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staff
James R. Fisk, W1DTY
editor
Patricia A. Hawes, WN1QJN
editorial assistant
Nicholas D. Skeer, K1PSR
vhf editor
J. Jay O’Brien, W6GDO
fm editor
Alfred Wilson, W6NIF
James A. Harvey, WA6I4K
associate editors
Wayne T. Pierce, K3SUK
cover
T.H. Tenney, Jr. W1NLB
publisher
Hilda M. Wetherbee
assistant publisher
advertising manager

offices
Greenville, New Hampshire 03048
Telephone: 603-878-1441

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December 1973
November 27th marks the fiftieth anniversary of one of amateur radio’s most memorable events — the first two-way amateur communications across the Atlantic Ocean. It was a hard-won goal, its path marked with failure and frustration, but when the Atlantic, at last, had been spanned, it was conquered by short-wave amateur radio, on wavelengths that previously were considered to be useless.

The first Transatlantic tests, in December, 1920 were a dismal failure, as were a second series of tests conducted in February, 1921. The 250 or so British stations which were listening for pre-arranged signals from the United States on a wavelength of 200 meters jammed each other so badly with radiations from their own regenerative receivers that they couldn’t hear any signals from across the pond!

A third Transatlantic test was scheduled for December, 1921. In November, Paul Godley, 2XE, designer of the famous Paragon receiver, sailed from New York with two receivers under his arm — one a standard variometer regenerative set with two stages of audio amplification, the other a 10-tube superheterodyne built especially for the tests. With this superhet and a Beverage antenna installed on the bleak Androssan moor on the coast of Scotland, Godley heard the first stateside signals coming through in the wee hours of the morning on December 8th.

A year later, two European stations, F8AB in Nice, and G5WS in London, were heard along the east coast of the United States, but two-way communications were as elusive as ever.

A fourth series of Transatlantic tests were scheduled for late 1923. However, these carefully laid plans were totally upset by the enterprise of one man, Leon Deloy, F8AB. Deloy came to the states during the summer of 1923 where he met with John Reinartz, 1XAM, and Fred Schnell, 1MO. Deloy picked up a lot of valuable advice from his talks with Reinartz and Schnell, and before returning to France he acquired a new Grebe receiver and the details of a “trick” circuit which, he was told, would “go down to about 100 meters.” Up until that time all the Transatlantic tests had been conducted on a wavelength of 200 meters.

Deloy put his new 100-meter station on the air in early autumn, and having satisfied himself that everything was in working order, cabled Schnell that he would transmit on 100 meters between 0200 and 0300 GMT on November 26, 1923. The signals from F8AB were heard by Schnell and Reinartz almost from the first dot he transmitted, but the Americans were not ready to transmit back. Unlike Deloy, who presumably did not think it was necessary to obtain official permission to transmit on such a short wavelength, Schnell had to seek the necessary authority from the Radio Supervisor in Boston.

On November 27th Schnell received special permits from Boston for himself and Reinartz. Late that night (early morning in Europe) they were both on the air. For an hour Deloy called the United States and then sent two messages. At 0330 GMT he signed off and asked for acknowledgement. Long calls followed from 1MO and 1XAM. Then came the eagerly awaited reply — Deloy had heard both stations clearly. Reinartz was asked to stand by as Deloy transmitted to Schnell, “R R QRK UR SGI QSA VERY ONE FOOT FROM PHONES ON GREBE FB OM HEARTY CONGRATULATIONS THIS IS A FINE DAY — PSE OSL. It was, indeed, a fine day.

Jim Fisk, W1DTY editor
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80 watts
for two meters

Construction details
for high-performance,
solid-state two-meter
power amplifiers

Evaluation results, component layout and
construction information for two 80-watt
vhf power amplifiers are described. These
solid-state amplifiers can be used to boost
two-meter output power levels to 80-
watts. Both units have been designed to
operate from a dc supply voltage of 12.5
volts with 50-ohm source and load impe-
dances. The 12.5-volt power requirements
are easily adapted to fixed or mobile
operation.

One of the amplifiers is a single-stage
design using two 2N6084 transistors com-
bined with simple LC components (fig.
1). It can be tuned to operate from 144
to 175 MHz, and requires a typical input
power level of 20 watts for 80-watts
output at 144 MHz.

The second amplifier uses the same
output stage design, but adds a 2N6083
transistor driver stage (fig. 2) to reduce
input drive requirements. This design is
also tunable from 144 to 175 MHz, and
will provide 80-watts output power at
144 MHz with only 2.5-watts of drive.

Six single- and two-stage amplifiers
have been constructed and evaluated with
similar performance exhibited by the
amplifiers in each group. Typical values
for the more important amplifier charac-
teristics are shown in table 1 and in figs.
3, 4, 5 and 6. The amplifiers have also
been subjected to momentary open- and
short-circuit load conditions without
damage to the transistors.

design philosophy

The amplifiers have been designed
to be efficient, reliable and stable without
sacrificing simplicity. All amplifier stages
are of the common-emitter configuration,
operated class-C. Two 40-watt 2N6084
transistors have been used in the high-
power output stage to provide excellent
heat distribution at full power. Combin-
ing the two 2N6084 devices is accom-
plished with LC signal splitting/combine-
ing techniques. For the single-
stage amplifier the combinations of L1
and L3 and L2 and L4 split the signal,
and inductance L5 recombines the sig-
als. The two-stage amplifier uses L4 and
L5 for signal splitting and L6 for com-
bining. These inductors provide impe-
dance transformation, isolation between devices and minimize unequal load sharing.

Low-loaded Q impedance matching network designs have been used to maximize bandwidth and to minimize insertion loss. This also results in reducing reflected voltage levels that can occur during high-output vswr conditions. A low-pass, low-loss, LC output filter can be used to provide additional attenuation of the harmonic components.

The two transistor types used in the amplifiers are part of the Motorola vhf land mobile series designed for 12.5-volt fm operation. They are multiple balanced-emitter transistors manufactured using the 1stothermal process technology to minimize temperature variations across the transistor chips. This process provides increased transistor protection over wide thermal and load vswr excursions. The devices are packaged in a 0.380 inch diameter, stripline-opposed-emitter stud package (case 145A-01).


†Trademark of Motorola Inc.
C1,C3, C9,C17 5-80 pF trimmers (ARCO 462)
C2 25 pF metal clad (Underwood Electric type J-101)
C4,C5,C6, C12,C13,C14 100 pF metal clad (Underwood Electric type J-101)
C7,C10,C16 40 pF metal clad (Underwood Electric type J-101)
C8 4-40 pF trimmer (Arco 403)
C15 250 pF metal clad (Underwood Electric type J-101)
C18 30 pF metal clad (Underwood Electric type J-101)
C19 1.0 µF tantalum
C20,C21,C22 680-pF feedthrough (Allen Bradley type FA5C)
C23 0.1 µF, 75 V ceramic disc
C24 5.0 µF, 25V, aluminum electrolytic
L1 1 turn number-16, 0.25" ID (18 nH)
L3 3 turns number-16 wound around R1 (60 nH)
L4,L5 1.1" long number-14 wire, formed around 0.6" diameter cylinder (12 nH)
L6 cut from 0.031" single-sided G10 circuit board (5 nH)
L7 number-12 wire, approximately 1.1" long (10 nH)
L8 3 turns number-14, 0.25" ID (50 nH)
L9 ferrite bead (Ferroxcube 5659065/3B)
RFC1, RFC2, RFC3, RFC4 0.15 µH molded choke with Ferroxcube 5659065/3B ferrite bead on ground lead
RFC5 10 turns number-14 wound around R4

fig. 2. Schematic diagram of the two-stage, 80-watt, 144-MHz power amplifier. Circuit is built on 0.062" single-sided G10 circuit board as shown in the photograph. Performance of this amplifier is shown in figs. 4 and 6.

To achieve the 80-watt power level, it is imperative that low-loss matching network components be used. It is also necessary that these components be characterized for the desired operating frequencies. Suitable low-loss coils can be made with a small length of wire, ribbon conductor or printed circuit board material. Economical capacitors for efficient high-power operation at 2 meters are more difficult to obtain. All fixed capacitors in the amplifiers, 250 pF or less in value, are Underwood mica dielectric units. The effective capacitance of these components at 2-meters will deviate only slightly from the low frequency value for nominal capacitance values up to approximately 60 pF. Larger capacitors of this type are characterized for operation at the selected frequency.
A full description of all necessary components for building the amplifiers along with the schematic diagrams are shown in figs. 1 and 2. Care must also be given to the physical location of the components. The photograph and the scale drawings in figs. 7 and 8 can be used to determine proper component placement. For the sake of simplicity, only those components necessary to establish the basic amplifier layout have been included in the drawings.

The amplifiers are built on 0.062 inch, single-sided, G10 circuit board with the components mounted on the ground plane side. In each case, the ground plane is continuous except for interruptions for the transistor and feedthrough capacitor (C13, C14 and C20, C21, C22) mounting holes. Coils L3, L4 and L5 of the single-stage amplifier isolate the transistor base and collector contacts from the ground plane. Coils L2 and L6 accomplish this function in the two-stage design. In addition, four small pads of 0.31-inch, G10 circuit board are used to provide isolation for the 2N6083 collector, the base of each 2N6084 and capacitor C7.

To prevent physical damage to the transistor stud package, the following precautions should be observed:

A. The maximum torque ratings for the mounting nut must not be exceeded (6.5 inch-pounds for the 2N6083 and 2N6084 devices).

B. The nut should be placed on the stud and tightened to the specified torque before soldering the transistor leads to the circuit. After the nut is properly torqued, a slightly downward pressure can be exerted on the leads to place them in contact with the circuit board connection points. The objective is to prevent an upward force being applied to the leads near the case body.

**table 1. Amplifier performance for a dc supply voltage of 12.5 volts.**

<table>
<thead>
<tr>
<th>Power output (watts)</th>
<th>single-stage design</th>
<th>two-stage design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power input (watts)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>144 MHz</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>148 MHz</td>
<td>20</td>
<td>2.5</td>
</tr>
<tr>
<td>165 MHz</td>
<td>21</td>
<td>3.5</td>
</tr>
<tr>
<td>175 MHz</td>
<td>23</td>
<td>5.5</td>
</tr>
<tr>
<td>Power gain at 144 MHz (dB)</td>
<td>6.0</td>
<td>15.1</td>
</tr>
<tr>
<td>Dc current output stage (amperes)</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Driver stage</td>
<td>—</td>
<td>2.5</td>
</tr>
<tr>
<td>Harmonic attenuation (dB)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Stability</td>
<td>Amplifiers are stable for input drive levels from zero to 30% overdrive and for supply voltages from 8.0 to 15.5 volts dc.</td>
<td></td>
</tr>
<tr>
<td>Ruggedness</td>
<td>With 80 watts power output into 50 ohms, no transistor damage from open- and short-circuit load conditions for all phase angles</td>
<td></td>
</tr>
</tbody>
</table>

**fig. 3. Power output vs power input for the single-stage amplifier.**

**fig. 4. Power output vs power input for the two-stage amplifier.**
heat sinks capable of keeping the transistor junction temperatures below their specified maximum temperature of 200°C. This requires extremely good thermal design and construction practice. A smooth heat-sink surface is required to maximize heat-sink to transistor case contact area. A proper amount of thermal-joint compound must be used between heatsink and transistor case interface to improve thermal transfer to the heatsink. Wakefield type 120, Thermaalloy Thermacote, Dow Corning type 340 or other thermal compounds exhibiting similar low thermal resistance properties are recommended. The heatsink must have a thermal resistance low enough to adequately transfer the heat from the transistor case to surrounding air.

Limiting the transistor junction temperatures to a maximum of 180°C during continuous operation into a 50-ohm load requires a heat-sink thermal resistance specification of less than 1.7°C/watt for the output stage devices at 60°C ambient. For an ambient of 30°C, the heat-sink thermal resistance requirement can be relaxed to approximately 2.3°C/watt. Similar operating conditions require the 2N6083 driver transistor heat-sink thermal resistance to be less than approximately 6°C and 8°C/watt for ambient temperatures of 60°C and 30°C, respectively.

Duty cycle operation, such as 1-minute on/3-minutes off, will significantly reduce the heat-sinking requirements. If operation into mismatched loads is anticipated, the heat-sink thermal resistance values must be reduced to account for the radical increase in transistor power dissipation that can occur with these operating conditions.

Several economical aluminum heatsinks are available with thermal resistance values in the order of 3°C/watt. These would be adequate for use with the amplifiers in most applications, since a 50-ohm load is used and continuous operation capability is not required. More expensive heatsinks can provide thermal resistance values less than 1°C/watt. Table 2 provides a brief description for some of the commercially available units.

amplifier adjustment

An amplifier alignment test set-up is shown in fig. 9. Initial amplifier tuning should be started with reduced supply voltage (approximately 8 volts) and reduced drive levels to prevent excessive device dissipation. For 144-MHz operation, a reasonably good starting point would be to set all variable capacitors approximately ½-turn from the fully closed (maximum capacity) position. During alignment, you may carefully touch each transistor case to detect excessive power dissipation in any of the transistors. Each transistor case should feel warm, but not too hot.

If a spectrum analyzer is available, it should be used to monitor the output signal during tuneup to verify proper alignment and to indicate the presence of low-frequency oscillations that can occur if the amplifiers are significantly mal-
adjusted. An oscilloscope connected to the dc voltage line (for example, at the top of the 5-µF filter capacitor, C15 or C24) can also be used to provide useful information on the presence of low-frequency oscillations. The scope probe will usually pick up enough of the two-meter signal energy to provide a signal display on the CRT.

If low-frequency oscillations are not present, the two-meter signal display will be constant in amplitude. If a low-frequency oscillation (typically less than 10 MHz) is present, it will show up as amplitude variations on the two-meter display. The frequency of the amplitude variations correspond to the frequency of the oscillation. High-frequency oscilloscopes (100 MHz) will provide a good display of the two-meter signal. Low-frequency oscilloscopes (20 MHz) are not capable of showing the two-meter signal itself, but they can be useful in determining if a low-frequency amplitude variation (envelope) is present on the two-meter signal. Any oscillation should be eliminated by adjusting the amplifier variable capacitors.

Single-stage amplifier. Start with low drive level (approximately 2 to 5 watts)

<table>
<thead>
<tr>
<th>part number</th>
<th>part number</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WE1 Corp. 3110</td>
<td>2.5</td>
<td>aluminum, 1.3&quot; x 4.0&quot; x 1.5&quot; &amp; 3.0&quot;</td>
</tr>
<tr>
<td>WE1 Corp. 3164</td>
<td>2.5</td>
<td>aluminum, 1.0&quot; x 4.12&quot; x 1.5&quot; &amp; 3.0&quot;</td>
</tr>
<tr>
<td>Thermalloy 6169</td>
<td>2.5</td>
<td>aluminum, 1.3&quot; x 4.12&quot; x 3.0&quot;</td>
</tr>
<tr>
<td>Wakefield NC-641</td>
<td>2.5</td>
<td>aluminum, 1.0&quot; x 4.12&quot; x 3.0&quot;</td>
</tr>
<tr>
<td>Wakefield FC-502</td>
<td>0.45</td>
<td>copper, 1.75&quot; x 3.5&quot; x 1.75&quot;</td>
</tr>
<tr>
<td>Wakefield FC-503</td>
<td>0.35</td>
<td>copper, 1.75&quot; x 3.5&quot; x 3.5&quot;</td>
</tr>
</tbody>
</table>

WE1 Corporation, P. O. Box 10577, Santa Ana, California 92705
Thermalloy Inc., 8717 Diplomacy Row, Dallas, Texas 75247
Wakefield Engineering Inc., Wakefield, Massachusetts 01881
Component location for the two-stage amplifier. Some components have been omitted for clarity. Transistor mounting holes are 0.80" center to center. RFC4, RFC5 and R4 are mounted on back of board.

large enough to turn on the transistors (indicated by the flow of dc collector current). Then adjust capacitor C10 for maximum output and C1 and C3 for minimum reflected power to the drive source as indicated by the swr bridge. Increase the supply voltage to 12.5 volts after this initial adjustment, and continue to increase the input drive power to approximately 8 to 12 watts while adjusting C10 first and then C1 and C3 as before.

Increase the drive power to approximately 20 watts, and tune for rated power output in a similar manner. After tuning for rated output power, capacitor C10 can be increased slightly in capacitance. This will minimize the required dc current with only a slight degradation, approximately 0.1 dB or less, in power output.

Two-stage amplifier. Start with low drive (approximately 0.25 to 0.5 watt) large enough to turn on the 2N6083 stage as indicated by the flow of dc collector current. Then adjust C8, C9 and C17 for maximum output power and C1 and C3 for minimum reflected power to the drive source as indicated by the swr bridge. Increase the supply voltage to 12.5 volts after this initial adjustment, and increase the input drive power to approximately 1.0 to 1.5 watts while adjusting C17 first and then C8, C9 and C1, C3 as before.

Now, increase the drive power to approximately 2.5 watts and tune for rated power output. After tuning for rated output power, capacitor C17 can be increased slightly in capacitance. This will minimize the output stage dc current requirement with only a slight degradation, approximately 0.1 dB or less, in power output.

fig. 9. Test setup for aligning the two-meter power amplifiers. Spectrum analyzer and power attenuators should be used if available.

fig. 8. Component location for the two-stage amplifier. Some components have been omitted for clarity. Transistor mounting holes are 0.80" center to center. RFC4, RFC5 and R4 are mounted on back of board.

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*SINAD = Signal + noise + distortion

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Kit HA-202-4, Fixed Station 2-Meter Antenna, 4 lbs. ...................... $15.95*

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Kit HM-2102, 4 lbs. ......................................................... $29.95*


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More Details? CHECK-OFF Page 126
crystal controlled

AFSK generator

Complete construction details for the RY-170 — an AFSK synthesizer for 170-Hz shift

How would you like to generate precise RTTY audio tones without the need for a counter to establish the correct frequencies? Many years ago, when faced with the same problem, I recall an attempt to use a guitar to help adjust an AFSK oscillator! With that technique leaving something to be desired, I often thought how nice it would be to have an oscillator which could generate the correct frequencies without adjustment, while not breaking the bank in the process. Enter the RY-170, described here.

It wasn’t until recently that surplus integrated circuits have made inexpensive frequency synthesis techniques possible. Start with a surplus crystal, divide by the correct ratios to generate 2125 and 2295 Hz, add a simple active bandpass filter, and for less than ten dollars you can have a 170-Hz shift synthesizer in your RTTY system.
The following goals were established prior to starting the RY-170 project:

- Generation of 2125- and 2295-Hz tones from one crystal, low output distortion (THD), minimal keying overshoot, control from a TTL compatible input, use of inexpensive components, and easily duplicated printed circuit board. The resulting design is shown in fig. 1, while the photographs show various views of the completed unit. A summary of the RY-170 specifications is given in table 1.

**circuit description**

The heart of the AFSK synthesizer is an oscillator using a surplus FT-241 crystal and transistor Q1 in a modified Pierce circuit. A channel 48 (459.259 kHz) crystal will yield output frequencies accurate to approximately 2 Hz, while preserving the relative shift (170 Hz) to within 0.1 Hz. If you desire even greater accuracy (with a slight increase in cost), an FT-241 crystal can be ordered which has been adjusted to the correct fre-
fig. 2. Waveforms of the RY-170 AFSK generator.

A. Collector Q1
horizontal scale, 0.5 microseconds/cm vertical scale, 5.0 volts/cm ground 2 cm from bottom

frequency of 459.000 kHz.* The output waveforms from the oscillator and its buffer are shown in figs. 2A and 2B, respectively.

B. Collector Q2
horizontal scale, 0.5 microseconds/cm vertical scale, 2.0 volts/cm ground 2 cm from bottom

output waveform of the complete divider is a TTL square wave, shown in fig. 2C.

The output bandpass filter, necessary to extract the fundamental frequency

C. Divider output
horizontal scale, 100 microseconds/cm vertical scale, 1.0 volt/cm ground 1 cm from bottom

Transistor Q2 interfaces the output of the oscillator to the divider input. JK flip-flops U1 through U3A and NAND gate U5 are wired as a programmable divider whose divide ratio depends on the logic state of the synthesizer input. When the input is grounded, the divide ratio is 25 (2295 Hz); when the input is high, the ratio is 27 (2125 Hz). The programmable portion of the divider is followed by an additional divide-by-eight circuit consisting of flip-flops U3B and U4. The

D. Filter output
horizontal scale, 100 microseconds/cm vertical scale, 0.5 volts/cm ground at center

*JAN Crystals, 2400 Crystal Drive, Ft. Myers, Florida 33901.
from the divider output, consists of dual-operational amplifier U6 and its associated components. The filter was designed with a Q of 10; raising the Q would result in increased filter sensitivity to component tolerances and increased keying overshoot, while lowering the Q would raise the THD.

**adjustments**

Resistors R8 and R11 are used to adjust the filter center frequency to pass the two tones. Resistors R8 and R11 should be adjusted, one for each tone, so that the transmitter has equal output power for 2125- and 2295-Hz inputs. The sinusoidal output waveform of the bandpass filter is shown in fig. 2D while the keying characteristics are shown in fig. 2E.

The output amplitude of the synthesizer can be adjusted with resistor R14 to match the transmitter audio requirements. R14 should be adjusted in conjunction with R8 and R11 to ensure that the audio stages of the transmitter are not overloaded.

Because the RY-170 is part of a larger system, I decided to use a common power supply for all accessories. If it is desired to use an internal supply with the AFSK board, a regulated supply meeting the requirements of the circuit can be used (see specifications in table 1).

**construction**

The RY-170 AFSK synthesizer was constructed in a Ten-Tec JG-5 enclosure. The front panel was painted with Krylon 2021 (Oldsmobile green) which closely matches the color of the Heath SB-series. An LED is used as a pilot light, powered from the +5-volt power supply through a 220-ohm current-limiting resistor. The front and back panels are labelled with press-on letters and sprayed with Datak Datakoat for protection.

The circuit board is single-sided G-10 board and requires four jumpers.* I used Molex connector pins to hold the ICs although the ICs can also be soldered directly to the printed-circuit board. Dipped mica capacitors are required in the oscillator circuit, while high-stability capacitors (Orange Drop or polystyrene) should be used in the active filter.

There is something satisfying in knowing your shift is, and will remain, at 170 Hz. The RY-170 is one answer, and an economical one at that, to stable 170-Hz AFSK shift.

---

*Drilled circuit boards and component layout information are available from the author for $5.50, postpaid.
This wide range signal generator covers the range from 600 kHz to 12 MHz and features a built-in 1-kHz modulator. Variable tuning capacitors have a maximum to minimum capacitance ratio of 20 to 1 or less.

The oscillator described here is not an LC type, and its output frequency is proportional to 1/C. Thus, the variable capacitor is capable of tuning the oscillator over a 20 to 1 range, from 600 kHz to 12 MHz! Since such a wide range of frequency is covered by a single 180° turn of the capacitor shaft, it is advisable to have a good sized dial for calibration. The largest dial of good quality that I could readily obtain (the biggest one in the junkbox) was a Millen 10035. The use of this dial is the only reason that the signal generator is as large as it is.

Most signal generators used by amateurs and other radio experimenters use the LC tuned oscillator in one form or another. Whether the exact circuit is a Colpitts or Hartley oscillator or some variation of these two basic designs, the output frequency is usually proportional to the inverse of the square root of the capacitance of the main tuning capacitor. That is, at least approximately

\[ f = \frac{1}{2\pi \sqrt{LC}} \]

Because of this relationship signal generator tuning is broken into bands, each of which encompasses a high-to-low-frequency ratio of only 3 or 4 to one (check the dial on your own signal generator, and see). The 3 or 4 to one frequency ratio is a direct consequence of the fact that parallel-resonant LC circuits vary in frequency as 1/√C, and most
A standard 365-pF broadcast tuning capacitor is used in the signal generator in conjunction with half of a relatively new Motorola IC, the Motorola MC4024P (or HEP 3805P). This IC is characterized as a dual voltage-controlled multivibrator, or vco. Since only half of the MC4024P is used to produce the rf output, the other half can be used to generate a 1-kHz modulation frequency.

The waveforms produced by both halves of the MC4024P are rectangular, and contain many harmonics. The harmonics of the rf oscillator section are not particularly troublesome, since most signal generators have appreciable harmonic content. However, it is desirable to filter the 1-kHz modulation waveform so that only one set of sidebands will be produced when the rf is modulated by the 1-kHz signal. Actually, since small index frequency modulation is used, there will be some small higher-order sidebands at 2 kHz and higher spacing around the rf carrier, but these will be insignificant if the generator is used within the bounds of narrowband frequency modulation (nbfm).

Nbfm has long since passed from the amateur scene, at least as a modulation method on the high-frequency bands. The main reason for nbfm’s disfavor is that it is useful only for simulating amplitude modulation with 50% or smaller percentages. If higher indexes of fm are used, the higher-order sidebands rapidly increase and the signal no longer resembles a-m.

To see how this works, look at the graphs of fig. 1. Note that the graph representing the first-order sidebands is approximately linear up to a modulation index of 0.5 and that the higher-order sidebands are almost nonexistent at lower indices. Fig. 2 shows the spectrum of a 100% a-m signal, a 50% a-m signal, a 1.0 order fm signal and a 0.5 order fm signal. Note that the 1.0 order fm signal succeeds in generating first-order sidebands comparable with those of the 100% a-m signal, but at the expense of producing 2nd and 3rd order sidebands of appreciable amplitude.
The 0.5 index fm signal gives a good approximation to a 50% a-m signal, with only small amplitude 2nd order sidebands. Since most amplitude modulated signal generators are only used at a-m percentages of about 50% (a standard measurement technique), you can use this 0.5 order fm signal to provide a simulated 50% a-m signal.

In fairness it must be mentioned that detection mode, where the receiver selectivity curve provides a frequency-to-amplitude conversion.

**the circuit**

The circuit of the signal generator is shown in fig. 3. Note that half of an MC3029P line-driver NAND gate follows each of the two multivibrators in the MC4024P. The line-driver NAND gates provide isolation and the capability to drive 50-ohm lines with either 1-kHz or rf output. It must be remembered that the output of the generator is well over one volt peak-to-peak, even when terminated in 50 ohms, so an external attenuator is usually required.

The modulation frequency is determined by the parallel tuned circuit consisting of the 88-mH toroid, T1, and the 0.33\(\mu\)F capacitor across it. This is because the frequency of the 1-kHz oscillator is adjusted (by voltage control) to maximize the output at the test point. This occurs

---

**fig. 3. Circuit for the wide-range rf signal generator that covers from 600 kHz to 12 MHz. Integrated circuit U1A is the 1-kHz modulation oscillator; U1B is the rf oscillator. U2A and U2B are used as line drivers. Transformer T1 is an 88-mH toroid with a secondary consisting of 30 turns no. 28 enamelled wire wound over it.**

nbmf approximates low percentage a-m only in the frequency domain. The signal is still fm since there is no variation in amplitude at the modulation rate. That this is true is immediately obvious because the entire system is made of digital ICs which are in essence limiters; that is, amplitude is constrained to be either 1 or zero.

Since the amplitude does not vary, a diode detector will, strictly speaking, be unresponsive to nbmf. However, most receiver systems having diode detectors will respond to nbmf by the slope-
when the 1-kHz oscillator frequency matches the resonant frequency of the 88-mH-0.33-µF parallel tuned circuit. The voltage observed at TP with a scope should be about 0.2 volts p-p. If the resultant frequency at maximum TP voltage isn’t close enough to 1-kHz to suit you, a somewhat different value of C (nominally 0.33-µF) will have to be used.

A simple but well-regulated power supply is shown in fig. 4. It uses a standard 6.3-Vac filament transformer and a full-wave bridge rectifier. The regulation is accomplished by one of the newer three-terminal IC voltage regulators of Fairchild, National or Motorola. The common terminal of each of these regulators is the case, so a good thermal connection to the chassis (for heat dissipation) is also the electrical ground. The 0.22-µF capacitor at the input of the voltage regulator is important and should not be omitted. This capacitor should be placed between the input and common inside the cast aluminum box and is mounted by screwing it to a Lucite plate, which in turn is mounted on 1/4-inch standoff spacers to the inside bottom of the box. The MC4024P and MC3029P ICs are socket-mounted upside-down on a 2-1/2x2-1/2-inch piece of double-sided copper-clad circuit board. The ICs themselves are not visible, but the socket terminals are conveniently exposed for wiring.

The power supply circuitry is built in the underside of the 11x7x2-inch aluminum chassis. In this way all the parts of the power supply which have large 60-Hz signals on them are well isolated from the MC4024P — which has quite a high modulation sensitivity.

Since the broadcast variable capacitor I used has two 365-pF sections, only one of which is used, it would be possible to add frequency coverage down to 300-kHz by simply adding an spst switch. This was not done in the preliminary model because it was not mechanically convenient. However, such an addition should be considered when building a new version, since the 455- to 500-kHz region is quite useful for i-f alignment.

fig. 4. Regulated power supply for the wide-range signal generator. Three-terminal regulator U1 is a Fairchild 7805, National Semiconductor LM309K or Motorola MLM309K.

The wideband signal generator Is built into a Bud CU-47 enclosure. Dial mechanism Is a Millen 10035.
two-stage cavity filter

for two meters

Complete construction details for a highly selective resonant filter for 144 MHz

Because of the popularity of the fm mode of communications, the amateur vhf bands are becoming much more active. With this activity comes the attendant equipment problems, which include interference to and from our landmobile service neighbors who, in some cases, use the same geographical location as the amateur station. Overloading the neighboring receiver, or being overloaded, are the most prominent problems. Spurious radiation is another nuisance.

Overloading manifests its presence by the sudden decrease in sensitivity of a receiver which has a signal forced into its input. The overloading signal does not have to be near the operating frequency of the overloaded receiver, but it will be strong enough to get into the frontend and cause the agc to cut down the overall gain of the receiver. Often, when this effect occurs, the operators will not be aware of it because the overload signal bears no intelligence. The reverse of this effect causes problems with the neighbor-

looking for the cure

To improve neighborhood relations with a technician who maintains equipment in the same building and uses the same antenna platform as I do, an investigation was completed which revealed the desensitization of several receivers. One receiver operated in the amateur two-meter fm band and another in the Land Mobile Service on an adjacent frequency allocation. The transmitters for each of these two services were at the 50-watt level.

A probe with a crystal detector was mounted on the tower, halfway between each antenna; meter indicators were located near each of the transmitter/receiver units so that observations of on time could be accurately known and used when comparison adjustments were being initiated. It was interesting to note that other services, 10 MHz away in frequency and located geographically on the other side of the hill, were detected and in several instances desensitized the commercial receiver. A plot of the input circuits for the rf amplifier and mixer for the amateur receiver was made. The input circuits and interstage coupling circuits are double tuned and critically coupled by the manufacturer, indicating that previous thought had been given to the matter of high-Q preselection.

A similar test was made on the commercial station receiver. The plot for the amateur receiver preselection circuits, fig. 1, is presented on a scale which clearly shows how the adjacent frequency transmitter could easily control its sensitivity through overloading. To eliminate this
problem it was obvious that further selectivity was required for the receiver frontend.

To accomplish this, a major circuit revision would be required. Further investigation of several of the commercial sets revealed that the same problem had been relieved satisfactorily by adding a coaxial filter to the antenna feedlines. These units were simple coaxial tanks, designed with a low coupling coefficient to maintain a high Q, and, therefore, improve selectivity.

![Diagram](image)

fig. 1. Typical selectivity curves of amateur two-meter receivers and adjacent Land Mobile equipment. Two meter selectivity is improved considerably by the addition of the two-stage cavity filter described here.

coaxial filter

A dual coaxial filter was designed for 145 MHz. The filter was built from plumbing house supplies because these parts are very readily available. Construction details are shown in fig. 2. A list of materials is included for 145 MHz which will assist the constructor in locating the required copper fittings (table 1).

Assembly of the multiple-cavity filter is simple. First, inspect two 1-1/2×3/4-inch reducing couplings to see that there are no dents on either perimeter. Next, carefully file smooth the lip found in the interior of the 3/4-inch entry. When filing try not to touch the smooth area of the 3/4-inch pipe wall on this fitting, just break down the step so that a piece of 3/4-inch pipe will slide through each fitting.

Lay out the holes to be drilled in the B section of 1-1/2-inch copper water pipe. The lengths of the pipe and hole locations can be determined from the chart accompanying fig. 3. Both holes should be concentric; one should be large enough to accommodate the round shoulder on the mounting flange of a SO-239 coaxial receptacle. At a point 180° away from the connector hole, a second entry is required which is large enough to allow a piece of 3/8-inch copper water pipe to slip in to a tight fit.

At the base of each reducing coupler drill two holes with a number-28 drill. Slide the B section of 1-1/2-inch copper pipe into the reducing coupler. Align the reducing coupler so that the number-28 holes are parallel with the two large holes in B section. Sweat solder the two parts; use just enough heat to cause the copper to slightly change color. Use soldering paste. When the joint has been soldered, wash away the paste residue with hot water or a cleaning solvent. Try to make the joints as nearly watertight as possible.

The next step requires the addition of part H, a 1-1/16-inch disc which is soldered to the end of part J, a section of 3/4-inch copper water pipe, 17-inches long. Two sections should be prepared. The disc can be a large steel washer or can be cut from sheet copper. It is half of a capacitor used to foreshorten the cavity. It is also part of the tuning system.

Prepare a SO-239 coaxial receptacle by soldering a 3-inch length of number-14 wire to the center conductor terminal. Bend the wire at a right angle directly...
where it exits the solder point on the connector, insert the end of the wire into the large hole provided for the connector on the B section of copper pipe, and feed the wire down so that it enters the drilled number-28 hole into the reducing coupling. Solder the SO-239 fitting into place. Likewise, solder the wire to the exterior base of the reducing coupling and trim off any excess wire and solder. Align the wire so it is parallel with the pipe wall. This completes the input coupling jack assembly.

**output coupling**

The next step provides the output coupling link. Prepare an 8-inch section of RG-8/U as follows: strip off the vinyl jacket and the shield braid. Measure 2-1/2-inches in from each end of the center dielectric and cut away the covering to expose the center conductor wire. Bend the wire 3/8 of an inch from the remaining covering, slide the end of the wire into the B section of the cavity through the 3/8-inch hole, and fish it down to the remaining number-28 hole in the reducing coupling. Prepare the second cavity in the same way, leaving out the last step. Slide a 3/8-inch copper pipe, 3-1/8-inches long, over the coaxial-cable center dielectric and into the hole on the B section of the first cavity wall; carefully solder it in place. Bend the remaining end of the center conductor in the same manner as the opposite end, insert it into the 3/8-inch hole in the second cavity and into the number-28 hole located in the second reducing coupling. The end of the 3/8-inch pipe will now be fitted to the wall of the second cavity and soldered in place. The input/output and inter-cavity coupling are now complete.

The cavity assembly at this point is quite fragile and must be handled as such. Two 1-1/2-inch pipe stands must now be added to each cavity. One stand should be located at the top of each cavity, the other just above the 3/8-inch pipe containing the coaxial coupling element. Fasten the stands to a section of aluminum panel which will serve as a mounting for the filter. Level each pipe stand so that no strain is given to the inter-cavity coupling. If pipe stands are not available, a pipe clamp can be used.

Now, take two 17-inch lengths of pipe with the washer or disc soldered in place and insert the open ends into the 3/4-inch opening of the reducing coupling. Slide each section down to point where the disc is 1/2-inch below the top of the B section.

Be sure to clean these two parts so
that they are very bright. Use fine steel-wool. Be sure the reducing section is also clean; these pieces will be soldered later and must make a very good connection. Place a tube cap on the open end of each cavity. Both contact points should be clean and bright since these parts also will be soldered. Push the cap down as far as it will go.

**tune up**

You are now ready to tune up the cavity. It is best to use the transmitter coupled through a vswr bridge to a 50-ohm load for tuneup as shown in the block diagram.

Since the vswr bridge will serve as a resonance indicator, it should be set to the forward position. Set the sensitivity control to minimum. When power is first applied to the filters a small indication will be observed. The end of each of the 3/4-inch pipes should be carefully moved in very small steps which will cause the vswr meter to indicate an increase in output. Adjust each pipe until there is no further increase in output level. The sensitivity of the bridge can be adjusted as required. The reflected vswr should be no worse than before the filter was inserted if you follow all the dimensions shown in fig. 2.

If you reverse the input and output connections, there should be no difference from the previous measurements. For this reason, it makes no difference which SO239 jack is used for the input or the output.

To determine the amount of signal loss through the filter simply connect the coax directly to the vswr bridge and note the level. Compare output power without the filter to the level of the output with the filter installed. If you want to determine the ratio of on frequency resonance to off frequency loss, simply switch the transmitter to the 144-MHz end of the band for the low-end ratio and to 149-MHz for the high end loss. Loss at the high and low ends of the band should be near 40 dB.

When the tuneup adjustments are complete, carefully solder the 3/4-inch pipe to the reducer entry. Solder the top cap in place. The filter is now complete and it can now be installed in the feedline of your transceiver. A set of dimensions for filters for other vhf bands is shown in fig. 3.

The improvement at my station has been worth all of the effort and at not too great a cost. I no longer have the desensitizing effect and my commercial neighbor now has a similar filter tuned up on his Land Mobile channel.

---

**fig. 3. Construction of the two-stage two-meter cavity filter. Dimensions for other vhf bands are shown in the attached chart.**

<table>
<thead>
<tr>
<th>Frequency MHz</th>
<th>50</th>
<th>144</th>
<th>220</th>
<th>440</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>A 41.00&quot;</td>
<td>17.0&quot;</td>
<td>7.0&quot;</td>
<td>5.0&quot;</td>
<td></td>
</tr>
<tr>
<td>B 38.00&quot;</td>
<td>12.6&quot;</td>
<td>5.0&quot;</td>
<td>3.0&quot;</td>
<td></td>
</tr>
<tr>
<td>C 31.60&quot;</td>
<td>12.9&quot;</td>
<td>5.0&quot;</td>
<td>3.8&quot;</td>
<td></td>
</tr>
<tr>
<td>D 3.00&quot;</td>
<td>3.0&quot;</td>
<td>3.0&quot;</td>
<td>3.0&quot;)</td>
<td></td>
</tr>
<tr>
<td>E 4.50&quot;</td>
<td>1.5&quot;</td>
<td>3.0&quot;)</td>
<td>3.0&quot;)</td>
<td></td>
</tr>
<tr>
<td>F 1.40&quot;</td>
<td>0.375&quot;)</td>
<td>1.0&quot;)</td>
<td>0.75&quot;)</td>
<td></td>
</tr>
<tr>
<td>G 6.00&quot;</td>
<td>2.1&quot;)</td>
<td>1.4&quot;)</td>
<td>0.75&quot;)</td>
<td></td>
</tr>
<tr>
<td>H 3.00&quot;</td>
<td>1.06&quot;)</td>
<td>2.75&quot;)</td>
<td>2.75&quot;)</td>
<td></td>
</tr>
<tr>
<td>J 0.75&quot;)</td>
<td>0.75&quot;)</td>
<td>0.75&quot;)</td>
<td>1.0&quot;)</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tbody>
</table>
Design and construction of regulated power supplies is simplified by the use of three-terminal voltage-regulator ICs.

The new Fairchild 7800-series three-terminal voltage-regulator ICs present some vastly new features not previously available to the amateur. For one thing, they provide a lot of regulation for very little money. However, the use of these regulators takes a new orientation, especially for those readers who have designed and/or built conventional regulated power supplies. In this article, I will cover some of the new aspects of using these IC regulators and will show several recommended circuits for different types of power supplies.

Many new integrated circuits no longer require the addition of several "generalized" circuit elements, such as transistors and diodes, to perform a specific function. Rather, these functional blocks are already combined, within the IC, to perform one very specific function.
The 7800 regulators are good examples of this new breed of IC. Each device in the series is preset to regulate a fixed output voltage. For example, the 7805 is a positive five-volt regulator. A complete list of the 7800 series and the respective preset voltages are shown in table 1.

The main advantage of a fixed-voltage regulator is the ease with which it can be used. Since the basic operation of the 7800 IC requires no external components, all you need is a power transformer, a bridge rectifier and a filter capacitor, and you have an instant power supply. You don’t have to worry about choosing transistors, biasing them, and protecting the regulator against short circuits.

**features**

The 7800 voltage-regulator series features a preset voltage tolerance of ±5%, more than adequate for the vast majority of electronics experimenting. The tolerance means that the actual output voltage of an individual 7805 sample, for example, may be anywhere between 4.75 and 5.25 volts. However, the actual voltage regulation, once you have chosen a particular device, is 0.01% per volt, or 0.05% for the five-volt 7805. I doubt that most experimenters need better regulation than that!

Another valuable feature of the 7800 IC regulators is their built-in protective circuitry. The circuit guards against the three most common causes of power supply failures: excess output current, output short circuit and excess heat. The first two causes are listed separately because of the subtlety of a current overload — you may have your project hooked up properly, but are simply demanding a little too much current. The 7800 regulators compensate for these failure modes by internally limiting the output current that can be drawn from the device. In the case of a complete short circuit, only 750 mA, typically, can be drawn from the 7805.

The thermal shutdown protects the regulator from overheating. Additional safe-area compensation of the output transistor prevents the circuit from trying to dissipate too much power. Power capability is 15 watts. This means that you can draw 1 amp of current at 5 volts if the average unregulated input voltage is 20 volts or less, and if adequate heat sinking is provided.

The 7800 series ICs come in two case styles: a TO-220 plastic power transistor case, and a metal TO-3 case. The TO-3, having a lower case-to-ambient thermal resistance, is easier to heat sink, but it is more difficult to mount. Electrical connections are shown in fig. 1.

**unregulated supply**

The unregulated power supply is a

---

**table 1. Low-cost three-terminal fixed-voltage IC regulators manufactured by Fairchild, Motorola, National Semiconductor and Silicon General.**

<table>
<thead>
<tr>
<th>Fairchild number</th>
<th>National number*</th>
<th>Motorola number</th>
<th>regulated voltage</th>
</tr>
</thead>
<tbody>
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<td>7805</td>
<td>LM340T-5</td>
<td>MC7805</td>
<td>5 volts</td>
</tr>
<tr>
<td>7806</td>
<td>LM340T-6</td>
<td>MC7806</td>
<td>6 volts</td>
</tr>
<tr>
<td>7808</td>
<td>LM340T-8</td>
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<td>7818</td>
<td>LM340T-18</td>
<td>MC7818</td>
<td>18 volts</td>
</tr>
<tr>
<td>7824</td>
<td>LM340T-24</td>
<td>MC7824</td>
<td>24 volts</td>
</tr>
</tbody>
</table>

*The letter T designates the TO-220 package; for the metal TO-3 package, substitute the letter K. Motorola devices are in a metal TO-220 package.
basic element for the properly operating regulated supply. An example of an unregulated power supply is shown in fig. 2A. The line voltage is stepped down by transformer T1, rectified by the diode bridge and filtered by the output capacitor. With no load, the output voltage is equal to the peak transformer output voltage (1.4 times the rms voltage), less twice the diode forward voltage drop. As current is drawn, however, the voltage decreases momentarily between the charging peaks of the bridge. This creates the ripple shown in fig. 2B.

The average output voltage is between \( V_{\text{peak}} \) and \( V_{\text{min}} \). The greater the load, the more capacitor C1 discharges between charging pulses, and the lower \( V_{\text{min}} \) becomes, thus accentuating the ripple. For the same load current, the ripple decreases with an increase in the size of C1, up to the point where the bridge can no longer recharge C1 fast enough. One way to eliminate the output ripple is by regulating the output voltage. However, you must never drain so much current as to allow \( V_{\text{min}} \) to dip below the desired regulated output voltage.

Thus, the first step in building a regulated power supply is to properly design the unregulated supply. For all the regulated circuits discussed here we will assume a properly designed unregulated supply which can provide 1 ampere of current without allowing \( V_{\text{min}} \) to drop below the sum of the desired output voltage and the regulator maximum voltage drop.

designing the unregulated supply

Although the discussion which follows pertains to the 5-volt 7805, a similar design approach is used with other members of this voltage regulator family. The 7800 series of ICs requires a minimum of 2 volts input-output differential for proper regulation. This means that \( V_{\text{in}} \), in fig. 3, must be at least 2 volts higher than \( V_{\text{out}} \). Since the preset voltage of the output is \( \pm 5\% \), the worst case is 1.05 times the rated voltage, or

\[
V_{\text{out (max)}} = 1.05 \times V_{\text{out}}
\]

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Since there must be at least a 2-volt differential across the 7800

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V_{\text{in (min)}} = V_{\text{out (max)}} + 2
\]

With a 10% ripple, at full current, the peak value of \( V_{\text{in}} \) should be 1.1 \( V_{\text{in (min)}} \). Since the transformer current must pass through two of the bridge diodes

<table>
<thead>
<tr>
<th>Desired operating voltage</th>
<th>5 volts dc</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% tolerance (1.05 ( V_{\text{out}} ))</td>
<td>5.25 volts dc</td>
</tr>
<tr>
<td>Differential (+ 2 volts)</td>
<td>7.25 volts dc</td>
</tr>
<tr>
<td>Ripple allowance (1.1 ( V_{\text{in (min)}} ))</td>
<td>7.98 volts dc</td>
</tr>
<tr>
<td>Diode drop (+ 1 volt)</td>
<td>8.98 volts dc</td>
</tr>
<tr>
<td>Transformer output (( V_{\text{peak}}/1.4 ))</td>
<td>9.88 volts dc</td>
</tr>
<tr>
<td>( V_{\text{rms}} )</td>
<td>7.06 volts rms</td>
</tr>
</tbody>
</table>

\[
V_{\text{out (max)}} = 1.05 \times V_{\text{out}}
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Since there must be at least a 2-volt differential across the 7800

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With a 10% ripple, at full current, the peak value of \( V_{\text{in}} \) should be 1.1 \( V_{\text{in (min)}} \). Since the transformer current must pass through two of the bridge diodes
during any charge pulse, two diode drops (approximately 0.5 volts) must be added, \(1.1 V_{\text{in}} (\text{min}) + 1.0\) volt. This is the peak output voltage required from the transformer. If you allow for a 10% variation in the line voltage (105.3 to 128.7 volts for a nominal 117-volt line), you require an extra 10% for the transformer output voltage. These considerations are summarized for a 5-volt supply in table 2. In the worst case, the transformer must be able to produce at least 7 volts rms to operate properly.

The only thing that remains is to choose capacitor C1. The capacitor must have sufficient capacitance to prevent its voltage dropping below 7.25 volts when 1 amp is being drawn. A few quick calculations will show that a capacitance of 12,000 \(\mu\)F will meet this condition. Of course, if the actual transformer voltage chosen is greater than the 7.06-volt minimum, a smaller capacitor will do fine, since more ripple can be tolerated.

**regulator circuits**

The basic hook-up for the 7800 voltage-regulator ICs is refreshingly straightforward, as shown in fig. 3. The only embellishment is the optional transient suppression capacitor, \(C_T\), at the regulator output. This capacitor, typically 10 to 50 \(\mu\)F, will improve transient and

*fig. 4. High current voltage regulator circuit using external power transistors. Circuit in (B) includes short-circuit protection for the power transistor (see text).*

high-frequency response, but at the cost of increasing output impedance at frequencies below 1 kHz. Additionally, if a battery is used for the unregulated supply, an input bypass capacitor of at least 0.22 \(\mu\)F should be attached across the input to the 7800 (pin 1 to ground).

To increase the current capacity of the 7800s ICs, you may wish to add a pnp series pass transistor as shown in fig. 4A. In this application, the pass transistor handles most of the supply current. The 2N4398 transistor shown has a maximum collector current of 30 amperes. The 7800 regulator IC holds the output voltage constant by varying the bias on the
As the load current increases, the output voltage drops slightly, causing the 7800 to draw more current. This increases the base current of transistor Q1, which brings the output voltage back up by supplying more current to the load. Thus, the output current is supplied by both the 7800 IC and the pass transistor.

If you are concerned about a short circuit burning out the power transistor, you can insert a protection circuit consisting of transistor Q2 and resistor RSC, as shown in fig. 4B. The 7800 IC protects itself, but has no feedback feature to protect external elements. The series resistor, RSC, may be set for the particular value of current you wish to limit. It should be a small value resistance capable of handling the power through it. Transistor Q2 may be any moderate gain npn transistor which can handle the short-circuit current of the 7800.

The use of this series pass transistor allows you to quickly build a fixed regulated voltage supply for almost any application you may have. In fact, if the protection circuit of fig. 4B is used, RSC may be made variable, so as to provide exactly the extent of current limiting needed to protect the load circuit.

Some applications, such as battery charging, require a constant load current, rather than a constant voltage. Fig. 5 shows the connections to a 7800 for current regulation. The 7800 tries to maintain a constant voltage across R1. In the case of the 7805, the voltage is 5 volts. Obviously, the 7800 will regulate the amount of current through R1 necessary to maintain this voltage. As this supplied current also passes through the load resistance, its current is likewise regulated. In the case of the 7805, five volts across a load of 100 ohms would produce a load current of 50 mA — the charging current for a 500 mA-hr nicad battery. Within the limits of the unregulated input voltage, the 50 mA will be supplied equally well to a simple battery, or a whole stack of them, and the charging current will not change as the cell voltage goes up during the charge cycle.

**summary**

In conclusion, you should find the 7800 IC voltage regulators to be an invaluable addition to your electronics repertoire. It will free you from the frequent and routine task of building regulated power supplies. Also, you will find yourself using regulated supplies more often because of the simplicity and low cost ($2.20 in single quantities) of the 7800 voltage-regulator ICs.

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- **Noise Level** – In excess of 40 db below single tone carrier.
- **Audio Frequency Response** – Minus 6 db approximately 300/2400 Hz determined by side band filter.
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- **Receiver Selectivity** – 2.1 KHz with 1.8 shape factor for SSB or 300 Hz sharp selectivity with optional CW filter.
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More Details? CHECK-OFF Page 126
low-voltage
audio agc amplifier

Description of
a wide range
audio agc system
that operates
from a 1.5-volt
flashlight battery

The circuit described here operates from a single penlight flashlight battery with a current drain of 0.5 mA, nominal. It should be ideal as a self-contained unit which can be connected in a microphone cable. The agc control element is a transistor used in the inverted connection to obtain better performance. Those readers who are unfamiliar with audio agc theory and applications are referred to a previous article.1

circuit

Fig. 1 shows a schematic of the agc amplifier. Transistors Q2, Q3 and Q4 form a 70-dB voltage amplifier; Q5 is the detector, and Q6 is an emitter follower required to drive the control transistor, Q1.

Resistor R1 and transistor Q1 form a voltage divider which attenuates the signal, as needed, to hold the amplifier output constant. When the input signal is 50 µV or less, the detector has zero output, and Q1 is turned off. As the signal increases, the detector feeds dc to the base of Q1 causing its collector-emitter resistance to decrease; this decreases the signal input to Q2.

With a power supply voltage of only 1.5 volt, the detector must be able to operate from a relatively small peak-to-peak ac voltage, or clipping will occur. The detector shown requires only 0.62 volt peak-to-peak input.

Notice that the control transistor, Q1,
is shown in the inverted connection as is used with chopper transistors; the transistor is turned on by current flow through the base-collector junction. Current gain is very low in this configuration, being on the order of 1.0, but collector-emitter resistance vs base current is about the same as with the normal connection.

The inverted connection is preferred because it produces a very low offset voltage; offset voltage is the dc voltage appearing between the collector and emitter when the base is biased on with no collector power supply. Fig. 2 shows how offset voltage is measured. Offset voltage in the normal connection can be 50 mV or more, but it is about 1 mV or less in the inverted connection.

Why is low offset voltage important? When the input signal to the agc amplifier suddenly increases from a very low value to a large value, the detector turns the control transistor on rapidly. If the control element produces a significant dc voltage across its terminals, a transient voltage spike is coupled to the amplifier input. This spike bears no relation to the signal amplitude and can drive the amplifier into hard saturation.

Suppose a 30-mV dc level suddenly appeared across the control transistor. The 70-dB gain of the amplifier would try to amplify the transient to a level of about 100 volts peak. Naturally, the amplifier cannot do this, so it saturates, upsetting the quiescent bias conditions. Recovery time from this strong transient may be one second or more. Under such conditions it is virtually impossible to achieve fast attack times.
Several transistor types were tried in the control transistor socket, but the 2N2222 was the only one that performed well. A transistor designed specifically for chopper applications should work best of all.

It is important not to omit the 1-megohm resistor, R2, because it prevents the buildup of dc voltage on the emitter of Q1 due to the capacitive voltage divider formed by C1 and C2.

Two outputs are shown in fig. 1; one is the full output of the amplifier, and the other attenuates the output to a level of about 1 mV rms, maximum. The attenuated output should be used when feeding the microphone input of other equipment so it will not be overdriven.

The value of the 10-megohm resistor, \( R_{fb} \), depends on the current gain of the amplifier transistors, and its value may need to be adjusted. The value should be set so that the dc voltage on the collector of Q4 is about 0.8 volt.

**operating characteristics**

Fig. 3 shows the input vs output voltage curve of the agc amplifier. Although the maximum input voltage shown is 100 mV, inputs up to 1.0 volt rms may be applied without significant distortion of the output. The 3-dB bandwidth of the amplifier is approximately 100 Hz to 8 kHz; attack time is less than 50 milliseconds, and release time is about 2 seconds.

**conclusion**

The results achieved with this circuit show that good performance can be obtained from a 1.5-volt agc amplifier, and that suitable transistors used in the inverted connection for the control element offer improved agc characteristics.

**reference**


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The TRITON is a One-of-a-Kind HF transceiver, totally solid state including the final amplifier. The new generation that does more things better than ever before.

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Very few amateurs attempt to design bandpass or band-stop filters, possibly because of the complex mathematical formulas involved. Most amateurs seem to be unaware of the analogy between low-pass and bandpass filters which can considerably reduce the amount of labor involved in the design of bandpass filters. This analogy has long been known in professional circles but apparently hasn't been described in the amateur literature.

The principal purpose of this article is to describe the lowpass/bandpass (LPBP) analogy. A secondary purpose is to provide some tips on filter design that I have found useful in both amateur and professional applications; specifically, how to design filters using only a reactance slide rule or resonance calculator such as the Shure Brothers or Allied Radio reactance slide rule.

It has been my experience that the biggest difficulty most amateurs find in filter design is simply one of making arithmetical mistakes in computing the parameters—slide-rule errors, plain and simple. When you get the parameters right, the filters usually work! Therefore, anything that will mechanize the calculations or serve to check the calculations is a big help in building filters that work the first time.

The LPBP analogy has the further advantage of giving the filter designer a much better physical insight into the
practical constraints imposed on bandpass filters than does a set of cold mathematical equations.

**image parameter filters**

The type of filters to be discussed are known as "image parameter" filters. Historically, this type of filter was the first to be developed and is entirely suitable for many amateur and professional applications. For completeness I will begin with a brief discussion of image parameter filter design.

A low-pass filter consists of a series of the value of shunt capacitance adds up to the full value of shunt capacitance.

A similar statement can be made for the series inductance of the tee-section. The equations to determine the full value of both the series inductance and shunt capacitance in terms of the cutoff frequency and impedance levels are also given in fig. 1. These values are known as the prototype values; one-half of either the inductance or capacitance value must be used in the actual prototype section, depending on whether a pi- or tee-section

sections as shown in the upper portion of fig. 1. As long as all sections are designed for the same impedance level, as many sections as are necessary may be connected in series to give the desired frequency response characteristics.

For convenience, filters are designed on a section basis, the basic section being known as a "prototype" section. After the prototype section has been specified, many different variations are possible, depending on the particular application. The sections are broken out of the composite filter in either of two ways: a mid-shunt (or pi-section) and a mid-series (or tee-section). Notice in fig. 1 that the value of shunt capacitor in the pi-section is one-half that of the composite filter; when two pi-sections are connected together the value of shunt capacitance is used. So as not to complicate the discussion, in the material that follows I will stick with the pi-section.

First, take the equations for the prototype L and C as given in fig. 1 and put these into the resonant frequency formula to obtain

\[ f = \frac{1}{2\pi \sqrt{LC}} = \frac{1}{2\pi \sqrt{R \cdot \frac{1}{\pi f_c}} \cdot \frac{1}{\pi R f_c}} = \frac{f_c}{2} \quad (1) \]

You can see that the prototype L and C values should resonate at one-half the specified cut-off frequency. This provides the designer with a means of using a reactance slide rule to compute (or check) the prototype parameters.

At this point a numerical example is
useful: Design an audio filter with a 3-kHz cutoff frequency working into a 2000-ohm load resistance. One-half of 3000 is 1500 Hz. Set the reactance rule to 1500 Hz and opposite 2000 ohms read approximately 0.22 henry and 0.054 μF. The prototype section appears as in fig. 2.

It is important to realize that the actual resonant frequency of the chosen inductance and capacitance is critical if the filter is to operate as desired. Although some liberties can be taken with the impedance values, the resonant frequencies should be as exact as possible. Therefore, care should be taken to insure that values of inductance and capacitance will resonate at the design frequency, even if the resulting impedance value is not exact. For this reason I suggest that the prototype values of L and C be calculated with a conventional slide rule or calculator, using the formulas, and checked with the reactance slide rule.

At this point a second check point is convenient. I previously pointed out that it is only necessary to add inductance in parallel with each shunt capacitor so that the combination is resonant at \( f_0 \). This is shown in fig. 3 along with the appropriate response curves.

If there is any confusion at this point, a numerical example should help clear things up. Let's design a bandpass filter centered at 455 kHz with a 15-kHz bandwidth such as would be suitable for an FM receiver. The load impedance will be assumed to be 5000 ohms.

First, calculate the inductance and capacitance values for a lowpass filter having a cutoff frequency of 15 kHz:
The basic lowpass filter is shown in fig. 4.

A quick check of these values with a resonance slide rule shows that the prototype values, \( C = 0.00425 \mu F \) and \( L = 0.106 \text{ H} \), resonate at 7500 Hz which is one-half 15 kHz, while the values of inductance and capacitance actually used, \( C = 0.00212 \mu F \) and \( L = 0.106 \text{ H} \), resonate at 10.6 kHz which is 70.7 percent of 15 kHz. Therefore, we are on a firm foundation and can proceed with confidence.

The first step in transforming a lowpass section into a bandpass section is to connect an inductance in parallel with the shunt capacitor to resonate at 455 kHz, the bandpass center frequency. This is easily done by using a resonance calculator to obtain a shunt inductance of 58 pH. The second step is to connect a capacitor in series with the series inductance. For this example the capacitance should be 0.00319 \( \mu F \). So far, so good; the lowpass filter is shown in fig. 5.

The next step is to transform the lowpass filter into a bandpass filter. Now comes the joker which is easily seen from the LPBP analogy. To make this transformation it is necessary to resonate the 3190-pF shunt capacitor to 50.5 MHz. Now, 3190 pF is a lot of capacitance at 50.5 MHz; it is impractical to resonate

The difference between using the LPBP analog and calculating the individual component values may be compared by considering the bandpass circuit equations shown in fig. 6. The interested reader may verify the component values obtained using the LPBP analog by actually solving the equations given in fig. 6. The ease of using the LPBP analog will be obvious.

---

**practical filters**

The lowpass/bandpass analog also has the advantage that it can give the filter designer a much better feel for the physical realities involved. As an example of this I will attempt to design an exceptionally narrow bandpass filter in terms of center frequency, a 1-MHz wide filter with a center frequency of 50.5 MHz at 50 ohms.

Using the concepts described above, first calculate a lowpass filter with a 1-MHz cutoff frequency at 50 ohms. For a pi-section the inductance will have a reactance of 50 ohms at 500 kHz, or 15.9 \( \mu H \). The capacitance actually used must resonate with this inductance at 70.7 percent of 1 MHz or 707 kHz. This is 0.00319 \( \mu F \). So far, so good; the lowpass filter is shown in fig. 7.

The next step is to transform the lowpass filter into a bandpass filter. Now comes the joker which is easily seen from the LPBP analogy. To make this transformation it is necessary to resonate the 3190-pF shunt capacitor to 50.5 MHz. Now, 3190 pF is a lot of capacitance at 50.5 MHz; it is impractical to resonate
this much capacitance with any reasonable inductance. Resonating the series inductance to 50.5 MHz presents no serious problem and requires about 6 pF.

Thus, you can see from the LPBP analogy why a filter of this type is not practical in this application; the band-

width is too narrow in terms of the center frequency. Before giving up, however, let’s try a tactic frequently used by filter designers when one or more of the components turns out to be an impractical value—change the impedance level.

If the impedance level is increased to 5000 ohms, a factor of one hundred, the shunt capacitors decrease in value to 31.9 pF and the shunt inductances become 0.31 μH, both of which are at least in the ballpark of being practical. The value of series inductance increases, however, to 1590 μH, requiring only about 0.06 pF to resonate at 50.5 MHz. This is an impractically small value.

Therefore, it appears that a filter centered at 50.5 MHz with only a 1-MHz bandwidth is impractical at any impedance level, and other types of filters, such as coupled tuned circuits, must be used to obtain the desired selectivity. These filters, however, are beyond the scope of this article.

The preceding example shows how the LPBP analogy gives the filter designer a much better feel for the practical problems involved than does a purely mechanical application of the design formulas. The 455-kHz bandpass filter with a 15-kHz bandwidth had a lower ratio of center frequency to bandwidth, and also operated at a considerably lower frequency so that component parameters were much more realistic.

fig. 7. First step in the development of a 1-MHz wide bandpass filter centered at 50.5 MHz.

summary

After reading the above material you may ask, “Does the LPBP analogy work in the opposite direction; i.e., is there a bandpass to lowpass analogy?” The answer is, “Yes, provided all tuned circuits are tuned to the same center frequency.”

It should also be noted that the LPBP analogy described here gives only one particular class of bandpass filter. There are many other types of bandpass filters, the most notable of which is probably a series of tuned circuits coupled by means of capacitance or inductance. The design of coupled tuned circuits is a subject in itself.

Although I have used an image parameter designed lowpass filter as the starting point in this article, the analogy applies equally well to lowpass filters designed on a Butterworth or Tchebyscheff basis.

reference


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Introduction to the digital mixer

How to use the D-type flip-flop IC as a frequency mixer

Basically, a mixer can be thought of as a switch operating at one frequency which will or will not pass a signal at another frequency. A signal interrupted in this manner generates a combination of various new frequencies with the difference- or intermediate-frequency as the desirable output. Normally, this desired frequency is filtered out for further processing.

In practice the requirements for a mixer are a nonlinear switching device and a large injection signal. These two requirements complement one another to a certain extent since a very nonlinear device requires less oscillator injection, while more injection is required with less mixer nonlinearity.

When working with digital circuitry you are dealing with two voltage levels; therefore, all signals must be square waves or close to it. This means that if you use a smooth sinusoidal signal, it must be converted to a square wave with a circuit such as a Schmidt trigger. If the sinewave is large enough, a simple diode clipper will do the job.

The digital equivalent of a simple frequency mixer is a gate with two inputs such as the 7400 IC. The output contains all the frequencies because the gate does not have a memory and follows momentary changes of either frequency; the desired output frequency must be filtered out.

If you use an edge-triggered D-type (delay) flip-flop such as the 7474 as a mixer, the leading edge of the square-wave oscillator pulse transfers the input signal to the output, and the output remains at this new level until the next oscillator pulse samples the input signal as shown in fig. 1. When the oscillator pulse is out of step with the input signal it turns off the output. Thus, the output is a square wave at the intermediate frequency which needs no filtering, except possibly to remove the odd-order harmonics.

There are several D-type flip-flops which can be used for this application. The common TTL 7474 can be used up to about 25 MHz. The high-frequency version of this IC, the 74H74, is usable up
to 43 MHz. The Schottky TTL version, the 74S74, can be operated to 100 MHz. For even higher frequency use, Motorola has introduced the new MECL MC12000 digital mixer, which is a D-type flip-flop which can be used up to 250 MHz. The MC12000 has built-in logic converters so it cannot be less than half; if the input frequency is higher, it cannot be higher than twice the oscillator frequency.

A typical digital mixer circuit using TTL ICs is shown in fig. 2. In this circuit a 7400 TTL gate is operated as a crystal oscillator. The other two gates of the 7400 are used as input buffers to the mixer, a 7474 D-type flip-flop. In this circuit the rf input signal must be lower than the crystal frequency, and the i-f signal must be less than half the crystal oscillator frequency.

fig. 1. Waveforms in the digital mixer. Information from the input signal (data pulse) is transferred to the output by the positive going edge of the oscillator pulse (clock pulse). When the oscillator input is at either the high or low level, the signal input has no effect.

fig. 2. Basic digital mixer circuit. In this circuit the frequency of the input signal must be lower than the crystal oscillator frequency, and the i-f output must be less than half the crystal frequency. For example, with an 8-MHz crystal and a 6.75-MHz rf signal, the i-f is 1.25 MHz.
narrowband modifications
for the
Regency HR-2
series of vhf-fm
transceivers

How to install the Regency narrowband kit in the popular HR-2 series of two-meter fm transceivers

The extremely popular HR-2 series of two-meter fm equipment introduced by Regency in 1970 has become an amateur favorite. At the time of introduction the desirability for an extremely selective narrowband receiver was not evident. This prompted Regency to build the HR-2 as a wideband unit.

As an increasing number of repeaters go into operation the wideband fm transceiver is plagued by annoying adjacent-channel interference. In many metropolitan areas all the repeaters are operating narrowband, in and out (deviation of ±5 kHz). With the large number of repeaters and growing popularity of two-meter fm, narrowbanding to conserve operating space is imperative.

The entire Regency family of HR-2 transceivers (HR-2, 2A, 2S and 2MS) can be easily modified for narrowband operation. Narrowbanding the transmitter is accomplished simply by setting the deviation control for a peak deviation of ±5 kHz. Narrowbanding the receiver requires some new parts and a few simple adjustments.

Before installing this modification in my receiver, I was plagued with adjacent-

fig. 1. Bottom view of the HR-2 series receiver i-f circuit board, showing modifications required before installing the Regency MA-46 modification kit. One circuit trace must be cut in two places. The black dots indicate new holes for the new, narrow-band ceramic filter supplied with the kit of parts. A drilling template is shown in fig. 2.
channel interference on 146.76 MHz from the local repeater on 146.79 MHz. It was impossible to copy anything on 146.76 when the local repeater was transmitting. This repeater has an effective radiated power of more than 60 watts and is located less than a mile away from my station. With the circuit modification MA-46 Narrow Band Filter (70-dB) Modification, the i-f board is identical to the one Regency uses in their FCC type-accepted marine and fm business-band equipment.

If you are the owner of a HR-2A, 2S or 2MS the instruction sheet provides all the information you need to install the modification kit. The basic kit of parts necessary to modify the HR-2 series transceivers is available from Regency. The kit consists of a new higher quality ceramic filter with an extremely steep selectivity curve that virtually eliminates adjacent-channel interference, two shielded coils to replace unshielded ones originally supplied with the rig, three capacitors to adapt the i-f circuit to the new ceramic filter, and two resistors to change the sensitivity of the noise-operated squelch to match the new filter. With the addition of the kit, the kit because Regency uses the same i-f board in most of their units; all the holes and spaces for the additional parts and the holes for the new narrowband filter are already there.

**HR-2 modifications**

If you are one of the many people who own the original HR-2 fm trans-
ceiver, don't despair. With a little change in the circuit board it is possible to add the modification kit to the earlier models. When the job is finished the i-f board will be electrically identical to the HR-2A.

Circuitwise, the HR-2 and HR-2A are nearly the same in the modification area, but a different circuit board and different parts numbers complicate the instructions supplied with the Regency MA-46 modification kit. The instructions furnished with the kit should be followed, except as noted here. The parts layout on the reverse side of the instruction sheet should not be used. Instead, use the information in fig. 3.

changes to MA-46 instruction sheet

1a. Remove the old ceramic filter, CF-1

b. Perform the modifications shown in fig. 1 to the i-f circuit board (301-528-B) and drill the holes for the new ceramic filter using the dimensions given in fig. 2, using the existing hole indicated to locate the new holes. Earlier models may have two resistors (R133 and R134) soldered to the foil side of the circuit board as shown in fig. 4. If R133 and R134 (both 6.8k) are present, remove them as they are no longer required.

c. Mount the new ceramic filter.

2. Replace the following capacitors with the values indicated.
a. Replace C108 with a 390-pF capacitor.
b. Replace C109 with a 270-pF capacitor.

3. Add C110, a 250-pF capacitor. In early models this capacitor may already be installed, but to assure the correct value, replace any existing C110 with the capacitor furnished in the MA-46 kit.

4. Replace the following resistors with the values indicated
a. Replace R111 with 5.6k resistor.
b. Replace R112 with 2.2k resistor.
c. Replace R137 with a 100 ohm, \(\frac{3}{4}\)-watt resistor (not furnished). R137 may be missing on early models. If it is missing it must be added. R137 is located just forward of L103 and installed vertically, as shown to the right (electrically, R137 is connected between C120 and the emitter of Q-102).

d. In early versions of the HR-2, R136 was omitted. In later models it was located on the foil side of the circuit board as shown in fig. 4. R136 is a 22k, \(\frac{3}{4}\)-watt resistor. If R136 is missing it should be added to the foil side of the circuit board as shown in fig. 4. Electrically, R136 is in parallel with L101.

5. Follow the instructions furnished with the MA-46 kit from step 5 thru to the end of the instruction sheet

With the addition of the MA-46 modifications described here the performance of the Regency HR-2 family of fm transceivers is as good as the latest fm equipment. Furthermore, it can be obtained without the expense of a new rig. The MA-46 modification kit is available from Regency for $22.50, not a bad price when you consider it's almost like getting a brand new receiver, free of that adjacent-channel interference that used to be so annoying.
If you like 2 METER . . . 

YOU'LL LOVE OUR

ALL NEW

HR-2B

NARROW BAND FM TRANSCEIVER

15 OR 1 WATT POWER OUT/SWITCH SELECTABLE /
FULL 12 CHANNEL TRANSMIT AND RECEIVE CAPABILITY

You'll like the crystal clear transmit and receive performance of this compact, 2 meter unit and so will those listening. The 12 transmit channels are provided with individual trimmer capacitors for the optimum in point-to-point and repeater applications. A HI/LO power switch provides 1 watt output or full rated output. The receiver has an audio output of 3 watts at excellent sensitivity. Solid state, American made quality at a low price.

$229.00 AMATEUR NET
includes plug-in ceramic mike, mounting bracket and transmit and receive crystals for 146.94 MHz.

THE FM LEADER IN 2 METER AND 6 METER . . . AND NOW 220 MHZ

More Details? CHECK-OFF Page 126
simple high-gain wire antenna for high-frequencies

Design and layout of a four-element, double-extended Zepp that provides up to 7-dB gain on 15 meters.

There’s an old saying that you can’t get something for nothing, especially when you’re working with antennas, but you can make one wire antenna, the length of a 75-meter dipole, work like a bomb on 75 and deliver 7-dB broadside gain on 15! This is only one-half dB less than a three-element beam on this band. I call the antenna the FEDEZ – Four-Element Double-Extended Zepp.

Many amateurs have used the extended double Zepp which gives 3-dB gain at its design frequency. However, with the addition of phasing stubs and two more elements you can obtain up to 4-dB more gain. All it takes is a little arithmetic which, in my case, was supplied by W6DMY. The basic design was taken from the 1943 edition of the ARRL Antenna Handbook. The dimensions for any frequency are given in electrical degrees in fig. 1 (remember that $180^\circ = 1/2$ wavelength).

Since most of my on-the-air activities are confined to nets on 75 and 40 meters, with hamming just for fun on 15, the four-element double-extended Zepp I use has a 21.3-MHz center frequency (see fig. 2).

Although the two 7.68-foot phasing stubs can hang straight down from the antenna as shown in fig. 2, I use lumped constants for the two outer stubs as shown in fig. 3. Part of the 450-ohm open-wire feedline is used as the center phasing stub. Each of the lumped-constant stubs I use consist of an 11-turn coil, 2-inches in diameter, 2-3/4 inches long, wound with number-12 wire. Each end of the phasing coil is supported by the strain insulator as shown in fig. 3.

With this antenna I have yet to receive less than an S9 report on the SARO Bourbon net that meets every night on 75 meters, especially from San Diego and Medford, Oregon. On 15 meters I have received numerous S9 reports from the East coast as well as from Japan. W0QWH in Stanley, Kansas, who has given me signal checks on 47 different antennas over the past year, gave me his
best report, although it wasn’t S9—he apparently has a very stingy S-meter!

The dimensions of my urban lot require that I use this antenna in the inverted-vee configuration. This detracts from the gain somewhat because the wide spacing between the centers of the elements determines gain, and the drooping legs reduce this distance slightly. However, since I feed the antenna with 450-ohm open-wire ladder line to the Ultimate Transmatch, I think I’ve at last found the ultimate antenna to go with my ultimate transmatch. I don’t think you can beat it for city-sized lots.

**Reference**


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fig. 1. Basic design of the four-element, double-extended Zepp antenna. All dimensions are given in electrical degrees (180° = 1/2 wavelength).

fig. 2. Four-element, double-extended Zepp antenna designed for 15 meters. Center design frequency is 21,300 kHz.

fig. 3. The two outer phasing lines can be hung down from the antenna as shown in fig. 2, or phasing inductances may be used as shown here. L1 and L2 are each 11 turns no. 12, 2" diameter, 2-3/4" long. Antenna may be used in the inverted-vee configuration if space is limited.
A discussion of antenna feedpoint impedance, and the effects of the resistance and reactance components in practical antennas

The feedpoint impedance, the radiator resistance and dissipative resistance, and the reactance of a common dipole antenna are matters that need clear understanding if you are to inquire deeply into the functioning of that indispensable component of a radio station: the antenna. The purpose of this article is to define and to describe the Z, R and X of antennas, not in a highly technical manner but simply and with only enough detail to distinguish one from another and to show the role each plays.

First, let's consider a center-fed dipole antenna, one a half-wave long (electrically) at the operating frequency, and one out in the clear far enough to have a very minimum modification of its normal characteristics by the influence of its environment. Textbooks tell us that such an antenna will have a feedpoint impedance (Zf) of 73 ohms, and that this impedance will be purely resistive (no reactance). In the real world, such an antenna seldom is found!

Let's deal first with the ideal dipole, then with the real. In the ideal dipole, Zf, the feedpoint impedance, will equal R, the composite of the radiation resistance and each of all of the dissipative resistances. These dissipative resistances include the ohmic resistance of the antenna, insulation losses, dielectric losses and absorption losses. These are easy to visualize. You know that the antenna wire has
resistance, even though it's made of highly-conductive copper. You know that no insulator is perfect; so even the best has some loss. You know that somewhere within the near-field of the antenna there must be an insulating object that introduces dielectric losses, however small. And you know that somewhere within the near-field there must be some material that will absorb radio waves.

radiation resistance

Radiation resistance, though, is a different matter! In the first place, it's not a true resistance. It acts like a resistance in some ways, but not in every manner. For instance, a real resistance, when radio-frequency current flows through it, converts the electrical energy into heat, another form of energy. Radiation resistance doesn't do this.

What, then, does it do? Nothing! It's just a term which describes an attribute of an antenna, an attribute which bears a superficial resemblance to a real resistor.

The need for such a term comes about from the fact that all of the rf power that flows into an antenna doesn't get converted into heat. Some (and, we hope, a greater part) of the rf power is radiated out into space. It's convenient to speak of an antenna's characteristics as if all of the rf energy fed into it were dissipated just like that portion which produces heat. To make this fiction plausible, we assign an imaginary resistor to the antenna and call it "the radiation resistance."

When we put a known amount of rf power into the antenna, defining it as \( W = I^2 R \), and having a known amount of current, we have a large enough value of resistance to make the formula valid. We've taken care of not only the amount of power that was dissipated in the various real resistances and equivalent resistances but also the amount of power radiated into space; the latter being equal to what a real resistance of a value the same as the radiation resistance would have dissipated in the form of heat.

Let's run that through again. Taking a purely imaginary situation, let's conjure up an antenna that has only real resistance, a real resistance of one ohm, and feed one ampere of rf current into it. According to the formula, only one watt of power is going into that antenna, and all of it is being converted into heat with none of it being radiated.

Now, conjure up another antenna with one ohm of real resistance and 49 ohms of radiation resistance. With the same one-ampere of rf current going into it, the formula tells us that 50 watts of rf power is going into the antenna — one watt is squandered as heat and 49 watts are radiated. Quite an improvement!

This brings us to a cardinal rule: Make the ratio of radiation resistance to dissipative resistance as high as you can. This is not too difficult to do with a half-wave or even a quarter-wave antenna, but when you attempt it with a really small antenna, say a tenth-wave, you run into a real problem. That's why the engineers who design 80-meter mobile antennas work up such a sweat over their drawing boards.

So much for radiation resistance. Just remember that it's an imaginary resistance that accounts for the power being radiated by the antenna.

antenna reactance

Now for the reactance. Remember, we started out with an ideal antenna, one that was resonant and therefore resistive. It might be resonant on, say, 7,257,376 Hz, but when you breathe on your transmitter and it drifts to 7,257,377 Hz, the antenna departs ever so little from resonance. As it departs from resonance, it loses that purely resistive status. If the frequency goes higher, a bit of inductive reactance is introduced; if it goes lower, the introduced reactance is capacitive.

Just how much the antenna departs from resistive to resistive-plus-reactive status, or, rather, the rate at which it departs for a given change of frequency, depends upon several factors. For the simple dipole we're considering, the chief of these factors is the antenna's diameter to length ratio. The larger the diameter of the radiator for a given length, the less
reactance introduced for a given change of frequency. The almost-obsolete cage antenna merits much consideration, for it gives a very favorable ratio of diameter to length.

When reactance is present the feed-point impedance, $Z_f$, no longer equals $R$. It is given by

$$Z_f = V \sqrt{R^2 + X^2}$$

with the $R$ still the grand total of all the resistances (radiation, ohmic, etc.) and $X$ either inductive ($+X_L$) or capacitive ($-X_C$), as the case may be. In either case when $X$ is squared it's a positive value, so forget the sign.

There's one thing you mustn't forget, though. That's the matter of reactance not being able to absorb power. Ponder this, for it's quite important! Think of what it involves. The feedpoint impedance may go high and you feel that the dissipative resistance of your antenna is low. You rejoice, believing you're radiating more power, a valid assumption only if it were the radiation resistance that was going up. You can't make a purely-reactive termination accept power. One that's partly-reactive and partly-resistive, yes. One that's purely reactive, no.

Don't jump to the conclusion that reactance in an antenna is an evil thing. In certain antenna designs it plays a vital role, but this is not an article on antenna design. If you want to look into that subject, get a reliable textbook, preferably one written by Kraus, LaPorte, or some other recognized authority on the subject. There's a wide difference between the simple dipole we're discussing and a complex antenna. For this article we'll stick to the dipole!

If your dipole is reactive to a degree, as are the vast majority of such antennas, don't worry about it. If it does give you concern, remember that the reactance can be cancelled out by the introduction of an equal and opposite reactance. For example, if the antenna exhibits 10 ohms capacitive reactance, this can be negated by introducing 10 ohms of inductive reactance. This conjugate reactance can be placed at the feedpoint of the antenna or at any point between that feedpoint and the active device in your transmitter. Its position doesn't matter so long as it reflects that conjugate reactance into the antenna. Keep in mind that the resistive component of the antenna's impedance, which will not be affected by these manipulations to cancel reactance, is going to accept the rf power.

**resistance transformation**

The resistive component can be transformed by many and various means to any convenient numerical value that you might elect to stipulate. Again, this can be done at the feedpoint of the antenna or at any place between that feedpoint and the active device in your transmitter.

In each instance, there is some slight advantage in having the transformation take place at the antenna's feedpoint. With some transmitters, ones poorly designed or manufactured to meet a price and not to provide quality, it is imperative that the transformation take place between the antenna's feedpoint and the transmitter's antenna terminal. This, though, is strictly a transmitter deficiency.

**summary**

To sum up, the feedpoint impedance of an antenna is a complex quantity, constituted by both resistive and reactive components. The resistance component may be made up of many constituents. Of these, one, the radiation resistance, is not a true resistance but an imaginary one invented to account for the rf energy radiated by the antenna. The several other constituents of antenna resistance are all dissipative in nature and should be held to a minimum in design. Radiation resistance should be high as compared to the total of the other resistances. Some element of reactance is present in most antennas, but this is not a significant deficiency and may even be used to advantage in some designs.
This improved logic test probe checks binary levels as well as pulse coincidence. Since I have always been interested in test equipment, the TTL logic probe with a built-in memory described in a recent issue of *Ham Radio* proved very interesting. I made some changes to the basic circuit so that it can take the place, in many instances, of an item we would all like to own but can’t afford, a dual-trace oscilloscope. The design uses three ICs, some additional switches and more hardware.

Since I wasn’t able to obtain some of the parts used in the original logic probe, like good, bright LEDs, some circuit changes were made as needed. The completed unit may look a little clumsy in its mechanical design because I used what was available, but the probe does the job it’s supposed to do, and that’s what counts. If you have access to better materials you can dress it up any way you like.

**the circuit**

The logic probe circuit, fig. 1, has two inputs, *main* and *auxiliary*. In the off position of the *off-aux* switch the unit operates as in the original design. However, in this circuit you can switch the memory off with the *off-mem* switch so you don’t have to keep pushing the button when using the probe as a binary level indicator.

In the *aux* position of the *off-aux* switch two inputs are needed at the same time. The level of the pulse into the *aux* jack is selected by the *aux + or −* switch (see fig. 2). To check the coincidence of pulses, just connect a patch cord from the *aux* jack to the second point on the logic circuit you are checking, and the probe will indicate it.

The parallel RC circuit in series with the *aux* input is to protect the probe against a direct short to common in case the *aux* input is connected and the *off-aux* switch is in the *off* position. The
fig. 1. Circuit for the improved logic test probe. All signal diodes are 1N914, all resistors are 1/2 watt.

470-pF capacitor prevents too much pulse slow down. The 1N914 diodes serve to bring up the high trigger threshold voltage to prevent noise triggering.

I was unable to obtain a decent, bright LED, so I used a long-life number-47 bulb with a switching transistor. At the voltage used, the bulb should last forever, and it's still bright enough to be seen, even in bright sunlight.

The common of the TTL circuit is connected to a pin jack for those cases where the circuit under test cannot handle the probe current requirements. With the 1847 bulb the probe needs a total of about 160 mA; changing to a LED would cut probe current to 60 mA.

observation

In use, the metal case of the logic probe is left floating. Supply current with the lamp off is 26 mA; with the lamp on, current drain is 160 mA. Main trigger threshold voltages are +1.5 volts (high) and +1.3 volts (low). Auxiliary trigger threshold voltages are 1.5 volts (high) and 0.7 volt (low). The aux input can be used by itself if the main input is switched to minus (−) and connected to common. This may be useful at times since the low level of the aux input is half as low as the low level on the main input.

If a separate power supply is used for the logic probe only the common of the probe must be connected to the negative line of the TTL circuit under test. It should also be kept in mind that when
fig. 2. Construction of the improved logic test probe. Unit is housed in a small aluminum box; power supply is external.

checking TTL pulse trains with the memory switched off, and the indicator does not dim, it is probably because the duty cycle of the pulse is not 50%. Switching the polarity with the plus/minus switch may show more dimming than usual as with a 50% duty cycle. Experience will quickly show what to expect.

If a separate power supply is needed, a transformer, some diodes, a filter capacitor and one of the new 5-volt IC regulators will do the trick.

reference
TTL clock oscillator

In the circuit shown, two IC one-shot multivibrators are cross-coupled to make an oscillator suitable for driving other TTL ICs for various logic applications. The outputs are somewhat more TTL compatible than those obtained using transistor or unijunction circuitry.

In addition, this circuit is well suited to applications where the clock must be started and stopped at suitable intervals. In fact, it is necessary to have at least one positive-going transition on the enable input to start the clock after power is applied. The circuit by itself will not free run simply by applying a logic one level to the enable input. Note that both one-shots must time out after the enable goes low before the clock comes to rest.

The output of the first one-shot produces a pulse immediately after the enable input goes high, while the second one-shot waits until the end of the first cycle before it produces a pulse. The duty cycle of the output waveform can be adjusted as required by making both timing resistors variable. These also set the frequency of the oscillator.

With the IC one-shots, both the normal and inverted outputs of the clock are available at the "Q" and "not Q" terminals. If RC\textsubscript{t2} is made a very short duration pulse and RC\textsubscript{t1} is made adjustable over a wide range, a variable frequency pulse train of thin widths is produced. Making the two time constants equal produces a square wave output.

Cal Sondgeroth, W9ZTK

yaesu sideband switching

For owners of the Yaesu Ft-101 who miss the convenience of switching sidebands without retuning, here's a simple modification which can be made without affecting any other function of this fine equipment.

fig. 1. Simple clock-oscillator circuit using two TTL 74121 monostable multivibrator ICs.
By taking advantage of the clarifier circuitry and adding a potentiometer between two of the circuit-board receptacles, MJ6-11 and MJ5-2, an adjustment can be made which puts the vfo frequency in the right spot when switching to upper sideband, tune or CW. A small piece of perfboard, a 2500-ohm PC-mounting pot (39 cents from Radio Shack) and a 2000-ohm, ½-watt resistor wired in series are the only things needed. To align the circuit after it is installed, tune in a 3800-kHz lower-sideband signal and zero-beat the calibrator signal to it. Now, switch to upper sideband and adjust the 2500-ohm pot for zero beat. That completes the alignment. The setting at the center of the vfo range holds within a few Hz throughout the tuning range of the vfo, and is the same for USB, tune or CW. It is a pleasure when switching sidebands or going from CW to ssb not to have to recalibrate the dial.

Ernie Schultz, W2MUU

nuvistor heatsinks

Transistor-type heatsinks make excellent heat-dissipating radiators for nuvistor-type vacuum tubes. If possible, choose a high emissivity black anodized heatsink and use thermal compound between the metal tube and the heatsink to maximize heat transfer.

Richard Mollentine, WA0KKC

exploding diodes

If you have done much experimenting with the very popular glass encapsulated diodes you will know that they tend to explode rather violently when subjected to a severe overload. Since most amateurs and experimenters don’t wear safety glasses, this could be a dangerous situation. When these glass diodes explode they blow very small fragments of broken glass over a considerable area with enough force to cause serious eye injury. To prevent this from happening when experimenting and building projects, take a small piece of Scotch tape and wrap it tightly around each glass diode before installation. If you accidentally short something the tape will contain the force of the explosion and prevent the glass from blowing all over the room, possibly saving someone’s eye.

Pete Walton, VE3FEZ

Heathkit HW-16 problems

While repairing a Heathkit HW-16 Novice transceiver, I found the answer to several problems which may have bothered others. Keying characteristics were harsh, with pronounced clicks. A capacitor up to half a microfarad across the key, in parallel with C92, helped greatly. A .01-µF ceramic capacitor across R14 also helped to keep down QRM in the novice band. The sidetone oscillator, a neon bulb, lit, but refused to oscillate. A larger resistor in place of R64 took care of this. I changed the original value of 1.5 megohms to 3 megohms. Varying this resistor also changes the tone. The meter read half-way up scale with no current through it. Investigation showed the metal band around the plastic meter case was magnetized. A careful application of a magnetized screwdriver reversed this condition, and after several trials, the pointer rested near zero, where it should.

Eugene A. Hubbell, W7DI
short circuits

HW16 modification

In the March, 1973, issue of *ham radio*, a 0.001-µF blocking capacitor should be placed in series with the shielded lead connected from the grid of V7 to the grid of V2A. A number of readers have complained of insufficient power on 15 meters, but WB6MZN, the author, indicates that his plate power meter reads 160 mA on 40 meters and 180 mA on 15. He points out, however, that in the original configuration the HW16 tends to oscillate and power decreases on 15 meters. He cured this by carefully tuning all the tank circuits especially for 15-meter operation, including L8 and C21, the neutralizing capacitor.

ac power supply for fm equipment

In the ac power supply on page 28 of the June, 1973, issue, the regulator transistor may oscillate under certain load conditions. This oscillation can be suppressed by installing a 0.47-µF bypass capacitor from the output to ground. When paralleling power transistors for greater current capacity, be sure to include 0.1-ohm, 2-watt balancing resistors in series with the emitters of each power transistor.

1296-MHz quad yagi

In the May, 1973, issue, the driven element for the 1296-MHz quad Yagi should be made from 1/32-inch-thick flat brass. The reflector and directors are made from flat aluminum stock, 0.050-inch thick, not rod as stated in the article.

phase I receiver

There were several circuit errors in the Phase I Receiver published in the August, 1973, issue of *ham radio*. In fig. 3 R35 should have a value of 100k ohms and C33 is not used on the PC board at all. The jumper just below U6 in fig. 4 should be connected to the circuit pad at the lower right hand corner of U6 (goes to pin 2 not to the pad on pin 15). Rf choke L1 is approximately 6 µH and may be wound on an Amidon T37-2 core.

The author reports that the mosfet, Q4, suffers from parasitics and is touchy to agc. The whole stage may be replaced with an emitter follower (2N3707) with a 680-ohm emitter resistor and a 470k base-bias resistor. The 100k agc control, R37, may be replaced with a 100k fixed resistor. True rf gain control can be obtained by replacing CR1 with a 1000-ohm pot. Reduced gain results in better cross-mod performance. The author has inserted two 1N914 diodes in the agc line running to Q1 to improve strong-signal performance. With only Q1 controlled, agc range is about 40 dB and much smoother. This range depends upon the setting of the new 1k rf gain control.

The dc offset to U3 (MC1741CG) may need to be adjusted if the quiescent voltage at pin 6 is not near 5 volts.

micropower receiver

In the schematic for the micropower communications receiver in the June, 1973, issue of *ham radio*, a 220k base bias resistor should be connected from the base of the 2N1307 transistor to the +6 volt supply line.

motorola test set

In the Motorola test set article in the November, 1973, issue of *ham radio*, it should be noted that in late model Motrac, Motrans, Mocom and Micor radios the first i-f has been changed from 12 MHz to 8 MHz. When aligning the first i-f it must be determined which frequency is involved. If the first i-f adjustments are tuning capacitors, the i-f is a 12-MHz unit. If the adjustments are slug-tuned coils, the i-f is at 8 MHz.

logic test probe

In the circuit for the logic test probe featured in the *ham notebook* section in the February, 1973, issue, no power connections were shown for the IC. Connect +5 volts to pin 14 and ground pin 7 of the IC.
antenna and control-link calculations

The appendix for W7PUG's "Antenna and Control-Link Calculations" article in the November, 1973, issue of ham radio was inadvertently not included with the article. The Tymshare Superfortran program for antenna pattern calculations is shown in table 1, below. Examples of computer printouts for the two types of antennas discussed in the article are shown in tables 2 and 3.

### Table 1. Tymshare Superfortran computer program for calculating antenna patterns. Sample computer printouts for a J-pole and Station-master antenna are shown in tables 2 and 3, respectively.

#### Table 2. Computer-generated antenna pattern information for a 4-element J-pole antenna.

<table>
<thead>
<tr>
<th>ELEV</th>
<th>GAIN</th>
<th>RELATIVE</th>
<th>DEG</th>
<th>DB</th>
<th>VOLTAGE</th>
</tr>
</thead>
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<td>8.9</td>
<td>0.00</td>
<td>1</td>
<td>8.9</td>
<td>1.00</td>
</tr>
<tr>
<td>1</td>
<td>8.8</td>
<td>0.00</td>
<td>10</td>
<td>8.9</td>
<td>1.00</td>
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#### Table 3. Computer-generated antenna pattern information for a type-2 antenna (Communications Products Stationmaster).

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ExCELTRONICS RESEARCH LABS
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THE ULTIMATE MORSE KEYBOARD

- 64 character buffer
- Standard typewriter format with space
- Compatible with KM-420 memory

Available 1 November Model #KB-4200
Write for specifications $499.95

THE ULTIMATE MORSE KEYBOARD

- MOBILE
- FIXED STATION
- EMERGENCY
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DUAL 16VCT 3AMP TRANSFORMER IDEAL FOR YOUR OP AMP SUPPLY STOCK # TDS-1625....$3.25, 2/$6

3AG FUSE POST, LITTLEFuse 342 MOUNTED ON A METAL L BRACKET NEW, UNUSED $5.30

IC SOCKETS BY T.I., THESE ARE BRAND NEW FIRST GRADE SOCKETS, LOW PROFILE SOLDER TAIL, 14 PIN DIP 45c, 10/$4.10
SOLDER TAIL, 16 PIN DIP 50c, 10/$4.50
WIRE WRAP, 14 PIN DIP 55c, 10/$5.00
WIRE WRAP, 18 PIN DIP 60c, 10/$5.40

MONOLITHIC CAR CERAMIC 22uf/25V C10122...$0.70

Brand new deposited carbon film resistors, 1/4WATT, 5%. COMPARE THESE LOW PRICES:
ALL STANDARD VALUES FROM 1 OHM TO 4.7 M
ANY SINGLE VALUE 10 per pkg., 10/45c, 100/3.75
MIXED VALUES (minimum 5 per value) 100/4.00

INC. BOX 4080 MOUNTAIN VIEW CA. 94040

Price 49.95

Net to Amateurs Complete with Tubes Power Supply $9.95

SIX METER TRANSMITTER

TUBE COMPLIMENT
6U8 Oscillator Multiplier
12AX7 Speech Amplifier
2E26 Final Amplifier
6BQ5 Modulator

The dual 16vct 3amp transformer is ideal for your op amp supply. Stock # TDS-1625 is available for $3.25 or 2 for $6. The 3ag fuse post, little fuse 342 is mounted on a metal l bracket and is new, unused for $5.30. New first-grade sockets by T.I., low profile solder tail, 14 pin DIP are available for 45c each, 10 for $4.10, or 16 pin DIP for 50c each, 10 for $4.50. Wire wrap, 14 pin DIP is available for 55c each, 10 for $5.00, and 18 pin DIP for 60c each, 10 for $5.40.

Monolithic car ceramic 22uf/25v is available as C10122 for $0.70.

Brand new deposited carbon film resistors are available in 1/4watt, 5% value from 1 ohm to 4.7 m. Detailed sample pricing includes:
- All standard values from 1 ohm to 4.7 m are available at 10 per pkg. for 45c, or 100 for $3.75.
- Mixed values (minimum 5 per value) are available for 100 for $4.00.

New and surplus electronic components for the pro and serious amateur. An order or 8c stamp puts you on our mailing list. Minimum order $3.00 US., $15.00 foreign. All orders postpaid. Please add insurance. Satisfaction guaranteed.
for the EXPERIMENTER!

INTERNATIONAL EX CRYSTAL & EX KITS
OSCILLATOR • RF MIXER • RF AMPLIFIER • POWER AMPLIFIER

1. MXX-1 TRANSISTOR
   RF MIXER
   A single tuned circuit intended for signal conversion in the 3 to 170 MHz range. Harmonics of the OX oscillator are used for injection in the 60 to 170 MHz range. Lo Kit 3 to 20 MHz, Hi Kit 20 to 170 MHz (Specify when ordering) $3.50

2. SAX-1 TRANSISTOR
   RF AMP
   A small signal amplifier to drive MXX-1 mixer. Single tuned input and link output. Lo Kit 3 to 20 MHz, Hi Kit 20 to 170 MHz (Specify when ordering) $3.50

3. PAX-1 TRANSISTOR
   RF POWER AMP
   A single tuned output amplifier designed to follow the OX oscillator. Outputs up to 200 mw depending on the frequency and voltage. Amplifier can be amplitude modulated. Frequency 3,000 to 30,000 KHz $3.75

4. BAX-1 BROADBAND AMP
   General purpose unit which may be used as a tuned or untuned amplifier in RF and audio applications 20 Hz to 150 MHz. Provides 6 to 30 db gain. Ideal for SWL, Experimenter or Amateur $3.75

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

6. TYPE EX CRYSTAL
   Available from 3,000 to 60,000 KHz. Supplied only in HC 6/U holder. Calibration is ± 0.02% when operated in international OX circuit or its equivalent. (Specify frequency) $3.95

for the COMMERCIAL user...

INTERNATIONAL PRECISION RADIO CRYSTALS

International Crystals are available from 70 KHz to 160 MHz in a wide variety of holders. Crystals for use in military equipment can be supplied to meet specifications MIL-C-3098E.

CRYSTAL TYPES:
- (GP) for "General Purpose" applications
- (CS) for "Commercial Standard"
- (HA) for "High Accuracy" close temperature tolerance requirements

write for CATALOG

INTERNATIONAL
CRYSTAL MFG. CO., INC.
10 NO. LEE • OKLA. CITY, OKLA. 73102

More Details? CHECK-OFF Page 126
Seconds To Bond... Years To Undo!

Literally thousands of uses; Repair printed circuit boards, cabinets, install knobs, controls, all types of hardware... metal, ceramic, porcelain, glass, etc. One Drop should be in every workshop. It's ideal for repairing jewelry, appliances, sporting goods, tools and countless other items.

If unavailable in your area order direct with 30 Day Money-Back Guarantee

☐ 132 Drop Dispenser (2 grams) $3.00 postpaid
☐ SAVE... Order two for only $5.00

Send check or money order — No C.O.D.'s.

Name __________________________
Address _________________________
City _____________________________
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Note: This One-Drop formula is not recommended for use on porous materials unless it is properly filled. Request Instant-Weid 240 for use on porous materials. No. 260 sets in about 3 minutes on most materials.

GATEWAY ELECTRONICS
8123 PAGE AVENUE
ST. LOUIS, MISSOURI 63130
314-427-6116

LASER DIODE $7.50
DIGITAL CLOCK CHIP — NATIONAL 5314 — 6 DIGIT — 12/24 HOUR $12.95
100 kHz Crystal $5.00
200 kHz Crystal $5.00
250 kHz Crystal $1.50
1 MHz Crystal $5.00
5 MHz Crystal $2.50
10 MHz Crystal $2.50

THUMBWHEEL SWITCHES
STANDARD SIZE — 0.5 x 2.125 x 1.78
— 10 position decimal $3.00
— 10 position BCD & Compliment $4.00
— End Plates (per pair) $1.45

MINIATURE SIZE — 0.312 x 1.3 x 1.3
— 10 position decimal $2.50
— 10 position BCD & Compliment $4.00
— 10 position BCD only $2.75
— End Plates (per pair) $1.00
— Divider Plates $1.25
— Blank Body $0.30

$5 Minimum Order.
Visit us when in St. Louis.
Please include sufficient postage.

NEW MODEL CWF-2BX $19.95
Model CWF-2 $12.95, K.I.

Ready to use. Please include $1.00 postage.

• Get Razor Sharp selectively from any receiver or transistor.
• Extremely high skirt rejection.
• Extremely reduced all background noise.
• No audible ringing.
• No impedance matching.
• Ultra modern active filter design uses IC's for super high performance.

We have what we think is the finest CW filter available anywhere. The 80 Hz selectivity with its steep aided skirts will allow you to pick out one signal and eliminate all other QRM and QRN. Simply plug it into the phonograph or connect it to the speaker terminals of any receiver or transmitter and use headphones, small speaker or speaker amplifier. Better yet, connect it between any audio stages to take advantage of the built in receiver audio amplifier. Build the 2'x3' CWF-2 PC board into your receiver or get the set contained and ready to use CWF-2BX and plug in!

SPECIFICATIONS
BANDWIDTH: 80 Hz, 110 Hz, 180 Hz (Switch selectable)
SIGNAL REJECTION: At least 60 db down 1 octave from center frequency for 80 Hz bandwidth
CENTER FREQUENCY: 750 Hz
INSERTION LOSS: None. Typical gain 1.2 at 180 Hz BW, 1.5 at 110 Hz BW, 2.4 at 80 Hz BW
INDIVIDUAL STAGE 0.4 (minimums ringing)
IMPEEDANCE LEVELS: No impedance matching required
POWER REQUIRED: CWF-2 6 watts (2 mA) to 30 watts (6 mA); CWF-2BX 15 watts (6 mA)
DIMENSIONS: CWF-2 2'x3' PC board, CWF-2BX 3.5'x2'x1/2' (black nickel steel top, white aluminum bottom, rubber feet)

For this fantastic CW filter, if you don't think it is the best you have ever used ask for your money back. We will cheerfully refund it. These filters carry a full one year warranty.

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NEW DRAKE TR-72

2-Meter FM Transceiver

- 23 Channels
- Superior Selectivity
- Completely Solid State

$320.00

Including dynamic microphone, DC power cord, mobile mount and desk mount brackets, microphone hanger, auxiliary connector, and external speaker plug.

GENERAL:
- Frequency coverage: 144-148 MHz
- 23 channels, 2 supplied (.52/.52 and .34/.94)
- Completely solid state
- Current drain: Rcv 0.4 A, Xmit 2.7 A (Hi power) or 1.2 A (Lo power)
- Voltage required: 13.8 VDC
- Antenna impedance: 50 ohms
- Frequency adjusting trimmers on every crystal
- Size: 7½"W x 2½"H x 9½"D (18 x 6 x 24 cm)
- Weight: 5½ lbs. (2.5 kg).

TRANSMITTER:
- RF output power: 10 W min. (Hi power) or 1 W (Lo power) at 13.8 VDC
- Solid State Frequency deviation: adjustable to 215 kHz max., factory set to 6.5 kHz
- Automatic VSWR protection

RECEIVER:
- Crystal-controlled, double conversion superhet
- Sensitivity: Less than .35µV for 20 dB quieting
- Selectivity: 20 kHz at -6 dB (±30 kHz and adjacent channel rejection at least 80 dB down)
- Audio output: 1 W
- Audio output impedance: 8 ohms
- Modulation acceptance: ±7 kHz
- Image rejection: -65 dB
- Intermodulation and other spurious responses: at least 70 dB down.

AC-10 POWER SUPPLY
for 115 VAC operation
$39.95

For complete details contact:
R. L. DRAKE COMPANY
540 Richard St., Miamisburg, Ohio 45342
Phone: (513) 866-2421 Telex: 288-017

More Details? CHECK-OFF Page 126
NEW - 440 MHz PREAMPS

$54.95
POSTPAID
432PA-1

Two stage preamps use KMC Bipolar and Mosfet Transistors. 20db gain, 20 MHz bandwidth. These are high quality preamps suitable for the most demanding applications. AC models have die cast case, others have metal enclosure.

432PA-1 3.5db NF 12VDC $29.95
432PA-1 3.5db NF 117VAC $54.95
432PC-1 1.5 to 2.0db NF 12VDC $69.95
432PC-1 1.5 to 2.0db NF 117WAC $94.95

Write for our Santa Claus wish list of Preamps and Converters.

JANEL LABORATORIES
P. O. BOX 112
SUCCASUNNA, N. J. 07876
201-584-6521

DIGITAL: THEORY, DESIGN, CONSTRUCTION
LOGIC NEWSLETTER
SAMPLE COPY $1.00
LOGIC NEWSLETTER
POB 252
WALDWICK, N.J. 07463

FM YOUR GONSET
(or your Clegg 22 or Poly Comm 2, PC 62, Johnson 6N2, Aeratron 500, HA-460, TX 62 or VHF 1)

- New Plug-in modulator puts a Communicator transmitter on FM.
- No modification or rewiring on your Communicator. Just plug into mike jack and crystal socket.
- Compact self-contained modulator measures 4" x 3" x 1 1/4".
- Works with Communicator I, II, III, IV and GC-105, and other rigs listed.
- Only a tenth the cost of a new rig.
- Frequency adjust for netting built in.
- $34.50 postpaid U.S.A. $36.50 for PC-2, PC-62, HA-460. Specify transmitter model. California residents add 5% sales tax. (HC-6/U crystal and 9 volt transistor battery not supplied.)
- Send for free descriptive brochure.

APOLLO PRODUCTS
by "Village Twig"

1500X-2
Rotary Antenna Switch
Single pole, 3 position Antenn a Switch - Low SWR - Use up to 30 MHz, 500 Watt handling capacity. Sloping Front Console Cab. $12.95

450X-S Antenna Switch
3-Position Slide Switch Low Loss - Walnut-grain Finish Chassis - Gold Cover $5.95

700X-2 KW Wattmeter
Dummy Load Wattmeter for 52 O'm Input. Measures RF in 4 ranges to 10000 watts. Measures modulation percentage on calibrated scale. Portable. $124.50

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- Send for free descriptive brochure.
COMPUTER KEYBOARD $7.00 (as is)

Several styles on hand in poor condition, broken key/keys, broken case or no case, etc. Still a good value at $7.00 for parts, switches, and each has encoder board in base.

$2N3152 - 45 volt 170 watt PNP-G $1.00
$2N3713 - 40 150 NPN-S $1.00
$2N3773 - 160 150 NPN-S $1.00
$2N3789 - 60 150 NPN-S $1.00
$2N5301 - 40 200 NPN-S $1.25
$2N5301 - 40 200 NPN-S $1.00

*Removed from used equipment

TRANSFORMERS
BRAND NEW, 115 volt AC input. OP - AMP XFMR, out puts: 16 VCT 1/2 amp, 17 VCT 1/4 amp.

$3.50

FILAMENT or BTRY CHARGER XFMR
output of 18 volts at 4.5 amp $3.50

CALCULATOR KEYBOARD
Brand new keyboards for hand held calculators. Two styles available. One for use with calculator chip CAL TEX 5001-5002-5012 or MOSTEK 5010-5012. Another for use with Gen. Inst. chip 5050. Priced at $8.00 each or two for $15.00.

CT 5005 CALCULATOR CHIP
Single MOS chip with all logic required for 12 digit 4 function desktop calculator with extra storage register for memory or constant. Multiplexed 7 segment outputs for LED, Incandescent, Fluorescent, or Gas Discharge displays. Brand new, bargain priced, with specs.

$8.00 each, 2 for $15.00

HP LED DISPLAYS
Brand new 4-on-a-strap LED readouts. End-butt two strips and come up with 8 digit readout. An unheard of Super Value . . . $8.00 per strip; 2 strips $15.00

Another strip . . . this one a Clock Chip readout. 2 digits . . . a space . . . and 2 more digits. Just right for a clock reading hours and minutes. This one only $8.00

313,344 CORE MEMORY $125.00
From SPECTRA computer, visually OK. 64 x 6 x 18 core stack. Figures out to 35K Byte.

LED 7 SEGMENT READOUT
Similar to MAN-1. Factory seconds but functionally OK. Fit 14 pin DIP socket.
7 segment w/left decimal #LED-A-L $3.00
7 segment w/right decimal #LED-A-R $3.25
7 segment no decimal #LED-A $2.75
Above LEDs—7 for the price of 5
Socket for above, gold plated leads 3/1.00

IC SALE YOUR CHOICE 3 for $1.00
µ1 900 BUFFER TO-5
µ1 914 DUAL 2 INPUT GATE TO-5
µ1 923 JK FLIP FLOP TO-5
µ1 926 Hi speed JK FLIP FLOP TO-5
µ1 931 JK/RS FLIP FLOP (DIP)
10 pin socket for TO-5 IC 3/1.00

GIANT NIXIE B7971
Used $1.00
Brand New $2.00
With schematic for GIANT clock.

COMPUTER TAPE DECK $75.00
Takes 1/2 inch tape, made by Computer Entry Systems. Visually ok, with electronics, no data available.

LASER DIODES, new listing just arrived, send SAE.

CMOS 4814 HEX INVERTER
CMOS HEX INVERTER, dual inline package. 3-18 volt range, dual diode protection against static charge. Dielectrically isolated complimentary MOS.

$1.00 each 12 for $10.00

DUAL 16 BIT MEMORY
Dual 16 bit memory, serial MOS by Philco TO-5 case, brand new with 2 page specs.

2048 BIT MOS MEMORY
2048 bit MOS LSI random access memory NEC 6003. All inputs and outputs are TTL compatible. 2048 word by 1 bit. 22 pin ceramic dual-in-line. With specs.

$9.00 each 2 for $17.00

ASCII KEYBOARDS LIKE NEW $45.00
From Raytheon, with encoder board in base, output on blue ribbon connector. This is the same keyboard we sell at $50 except this one has no case. 5 extra function buttons each side. Price includes shipping world wide.

JOHN MESHNA JR. ELECTRONICS
P. O. Box 62 E. Lynn, Mass. 01904

More Details? CHECK-OFF Page 126
december 1973 73
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<th>Product Code</th>
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**LOW POWER TTL**

- **74L00**: .40 ea.
- **74L02**: .40 ea.
- **74L04**: .40 ea.
- **74L10**: .40 ea.

**8000 SERIES**

- **8091**: .69 ea.
- **8092**: .69 ea.

**LINEAR**

- **LM301 TO5**: .45 ea.
- **LM302 TO5**: .95 ea.
- **LM304 TO5**: 1.25 ea.
- **LM306 TO5**: 1.25 ea.
- **LM309 TO3**: 1.95 ea.
- **LM309H TO5**: 1.25 ea.

**PHASE-LOCKED LOOP MEMORIES**

- **NE561**: 2.95 ea.
- **NE565**: 2.95 ea.
- **NE566**: 2.95 ea.
- **NE567**: 2.95 ea.

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- **MV10B Visible red SUPER SPECIAL**: .25 ea.
- **MV50 TO3**: .25 ea.
- **MV520 Large red**: .35 ea.
- **ME4 Infra red TO18**: .69 ea.
- **MA1 The original**: 4.25 ea.
- **MAN 3 type**: 1.95 ea.
- **MAN 4 type**: 2.75 ea.

**Data-Lite 707** (MAN 1 repl)

- 4.25 ea.

**CALCULATOR CHIPS**

- **SM01 LSI (40 pin)** with data
- **SM02 LSI (40 pin)** with data
- **SM03 LSI (40 pin)** with data

**DIGITAL CLOCK**

- **MM5311 (28 pin)** with spec sheet
- **MM5312 (24 pin)** with spec sheet
- **MM5313 (24 pin)** with spec sheet
- **MM5314 (24 pin)** with spec sheet

**SYNCHRONOUS**

- **SM05 (0 pin)** with spec sheet

**SPECIAL**

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**Satisfaction Guarantee**

All items except as noted are fully tested. Minimum order $5.00 prepaid in the U.S. and canad. Calif. residents add sales tax. Orders filled in 3 days after receipt. Please add $.50 per spec sheet for items priced at less than $1.00 ea.
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18995
Plus S3 Shipping

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• Manufactured Prior to Revaluation of the Dollar — Manufacturer's Cost Today Would Be Greater Than Our Selling Price!

The Unimetrics ULTRACOM-25 is a 144-148 MHz FM transceiver with provision for 12 crystal-control transmit channels and 12 crystal-control receive channels. It features rugged, commercial-quality construction throughout. The dual-gate FET front end results in a sensitivity of better than 0.5 µV for 20 dB quieting. It includes controls for volume, power and squelch, illuminated channel selector, RF power output signal-strength meter, hand-held dynamic mike and mobile mounting bracket. The transceiver is factory equipped for operation on the following frequencies — 94/94 Simplex, 34/76 Duplex, 76/76 Simplex and 34/94 Duplex. It also has an integral 12 VDC power supply — if you purchase it with our antenna below, you will be ready for immediate mobile operation. Its compact size, 8 1/2 x 3 x 10 1/2” (WHD), makes it ideal for mounting in most any vehicle. An AC power supply, additional crystals, and touch-tone pad for auto patch are also available. For further information or phone orders, contact Walt Corrigan W8BPCP, Olson Electronics (216) 535-1800.

Hustler 2-Meter Mobile Antenna. 9° wavelength, stainless steel, 3.4 dB gain. With trunk lip mobile mount.

Regulated AC Power Supply, 4 amps, 12 volts. Operate the Ultracom-25 from 117 VAC house current.

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Olson electronics THE VALUE LEADER SINCE 1931
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BA-234
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☐ Master Charge* *Interbank No. [ ] [ ] [ ] [ ]

Good Thru Date:________________________

More Details? CHECK—OFF Page 126
december 1973 75
Dual tone decoder decodes one Touch-Tone digit.

Available for 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, *, #, * and other dual tones 700-3000 Hz.

Latch and reset capability built-in.

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- Free descriptive brochure on request.

T-2 Touch-Tone Decoder ... $39.95 PPD.

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Package of 12. $2.00

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76 December 1973
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Raleigh, North Carolina 27611

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COMPANY

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Federal Supply Schedule Group 58 Part VII, Contract 05-005-24916

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ONLY $199.95

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3 1/2-DIGIT DVM
- DC accuracy, 0.5%.
- Automatic polarity.
- 1 mV resolution.
- 100% solid state.

For fast, easy-to-read, accurate multimeter readings. 100% overrange capability, all ranges; auto polarity and decimal point positioning; very large, 7-segment, non-blinking display; 10 meg input impedance; full overload protection. SPECs: DCV, 0-1000V, 4 ranges; ACV, 0-1000V RMS, 4 ranges. Current: AC and DC, 0-1000 mA, 4 ranges each. Ohms: 0-10.00 megohms, 6 ranges. AC Response: Volts and current, 50 Hz to 1 kHz. Size: 3½" x 7 x 9". For 105-125 VAC, 50-60 Hz; 3-wire cord. With PR-21 probe with switchable 100K ohm isolation resistor — prevents capacitive loading when measuring DC in RF circuits.

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Finest Quality for PCB’S, Made in USA Three For $1.00

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CRYSTAL FILTERS
and
DISCRIMINATORS

by
K.V.G.

9.0 MHz MODELS

9.0 MHz FILTERS
XF9-A 2.5 kHz SSB TX $33.55
XF9-B 2.4 kHz SSB RX $47.70
XF9-C 3.75 kHz AM $51.40
XF9-D 5.0 kHz AM $51.40
XF9-E 12.0 kHz NBFM $51.40
XF9-M 0.5 kHz CW $35.95

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XD9-02 ± 10 kHz NBFM $26.35
XD9-03 ± 12 kHz NBFM $25.30

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XF901 8998.5 kHz USB $4.00
XF902 8991.5 kHz LSB $4.00
XF903 8999.0 kHz BFO $4.00
F-05 Hc25/u Socket .50

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XF107-B 16kHz NBFM $42.65
XF107-C 32kHz WBFM $42.65
XF107-D 38kHz WBFM $45.90
XM107-S04 14kHz NBFM $19.95

XM107-S04 14kHz NBFM $19.95
(CRystal SOCKET (for XM107-S04) type DG1 $1.50

10.7 MHz DISCRIMINATORS
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XD107-02 50kHz WBFM $23.15

1296-1300 MHz

CRAYAL SOCKET (for XM107-S04) type DG1 $1.50

VHF CONVERTERS

MMc 50
RF Freq. (MHz) ±
50-54 144-148
IF Freq. ±
28-32 28-32
N.F. (typical)
2.5dB 2.8dB
Nom. Gain
30dB 30dB
Power 12V D.C.
$53.70 $53.70
1¾” x 2½” x 4½” + connectors

MMc 144

1220-1244 144-148
28-32 28-32
3.4dB 3.8dB
26dB 28dB
$64.45 $64.45

1296-1300 MHz

144-148
9.0dB 9.0dB

12 watts min.
12 watts min.

12 watts min.

VHF VARACTOR TRIPLERS

MMv 432
INPUT: 140-153 MHz
20 watts max.
OUTPUT: 420-459 MHz
12 watts min.
Size: 4½” x 2½” x 1¼” + connectors

MMv 1296
INPUT: 420-459 MHz
20 watts max.
OUTPUT: 1260-1377 MHz
12 watts min.
Size: 4½” x 2½” x 1¼” + connectors

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a Very Happy Christmas
and a Successful New Year

J-BEAM AERIALS $47.50
70/MBM46 420 — 460 MHz
46 ELEMENT BEAM
GAIN. REF DIPOLE 17.3 dB
STACKING KITS AVAILABLE

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BOX 1084 CONCORD
MASSACHUSETTS 01742

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**NEW** Transformer — American Made — Fully shielded. 115 V Primary. Sec. 24-0-24 @ 1 amp with tap at 6.3 volt for pilot light. Price — A low $2.90 each ppd.

400 Volt PIV at 25 Amp. Bridge Rectifier. $4.00 ea. or 3 for $10.00 ppd.

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**NEW** TRANSFORMER. 115 volt primary, 12 volt ½ amp secondary. $6.00 ea. ppd.

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**HIGH GAIN • LOW NOISE**

35dB power gain, 2.5-3.0 dB N.F. at 150 MHz. 2 stage, R.F. protected, dual-gate MOSFETS. Manual gain control and provision for AGC. 4¾" x 1¾" x 1¾" aluminum case with power switch and choice of BNC or RCA phone connectors (be sure to specify). Available factory tuned to the frequency of your choice from 5 MHz to 350 MHz with approximately 3% bandwidth. Up to 10% B.W. available on special order.

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**Vanguard Labs** 196-23 JAMAICA AVE. HOLLIS, N. Y. 11423

**RECEIVERS, OK GRTD, WITH BOOKS:**

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency Range</th>
<th>Price</th>
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<tr>
<td>SP-600-JX</td>
<td>0.54-54 MHz continuous</td>
<td>275.00</td>
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<tr>
<td>R3688U/R</td>
<td>AM, CW, ½-30 MHz linear dial, PTO</td>
<td>325.00</td>
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<tr>
<td>R390A/R</td>
<td>½-32 MHz by digits, PTO tuning</td>
<td>595.00</td>
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<tr>
<td>AN/WRR-2: 3-32 MHz digital tune each 500 Hz or continuous, A1, 2, 3, 9, F1, 4, FAX FSTTY, SSB, carrier suppressed, either band or both for 2 different intelligences. Stable and accurate enough to use as freq. meter. Net wt. 276 lbs. in 2 cabinets in rack cradle</td>
<td>750.00</td>
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<td>Less the rack cradle but interconnected</td>
<td>700.00</td>
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<tr>
<td>NEMS-CLARKE #1670-T-F &amp; receiver 55-150 MHz</td>
<td>195.00</td>
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<tr>
<td>WWVB 60 KHz rccr/comparator</td>
<td>295.00</td>
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<tr>
<td>WWVB 1 KHz tones, use to calib. 100 KHz</td>
<td>175.00</td>
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<td>38-1000 MHz by Band Switching, 4 bands: Separate antenna for each band. AN/FALR-5 modified for 117 v 50/60 cy line, AN/FM. The Tuner is a plug-in converter; the receiver is 30 MHz IF and all that follows IF. Choose selectivities 200 KHz or 2 MHz each side of center. Factory checkout sheet, typical for the original-pack tuner you got, says sensitivity ranges from 1.1µV at 28 MHz to 7 at 1 GHz. IF attenuator is calibrated in 6 dB steps to —74 dB. Diode current meter makes this rccr useful for relative field strength measurements and harmonic finder. Rccr unit is exc. used and checked out OK</td>
<td>375.00</td>
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<tr>
<td>30 MHz PANADAPTER may be used with above</td>
<td>245.00</td>
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<tr>
<td>A.I.L. #132 30 MHz rccr/amplifier/atten. calib.</td>
<td>199.50</td>
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<tr>
<td>EDDYSTONE AM/GW/FM/NSFM 19-165 MHz rccr</td>
<td>295.00</td>
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<tr>
<td>CV-591A: SSB Converter either sideband</td>
<td>137.50</td>
<td></td>
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<tr>
<td>OCT-3 TTY PSK deviation meter receiver, new</td>
<td>49.50</td>
<td></td>
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<tr>
<td>MOTOROLA 3 MHz OSCIL. 5 parts in 10 to 11th</td>
<td>199.50</td>
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More Details? CHECK-OFF Page 126
Now . . . SBE opens up a new high speed route that leads to instant 450MHz operation from any 2 meter transceiver! Rev up—
switch in the exclusive SBE, SB-450TRC "Cloverleaf"—arrive instantly on 450! Return at will!

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

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

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

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

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

Only $2.00 each - 3/35 50-MF or Mutch.

Measures only 3/4 x 1 x 1'/4. Plastic case. Like KNP type.
For pc board or socket. 14 amps, 18/32 stud to. Both 404T.
All ceramic construction. 3 amp, contacts. For r.f. only.
Switching. Dc. 1'0. Wherever space is prime, you need a
"mini cap" relay.

115 VAC 60 cpi
24 VDC

MODEL "A" Frequency Counter  Price $299.00
10Hz to 20 MHz (±1 Hz) Direct Count guaranteed (1Hz to over 100MHz) typical.
Read Out: 5 LED digits + LED Over Range Sensitivity: Less than 100 millivolts over entire range.
Power Req.: Either 120 VAC or 12 VDC 15 watts approx.
Small Size: 2-3/4" x 5-6/8" x 8-1/8" Overload protected input and DC power input.
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Exactly as above plus an internal 250MHz Scaler (±10Hz to well over the guaranteed frequency of 250 MHz). No external power is required.
Shifting DECIMAL POINT gives a DIRECT READOUT of VHF Frequencies.
One BNC INPUT for both ranges. No cable changing from HF to VHF.
(CA residents add State Sales Tax)
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YAESU FT-101
now with 160 meters
SEE WILSON for your Yaesu products

FTDX 401 Transceiver
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FL2000B Linear Amplifier
Interested in trading Tempo One's and other Yaesu equipment.

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702-451-5791

MORE DETAILS? CHECK-OFF PAGE 126
Now . . . a universal AC power supply for your FM transceiver and your amplifier!

At last, you can get the power you want at the price you want, with the new PW-4 from E&L. Plug it into any 110-120 volt AC source and you get a rated output of 13 volts DC @ 12 amps, I.C. regulated to ±3%! The PW-4 features a circuit breaker reset, modern cabinet design, and heavy duty components for reliability. Use it with most 12-13 volt DC transceivers, together with your 50-60 watt amplifier. The PW-4 sells for $84.95, direct from the factory.

Get your mobile rig into the house . . . get a PW-4!

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61A First Street
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A COMPLETELY PORTABLE FREQUENCY COUNTER WITH . . .

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

FEATURES

• High capacity rechargeable Ni Cd batteries
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• Convenient 3-position range select switch allows:
  1. Readout always in MHZ.
  2. Eight digit resolution by range selection
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Each of our lives are governed with decisions where we must decide between right and wrong. During this Christmas Season open your heart and "ask Jesus Christ to help you live as you should." Jesus said, "I have been standing at the door and I am constantly knocking. If anyone hears me calling him and opens the door, I will come in and fellowship with him and he with me." (Rev. 3:20)

Don't put off until tomorrow what you should do today!

Merry Christmas and Happy New Year from the gang:

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88 december 1973 More Details? CHECK-OFF Page 126  

Central Lab DPDT push momentary. SPEC.  

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8. Ladies who register will receive admission ticket for their program on Saturday.
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10. Ticket for Flamingo Hotel Buffet Hunt Breakfast with Champagne, Sunday.
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More Details? CHECK-OFF Page 126
december 1973
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**PA30-140B**

<table>
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<th>Model</th>
<th>Input Range</th>
<th>Nominal P0</th>
<th>Nominal Amps</th>
<th>Price</th>
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ELECTRONICS

BOX 1201H
CHAMPAIGN, ILL. 61820

More Details? CHECK—OFF Page 126
december 1973
# TEST EQUIPMENT SALES

<table>
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<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP 542A</td>
<td>COUNTER: DC to 10 MHz, 6 digit neon, 2 meters</td>
<td>$125.00</td>
</tr>
<tr>
<td>HP 542C</td>
<td>COUNTER: DC to 10 MHz, 8 digit nixie</td>
<td>$295.00</td>
</tr>
<tr>
<td>HP 542D</td>
<td>COUNTER: DC to 10 MHz, 8 digit neon</td>
<td>$195.00</td>
</tr>
<tr>
<td>HP 525A</td>
<td>CONVERTER PLUG-IN: 10 MHz to 110 MHz</td>
<td>$75.00</td>
</tr>
<tr>
<td>HP 525B</td>
<td>CONVERTER PLUG-IN: 110 MHz to 220 MHz</td>
<td>$75.00</td>
</tr>
<tr>
<td>HP 526B</td>
<td>CONVERTER PLUG-IN TIME INTERVAL UNIT</td>
<td>$40.00</td>
</tr>
<tr>
<td>HP 526C</td>
<td>CONVERTER PLUG-IN PERIOD UNIT</td>
<td>$35.00</td>
</tr>
<tr>
<td>NORTHEASTERN 14-26C CONVERTER PLUG-IN: 200-1000 MHz for HP 524 series &quot;As Is&quot;</td>
<td>$150.00</td>
<td></td>
</tr>
</tbody>
</table>

**BECKMAN 8175R COUNTER:** 10 Hz to 110 MHz, 8 digit readout | $195.00

**HP 540BR TRANSFER OSCILLATOR:** 10 MHz to 12.4 GHz | $125.00

**LAMPKIN 105B FREQUENCY METER:** | $195.00

**MCTARY F-531 FREQUENCY METER:** 1 to 20 MHz | $50.00

**BALLANTINE 300 VTVM:** 1mV to 100V, 10 Hz to 150 kHz | $35.00

**BALLANTINE 310AR VTVM:** 100mV to 100 volts, 10 Hz to 2 MHz | $65.00

**BALLANTINE 314 VTVM:** 1mV to 1kV, 15 Hz to 6 MHz, less probe | $75.00

**BALLANTINE 316R VTVM:** Peak to peak, 0.05 Hz to 30 MHz | $35.00

**GENERAL PURPOSE 45, 50, 500 METER:** | $35.00

**GR 1800 VTVM:** 0.1 to 150V full scale, DC-800 MHz, 2% | $50.00

**GR 1803A VTVM:** 1.5V to 150V | $35.00

**HP 400V VTVM:** 10 Hz to 4 MHz, 1mV to 300V | $75.00 to $115.00

**HP 400DR VTVM:** 10 Hz to 4 MHz, 1mV to 300V, 2% accuracy | $65.00

**HP 400H VTVM:** 10 Hz to 4 MHz, 1mV to 300V, 1% accuracy | $120.00

**HP 400HR VTVM:** 10 Hz to 4 MHz, 1mV to 300V, 1% accuracy | $95.00

**HP 410B MULTI-FUNCTION VTVM:** AC/DC volts and ohms, 20 Hz to 700 MHz, ±3% accuracy, probes built-in | $90.00

**HP 415A VSWR INDICATOR:** | $25.00

**HP 430B MICROCHROME POWER METER:** Reads directly in dBm or mW, 0.01 to 10W full scale, 10MHz to 40 GHz with appropriate thermistor mount | $35.00

**HP 430C MICROCHROME POWER METER:** Later version of 430B | $65.00

**HP 51A MICROCHROME POWER METER:** Automatic self-balancing power meter uses temperature compensated thermistor mounts | $150.00

**TEKTRONIX 310 OSCILLOSCOPE:** Portable, DC to 4 MHz | $350.00

**TEKTRONIX 517 OSCILLOSCOPE:** DC to 1 GHz with power supply | $295.00

**TEKTRONIX 531 OSCILLOSCOPE:** DC to 11 MHz less plug-in | $295.00

**TEKTRONIX 533 OSCILLOSCOPE:** DC to 15 MHz less plug-in | $325.00

**TEKTRONIX 535 OSCILLOSCOPE:** DC to 11 MHz less plug-in | $425.00

**TEKTRONIX 541 OSCILLOSCOPE:** DC to 30 MHz less plug-in | $350.00

**TEKTRONIX 543 OSCILLOSCOPE:** DC to 30 MHz less plug-in | $425.00

**TEKTRONIX K PLUG-IN:** DC-30 MHz Fast rise time | $50.00

**TEKTRONIX B PLUG-IN:** DC-20 MHz high gain wideband | $50.00

**TEKTRONIX C PLUG-IN:** DC-24 MHz dual trace | $125.00

**TEKTRONIX CA PLUG-IN:** DC-24 MHz dual trace | $150.00

**TEKTRONIX E PLUG-IN:** DC-60 kHz differential | $75.00

**TEKTRONIX R PLUG-IN:** Transistor Rise-Time | $75.00

**SORENSEN T50-15 POWER SUPPLY:** 0 to 50 VDC @ 1.5 amps | $75.00

**SORENSEN 500B POWER SUPPLY:** 0-500 VDC @ 150mA | $35.00

**SORENSEN 500BB POWER SUPPLY:** 0-500 VDC @ 500mA | $65.00

**HAMMARLUND SP500 RECEIVER:** 560 kHz to 54MHz | $225.00

**NEMS-CLARKE 1306 RECEIVER:** 30 to 260 MHz, BW 10, 300, 500, 1000 kHz, receives AM, CW and SSB | $400.00

**NEMS-CLARKE 1400 RECEIVER:** 215-260 MHz, crystal controlled, selectable IF bandwidth of 100 or 500 kHz | $50.00

**NEMS-CLARKE 1412 RECEIVER:** 215-260 MHz, crystal controlled | $75.00

**NEMS-CLARKE 1455 RECEIVER:** 215-260 MHz, crystal controlled or internal VFO, 150/300 IF bandwidth | $125.00

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HELP! Eastern Stereo Servicenter in Bergen County, N. J. needs a top-flight technician strong on theory, solid state circuitry, experience, who loves to fix equipment. We are leading audio component service facility. Have latest and best test gear. Top conditions, benefits. Top pay, position, bonus plan for right person. Write 127 Pleasant Avenue, Upper Saddle River, N. J. 07458, or call Dave at (201) 327-9333.


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709C TV sound IF system $1.50
709CV Op amp (mini DIP) $0.45
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711C Dual diff. comp. (B) $0.95
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711C Dual microamp (B) $0.95
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100 december 1973

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DECEMBER 1973 More Details? CHECK-OFF Page 126
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144-146 MHz

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  PA-2501H — 25-30 WATTS OUT
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ham radio
cumulative index
1968-1973

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Vertical dipole, gamma-loop-fed
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Vertical-tower antenna system
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<td>Radio Amateur Callbook</td>
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<td>Regency Electronics, Inc.</td>
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<td>Stroff-Friedman Co.</td>
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<td>Swan Electronics</td>
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<td>Telectron Corp.</td>
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<td>Ten-Tec, Inc.</td>
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<td>Tri-Ex Tower Corp.</td>
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<td>Tristao Tower Co.</td>
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<td>Tri-Tek, Inc.</td>
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<td>Tropical Hamboree</td>
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<td>VHF Engineering, Div. of British Elect. Corp.</td>
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<td>Vanguard Labs</td>
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<td>Vintage Radio</td>
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<td>Weinschenker, M.</td>
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<td>Wilson Electronics</td>
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<td>Wolf, S.</td>
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<td>World Radio</td>
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<td>World QSL Bureau</td>
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<td>Y &amp; C Electronics</td>
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<td>Yaasu Musen USA</td>
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</table>
INVERIER/CONVERTER:
INVERTER, 12 volt DC input, 115 volt AC output, Model 12-115 solid state power supply, 200 watts continuous........................... new, $59.95

SBE
SB-450 TSC, used with 10 watt, 2 meter transceiver to operate on 450 MHz.......................$195.00

BARRY HAS ANTENNAS
C.D. HAM "M" ROTATORS, new complete............ $99.95
C.D. HAM-M for 250 VAC in stock.................... $175.00
C.D. TR-44 ROTATORS, new (complete)................. $63.95
CABLE for Ham-M & TR-44 @ 14/efl. .................. $35.95
CD AR-22R emplt. rotator for small beams............. $33.95
BN86 Balun by HyGain................................... $14.95
RG-8/A-U 100 ft. rolls, VHF connector PL-259 one end Type "N" (UG-21E/U) other end $12.50
RG-8/A - 65 feet with PL-259 connectors on each end..................... $9.50

Times Wire & Cable, T-4-50 (FM-8) 50 ohm lowest type RG-8 cable..................... 20/ft.

Columbia Superflex, RG-8/A-U 50 ohm high quality foil..................... 12/efl.

Coaxial Cable for VHF to RG-17 (Amplon 83-86) RG-17 plug to VHF female connector $6.95

BNC to RG-17 adapter UG-167C/U $7.95

B & W Vertical, 2000 ohm, front panel antenna, 2, 6, 10, 15 & 20 meters. Hang out your window. $24.95

Take along on your vocation $19.95


Cush-Craft Trick Stick, universal dipole. 2 to 10 meters, 1.5 dB gain at 146 MHz. $8.95

English deluxe balun, low power..................... $9.95

RINGO Mag 350 dB gain, 135-175 MHz............ $14.50

BBLT-144 Trunk Lip, 3.75 dB gain................. $34.95

Newtronics CGT-144 mobile 5.2 dB gain, $37.95

Quick Disconnect by Newtronics for CGT, etc. ...................... $10.95

GC-1 Gutter Clip by Newtronics...................... $1.25

2M MAGNETIC MOUNT w/RG58 & PL259 with 10 ft. RG 58 ready to go..................... $9.95

14AV/WB VERTICAL........................................ $55.00

18AV/WB VERTICAL........................................ $50.00

HY GAIN 2 METER, 15 ele. beam, demo..................... $35.00

TELEX
610-2 Deluxe Economy 2000 ohm headset with cushions........................................... $9.95

EN-5 Stereo Headphones........................................... $9.95

LITTLE LULU
6 Meter AM Transmitter with VFO 12 VDC/115 VAC Power Supply
Available factory wired or as parts
Write for details

Tube Headquarters, Diversified Stock, Heavy inventories of tubes, chinnys, sockets, etc.

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

Barel New Stocks, Bogen, Electrovoice & University. Compact space, light weight.

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

Send for Green Sheet Supplement 23. Send 50¢ postage & handling (refund 1st order).
BARRY presents

CLEGG FM-27B

Total 146-148 MHz coverage without buying a crystal. 25w. out, fully synthesized. $479.95

Clegg FM-27B Regulated AC power supply $79.95

HALICRAFTERS

SR-160 Transceiver 80, 40, 20 meters write FPM-300 new, $950.00

TEMPO

2 Meter Linear Amplifiers, 502, 5-12 watts input, 35-55 watts output $105.00
802-B 1-21/2 w. input, 80-90 w. output $195.00
CL-146 2 Meter, 15 watts $299.00

BIRD 43 WATTMETER

$100.00

Bird 43 Slugs specify frequency and power
HF $35.00 each
VHF $32.00 each
Also 4350 80-10M dual scale 200w/2kw HamMate — $79.00

MARINE

Barry stocks and has fast availability Sonar, Pearce-Simpson, Andrea, SBE and Antenna Specialists VHF Transceivers, Antennas, Depth Finders and compasses by Andrea.

DRAKE

R4B Receiver xint. $295.00
AC-10 AC Supply for AA-10, TR-22, TR-72, 13.8 VDC @ 3 amps $39.95
TR-22, in stock $219.95
AA-10 Amplifier for TR-22 $49.95
TR-72 2 meter FM Transciever, 23 channel, 1 & 10 watts, 13.8 VDC $320.00
TR4/C new, $599.95 T-4XC Trans. $530.00
R4C Rec. $499.95
AC-4 Drake A.C. Power Supply $99.95

GE INDUSTRIAL SILICON RECTIFIER
1400 PIV
250 amp., GE #41A281049-11. Quantities in stock. $90.00 value, brand new, $15.00

SWAN

SS-200 Solid State SSB Transceiver with power supply & 16 pole filter. Brand new, Write

TEN TEC

TRITON II 5 Band Solid State Transceiver 200 W pep R.I.T. $600.00
AC Power Supply 252 $89.00
315 RECEIVER 10-80 meters SSB, AM, CW $229.00
CW FILTER FOR 315 $14.95
AC4 SWR Bridge KR2 $12.95
$14.95 KR40 $89.95

ETO

ALPHA-77. The finest amplifier ever offered for amateur, commercial or military service. $3000

ETO

FM-27B Regulated AC power supply watts PEP continuous duty. $79.95

Signal/One CXTA Write or Call

SWR BRIDGE COUPLER, DC-800 MHZ
TNC Connectors (no indicator) full amateur power $90.00 Value $10.95

DX ENGINEERING

SPEECH COMPRESSORS
DIRECT PLUG-IN FOR COLLINS 32S
DIRECT PLUG-IN FOR KWM-2
$79.50 ppd. U.S.A.
$79.50 ppd. U.S.A.

INSTRUMENTS

Millen 90652 Solid State Dipper. New with 7 coils and carrying case. 1.6 - 300 MHz $110.00
PAN ADAPTER BC-100A $100.00

E. F. JOHNSON

Matchbox complete with directional coupler and indicator, 10-50 meters. 2KW PEP, 1 KW AM — new, $275.00
275 watts — new, $145.00
151-1-4 Variable Capacitor, 250 pF, medium Xmitting type $55.00

VIBROPLEX

Vibro Keyer Standard $24.95
Deluxe $32.95
Original Standard Vibroplex Bug $29.95

More Details? CHECK-OFF Page 126

BARRY 512 Broadway NY, NY 10012
DEPT. H-12
212-WA-5-7000
TELEX 12-7670
**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 1% 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:** 1.5 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.

**POWER SUPPLY:** Separate AG or DC required. See AC-ONE and D01-A.

**TUBES AND SEMICONDUCTORS:** 16 tubes, 15 diodes, 7 transistors

**TEMPO™ "ONE" TRANSCEIVER**

<table>
<thead>
<tr>
<th>Price</th>
<th>Description</th>
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<tbody>
<tr>
<td>$349.00</td>
<td>Transceiver</td>
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<tr>
<td>$99.00</td>
<td>AC/ONE POWER SUPPLY 117/230 volt 50/60 cycle</td>
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<tr>
<td>$120.00</td>
<td>DC/1-A POWER SUPPLY 12 volts DC</td>
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<tr>
<td>$99.00</td>
<td>VF-ONE EXTERNAL VFO</td>
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</tbody>
</table>

**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

**YAESU**

... a name proven through world-wide use...

... now available at Henry Radio. Come in, phone or write for complete specifications. We ship almost everywhere.

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<thead>
<tr>
<th>Price</th>
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<tr>
<td>$649.00</td>
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<tr>
<td>$599.00</td>
<td>Transceiver</td>
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<tr>
<td>$339.00</td>
<td>Linear Amp with tubes</td>
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<td>$289.00</td>
<td>Digital Counter</td>
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<td>$99.00</td>
<td>External VFO</td>
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<td>$59.00</td>
<td>Speaker/patch</td>
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<tr>
<td>$19.00</td>
<td>Speaker</td>
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<td>$19.00</td>
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<td>$29.00</td>
<td>Dynamic microphone</td>
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<td>$40.00</td>
<td>C.W. filter</td>
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<td>$19.00</td>
<td>Fan</td>
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<td>$9.00</td>
<td>Mobile bracket</td>
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**Prices subject to change without notice.**
This compact, single tube amplifier, located in the EIMAC facility, develops over 1300 kilowatts of 100% modulated carrier. It is quickly and easily tunable over the range of 15 to 30 MHz. Drive power at the grid of the tube is less than 5 kilowatts.

Using a single EIMAC X-2159 super-power tetrode in a Continental Electronics transmission line-cavity configuration, this amplifier combines high power gain with excellent operating stability and complete freedom from circuit parasitics.

A single amplifier stage using two EIMAC X-2159 tubes is capable of over 2.5 megawatts of 100% modulated carrier. Two amplifiers combined would make a 5 megawatt transmitter a practical reality.

The EIMAC X-2159 super-power tetrode is designed for MF and HF broadcast service, VLF communications, SSB linear service and extremely high power pulse modulator applications.

The X-2159 is another example of tomorrow's tube that's ready today at EIMAC. For complete information, contact EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070. Or any of the more than 30 Varian/EIMAC Electron Tube and Device Group Sales Offices throughout the world.