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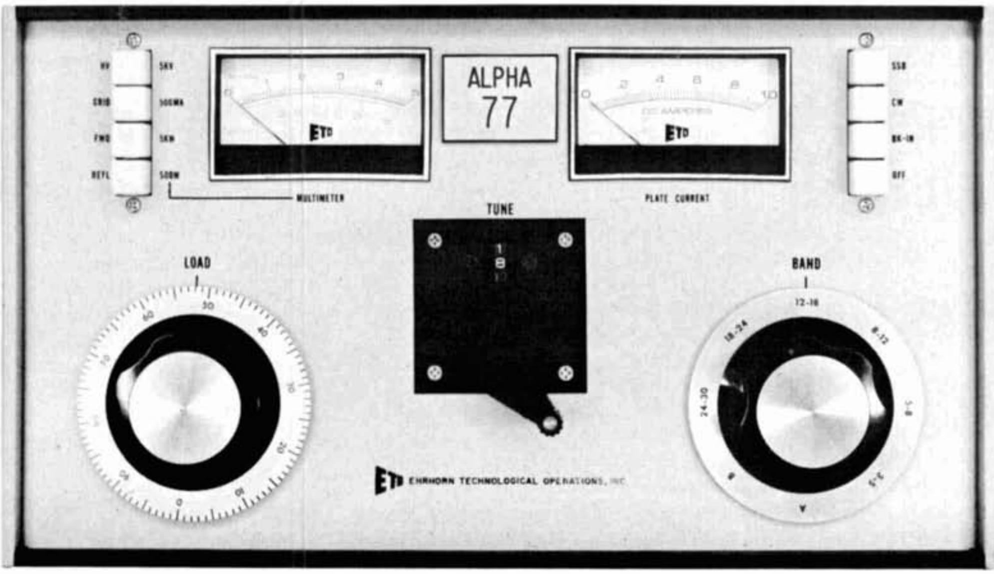

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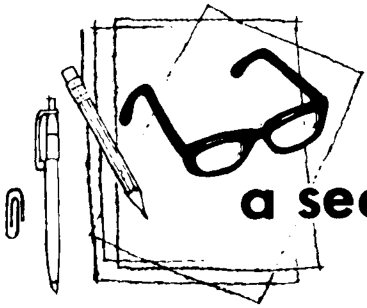

a second look

by jim fisk

Amateur radio operators, especially those on two-meter fm, are using more and more dry batteries than ever before. Zinc-carbon batteries rate very high on the list because they are relatively inexpensive and easy to find, although some amateurs use the more expensive but higher powered alkaline-manganese cell, and a few swear by rechargeable nicads. A new dry battery, which will be on the market in the near future, just might revolutionize the whole field of portable dc power.

The new battery, the lithium organic cell, has been receiving enthusiastic reviews from the military, which depends on man-carried batteries for much of its power. The reason for the enthusiasm is that lithium apparently produces a battery with greater energy density than that of any other existing type. Lithium batteries are lighter, have greater power output, can operate over wide temperature ranges and have a remarkably long shelf life -- up to 20 years.

Several companies are currently manufacturing lithium cells, including Mallory, Eagle-Picher and Power Conversion, Inc. Both Mallory and Power Conversion use lithium with a sulfur dioxide electrolyte; experimental Eagle-Picher lithium batteries are based on lithium and a carbon flourine compound in conjunction wtih an organic electrolyte.

Mallory also has a solid-state lithium battery that uses a metal lithium anode and a metal salt as the cathode. The electrolyte is an electronically insulating solid. Because of the reactive nature of these materials when exposed to the atmosphere, this battery must be hermetically sealed. However, the absence of any liquid in the battery completely eliminates any corrosion or gassing. In fact, these cells have been stored for long periods at more than 200° F with no detectable loss in energy capacity.

One of the big advantages of the new lithium batteries is their very high energy density. Prior to this, the most energetic batteries have been the silver-zinc units used on the manned Apollo program – they provided approximately 110 watt-hours per pound per cell. Some of the new lithium batteries can generate 200 watt-hours per pound per cell, a nearly 85% increase. When compared to carbon/zinc and other commonly used batteries, the energy density of the lithium cell is even more impressive. What this means, basically, is that if you presently use 5 pounds of batteries to power your communications gear, lithium batteries would cut the weight in half, approximately.

As far as power output is concerned, the energy from one lithium D-cell at a discharge rate of 1 ampere is equivalent to four mercury-zinc cells, five alkaline-manganese or 30 carbon-zinc cells! The introductory cost for these new lithium batteries is expected to be quite high, about $9.00 each for D-cells, but that price can be expected to come down as usage and production increase. However, when you consider that one lithium D-cell can provide the same power as 30 carbon-zinc units, the price isn't nearly as astronomical as it first appears. Now, if somebody can figure out a way to recharge them. . .

Jim Fisk, W1DTY
editor

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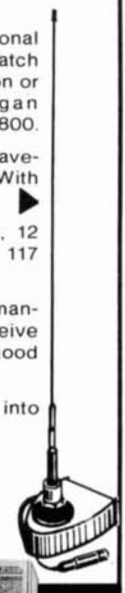

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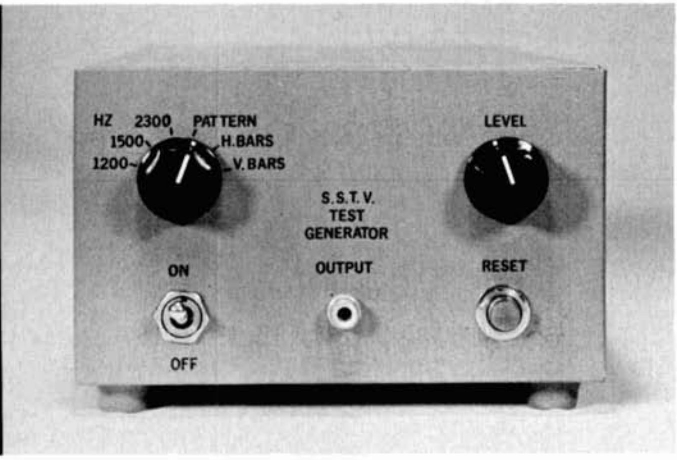


slow-scan tv test generator

Complete construction details for a slow-scan tv pattern generator for troubleshooting sstv equipment

Bert Kelley, K4EEU, 2307 South Clark Avenue, Tampa, Florida 33609

Anyone who builds his own slow-scan television equipment soon learns why so many other operators go the commercial equipment route. It's not so much the circuit complexity or parts procurement problems as it is the difficulty of getting the circuits properly adjusted. Almost all the circuits in the sstv monitor have to be operating correctly before you can see any results on the picture tube, so the monitor itself is useless as a test unit.

Some authors have suggested that a tape recorder and a length of audio tape be used as a test signal during adjustments. However, unless this tape is obtained from a sstv manufacturer, the quality is questionable. The sync and video pulses may be off frequency because it is almost impossible to accurately tune in a sstv signal without a monitor. To add to the difficulty, video quality will vary from station to station, and there is usually interference from nearby stations. Any good transmissions will be short so the tape will have to be rewound again and again during use.

What is needed is a sstv test generator which can deliver a continuous high quality test signal and require no attention. The unit described here can be used to align and test bandpass filters, video discriminators, video amplifiers and sync separators, as well as to check horizontal and vertical sweep linearity and size.

features

If test equipment is to be useful, it should be accurate. The sync and video frequencies in this sstv test generator are inherently accurate because they are derived from sources that do not vary. Digital logic does the rest. The division ratios are set by selection of IC types and the pin-to-pin strapping. There are no multivibrators that have to be locked in with a pot adjustment.

nominal 1200 Hz. This means that the sstv circuits may be adjusted with confidence in your signal source.

test signals

A checkerboard test pattern was chosen as the primary test signal because the deep transitions between peak white and picture black will critically test any sync separator circuits. The 60-Hz square wave "video" is an easily recognized pattern that can be traced through the video circuits of the sstv monitor with any scope.

Since the transitions are sharp and clean, the reproduced picture should have sharp, clean edges and this gives an

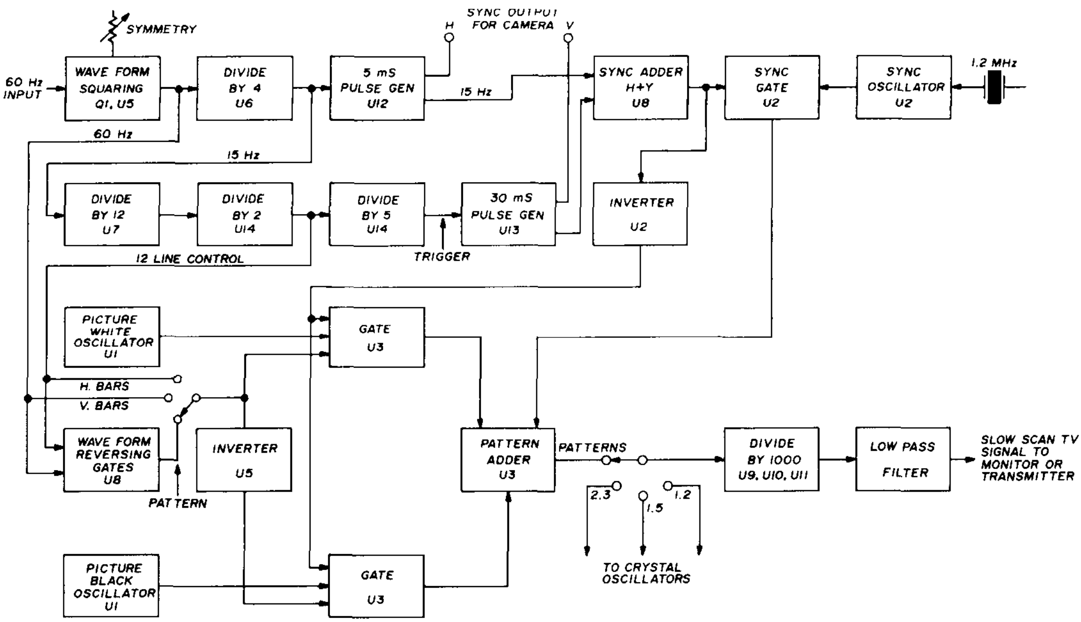


fig. 1. Block diagram of the slow-scan tv test-pattern generator.

The three basic frequencies are derived from crystal oscillators and divided down to the sstv range with digital logic. Digital division removes switching transients and increases the accuracy of the audio tones. The 1.2-MHz crystal may be as much as 1 kHz off frequency, but the sstv sync frequency will still be within 1 Hz of the

excellent indication of picture resolution (see checkerboard photo).

The horizontal and vertical bars are a good indication of sweep linearity although the checkerboard pattern could also be used for this purpose. Since the horizontal and vertical signals are already available in the circuitry, it was only a

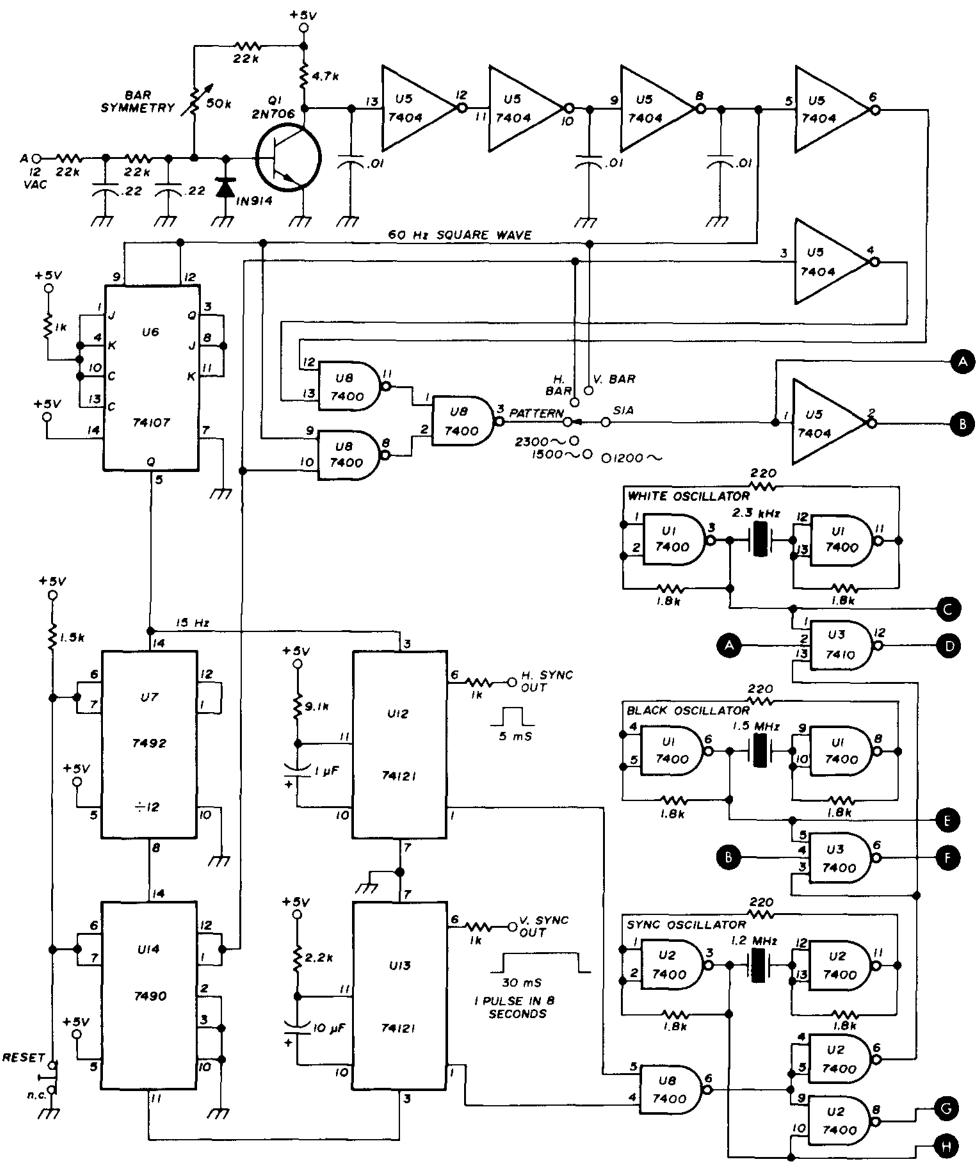


fig. 2. Circuit for the sstv test generator makes extensive use of integrated circuits. Complete unit is housed in a small 3-1/2x6x10-inch Minibox.

matter of adding a selector switch to provide three video patterns as well as the three basic slow-scan audio tones of 1200, 1500 and 2300 Hz. These tones can be used to tune discriminator coils or the all important sync-separator circuit.

how it works

Refer to the block diagram in **fig. 1** and the logic diagram in **fig. 2**. The 60-Hz signal that drives the test generator is obtained from one side of a 24-volt center-tapped power transformer, filtered, and connected to a transistor, Q1, which turns on for each positive going half-cycle of the waveform. The bias on Q1 is adjusted by a 50k trimmer to make the output symmetrical. The signal is further squared by three sections of a SN7404 integrated circuit, U5.

The square-wave output from U5 is applied to a JK flip-flop, U6, which divides by four. This is the slow-scan horizontal scanning frequency. However, the pulses are too long so they are used to trigger a 5-millisecond pulse generator, U12. Each pulse generator IC has two outputs. One output is normally low and one is normally high. The positive-going pulse at the Q output is connected to the rear panel jacks for external use.

Two cascaded IC counters, U7 and U14, count the 120 horizontal lines and trigger the 30-millisecond vertical monostable oscillator, U13. Horizontal and vertical sync pulses are then combined in the sync adder, U8. The sync signal is connected to signal gates so that sync always has precedence.

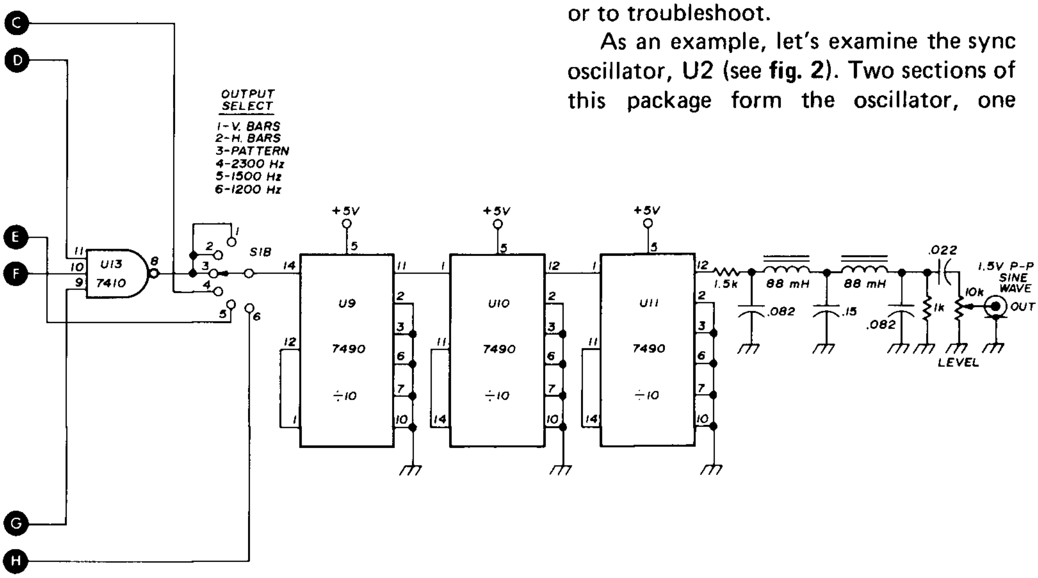
The three key frequencies in the generator are provided by continuously operating crystal oscillators that generate rf square waves. These three oscillators are gated so that only one signal may be on at a time. The output is a sequentially switched rf waveform divided down to the audio range by U9, U10 and U11.

The lowpass audio filter* does a good job cleaning up the square wave output from U11. The measured harmonic distortion is only 2.4% at 1200 Hz, 0.53% at 1500 Hz and 0.1% at 2300 Hz.

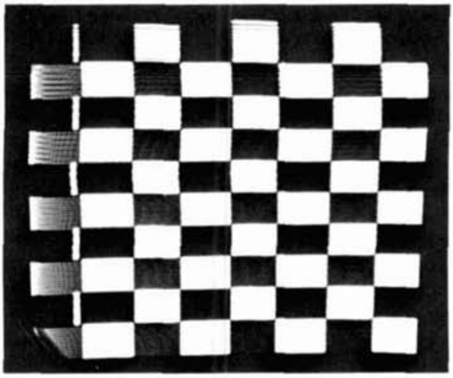
the digital logic

The TTL logic used in this circuit is fairly fast – much faster than needed. This can be a problem if the filtering is omitted at the base of Q1 or the input to U5 – the unit would become sensitive to power line spikes and result in erratic operation. This logic, however, provides at least two advantages. First, the signal frequencies used in this generator are mostly dc or 60 Hz so any small oscilloscope may be used. Also, most of the circuits are ordinary simple TTL NAND gates, so they are not hard to understand or to troubleshoot.

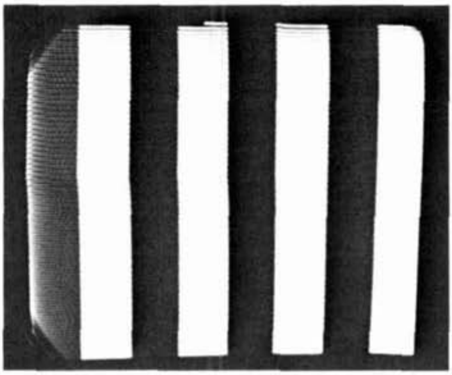
As an example, let's examine the sync oscillator, U2 (see **fig. 2**). Two sections of this package form the oscillator, one section is used as a gate, and one as an inverter. A NAND gate has to have all inputs positive to get a low, or zero, volt output. If pins 4 and 5 of U2 are connected together the gate is converted to an inverter. If, on one section of the



*The 88-mH toroids used in the low-pass filter may be obtained from M. Weinschenker, Box 353, Irwin, Pennsylvania 15642, five for $2.00, postpaid.



Checkerboard test pattern displayed on the K4EEU sstv monitor. The gray bars on left are due to second harmonics of the sync frequency, removed by the test-generator filter, but restored by the limiter in the monitor. This second harmonic, at 2400 Hz, is close to 2300 Hz, sstv picture white.



Vertical-bar test pattern displayed on the sstv monitor. Gray bar on the left side of the monitor tube is caused by the second harmonic of the sync frequency.

Sstv horizontal-bar test pattern, displayed on K4EEU's monitor.

IC, the output is connected back to the input with a resistor, an inverse feedback connection is made which linearizes the gate to a degree and prevents crystal lockup or starting problems.

The output at pin 3, U2, is a 3.5-volt p-p rf square wave, or, more accurately, it is a pulsating dc voltage which rises in a positive direction from the zero baseline up to 3.5 volts and falls again to zero at an rf rate. If this square wave is applied to pin 10, U2, it will pass through, inverted, to pin 8 provided the gate is enabled by making pin 9 positive. Normally, however, pin 9 of U2 is at zero volts and the gate is inhibited. Therefore, the output at pin 8 is high and stays high regardless of what signal is applied to the input, pin 10. To turn off any input to a NAND gate, any of the other inputs can be made low.

The sync-pulse monostable outputs at pin 1 of U12 and U13 are normally high; both are connected to the sync adder gate, U8. With both inputs high, the output at pin 6 of U8 is low. If either input to this gate goes low, as during a horizontal or vertical sync pulse, pin 6 goes high for the duration of that pulse. This enables pin 9, U2, and the sync rf passes through the gate.

When any gate is cut off, the output is high, so several such gates may be connected to a mixer such as U3 without inversion. When U2, pin 9, is high, turning on the sync, U2, pin 6, is low, or inverted, which inhibits the other two gates and prevents picture frequencies from passing during the sync interval. Pin 2, U5, is connected to pin 4, U3, so that either the black or white picture gates may be enabled, but not both at the same time.

The waveform reversing gate, U8, reverses the phase of the 60-Hz square wave every twelve picture lines. The output appears alternately at pin 8 or pin 11 of U8, but not both at the same time.

construction

Most of the components are mounted on a 5½ x 8-inch circuit board with the rest of the parts mounted on the ends of a small 3½ x 6 x 10-inch Minibox. A LM309K voltage-regulator IC is directly bolted to the rear of the Minibox, which is used as a heat sink.

Complete information on board layout is given in **fig. 6.** The circuit trails are the input of the LM309K voltage regulator is properly connected before turning on the supply. Verify the 5-volt output before wiring in any of the TTL devices (it is possible to have 18 volts unregulated where there should be only 5 volts). The regulator needs no adjust-

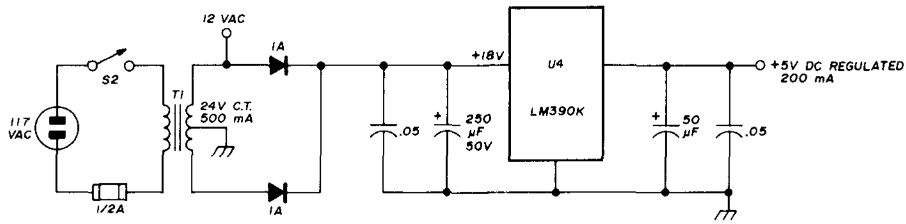


fig. 3. Power supply for the sstv generator. LM309K voltage-regulator IC uses one end of the Minibox enclosure for a heat sink.

drawn on the copper with a RMP-700 Kepro resist pen, or one similar. A parts list and epoxy, plated circuit board is available from the author for $10.00 postpaid in the United States.*

Inexpensive crystals are available from JAN crystals from stock in the FT-243 holder, but I prefer the HC-6/U crystal holder since it takes less space on a printed-circuit board. The tolerance of the crystal is not critical; if you wish, however, 0.005% tolerance custom ground crystals can be obtained.

Since this is a fairly complex construction project, I always build in sections and debug if necessary, starting at the power supply, **fig. 3.** Make sure

ments and has built-in current limiting so that, if the 5-volt line is shorted, the current is held to about 1 ampere, protecting the power supply.

The sync generator section can now be built and checked out with an oscilloscope. There should be a square wave at the collector of the transistor Q1 at the input to U6, pins 9 and 12. The pulse width at pin 6, U12, should be 5 milliseconds. This can be measured with suf-

*A kit of parts is available from Truman Boerkoel, K8JUG, Stotts-Friedman Company, 108 N. Jefferson Street, Dayton, Ohio 45402.

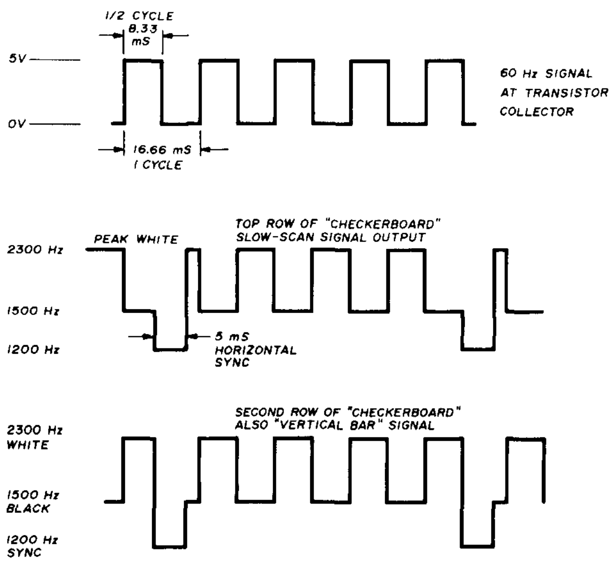


fig. 4. Output waveforms of the slow-scan television test generator.

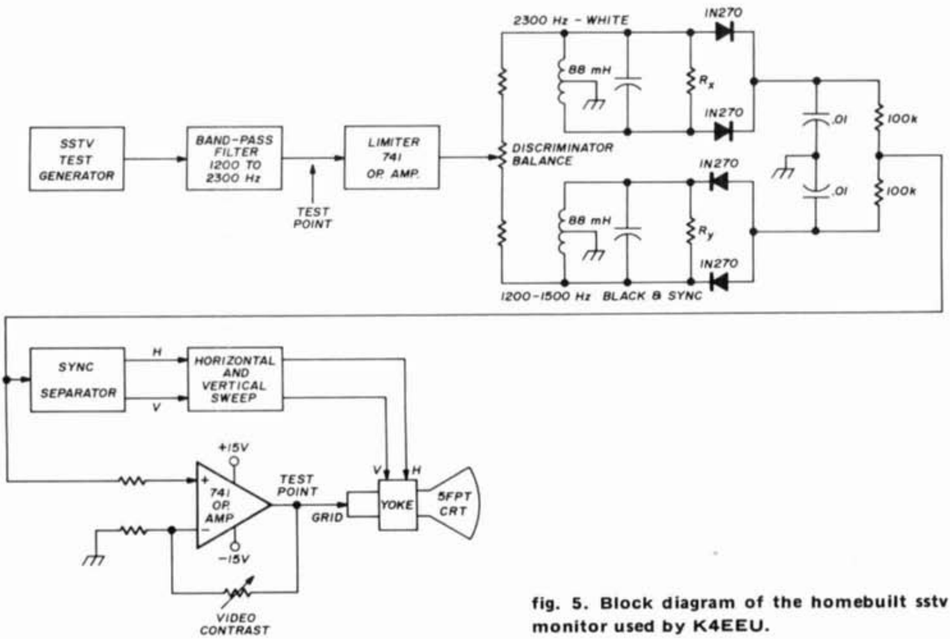
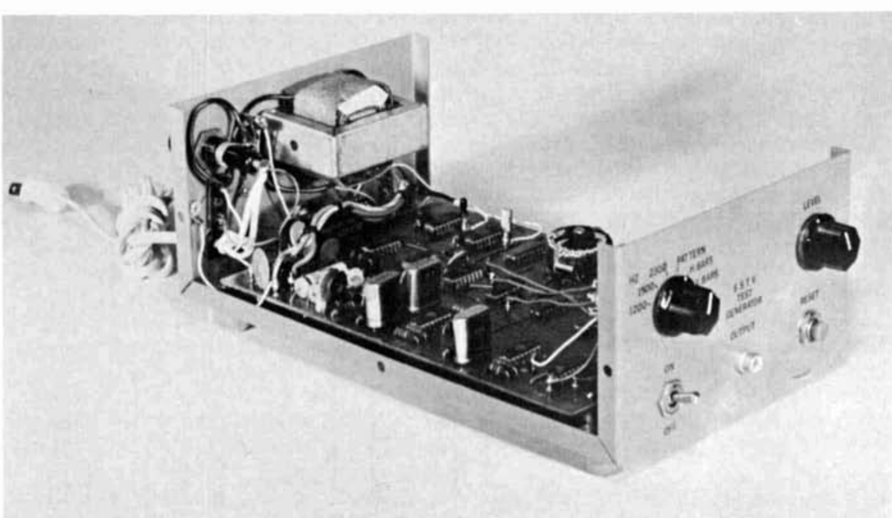


fig. 5. Block diagram of the homebuilt sstv monitor used by K4EEU.

ficient accuracy by referencing the scope to one cycle of the 60-Hz signal which has a time interval of 16.66 milliseconds. The sync pulse width should be about one-third the length of one 60-Hz cycle (see **fig. 4**).

The vertical sync pulse is a little more difficult to measure because it occurs once every eight seconds. This may be speeded up, either by repeatedly operating the *reset* button or by *temporarily* rerouting the lead that runs from pin 3, U13, to U14 so that it is connected directly to pin 5, U6. The pulse from U13 will then be at a 15-Hz rate and much easier to measure on a scope.



Construction of the slow-scan tv test generator.

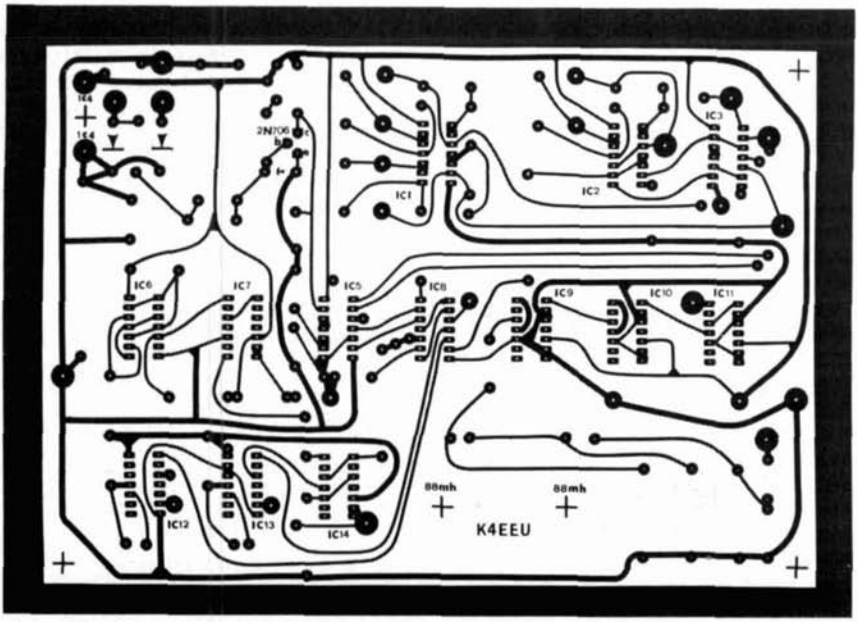


fig. 6. Layout for the printed-circuit board for the sstv test generator. A circuit board and parts list is available from the author.

The pulse width should not be less than 30 milliseconds. Two 60-Hz waves are about 33-milliseconds long and this is close enough for practical purposes. The pulse widths should be sufficiently close without any circuit changes. However, if they are not, the pulse width can be adjusted by changing the value of the resistor connected to pin 11 of the appropriate 74121 IC.

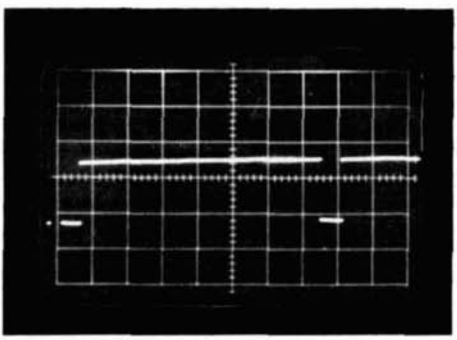
The pattern generator can be checked out by wiring in the waveform reversing gate, U8, and checking the waveform at pin 3. Externally sync your scope and see if the polarity of the waveform is reversing about once a second.

If you cannot observe the crystal oscillators on a scope, the signal can be detected on a broadcast receiver. Of course, if you have an output at the filter, it's a good indication that the crystal oscillators are operating all right.

The foregoing is not intended to emphasize the complications but to be of assistance if troubleshooting becomes necessary. Usually ICs can be wired into a circuit as so many building blocks, and, if wired correctly, everything works.

operation

The sstv test generator can be used with an oscilloscope to check the slow-scan signal at the different points in the monitor. If you want to see if the input bandpass filter is operating correctly, put the test generator switch on pattern or bars and look at the output of the filter with a scope. The amplitude should be the same for the three frequencies. Similarly, the demodulated composite video signal can be seen at the discriminator

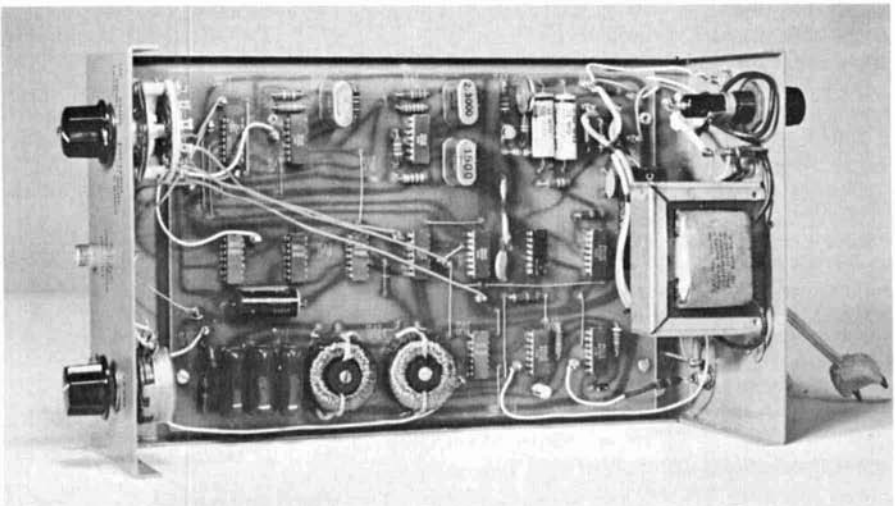


Clipped and restored horizontal sync pulse taken from the sync separator of the K4EEU sstv monitor.

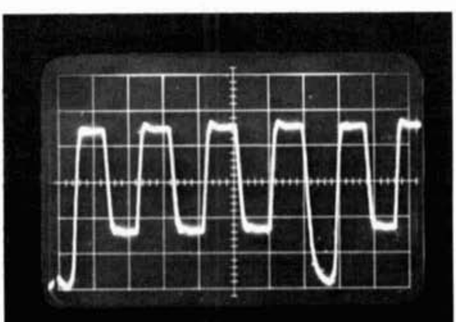
output and traced up to the picture tube grid.

The sync separator circuit in the monitor should show a clean sync pulse with no interference between the sync and the black video pulses. This circuit can be optimized by setting the selector to 1200 Hz and tuning.

The sstv monitor may use a discriminator circuit similar to that used in a RTTY demodulator (**fig. 5**). The discriminator coils can be individually set on frequency with the test generator and then the exact value of the damping resistors selected by viewing the demodulated pattern on a scope. The correct resistor will result in minimum ringing and best square wave response, and can be found in less time than it takes to tell about it by using variable pot (about 50k). The sync pulse waveform is relatively unimportant here but it should be separated from picture black. The sync circuit will clean up the sync pulse.



Complete sstv test generator is built on 5-1/2x8-inch printed-circuit board and installed in a 3-1/2x6x10-inch Minibox. LM309K voltage-regulator IC is mounted on the rear of the Minibox.



Demodulated test-generator signal at the output of the monitor discriminator.

The reset button was installed on the test generator so that a vertical pulse could be obtained immediately at any time when working with a sync circuit in a monitor. Otherwise, the pulses are separated with an 8-second time interval. If this button is omitted, pins 6 and 7 of U7 and U14 must be grounded or the dividers will not operate.

Once you build this sstv test set, you will wonder how you ever got along without it. At my station it revived a faltering monitor project. With only a few hours work a trouble in the monitor sync separator was cleared and I started receiving good pictures.

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Complete construction details for the SOOPAR — a Signal-Operated Operational Relay

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squelch circuit

The Motorola compensated squelch circuit, diagrammed in **fig. 1**, operates to silence the speaker when no signal is present. The SOOPAR derives its input signal from this squelch circuit.

The squelch circuit operation is as follows: Signal and noise from the antenna, mixers and the i-f amplifier stages are fed into the limiter stages which are driven into saturation, thus limiting the limiter output to a constant voltage. This output voltage, at the last i-f, is the same whether it is signal or noise or any proportion of both.

The action of driving the last limiter stage into saturation generates limiter grid current and, thus, a negative voltage at the limiter grid. This grid voltage is picked off, filtered and used as bias by the later squelch stages. The i-f output of the limiter is connected to the discriminator stage where it is converted to audio. The voice-audio components are amplified by the audio amplifiers and drive the speaker when the first audio stage is unsquelched.

Audio components produced by the discriminator that are above the voice-range (noise) are filtered out from the voice-range components and amplified by the noise amplifier. The noise amplifier gain may be adjusted by a variable resistor in the cathode circuit; this variable resistor is the squelch control.

The output of the noise amplifier is rectified by the noise rectifier. The positive-going dc output of the noise rectifier is proportional to the noise output of the noise amplifier. That is, more noise into the rectifier produces a more positive dc voltage out of the rectifier.

The dc output of the noise rectifier is connected in series with the negative bias obtained from the limiter stage and is applied to the dc amplifier grid. The dc amplifier turns the first audio amplifier stage on and off. Typically, the dc amplifier keeps the first audio amplifier turned off (squelched) whenever its dc input from the noise rectifier is zero volts or more positive.

The dc amplifier turns the audio amplifier on when the dc voltage applied to it from the noise rectifier becomes more negative than zero volts. This condition occurs when the noise voltage is removed from the noise amplifier and rectifier. This "quieting" occurs when a carrier is received by the receiver.

This circuit has a measure of compensation built into the biasing arrangement. When the drive to the limiter stage is reduced as a result of tube aging or low supply voltage, the negative bias derived from the limiter is reduced proportionately. The noise component of the discriminator output is also reduced with tube aging or reduced supply voltage, resulting in a lower positive going noise rectifier output. Since these two voltages are of opposite polarity and are connected in series, the result is a negligible change in

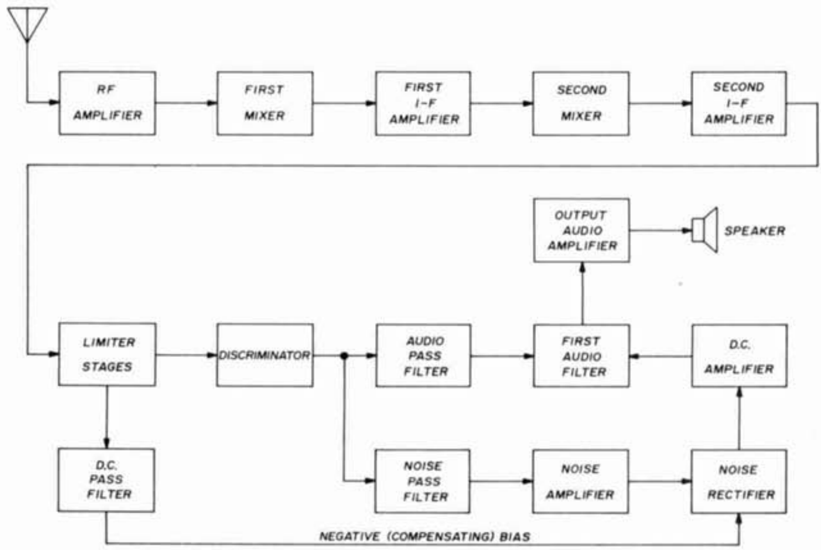
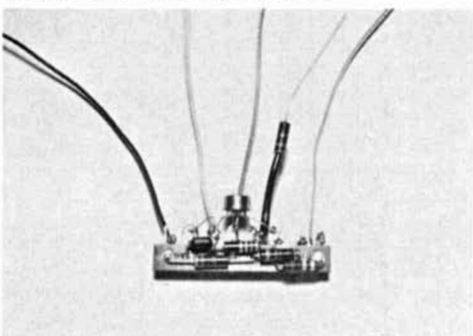


fig. 1. Block diagram of a typical Motorola receiver using a Motorola compensated squelch circuit.

Editor's note: This is more than an article on a signal-operated op-amp relay — it also presents a comprehensive review of squelch operation in Motorola tube-type fm receivers.

photos by Mike Keller, WA6RWR



The SOOPAR, ready to be installed and connected to an external relay.

the voltage fed to the dc amplifier from the noise rectifier. Thus, supply voltage changes and tube aging tend to be automatically compensated for by this circuit.

When the squelch control is set for reception of a slightly noisy but useable signal, the voltage presented to the dc amplifier when no signal is being received is approximately +5 volts.

tube-type carrier-operated relays

Tube-type carrier-operated relay (COR) circuits, when used, are connected to sample the voltage presented to the dc amplifier. A representative circuit is shown in **fig. 2.**

The signal voltage applied to the grid of the dc amplifier is sampled through R1 and connected to the grid of the first half of the COR tube which goes into conduction whenever the sampled voltage is more positive than the 1.8-volt cathode bias developed by R2 and R3. When the first half of the tube conducts, the voltage at its plate approaches zero. This is connected to the grid of the second half of the tube, which, under this condition, draws little current. The voltage drop across relay K1 is 27 volts or less, and K1 is released.

When the receiver is unsquelched, the voltage presented to the dc amplifier and sampled by the COR goes negative. This causes the current drawn thru R4 by the first half of the COR tube to reduce. As this current reduces, the voltage drop across R4 reduces, making the voltage on the grid of the second half of the COR more positive. When this voltage rises to about 50 volts, the neon tube fires, preventing the voltage from reaching a higher potential that could damage the tube.

When the voltage at the second grid goes more positive, the second half of the COR draws more current through K1. When the current is sufficient to produce a 35-volt drop across K1, it closes, actuating the external device.

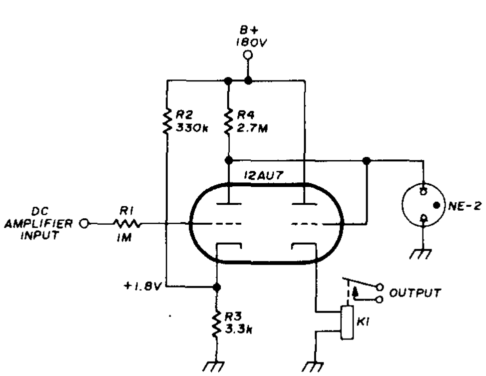


fig. 2. Motorola carrier-operated relay circuit. Relay K1 is an 8000-ohm relay which picks up at 39 volts and drops out at 27 volts.

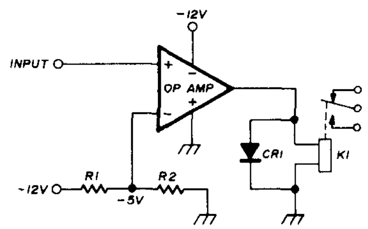


fig. 3. Circuit for using an operational amplifier IC to operate a relay.

cor disadvantages

Users of conventional tube type CORs will agree that the COR is the real trouble spot in a repeater receiver. Part of this is due to the fact that the voltage across the relay does not go from zero to "all on" when a signal is received. Rather, the relay operate and release voltages play an important part in COR operation. As the COR tube ages, the voltage presented to the relay changes, thus effectively changing the COR sensitivity. A circuit that would only produce two relay voltage conditions, full on and full off, would eliminate most of these relay problems.

Another problem is the inconsistent loading effect that the COR has on the receiver squelch circuit. When the squelch voltage is more positive than the voltage on the cathode of the first half of the COR tube, the grid and cathode act like a diode and conduct current, placing a 1-megohm load on the squelch circuit and reducing its adjustment range. Below this voltage, the current is negligible unless the COR tube becomes gassy; when this happens, the effect is unpredictable.

It is difficult to adjust this type of tube COR to open and close in the correct relationship to the audio squelch. The proper relationship is one where the audio squelch opens just before the COR closes as a received signal is slowly increased in level, and where the COR opens just before or at the same time as the audio squelch closes when the signal is decreased. This is almost impossible to maintain with a tube-type COR, even if an additional control is added to independently adjust COR sensitivity.

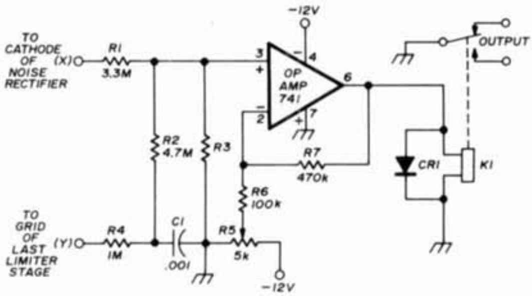


fig. 4. Schematic for the SOOPAR, signal-operated operational relay. Relay K1 is a Sigma 65FP1A. Diode CR1 is silicon. See table 1 for value of R3.

op-amps

Operational amplifiers are miracle devices that seem to perform magic. In the case of the SOOPAR, an op-amp is used as a dc amplifier with almost infinite gain. In this case the op-amp looks at two input voltages; one constant (adjustable) and one variable with signal level. When the variable input is equal or more positive in voltage than the constant, the output from the op amp is in the "off" condition.

When the variable input is slightly negative as compared to the constant, the output of the op amp changes to the "on" condition. A 10-volt change (from 2 to 12 volts) at the output is produced by an input voltage change of a hundredth of a volt or so. The op amp in the SOOPAR is capable of directly operating a relay; of course, this voltage change can be adapted to solid-state circuits that do not use any relays.

op-amp relay

A simple circuit using an op-amp to sense an input voltage and operate a relay is shown in **fig. 3.** A negative 12-volt supply is connected to the op-amp and to a voltage divider, R1 and R2. The inverting input of the op-amp is connected to the junction of R1 and R2, whose values are chosen to present a bias potential of −5 volts. The non-inverting input of the op-amp is the input terminal of the op-amp relay.

If the input voltage is between zero and −5 volts, the relay is released. When the voltage is raised above −5 volts, the relay is operated. To prevent damage to the op-amp the input voltage should not exceed the supply voltages. The current drawn by relay K1 must not exceed the rating of the op-amp. Diode CR1 prevents damage to the op-amp from reverse voltage spikes generated by K1 when it is released.

soopar

The signal-operated op-amp relay or SOOPAR is an adaption of the op-amp relay circuit and is shown in **fig. 4.** Resistor R5 takes the place of R1 and R2 in **fig. 3** and is set, nominally, to about −5 volts. R1 is connected to the squelch circuit of the receiver, and R4 picks off the limiter voltage. C1 and R4 act as a filter to remove the i-f signal voltage present at the grid of the last limiter.

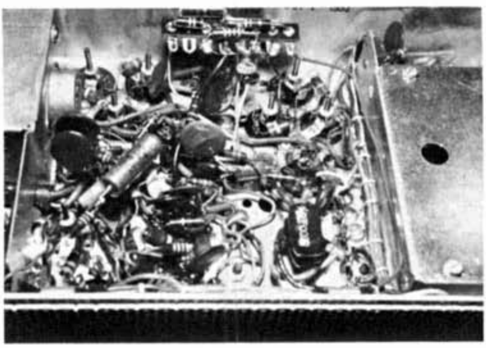
Resistors R1, R2, R3 and R4 make up

A SOOPAR and power supply mounted on the Permakay filter of a Motorola Sensicon G receiver. The relay is shown mounted on the power-supply chassis.

a complex voltage divider; their values are chosen to present a potential of about −5 volts to the non-inverting input of the op-amp. The values are also chosen to limit the maximum voltage presented to the op-amp to less than the +12-volt op-amp supply voltage.

hysteresis

The advantage of the SOOPAR to turn on and off with a very small input voltage change is a disadvantage when very weak signals are received. The relay will chatter, going on and off rapidly. The tube-type COR avoids this due to the inherent magnetic "hysteresis" in the relay; that is, once the relay is operated, you can reduce the voltage across the relay somewhat and it will remain energized.



A SOOPAR mounted on the side of the chassis of a Motorola Sensicon A receiver.

The relay's pick-up and drop-out voltages are a major factor in the proper operation of a tube-type COR. Resistors R6 and R7 are added to the SOOPAR to introduce electrical hysteresis. The bias presented to the inverting input of the op-amp is raised when voltage is applied to K1 by the op-amp. The amount of this change in potential is determined by the values of R6 and R7.

The net effect of the hysteresis is to cause the relay to release at a SOOPAR input voltage lower than the input voltage required to operate the relay. For example, if the relay drops out at −3 volts (at the non-inverting, or + op-amp input), and picks up at −4 volts, it will release again at −4 volts if there is no hysteresis. By adding hysteresis, it drops out at −3.5 volts.

Incidentally, if you don't want it, this action is called "slop" or "backlash;" it is called "hysteresis" if you do want it. If more hysteresis is desired in the SOOPAR, raise the value of R6 — try 220k or 330k. For less hysteresis try 47k; if no hysteresis is desired, disconnect R7 and short out R6.

receiver connection

Typical connections to Motorola receivers are shown in **table 1.** Resistors R1 and R4 should be connected directly to the tube socket pins shown, and C1 should be connected directly to R4 and ground. The lead length from R1, R2 and R3 to the op-amp should be kept at a minimum to reduce stray rf pickup. The op-amp itself should be mounted inside the receiver; relay K1 may be mounted externally.

If you adapt the SOOPAR to a different receiver, connect R1, R2, R3, R4 and C1 before connecting the op-amp. Measure the voltage at the junction of R1, R2 and R3 with a vtvm or high-impedance fet volt-meter. It should be between −3 and −6 volts with the receiver set for nominal squelch sensitivity, and should not exceed −12 volts with a saturating signal applied to the receiver input. If necessary, adjust R3 (and perhaps R2) to satisfy these conditions, then

table 1. Connection points for installing the signal-operated operational relay into Motorola fm receivers.

typical Motorola receiver	lead X	lead Y	R3 value
Sensicon A high-band PA 8433/8476	V309 pin 1	V312 pin 5	2.2M
Sensicon G high-band TA 140	V110 pin 1	V113 pin 7	not used
T44 type uhf rcvr TA 141	V14B pin 8	V12B pin 2	2.2M

connect the remainder of the SOOPAR circuit.

adjustment

The threshold adjustment is R5. First adjust the receiver squelch control to quiet the receiver, then adjust R5 to the point where K1 just releases. This adjustment should suffice for most applications, but R5 may be trimmed as necessary to track the SOOPAR operation with the audio squelch.

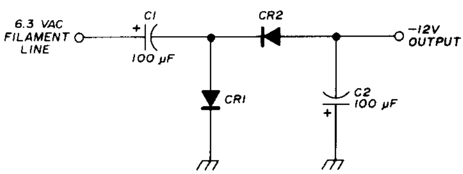


fig. 5. Power supply for the op-amp relay. Diodes CR1 and CR2 are silicon units.

construction

As long as the input leads are kept short, the layout of the SOOPAR is not critical. Small 8-lug terminal strips have been used by some builders. Spare terminals on existing terminal strips within receivers have been used by others. The recommended relay, a Sigma 65FP1-12DC, is a 90-mW, 12-volt dc relay with a 1600-ohm coil. These are available from Allied Radio and others for less than $3.00 each.

A simple voltage-doubler power supply for the SOOPAR is shown in **fig. 5.** Any small power diodes may be used for CR1 and CR2, and any value of capacitance of 100 µF or more will suffice for C1 and C2. This power supply may be built on a small multi-lug terminal strip similar to the SOOPAR.

conclusion

Several SOOPARs are presently in use in Northern California repeater receivers, including the vhf input receivers of the Mt. Vaca Radio Club's repeaters. This circuit has proven itself reliable under temperature extremes and continuous usage.

ham radio

low-voltage superregenerative receiver for vhf

This superregenerative receiver tunes from 100 to 170 MHz and operates from a single flashlight battery

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This receiver was built as an experiment to investigate the quality of reception that could be expected from various modulation modes using a superregenerative detector, and to experiment with the diode tank loading technique discussed in previous articles.[1,2] Another design goal was to operate the receiver from a single flashlight battery and to achieve long battery life at low cost. The frequency range of approximately 100 to 170 MHz covers wide-band fm in the fm broadcast band, a-m in the aircraft band and narrow-band fm in the public service band.

Since superregenerative detector theory is covered in the above referenced articles and elsewhere, I will not go into that here.

circuitry

As shown in **fig. 1,** the receiver consists of a superregenerative detector followed by a three-stage audio amplifier which drives a pair of 2000-ohm headphones. Regeneration is controlled by varying the base bias on the detector transistor. A two-section RC filter between the detector and audio amplifier attenuates the detector's quench frequency, and each stage of the audio amplifier is "rolled off" with a 180-pF feedback capacitor to prevent response at the quench frequency.

The TIS97 transistors used in the audio amplifier have dc current gains of around 500; if lower beta transistors are substituted, the 150k base-bias resistors may need to be decreased to set the dc collector voltage at about 0.8 volt. Since current drain is about one milliampere, an AA penlight cell could be used instead of the D cell I used.

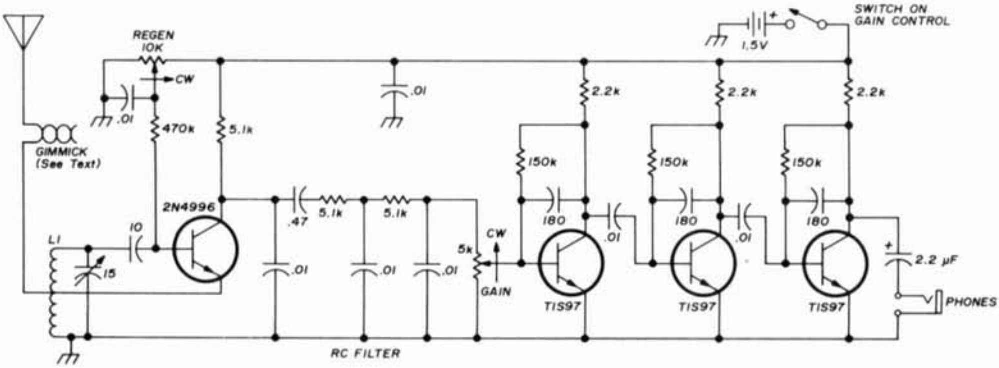


fig. 1. Schematic of the low-voltage superregenerative receiver that tunes from 100 to 170 MHz. Coil L1 is 3 turns Mini-ductor stock, ½" diameter, 8 turns per inch.

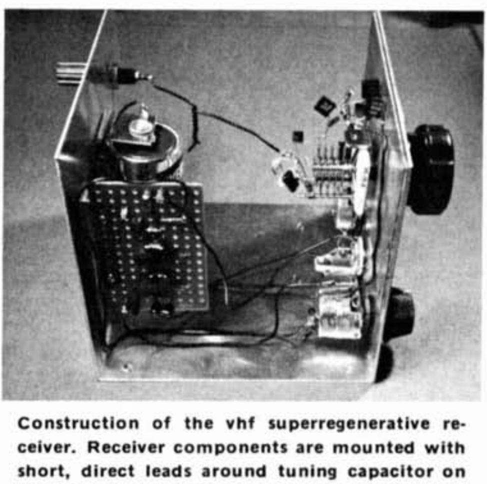
The tuning capacitor is a Hammarlund HF-15-X having about 15-pF maximum capacitance; the coil is three turns of Miniductor stock, 0.5 inch diameter, 8 turns-per-inch. The emitter and antenna are connected to the center of the coil. I found that if the antenna was coupled too tightly to the tank circuit, the detector would not operate properly at the high end of its frequency range.

I used a gimmick capacitor made from two pieces of number-22 hookup wire twisted together for a length of 1.25 inches and inserted between the antenna terminal and the coil. This seemed to provide a good compromise between sensitivity and stable operation when using a three-foot wire antenna.

construction

The entire receiver, including battery, is housed in an LMB 555N aluminum cabinet, which is a five-inch cube. A piece of copper-clad board is held on the inside of the front panel by the tuning capacitor's mounting bushing. This provides a ground plane to which all of the detector's ground connections are soldered.

All detector wiring should be as short and direct as possible. In my receiver most of the detector components are just soldered together and supported by their leads. The audio amplifier is assembled on a piece of perf-board mounted on the rear panel with the battery holder and antenna terminal.



Construction of the vhf superregenerative receiver. Receiver components are mounted with short, direct leads around tuning capacitor on front panel. Audio power module is mounted on perf board in rear of enclosure.

operation

For best results, the regeneration control should be advanced to a point just above the spot where the rushing sound begins; this adjustment is not critical, but may need to be varied somewhat with tuning. The receiver should be tuned slightly to one side of an fm station's frequency to achieve slope detection.

Using a three-foot wire antenna, local fm broadcast stations and aircraft came in loud and clear; the aircraft signals are a-m while the fm broadcast signals are wideband fm. Narrowband fm signals in the public-service band were difficult to copy; although their carriers can completely quiet the receiver's noise, their low deviation doesn't provide much audio output from the detector.

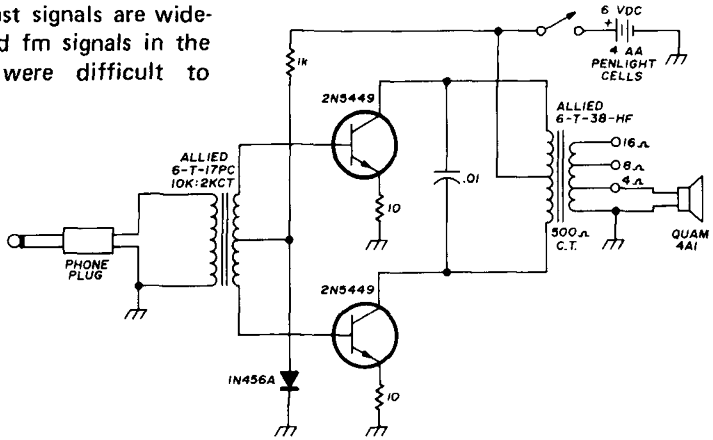


fig. 2. Simple audio power amplifier may be used with any small receiver which is capable of driving a pair of 2000-ohm headphones.

I experimented with germanium diodes connected across part or all of the tank coil as described in the referenced articles, but I was unable to detect any improvement in performance.

audio power amplifier

Most of my audio circuits are designed to drive 2000-ohm headphones; these phones are easy to drive, and the rest of the household doesn't want to listen to all that shortwave racket, anyway. At times, however, it's desirable to have speaker capability so I built a simple power amplifier which plugs into the phone jack (**fig. 2**). It is mounted with a 4-inch speaker and batteries in a 6x6x4-inch LMB 664 aluminum box.

Any circuit which will drive a pair of 2000-ohm headphones will drive this unit and produce plenty of room volume. Although I have used only 2N697s and 2N5449s, the circuit should work well with almost any medium power silicon npn devices.

Allied Radio part numbers are shown for the transformers, but any of the less expensive imported transformers having the same impedance levels should be ok. No volume control is included because I usually have one on the equipment designed to drive the phones. Battery drain is 10 mA or less, depending on output level, and four AA penlight cells connected in series will last a long time.

conclusion

Superregenerative receivers can be designed to operate from a 1.5 volt dc supply; they are suitable for a-m and wideband fm reception, but their performance with narrowband fm is poor. Operation of these detectors from a very low voltage source can decrease their radiated power and lessen the possibility of interference to other nearby receivers.

references

1. C.L. Ring, "Optimizing the Superregenerative Detector," *ham radio,* July, 1972, page 32.
2. A. Iwakami, "Improved Superregenerative Receiver," *ham radio*, December, 1970, page 48.

ham radio

importance of standing-wave ratios

This discussion of standing-wave ratios should clear up many of the misunderstandings that persist among many radio amateurs

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Twenty five years ago the Micromatch, the first of many vswr bridges designed for use by the radio amateur, was introduced in the pages of *QST.*[1] Prior to that time the radio amateur had not given much attention to vswr and his understanding on the subject was accordingly limited. The fact that vswr measurement might provide a means of effectively evaluating and monitoring the performance of an antenna system was an exciting prospect, and amateurs began to realize that the vswr bridge was a significant development.

Thus, vswr became the subject of many technical articles in the amateur journals, with each writer addressing himself to a discussion of the various phenomenon associated with the presence of standing waves. A considerable bibliography on the subject of vswr has been accumulated, but, nevertheless, a brief period of listening on the amateur bands will reveal that a great deal of misunderstanding continues to exist. For example, it is still a widespread belief that radiated power will increase with decreasing vswr; that reflected power represents lost power; and that the reflected power is somehow dissipated within the transmitting system. One of the invalid theories postulates the reflected power returning to the output stage of the transmitter where it causes overheating of the output tube.

The following discussion is aimed at enabling the reader to obtain a better understanding of the effects of standing waves, and to do so in terms of transmission line theory with which the radio amateur is already well acquainted. In particular, the role of the reflected wave, which has become such an enigma as a result of so many conflicting opinions, will be explained in a way that I believe to be unique.

Part of the discussion will be in the form of a description of experiments performed upon a transmission system which has been mismatched to cause a vswr of 2:1 to exist. In addition, the effects of system vswr upon the output network of the transmitter will be discussed with the aid of numerical examples, and it will be shown that the criteria of proper operation is simply the ability to tune the transmitter for normal rated plate current.

Knowledge of basic transmission line theory, such as found in the *ARRL Handbook,* is all that is necessary to understand this material. However, a brief review of this theory, with particular emphasis on the aspects most pertinent to this discussion, is included with this article in the form of an appendix. It is suggested that you first review this appendix if only to identify the theoretical aspects which I wish to emphasize.

stalled in the transmission line, dividing it into three identical line-sections, each one-quarter wavelength (90°) long. The total length is, therefore, 3/4-wavelength (270°).

The transmission line may be readily opened at the junction points for measurements, and for other purposes to be detailed later in this article. Each line-section, each junction-point and each connector have been assigned a number for reference in the text. In addition, means for monitoring the vswr on each line-section has been provided.

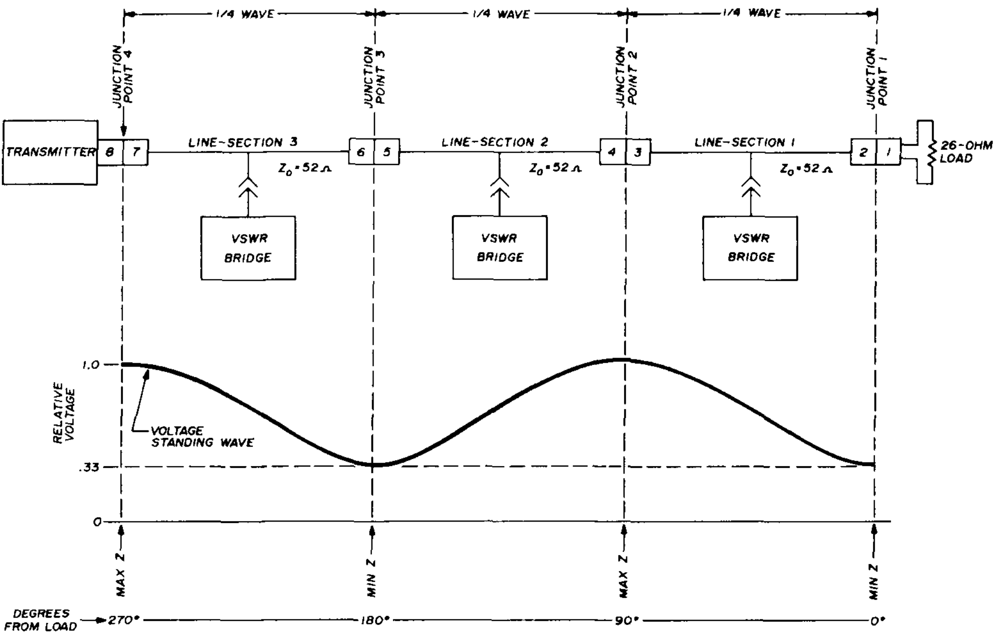

fig. 1. Antenna system discussed in text includes a 3/4-wavelength transmission line with a vswr of 2:1. For diagram of transmitter matching network, see fig. 4.

the experimental system

The most common form of amateur antenna installation in use today uses coaxial cable for the transmission line. Therefore, it is appropriate to base this discussion on the coaxial system shown in **fig. 1** where provisions have been made to facilitate the performance of some experimental tests. Connectors have been installed in the transmission line, dividing it into three identical line-sections, each one-quarter wavelength (90°) long.

Although a means for opening the transmission line at the resistive impedance points is essential for the experiments to be performed, it is not necessary to control total line length or to select a specific load impedance. The values selected for the system of **fig. 1** are simply convenient and lead to less complication in the analytical discussion.

Fig. 1 also shows the position of the standing wave and the location of the points of maximum and minimum impedance. From transmission line theory we know that the maximum and minimum impedance points are the only points on the transmission line where the impedance is a pure resistance. Later it will be shown that the points of pure resistance are of particular significance in understanding the action of reflected waves.

The system of **fig. 1** has other conditions to be specially noted and kept in mind: First, each line-section is made of RG-8A/U coaxial cable which has a characteristic impedance (Z_o) of 52 ohms; second, a vswr of 2:1 exists on each line-section as a result of the 26-ohm resistive load at connector no. 1. Finally, each line-section may be considered separately as a quarter-wave impedance transformer where the impedance at its input connector (connectors 3, 5 and 7) may be readily found by dividing the square of line impedance, Z_o (52^2 = 2704), by the impedance at its output connector (connectors 2, 4 and 6). Thus, *the impedance at connector* 3 is 2704/26 = 104 ohms. Since connector 3 and connector 4 are joined together, the impedance at connector 5 is 2704/104 - 26 ohms. In a like manner, the impedance at connector 7 is found to be 104 ohms; this is the impedance seen by the transmitter.

experiments and observations

Referring again to **fig. 1**, let's conduct our first experiment by inserting a short *section of transmission line* between connector 3 and connector 4 so that the system appears as shown in **fig. 2.** A section of transmission line with a characteristic impedance of 104 ohms is chosen for this purpose so that it will be perfectly *terminated (matched) by the 104-ohm* resistive load which we know exists at connector 3.

We also know that when a transmission line is operated in this manner there will be no standing wave on it, and the input impedance *will* be equal to the characteristic impedance, Z_o, regardless of the length of the line. Therefore, at connector 2A the impedance is 104 ohms, and the load *impedance* on line-section 2 remains unchanged. Indeed, if you made detailed comparisons of vswr and impedance between the system of **fig. 1** and the system of **fig. 2**, you would be unable to detect any differences — in spite of the fact that the latter system includes the 104-ohm line-section on which there is no reflected wave. The only change is some additional phase delay which is not important to this system.

An interesting and extremely important point has been demonstrated by this experiment. Since no standing wave is present on the 104-ohm line-section, the reflected wave on line-section 1 has ceased to exist at the junction of connectors 3 and 1A. More significant, however, is the fact that the reflected wave has ceased to exist at a point on the transmission line where the impedance is a pure resistance. And, if you were to repeat the above experiment for all other points where the impedance is a pure resistance, the results would be the same.

Thus, in the system of **fig. 1** there are three points on the line where the reflected waves cease to exist. However, the impedance at junction-point 2 (104 ohms) is a mismatch for line-section 2, and the impedance at junction-point 3 (26 ohms) is a mismatch for line-section 3. Thus, each of the three line-sections is mismatched by the load impedance at its respective output connector, and the magnitude of the mismatch is such as to cause a vswr of 2:1 on each line-section. Reflected waves are therefore developed independently on each line-section and it is apparent that the reflected wave due to a mismatched antenna load does not travel back toward the transmitter *without interruption.*

Although it may be somewhat redundant to discuss further the change that was made to convert the system of **fig. 1** into the system of **fig. 2**, some readers may appreciate further clarification of the role of the *inserted line-section.* Suppose that we experiment further with the system of **fig. 2** by shortening the 104-ohm line-section in successive steps, each time cutting the remaining line-section in half. Theoretically, the line-section would never be reduced to zero length. However, from a practical standpoint you can see that, as a limit, its length would approach zero, thereby making the systems of **fig. 1** and **fig. 2** identical. Furthermore, if the system is examined applied years ago in the design of the "Q-Match Antenna."[2,3] In this system the 75-ohm impedance of a center-fed half-wave dipole is matched to 600-ohm open-wire transmission line by using a quarter-wave section of transmission line with a Z_o of 212 ohms. The 212-ohm line operates with a vswr of 2.8:1, and the 600-ohm line with a vswr of 1:1. Thus, as demonstrated in the foregoing, the re-

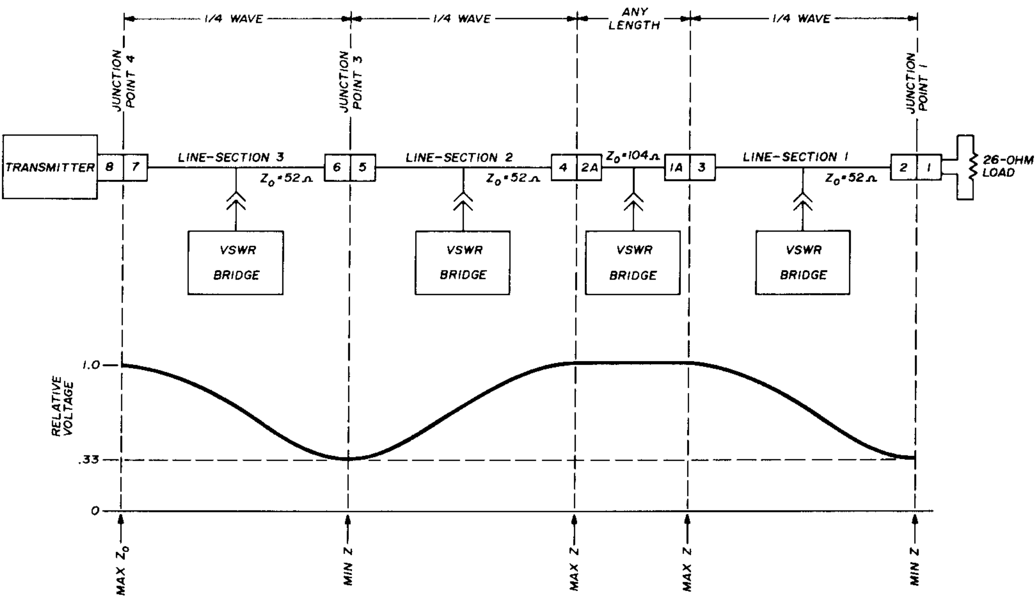

fig. 2. Since the impedance at junction point 2 in fig. 1 is 104 ohms, a section of 104-ohm transmission line, any length, may be inserted at that point with no effect upon the performance of the rest of the transmission line.

after each shortening operation, you would find the operational characteristics (such as vswr and impedance at each junction-point) unchanged. Therefore, it must be concluded that the system is independent of the length of the 104-ohm line-section, including zero length.

The 104-ohm line-section in this case has served as an analytical tool to enable the behavior of the reflected wave to be observed, and to further prove that this behavior remains unchanged after the line-section is removed from the system.

The principle applied in the foregoing experiments is the basis of many impedance-matching systems and was flected wave on the 212-ohm line ceases to exist at the junction of the two lines because the impedance exhibited at that point is a pure resistance of 600 ohms.

effects on the transmitter

Most present day transmitter designs use a pi-network to couple the antenna system to the output stage. In general the pi networks are designed for a nominal load impedance of 50 ohms at a maximum vswr of 2:1. This means that the transmitter can be loaded to its rated power input as long as the load impedance is maintained within specific limits. By specifying a maximum allowable vswr the manufacturer is indirectly specifying the impedance limits of the transmitter and the amateur is provided with a parameter he is able to measure.

The easiest way to determine the impedance values which this specification permits is to make a plot on a Smith chart. Simply scribe a circle, with a radius equivalent to a vswr of 2:1, about the center of the chart. This circle is the locus of all possible values of impedance on a system with a vswr of 2:1. A Smith chart with a vswr = 2:1 plot, based upon a Z_o of 52 ohms, is shown in **fig. 3**; points 1 and 2 on the circle locate the only resistive impedances (26 ohms and 104 ohms, respectively) and point 3 locates the complex impedance of 41.6 + j31.2 ohms for later use in this discussion.

When designing a pi network the value of inductance, L, is determined such that the inductive reactance

$$X_L = \frac{QR_1 + \left(\frac{R_1 R_2}{X_{C2}}\right)}{Q^2 + 1}$$

This expression contains two terms which may be separately equated, one to X_{L1} and the other to X_{L2}, the sum of which is equal to X_L. The significance of X_{L1} and X_{L2} lies in the fact that any pi network can be shown to be exactly equivalent to two L-networks connected back-to-back as shown in **fig. 4A**. It is no coincidence therefore that X_{L1} and X_{L2} are the respective values of inductive reactance required for L-network 1 and L-network 2. The junction point of the two L-networks must be an impedance match. In fact, if you were to analyze any specific pi-network design you would find that at the junction point the impedance is always a pure resistance with a value lower than either the input or output impedances. For convenience, this point will be referred to as the intermediate impedance of the pi network. Referring again to **fig. 4A**, capacitors C1 and C2 are the conventional tuning and loading controls, respectively, and L is an inductance value that is fixed for each band. Specific values of reactance for each of these elements is required when a particular pi-network design is desired.

As an example, a pi-network designed to match a single 6146 AB1 linear amplifier to a nominal 52-ohm resistive load is shown in **fig. 4B**. This network is designed to provide a 3000-ohm resistive load for the 6146 and to operate at a Q of 15. In this case the intermediate impedance is 13.27 ohms. When a load impedance other than 52 ohms resistive is used with this network, C1 and C2 are simply adjusted until normal rated plate current is obtained. When this is done the plate load will always be 3000 ohms resistive — however, the intermediate impedance and the operating Q of the network will change. **Fig. 4C** shows the values of X_{C1} and X_{C2} readjusted to match a load of 104 ohms resistive; the intermediate impedance is now 11.95 ohms and the operating Q has increased slightly to about 15.8.

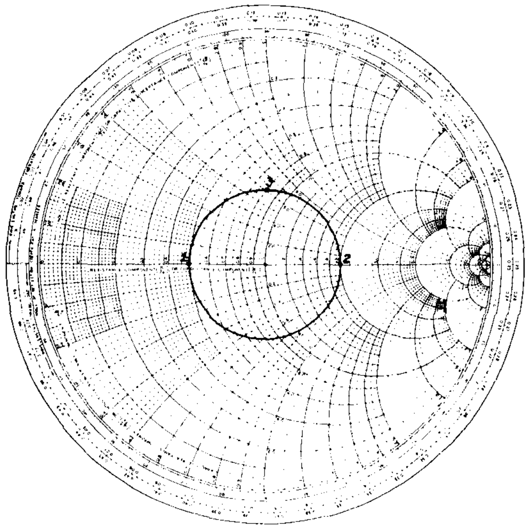

fig. 3. Smith chart plot of vswr of 2:1. Only two pure resistances are possible: point 1 and 2 at 26 and 104 ohms, respectively. Point 3 locates the complex impedance, 41.6 + j31.2 ohms, discussed in the text. (Since this is a normalized Smith chart, all values on the chart must be multiplied by the characteristic impedance of the system, 52 ohms in this case.)

When the load at the transmitter's

terminals is complex, i.e., some combination of resistance and reactance, the reactance will affect the tuning of the output network in the transmitter.

Every value of complex impedance can be shown to be simultaneously equivalent to either a resistance in series with a reactance, or a resistance in parallel with a reactance. Thus, there is a choice of using either a series or parallel reactance can be determined for a match to this value of resistive load. This value of X_{C2} is then combined with the required compensating reactance to obtain the final circuit value of X_{C2}.

The result of applying the above procedure to a pi-network designed for use with the 6146 linear amplifier is shown in **fig. 5. Fig. 5A** illustrates that when an 86-ohm capacitive reactance, X_{CL}, is

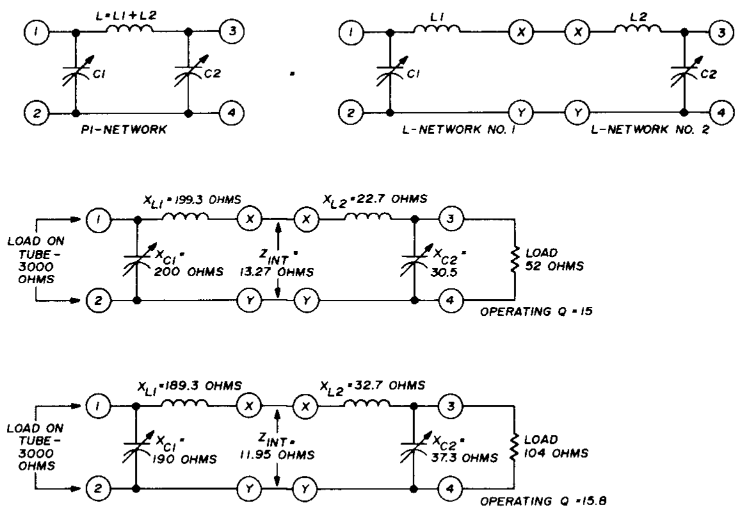

fig. 4. The inductor in the basic pi network consists of two theoretical parts, L1 and L2 (A). When operating into the design load of 52 ohms the operating Q is 15 and the intermediate impedance is 13.27 ohms (B). With a 104-ohm load (vswr = 2:1) the operating Q is 15.8 and the intermediate impedance is 11.95 ohms (C).

to tune out, or compensate for, the load reactance. However, the value of the compensating reactance, and the value of the resulting resistive load, are different in each case.

Thus, point 3 on the Smith chart, **fig. 3**, is a complex impedance consisting of a 41.6-ohm resistance in series with a 31.2-ohm inductive reactance; its parallel equivalent is a resistance of 65 ohms and an inductive reactance of 86 ohms. The parallel form is of special interest because C2 in the pi network is ideally situated to provide the required compensating reactance in addition to performing its normal function. Since the compensating reactance converts the load impedance into a pure resistance, values of X_{C1} and X_{C2} shunted across the parallel equivalent of the above complex lead the result is a pure resistance of 65 ohms. **Fig. 5B** shows the network of **fig. 4B** tuned for a load of 65 ohms resistive. **Fig. 5C** shows the final network values when X_{C2} is adjusted to include the compensating reactance. Note that the network's internal impedance is 12.6 ohms and its operating Q is 15.6. Thus, the capacitance of C2 had to be increased to supply the compensating reactance. If the load had contained a capacitive reactance, the capacitance of C2 would have to be decreased to achieve compensation.

In practice, the dual role of C2 is obscured by the ease with which the circuit can be adjusted. As long as normal rated plate current can be obtained the compensation takes place without the operator being aware of it. If it is found that the transmitter cannot be tuned for normal plate current, the vswr is probably in excess of that specified for the transmitter and the output network is unable to provide the required amount of compensation. The solution is either to revise the antenna system or to use some type of antenna tuner.

Figs. 4B, 4C and **5C** demonstrate that a pi network designed for a nominal load of 52 ohms resistive can be used with an antenna system on which the vswr is 2:1. In each case the network is tunable to provide a pure resistance load of 3000 ohms for the plate circuit of the tube, the internal impedance of the pi network is a pure resistance, and the deviation from the desired operating Q is minimal.

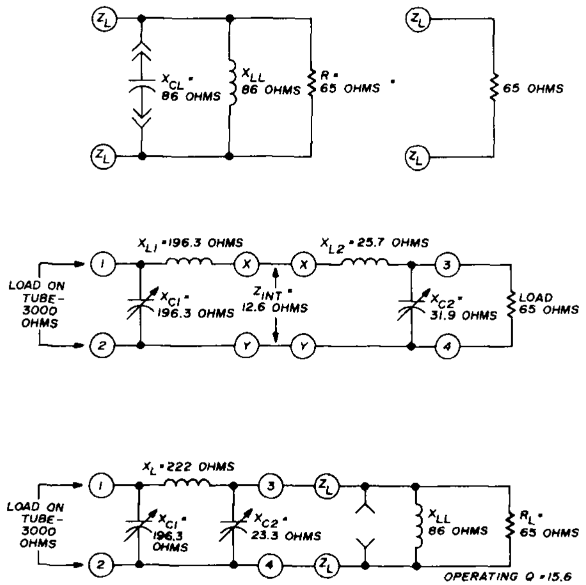

fig. 5. A capacitive reactance may be shunted across an inductive load to tune out the inductance, leaving a resistance of 65 ohms (A). The pi network of fig. 4 may be adjusted to match a resistive 65-ohm load (B). Final pi network reactance values, when C2 has been adjusted to include the compensating capacitive reactance, are shown in (C).

summary

Throughout this article the points of resistive impedance have been given special emphasis. When the experiments performed on the transmission line were discussed, the points of resistive impedance were significant because it was shown that reflected waves cease at these points. When the operation of the pi network was discussed it was shown that, for moderate values of system vswr, the network can always be tuned to produce the proper value of resistive load for the power tube and the intermediate impedance is always a pure resistance.

Whenever a pure resistance exists in a circuit, at that point power can flow in *only one direction*. Therefore, power must flow from the generator (or transmitter) toward, and into, the point of pure resistance. This is so because resistance is *strictly passive*. That is, it cannot reflect, and all of the power that flows into it must be absorbed. A resistive point in a circuit is no different than any other resistor in this respect. Therefore, you should not expect it to act any differently when it occurs in a transmission line system.

Thus, you can see that there is no way for power to return to the transmitter, and except for minor transmission line losses, the transmitter's power has no place to go except into the antenna, regardless of the presence of standing waves.

appendix

Standing waves on a transmission line are the result of a reflected voltage wave combining with (or interferring with) the forward voltage wave. Since the two waves are traveling in opposite directions at a constant velocity, the resulting rms voltage at any point on the transmission line will be constant and will depend upon the relative phase and amplitude of the two waves.

Locations of peak voltage will occur where the forward and reverse wave voltages are in exact phase and add together; in the same manner, voltage nulls will occur where the forward wave voltage and the reverse wave voltage are in exact opposite phase and the resulting amplitude is the difference between the two voltages. Peaks and nulls will be alternately spaced at one-quarter wave intervals (90 electrical degrees) along the transmission line with their number dependent upon the electrical length of the line.

The vswr is obviously the ratio of the voltage at peak to the voltage at a null and may be stated algebraically as

$$\text{vswr} = \frac{E_f + E_r}{E_f - E_r} \qquad (1)$$

where E_f is the voltage amplitude of the forward wave and E_r is the voltage amplitude of the reflected wave. **Eq. 1** can be rearranged, and if at the same time E_f is assigned a value of unity, a new expression is obtained

$$E_r = \frac{\text{vswr} - 1}{\text{vswr} + 1} \qquad (2)$$

The amplitude of the reflected wave voltage can now be expressed as a fraction of the forward wave voltage for any value of vswr. For example, if the vswr is 2:1, the reflected wave will be 1/3 the amplitude of the forward wave.

Transmission-line theory is frequently discussed in what is termed "the lossless case." The assumption is made that there is no loss in the dielectric material of the transmission line and no losses in the electrical conductors. Nevertheless, in the practical case losses do exist in both the dielectric and the conductors. However, if the system being considered is limited in length to a few wavelengths, and if the operating frequency is not above the high-frequency range, there is little error involved in assuming the losses to be zero and the discussion becomes much more manageable.

If the transmission-line losses are assumed to be zero, the product of line voltage and line current must be the same for any point on the line. It follows that to satisfy this condition of constant power, a standing wave of current must exist such that the current nulls coincide with the voltage peaks, and the current peaks coincide with the voltage nulls. Since impedance is the ratio of voltage to current, Z = E/I, it should be noted that high line impedance occurs at voltage peaks, and low line impedance occurs at voltage nulls. With a little further manipulation of the foregoing analysis the ratio of maximum impedance, Z_{max}, to minimum impedance, Z_{min}, may be expressed as a function of vswr

$$\frac{Z_{max}}{Z_{min}} = \text{vswr}^2 \qquad (3)$$

This ratio is 4 when the vswr is 2:1.

One quarter-wavelength (90°) sections of transmission line have the unique property of operating as impedance transformers when terminated in any impedance other than Z_o. Thus, the input impedance (Z_{in}) for any value of output impedance (Z_{out}) is readily found from

$$Z_{in} = \frac{{Z_o}^2}{Z_{out}} \qquad (4)$$

It is obvious that when Z_{out} is equal to Z_o the input impedance will be equal to Z_o and no impedance transformation will take place. It is also apparent that the input impedance will be a pure resistance only when the output impedance is a pure resistance.

references

1. Jones and Sontheimer, "The Micromatch," *QST*, April, 1947.
2. Marshall, "Antenna Matching with Line Segments," *QST*, September, 1948.
3. Geiser, "Resistive Impedance Matching with Quarter-Wave Lines," *QST*, February, 1964.

ham radio

frequency synthesizer

for two-meter fm

Although this all-channel two-meter frequency synthesizer was designed for the GE Progress Line, it may be used with other equipment

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One of the first things a newcomer to fm learns is that he never seems to have enough room in the rig for all the crystals he wants, or needs, especially when using obsolete commercial equipment. While he could go out and buy a commercial amateur transceiver, with multi-channel capabilities, there is a considerable price differential between these and surplus commercial equipment, not to mention that commercial equipment usually has a far better intermodulation figure than most of the amateur rigs currently available. This can be a very valuable asset in areas served by several repeaters that are not very far apart in frequency.

Obviously, to invest in a large number of crystals would be a financial hardship to the ham with a limited pocketbook, and hardly anyone would be interested in purchasing 100-plus crystals just to be able to cover all the available channel combinations, simplex and duplex. My aim in designing this unit was to have a low-cost unit with limited capability. This unit will only synthesize frequencies that are spaced at 30-kHz intervals starting at 146.01 MHz, which allows full coverage of the entire portion of the two-meter band which is available for repeater operation.

Naturally, this presents certain limitations, as in some areas there are still repeaters which are not on "standard" frequencies. But they are (fortunately) few and far between. In a situation like this, the synthesizer could be used to drive one channel of a two-frequency rig, and the special crystals could be installed in the other channel.

Synthesizers have been covered in quite great detail in recent months in various publications, so I refer you to the articles mentioned in the reference list at the conclusion of this article.

While I designed this unit for use with the GE Progress Line equipment, it can be modified to operate with other commercial equipment such as Motorola, RCA, etc. I would be glad to assist anyone interested in adapting the unit to other equipment if they will send me full details of what they want to do, as well as the multiplication factors of the receiver and transmitter and the receiver first i-f frequency, etc., along with a stamped, self-addressed envelope.

To permit rapid channel switching, channel selection is accomplished by means of a 24-position, 10-deck rotary switch, in conjunction with small diode matrices, which are used to convert the binary-coded decimal (BCD) numbers required by the programmable dividers into their decimal values. While this involves considerable wiring at the switch, it also makes operation much simpler, as changing channels only requires a twist of the wrist, as would be compared to some similar circuits which would require setting 6 to 8 thumb-wheel switches. Again, some versatility is sacrificed, but there is a way out of this which I will discuss later.

The 10-deck switch is in reality, two 5-deck switches on a common shaft. A second *band* switch, a 6 pdt rotary switch, selects either one or the other bank of five decks, depending upon whether the frequency desired is above or below 147.00 MHz. In this manner, 24 possible combinations are available in either bank, each covering a full MHz. A dual set of channel markings is provided on the front panel, one set for Band A, the other for Band B. You could simply eliminate all frequencies above 147.00 MHz, and use a 5-deck switch (which would also eliminate the other band-switch) as you would have to retune the transmitter at least in order to operate over the frequency spread that the synthesizer is capable of. The receiver will operate reasonably well over a wider range than the manufacturer specifies, however. A base-station operator might wish to retain the full coverage so he can take advantage of possible DX openings.

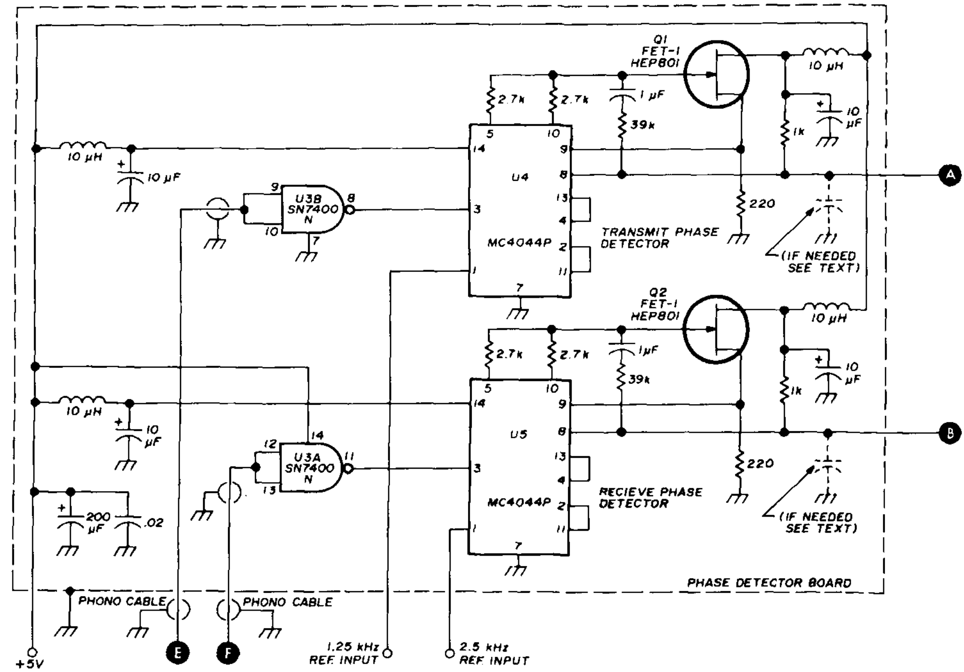
Whenever possible, I used low-cost general-purpose replacement type transistors to eliminate any problem of procuring replacements (these items can be obtained in most any radio/tv supply house in the country). All ICs used were of the lowest cost types available at this time, and can be obtained from most of the specialty houses dealing in these items at very nominal cost.

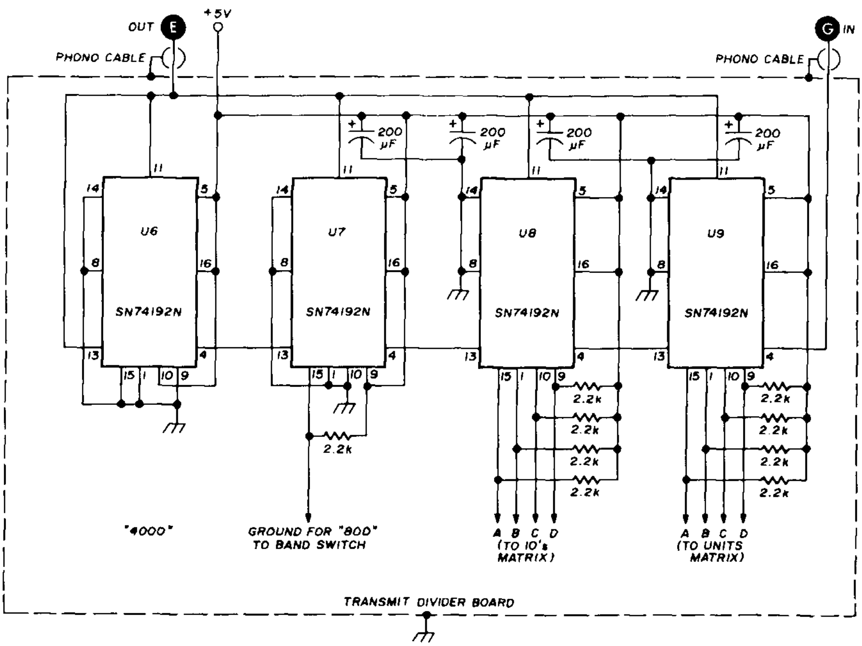
circuit description

The programmable dividers are made from SN74192N decade up/down counters, wired in a modulo n configuration. These divider ICs have a parallel load capability, which allows you to enter a certain count, and then count down to zero, whereupon, an output will be generated and the number will again be reentered into the dividers.

The number is entered in BCD form, as was mentioned previously, which is derived from diode matrices. Note that only the units and 10s of the numbers to be entered require the matrices, as the 100s only change at infrequent points during the coverage of the 2-MHz segment. The 1000s never change and are coded directly at the PC board. The coding of the 100s occurs at two decks of the channel switch.

For those readers not acquainted with BCD numbers, each of the dividers is provided with a parallel input lettered A, B, C and D which correspond to the BDC numbers 1, 2, 4 and 8, respectively. If we were to connect the A input to a 1 voltage (more than approximately +2.0 V), the divider would preset to the count of 1; if we wanted to encode the number 7, we would connect the A, B and C inputs to 1, etc. All other inputs are connected to zero (less than 0.8 V) or grounded. Of course, we would also have to apply the proper signal to the load control lead from this package before we could enter





C1	10 pF, N750
C2	20 pF, N750
CR1,CR2	22-pF varicap (TRW PC-116)
L1	24 turns no. 24 enamelled on Millen 69041 slug-tuned form
L2	10 turns no. 24 enamelled on Millen 69041 slug-tuned form
L3,L4	turns as required on Millen 69041 slug-tuned form (see text)
C_A,C_B	temperature-compensating capacitors (see text)
C_T	0.8 to 11 pF piston capacitor (JFD NVC9G)
X1	5-MHz crystal (International Crystal HA-1)

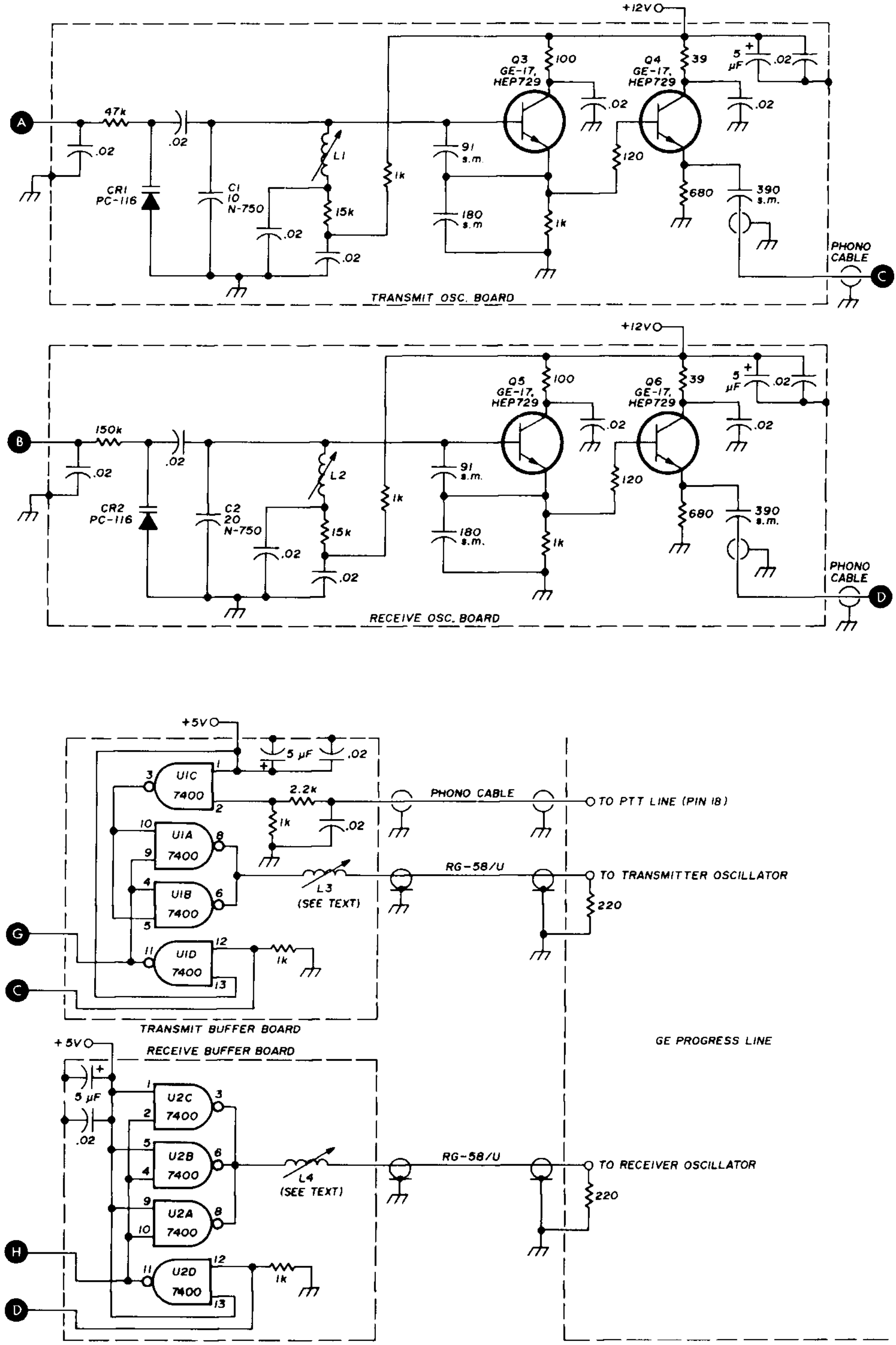


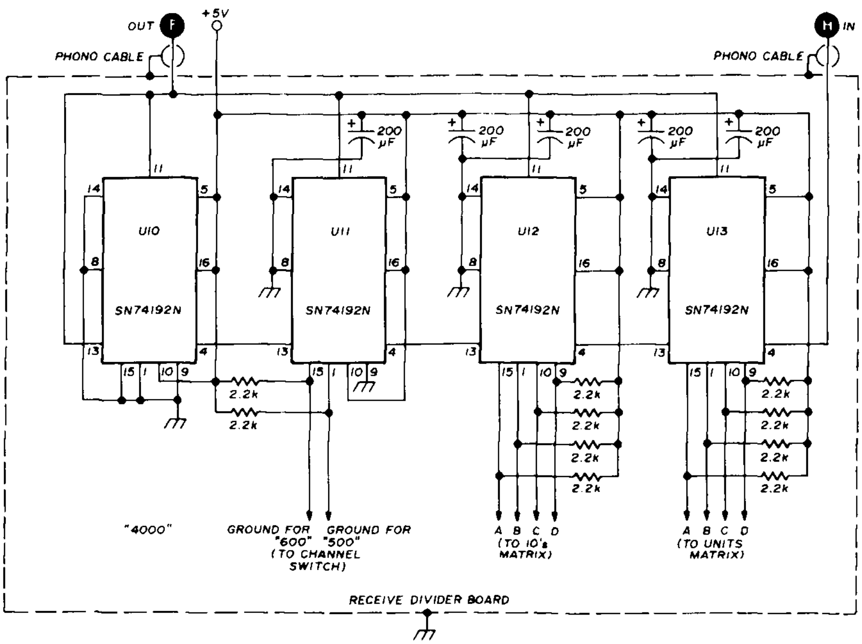
fig. 1. Circuit diagram for the two-meter transmit and receive synthesizer. This unit covers the entire two-meter fm band in 30-kHz steps, starting at 146.01 MHz. The 10-μH rf chokes are J.W. Miller type 9340-20. L1-4 are James Millen type 69041. L1 is 24 turns no. 24 enameled wire. L2 is 10 turns no. 24 enameled wire (scramble wound). Schematic for receiver divider board is on the next page.

the numbers. The load lead requires a zero to enter the data.

Each package has two clock inputs and two outputs marked count up, count down, carry and borrow. In this particular application we are only going to count down. The rules for using this IC require that the unused clock input be connected to 1 voltage. The carry output is not connected to anything in this particular application.

when an output occurs at its borrow, toggling the second divider in the chain one time. The first divider continues to count down 9,8,7, etc., until zero is reached again, and the second divider is again toggled. As you will note, the divider is working as a decade divider after it counts down the initial 6 of our number 4866.

This process continues until the second divider has counted down from



Schematic for the receiver divider board. Circuit points F and H are connected to the circuit in fig. 1, shown on the preceding pages.

Note that all the load inputs are connected to the *borrow* of the last (most significant number) divider. It happens that whenever an output occurs from the *borrow* the output changes from 1 to zero. It becomes apparent then that every time an output occurs from the divider chain the same signal is applied to all the parallel load leads re-entering the number into the dividers.

Suppose we take a short-cut and say we already have the number 4866 entered in our dividers. Now we apply clock pulses to the first count down input and the divider counts down, "6,5,4,3,2,1,0,"

the initial 60 it was coded with, indicating we have counted the 66 part of our original number, where the second divider also now acts as a decade divider in conjunction with the first divider to divide by 100 which will toggle the third divider in exactly the same fashion until the total number 4866 is reached, whereupon an output will occur at the borrow of the last divider in the chain. This causes the number to be re-entered into all the dividers again though the action of the output signal also being applied to the load leads of each package.

However, one little problem slips in

here, but it's quite simple to solve. Note that the dividers don't toggle on the negative transition of the clock pulse or the borrow pulse, but on the positive transition, meaning that the total count is short-changed by almost a full clock pulse. Note that as soon as the borrow occurs (not at the end of the borrow as is occuring between the sections of the dividers) the new number is re-entered into the dividers again. As soon as this number is reentered, the output obviously cannot any longer be zero because the number 4 has just been entered. So instead of getting an output pulse that is equal in length to one cycle of the input frequency (about 166 nanoseconds at 6 MHz) the output pulse is shortened to something on the order of 5-10 nanoseconds – the switching time of the TTL logic, and counting starts immediately instead of at the end of 166 nanoseconds as would be the case if you were using the more expensive modulo n dividers such as are manufactured by Motorola.

The solution to this problem is quite simple. We merely say that, instead of counting by 4866, we actually counted by 4867. The net result is that the frequency error is quite minute if we simply deduct one number from the division ratios that we calculate (the tables accompanying this article take this into account), and we end up with modulo-n counters at about one-half the price of devices intended specifically for this purpose.

Note that all the inputs that will require programming are connected to 1 via resistors. Those inputs that never change are connected to either zero or 1 directly at the PC board, as is appropriate in each instance. By shorting the inputs that go to 1 to ground (via resistors) through paths developed within the diode matrices or the bandswitch and channel switch, you can program the dividers for any count, within certain limits. The count can be programmed for considerably further range than is listed in the tables, however, if desired.

Since the basic crystal frequency of the GE Progress Line transmitter is in the 6-MHz range, and is multiplied by 24 to the output frequency, you can determine the required division ratio for the divider by dividing the desired output frequency by 24, and then by the reference frequency (1250 Hz in the case of the transmitter) remembering to subtract one count from the answer as explained above. After working out a few of these it becomes apparent that the reference frequency is related to the channel spacing (1.25 kHz x 24 = 30 kHz).

The same procedure is used to determine the division ratio required for the receiver divider, bearing in mind that the multiplication factor is only 12 in this case and subtracting the first i-f frequency from the desired receive frequency before dividing by 12. This figure is then divided by the reference frequency which in the case of the receiver is now 2.5 kHz (2.5 kHz x 12 = 30 kHz). Don't forget to deduct the one count from the final answer here, also.

The output of each programmable divider is buffered through a TTL gate to eliminate any possible transients that may appear in the output signal which are below the threshold level of the gate but which might affect the action of the phase detector. Large value capacitors are provided liberally on the PC boards to help reduce transient amplitude which could alter the total count.

phase detectors

Phase detector circuits are provided for each of the programmable dividers, and their associated vcos. External components must be added to provide an active low-pass filter circuit which is tailored to the referency frequency, the maximum number of divider steps (loop sensitivity), the maximum lockup time desired, and the maximum permissible overshoot. To go into the math for the design of these filters would be beyond the scope of this article and the interested reader is referred to Motorola Application Note AN-535. The use of a fet transistor rather than a bipolar type in the low-pass filter circuit makes the filtering easier to accomplish as the time constants of the associated R-C components are not affected as badly by the relatively high gate impedance of the fet.

Notice that the circuit provides for rf decoupling in the supply leads to both the active filters and phase detectors. This is required to prevent the steep wave front of the reference and output signals from the dividers from pulse modulating the resulting dc control voltage which is being obtained from the phase detector circuit and which would also modulate the vcos in turn.

voltage controlled oscillators

The vcos are conventional Colpitts design, with a single transistor buffer stage. Frequency variation is accomplished by applying the voltage derived from the phase detectors to a varicap diode wired into the tank circuit. Isolation of the rf is adequately provided by a series resistor to this diode, which also serves the purpose of limiting the swing of the oscillator, as the diode will be somewhat self-biased by some rectified rf from the oscillator tank circuit. This requires that the applied control voltage be *raised above* this value before any appreciable change in capacitance can occur.

The chosen L/C ratios for the two oscillators cover the required frequency spread by about a ratio of 2:1, ensuring that adequate margin will exist in the event that the oscillator changes frequency due to changes in temperature, but when corrected by the output from the phase detector, will still be within the range of that circuit. Some frequency stability is imparted by the parallel padding capacitors in each tank circuit. However, this could probably be improved somewhat if the builder has available N-1500 type capacitors instead of the specified N-750 types. The oscillators operate from 12 volts, and are ac coupled to the following logic buffer stages. The two oscillators are identical in construction, with the exception of the

table 1. Division ratios for standard repeater pairs and simplex pairs. (Channel 22 of group A, and channels 20, 21, 22, 23 and 24 of group B are spares.)

switch pos	xmit freq (MHz)	receive freq (MHz)	xmit xtal frequency (kHz)	xmit divisor	rcv xtal frequency (kHz)	receive divisor
group A						
1	146.01	146.61	6083.75	4866	11492.5	4596
2	146.04	146.64	6085.00	4867	11495.0	4597
3	146.07	146.67	6086.24	4868	11497.5	4598
4	146.10	146.70	6087.50	4869	11500.0	4599
5	146.13	146.73	6088.75	4870	11502.5	4600
6	146.16	146.76	6090.00	4871	11505.0	4601
7	146.19	146.79	6091.25	4872	11507.5	4602
8	146.22	146.82	6092.50	4873	11510.0	4603
9	146.25	146.85	6093.75	4874	11512.5	4604
10	146.28	146.88	6095.00	4875	11515.0	4605
11	146.31	146.91	6096.25	4876	11517.5	4606
12	146.34	146.94	6097.50	4877	11520.0	4607
13	146.37	146.97	6098.75	4878	11522.5	4608
14	146.40	146.40	6100.00	4879	11475.0	4589
15	146.43	146.43	6101.25	4880	11477.5	4590
16	146.46	146.46	6102.50	4881	11480.0	4591
17	146.49	146.49	6103.75	4882	11482.5	4592
18	146.52	146.52	6105.00	4883	11485.0	4593
19	146.55	146.55	6106.25	4884	11487.5	4594
20	146.58	146.58	6107.50	4885	11490.0	4595
21	146.70	146.70	6112.50	4889	11500.0	4599
22	-	-	-	-	-	-
23	146.94	146.94	6122.50	4897	11520.0	4607
24	147.00	147.60	6125.00	4899	11575.0	4629
group B						
1	147.03	147.63	6126.25	4900	11577.5	4630
2	147.06	147.66	6127.50	4901	11580.0	4631
3	147.09	147.69	6128.75	4902	11582.5	4632
4	147.12	147.72	6130.00	4903	11585.0	4633
5	147.15	147.75	6131.25	4904	11587.5	4634
6	147.18	147.78	6132.50	4905	11590.0	4635
7	147.21	147.81	6133.75	4906	11592.5	4636
8	147.24	147.84	6135.00	4907	11595.0	4637
9	147.27	147.87	6136.25	4908	11597.5	4638
10	147.30	147.90	6137.50	4909	11600.0	4639
11	147.33	147.93	6138.75	4910	11602.5	4640
12	147.36	147.96	6140.00	4911	11605.0	4641
13	147.39	147.99	6141.25	4912	11607.5	4642
14	147.42	147.42	6142.50	4913	11560.0	4623
15	147.45	147.45	6143.75	4914	11562.5	4624
16	147.48	147.48	6145.00	4915	11565.0	4625
17	147.51	147.51	6146.25	4916	11567.5	4626
18	147.54	147.54	6147.50	4917	11570.0	4627
19	147.57	147.57	6148.75	4918	11572.5	4628

changed circuit values of the tank components and the series resistor to the varicap diode.

logic buffer stages

A quad two-input gate is used to provide direct coupling to the GE unit and the logic divider stage. One section is used as a buffer between the vco and the dividers, and also drives the inputs of two gates wired in parallel that are used as the output buffers to drive the GE unit. Note that by ac coupling the output of the oscillator stage in the synthesizer to this gate, the gate can only respond to that portion of the sine wave output of the oscillator that is 0.8 volt above the zero axis of the ac signal. Consequently, the rise and fall times of the output of the gate are more than adequately fast enough to drive the divider stages without the need of a Schmitt trigger or other pulse-forming device (approximately 40 nanoseconds rise/fall time as measured on a Tektronix 513D scope).

The output from the paralleled gates is fed to the GE unit through a length of coaxial cable. The length is not especially critical, as I tried lengths up to 15 feet and still obtained adequate drive for the multiplier stages, even though the end of this line was terminated in a 220-ohm resistor.

The two buffer stages are essentially alike in their function, although the receiver buffer has three gates tied in parallel, and the transmitter buffer only two, as I wanted to use one gate section as an inverter. Note that the unused inputs to the gates in the transmitter buffer are not returned to +5 volts as they are in the receiver buffer, but are connected to the output of this inverter stage. The input of this inverter is connected to the line running between the transmitter push-to-talk relay and the microphone switch contacts. When the push-to-talk button is released, approximately +12 volts* appears on this line, driving the output of this gate to zero, which disables the two buffer gates. During transmitter operation this same point is at ground and consequently the output of the inverter is at 1, which enables the buffer gates. Since it only controls the buffers and doesn't interrupt the path between the output of the vco and the dividers, no frequency searching occurs when going from transmit to receive. This suppresses the output of the transmitter oscillator signal to a level below the internal noise level of the receiver strip so as not to interfere with weak-signal reception.

This was ascertained with a narrow-

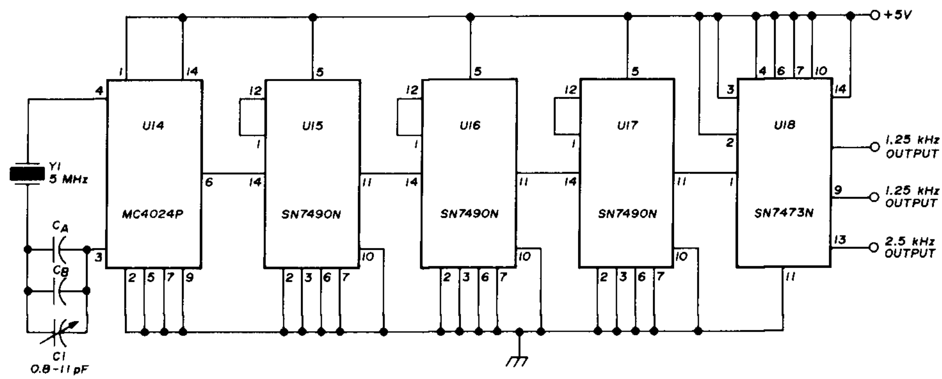


fig. 2. Crystal oscillator reference generator board.

*Some GE Progress Line equipment uses the -22 volt bias supply to operate the relays. In this case connect the center pin to the cathode of the 6AQ5 audio output tube in the receiver instead of connecting it to pin 18 of the Jones connector.

band receiver strip that was carefully checked for sensitivity and found to be somewhat better than the original specifications for this strip. However, the addition of a preamplifier would probably change the entire picture, and it would probably become necessary to supply transmit excitation through a coaxial relay keyed along with the transmitter relays. Good shielding will help in this instance more than any other technique.

match to the logic and also act as a rudimentary low-pass filter.

construction details

The printed-circuit boards are stacked to provide as compact a package as possible. With the arrangement shown, all the ICs can be replaced without the necessity of dismantling anything. It is most important that the two oscillators and their two buffers be mounted in as rf

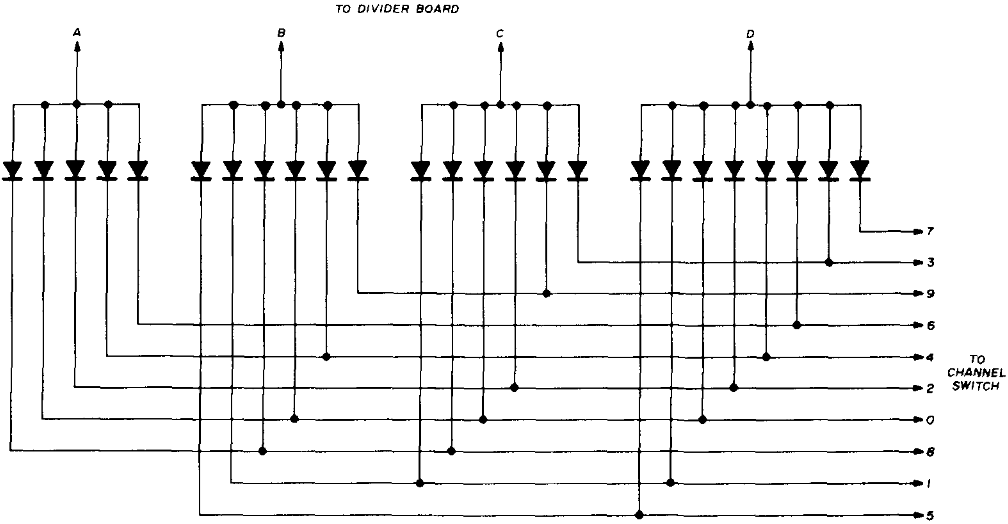


fig. 3. One-half of each diode matrix. All diodes are germanium types with a forward current rating of 10 mA, PIV = 10 volts (minimum).

Of course, this presents no problems when operating duplex as the synthesized transmit frequency is considerably removed from the receiver frequency. If only this type of operation is contemplated the additional circuitry can be deleted. I originally tried tank circuits at each end of the feed line in an attempt to improve the waveform and consequently, reduce the harmonic content. However, the additional complexity of the circuit was considerable as additional drive requirements would have to be provided to make up for losses in all these additional inductors. I feel that the simplicity of this circuit far outweighs any disadvantage it may incur. The small inductors wired in series between the end of the coax and the buffers provide a better impedance

tight a package as you can possibly make! Any coupling between the two oscillators will result in spurious outputs due to the fact that the mixing of the two signals will produce sidebands at intervals of 312.5 and 412.5 kHz when operating on repeater pairs spaced at 600 kHz. These spurious outputs will be treated by the transmitter as modulation components due to their equal spacing from the synthesized frequency, and will be multiplied, and appear in the output at the same spacing!

Bear in mind that an fm transmitter, although it multiplies the carrier and the sideband frequencies an identical amount, also causes the modulation index to increase with each multiplication. Consequently, the spurious outputs still appear at the output. However, these that are apparent are the offspring of the original pairs since multiplication causes additional side frequencies to appear which will be spaced at the same intervals from the carrier as the original pairs were.

The compartment for the two oscillators was made from sheet copper bent into a channel shape to form the sides, and has an internal divider also made of sheet copper, and top and bottom made of PC board. Input power leads, vco control leads, etc., are bypassed immediately inside the compartment. Each oscillator has its own separate power leads. This is also most important to prevent mixing of the two rf signals. The buffer stages are treated in the same manner. However, in this case I constructed the shielded compartments entirely from copper clad PC board, soldering the sides and bottom entirely, and then lining the openings with Eimac finger stock. A rectangular shaped piece was then formed from a strip of ¼-inch wide copper strap, which was made a tight press fit into the opening.

The edges of these pieces were then soldered to lids made from PC board to complete the installation. The circuit boards that are installed inside these compartments are soldered to the sides of the compartment using small no. 6 solder lugs bent at right angles to reinforce the solder joint. Leads are then run from the boards to the appropriate terminal connections on the wall of the enclosure.

This type of construction is most necessary at these points to prevent rf from the output of the transmitter from being re-amplified which would cause hum, excessively wide bandwidth of the transmitter output, audio distortion, etc. The series inductors that I mentioned earlier in the discussion of the buffer stages also help to some extent to decouple the rf path that would otherwise exist on the center conductor of the coax. BNC connectors were used extensively here, which also helps in this regard.

Good quality phono connectors such as the Switchcraft 3502 plugs and 3501FP jacks are a good choice for the reference leads going from the buffer compartments to the programmable dividers. These plugs are completely shielded, and the jacks only require a single ¼-inch hole for mounting.

Notice that the 24-position channel switch is mounted directly to the two matrice boards (front two boards) that contain the four diode matrices. This provides for very short leads here (not really a necessity here as only dc paths are located here) which makes for a neater layout. The front board contains the two matrices for encoding the units of the receive and transmit dividers, the board immediately to the rear of this contains the two matrices for encoding the receive and transmit 10s of the dividers, and the board next to the rear of that position is the transmit divider board. To the rear of that board is the receive divider board, the phase-detector board, then the compartments housing the two oscillators, and lastly, the compartments housing the buffers.

The diodes used in the matrices are germanium types to permit remote location of the channel switch if desired, as this would allow for almost 0.5 V drop across the interconnecting wiring. This type of diode is recommended in all cases to provide margin for error, and to allow future additions to the equipment. This would permit the synthesizer to be trunk mounted in a mobile installation with just the channel switch mounted at the dash in a Minibox.

Not included in my rig are the timebase and power supply boards, which were not used with this particular unit as the reference and supply voltages were obtained from a frequency standard that was already in the shack. However, I have included the necessary information for building these boards. The crystal oscillator board and its dividers can be mounted to the left of the stack of boards so the trimmer capacitor would be accessible from the front panel through a small opening. The power supply board can be mounted on the righthand side or wherever is most convenient to the constructor.

The oscillator board uses the Motorola dual-vco package (only one-half used) as the crystal oscillator circuit. This makes construction quite simple as the only external components required are the crystal, trimmer capacitor and a temperature compensating capacitor. A high quality crystal is recommended here, as the output frequency stability of the synthesizer can never be any better than the stability of the reference frequency. The International type HA-1 crystal is recommended for this purpose. It should be ordered for room temperature, 12-pF parallel load for this circuit (HC6 type holder).

For mobile use an oven and suitable oven-type crystal would be required, especially in northern climates. The oscillator is then followed by three decade dividers, whose output is divided by two by the first section of a dual J-K flip-flop, yielding the 2.5-kHz reference output. This is then again divided by two by the other half of the flip-flop producing the 1.25-kHz reference output.

Due to variations in crystal and component tolerances and characteristics, the determination of the fixed temperature compensating capacitor is left to the builder. As a start, set the trimmer to approximately half capacity and install a 10-pF N-750 capacitor on the pads provided (CA). Tune in WWV (at the highest frequency possible) and attempt to zero beat the oscillator to WWV's signal by adjusting the trimmer. It may be necessary to add or subtract some capacitance from CA in order to get the oscillator in the proper range of the trimmer. Once in zero beat, hang a 100-watt lamp a foot or so above the board and allow the board to be warmed by this for about an hour.

Unless you are extremely lucky, the oscillator should no longer be in zero beat with WWV. Carefully noting which way you have to turn it, adjust the trimmer to bring the oscillator back into zero beat again. If you had to turn it clockwise (more capacitance) then the oscillator is over-compensated. Remove the capacitor from CA and install one of half that value (still type N-750) and in addition, install another capacitor of the same value at CB (type NPO) and repeat the test. If, after the initial test, you instead had to turn the capacitor counter-clockwise (less capacitance) the oscillator was not sufficient-

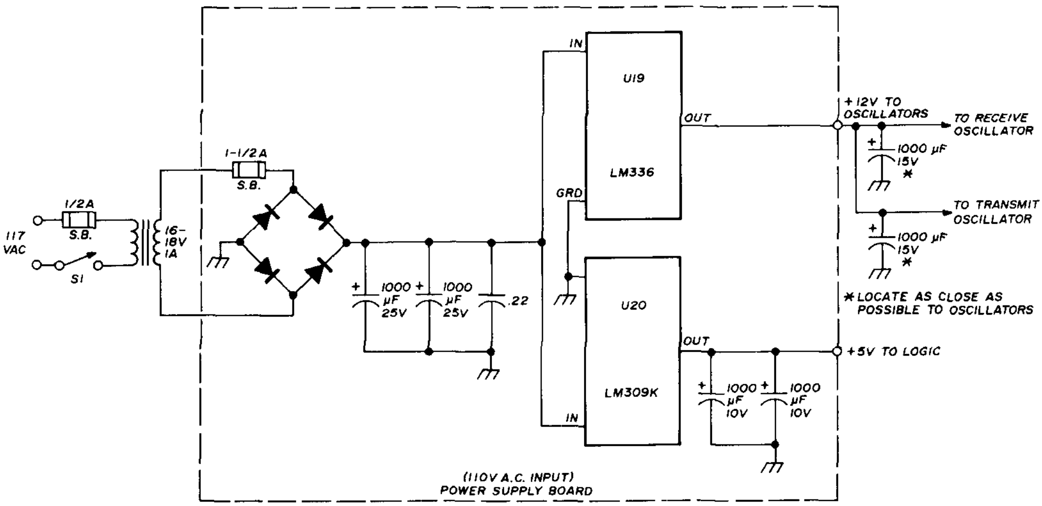


fig. 4. Ac power supply for the frequency synthesizer. Transformer T1 is a control or doorbell transformer with 16 to 18 volts output across the secondary.

ly compensated. In this case install a N-1500 type capacitor as a replacement for the original N-750 type and again repeat the test. (The circuit board should be permitted to cool between tests so as not to give meaningless indications.) By using various ratios of capacitance at CA and CB (the former being either N-750 or N-1500, the latter NPO) any intermediate value of compensation can be obtained.

power supply

The power supply is quite simple, using two self-contained, protected ICs to provide the regulated outputs. The power transformer can be a doorbell transformer or control transformer with 16-18 volts output at 1 amp. This output is rectified by a bridge circuit and applied to the two regulators. A fuse is provided in the secondary (as well as the primary) in the unlikely event of a short in one of the rectifiers or ICs. The 5-volt regulator is a National Semiconductor LM-309K (in a TO-3 case). The 12-volt regulator can be either the National LM-336 (in TO-5 case) or the Fairchild μA7812 (TO-220 case). For mobile use, the 12-volt regulator is deleted, the 12-volt battery is applied directly to the 5-volt regulator input, and also to a simple shunt zener diode regulator operating at 10-volts. (This will require readjustment of the oscillators with the lower supply voltage, however.) The output from the zener regulator is additionally filtered through four 88-mH toroids wired in series.

If PC board layouts shown* are used, the construction of the boards is just a matter of mounting parts. It is strongly recommended that you use IC sockets on all the boards (as well as transistor sockets in the two oscillator boards) to make changing of defective ICs and transistors simple, as some of the PC board wiring is quite minute and could easily be damaged by repeated soldering and unsoldering of components. Also, in the oscillator compartments, the sockets would eliminate the need of unsoldering the small printed-circuit boards from the enclosure if a transistor becomes defective. After all the boards are mounted, solder a heavy braid from each board to the next with as short a lead as possible.

All cables that are indicated as shielded on the schematic diagram should be RG-58/U coax unless otherwise indicated. Both ends of the cable shield must be grounded to the nearest ground point and the inner conductor should be as little exposed as possible. Note that all power and control leads leaving or entering the vco and buffer shielded compartments must be bypassed immediately within the compartment with 0.02-μF disc capacitors with the shortest possible leads, soldered directly to the copper surface of the compartment. (The small electrolytic capacitors indicated are also mounted in a similar fashion.) The power and control leads were made through miniature pin jacks to make it easy to disconnect a sub-assembly for repair or testing. Feedthrough capacitors could also be used in lieu of these but would require that the leads be unsoldered to disconnect it from the rest of the wiring.

synthesizer adjustment

After completing construction, connect the logic circuits to the output of the 5-volt supply with a milliammeter inserted in series (0-1 amp range). Note the current, which should be between 450-550 mA for the logic circuits, exclusive of the crystal oscillator and divider board. If it is more or less than this range you have either a defective IC or filter capacitor or something that isn't connected. If this checks ok, connect the oscillators to the 12-volt supply with a series milliammeter (0-100 mA scale) and note the current here, which should be 30-40 mA (both oscillators). If all checks well to this point, connect a voltmeter (20,000 ohm/volt or vtvm) from the vco control line to the receiver oscillator (and to ground) and turn the channel switch to

*Full-size templates of the original prototype printed-circuit boards are available from the author along with additional schematics and parts placement diagrams for $1.00 postpaid.

the highest receive frequency (refer to the chart, as the highest receive frequency is not necessarily the highest switch position) and adjust the slug in the receive oscillator coil form (L2) for a reading of 3.8-4.0 V (use the 0-10 volt scale). Then turn the channel switch to the lowest receive frequency and note the meter reading, which should be between 2.5-3.0 volts. If outside these limits, the L/C ratio of the oscillator tank circuit must be adjusted, since this indicates that the oscillator control sensitivity is not correct.

If the voltage is too high, add more parallel padder capacitance to the tank circuit and reduce total inductance. Repeat the adjustment procedure until the voltage falls within these limits. If the voltage is too low, remove some of the parallel padder capacitance and increase the inductance.

Repeat this procedure for the transmit oscillator (L1), checking at the transmit vco control lead. This is probably locking the barn door after the horse has strayed, but I hope you read all the instructions before starting on this project. The oscillator compartments should be provided with access holes for adjustment of the coil slugs. Do not remove the compartment covers to make this adjustment. The coil forms should not be mounted to the exterior wall of the compartment and the threaded shank should be used to make the adjustments.

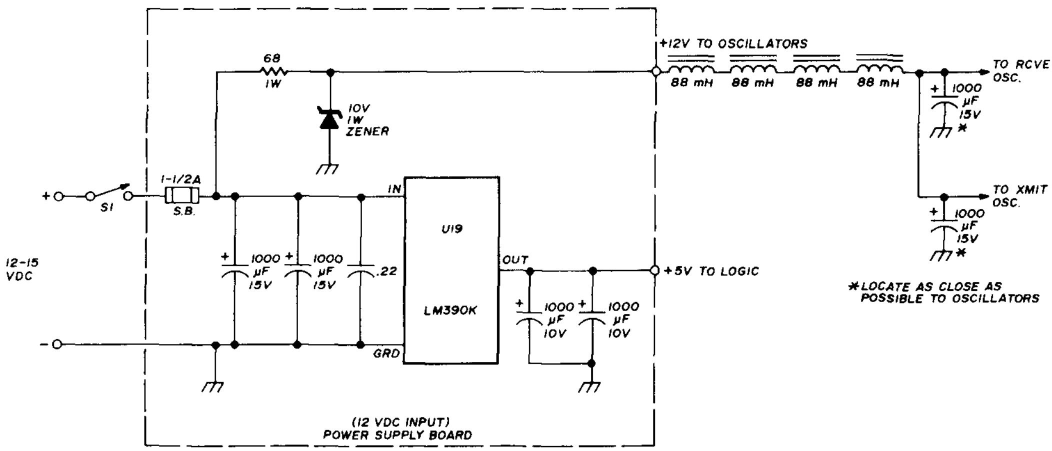


fig. 5. Alternate dc power supply for 12 to 15 Vdc input.

troubleshooting

If the voltage stays at or near zero or +4.8 volts, some problem exists in the loop circuits. This can be caused by any number of interrelated problems such as no reference input to the phase detector, no input to or output from the programmable dividers, improper operation of oscillators or buffers, or oscillator frequency so far removed from the desired frequency that the loop cannot make the necessary corrections. Obviously, some troubleshooting will be required here and a good oscilloscope will be quite useful.

Check to see if the oscillators are actually operating near the desired frequencies by listening for their outputs on a general-coverage receiver. The oscillators should, with the vco control lead disconnected, be operating about 200 kHz below the lowest frequency in the list. Generally speaking, a reading of +4.8 volts on the vco control lead indicates that there is no input from the programmable dividers to the phase detector (or no input to the dividers from the buffer stage, etc.) or the oscillator is tuned too low in frequency.

A reading of zero (or nearly zero)

indicates that there is no input to the phase detector from the reference frequency source, or that the oscillator is tuned too high in frequency. A general-coverage receiver is handy at this point to determine if there is any output from the oscillators at all or any output from the buffer stages.

Once you have determined that the oscillators are working and the loops are locking, tune in the output frequencies on a general-coverage receiver and, with the bfo turned on, note whether the tone is stable and reasonably pure. (Don't overload the frontend of the receiver as this will give erroneous results. Keep the rf gain control turned as low as possible while making this test.)

interconnections

Once you have determined that the synthesizer is working correctly, the next step is to make the necessary connections to the GE unit. Begin by installing a phono jack on the front panel as near to the receiver oscillator crystal socket as possible. Attach one of the ends of a short piece (6 to 8 inches) of RG-58/U coax to this jack, and install a suitable plug on the other end that will mate with the crystal socket. (A suitable plug can be made from a defunct FT-241 crystal holder. Some radio/tv supply houses carry a twin-lead plug that also has the correct dimensions.) Solder a 220-ohm resistor across the plug, too.

The grounded side of the plug should go in the crystal pin hole that is nearest the right-hand edge of the receiver chassis (when looking from the front). Install a known, good crystal and measure the multiplier voltage at the jack provided on

table 2. Channel switch connections for programming per table 2. Column heading AT indicates group A, transmit; BT: group B, transmit; AR: group A, receive; BR: group B, receive.

switch pos	Deck 10 units AT	Deck 9 units BT	Deck 8 units AR	Deck 7 units BR	Deck 6 10s AT	Deck 5 10s BT	Deck 4 10s AR	Deck 3 10s BR	Deck 2 100s AR	Deck 1 100s BR
1	6	0	6	0	6	0	9	3	5	6
2	7	1	7	1	6	0	9	3	5	6
3	8	2	8	2	6	0	9	3	5	6
4	9	3	9	3	6	0	9	3	5	6
5	0	4	0	4	7	0	0	3	6	6
6	1	5	1	5	7	0	0	3	6	6
7	2	6	2	6	7	0	0	3	6	6
8	3	7	3	7	7	0	0	3	6	6
9	4	8	4	8	7	0	0	3	6	6
10	5	9	5	9	7	0	0	3	6	6
11	6	0	6	0	7	1	0	4	6	6
12	7	1	7	1	7	1	0	4	6	6
13	8	2	8	2	7	1	0	4	6	6
14	9	3	9	3	7	1	8	2	5	6
15	0	4	0	4	8	1	9	2	5	6
16	1	5	1	5	8	1	9	2	5	6
17	2	6	2	6	8	1	9	2	5	6
18	3	7	3	7	8	1	9	2	5	6
19	4	8	4	8	8	1	9	2	5	6
20	5	spare	5	spare	8	spare	9	spare	5	spare
21	9	spare	9	spare	8	spare	9	spare	5	spare
22	spare	spare	spare	spare	spare	spare	spare	spare	spare	spare
23	7	spare	7	spare	9	spare	0	spare	6	spare
24	9	spare	9	spare	9	spare	2	spare	6	spare

the chassis with a 20,000 ohm/volt meter set on the 0-2.5 V scale. Note this reading. Remove the crystal and connect the plug from the synthesizer instead, and again note the reading. It should be nearly the same or higher.

Adjust the series inductor in the buffer compartment (L4) to obtain the highest possible reading and tune the synthesizer to a channel that is in use. Observe if the audio output from the receiver is distortion free and if there is anything more than just the slightest trace of the 2.5-kHz reference frequency apparent. (If everything is working correctly you should only be able to hear, and then just barely, the reference frequency with receiver gain wide open when listening to a strong unmodulated carrier.)

If an objectionable level of reference frequency is apparent it is probably due to insufficient shielding of the oscillator in the synthesizer, or of the buffer stages, or insufficient bypassing of the supply and control leads. It is possible, but not very likely, that the components used in the phase detector are incorrect in value. However, there is quite a bit of leeway here, and the values would have to be drastically different from those specified to cause this. In some instances, adjustment of the series inductor in the buffer compartment will reduce the amplitude of the reference-frequency trace and should be tried first. However, after the final adjustment you should still have adequate meter indication at the multiplier test jack.

Assuming that the receiver is now working correctly, install a BNC connector on the front panel of the GE unit as far to the left as possible from the jack installed for the receiver. This should be a bulkhead-type connector so that the cable shielding is uninterrupted. Attach an 18-inch length of RG-58/U cable to this connector and install a phono plug on the other end. Route this cable down the left-hand edge of the receiver chassis, around the rear of the receiver to the left-hand corner of the transmitter chassis. There is just enough room in the left rear corner of the transmitter chassis to mount a phono jack. From the center pin of this jack, run a short stiff wire to the grid of the **A** oscillator tube (single-channel versions) or a short length of miniature coax to the grid of the **B** oscillator tube (two-frequency versions). Wire a 220-ohm resistor across the existing 100k grid resistor. For best results it is strongly recommended that you convert the oscillator tube to an amplifier by bypassing the screen and cathode of the tube with .02-μF disc capacitors.

If you only have a single-channel rig it is suggested that you convert it to a two-frequency version for this application. You don't need any special parts such as trimmers or temperature compensating capacitors if it's only going to be used as an amplifier, and this will leave the **A** channel available for crystal operation if so desired. In the two-frequency version, the screen lead of the **B** oscillator should be disconnected from the screen lead of the **A** channel oscillator tube socket, and then connected through a 47k resistor to the B+ point. This will prevent the added bypassing at the screen and cathode of the **B** oscillator from bypassing the **A** oscillator as well. Refer to the appropriate GE manual for your rig for the proper connections for making a two-frequency rig from your unit. It's a simple job.

tuneup

The transmitter can now be connected to a dummy load, placed in the tune position, and, with a multimeter connected to the first multiplier test jack, note the voltage which is obtained from a known, good crystal. (If you have a single frequency model, make this measurement before converting the oscillator to an amplifier and note the reading for future reference.) Connect the synthesizer, preferably at or near the same frequency as the crystal was, and compare the readings. These should be as nearly alike as possible, and may be changed by adjusting the series inductor in the buffer compartment (L3).

If the voltage is too high, you probably have too much series inductance; too low, not sufficient inductance. About 8 to 10 turns of no. 24 enameled wire is correct for a three-foot length of cable between the synthesizer and the front panel of the GE unit. This is approximately correct for the receiver coil, too, by the way. With a 15-foot length of cable, about 18 turns is correct. As a rough starting point, the inductive reactance of the coil should be approximately equal to the capacitive reactance of the cable. The voltage at the multiplier test point must remain nearly the same as with a crystal as otherwise the modulation index will change.

table 3. Division ratios for all frequencies between 147.99 and 146.01 MHz.

frequency (MHz)	transmit divisor	receive divisor	frequency (MHz)	transmit divisor	receive divisor
146.01	4866	4576	147.00	4899	4609
146.04	4867	4577	147.03	4900	4610
146.07	4868	4578	147.06	4901	4611
146.10	4869	4579	147.09	4902	4612
146.13	4870	4580	147.12	4903	4613
146.16	4871	4581	147.15	4904	4614
146.19	4872	4582	147.18	4905	4615
146.22	4873	4583	147.21	4906	4616
146.25	4874	4584	147.24	4907	4617
146.28	4875	4585	147.27	4908	4618
146.31	4876	4586	147.30	4909	4619
146.34	4877	4587	147.33	4910	4620
146.37	4878	4588	147.36	4911	4621
146.40	4879	4589	147.39	4912	4622
146.43	4880	4590	147.42	4913	4623
146.46	4881	4591	147.45	4914	4624
146.49	4882	4592	147.48	4915	4625
146.52	4883	4593	147.51	4916	4626
146.55	4884	4594	147.54	4917	4627
146.58	4885	4595	147.57	4918	4628
146.61	4886	4596	147.60	4919	4629
146.64	4887	4597	147.63	4920	4630
146.67	4888	4598	147.66	4921	4631
146.70	4889	4599	147.69	4922	4632
146.73	4890	4600	147.72	4923	4633
146.76	4891	4601	147.75	4924	4634
146.79	4892	4602	147.78	4925	4635
146.82	4893	4603	147.81	4926	4636
146.85	4894	4604	147.84	4927	4637
146.88	4895	4605	147.87	4928	4638
146.91	4896	4606	147.90	4929	4639
146.94	4897	4607	147.93	4930	4640
146.97	4898	4608	147.96	4931	4641
147.00	4899	4609	147.99	4932	4642

Next, listen to the transmitter on a good fm receiver and carefully adjust the series coil, until you null out any hum that is apparent on the carrier. Hum in this case is usually caused by rf feedback, and careful adjustment will usually eliminate the path through the coax. If the hum persists, and the adjustment of the inductor doesn't seem to change it, then possibly rf is getting back into the buffer or oscillator stages by another path. All the shielding should be carefully checked to eliminate any other entry points for rf. If this eliminates the hum switch to high power and listen again. Note if there is any audio distortion or echo apparent; this is also an indication of rf feedback.

If everything is fine up to this point, listen carefully to the unmodulated carrier with an fm receiver for noise (this noise, if present, will probably sound like weak static). If this condition is noted, try adding a 5-μF capacitor from the transmit vco control line to ground, and increase this value up to 20-μF to eliminate this condition. This problem is caused by variation in tolerances in the components used in the low-pass filter in the phase detector. Don't add this capacitor unless it's really needed, as it will slow down the loop lock-up time.

At this point the only remaining thing to do is to install a phono jack on the front panel of the GE unit near the Jones connector going to the control head. From the center pin of this jack run a lead to pin no. 18 of the Jones connector. Install a shielded cable from the jack to the control connection to the inverter stage in the transmitter buffer compartment. This circuit will suppress the output from the transmit buffer during receiving periods.

The oscillator board (crystal oscillator) should now be zero beat against WWV. If a frequency counter is available the output of the synthesizer should be measured and the crystal trimmer adjusted accordingly. It's not a bad idea to check all the output frequencies (including the receiver) to make sure that you actually wired the band and channel switches correctly as well as to make certain that the synthesizer is locking on all frequencies.

other frequencies

As I mentioned earlier there is a way to externally program the unit for unusual channel combinations if desired: for example, you might want a .34 simplex combination for some testing purpose. This is quite simple to do if you leave the last position of the rotary channel switch in the second group (**B**) of frequencies blank and mark this *external* on the front panel. You then bring out all the decimal leads from the matrices, the hundreds leads from the receiver divider board, and the hundred lead from the transmit divider board. The Units and 10s leads are wired to thumb-wheel switches (the decimal encoding types, not the BCD type) with the hundreds leads from the receiver divider board going to a spdt toggle switch. The common leads from all these switches are returned to the position 24 segments of the **B** group decks on the channel switch.

The hundreds lead from the transmit divider can be obtained from the unused connection on the bandswitch, run to one side of a spst toggle switch the other side of which is connected to ground.

The proper division ratios are then read from a frequency chart and entered into the switches to obtain these special frequencies. You must remember to leave the transmit hundreds switch in the 900 position, however, whenever using the regular channel selector switch in the **B** group. (When using the **A** group this precaution is not necessary as the external switch will be disconnected by the bandswitch and the lead is normally grounded by the bandswitch.) A chart of the division ratios that would have to be set on the thumbwheels and toggle switches is included for frequencies from 146.01 to 147.99 MHz (see **table 3**).

acknowledgement

I would like to express my thanks to Don Rees, W4VQA, and Chuck de Santis, WB8FQY, who were most helpful in providing suggestions and assistance in the initial testing of the synthesizer, as well as to all the patient people who use the Huntington *machine* who had to live through the birth pains and countless hours of discussion and testing that went on. Their patience and comments are greatly appreciated.

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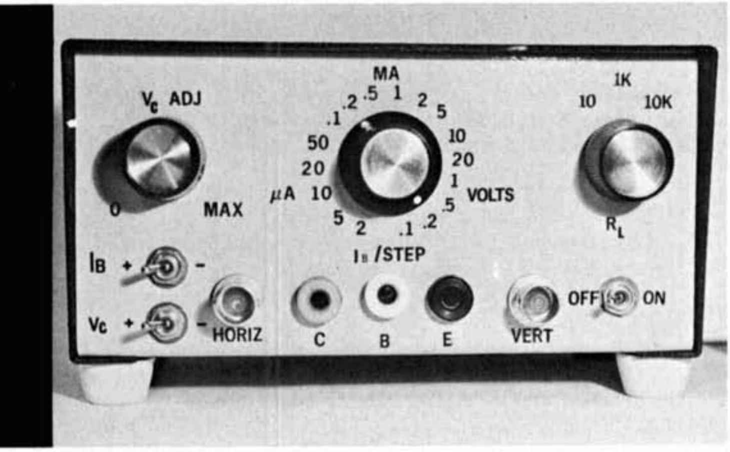
ham radio

"Mother, I'm positive he's having an affair with another woman. I just heard him say Juliet. . .Sugar. . .Hotel. . .Whiskey. . . Two. . .Love."

More Details? CHECK—OFF Page 110



Photos by WAØLOG

transistor curve tracer

This semiconductor curve tracer can be used with npn and pnp transistors, junction fets and mosfets, as well as diodes

Dan Wright, WA9LCX, 286 East 4575 South, Ogden, Utah 84403

Nothing is more frustrating than trying to design a circuit without the family of characteristic curves for the device you're going to use. In many instances the curves are not readily available or the device is unmarked. The simple-to-build, low-cost (less than $30) curve tracer shown in the photograph is the answer to this problem. It will display a family of collector characteristic curves for npn, pnp, jfets (P and N channel) and mosfets. It can also be used to display the volt/current characteristics of two-terminal semiconductors.

circuit

To produce the family of curves it is necessary to vary the base voltage in discrete steps while sweeping the collector voltage from zero to maximum at each step. As shown in **fig. 1,** the collector voltage is a 120-Hz rectified sine wave from a bridge rectifier, CR10-CR13. The maximum collector voltage is varied by R36 and the proper polarity is selected by S5.

The base voltage steps are synchronized to the 120-Hz collector voltage by Q1, Q2 and Q3. Transistor Q1 is an input amplifier that squares up the rectified sine wave. Q2 and Q3 form a one-shot

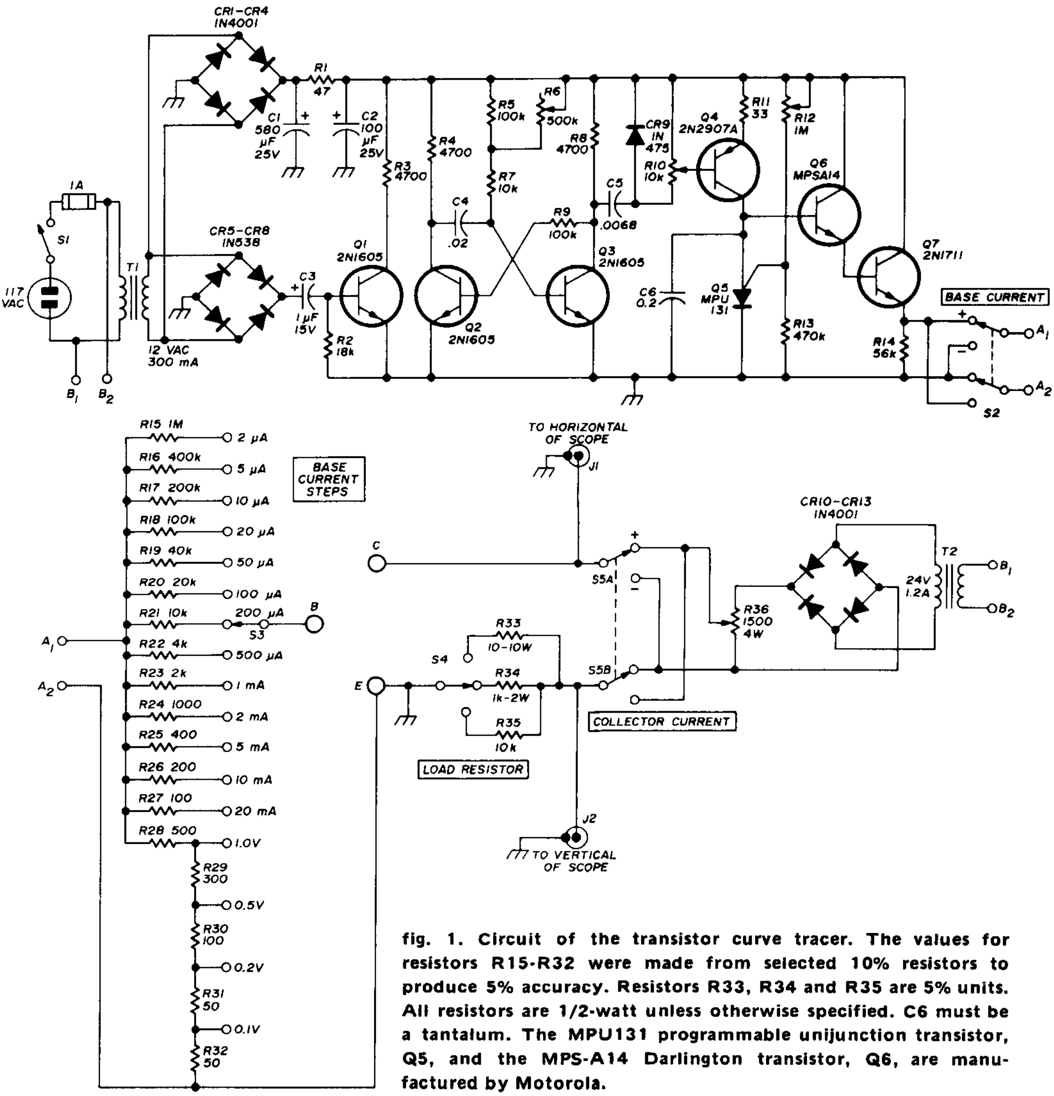


fig. 1. Circuit of the transistor curve tracer. The values for resistors R15-R32 were made from selected 10% resistors to produce 5% accuracy. Resistors R33, R34 and R35 are 5% units. All resistors are 1/2-watt unless otherwise specified. C6 must be a tantalum. The MPU131 programmable unijunction transistor, Q5, and the MPS-A14 Darlington transistor, Q6, are manufactured by Motorola.

multivibrator. The output pulse from the multivibrator is differentiated by R10 and C5. This pulse is synchronized with the beginning of the collector sweep by adjusting R6. Each time the step generator transistor Q4 is turned on by the synchronizing pulse, C6 receives equal current pulses, producing equal voltage steps.

The voltage between each step is controlled by R10. The programmable unijunction transistor, Q5, resets the stairstep generator back to zero. When the anode voltage goes higher than the gate voltage, the unijunction transistor fires and the generator is reset. The gate voltage is adjusted by R12. The stairstep voltage waveform is coupled to the selectable bias resistors (R15 - R32) for the test transistor by Q6 and Q7. The base bias is selected by S3 and the proper bias polarity is selected by S2.

The collector voltage is measured directly and applied to the horizontal input of the oscilloscope. The collector current is determined by measuring the voltage across one of the load resistors (R33, R34 or R35) and applying it to the vertical input of the scope.

selecting and combining 10% resistors to obtain the necessary 5% tolerance.

Alignment is fairly simple. First, preset R12 to minimum resistance. Monitor the step voltage output at the emitter of Q7

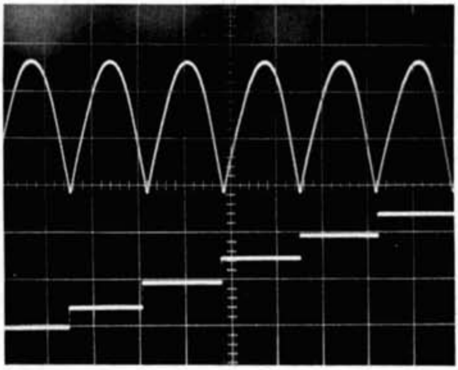


fig. 2. This dual-trace oscilloscope display shows the relationship between the base and collector voltage waveforms.

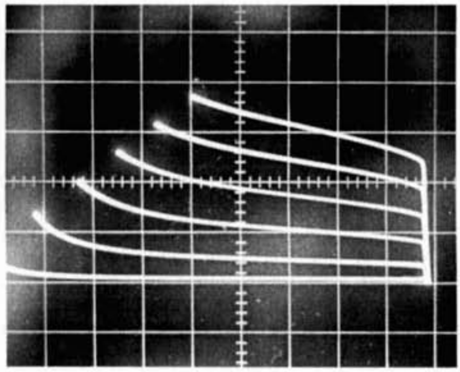


fig. 3. Curves for a 2N404 pnp transistor. Horizontal sensitivity is 2V/cm and vertical sensitivity is 2mA/cm. Base current is 5 μA per step.

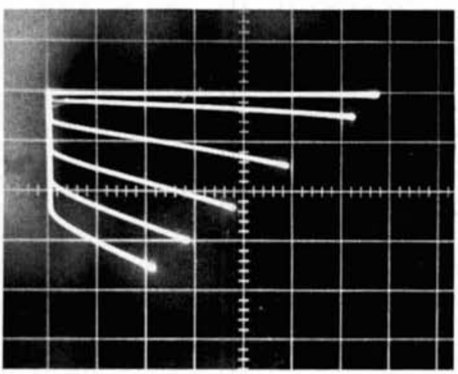


fig. 4. Curves for a 2N3055 npn power transistor. Horizontal sensitivity is 10V/cm and vertical sensitivity is 100mA/cm. Base current is 0.5 mA per step. The curves for all npn transistors will be inverted unless your oscilloscope has the capability to reverse signal polarity.

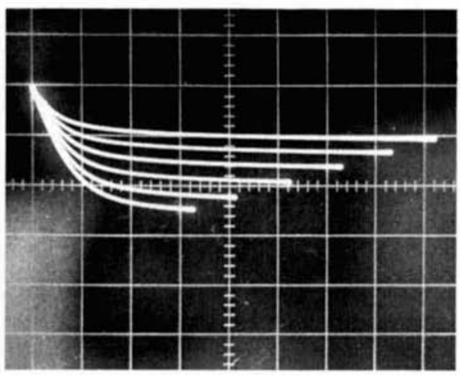


fig. 5. Characteristic curves for 2N4416 n-channel fet. Horizontal sensitivity is 2V/cm and vertical sensitivity is 5mA/cm. Gate voltage is +0.2 volts per step. Switch S2 can be used to provide characteristic fet curves with negative values of gate voltage.

construction and alignment

The curve tracer can be built on a perforated board or a printed circuit board, depending on the builder. Parts layout is not critical although it seems logical to keep all lead lengths short to minimize any stray signal pick-up. The base resistors (R15 - R32) are made by

with a scope and adjust R10 to produce the first step at approximately 2.2 volts. Adjust R12 to produce six steps before Q5 resets the generator. Adjust R6 so the base steps are synchronized with the collector waveform as shown in **fig. 2.** If a dual-trace scope is not available, this alignment can be made by adjusting R6 for the least amount of clutter on the scope when a transistor is being tested on the curve tracer.

parts substitution

Before starting a project such as this, you always wonder if your junkbox parts can be substituted. This circuit seems to be very forgiving. Almost any npn transistor can be used for Q1, Q2 and Q3 (I used 2N1605s because that is what was in my junkbox). Almost any pnp transistor can be used for Q4. If you replace Q7, be sure to replace it with one of equal power dissipation and collector current.

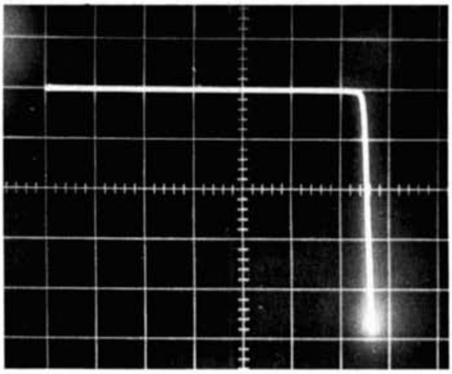


fig. 6. The curve tracer can also be used to display the voltage-current characteristics of a two-terminal semiconductor, such as a diode. This is the characteristic curve of a 1N429 zener diode. Vertical sensitivity is 2mA/cm and horizontal sensitivity is 1V/cm.

I do not recommend any substitutions for Q5 or Q6. They seem to work better than any of the other devices I tried, and they only cost 80 cents each from the surplus houses. The diodes can be substituted as needed so long as the replacements have similar PIV and forward current characteristics.

operation

Operation of the curve tracer is straightforward. First, select the proper base current and collector voltage for the device being tested. Select a load resistor, 1000 ohms for most small-signal devices, 10 ohms for power devices or 10k when you want to limit current for breakdown tests. Adjust your scope for a horizontal sensitivity of 2 volts/cm (this setting is convenient for most cases). The vertical sensitivity can be computed from the formula

$$I_c/\text{cm} = \frac{\text{sensitivity/cm}}{R_L}$$

Now, connect the transistor to the curve tracer. For fets the C terminal is connected to the drain, the B terminal is connected to the gate and the E terminal is connected to the source. **Fig. 3** through **fig. 6** show actual scope displays for various devices that were tested on this curve tracer.

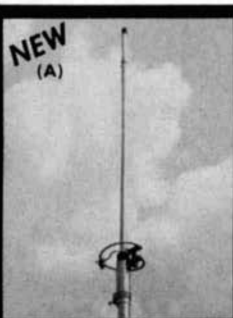
conclusion

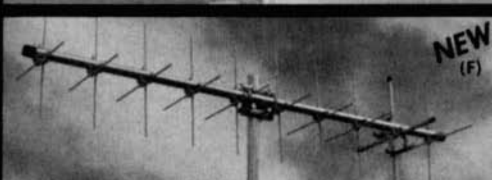
The completion of this project is only the beginning. If you consult a good textbook on transistors the meaning of these curves becomes much more explicit. If you do much work with semiconductors the information gained from these curves will save you countless hours of trial and error. I wish to thank my wife for her encouragement throughout this project.

ham radio

"Get that thing out of here!"

More Details? CHECK—OFF Page 110





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designing impedance-matching systems

A graphical method of designing impedance-matching networks for your favorite antenna

Bob Baird, W7CSD, 3740 Summers Lane, Klamath Falls, Oregon 97601

There's a line from Porgy and Bess, "the things that you're liable to read in the Bible — they ain't necessarily so." It's also a fact that the things you read in a good antenna theory book ain't necessarily so when it comes to your particular antenna.

What is the impedance of a vertical antenna? Well, you can look up the impedance on carefully constructed charts with electrical height in one direction and ohms in the other and get some ball-park estimates for both resistance and reactance. But what is the impedance of *your* vertical? What is its electrical height and is it the same for a 3-inch pipe as it is for a piece of wire? Down at the bottom of the page containing the graph you may find a footnote that says, "over a perfect ground." (Sometimes this footnote appears 3 pages removed from the chart.) Now, do you have a perfect saltwater ground or do you have a piece of wire ten-feet long or do you have the body of a motor vehicle?

There are just too many variables to come up with an answer either by eye balling or by taking physical measurements. To really know, you need to take some electrical measurements. And, to get any kind of precision, you need a good rf bridge. A $1000 rf bridge is not available to everybody but I had the use of one for a short time and came up with some rather surprising results.

mobile-mounted vertical

This article will involve itself with a couple of outstanding examples, but to start with, I was motivated by the results I obtained from a vehicle-mounted vertical. I don't care much about mobiling but I do like to ham from a camp location once I get there. If there are trees around, a good dipole is hard to beat. I get mine up by shooting a fish sinker, attached to a spinning outfit, with a slingshot. These surgical rubber tubing slingshots (available in any sports store) will shoot a one-ounce sinker over a fifty-foot-high limb quite easily. Then you reel the fish line back with a nylon cord attached, and raise your antenna.

But in some places, like the seashore, trees are not handy. So, I wanted a good vertical whip, a full quarter-wavelength high on 20, 15 and 10 meters. This was made from telescoping aluminum tubing.

The time-honored method of grid dipping to achieve resonance was followed to get the required length on the three bands.

I have a Ford van station wagon which has quite an expanse of roof for a ground plane. I looked in the good book for an approximate resistance for a quarter-wave ground plane and came up with the magic number of 36 ohms. "Aha, two hunks of 72-ohm coax in parallel should yield 36 ohms." Well, maybe it does, but my swr was higher than a cat's back and adjusting the telescoping whip to some point off resonance didn't help at all.

Finally, I took off one of the pieces of coax and things were just as bad as before (this was on 20 meters). In desperation I got a piece of 50-ohm coax and everything was hunky-dory. Then, I went to 15 meters – with 50-ohm line the swr was way too high. I changed back to 72-ohm coax and got on board. I had the same experience on 10 meters.

impedance measurement

Well, I finally got everything working all right, but I wondered just what was really going on, anyway. So, I borrowed an rf bridge and made some measurements. The General Radio 1606A rf bridge has two dials that read out resistance and reactance. At resonance the so-called j-factor or reactive component should read zero. With the vertical adjusted to the proper height in the middle of the 20-meter phone band I obtained a readout of 52 ± j0. On 15 meters the reading was 70 ± j0, and on 10 meters, 75 ± j0. All of these measurements were for one-quarter wavelength height. The differences in R seems to be attributable to the mounting (one corner of the van) and the extent of the ground plane (vehicle body). They would, of course, differ for every installation and every vehicle. However, I suspect that a lot of installations would work best with a 50-ohm line on one band and a 72-ohm line on another.

Measurements were actually made at the end of an electrically measured half wavelength of line in each case, in order to remove the equipment from proximity to the vehicle.

vertical antenna

In the W7CSD part of the world, crops are irrigated, and a 40-foot length of aluminum irrigation pipe is pretty easy to come by. ($14.30 for 3-inch tubing.) I set a one-quart soft-drink bottle in concrete and mounted a 40-foot section of irrigation pipe on top of it guyed with polyurethane rope (the kind used for water skiing). I thought this would work pretty

Author W7CSD with his three-band 40-foot irrigation-pipe vertical.

well on 20 meters and also 40 and 75. The big problem was building matching networks for each band.

First of all, I needed to make some impedance measurements to see what I had. The first thing that I determined was that long radials will work fine on 20 meters, but short radials will not work well on 75. So, I used three 75-foot radials (actually, not really radial, but following convenient fence lines). More would be better — the more the merrier. The same problems result as far as network design is concerned, whatever the ground system.

Forty feet on 20 meters is nearly 5/8 wavelength so you expect some kind of medium resistance value and capacitive reactance. 40 feet on 40 is more than 1/4 wavelength so you expect greater than quarter-wave resistance and inductive reactance. On 75 meters a 40-foot antenna is less than a quarter wavelength long so you would expect low resistance and a capacitive reactance. Actually, you need to know pretty close to the right values to be able to design the matching networks. With a ballpark estimate and a swr meter you might be able to get on board with some trial and error.

Taking advantage of the availability of the rf bridge again, I obtained the following measurements:

frequency	impedance
14.30 MHz	80 − j260 ohms
7.25 MHz	142 + j90 ohms
3.90 MHz	54 − j167 ohms

I wanted to match the above impedances to a 50-ohm line.

Matching a complex impedance to 50-ohm line with a T- or L-network by analytical methods is a lot of work. However, George Frese, A Consulting Radio Engineer in Wenatchee, Washington (ex W7FMI) came up with a fairly simple graphical solution to this type of problem.[1] Non-resonant vertical antennas are typical in a-m broadcasting.

Experimental loading system for using the 40-foot vertical on 75 meters.

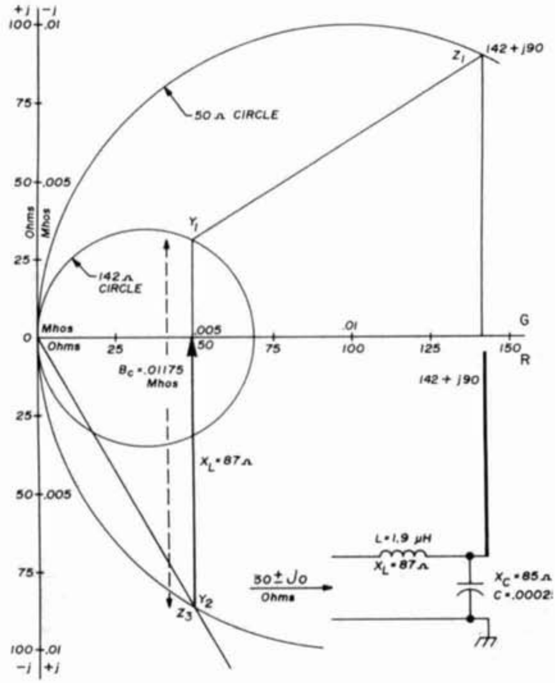

fig. 1. Graphical solution of an impedance-matching network for a 40-foot irrigation pipe vertical for operation on 7.25 MHz.

The graph has two calibrations, one for impedance in ohms and one for admittance in mhos. The two vertical calibrations have reversed signs; i.e., reactance going up is a +j, susceptance going up is −j (see **fig. 1**). Choice of scales is determined by the characteristics of the line and the antenna.

example 1

Let's take the 40-meter situation above as an example. I want to match 142 + j90 ohms to a 50 ± j0 transmission line. Since I have 142 ohms of resistance, the horizontal axis should go out to about 150 ohms. Likewise, the vertical should go to ± j100. The transmission line has an R of 50; 1/50 = 0.02 mhos = diameter of circle corresponding to 50 ohms. Therefore, 0.01 = radius of 50-ohm circle, needs to be on the paper, 20 squares = 0.01 seems appropriate, **fig. 1**.

1. With a good compass, draw the 50-ohm circle, radius = 0.01 mhos.

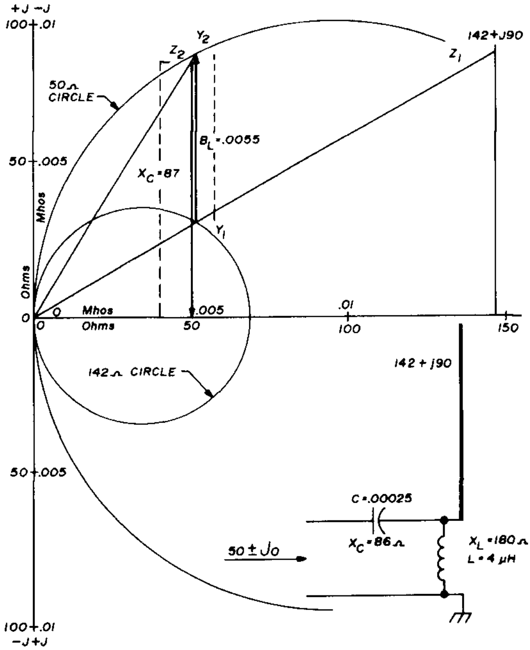

fig. 2. Another graphical solution for an impedance-matching network for a 40-foot irrigation pipe vertical for use on 7.25 MHz. Compare this network with the one shown in fig. 1.

2. Draw the 142-ohm circle, diameter = 1/142 = 0.00705, radius = 0.00352.

3. Point Z1 = 142 + j90 = 142 to right and 90° up.

4. Draw line from Point Z1 to origin.

5. Transfer Z1 to Y1 along this line to the 142-ohm circle.

6. Draw vertical line from point Y1 down to Y2 on the 50-ohm circle. The distance Y1 to Y2 is the susceptance of Y_c = +jB = 0.01175 mhos or X_c = 85 ohms. C = 0.000256 µF at 7.25 MHz (use a 0.00025 mica).

7. Draw line from Y2 through origin.

8. From the origin go out 50 ohms on the horizontal and draw a vertical line to the intersection of the line drawn in **step 7.** (In this case it just happens to coincide with line drawn in **step 6.**) This vertical distance (actually from Z3 to the horizontal) is X_L = 87 ohms; L = 1.9 microhenries.

Now, in case you are suspicious of all this hocus-pocus, let's take the result and work it out to see if it is true. Looking into the network, we are supposed to see 50 ± j0 ohms. Going out to the far end, we have the antenna, 142 + j90 ohms in parallel with the capacitor, 0 − j85 ohms. Using the formula for parallel impedances,

$$Z_{combination} = \frac{Z1\,Z2}{Z1 + Z2}$$

$$Z = \frac{(-j85)\,(142 + j90)}{-j85 + 142 + j90}$$

Changing to the polar form,

$$Z = \frac{(85\,\underline{/-90^\circ})\,(168\,\underline{/32.4^\circ})}{142\,\underline{/2^\circ}}$$

$$= 101\,\underline{/-59.6^\circ} = 51 - j87 \text{ ohms}$$

Combining the series inductance, X_L = 87 ohms, we obtain 51 − j87 + j87 = 51 ± j0 ohms. Accuracy is as good as the graphical method. Greater accuracy can be obtained from a larger graph.

The above solution is the one you want for two reasons. First of all, the network should look like a low-pass filter which will discriminate against harmonics. Also, you can eyeball the 75-meter situation and see that all you need is a series inductance, X_L = j167 ohms – the 54 ohms R is close enough. Likewise, the same kind of network is desirable for 20 meters so that the same coil, tapped at the proper places, can be used for all three bands. However, there is another solution which, for another problem, might be more desirable.

example 2

Steps 1 through **5** same as in example 1.

6. Draw vertical line from point Y1 *up* to Y2 to the 50-ohm circle. This vertical distance (in the up direction = −jB, is the susceptance Y_L = −jB = 0.0055 mhos or K_L = 180 ohms; L = 4 microhenries (see **fig. 2**).

7. Draw line from Y2 through the origin.

8. From the origin go out 50 ohms horizontal and draw a vertical line to intersect the line drawn in **step 7.** (This line happens to nearly coincide with the line of **step 6.**) This vertical distance equals 87 ohms and is downward going so has capacitive reactance; C = .00025 μF, approximately.

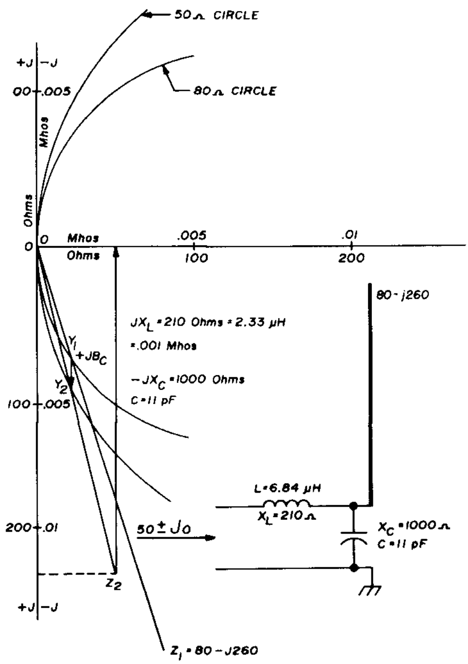

fig. 3. Graphical solution for an impedance matching network to the 40-foot vertical on 14.30 MHz. This network can be combined with the network in fig. 2 to provide the multiband system shown in fig. 4.

Working the problem again, the 142 + j90-ohm antenna is in parallel with the inductor X_L = j180 ohms

$$Z = \frac{(j180)\,(142 + j90)}{j180 + 142 + j90}$$

$$= \frac{(180 \angle 90^\circ)\,(168.5 \angle 32.4^\circ)}{305 \angle 62.3^\circ}$$

$$= 99.5 \angle 60^\circ = 49.8 + j86.2 \text{ ohms}$$

Combining with the series capacitor

$$Z_{in} = 49.8 + j86.2 - j87 = 49.8 - j0.8 \text{ ohms}$$

Both answers should be 50 ± j0, but due to the inaccuracies of graphic construction, X_L in **example 1** appears to be a little to the right of where it should be, and X_c in **example 2** seems to be to the left of where it should be. Either way, you are within ±2%. It is doubtful that you will be able to get a capacitor or wind an inductor within this tolerance.

example 3

Now, let's look at 20 meters (14.3 MHz). You can use the same admittance scale but the impedance scale will have to be one square = 10 ohms to get everything on the graph **(fig. 3)**. Since you want capacitance to ground and a series inductor, raise the horizontal axis and work below the line only. The distance Y1 to Y2 is very short and, hence, of questionable accuracy. If you had used the other solution and gone up instead of down, Y1 to Y2 would have been much greater and much more accurately measurable. But, for the reasons mentioned before you do not want this solution.

So, as closely as you can measure, Y1 to Y2 = 0.001 mhos or X_C = 1000 ohms and C = 11 pF. Locating Z2 is a little uncertain on this graph, too, but it comes out with X_L = 210 ohms and L = 2.33 microhenries. If you care to work out the problem again you will get Z = 48 + j8. This is still pretty close to 50 ohms.

proof of the pudding

Two months transpired between making the measurements and building the matching networks, and the commercial rf impedance bridge had been returned. With the aid of an L/C meter I wound and tapped a coil at 1.9, 2.33 and 6.84 microhenries. This could be done by any other method, including grid dipping using a known capacitor in a resonant circuit and solving for L. A 0.00025-μF mica capacitor was readily available. I used a small variable for the 11-pF capacitor.

On 75 and 40 meters I had an swr of

1.0:1 on the first trial. The swr on 20 meters was up near 1.5:1 and minimum was with the little 11-pF variable wide open. Removal of the variable capacitor and moving the inductor tap one-half turn yielded an swr of 1.0:1. Apparently, the capacitance of the coil to the aluminum box housing the network was very close to the required 11-pF. The final circuit of the network is shown in **fig. 4.**

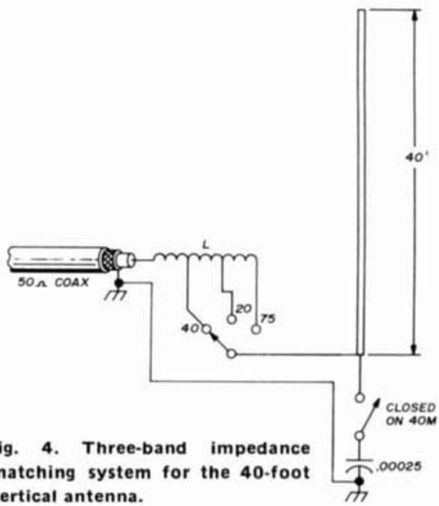

fig. 4. Three-band impedance matching system for the 40-foot vertical antenna.

summary

I have received excellent reports on all bands. I have no comparison on 75 and 40. On 20 the vertical cannot compete with a cubical quad, but this is not surprising. However, on DX contacts it is only down about 1 S-unit.

The big problem is how to measure the impedance of the antenna without a $1000 bridge. I think I may have some answers for this which I will verify when antenna weather comes again. There are several possibilities that are close enough that little trial and error would be necessary to get everything tuned up.

reference

1. George Frese, "Graphical Solutions to RF Networks," *Broadcast Engineering,* January, 1964, page 12.

ham radio

how to compare the efficiency of linear power amplifiers

Accurately comparing the efficiency of two linear amplifiers is not difficult, but it requires some care

Carl Drumeller, W5JJ, 5824 N.W. 58 Street, Warr Acres, Oklahoma 73122

While listening on an amateur band, I overheard one amateur telling another his results in comparing the efficiency of two commercially-built rf power amplifiers. Each of these amplifiers used vacuum tubes, and was designed for amplifying the output of ssb exciters. The comparison was based solely upon the ratio of dc power input to rf power output while speaking the same words into the exciter's microphone at approximately the same amplitude.

This seems to be a commonly-used and more or less universally accepted means of evaluating the efficiency and effectivity of rf power amplifiers used as linear amplifiers. But is it a valid comparison?

In the particular instance in question, one rf power amplifier showed an efficiency of 67%, the other 40%. The high apparent efficiency of one is an immediate *flag* for suspecting the validity of the test. That figure, 67%, borders upon the theoretical maximum that a vacuum-tube amplifying stage can produce in linear service. It supposes that every parameter is at its perfect peak of optimum adjustment, that associated circuits are without loss, that nirvana has been achieved. The other figure, 40%, is a much more believable one!

the comparison

What, then, constitutes a valid means of comparing the efficiency of two linear amplifiers? The clue lies in that term, *linear.* Vacuum-tube amplifiers can be designed and constructed to be amazingly efficient as converters of dc power input into rf power output. By running dc grid bias very, very high (many times the cutoff point) and running the rf grid excitation high enough to saturate the tube, an efficiency of around 90% can be achieved.

But, would you want it? You probably wouldn't, for that rf output would contain as much power in harmonics as in the fundamental. This is not precisely what you would desire if you wanted to keep on good terms with the FCC. Nor is it what you would want for amplifying any form of amplitude-modulated signal, and, of course, ssb is one form of amplitude modulation.

Leaving such an extreme, really a class-C stage, and looking toward class B or AB, the classes usually associated with linear amplification, you do not find a high degree of efficiency. The true efficiency, the conversion of dc input power into rf output power of the desired frequency, is not significantly less than that achieved with a class-C stage. What you do find, however, is the possibility of approaching truly linear amplification, amplification in which the output waveform is a true reproduction (in every manner except amplitude) of the input waveform. And this is what you desire when you build, buy, or tune up an amplifying stage connected to the output of a ssb exciter. A serendipitous side effect of such a stage is a satisfying reduction in the generation of harmonics.

how to do it

This suggests some guidelines for comparative tests. You would like to set some limits on just how much of a departure from linearity you will tolerate in the interest of efficiency. Manufacturers do this sort of thing; they come up with a figure like, say, -35 dB for third-order intermodulation products.

Like most trustworthy and informative measurements, such a measurement requires rather expensive tools. In this case, the tools are a two-tone oscillator (really neither difficult to build nor expensive to buy) and a simple spectrum analyzer, such as the Heathkit SB-620. The two-tone audio-frequency signal generating device needs to embody a low duty cycle pulser, something that will let the signal through for a third or less of the time. This permits running the amplifier under test at full load for moderate periods of time without cooking the tubes.

Of course, for any power output test you have to have a dummy load/rf wattmeter. And for the dc input measurements you have to have the needed voltage and current meters.

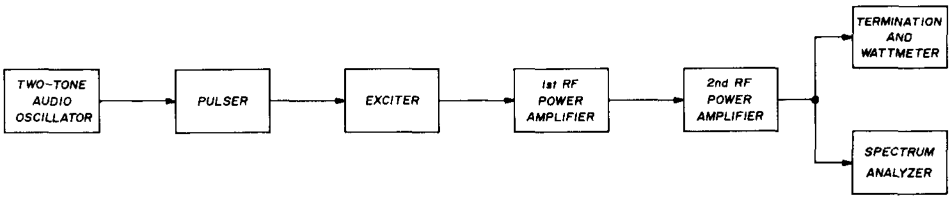

fig. 1. Equipment arrangement for comparing the efficiency of two rf power amplifiers. The amplifiers are switched in and out of the line with their own built-in bypass relays.

As most linear amplifiers are built with integral dpdt bypass relays, a convenient way of making a comparison test is to arrange the two linear amplifiers in series, following the exciter. The control actuating the in-circuit or out-of-circuit status of the bypass relay can then be used to instantly select the particular amplifier to be observed. **Fig. 1** shows a block diagram of the necessary arrangement.

linearity

Since it's highly probable that any amplifier approaching true linearity will have low harmonic output, it is not necessary to use a wideband spectrum analyzer to check the relative (or the absolute) power contained in harmonics. Only a narrow-band analyzer is needed. The odd-order, or intermodulation, distortion products shown in **fig. 2** can be observed only with an analyzer that has fairly good resolution. However, such resolution is not absolutely necessary; an ideal of relative magnitude of, say, $2f_2 \text{-} f_1$

as compared with either f_1 or f_2 (which probably will be seen as a single blip) can be quite definitive. By making a note of this relationship and then shifting over to the other amplifier, you can form an accurate idea of their relative linearity.

Having established an idea of relative linearity, the next step is to optimize the linearity of each amplifier by careful adjustment of tuning, loading and rf

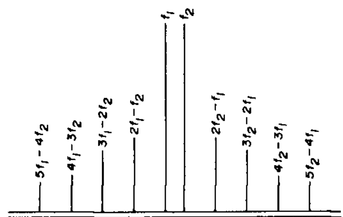

fig. 2. Spectrum of odd-order distortion products in an rf amplifier with input frequencies f1 and f2.

excitation. Then, make both amplifiers exhibit equal linearity by decreasing the rf excitation to the amplifier having the greater distortion. Measure its dc power input and rf power output. Go to the other amplifier, remembering to restore the rf excitation to its optimum value, and measure its input and output. Then and only then are you in a position to talk about the relative efficiency of two different rf power amplifiers.

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ham radio

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More Details? CHECK—OFF Page 110

ham radio sweepstakes winners

WA9YII wins grand prize, puts new Drake TR-4C hf transceiver and L-4B linear on the air; WB4KIT is lucky winner of Robot sstv camera and monitor

Skip Tenney, W1NLB, Publisher, Ham Radio Magazine

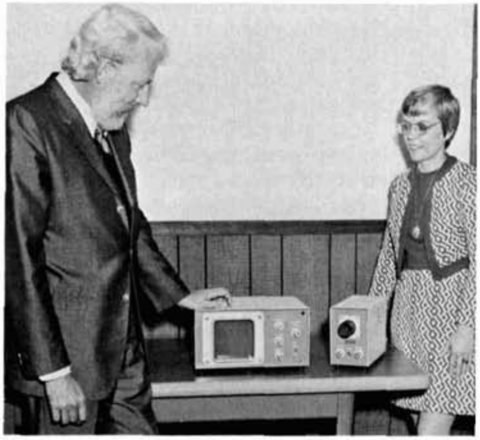
It was more work than ever, opening ten's of thousands of your letters and trying to keep our records straight. However, the *1973 Ham Radio Sweepstakes* is now history, and our local post office can take a breather and so can we.

This year's contest seems to have created more interest than ever before, not only through the mail, but also at many of the Hamfests we have visited this year such as SAROC, the Tropical Hamboree, the Dayton Hamvention and a number of others.

Our Grand prize winner was Randy E. Thompson, WA9YII. He won a brand new R.L. Drake TR-4C Transceiver and AC power Supply plus a Drake L4-B Linear Amplifier. Randy tells us that although he is now a Technician he is going for his Advanced license in the very near future. He is in the graduating class at the Vocational-Technical Institute of Southern Illinois University and has accepted a position with the National Accelerator Laboratory near Batavia, Illinois.

The new TR-4C offers everything that made it's predecessor, the TR-4, so popu-

Jim Fisk and Pat Hawes of the Ham Radio editorial staff look over the Robot SSTV Camera and Monitor won by WB4KIT.



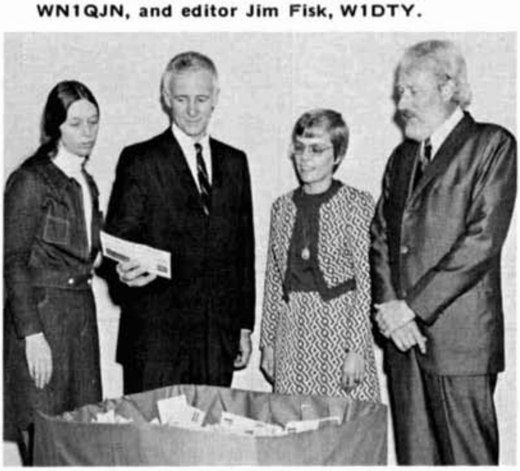
lar, plus a number of new features including 1-kHz dial calibration. This versatile transceiver provides ssb, CW and a-m operation on all amateur bands from 80 to 15 meters plus 28.5 to 29.1 MHz. Accessory crystals are available to cover the complete 10 meter band.

Of course, the L4-B is one of the best known 2-kW amplifiers in the business. Rugged and dependable, it features a trouble-free, conservative design. Randy should be set for many years of service from this fine equipment. The L4-B uses a pair of Eimac 3-500Zs in a class-B grounded-grid circuit featuring a broadband-tuned input, negative rf feedback and transmitting agc for higher audio level without clipping.

The second prize, a Robot Slow-Scan Television Camera and Monitor, created much interest from many of our entrants. This is the same package that has added a whole new dimension, that of sight, to amateur radio for so many operators all over the World. The lucky winner of the Robot Model 70 SSTV Monitor and Model 80 SSTV Camera was John S. Harvey, WB4KIT. We'll all be "looking" for him on the air very soon.

Both the Robot Camera and the Robot Monitor feature an all solid-state design except for the picture and camera

Skip Tenney, W1NLB, publisher of Ham Radio, picks the Grand Prize winner in the 1973 Ham radio Sweepstakes. Looking on are assistant publisher Hilda Wetherbee, editorial assistant Pat Hawes, WN1QJN, and editor Jim Fisk, W1DTY.



Skip Tenney calls WA9YII to let him know he has won the Grand Prize — a new Drake TR-4C transceiver and L-4B linear. Randy, obviously very pleased, said, "This is the first time I've ever won anything!"

tubes. Particular design attention has been given to making these units easily adaptable to virtually any ssb station. A couple of patch cables, one to the microphone jack and one to the audio output, is all that is necessary to connect the equipment to your rig, and put it on the air.

Versatility plus was the third prize. Each of our three third-prize winners received a Drake TR-22 Two-Meter FM Transceiver. This is that wonderful little unit that is equally at home over your shoulder, in your car or at home. It can operate on its own battery pack or on 12 Vdc or 115 Vac. John R. Low, K3YHR, Vinton A. Buffenarger, W6PSC, and Robert K. Jackson, WBØISI will be coming through on their local repeaters in the near future, and we're sure that they'll be saying good things about their nifty new rigs.

We're sorry that everyone couldn't win this year, but there are some exciting, new prizes that we're lining up for 1974. We hope that you'll plan on winning one of them and we will try our best to help you out.

ham radio

the ham notebook

arc suppression networks

Unless special precautions are taken, operation of a relay or switch in close proximity to sensitive electronic circuits is a potential source of trouble. This trouble generally results from arcs caused by opening of the relay contacts, causing transients that can easily interfere with the proper operation of sensitive circuits.

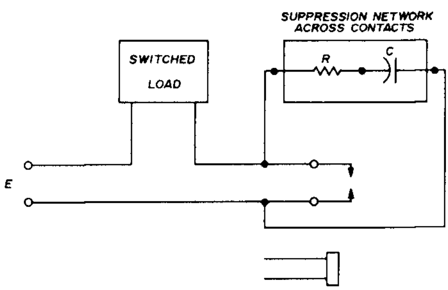


fig. 1. Simple arc-suppression network eliminates transients which can cause problems in sensitive circuits. Values of R and C may be determined with nomograph in fig. 2.

The effects of these arcs can be minimized by the installation of an arc suppression network directly across the relay contacts to absorb the energy which would otherwise be dissipated in the arc itself.

The network itself is simply a resistor and capacitor in series. The capacitor just "absorbs" the arc by charging when the contacts open (see **fig. 1**). The resistor limits the current generated by the discharging capacitor upon contact closure. Were it not for the resistor, severe contact pitting could result from large momentary discharge currents.

The optimum values of R and C can be chosen by the equation

$$R = \frac{E}{10\,(3.16\sqrt{C})^{\,1 + 50/E}}$$

where R is the resistance in ohms, C the capacitance in microfarads and E the open-circuit potential in volts. Obviously, this equation is rather unwieldy, and selection of values from it could prove to be quite a chore! For convenience, this equation has been solved graphically in **fig. 2.** By using this nomograph any number of R-C combinations can be chosen with ease.

Suppose, for example, that a suppres-

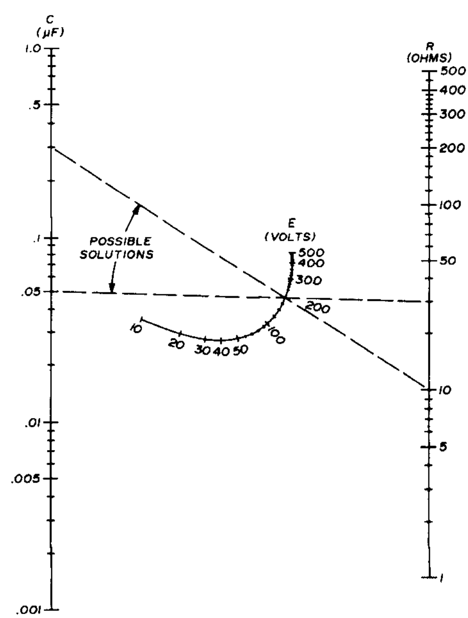


fig. 2. Nomograph for finding R and C values for the arc-suppression network shown in fig. 1.

sion network must be selected for a switched potential of 200 volts and that a 0.05-μF capacitor is readily available. Drawing a line from 0.05 on the C scale through 200 on the E scale yields a value of 30 ohms on the R scale. The network, therefore, will be the series combination of 30 ohms and 0.05 μF. An infinite number of other combinations of R and C are possible, and the final choice of components will probably depend upon what you have on hand. Another suitable choice here would be 0.3 μF and 10 ohms. This can be verified from **fig. 2.**

Since the nomograph is so easy to use, several combinations of R and C should be tried to find the one which is physically smallest and can be constructed with only two standard values. The result will be a network which will go a long way in eliminating headaches caused by contact arcing.

James McAlister, WA5EKA

pilot-lamp life

For some time, I have been experiencing relatively short life for the 120-volt pilot lights I use. Investigation showed that the green light had short life, but the high-voltage indicator (red bulb) seemed to last indefinitely. The reason? The red indicator came on by steps — that is, half-power, then full power.

An ohmmeter check showed that the hot resistance of the S6 bulb was 2400 ohms, while the cold resistance was only 200 ohms. This meant that the small bulb had to sustain a temporary power surge of 72 watts. I recalled that BC stations, where dependability is of great importance, have, for years, used a dropping resistance in series with most indicator lamps. The resulting setup at W2OLU calls for a dropping resistor of approximately 450 ohms. This is not at all critical — any value from 400 to 500 ohms will do. The resultant *hot* current is about 42 mA and the maximum surge is reduced to a small fraction of its former value.

Neil Johnson, W2OLU

pogo stick for reflex klystrons

Stabilizing klystrons is an important part of the microwave station. There are several ways of accomplishing this, but the following, I feel, is more advantageous than others. The primary problem is connecting the output of the afc network which is operating at low voltage levels to the high voltage levels of the klystron.

The output from the receiver discriminator is around zero. It is therefore logical to make the afc compatible. Type 741 op amps connected as an integrator, impedance matcher and inverter perform this function at minimum cost and parts.

Now the problem comes to light. How do we get this to the reflector of the klystron and do it inexpensively with semi-conductors? After all, excluding the klystron, the entire station consists of semiconductors. Let's not spoil it.

ICU1 is not necessary to the operation of this circuit (see **fig. 3**). However, with the afc disconnected, the voltage at point C is not controllable. The fact that the input to U1 is a voltage node and the loop is operating around zero means we can open the loop at point X and not appreciably change the output frequency of the klystron. The slight change that does occur is due to the input offset current of the 741 IC.

Let's disconnect R7 at point X and look at the operation of this circuit. The output of U1 is zero with R7 open or grounded. If point A is zero, and the base of Q1 is at −12 V, we must have approximately 1 mA through R1. If the emitter current of Q1 is 1 mA then the collector current is 1 mA; 1 mA through R2 gives us 75 volts across R2.

Note the voltage divider R3 and R4 which makes the base of Q2 −150 V. Therefore, the emitter must be the same, plus one diode drop, which is insignificant. With the emitter of Q2 at −150 V, 75 V across R2 and 12 V across R1, we are left with approximately 63 V across Q1.

The reason for Q2 is now evident. It is not necessary except that if only Q1 was used it would have to be a high-voltage device which implies high cost. As the circuit stands, Q1 and Q2 can be 100 volt devices and still maintain a good safety margin.

We established earlier that the current through R1 was 1 mA. Q1 and Q2 are in series with R1, thus the current in the series string is 1 mA. This results in Q2 and R5 having the same voltage drops as Q1 and R2 respectively. The voltage at point Y is now 300 volts. This leaves 300 volts across R6 and R9. R6 is a ten-turn Helipot for adjusting the voltage on the klystron repeller so it is operating in its proper mode (160 volt mode is used at this station).

Understanding that Q1, Q2 and the resistors constitute a series circuit is important. With this in mind let's put a positive voltage at point X. Point A goes negative (U1 inverts). With point A less than zero the current in R1 reduces, thus reducing the current in the series string. With a reduced current the voltage across R9 reduces, making point C more negative. With a negative voltage at point X, A goes positive. More current results in the string causing point C to become less negative (positive direction).

By changing R7, the gain of U1 changes, thus changing the loop transfer function (ratio of point-X voltage change to point-C voltage change). The value of R7 will thus be determined primarily by the transfer function of the particular afc circuit used. (In my station U1 is operated with a gain of −10.)

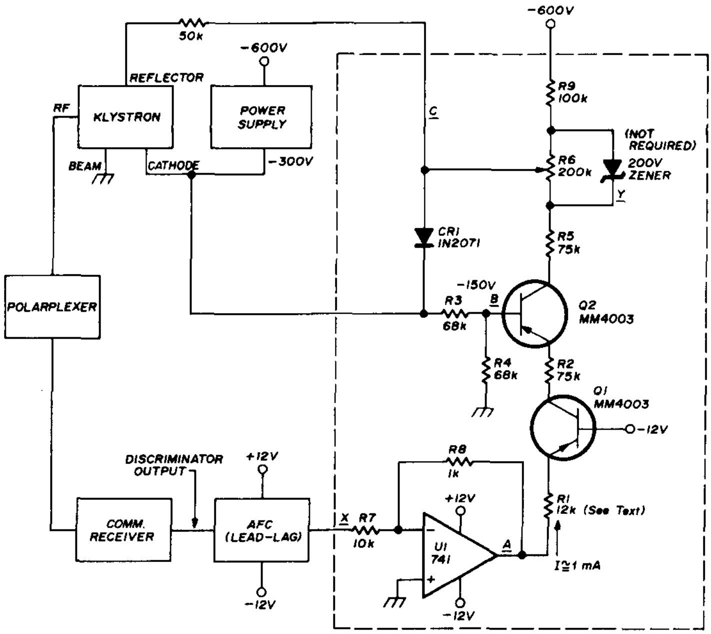


fig. 3. Solid-state voltage-tracking circuit for reflex klystrons.

Resistor R1 is chosen so the voltage at point-Y is approximately −350 V (slightly more than 1 mA). This is to insure a good voltage swing at point C without causing point C to go above −300 volts. CR1 is for protection of the klystron. The repeller should never go positive with respect to the cathode.

This circuit is in use at two stations operating at 3335 and 3365 MHz with great results. The klystron is able to track over its entire electrical tuning range. Total cost was less than $5.

Francis E. Adams, W6BPK

More Details? CHECK—OFF Page 110

new products

electronic frequency counter

Regency Electronics has moved in to a new area of electronic equipment with production of a six-digit electronic frequency counter. The all American made unit, the EC-175 Electronic Counter, is priced at $449.00

The unit's low price, combined with high stability, ease of operation and portability make the Regency Counter very desirable. The EC-175 is designed to enable the operator to measure crystal frequencies without mathematical computation. The counter reads out frequencies ranging from 5 Hz to 175 MHz. A five-position range switch with gate times of 1 ms, 10 ms, 100 ms, 1 second and 10 seconds allows direct measurement of any in-range frequencies to within 0.1 Hz.

The six-digit LED display features automatic blanking, automatic decimal point positioning and leading zero suppression. There is an overrange LED indicator for readings over 6 digits and separate LED indicator for count rate.

EC-175's proportional oven-controlled time base gives a short-term stability of 2 parts in 10^8 per day for FCC certification work. Long term stability is one part in 10^6 per 6 months. Temperature stability is 3 parts in 10^9 per degree Centigrade from zero to 50^o C.

The Regency frequency counter has a built-in 100-kHz harmonic generator for direct calibration to WWV. A 10,7-MHz crystal oscillator for afc locking and i-f alignment work is also a built-in feature. A built-in mosfet preamp gives sensitivity of 100 mV at 100 MHz.

The Regency EC-175 Electronic Counter is now available from Regency distributors throughout the country. For more information, write to Regency Electronics, Inc., 7900 Pendleton Pike, Indianapolis, Indiana 46226 or use *check-off* on page 110.

keyer memory

A large capacity programmable-reprogrammable CW message memory, designed as a plug-in accessory for the EK-420 keyer, has been announced by Curtis Electro Devices. Aimed to satisfy the most demanding contester or traffic handler, the standard KM-420 offers a solid-state memory capacity of 1,024-bits – equivalent to 100 Morse characters. A second, options, 1,024-bit plug-in memory doubles this capacity. For maximum flexibility, the memory organization is switch selected to yield four different program arrangements.

Programs are selected and started by

 More Details? CHECK–OFF Page 110

pushbuttons; terminated by a message pause or by manual break-in. A "reset" button instantly stops and resets the memory, a "hold" function allows manual insertion into a sequency. A 1 to 20 second repeat feature allows send and wait operation.

Memory programming is accomplished simply by sending the desired sequence in the "record" mode. Messages may be written as often as desired and stored indefinitely. Automatic and manual sending are indistinguishable. The KM-420 is priced at $299.95. The optional extra memory is $34.95. A remote control head for the Brown Brothers CTL Key is also $34.95.

For additional information, contact Curtis Electro Devices, Inc., Box 4090, Mountain View, California 94040, or use *check-off* on page 110.

vintage radio

This new pictorial album of old radio equipment, edited by Morgan E. McMahon, should hold particular interest to amateurs and antique radio buffs who would like to know more about radio during the early part of the century. The book is full of interesting photographs and text describing much of the early apparatus used by such wireless pioneers as Marconi, DeForest and Sir Oliver Lodge. There's a complete section on early receivers including models manufactured by Grebe, Remler, Atwater-Kent and RCA; early vacuum tubes, coherers, crystal sets, headphones, horn speakers, test equipment and many special components. The list of 3000 radio models by manufacturer and year should be a particular aid to collectors who are having trouble dating a particular radio in their collection.

Soft-bound, 263 pages, hundreds of photographs and drawings, $4.95. Also available with hard cover for $6.95. Order from Vintage Radio, Box 2045, Palos Verdes Peninsula, California 90274. For more information, use *check-off* on page 110.

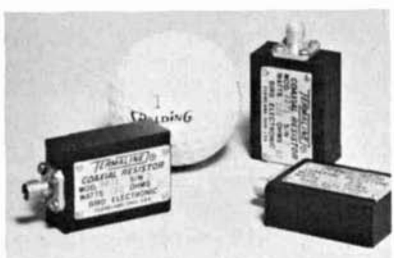
MECL data book

Motorola's new *MECL Data Book* is a fact book and a design guide wrapped in one cover. Basic performance specifications are provided for each IC device in the MECL II, MECL III and MECL 10,000 logic families. In 410 pages, complete dc, ac and performance data are given for each MECL product announced up to press-time. Convenient abbreviated guides offer a quick selector for MECL logic blocks.

In the 36-page general information section is contained a synoptic discussion of topics of value to the designer planning a MECL system: product performance data, design rules, system considerations,etc. In addition, dimensioned drawings of MECL IC packages are shown. References to the extensive MECL software support available are included by way of Motorola Application note abstracts, as well as references to a sampling of MECL articles in the trade press.

Motorola's *MECL Data Book* may be purchased for $2.00 per copy. Copies may be obtained by sending check or money order payable to Motorola, Inc. at Post Office Box 20924, Phoenix, Arizona 85036.

rf load resistor



A nearly hundred-to-one breakthrough in size reduction for a coaxial rf load resistor has been accomplished by Bird Electronic Corporation. The New *Termaline Miniload®* Model 8071 100-watt load weighs just 1¼ ounces and requires less than 3/4 cubic inch of space. Designed for reflection-free termination of 50-ohm coaxial systems, these dry miniature

More Details? CHECK—OFF Page 110

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computer dictionary and handbook

Computers are quickly becoming common-place in today's technological society. In fact, computer language has expanded an astounding 250% in the past ten years. The second edition of the popular Howard Sams *Computer Dictionary and Handbook* is designed especially to keep abreast with the constantly changing computerized world.

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Over 450 pages are devoted to defining computer-related terms. Principles and procedures of computer systems, computer systems personnel, operations research, number systems, mathematical definitions, and computer languages are just a few of the subjects covered in the 13 appendices. The book concludes with a sound report on the progress, impact, and future of computers.

New additions include: a description of the structure of the computer industry, an evaluation of the latest types of main memory hierarchies, a discussion of the intricacies of the various operating systems and a classification of new information storage devices by function. These and others enhance the reference value of this already popular book.

It's authoritative and unabridged – a must professional resource for libraries, schools, and literally anyone in the computer industry. Written by Charles J. and Charles P. Sippl, 784 pages, hardbound, $16.95 ($22.25 in Canada). Available from Comtec Books, Greenville, New Hampshire 03048.

portable uhf/vhf a-m radio

A new three-band portable radio that includes uhf has been introduced by Radio Shack at a price the company says is well below any other radio with uhf capability presently on the market.

The Realistic® Patrolman®-3 tunes a-m, 450-470 MHz uhf and 144-174 MHz vhf for police, fire, public utilities, business radio, weather broadcasts, two-meter amateur radio and other two-way radio services. The uhf band is currently used by many major metropolitan areas for

More Details? CHECK–OFF Page 110

police, fire and municipal services. Separate tuning controls are provided for a-m and for uhf/vhf, and each band has a window-type rotary dial for accurate frequency selection. An adjustable squelch control reduces background noise while monitoring.

The Realistic Patrolman-3 is priced at $49.95 and includes four penlight cells and an earphone, and high-impact case with carrying handle. An optional ac adapter is available for $4.95.

Realistic products are available at more than 1600 Radio Shack and Allied Radio stores in all 50 states and Canada. For more information, use *check-off* on page 110.

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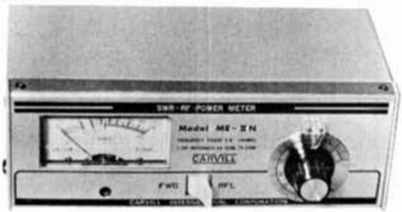

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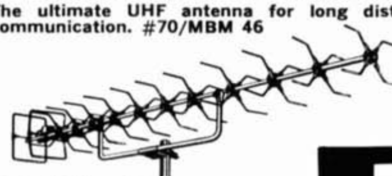

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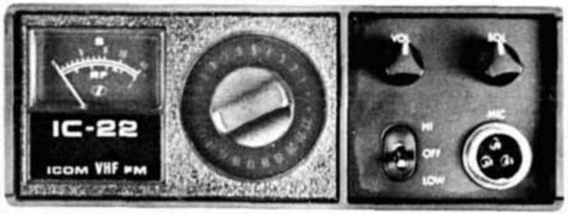

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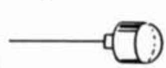

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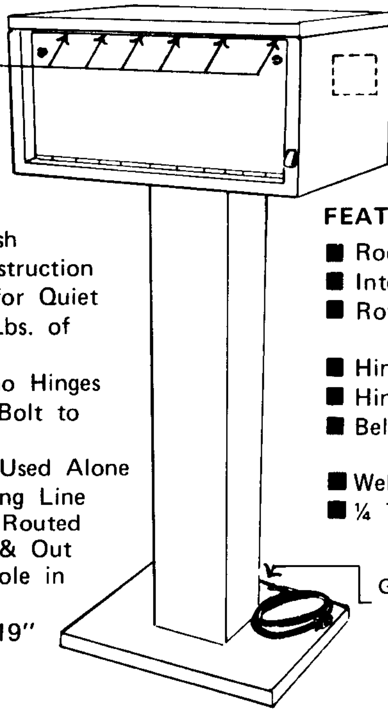

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STORE HOURS 11 AM TO 7 PM CLOSED SUN. & MON.

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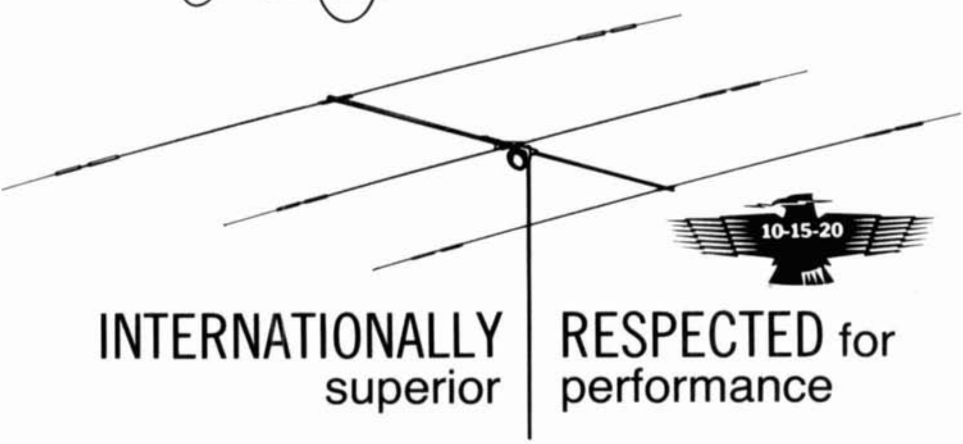
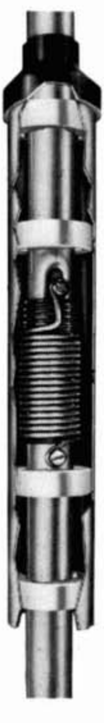
The most popular three band beam in the world!

hy-gain TH3Mk3



INTERNATIONALLY superior | RESPECTED for performance



Superior construction and performance make the difference in Hy-Gain's popular 3-element Thunderbird.

- Thunderbird's "Hy-Q" traps provide separate traps for each band. "Hy-Q" traps are electronically tuned at the factory to perform better at any frequency in the band—either phone or CW. And you can tune the antenna, using charts supplied in the manual, to substantially outperform any other antennas made.
- Thunderbird's superior construction includes a new, cast aluminum, tilt-head universal boom-to-mast bracket that accommodates masts from 1¼" to 2½". Allows easy tilting for installation, maintenance and tuning and provides mast feed-thru for beam stacking.

  Taper swaged, slotted tubing on all elements allows easy adjustment and re-adjustment. Taper swaged to permit larger diameter tubing where it counts! And less wind loading. Full circumference compression clamps are mechanically and electrically superior to self-tapping metal screws.
- Thunderbird's exclusive Beta Match achieves balanced input, optimum matching on all 3 bands and provides DC ground to eliminate precipitation static.
- Up to 8 db gain
- 25 db front to back ratio
- Power capability 1Kw AM, 2Kw PEP
- SWR less than 2:1
- Extra heavy gauge, machine formed, element to boom brackets with plastic sleeves used only for insulation. Bracket design allows full mechanical support.

Model 388 $144.95

Other tri-band beams to choose from:

• 6-element Super Thunderbird TH6DXX	**Model 389 $179.95**
• 3-element Thunderbird Jr. TH3JR	**Model 221 $ 99.95**
• 2-element Thunderbird TH2Mk3	**Model 390 $ 99.95**

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HY-GAIN ELECTRONICS CORPORATION

8601 Northeast Highway 6 Dept. WG Lincoln, Nebraska 68507
402/434-9151 Telex 48-6424

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NATIONAL MOS

DYNAMIC shift registers TO-5

MM502	dual 50 bit	1.25
MM506	dual 100 bit	1.50
MM5006	dual 100 bit	1.50
MM5013	1024 bit	2.00
MM5017	dual 512 DIP	2.00
MM5016	512 bit	1.50

STATIC shift registers

MM504	dual 16 bit	1.50
MM505	dual 32 bit	1.75

MM550 dual differential analog switch 2.50

3 CHIP

CALCULATOR SET

This calculator set has eight digit, floating point with left hand entry. It will add, subtract, multiply, and divide. Overflow and negative signals are provided.

- Chips and data---$6.95
- Data only-------- 1.00 (refundable)

CT5005

CALCULATOR ON A CHIP

This chip has a full four function memory. Memory is controlled by four keys, +M (adds entry to memory), -M (subtract entry from memory), CM (clear memory--without--clearing rest of registers), RM (read memory or use as entry).

- 12 DIGIT DISPLAY AND CALC.
- FIXED DECIMAL AT 0,1,2,3, 4, OR 5
- LEADING ZERO SUPPRESSION
- SEVEN SEGMENT MULTIPLEXED OUTPUT
- TRUE CREDIT SIGN DISPLAY
- SINGLE 28 PIN CHIP

Chip and data--$14.95
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MC1023	ECL driver	2.00
MC1039	ECL-TTL interface	2.00
8850,9601	one shot multivibrator	1.00
8269	Signetic is same as 8200 National 4 bit comparator	1.60
MC853	dual JK DTL	.30
LU321	dual JK "Utilogic"	.60
SP629	RS/T Signetic	.40
SP659	dual 4 input buf.	.25

MV-50 red emitting 10-40ma @ 2V .39
MV5020 red LED .45
MV-10B Visible red 5-70ma @ 2V .45

7400 TTL *DIP*

7400	$ .35
7401	.35
7402	.35
7403	.35
7404	.35
7405	.35
7408	.40
7410	.35
74L10	.35
7420	.35
7430	.35
7440	.35
7441	1.30
7442	1.00
7446	1.50
7448	1.25
7450	.35
7451	.35
7453	.35
7454	.35
7460	.35
7472	.40
7473	.55
7474	.40
7476	.55
7480	.50
7483	1.15
7486	.65
7489	3.00
7492	.90
7493	.90
7495	1.15
74107	.55
74154	2.50
74181	3.50
74193	2.00
74195	1.00

LINEARS

LM100	$ .80
LM309H	1.00
LM309K	2.50
NE5556	.75
NE5558	1.00
741(MINI DIP)	.45
747	1.10
709	.30
710	.40
711	.40
723	1.00

CMOS

CD4001	$ .75
CD4002	.75
CD4011	.75
CD4012	.75
CD4023	.75

SCHOTTKY TTL $3.00 EACH

82S30	8 input multiplexer
82S33	2 input 4 bit multiplexer
82S41	quad EX/OR element
82S42	4 bit comparator
82S62	9 bit parity gen./checker
82S67	2 input 4 bit multiplexer

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3.50 for ten
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DM8880(Sperry DD700 202) 7 segment high voltage nixie driver-------$1.75

MAN3M Each........$3.00
Ten or more..2.50

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Center Freq.	9.0 MHz	9.0 MHz
Band Width at 6db	2.5kHz	2.5 kHz
60db/6db Shape	2.0 (45/6)	1.8 max.
Ultimate Rejection	45 db	100 db min.
In/Out Termination	120 Ω	140 Ω
PRICE	$18.95	$26.95

Matching Crystals USB (8998.5 kHz) or LSB (9001.5 kHz) $2.75 each
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See Page 112 for more from Barry

for the EXPERIMENTER!

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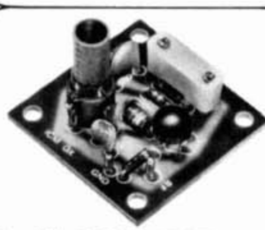

5. OX OSCILLATOR

Crystal controlled transistor type. Lo Kit 3,000 to 19,999 KHz, Hi Kit 20,000 to 60,000 KHz. (Specify when ordering) **$2.95**

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7400	.34	.32	.30	.28
7401	.34	.32	.30	.28
7402	.34	.32	.30	.28
7403	.34	.32	.30	.28
7404	.36	.34	.32	.30
7405	.36	.34	.32	.30
7406	.56	.53	.50	.47
7407	.56	.53	.50	.47
7408	.38	.36	.34	.32
7409	.38	.36	.34	.32
7410	.34	.32	.30	.28
7411	.34	.32	.30	.28
7413	.60	.57	.54	.51
7416	.54	.51	.48	.45
7417	.54	.51	.48	.45
7418	.38	.36	.34	.32
7420	.34	.32	.30	.28
7421	.34	.32	.30	.28
7423	.84	.80	.76	.72
7425	.54	.51	.48	.45
7426	.40	.37	.34	.31
7430	.34	.32	.30	.28
7437	.56	.53	.50	.47
7438	.56	.53	.50	.47
7440	.34	.32	.30	.28
7441	1.73	1.64	1.55	1.46
7442	1.34	1.27	1.20	1.13
7443	1.34	1.27	1.20	1.13
7444	1.34	1.27	1.20	1.13
7445	1.71	1.62	1.53	1.44
7446	1.34	1.27	1.20	1.13
7447	1.30	1.23	1.16	1.09
7448	1.44	1.37	1.29	1.22
7450	.34	.32	.30	.28
7451	.34	.32	.30	.28
7453	.34	.32	.30	.28
7454	.34	.32	.30	.28
7459	.34	.32	.30	.28
7460	.34	.32	.30	.28
7470	.46	.43	.40	.37
7472	.40	.38	.36	.34
7473	.52	.49	.46	.43
7474	.52	.49	.46	.43
7475	.80	.76	.72	.68
7476	.58	.55	.52	.49
7480	.80	.76	.72	.68
7482	1.10	1.05	1.00	.95
7483	1.72	1.64	1.56	1.48
7485	1.58	1.51	1.44	1.37
7486	.60	.57	.54	.51
7490	.85	.80	.75	.70
7491	1.48	1.41	1.34	1.27
7492	.85	.80	.75	.70
7493	.85	.80	.75	.70
7494	1.32	1.26	1.20	1.14
7495	1.32	1.26	1.20	1.14
7496	1.32	1.26	1.20	1.14
74100	1.80	1.70	1.60	1.50
74104	.70	.67	.64	.61
74105	.70	.67	.64	.61
74107	.54	.51	.48	.45
74121	.60	.57	.54	.51
74122	.74	.71	.68	.65
74123	1.30	1.20	1.10	1.00
74141	1.75	1.66	1.57	1.48
74145	1.50	1.43	1.36	1.29
74150	2.00	1.85	1.70	1.55
74151	1.30	1.24	1.18	1.12
74153	1.70	1.60	1.50	1.40
74154	2.75	2.55	2.35	2.05
74155	1.56	1.49	1.42	1.35
74156	1.46	1.39	1.31	1.23
74157	1.56	1.48	1.39	1.31
74158	1.56	1.48	1.39	1.31
74160	2.20	2.10	2.00	1.90
74161	2.20	2.10	2.00	1.90
74162	2.20	2.10	2.00	1.90
74163	2.20	2.10	2.00	1.90
74164	2.20	2.10	2.00	1.90
74166	2.30	2.20	2.10	2.00

Catalog Number	*Any Quantity Per Item (Mix)* 1-99	100-999	1000 up	*Multiples of 10 Per Item (Mix)* 100-990
74175	2.00	1.90	1.80	1.70
74180	1.30	1.23	1.16	1.09
74181	5.20	4.90	4.60	4.30
74182	1.26	1.19	1.12	1.05
74192	2.10	2.00	1.90	1.80
74193	2.10	2.00	1.90	1.80
74198	3.10	2.95	2.80	2.65
74199	3.10	2.95	2.80	2.65
SCHOTTKY TTL				
74S00	.88	.84	.79	.75
74S01	.88	.84	.79	.75
74S03	.88	.84	.79	.75
74S04	1.00	.95	.90	.85
74S05	1.00	.95	.90	.85
74S08	.88	.84	.79	.75
74S09	.88	.84	.79	.75
74S10	.88	.84	.79	.75
74S15	.88	.84	.79	.75
74S20	.88	.84	.79	.75
74S21	.88	.84	.79	.75
74S22	.88	.84	.79	.75
74S40	1.00	.95	.90	.85
74S50	.88	.84	.79	.75
74S51	.88	.84	.79	.75
74S60	.88	.84	.79	.75
74S64	.88	.84	.79	.75
74S65	.88	.84	.79	.75
74S73	1.82	1.73	1.63	1.54
74S74	1.82	1.73	1.63	1.54
74S107	1.82	1.73	1.63	1.54
74S112	1.82	1.73	1.63	1.54
74S114	1.82	1.73	1.63	1.54
74S140	1.00	95	.90	.85
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NE526A	3.59	3.38	3.17	2.95
NE531V	3.81	3.58	3.36	3.14
NE536T	7.31	6.88	6.45	6.02
NE540T	2.40	2.25	2.10	1.95
SE540T	4.48	4.20	3.92	3.64
NE550A	1.30	1.23	1.16	1.09
NE555V	1.10	1.05	1.00	.95
N5556V	2.10	1.95	1.80	1.65
N5558V	1.00	.95	.90	.85
NE560B	3.57	3.36	3.15	2.94
NE561B	3.57	3.36	3.15	2.94
NE562B	3.57	3.36	3.15	2.94
NE565A	3.57	3.36	3.15	2.94
NE566V	3.57	3.36	3.15	2.94
NE567V	3.57	3.36	3.15	2.94
N5111A	.90	.86	.82	.78
N5595A	3.40	3.20	3.00	2.80
N5596A	1.87	1.77	1.66	1.56
709V	.50	.47	.44	.41
710A	.50	.47	.44	.41
711A	.55	.52	.49	.46
723A	1.00	.95	.90	.85
733A	1.90	1.80	1.70	1.60
741V	.55	.52	.49	.46
747A	1.10	1.04	.98	.92
748V	.60	.57	.54	.51
LM335	2.85	2.72	2.64	2.55
LM336	3.85	3.66	3.46	3.27
LM337	4.05	3.70	3.51	3.31
TRANSISTORS AND DIODES				
1N270	.15	.14	.13	.12
1N914	.10	.09	.08	.07
1N4001	.10	.09	.08	.07
1N4002	.11	.10	.09	.08
1N4003	.13	.12	.11	.10
1N4006	.15	.14	.13	.12
1N747A - thru 1N758A	.25	.22	.19	.16
2N3860	.25	.23	.21	.19

All IC's are supplied in 8–, 14–, or 24–pin DIP (Dual-in-line) plastic or ceramic package except for NE536, NE540, and SE540 which come in TO–5 package. Voltage Regulators LM335, LM336 and LM337 are supplied in TO–3 (Diamond) package.

We give FREE data sheets upon request, so ask for those data sheets that you NEED, even for those listed IC's that you are not buying.

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Solid State Systems has now expanded it's line of LED Displays and also reduced their cost. The following are now available from us at these prices.

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SSS-1C	4.75	4.50	4.00	3.65	3.25
SSS-2	4.50	4.25	3.75	3.40	3.00
SSS-3	7.75	7.50	7.00	6.75	6.50
SSS-4	7.75	7.50	7.00	6.75	6.50
SSS-7	3.50	3.25	3.00	2.75	2.50
SSS-9	3.50	3.25	3.00	2.75	2.50
Minitrons*	3.00	2.75	2.50	2.25	1.90

The SSS-7 and SSS-9 are the common .33 in character height 7-Segment and overflow display respectively, with decimal point on the left and wide angle viewing. The SSS-1 and SSS-2 have the same physical dimensions as the SSS-7 and SSS-9 with increased life and slightly lower current requirement. The SSS-1C is the same as the SSS-1 except it has a colon instead of a decimal point, making it ideal for use in a digital clock. The SSS-3 and SSS-4 are the new giant .77 in character height 7-Segment and overflow display respectively, with decimal point on the right and readability up to 40 feet. *Also included above is a new reduced price on our Incandescent 7-Segment Display.

Package of 8, 1/4 watt current limiting resistors . . . . $0.30.

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900 for $7.40 — 1000 for $8.20 — each additional 1,000 $7.50

Dual-in-line SOCKETS. Brand new with gold plated pins.

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16 Pin Solder	.55	.50	.45	.40	.30
14 Pin Wire Wrap	.55	.50	.45	.40	.30
16 Pin Wire Wrap	.60	.55	.50	.45	.35
14 Pin Closed-Entry Cap	.05	.05	.04	.04	.03
16 Pin Closed-Entry Cap	.05	.05	.04	.04	.03

STANCOR TRANSFORMERS: Ideal for use with LM series.

P-8180, 25.2VCT, 1 amp $3.00
P-6134, 6.3VCT, 1.2 amp $2.75

HEAT SINKS: Wakefield series 680 circuit board coolers. 1¼" high with a dissipation up to 20 watts. Designed for use with TO–3 package.

	1–49	50–99	100–499	500–999	1000 up
Type 680–1.25A	1.20	1.10	1.00	.90	.80

ALLEN-BRADLEY MIL-GRADE (5-band) RESISTORS. Any of the 84 STANDARD 10% values from 2.7Ω to 22MΩ ¼ or ½ WATT. EACH . . . . $0.05.

CERAMIC DISC CAPACITORS. Type 5GA-1000WVDC:
5, 7.5, 10, 12, 15, 20, 22, 25, 27, 30, 33, 39, 50, 56, 68, 75, 82, 100, 120, 150, 180, 200, 220, 250, 270, 300, 330, 360, 390, 470, 500, 560, 680, 750, 820, 1000, 1200, 1500, 1800, 2000, 2200, 2500, 2700, 3000, 3300, 3900, 4700, 5000μμF.
EACH . . . . $.10
0.01μF. EACH . . . . $.11 0.02μF. EACH . . . . $.12

LOW VOLTAGE DISCS, Type UK.

1.0μF, 3V . . . . $.25 0.47μF, 3V . . . . $.25 0.2μF, 10V . . . . $.20
.1μF, 10V . . . . $.12 2.2μF, 3V . . . . $.30 0.01μF, 16V . . . . $.10

ELECTROLYTIC CAPACITORS: All values are available in both, axial or upright (PC Board) mount. Please indicate your choice.

10μF, 15V . . . . $.10 30μF, 35V . . . . $.20 5μF, 50V . . . . $.10
30μF, 15V . . . . $.10 50μF, 35V . . . . $.20 10μF, 50V . . . . $.15
50μF, 15V . . . . $.10 100μF, 35V . . . . $.20 20μF, 50V . . . . $.20
100μF, 15V . . . . $.10 500μF, 35V . . . . $.40 50μF, 50V . . . . $.20
220μF, 15V . . . . $.15 1000μF, 35V . . . . $.50 100μF, 50V . . . . $.20
500μF, 15V . . . . $.20 1μF, 50V . . . . $.10 200μF, 50V . . . . $.40
1000μF, 15V . . . . $.30 2μF, 50V . . . . $.10 500μF, 50V . . . . $.55
20μF, 25V . . . . $.15 3μF, 50V . . . . $.10

TERMS: Rated firms NET 30 days. Otherwise check or money order with order. BankAmericard and Mastercharge are welcome. All invoicing is now done by computer therefore, the following standard charges will automatically be added to your order.

If your merchandise total is between:

$ 0.00 - $ 4.99	add	$1.00
$ 5.00 - $24.99	add	$0.75
$ 25.00 - $49.99	add	$0.50
$ 50.00 - $99.99	add	$0.25
$100.00 and up	add	$0.00

SPECIAL CHARGES

COD	$1.00	additional
Air Mail	$0.50	additional
Postal Insurance	$0.25	additional
Special Delivery	$0.75	additional

With this new system all shipments will be F.O.B. destination, via First Class or UPS (your choice). These charges include shipping, handling and insurance.

MISSOURI RESIDENTS: Please add 4% sales tax.

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flea market

RATES Commercial Ads 25¢ per word; non-commercial ads 10¢ per word payable in advance. No cash discounts or agency commissions allowed.

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.

FOR SALE Drake R4A, T4X, AC4, and MS4. Factory re-conditioned three months ago. Asking $525. 601-896-4062. Alvin Schmidt, 147 Brentwood Blvd., Gulfport, Miss. 39501.

WILL CONSIDER TRADE of your Drake 2-C for my Drake ML-2. For details write K9DHD, 1006 Wilson, Wheaton, IL 60187.

METERS, Parts, etc. List. Barlowe, 55 Wilson, Bethpage, N. Y. 11714.

VIKING THUNDERBOLT LINEAR, 10-80 meters. 2000 w. P.E.P. mint, $200.00 F.O.B. Not modified, with manual, two extra 4-400 A's. WA0KOE, Chet Dill, 1037 Manatt St., Lincoln, Nebr. 68521.

MODERNIZE FOR PEANUTS! Frame & Display QSL's with 20 pocket plastic holders. Two for $1.00, seven for $3.00. Prepaid, guaranteed. Universally used and approved. Order now. TEPABCO, Box 198H, Gallatin, Tennessee 37066.

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

THE CHESAPEAKE BAY BRIDGE-TUNNEL AWARD is awarded to stations which are operated within the continental United States who work 25 Virginia stations, 5 of which must be located in Virginia Beach. Foreign stations must work 10 Virginia stations, 3 of which must be in Virginia Beach. Amateurs must submit log data, including the dates, times (GMT), stations worked, bands, modes. All contacts must be dated after April 15, 1964. The club reserves the right to request the cards be sent in for examination whenever uncertainty exists. Please send 16¢ in U. S. stamps or two IRC's to cover the cost of postage. The Virginia Beach Amateur Radio Club, 1040 Lockwood Court, Virginia Beach, Virginia 23462 U.S.A.

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

NEW JERSEY QSO PARTY from 1900 GMT, Aug. 18 to 0600 GMT Aug. 19 and from 1200 GMT on Aug. 19. Phone and CW are the same contest. A station may be contacted once on each band — phone and CW are considered separate bands. N.J. stations may work other N.J. stations. N.J. stations are to identify by signing "DE NJ" on CW and "New Jersey calling" on phone. Suggested frequencies: 1810, 3535, 3735, 3905, 7035, 7135, 7265, 14035, 14280, 21100, 21355, 28100, 28600, 50-50.5, 144-146. Suggest phone activity on even hours. Exchange consists of QSO numberr, RST, ARRL Section or country. N.J. stations send their county. Other stations multiply number of contacts with N.J. stations by the number of N.J. counties worked. N.J. stations: W-K-VE-VO QSOs count 1 point; DX stations 3 points. Multiply total points by number of ARRL sections (including NNJ and SNJ. KP4, KH6, KL7, KZ5 count both as DX contacts and as section multipliers. Logs must show GMT, date, band, and emission, and be received by Sept. 15, 1973. The first contact for each multiplier must be indicated and numbered. A check list of contacts and multipliers should be attached. Multi-operator entries should be noted and calls of operators listed. Logs and comments should be sent to Englewood Amateur Radio Association, Inc., 303 Tenafly Road, Englewood, N. J. 07631. A #10 SASE should be included for results. Stations planning participation in N. J. are requested to advise the EARA by Aug. 4th so that we may plan for coverage from all counties.

REPAIR TV TUNERS — High earnings, complete course details, 12 repair tricks, many plans, two lessons, all for $1. Refundable. Frank Bocek, Box 3236 (Enterprise Branch), Redding, Ca. 96001.

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

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

MONTREAL AREA HAMFEST. Aug. 5, Flea Market, bingo, games, talk-in on all area RPTR's & 146.94 Simplex. For more info, MARC Hamfest, 535 Lansdowne, Westmount, Que.

REWARD, info., recovery. Stolen: Yaesu FT-101 s/n 82G12279/CW, 1.8 MHz, Regency HR-2 s/n 03-02030, W4GF, 7216 Valleycrest Blvd., Annandale, Va. 22003, (703) 560-5229.

27TH ANNUAL VHF Picnic and Hamfest on Sunday, July 29, 1973, at Turkey Run State Park near Marshall, Indiana. Registration $1.50 or 4 for $5.00. There will be prizes, huge flea market, XYL Bingo, and plenty of good fellowship. Talk in on .94/.94 and 52.525 MHz.

BECKMAN MDL. 1453 recorder vg. $90.00; Beckman 1453 with 4005 scanner vg., $120.00; HP/Sanborn twinviso with gears, manual and most attachments in cabinet, $130.00; WE RO67/FSA-14 oscillograph, g-vg., $24.00; Cleary printers 16 column, 15 lines per second. One good, $115.00, one better, $130.00; Librascope Md1 200B XY plotter, $105.00; Amperex NRZ amplifiers for GS 80 as new, $20.00. Douglas Craton, 5625 Balfrey Dr., W. Palm Beach, Fla. 33406.

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

VERY in-ter-est-ing! Next 6 big issues $1. "The Ham Trader," Sycamore IL 60178

SOUTH DAKOTA HAM PICNIC, August 4, 1973 at Wylie Park, Aberdeen, from 10:00 to ??? Prizes, flea market, activities for XYL and Jr. ops. Limited camping available. For information or tickets contact: W0OGS, 1017 7th Ave. S.W., Aberdeen, S. D. 57401. Talk in on 3955 kHz and 146.94 MHz.

WORLD QSL — See ad page 105.

FIGHT TVI with the RSO Low Pass Filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada. MIS 3B4

WANTED: Lafayette HA46, Bob, K6GEV, 11 Wool, San Francisco 94110.

PLASTIC ENGRAVED CALL PLATES, w/pin $1.25. WA2UUY, 15 Vincent St., Parlin, N. J. 08859.

More Details? CHECK—OFF Page 110

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).

THE MT. AIRY VHF RADIO CLUB (Pack Rats) will hold the 18th annual family day and picnic, Sunday, August 12 (rain date August 19) at the Fort Washington State Park, Flourtown. The event features games, entertainment, and free soda. Talk-in stations will be on 50.2 MHz AM, 52.525 MHz FM, and 146.52 MHz FM.

16TH ANNUAL PICNIC AND HAMFEST, on Sunday August 5th at the Frankfort Picnic Grove, 1 mile north of U. S. 30 on U. S. 45, Frankfort, Ill. Food and Drinks, Swap and Shop. Advance registration $1.50. Admission at gate $2.00. For further information and advance tickets contact Val Hellwig, K9ZWV, 3420 South 60th Court, Cicero, Ill. 60650.

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.

W9OG, will be on the air daily during the Evansville Freedom Festival, June 29 through July 4, 1973. This year will mark the fourth annual Freedom Festival, a six day celebration, ending with the nation's largest aerial fireworks display. All amateurs are invited to attend in person or call CQ Freedom Festival during the festival. An appropriate QSL card will be sent to all stations worked.

DISCOUNT SPECIALS! Clegg FM-27A @ $378! Standard SR-C146 @ $219.50, SR-C826M @ $258! Genave, Miida, Mosley, Tri-Ex, Gladding, Sonar, Shakespeare, many others. Also Marine and C.B. Arena Communications, Dept. C., 1169 N. Military Highway, Norfolk, Virginia 23502.

TO CELEBRATE the 350th Anniversary of the first settlement in the State of New Hampshire, the special events station WP1ORT will operate during the period 1-19 August 1973. Modes of operation will be cw, ssb and SSTV. Probable phone frequencies are 14.230 (SSTV), 14.300, 7.250 and 3.925 MHz. QSL with s.a.s.e. or s.a.e. and IRC to P. O. Box 1973, Portsmouth, New Hampshire 03801.

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.

BECKMAN R1 Fitgo amplifier 1000 Mohm input imped. Transistorized, rack mount, $125.00; Servo Corp. 880CS sweeper. Sweeps up or down, Adjustable sweep width, rate and markers, $250.00; Hermach Englehart transfer standard mdl, A, $170.00; Elin precision power oscillator, rm, $65.00; Sylvania H35F black light, approx. 4-6 watt, $3.00 ea., 5/$10.00 ppd.: 2N575 180 w. Honeywell, good for high power inverter, $3.00; 100v 125A rectifier, $2.50, 100v 160A, $3.50, 200v 160A, $5.00, 200v 260A, $8.00; 70/752 vdt 12″ ASCII RS232, vg., $900.00; 70/752 vdt with 3 special features and tty coupler, $170.00. Douglas Craton, 5625 Balfrey Dr., W. Palm Beach, Fla. 33406.

TOROIDS, iron "E" powder 80-10 meters. .500″ — 8/$1.00, .680″ — 5/$1.00, .940″ — 4/$1.00, 1.437″ — 75¢ each or 3/$2.00, 2.310″ — $1.50 or 3/$4.00. Please include 50¢ postage, slightly more on large orders. Fred Barken, WA2BLE, 274 E. Mt. Pleasant Ave., Livingston, N. J. 07039.

COLLINS F500, Y500, A6910 455 kHz mechanical filters, 6 kHz wide $20.00 ppd. John K7DOT, 1462 Harrop, Ogden, Utah 84404.

GREATER INDIANAPOLIS HAMFEST, August 12, 1973. Gas Co. Recreational Area, 2 miles East of Emerson Ave. on Thompson Rd. P. O. Box 19449, Indianapolis, Ind. 46219.

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.

YOUR KWM2 CAN WORK BETTER — You can do it, too. Write W0BNF, Box 105, Kearney, Nebr. 68847.

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More Details? CHECK—OFF Page 110

MOTRACS: Late solid state models, Hi-Band, low-split, with all accessories and manuals. A-1 condition. Best reasonable offer. Paul Cuda, WA7QEX, 13502 SE Harold St., Portland, Ore. 97236. Tel. 503-760-2846.

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

TR-22: 50 watt dycomm, gain ant., extra xtals. May separate. $315.00 or trade. Dave Leonard, WA7VKC, 4296 SW Sunset Dr., Lake Oswego, Ore. 97034. Tel. 503-636-2379.

WARREN HAMFEST, Largest family style Hamfest in East. Sunday, August 19th, at famous Yankee Lake Park. Giant Fleamarket, swimming, picnicing — All free. QSL W8VTD, Box 809, Warren, Ohio 44482.

"DON AND BOB" NEW GUARANTEED BUYS. Triex MW50 tower 250.75; MW65 331.50; W51 (FOB Calif.) 386.00; Ham-M 99.00; TR44 59.95; AR22R 31.95; Hygain TH6DXX 139.00; 204BA 129.00; TH3MK3 114.00; Mosley CL36 149.00; CL33 124.00; TA33 114.00; MCQ3B 91.00; S402 143.00; MP33 90.00; Belden 8214 RG8/U foam coax 17¢/ft; 8448 8-wire rotor cable 10¢/ft; Mallory 2.5A/1000 PIV epoxy diode 29¢; write specific needs new panel meters, many stock; quote discontinued tubes; quote Clegg FM27B; Hallicrafters FPM300A; Standard; Regency; Eimac; Midland 2MFM; Collins and CDE replacement parts stock; hardbound technical magazines, many types from Petro library 3.00/yr, write needs. 9-pin ceramic 6LQ6 socket 50¢; 6V/12V/24V/1.5A transformer 2.49; 135V/500MA-6.3V/3A 2.95; All items guaranteed, shipping charges collect. Madison Electronics, 1508 McKinney, Houston, Texas 77002 (713) 224-2668.

CLEANING OUT SHACK, Eico 753 transceiver with AC supply, $100.00; Motorola 41 TRU, 2 meter FM transceiver with accessories, $50.00; Viking Adventurer novice transmitter, $25.00; Lafayette communications receiver HA-225, $40.00. Barry Fluxe, WB8LSV, 32 Willow Spring, Wheeling, W. Va. 26003.

WANTED — Hammarlund SP-600JX21 receivers — Need 20 or more. P. O. Box 4039, Foster City, California 94404.

FINDLAY ANNUAL HAMFEST, Riverside Park, Findlay, Ohio, Sunday, Sept. 9. Advance donation tickets $1.00 from C. Foltz, W8UN, W. Hobart, Findlay OH 45840.

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

MOBILE OPS — Completely shielded ignition system kits available for most U.S. cars 1965-72. Alternator, generator and regulator filters, feed-thru capacitors, copper braid in stock. Write Summit Enterprises, 36 Winchip Road, Summit, N. J. 07901.

PC BOARDS, CW time indentifier $12.50, RTTY speed converter $5.00, TT decoder $6.50, 200 MHz decade scaler $1.95. All boards sent ppd. & drilled. Many others available. Charles R. Sempirek/K8WDC, Rt. 3, Box 1, Bellaire, Ohio 43906.

"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.

ACTIVE HAMS — Monthly mailer of reconditioned and new equipment specials. Sell · Buy · Trade. Write: Associated Radio, 8012 Conser, Overland Park, Kansas 66204.

THE NORTH ALABAMA HAMFEST will be held in Decatur, Alabama, August 19, 1973. For information write: North Alabama Hamfest Assn. Inc., Box 9, Decatur, Alabama 35601.

FREQUENCY SYNTHESIZER REPLACES VFO and delivers clean output from 1 to 30 MHz continuous coverage with calibration accuracy, resolution, and stability to one hertz: $490. Video adapter converts your oscilloscope into flexible 1024-letter readouts: $400. Reduced price on MT-5 Morse-RTTY translator gives you complete kit for $390. TMC-1 Baudot loop to ASCII converter, $120, Baudot to Morse complete kit $290. Write for full information. Petit Logic Systems, Box 51, Oak Harbor, Wa. 98277.

'HAM' UHF 400 MC HIGH POWER TRANSISTORS

☐ 3 for $10. **$3.95**

By RCA or equal 2N3632. NPN, 23 watts, 3 amps, TO-60 case, with stud mtg. VCEV max 65.

3 for $10.

LED 7-SEGMENT READOUTS ☐

MAN-4 EQUAL 3.95

0-9 plus letters. Snaps in 14-pin DIP socket. 3/4" x 1/4" x 3/8". 5V 10ma, with decimal point. Like MAN-1

☐ Socket for above, 50c

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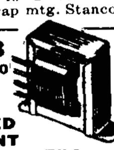
115/1/60 to 5 volts @ 120 ma. Strap mtg. Stancor



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1 AMP STRAP MOUNTED FILAMENT TRANSFORMERS

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☐ 115/1/60 in to 24VCT

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Type	Sale						
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☐ SN7401	.30	☐ SN7440	.30	☐ SN7482	.95	☐ SN74151	1.25
☐ SN7402	.30	☐ SN7441	1.40	☐ SN7483	1.50	☐ SN74153	1.60
☐ SN7403	.30	☐ SN7442	1.25	☐ SN7485	1.41	☐ SN74154	2.10
☐ SN7404	.35	☐ SN7443	1.35	☐ SN7486	.55	☐ SN74155	1.55
☐ SN7405	.32	☐ SN7444	1.35	☐ SN7489	3.75	☐ SN74156	1.55
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☐ SN7407	.55	☐ SN7446	1.65	☐ SN7491	1.50	☐ SN74158	1.55
☐ SN7408	.35	☐ SN7447	1.65	☐ SN7492	1.10	☐ SN74160	1.95
☐ SN7409	.35	☐ SN7448	1.50	☐ SN7493	1.10	☐ SN74161	1.95
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☐ SN7432	.30	☐ SN7474	.65	☐ SN74114	1.25	☐ SN74194	1.95
☐ SN7437	.60	☐ SN7475	1.30	☐ SN74121	.70	☐ SN74195	1.35
		☐ SN7476	.75	☐ SN74122	.75	☐ SN74198	2.65
		☐ SN7478	.95	☐ SN74123	1.20	☐ SN74199	2.65
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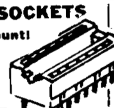

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☐ LM-309H	5V 200 mil V. reg.	1.50
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☐ LM-350	Dual peripheral driver	.59
☐ LM-370	AGC squelch op amp	1.49
☐ LM-371	R-F, I-F, op amp	.69
☐ LM-373	AM, FM, SSB, I-F strip	3.75
☐ LM-380	2-watt audio amplifier	1.95

*TO-3 case, — others TO-5

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☐ 703C	RF-IF, amp, 14 ckts (TO-5)	1.00
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☐ 709CV	Op amp (mini DIP)	.49
☐ 710C	Differential amp (A)	.44
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(A) TO-5 or DIP dual in line pak

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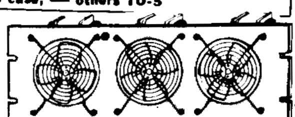

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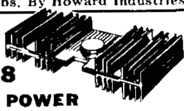

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*Money Back Guarantee! *With Spec Sheet!

Any "Chip" **$12.88**

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Mfrs #	Description	Sale
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☐ 5314	24-pin, plastic, LED and incandescent readouts, 6-digits: A-B	$12.88

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

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LED

This display is excellent for small portable electronics, such as DVM's, calculators, etc. Equivalent to Monsanto MAN 3A. Operates from 5V, 20 milliamperes, with 47 ohm dropping resistor.

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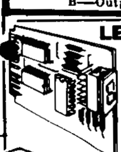

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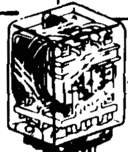
☐ **9.99** Digital Counting Modules

INCLUDES P.C. EDGE CONNECTOR — FREE!

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

Potter & Brumfield KAP RELAYS

Your choice 3 for $7.50 **$2.98**



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 mils 168 ohms. Size: 2¼" x 1 5/16". Wt. 4 ozs. Center pin missing. Comar Mfg. type equal too. ☐ 115 VAC ☐ 12 VDC

3PDT

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

BAY STATE SG-132A, 15 Mc - 400 Mc sweep gen. Ex. cond., manual included, $750. B. F. Williams Co., P. O. Box 7057, Norfolk, Va. 23509.

FT-101 YAESU SSB, AM, CW transceiver. Like new. 260 watts PEP with built in 110/220 volt AC and 12 volt DC power supply. Complete with power cables, microphone, and manual. CW filter and fan. $555.00. Schedler, W3GQS, 14322 Heathersfield, Houston, Texas 77024.

KLEINSCHMIDT TELETYPES, all types. Inquire for prices. All kinds surplus equipment. Send 25¢ for catalog. Andy Electronics, Inc., 6431 Springer, Houston, Texas 77017.

GLOBAL RESEARCH & Supplies. Ham equipment & supplies. Dycomm, Galaxy, Tempo, Kenwood, Inoue, B & W, SBE, Hy-Gain, Cush-Craft, Larson. 312/279-4658, P. O. Box 271, Lombard, Ill. 60148.

GONSET Communicator III 2 meters $100, Gonset 3063 2 meter power amplifier $75, package $150; Motorola P-33BAC with Ni-Cads 94/94 34/94 $125; Heath HX-20 $110, HR-20 $75, HP-20 $25, HP-10 $35, Hustler 80-10 mobile antennas, mast mount $35, package $245; you pay shipping — W5PNY, 2506-A 35th St., Los Alamos, New Mexico 87544.

HAMFESTERS 39th Hamfest and Picnic, Sunday, August 12, 1973, Santa Fe Park, 91st and Wolf Road, Willow Springs, Illinois, Southwest of Chicago. Exhibits for OM's and XYL's, Famous Swappers Row. Information contact John Raiger, K9DRS, 8919 Golfview, Orland Park, Illinois 60462. Tickets write Joseph Poradyla, WA9IWU, 5701 So. California Ave., Chicago, Ill. 60629.

VICTOREEN SURVEY METER for sale, Model 440 — RF/C New. $90 or best offer. Bayard Rowan, W2GKF, 55 Runnymeade Road, Berkeley Heights, N. J. 07922.

AMERICAN PRODUCTS WANTED for sales in the Far East. W6PHA, Global America Corp., Box 246, El Toro, Calif. 92630.

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.

THE TIPPECANOE ARA and the Indiana Radio Club Council is again sponsoring the Annual Indiana Club Council Picnic and Hamfest on August 19 at the Tippecanoe County Fairgrounds, located at 1100 Teal Road (Indiana Route #25), Lafayette, Indiana. This is a family hamfest. Flea market, games, trailer parking, awards, and more! Tickets from any IRCC club, by mail, or at the gate. Tickets by mail from WB9FOT, 2233 Delaware Drive, West Lafayette, Indiana 47906. All tickets $2, but if purchased by August 1, owner is eligible for pre-registration prize of a Motorola HT 220.

FOR SALE — Must sell brand new CX7A Signal/One, $1600.00. Contact Lewis Grigsby Jr., Farmers State Bank, Pittsfield, Ill. 62363. 217-285-2194.

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ALPHA-77. The finest amplifier ever offered for amateur, commercial or military service. 3000 watts PEP continuous duty. Perfect companion to CX-7A .... $1,495.00 net

1 CX7A brand new, latest version, trade or cash. RTTY Filters & CW Filters for CX7 & CX7A, write

INSTRUMENTS

Pan Adapter BC-1031A ± 100 kc unused with spare parts & book .... $ 75.00

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110 AC OUTPUT, all with full factory warranty
MODEL 102, is a 4 amp overload protected power supply that automatically resets itself when the overload is removed .... new, $24.95
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SRC-146A 2 meter handheld transceiver $289.00
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Your chance to build a high quality deluxe AM, CW 6 meter transmitter. Can be converted to FM. See Aug. '63 QST, page 45 for complete details. 115 VAC and 12 VDC power. Parts and information available. Call or write for further details.

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IN LESS THAN THREE YEARS THE TEMPO LINE HAS ESTABLISHED A SOLID REPUTATION FOR FIRST RATE PERFORMANCE AT A REASONABLE PRICE. WHETHER YOUR INTERESTS LIE IN HIGH FREQUENCY SSB OR VHF/UHF FM, TEMPO DESERVES YOUR SERIOUS CONSIDERATION. YOU WILL NEVER BE SORRY.

THE TEMPO ONE SSB TRANSCEIVER

Look at the specifications . . . look at the price tag . . . ask any of the thousands of Tempo ONE owners about its reliability . . . and the reason for its unparalleled popularity will be obvious. The Tempo ONE is now the proven ONE.

FREQUENCY RANGE: All amateur bands 80 through 10 meters, in five 500 khz, ranges: 3.5-4 mhz., 7-7.5 mhz., 14-14.5 mhz., 21-21.5 mhz., 28.5-29 mhz. (Crystals optionally available for ranges 28-28.5, 29-29.5, 29.5-30 mhz.)
SOLID STATE VFO: Very stable Colpitts circuit with transistor buffer provides linear tuning over the range 5-5.5 mhz. A passband filter at output is tuned to pass the 5-5.5 mhz. range.
RECEIVER OFFSET TUNING (CLARIFIER): Provides ±5 khz. variation of receiver tuning when switched ON.
DIAL CALIBRATION: Vernier scale marked with one kilohertz divisions. Main tuning dial calibrated 0-500 with 50 khz. points.
FREQUENCY STABILITY: Less than 100 cycles after warm-up, and less than 100 cycles for plus or minus 10% line voltage change.
MODES OF OPERATION: SSB upper and lower sideband, CW and AM.
INPUT POWER: 300 watts PEP, 240 watts CW
ANTENNA IMPEDANCE: 50-75 ohms
CARRIER SUPPRESSION: −40 dB or better
SIDEBAND SUPPRESSION: −50 dB at 1000 CPS
THIRD ORDER INTERMODULATION PRODUCTS: -30 dB (PEP)
AF BANDWIDTH: 300-2700 cps
RECEIVER SENSITIVITY: ½ μv input S/N 10 dB
AGC: Fast attack slow decay for SSB and CW.
SELECTIVITY: 2.3 khz. (−6 dB), 4 khz. (−60 dB)
IMAGE REJECTION: More than 50 dB.
AUDIO OUTPUT: 1 watt at 10% distortion.
AUDIO OUTPUT IMPEDANCE: 8 ohms and 600 ohms
POWER SUPPLY: Separate AC or DC required. See AC "ONE" and DC1-A.
TUBES AND SEMICONDUCTORS: 16 tubes, 15 diodes, 7 transistors

TEMPO "ONE" TRANSCEIVER	$349.00
AC/ONE POWER SUPPLY 117/230 volt 50/60 cycle	$ 99.00
DC/1-A POWER SUPPLY 12 volts DC	$110.00
VF-ONE EXTERNAL VFO	$ 99.00

THE TEMPO 2001 LINEAR AMPLIFIER

Small but powerful, reliable but inexpensive, this amplifier is another top value from Henry Radio. Using two 8874 grounded grid triodes from Eimac, the Tempo 2001 offers a full 2 KW PEP input for SSB operation in an unbelievably compact package (total volume is .8 cu. ft.). The 2001 has a built-in solid state power supply, a built-in antenna relay, and built-in quality to match much more expensive amplifiers. This equipment is totally compatible with the Tempo One as well as most other amateur transceivers. Completely wired and ready for operation, the 2001 includes an internal blower, a relative RF power indicator, and full amateur band coverage from 80-10 meters. PRICE: $545.00

THE TEMPO 6N2

For 6 and 2 meter amateur operation. 2000 watts PEP input on SSB or 1000 watts input on FM or CW. Completely wired in one small package with an internal solid-state power supply, built-in blower, and RF relative power indicator.
$595.00

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Dual meters continuously monitor output power and SWR during transmission. Offers two power scales of 0-200 and 0-2000 watts plus operation from 1.9 to 150 MHz. Tempo offers this combination in-line SWR bridge and wattmeter at a surprisingly low **$33.50**

Prices subject to change without notice.

The Tempo line is available at select dealers throughout the U.S.

Henry Radio stores can now supply the complete line of Yaesu equipment.

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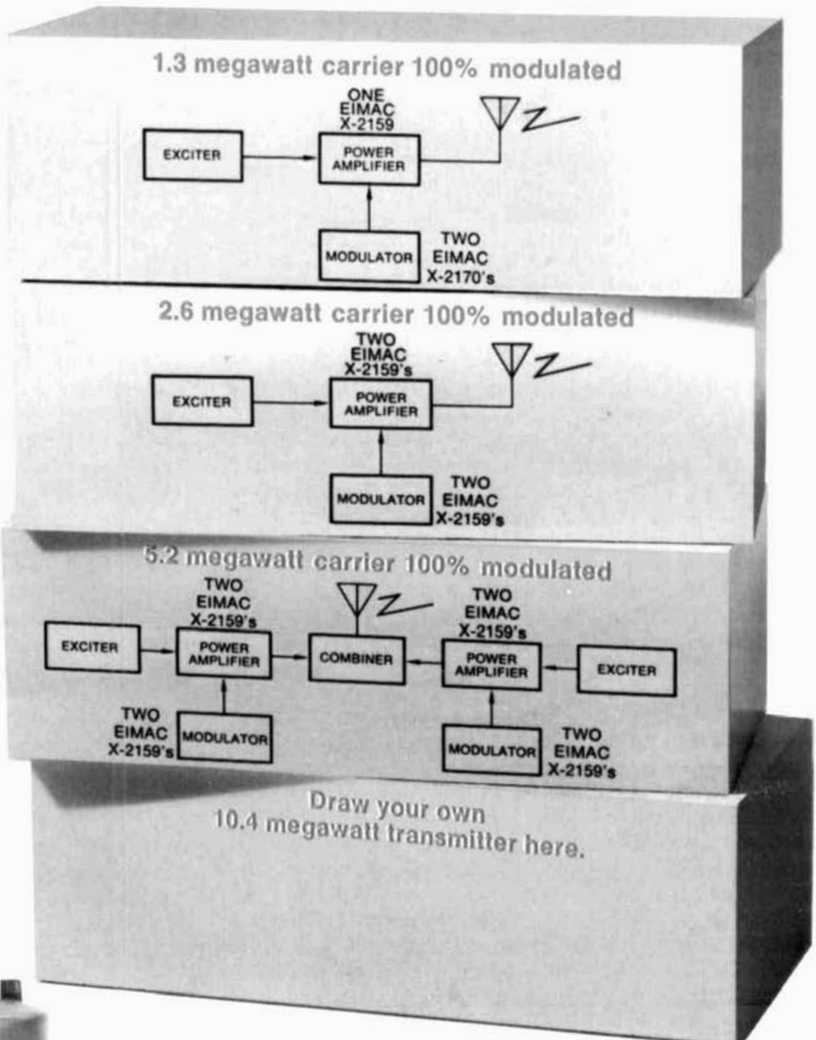

X-2159

For information on the X-2159 and X-2170 super-power tetrodes, contact the EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070. Or any of the more than 30 Varian / EIMAC Tube and Device Group Sales Offices throughout the world.

X-2170

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