference on September 7th, 8th, and 9th in the Washington, D. C. area. The conference will be held in the Quality Inn in Pentagon City, Virginia and will have representatives from every state from Maine to Florida. The highlights of the conference will be the banquet and awards presentation at 8:00 P.M. on Saturday, September 8th. The guest speaker will be Senator Barry Goldwater, AFA7UGA. A number of other notable persons associated with Air Force MARS are expected to attend.

PERSONAL TO MAX: All is forgiven! Meet me at the Memphis Hamfest on October 7th and we'll start over. Alice

WANTED: FV400S VFO for Yaesu FTDX560. Mint or good used condition. Also FL2000B or FL2100 Linear. Write Jerry, W6JIZ, 1020 So. Highland, Los Angeles, Calif. 90019.

RESISTORS: Carbon composition brand new. All standard values stocked. ½W 10% 40/$1.00; ¼W 10% 30/$1.00 — 10 resistors per value, please. Minimum order $5.00. 15W RMS 1C Audio Amplifier — Panasonic. Frequency response 20Hz-100 kHz. ½% distortion. Price $6.95 Postpaid. Pace Electronic Products, Box 161-H, Ontario Center, New York 14520.

TONE-LOGIC Educational Systems for WWV, SSTV, RTTY. Eight 2¼″ x 3″ PCB's, plans, $3. Hornung, Box 24614, San Jose, CA. 95154.

SIGNAL ONE OWNERS, expert and prompt service by ex-Signal/One engineer. Write or call for details. Larry Pace, K2IXP/7, 1071 W. Roller Coaster, Tucson, AZ. 85704 (602-888-5234).

WANTED: NOV. '68 Issue Ham Radio. Contact Steve, P. O. Box 253, Deerfield, Ill. 60015.

EMBROIDERED EMBLEMS AND PATCHES. Custom made from your design. 10 to 1000's. Write Russell, 1109 Turner St., Augusta, Maine 04210.

WORLD QSL — See ad page 106.

THE SOUTHERN COUNTIES AMATEUR RADIO Association (SCARA) plans to operate a special event station at the Miss America Pageant in Atlantic City, New Jersey. The call will be WP2MAP since Atlantic City considers itself the World's Playground. Operation will be from August 26 until September 9, 1973, in the Pageant Headquarters, Atlantic City. Operation will be on 80 through 10 meters: CW frequencies will be 30 kHz inside the band edge, SSB frequencies will be 10 kHz inside the general class portion of the phone band, when possible. A special QSL will again be issued. K2JOX will handle the QSL requests; an SASE would be appreciated.

FOR YOUR FUTURE ROBYN RADIOS send your order to, Two Way Radio Sales, 1501 Monroe Street, Bogalusa, La. 70427 or 202 Farrell Street, Picayune, Miss. 39466.

GOING QRP? British Joystick/Joymatch antenna systems available from stock. American plugs. Tunes any band 10 to 160. Used worldwide. $59.00. Gilfer Associates, Box 239, Park Ridge, N.J. 07656.

HEATHKIT APACHE $85, Mohawk & spkr $115, the pair $175. Fine shape with manuals. No shipping. K1GAW, 484 Main St., Portland, Ct. 06480.

MEMPHIS AREA HAMFEST, Sunday, October 7, at State Technical Institute, conveniently located at Interstate 40 and Exit 11. Tennessee Section ARRL Convention in conjunction. ARRL forum, MARS meetings, prizes, Flea Market, XYL entertainment. Informal group dinners Saturday night. Talk-in on 34-94 and 3980. **All your friends will be there!**

FOR SALE: DRAKE R4B with ten crystals, T4XB, AC4, MS-4.Premium condition $750.00. TC-2 with SC-2 $300.00, TC-6 with SC-6 $275.00, CC-1 converter console with vhf calibrator, a.c. power supply $65.00. All above like factory new, with all manuals and cables. Complete package $1275.00. Jim Gysan, W1VYB, (617) 922-3850.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines in assembled or kit forms, plus many other suppression accessories. Free literature. Estes Engineering, 543-H West 184th, Gardena, California 90248.

ANNUAL MELBOURNE HAMFEST will be held September 8th and 9th at the Melbourne Civic Auditorium. Hours 9 a.m. - 4 p.m. Advance registration $1.00, at the door $1.50, 25,000 sq. ft. swap area, parking for 2,000 cars free, 100% air conditioned building. The childrens entertainment will be a full length Walt Disney movie, a fishing derby, novice symposium, radio controlled boats and airplanes, and a left-footed code contest. A buffet style Hamfest Banquet for everyone Saturday, 7 p.m.

FOR SALE: REGENCY HR-2A with preamp and extra xtals. Also Dycomm 500D amplifier. WA2DGN, 159 Fisher Road, Rochester, N. Y. 14624.

CAPE COD'S fabulous Hyannis! N. E. ARRL Convention, September 29 & 30. Flea market, seminars, FM, SSTV, AMSAT, YL trips, 2 pools, golf, beaches, sailing. Early bird registration $3. W1KCO, 572 Berkley Street, Taunton, MA. 02780.

WANT OLD RADIO SHOW TRANSCRIPTION discs. Any size or speed. Send details to, Larry Kiner, W7FIZ, 7554 132nd Ave. N.E., Kirkland, Wa. 98033.

TEKTRONIX OSCILLOSCOPE 535A, with dual trace, triggered and delayed sweep. $585 or best offer. G. Daly, 33 Walnut, Mill Valley, CA. 94109. (415) 383-6642.

"P.C.'S" I can supply boards for any construction article that includes the full size artwork. Many in stock. Write: D. L. McClaren, W8URX, 19721 Maplewood Avenue, Cleveland, Ohio 44135.

TELL YOUR FRIENDS about Ham Radio Magazine.

CW or RTTY, whichever way you go,

HAL HAS TOP QUALITY YOU CAN AFFORD!

TOP QUALITY RTTY...WITH THE HAL MAINLINE ST-6 TU. Only 7 HAL circuit boards (drilled G10 glass) for all features, plug-in IC sockets, and custom Thordarson transformer for both supplies, 115/230 V, 50-60 Hz. Kit without cabinet, only $135.00; screened, punched cabinet with pre-drilled connector rails, $35.00; boards and complete manual, $19.50; wired and tested units, only $280.00 (with AK-1, $320.00).*

TOP QUALITY...WITH THE HAL 1550 ELECTRONIC KEYER. Designed for easy operation; perfectly timed CW with optional automatic ID for sending call letters, great for DX and RTTY; TTL circuitry, transistor switching for grid block, cathode keying. Handsome rugged crackle cabinet with brushed aluminum panel. With ID, only $90.00; without ID, $65.00.*

OTHER HAL PRODUCTS INCLUDE:

ID-1 Repeater Identifier (wired circuit board)	$ 75.00*
ID-1 (completely assembled in 1½" rack cabinet)	$115.00*
HAL ARRL FM Transmitter Kit	$ 50.00*
W3FFG SSTV Converter Kit	$ 55.00*
Mainline ST-5 TU Kit	$ 50.00*
Mainline AK-1 AFSK Kit	$ 27.50*

TOP QUALITY... WITH THE HAL MKB-1 MORSE KEYBOARD. As easy as typing a letter—you get automatic CW with variable speed and weight, internal audio oscillator with volume and tone controls, internal speaker, and audio output jack. Smooth operation; completely solid-state, TTL circuitry using G10 glass boards, regulated power supplies, and high voltage transistor switch. Optional automatic ID available. Assembled MKB-1, $275.00. In kit form, $175.00. *

NEW FROM HAL—TOP QUALITY RVD-1002 RTTY VIDEO DISPLAY UNIT. Revolutionary approach to amateur RTTY . . . provides visual display of received RTTY signal from any TU, at four speeds (60, 66, 75, and 100 WPM), using a TV receiver modified for video monitoring. Panasonic solid-state TV receiver/monitor, or monitor only, available. RVD-1002, $525.00; Panasonic TV receiver/monitor, $160.00; monitor only, $140.00.*

TOP QUALITY...WITH THE HAL RKB-1 TTY KEYBOARD. Gives you typewriter-easy operation with automatic letter/number shift at four speeds (60, 66, 75, and 100 WPM). Use with RVD-1002 video display system, or insert in loop of any teleprinter, for fast and easy RTTY. Completely solid state, TTL circuitry using G10 glass boards, regulated power supplies, and transistor loop switch.
RKB-1 assembled, only $275.00.*

HAL provides a complete line of components, semi-conductors, and IC's to fill practically any construction need. Send 24¢ to cover postage for catalog with info and photos on all HAL products available.

*Above prices do not include shipping costs. Please add 75¢ on parts orders, $2.00 on larger kits. Shipping via UPS whenever possible; therefore, street address required.

HAL COMMUNICATIONS CORP., Box 365 H, Urbana, Illinois 61801

More Details? CHECK—OFF Page 110

+−×÷ **CALCULATOR OWNERS:** Compute SQUARE ROOTS, trigonometric functions, logarithms, exponentials, and more! Quickly, accurately, easily! Manual $2.00. Send today — Unconditional money-back guarantee! Mallman Optics and Electronics, Dept.-B, 836 South 113, West Allis, Wisconsin 53214.

CINCINNATI HAMFEST: The 36th Annual Hamfest *will be held Sunday, September 16, 1973 at the* ALL NEW Stricker's Grove on State Route 128, one mile west of Ross (Venice), Ohio. Check local area map for location. Lots of food, flea market, contests, and model aircraft flying. $7.00 covers everything. For further information, contact: Jim Wellman, W8HSI, 725 Stout Avenue, Wyoming, Ohio 45215.

DX'ERS — Dig them out of the mud. Low noise Dual Gate MOSFET preamplifier. Nominal 20 dB gain. 10-30 MHz. In cabinet. DC-100, $39.95. Dynacomm, 1183 Wall Road, Webster, N. Y. 14580.

TELETYPEWRITERS — Kleinschmidt — portable, fixed, sets, punches, parts, reconditioned, reasonable. Mark/Space Systems, 3563 Conquista, Long Beach, Calif. 90808. 213-429-5821.

THE NORTHWEST GEORGIA *Amateur Radio Club* and Repeater Association, is having its annual hamfest on Sunday, October 7, 1973 at the Coosa Valley Fair Grounds in Rome, Georgia. Everyone is invited to attend. Gates open at 9:00 a.m.

PRINTED CIRCUIT DRILL BITS. Trumbull, 833 Balra Drive, El Cerrito, California 94530.

WE BUY ELECTRON TUBES, diodes, transistors, integrated circuits, Semiconductors. Astral Electronics, 150 Miller Street, Elizabeth, New Jersey 07207, (201) 354-2420.

WESTERN UNION DESK-FAX Telefax Transceivers: Several extra machines (checked out), $14 each, shipping collect. Bill Johnston, 1808 Pomona Drive, Las Cruces, New Mexico 88001.

QSL'S — BROWNIE W3CJI — 3111B Lehigh, Allentown, Pa. 18103. Samples 10¢. Cut catalogue 25¢.

WANTED — 40 ft. E-Z Way Crank down tilt over tower, prefer Long Island. Daniel J. Meade, 7 Brookhaven Drive, Rocky Point, N. Y. 11778.

USED MYLAR TAPES — 1800 foot. Ten for $8.50 postpaid. Fremerman, 4041 Central, Kansas City, Mo. 64111.

TECH MANUALS *for Govt. surplus: $6.50 each* — R-389/URR, R-390/URR, URM-25D, RCK, R-220/URR, TS-382D/U, URM-32, TT-63A/FGC, CV-591A/URR, TS-497B/URR, USM-25A. Hundreds more. Send 50¢ (coin) for large list. W3IHD, 7218 Roanne Drive, Washington, D. C. 20021.

CANADA'S MOST UNUSUAL Surplus and Parts Catalog. Jam packed with bargains and unusual items. Send $1. ETCO-HR, Box 741, Montreal, Canada.

"DON AND BOB" NEW GUARANTEED BUYS. Discount prices plus full warranty. SBE144 2MFM (259.95 list) 199.95; SBE 450 TRC converts 2MFM to 3/4M. T & R (179.95 list) 149.95; Triex MW50 tower 250.75; MW65 331.50; W51 386. FOB Cal.; W67 (983.50L) 834.50 FOB Cal.; Ham-M 99.00; TR44 59.95; AR22R 31.95; Belden 8-wire rotor cable #8448 10¢/ft; Mosley CL36 149.00; CL33 124.00; TA33 114.00; MCQ3B 91.00; S402 143.00; MP33 90.00; Hygain TH6DXX 139.00; 204BA 129.00; Belden 8214 RG8 foam 17¢/ft; Motorola HEP 170 epoxy diode 2.5A/1000PIV 29¢ ea., 25.00/100; Calrad KW SWR-relative power dualmeter bridge 15.95; write specific needs new panel meters, stock; quote discontinued tubes; Radio Masters 1972 3.50; Motorola Semi-conductor data book series 7.50; quote Clegg FM27B; Genave GTX2; Regency HR212; Midland 13500; Standard 826MA; 146A; hardbound technical magazines, many types *from petrochemical library 3.00/yr; Amphenol* PL259 49¢; used: Collins 75A4 345.00; Kenwood T599 350.00; R599 300.00; shipping charges collect. Madison Electronics, 1508 McKinney, Houston, Texas 77002, 713-224-2668.

L. I. Electronic Supermart

(Off the wall self service)

New P.C. Boards — G10, 1 oz. - 1 side copper-fiber glass
6″ x 6″, 80¢ ea. — 6 x 12, $1.50 ea. - 12 x 12, $2.85 ea.
New P.C. Boards — G10, 1 oz. - 2 side copper-fiber glass
6″ x 6″, $1.10 ea. - 6 x 12, $2.00 ea. - 12 x 12, $3.75 ea.
New P.C. Boards — G10, Fiber glass punch:
F Pattern 4.5 x 6.5, .062 holes, 5 per 1″ $1.30
P Pattern 4.5 x 6.5, .042 holes, 10 per 1″ $1.35
G Pattern, 4.5 x 6.5, .062 holes, $1.30
Pkg. 10 Bircher P.C. Board, metal 2″ slides $1.00
Package of 50 flea clips for above punched Boards, .062 .... 75¢
30 ¼ or ½ W resistors, packaged 5 per value your choice of values $1.00
25-1W resistors, packaged 5 per value, your choice of values $1.00
15-2W resistors, packaged 5 per value, your choice of values $1.00
5 ¼ or ½ W, 1% resistors, packaged 5 per value, your choice of values .... .50
5 ceramic disk caps, .001-01, packaged 5 per value, your choice of values .... .50
5 mica dip caps, 1 pf-150 pf, packaged 5 per value, your choice of values .... .50
5 mica dip caps, 180 pf-820 pf, packaged 5 per value, your choice of values .... .75
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Wire Kit # 22 stranded PVC, 6 spools, 6 colors, 50′ ea. spool $3.50
Wire Kit #24 Solid PVC, 6 spools, 6 colors, 50′ ea. spool $3.50
Wire Kit #24 stranded PVC, 6 spools, 6 colors, 50′ ea. spool $3.50
10′ — Ten cond. ribbon wire, color coded, #22 or #24, stranded $1.50
C & K #7101 mini switch, SPDT on-on $1.05
C & K #7103 mini switch, SPDT on-off-on $1.20
C & K #7201 mini switch, DPDT on-on $1.35
C & K #7203 mini switch, DPDT on-off-on $1.55
Alco 105D MST momentary on-off-momentary on $1.25
Central Lab DPDT push momentary. SPEC. 4/$1.00
Connectors, PL259, $.45; PL258, $.70; 175U or 176U, $.20 ea.; UG 88 cu., $.50; UG 201 a/u (N to BNC adapter), $.75; RCA to UHF, $.90.
Encapsulated chokes 1uh to 5 Mh, choice 3/$1.00
Varo type mini bridge rectifiers, approx. ⅝″ sq. size: 2 amp. - 50 v., $1.25; 4 amp. - 50 v., $1.25; 6 amp. - 50 v., $1.25; 2 amp. - 100 v., $1.25; 4 amp. - 100 v., $1.25; 6 amp. - 100 v., $1.25; 2 amp. - 200 v., $1.50; 4 amp. - 200 v., $1.50; 6 amp. - 200 v., $1.50; 2 amp. - 400 v., $1.50; 4 amp. - 400 v., $1.50; 6 amp. - 400 v., $1.50
Triacs — thermo tab package — 1 amp. - 400 v., $.80 ea.; 3 amp. - 400 v., $1.40 ea.; 4 amp. - 200 v., $1.20 ea.; 6 amp. - 200 v., $1.40 ea.; 6 amp. - 400 v., $1.60 ea.; 6 amp. - 500 v., $1.80 ea.; 8 amp. - 200 v., $1.60 ea.; 8 amp. - 500 v., $1.80 ea.
To-5 case, 1 amp. - 200 v., $.70 ea.; 1 amp. - 400 v., $1.00 ea.
SCR 200 v. - 8 amp. thermo tab .... $.80 ea.

SEND SELF ADDRESSED ENVELOPE FOR FREE MAILER. INCLUDES MANY HUNDREDS OF ITEMS NOT LISTED ABOVE.

Send check or money order - include 60¢ to cover parcel post and handling. UPS shipping available. Minimum order $4.50.

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50′ SPOOL 600 V. #22 PVC WIRE

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THE ADRIAN AMATEUR RADIO CLUB INC. presents their fall Hamfest, Sunday, October 14, 1973 from 8 a.m. to 3 p.m.. The location is at the Lenawee County Fairgrounds, Dean St. in Adrian, Mich. The talk in frequencies to be monitored are 1812 kHz, 3935 kHz, 52.525 MHz, 146.46 MHz, 146.52 MHz and 146.94 MHz. All buyers, sellers, and visitors are welcome, plenty of refreshments and prizes. Cost $1.00 in advance, $1.50 at the gate. Tables $1.50 per half table. Normal table size 8 ft. long. Table tickets prepaid will be held until 10:00 a.m. then resold. Information on tickets or tables, send to Adrian Amateur Radio Club, P. O. Box 26, Adrian, Mich. 49221, or see any member.

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PACK RAT HAMARAMA, The Mount Airy V.H.F. Radio Club, Inc. presents the annual Pack Rat Hamarama, Sunday, October 7, 1973, at the Warwick Fire Co., Jamison, Pa. located on Rt. 263 north of Philadelphia, Pa. Activities include a giant flea market, auction, and an amateur television demonstration. Festivities begin at 10:00 a.m., auction at 3:00 p.m. Food concession on premises. Registration is $1.00, flea market tables or tailgate sales, $2.00. Talk-in on 146.52 and 52.525. For further information contact W3ZD, 520 Centennial Rd., Warminster, Pa. 18974.

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THE PUGET SOUND COUNCIL of Amateur Radio Clubs will issue a certificate signed by Governor Evans for contacts made during Washington State Amateur Radio Week, September 8th to 16th, 1973. Out of state hams must contact 10 Washington hams, and in state hams must contact 20 other Washington hams during this period. Send list of stations contacted, their locations, dates of contact, your name, call, address, and a self-addressed stamped legal size envelope to: The Puget Sound Council of Amateur Radio Clubs, 12306 80th Ave. East, Puyallup, Washington 98371.

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SEPTEMBER 9, 1973 the Wichita Amateur Radio Club will have its annual Hamfest at the Sedgwick County 4-H building on the N.W. corner of West St. and Central Ave. in West Wichita. There will be talk-ins on: 3.920, 7.275, 146.34, 146.94 MHz, MARS, ARRL, and Kansas Net Meetings. Games, free pop, prizes. Starts 10:00 a.m., ends 4:00 p.m. CDT. Admission: $1.75. For information write: Todd Gearheart, 1320 Summitlawn Ct., Wichita, Kansas 67212.

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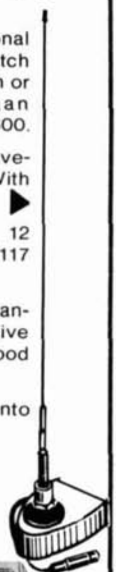

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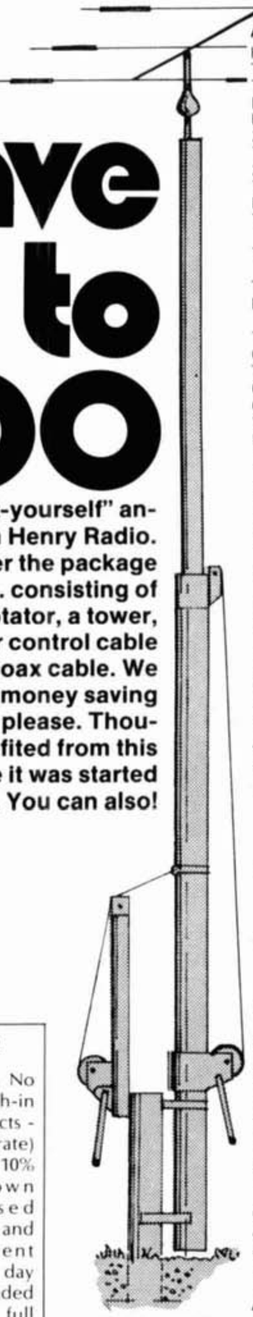

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WILSON	
M510 - 5 element, 10 meter beam	89.95
DB-32 - 3 element-20 meter and 2 element-15 meter beam	118.95
M420 - 4 element, 20 meter beam	151.95
M615 - 6 element, 15 meter beam	139.95*
M240 - 2 element, 40 meter beam	189.95*
DB-65 - 6 element-15 meter and 5 element-20 meter beam	219.95*
DB-54 - 5 element-20 meter and 4 element-15 mete meter beam	244.95*
M620 - 6 element, 20 meter beam	317.00*
DB-52 - 5 element-20 meter and 2 element-40 meter beam	364.00*

ROTATORS

CDR AR-22R Rotator	44.95**
CDR TR-44 Rotator	69.95
CDR Ham-M Rotator	129.95
HyGain 400 Rotator	229.95

TOWERS

TRISTAO	
MM-40 - Mini-mast, 35' crank-up tubular self-supporting tower	174.95
Optional MB-10 free-standing base	46.25
Optional MF-50 raising fixture	57.95
Optional MRB-80 rotor base	98.95
MA-490 - Magna-mast, 49' crank-up tubular self-supporting tower	357.45
Optional MAF-40 raising fixture	104.95
Optional MARB-40 rotor base	225.45
MA-660 - Magna-mast, 66' crank-up tubular self-supporting tower	974.45
Optional MAF-60 raising fixture	119.95
Optional MARB-66 rotor base	419.45
CZ-454-FX - 54' crank-up, free-standing tower with 10 foot mast	464.95
CZ-471-FS - 71' crank-up, free-standing tower with 10 foot mast	869.95
TRIEX	
MW-35 - 35' self-supporting, crank-up tower	173.00
W-51 - 51' free-standing, crank-up tower	454.50
TM-240 - 40' crank-up, sky needle tower	595.00
TM-358 - 58' crank-up, sky needle tower	1050.00
LM-470D - 70' Self-supporting, crank-up tower	1679.00***
TM-370 - 70' Sky needle tower with motor raising and lowering unit	2520.00***

CABLE

4 conductor rotator cable (AR-22 only)	per foot	.07
8 conductor rotator cable	per foot	.18
RG-58A/U Coax	per foot	.06
RG-8/U Coax	per foot	.16

ACCESSORIES

HyGain BN-86 Balun	14.95
Triex TB-2 Thrust Bearing	22.50
Unadilla W2AU Balun	12.95

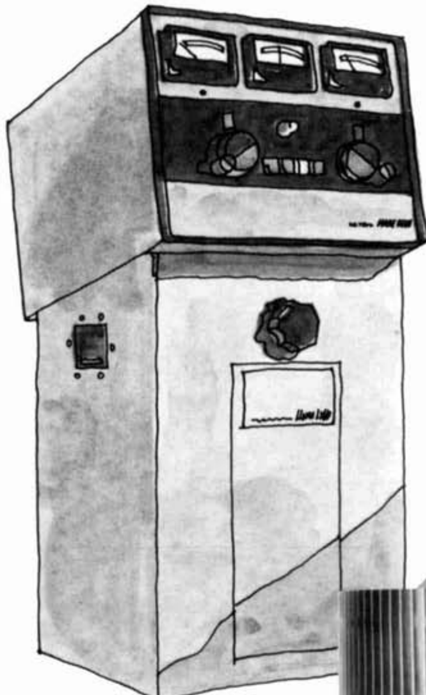
* These antennas are not recommended for use with the MM-40 or the MW-35
** Recommended for use only with the smaller antennas
*** These towers are ideal for stacked antenna arrays

You may specify components not shown on this list

Henry Radio

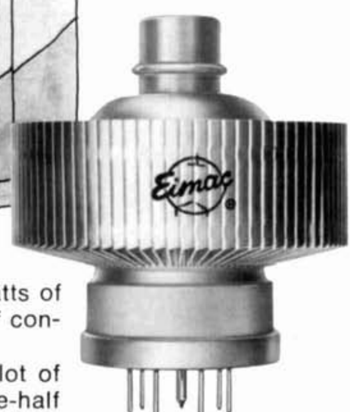
11240 W. Olympic Blvd., Los Angeles, Calif. 90064 213/477-6701
931 N. Euclid, Anaheim, Calif. 92801 714/772-9200
Butler, Missouri 64730 816/679-3127

EIMAC's rugged 8877 powers Henry Radio's reliable 4K Ultra linear commercial amplifier.



When Henry Radio set out to design a sophisticated linear amplifier for high reliability communications in the high frequency range, they chose EIMAC's high-mu 8877 power triode.

The result is the new 4K Ultra, which operates with 4000 watts input in heavy-duty commercial service. The 4K employs continuous variable capacitive and inductive elements tunable over the 3.0 to 30 MHz range. Optimum input and load conditions are provided for a wide variation in antenna systems. EIMAC's 8877 enables the 4K to deliver over 2500 watts of continuous SSB or CW output with only 50 to 75 watts of drive. For RTTY the 4K will provide about 2000 watts of continuous duty output.



The 8877 is a ceramic-metal triode that delivers a lot of power and linearity in a package only three and one-half inches high. At 30 MHz, typical power gain is 15 dB. This impressive gain is achieved with 3rd order intermodulation products −38 dB below one tone of a two equal-tone drive signal.

With Henry Radio, you know quality counts. And they know you can't do better than EIMAC. For full specifications on the 8877, write to EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070. Or contact one of the more than 30 Varian/EIMAC Electron Tube and Device Group Sales Offices throughout the world.

Eimac®
division
varian