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There are so many nooks and crannies to the hobby of amateur radio that it's difficult to say what facet is the most popular. Certainly, there is tremendous fm activity on two meters, and there's a host of operators up on the six-meter band, trying to add another state to their WAS list. Down on 75 meters there is a preponderence of rag chewers who gather on the same frequency, night after night. Then there is RTTY, slow-scan tv and traffic, brass pounders, county hunters and net nuts.

However, from listening on the air, I'd say that one amateur radio activity that is near the top of the list is certificate chasing and DXing. Actually, the two go together — what serious DXer do you know who doesn’t have DXCC (as well as WAZ, WPX and at least a few others)?

With all the interest in certificates and awards, everybody and his brother is busy churning out another new one (with seals), for working continents, countries, counties, towns and club sites, all one mode and band seals, 25 cents extra. If you're looking for wallpaper, some of the certificates are worth applying for, but all too many times they are poorly printed on a lousy grade of paper and don't even warrant space in your round file.

It's been my experience, as a one-time certificate chaser, that operating awards offered by national amateur radio societies (ARRL, RSGB and NZART, for example) are well done; awards offered by national magazines are usually worth while as are the beautiful awards sponsored by the YL International SSBers. But, for every nice certificate available, there are a dozen others that would make passable toiletries.

You can usually predict the type of certificate you're going to get by return mail by considering the sponsor, the difficulty of the award and the cost. If the award is for working three members of the Podunk Amateur Radio Club while on safari to Omallabug county, and they want 50 cents to cover postage and handling, don't expect too much! On the other hand, when the Organization of American States Association offers an award for working all member nations (WAAN) at no cost, you can look forward to a handsome certificate.

It is unfortunate that the biggest bulk of junk certificates seems to originate in the United States. The certificates from overseas are almost always very tastefully done and are a welcome addition to the hamshack wall. I think it's high time we brought some of our homegrown awards up to snuff.

If your club offers a certificate of any kind, get it out and take a good, close, unbiased look at it. First of all, is it printed on a good grade of paper? (It doesn't have to be on parchment, but the paper shouldn't look like it escaped from a newsprint factory, either.) How about the printing? Are the letters clear and sharp? Are there ink smudges and dirty fingerprints, deposited by a careless printer? Finally, was your name and callsign scribbled on the certificate by some refugee from the third grade, or is it carefully lettered or typewritten?

If your club award passes these three simple tests, congratulations! Put it back in its frame and hang it on the wall. If it doesn't pass, resolve to take it up with your fellow club members at the next meeting. Let's relegate all those junk certificates to the trash can.

Jim Fisk, W1DTY
editor
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The modified Clegg FM 27B transceiver now covers the entire range of 146-148 MHz... and needs NO additional crystals. It's the only 2 meter rig available now with built-in total coverage that also offers greater than 25 watts output power, uses 10 IC devices, and has Teflon* wiring throughout. Not a single bi-polar device is in the RF path in transmitter or receiver... ensuring greater reliability. Accessory power supply and sub-audible tone on transmit are available too. At home or in your car, the FM 27B gives you the ultimate in total 2 meter performance. See your Clegg Dealer NOW or write or phone us today for detailed data sheet on our 2 meter leader.

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Current Consumption at 13.5 VDC:
Receive: 4 amps squelched, 1.2 amps unsquelched.
Transmit: 6 amps max.
DIMENSIONS: 7½" x 3½” x 9¾” deep; 4 lbs. net weight.
RECEIVER
TUNING RANGE: 146.00 to 148.00 MHz, continuously tuneable with reset capability of approx. 1 KHz to any frequency in range.
SENSITIVITY: .35 µV max. for 20 db quieting; .1 µV for reliable squelch action.
SELECTIVITY: 11 KHz at 3 db; Less than 30 KHz at 70 db. Adjacent (30 KHz spaced) channel rejection more than 70 db.
AUDIO OUTPUT: 2.0 watts (min.) at less than 10% THD into internal or external ohm speaker.
TRANSMITTER
TUNING RANGE AND CONTROLS: Same as RECEIVER.
POWER OUTPUT: 25 watts Min. into 50 ohm load.
P/A transistor protected for infinite VSWR.
MODULATION: Internally adjustable up to 10 KHz deviation and up to 12 db peak clipping.

*DuPont trademark

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march 1973

More Details? CHECK-OFF Page 94
Complete circuit details for an all solid-state 10-watt ssb transceiver — building-block construction simplifies future circuit revisions.

This single-band 80-meter ssb transceiver was built using a combination of solid-state building-blocks in crucial circuitry, as well as discrete components in subordinate circuits. No transmit-receive switch, as such, was used; instead, seven tiny surplus hermetically-sealed relays were used and located at the site of each associated building-block. Also, the number of tuned circuits was kept to an absolute minimum. For example, the only tuned circuits employed in the receive mode are in the front-end, the vfo and optionally in the i-f amplifier.

Plans for revision will eventually eliminate the tuned circuit in the i-f amplifier stage when the present MPF102 fet and single tuned circuit are replaced with a single broadband IC amplifier (for example, the MC1350P gives 60 dB gain at 60 MHz and is available for under two dollars).

In the transmit mode, the only tuned circuits are in the vfo and the buffer, and the driver/final. The only tuning needed on transmit is the vfo and the collector of the final. The three tuned circuits ahead of the final are staggered-tuned to give reasonably broadband performance across the 200 kHz I use most. There is plenty of drive, as the mike gain control is about...
half open for the beginning of clipping.

One of the advantages of the building-block method of construction is that it allows for constant and unpredictable later modifications and changes in the circuit as various other ICs and discrete components become available. For my

pass of 400 Hz to 2500 Hz at 6 dB down. Filter insertion loss is only 1.5 dB and 50 dB suppression of the unwanted sideband is provided.

The other most significant block used in the design is the Motorola MC1496 integrated-circuit dual-differential ampli-

fig. 1. Block diagram of the 80-meter ssb transceiver. Relays are used for the bulk of the transmit-receive switching.

part, about 90% of the enjoyment of amateur radio is found at the workbench, and this little rig is built to provide for an almost never-ending series of re-engineering.

The heart of the rig is a Snelgrove* F9000-1 crystal lattice filter with a band-

fier which offers exceptionally attractive characteristics as a balanced modulator, double-balanced mixer and product detector. As a balanced modulator, when

*C.R. Snelgrove Company, Ltd., 141 Bond Avenue, Don Mills 404, Ontario, Canada.
supplied with the appropriate signal levels, the MC1496 easily provides 35 dB carrier suppression, 50 dB spurious sideband suppression and 20 dB suppression of the second carrier harmonic. These

figures, along with the 50 dB suppression of the crystal filter, add up to a very respectable single-sideband signal at the antenna. Also, the MC1496 provides for carrier balance adjustment through a dc potentiometer, and simplifies things considerably in this respect.

It should be noted that the MC1596, which was written up by K7QWR,1 is almost the same as the MC1496, and this tremendous little IC is used to good advantage in this rig in three key circuits.

The most significant difference between the MC1596 and MC1496 is in their respective operating temperature ranges. The 15-series meets exacting military requirements (-55 to +125 degrees C), while the 14-series is designed for operation in the 0 to +70 degree C range.

The MC1496 offers only slightly less carrier suppression than the MC1596 (see the specification sheet for the MC1596/1496 as well as Motorola’s very helpful Application Note AN-531). The MC1496, therefore, is entirely adequate for most amateur applications. Also, the 14-series is approximately half the cost of the 15-series device, another worthwhile consideration.

fig. 2. High-stability mosfet vfo tunes from 5.0 to 5.5 MHz. Regulated power supply is shown in (B).
basic interconnections

The two blocks that make this rig such a good performer are the high quality filter, with its nice steep skirts, and the MC1496 ICs. In order to achieve maximum performance from the filter, it must be impedance matched at both input and output. The circuit shown in fig. 7 meets the manufacturer's requirements, although the F9000-1 specifications were originally designed for use around vacuum-tube circuitry. The circuit in fig. 7 uses two MPF102 field-effect transistors and provides a perfect match for the filter.

For maximum performance from the MC1496, however, the crucial variables rest in the voltage levels supplied to the MC1496 ICs. In order to achieve maximum performance from the filter, it must be impedance matched at both input and output. The circuit shown in fig. 7 meets the manufacturer's requirements, although the F9000-1 specifications were originally designed for use around vacuum-tube circuitry. The circuit in fig. 7 uses two MPF102 field-effect transistors and provides a perfect match for the filter.

For maximum performance from the MC1496, however, the crucial variables rest in the voltage levels supplied to the signal levels. Once the given voltages are obtained, however, it is a relatively straightforward matter to experimentally adjust coupling parameters to achieve the desired operating characteristics.

For example, I found that a small amount of i-f gain was needed to achieve good product detector operation. The original plan was to operate with an i-f gain of unity, but this resulted in inadequate ssb signal levels for good mixing in the MC1496. Very little additional signal was required to obtain the desired results from the product detector.

<table>
<thead>
<tr>
<th>function</th>
<th>input at pin 8</th>
<th>input at pin 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>balanced modulator</td>
<td>carrier oscillator, 60 mV rms</td>
<td>audio, 3 - 300 mV rms</td>
</tr>
<tr>
<td>double balanced mixer</td>
<td>vfo 100 mV rms</td>
<td>ssb signal</td>
</tr>
<tr>
<td>product detector</td>
<td>carrier oscillator, 300 mV rms</td>
<td>ssb signal</td>
</tr>
</tbody>
</table>

differential inputs. The MC1496 has an excellent dynamic range, as demonstrated by the 90 dB figure which it provides when used as a product detector. However, to achieve maximum carrier suppression as a balanced modulator, the levels of carrier and audio supplied at the inputs must be carefully set to within prescribed limits. Recommended signal levels for the MC1496, under the three utilized functions, are given in table 1. For obvious reasons no figure is given for the ssb the vfo

The only change from W2YM's original plans, apart from greatly reduced enclosure size, was the coil/tuning capacitor combination. I used a ceramic, slug-tuned surplus coil form and have found it to offer very slight upward frequency drift.
without temperature compensation. However, a few picofarads in parallel with a +650 temperature coefficient served to stabilize the drift. This determination is best done with a digital counter, over a period of several days. The value needed depends upon the physical characteristics of the inductor you use, but this is open to considerable latitude of design. My vfo was designed to give a 500-kHz tuning range, from 5.5 to 5.0 MHz, but the vfo could just as easily be designed to cover a smaller range if access to the whole band is not desired.

One of the later modifications I'm keeping in mind is the possibility of putting the rig on 20 meters, which would require the full 500-kHz vfo spread. (i.e., 9.0 MHz minus 5.0 MHz = 4.0 MHz; 9.0 MHz minus 5.5 = 3.5 MHz, and 9.0 MHz plus 5.0 MHz = 14.0 MHz; 9.0 MHz plus 5.5 MHz = 14.5 MHz.) To put the rig on 40 meters would require an extra converter stage.

balanced modulator

The Motorola MC1596G IC was used as the balanced modulator because the MC1496 was not commercially available at the time I built the circuit shown in fig. 3. The speech compressor and balanced modulator circuits were etched on a small printed-circuit board 2½-inches square. Care was taken to provide shielding between this module and all others, particularly the carrier oscillator.

Both the balanced modulator and carrier oscillator were shielded on all six sides. Rf chokes and feedthrough capacitors were placed in all B+ and relay leads in and out of the shielded compartment. Carrier balance and microphone gain controls were brought out to the front panel with leads no more than 0.75-inch long.

The speech compressor circuit, fig. 4, is built on the same PC board as the balanced modulator. This ingenious little circuit was designed by Basil Barnes, VE6BB, and works very well. The B+ supply to the speech compressor is isolated from the balanced modulator with a series-connected 280-ohm resistor and 0.1-μF bypass capacitor.
All parts for the double-balanced mixer shown in fig. 5, including the MC1496G IC were mounted on a small PC board. The board was mounted on the chassis so the 50k balance adjustment up the 1.5 dB insertion loss to the filter and the overall circuit has approximately unity gain (see fig. 7). The only caution is that it is necessary for good suppression that the input electronics not be able to

potentiometer could be reached through a ¼-inch access hole in the chassis.

The product detector (see fig. 6) needs no adjustment and was built on a small PC board which was mounted in a Mini-box installed on top of the main chassis. Carrier injection to the product detector is through a 52-pF capacitor. Signal output to the audio stage is through a 0.47-µF disc capacitor. (As with the other building blocks in the rig, the value of the coupling capacitor must be determined experimentally for best performance.)

crystal filter

Two MPF102 fets were used to make "see" the output electronics, except through the window of the filter. Any stray coupling between the input and output circuitry will undermine the filter’s suppression capability. The filter itself should be mounted so that its metal can presents an rf barrier to the two MPF102s and their associated circuitry. The PC board was made extra large to assure good isolation between the input and the output of the 9-MHz filter.

The carrier oscillator circuit (fig. 8) uses the Snelgrove crystal, and the circuit should be provided to the Snelgrove company when the filter and crystals are ordered. Some carrier level adjustment is
available by adjusting the iron-core, slug-tuned coil, but better adjustment is facilitated by the 30k trim-pot. The trim-pot should be accessible through a hole in the chassis when the shielded compartment is closed up. Rigidity of construction is just as important for this circuit as for the vfo if stable operation is to be obtained.

receiver

A two-stage mosfet rf amplifier was used in the receiver (see fig. 9). Receive sensitivity was determined only by comparing overall performance to the communications receiver I normally use, a Drake R4B. The noise figure of the homebrew receiver was not quite as good as the R4B, but sensitivity seems to be nearly similar. The agc operation of my receiver doesn’t compare too well with the R4B, but this is probably the weakest point in the receiver’s operating characteristics.

The mosfet front end shown in fig. 9 performs about twenty times better than the MPF102 fet I tried earlier. Also, better agc performance is available with the MPF121 mosfets.

The front end is tuned with a dual L1 40 turns no. 30 on ¼" slug-tuned coil form. Antenna winding is 10 turns no. 25 on ground end of same form. Windings are isolated by 3/8" length of plastic sleeving

L2 40 turns no. 30 on ¼" slug-tuned coil form. Input link is 15 turns no. 30 on ground end of gate coil, two windings isolated as with L1
365-pF broadcast variable (remove all but two plates per section). The preselector adjustment offers good selectivity, and the front end is very responsive to a resonant antenna. The simple rf gain control, a 500-ohm potentiometer voltage divider between the antenna and the input to the first stage, works well.

At the present time I am using the simple hang agc circuit shown in fig. 10. The audio input is picked up from the audio stage prior to the volume control. A 2-megohm trim-pot provides agc voltage control.

A superior agc system is illustrated in fig. 11. This agc system, originally described by DL6WD\(^3\) uses a single RCA CA3035 IC. With this agc system the input signal is taken from the unused differential output of the MC1496 product detector at pin 6 through an appropriate coupling capacitor. With this system, the discrete audio output stage can be replaced by an IC such as the Motorola MFC9020 2-watt audio IC for superior audio performance.

Atmospheric noise was reduced dramatically by adding a small amount of i-f gain. A two-stage fet i-f stage with 9-MHz tuned circuit in the input gate and 1-mH rf chokes in both drains gave better performance with either 25- or 100 kHz markers. A momentary-contact pushbutton, S1, activates the circuit by completing the source circuit of the fet. Two inexpensive \(\mu\)L923 J-K flip-flops were used to divide the 100-kHz crystal frequency. The 20-pF trimmer is adjusted to zero beat the 100-kHz crystal signal against a receiver tuned to WWV.

**i-f amplifier**

As I mentioned earlier, the original plan was to use an effective i-f gain of unity. However, I found that product detector performance was enhanced tremendously by adding a small amount of i-f gain. A two-stage fet i-f stage with one 9-MHz tuned circuit in the input gate and 1-mH rf chokes in both drains gave better performance.

---

**marker generator**

The circuit for a very useful crystal-controlled frequency marker is shown in fig. 12. This circuit, which is similar to the circuit used in the Drake R4B receiver, provides front-panel control of the 100-kHz crystal frequency. The 20-pF trimmer is adjusted to zero beat the 100-kHz crystal signal against a receiver tuned to WWV.
performance than the circuit shown in fig. 13, which I used, but due to space considerations this postage-stamp sized circuit was installed until such time as an IC can be put in its place.

![Circuit Diagram](image)

**fig. 12.** Crystal marker generator provides 25- and 100-kHz markers.

A good candidate for this job is the Motorola MC1350P, which, without any tuned circuits, can provide 35 dB gain. The MC1350P i-f circuit shown in fig. 14 was found to offer excellent performance with the presettable gain control connected to the agc input of the IC. It would be difficult to incorporate the device's agc input into the receiver agc system due to the low impedance of the IC. However, i-f stage agc would not offer any special merit anyway, because the MC1350P does not add seriously to receiver noise at the moderate gain level at which it is used.

It is hardly necessary to include data on the audio output amplifier (fig. 15) except to mention that it is handy to have one of the speaker leads at ground potential, not always a feature of IC amplifiers. With a grounded speaker system, a two-circuit headphone jack can be used to switch the output.

**transmitter**

A simple two-stage fixed tuned amplifier with two MPF102 fets is used for the transmitter buffer circuit shown in fig. 16. Depending on the frequency range which is used, these two stages, as well as the pre-driver buffer in the next circuit block, can be stagger tuned, leaving only the collector of the final power amplifier which must be tuned from the front panel.

Alternately, if access to the entire 80-meter band is desired, the tuned circuit may be tuned with a ganged variable capacitor which is brought out through the front panel. Since the transmitter buffer has relatively high gain, care must be taken to isolate the input from the output.

There have been a number of solid-state transmitting circuits published in the past, but most have been designed for low-power CW, so they are not suitable for linear ssb operation. When working with the circuit shown in fig. 17 I gained...
considerable insight from W3TLN's experience with biasing QRP transistor finals to obtain linear operation. Other articles contributed to the circuit I eventually used, but since base bias current is the crucial factor when using transistors in a linear amplifier, my own improvement was to add zener regulation to the bias voltage supply.

The 36-volt zener in the collector circuit clips any peaks beyond that voltage. The value of the capacitor, C1, is adjusted experimentally to resonate L1 at the desired center-band frequency, and falls in the range from 100 to 330 pF. The 20k trim-pot is adjusted for 5 to 8 mA of idling collector current.

Later, I added a 10-watt linear to the rig which is easily driven by the 1.5-watt stage. The circuit is shown in fig. 18. This mounted on 1-inch ceramic standoffs with a small PC board mounted on the other end of the standoffs. The SE9081 could easily be driven to 2 to 2.5 amps of collector current (24 to 30 watts input), but running the device at a cool 10 watts input provides a good safety factor so the rig can be operated safely for a moment or two with a mismatched antenna load. The 20k trim-pot is adjusted for 8 mA of idling collector current.

power supply

For portable operation, I use a 7 amp/hour rechargeable lead-acid motorcycle battery. This provides a very stable supply voltage over extended operating conditions. For mobile operating I plug a cord into the car's cigarette lighter. The rig requires about 150 mA on receive, and 1.5 amps on transmit. The high transmit current drain is due, in part, to the number of 12-volt relays which are used for the transmit-receive switching.

construction techniques

From my point of view, the average experienced amateur homebrewer is not looking for Heathkit-style plans before undertaking a new project. Physical dimensions and chassis layouts are, in my view, quite unnecessary for the average home-brewer. The only crucial data are the details on the electronics, and those
physical matters which affect electronic functioning, such as shielding.

The circuits used for this rig were adapted and borrowed from a variety of sources. Usually, however, only the

schematic was utilized, and the physical form of construction was determined solely by electronic requirements and available materials. For example, the vfo, which is electronically almost exactly the one designed by W2YM, was built in a small metal box and works perfectly. The original plan calls for a much larger enclosure with front panel measuring 7 by 10 inches.

The rig was built around a Hammond aluminum chassis (3 x 8 x 16 inches). The front panel is 16-inches wide by 6¾-inches high. Actually, the whole rig could be built in about 2/3 this space, and for the sub-miniature minded, this should be kept in mind. But then, layout is non-critical when using the modular building-blocks technique, as each block is interconnected by RG-174/U coaxial
cable and the blocks adjacent electronically may be located at opposite ends of the enclosure physically, provided adequate shielding is used.

Stability, of course, requires that the

vfo and carrier oscillator be constructed as rigidly as possible so that physical stress on the cabinet itself produces the minimum corresponding frequency change.

All circuits were built on single-sided

fig. 17. Circuit for the driver and 1.5 watt final (linear) amplifier. The 2N3053 power transistor requires a small heat sink for proper cooling. The 20k trim-pot sets collector idle current so the transistor operates as a linear amplifier.

fig. 16. Two-stage transmitter buffer circuit is stagger tuned to cover the Canadian phone band (first stage tuned to 3.6 MHz, second stage to 3.8 MHz).
epoxy printed-circuit boards, and these are mounted by one or two threaded metal standoffs. It would be possible to build the entire rig on only a few larger boards. However, the point of the build-
general-coverage receiver (ssb) capable of tuning the 5.5 to 5.0 MHz and 8998.5 to 9001.5 kHz range. The more accurate the receiver, the more precisely carrier suppression can be set, and desired filter

![fig. 18. Ten-watt linear amplifier. Idle current is set by 20k trim-pot. RFC3 is home-made, to carry 1 amp; see text.](image)

C1 165-pF variable in parallel with 100-
to 330-pF fixed ceramic
L1 34 turns no. 19 on Amidon T-80-2

RFCl 94 turns no. 31 on Amidon T-50-2
toroid core
RFCl 2 ferrite beads on no. 19 wire, close
to SE9081 socket
RFC3 67 turns no. 22 enameled on Ami-
don T-50-2 toroid core

ing-block approach is to permit maximum flexibility for later changes and PC boards do not lend themselves to later modification, except in the sense of replacement of the board itself.

test equipment

A vtvm with rf probe is required to determine appropriate signal levels between the various blocks of the rig. The other necessary tool is a good quality

action obtained. Of course, the use of a digital frequency counter makes things a lot easier, especially when constructing the vfo. The vfo could be set up by the use of a general-coverage receiver, but there would be two drawbacks to this: first, the resultant vfo calibrations would be limited to the accuracy of the receiver, and secondly, it would be impossible to determine and correct drift problems.

references
When I encouraged my wife and daughter to become hams, they took over my receiver and transmitter, which were equipped with outboard converters for six and two meters. This situation left me without means for chasing DX on 20 meters, so some changes were in order. The all-mode companion receiver described here was designed and built for use with vhf converters so I could retrieve my receiver, an R4A, for DX work.

features

The all-mode companion receiver uses solid-state devices available on the surplus market. Most are available from advertisers in the amateur magazines. Construction is not difficult for amateurs who like to build their own equipment. Substitution of ICs and diodes can be made easily. All transistors should be npn silicon devices that work up to 50 MHz. The fets, however, should be those shown, which are also available from surplus sources.

The receiver uses a reciprocating detector. This circuit works extremely well as an fm discriminator and as a synchro-
A narrow filter in the circuit helps provide impulse noise suppression.

design development

The two converters in use at my station require an input frequency of 14-18 MHz for their i-f strips, so the first mixer operates within this range (fig. 1). The second converter input is 1.5 MHz and output is 500 kHz. Why 500 kHz? That's easy. I had three mechanical filters designed for a 51J4 - 0.2 Hz, 2.8 kHz and 500 kHz and WCC, WSL, and many other coastal stations were heard very strongly. Not a trace of these signals was detected on any of the four receivers, which were operating simultaneously.

A comparison of the internal shielding of the three Collins receivers indicated almost identical construction. Lead dress and bottom plates were arranged to inhibit coupling of external signals. The all-mode set uses quite a bit of decoupling and extremely tight shielding, which accounts for its very good rejection of signals on 500 kHz. The first conversion i-f at 1.5 MHz performs just as well for

6 kHz were the bandwidths - nice for CW/ssb and maybe a little sharp for fm, but okay for a-m, so these goodies were included in the design.

The question of signal leakage from coastal and maritime stations, which use 500 kHz as a calling frequency, was resolved by comparing the completed all-mode companion receiver with three other very fine receivers that use 500-kHz i-fs: a Collins 51J4, a 51S1, and a military version of the 51J4 known as an R-388/URR. The three Collins receivers were connected to a common antenna along with the all-mode job and tuned to 14 MHz. A BC453 receiver was tuned up the same reasons. If the coax cables described are used to couple one unit to the other, and good shielding is used, no problem should be encountered with feed-through interference.

construction

This article was prepared with the serious builder in mind. I've tried to give construction tips and guidelines for those who enjoy constructing radio equipment. You are urged to consult the material listed in the references at the end of the article, which I've chosen to provide further information on working with PC boards and toroid inductors.
The receiver is built on a 6 x 6 x 2½-inch aluminum chassis, which was fitted with a panel and side brackets. The first conversion section (fig. 2) is constructed on a piece of epoxy copper-clad board, which was drilled and fitted with flea clips to support the mosfet RCA 40673 and its input circuits and the coil for the first local oscillator. An MPF102 fet, which serves as the transistor for the tunable oscillator, is also mounted on this board.

When winding the oscillator toroid, first wind the wire on a match stick, which serves as a bobbin and can be passed easily through the core center. Pull the wire as tight as possible. Anchor the wire endings with small pieces of tape, then dope the windings into place.

The tunable oscillator main capacitor is a surplus unit. It was used in a LM or BC221 frequency meter and bears the inscription Cardwell BC11-71-48. It has an excellent loaded gear train and an extension on its main shaft, which allows a dial-cable pulley to be added. The dial-cable pulley assembly was fashioned on the front panel to accommodate a slide-rule dial with a large calibration area. A piece of graph paper provides the dial division marks, which are calibrated by pencilling in the main divisions.

The oscillator/mixer assembly is mounted in a Zero box.* The box cover is mounted to the main chassis. All component supports and the two tuning capacitors are mounted on stiff brackets; their shafts extend through slots cut into the box. Aluminum deep-drawn boxes are used as shields and compartments throughout the receiver. These boxes

* Zero Manufacturing Company, 288 Main Street, Monson, Massachusetts 01057.


first converter

The first conversion i-f transformer is located on the same board with the components described above. The input circuit to the first mixer, which allows either of the converters to be switched in, is a coupling link to allow low input impedances of the vhf converters to match this input. A shaft extends through the front panel so that the input circuit can be peaked across the 14-18 MHz band. The first mixer output coil is link coupled to the second mixer input through a short length of coax.

The possibility of coil interaction is remote, but care should be used in mounting each coil, particularly the oscillator coil, since movement of any parts will cause frequency instability.
provide rf-tight shielding, which is essential. Sheet-metal screws are used to secure box covers.

If you wish to use a different dial and main tuning capacitor, choose a variable capacitor with double bearings. A Miller 2101 capacitor can be used as a substitute for the unit used in this construction. A dial with a gear reduction may be used in place of the slide-rule dial described here.

**second converter**

The second converter (fig. 3) is almost a duplicate of the first.* It uses 1.5 MHz as its input frequency. The input to this circuit is fed through a phone jack, which connects to a low-impedance link to the mixer input coil. A short piece of coax connects the first and second converters through this jack.

The second mixer also uses an RCA 40673. The second oscillator is crystal controlled and uses the divider method to generate the local oscillator signal.2,3 The output of a 2-MHz crystal oscillator is fed into one-half of a 7473 flip-flop, which operates as a frequency divider to provide a 1-MHz signal. The output of the crystal oscillator at 2 MHz, or the 1-MHz output from the divider, is filtered through tuned circuits. Either of the two filtered outputs is presented to the mixer by a selector switch, which allows the lower or upper sideband to appear in the mixer output, which is 500 kHz. If a lower i-f, say 455 kHz is desired, a different crystal oscillator frequency must be chosen, which would be 1955 kHz for the upper sideband and 1045 kHz for the lower sideband. These outputs are the second converter local oscillator frequencies.

The second oscillator and divider are constructed on a piece of copper-clad epoxy board. The crystal oscillator, its tuned output circuit, and the frequency divider are also constructed on a piece of copper-clad epoxy board. Flea clips are used to mount all parts including the 7473 IC.

A Vector pad drill,† used in conjunction with a small drill that is used to cut a pilot hole for the pad drill, is a commercial version of a device described in an earlier *Ham Radio* article on the construction of instant printed circuits.4 These tools can be used to cut out copper pads in copper-clad board so that terminals can be fastened to them for easy mounting of components. This technique was employed throughout the entire construction of this project and is highly recommended.

The second LO board is mounted on 4%-inch standoff bushings within the cover of a 2½ x 1½-inch Zero box cover. The cover is mounted on the chassis to the right of the first converter box. Clearance holes through the bottom of the box and the main chassis allow connection to the upper or lower sideband selector switch. The second conversion input transformer, the mixer fet, and the two oscillator filters are in the same shield box. The output of the mixer is fed to a Millen 61455 i-f transformer, which is retuned to 500 kHz by replacing the capacitors presently installed in parallel with the primary and secondary coil with two 100 pF mica capacitors. This transformer, located to one side of the second-conversion mixer shield, provides the signal for the mechanical filters mounted below the chassis directly under the first converter box. This construction allows short leads from the band-width selector switch, SW1, to the filters. A single-stage transistor amplifier is mounted on the back of SW1. This amplifier compensates for filter losses and transforms the filter output impedance to match the two-stage i-f amplifier.

**i-f amplifier**

The ICs for the i-f amplifier are Motorola 1550Gs. A Millen 61455 i-f transformer, retuned to 500 kHz, is used as an interstage transformer. The output i-f transformer is a toroid. All these components are mounted in a third Zero box in the same manner as the second converter. Amplifier output is by means of a small length of coax to the detector compart-

*†A complete parts list is available from *Ham Radio* for $1.00 and a self-addressed stamped envelope.

†Vector pad cutting tool no. 116.
fig. 3. Schematic of 500-kHz i-f strip. L2: 74 turns no. 32E on Amidon T-144-15 core. L1: add 6 turns no. 32E over L2. T3A, T3B, T3FM: primary 14 turns no. 34E; secondary 92 turns no. 34E. All three coils wound on Amidon T-144-15 core. T4: Miller 12W1 i-f transformer.
ment on the bottom left front of the main chassis.

The second detector is a reciprocating detector. This circuit does not require a bfo. It synthesizes a reference signal from the received signal, which serves as a beat-oscillator signal. The reference level is proportional to the average signal received. The circuit does not contain the background hiss prevalent in bfos used with conventional detectors. Further low-noise improvement is due to a nar-
rowband filter employed in the circuit that extracts the reference signal.

A recent investigation on fm, revealed that the reciprocating detector is a satisfactory fm discriminator. As a discriminator it makes its introduction in this unit, which makes possible an all-mode receiving system. By adding a tuned circuit to the components used in the reciprocating detector, it's possible by means of a switch to extract the sum instead of the difference frequency of the output. Suppression of any tendency toward positive feedback and a 90-degree phase shift produces essentially a conventional fm discriminator. In our unit (fig. 3) the tuned circuits are designated T3B for a-m, ssb, and CW and T3FM for fm.

All detector components are on a piece of epoxy board, which is mounted on %-inch bushings fastened to the main chassis next to the mode selector switch. A shield for the detector circuits, made of a 1% x 2 x 3-inch box with a removable cover, is mounted over the epoxy board.

Agc voltage is extracted from the reference emitter-follower output in the reciprocating detector, rectified, and applied to an agc amplifier, which assures a wide range of control. An S-meter output is included, but no meter was mounted on the panel for lack of space. The audio amplifier has enough gain to drive a speaker. The power supply shown in the schematic is adequate for the entire receiver.

alignment and test

Alignment procedure is straightforward. A vtvm, rf probe, and signal generator are required.

First determine that wiring is correct and that coil sense is proper. Begin by applying voltage to the first converter. To determine if the first LO is working, place the vtvm rf probe on the drain and rf choke junction. The rf level will be around 3 volts at the low-frequency end of the oscillator range. It will drop off slightly at the high end. Next adjust range-setting capacitors C7, C8 to about 50% closed.

The main tuning capacitor, C9, should be 95% closed. Tune in the oscillator on a receiver or frequency meter; its frequency should be very near 12.5 MHz. If not, carefully adjust the range setters until the signal is audible in the receiver. Now adjust the main tuning dial until the capacitor is about 75% open, where 16.5 MHz will be audible in the receiver or frequency meter.

With dc applied to the second converter and with the vtvm rf probe connected to the arm of the sideband selector switch at the junction of the 15-pF capacitor, determine that the 2-MHz crystal is oscillating by placing the switch in the upper sideband position. Approximately 3 volts will be available here and nearly the same on lower sideband position if T4 is correctly resonated. If not, tune the primary side first, then the secondary for maximum output as indicated on the vtvm.

Switching between U or L should indicate about the same voltage level. These two frequencies will be 2.0 MHz for U and 1 MHz for L. Place the rf probe on terminal 2 of T1, place the sideband selector switch on U, apply a weak 1.5-MHz signal input to J1, and adjust T1 primary for maximum on the voltmeter via the rf probe. Move the probe to the junction of the 3.3k resistor and the arm of SW1A, adjust T1 secondary for maximum and repeak the primary. The transformer coupling should be adjusted to mid position. Now move the rf probe to terminal 6 of U1 and place filter selector switch SW1A, SW1B to no. 3 position, which puts the 6 kHz mechanical filter into the circuit.

Move the probe to pin 6 of U2, adjust the primary coupling of T2 to midway, then adjust the primary and secondary of T2 to midway, then adjust the primary and secondary of T2 for maximum on the vtvm. Adjust C20A of T3A for maximum. Move the probe to the high side of the output link of this transformer, and note that output exists at a 1½ times decrease in level.

With the rf probe still in the same position, move the bandwidth selector to the 0.2 kHz position and retune each
adjustment for T3A, T2, and T1 for maximum output in that order. At this point less input signal may be required. Decouple the signal generator to a level that ensures limiting has not occurred due to over driving. This signal will be approximately 10 microvolts.

Connect the first converter output to the 1.5-MHz input jack. Tune the main tuning dial to the point determined to be 12.5 MHz when the first converter was aligned. Remove the second converter aligned, and we can proceed to the detector alignment. By now some indication of a signal must be evident from the speaker or phones.

detector alignment

With the sideband selector switch in the L position and the mode selector switch in a-m, CW, and ssb (which is the same switch position), connect a vtvm, set to measure dc at a very low voltage, to the emitter of Q8. Disconnect C21 from shield and connect a small piece of wire to the first converter input jack. Adjust the second converter input coil tuning capacitor, C3, for an increase in signal as indicated on the vtvm. The rf probe should still be connected to pin 6 of U2. Now adjust the main trim control on the front panel for a further increase in signal. This signal is at 14 MHz. Each megahertz throughout the 14-18 MHz range can be determined by tuning in the beats with the main tuning control. Replace the Zero box cover and the signal should disappear.

The front-end and i-f stages are now the i-f output. A voltage between 100 and 200 millivolts should appear across the R29, R30 combination.

Transistor Q8 functions as a half-wave rectifier as well as a current source; for maximum dynamic range it should draw a small amount of current even in the absence of a signal. The voltage described, therefore, is the result of the current flow across these two resistors. A too-low voltage will cause distortion or even complete silence at low signal levels; conversely, a too-high biasing current will cause a loss of impulse-noise rejection and synchronous bandwidth.
The narrowband filter used in the reciprocating detector is very simple to construct. A 500-kHz crystal is used. Since the bandwidth must be 500 Hz to the 3-dB points, an inductance could not provide sufficiently high Q, so a combination of inductance and the Q of a quartz crystal is used. The crystal is a surplus HC6. The inductance across the crystal tunes out the crystal capacitance so that a uniform band shape is achieved. The input transformer allows the filter to be driven balanced; its unbalanced output is taken from the top of a 33k termination, which drives an emitter follower to the input of the synchronous switch.

filter alignment

To adjust the filter, turn the receiver off as no power is required for this adjustment. Apply a 500-kHz signal to the emitter of Q4, connect a vtvm rf probe to the output of the filter, which should be disconnected from R39, a 510-ohm resistor. Now adjust C42 for maximum signal and tune through the signal several times to determine that resonance has been achieved. Measure the signal generator rf level and compare it with the filter output level; the ratio of the generator output, $E_g$, divided by the filter output, $E_o$, should be at least 3.5 with the 33k termination in place. The filter bandwidth will be approximately 500 kHz when R38 is 390 ohms.

Reconnect the filter to R39. Reconnect C21, turn on the power, and apply a 14-MHz signal to the converter input jack. A heterodyne will be heard, which will disappear when the main tuning is adjusted through zero beat on this signal. The zero-beat range will have a small area where nothing will be heard; this is the lock in range of the detector. If the beat is not present, reverse the secondary leads of T3A to put the transformer in the correct phase relationship.

final adjustments

To tune up the detector for fm, resonate transformer T3FM to 500 kHz in exactly the same way you adjusted T3A. The exceptions are that the tuning will be a little broad and it is not necessary to plot the $E_g/E_o$ level. The bandwidth will be about 15 kHz.

To adjust the agc and the S-meter amplifier, complete the following procedure: The 14-MHz signal at the converter input must be reduced in level so that it is hardly perceptible. Connect a 0-100 microamp meter to the point marked S-meter in the diagram. The meter should show some indication of noise impulses near its zero point. If such is not the case, adjust R47, a 5k trimpot, until the meter reads zero. Now increase the signal generator output until a 2.8-volt signal is measured at the output of U6, then adjust R48 until the meter is at full-scale deflection.

In my construction this meter was not put on the front panel but is a part of a console, which contains an antenna rotator control. The meter is used to peak signals with a beam, so an external connection is made through a jack at the rear of the receiver.

There’s not much more to be said about this receiver except that it fulfills its requirement with vhf converters and will hold its own with my R4A, which I now happily operate on 20 and 15.

I hope this project will be a useful guide in construction if you too become a DX widower.

references

After trying several circuits for a stable AFSK tone generator, and meeting with various forms of failure, I finally decided to do what I should have done in the first place — use a phase-locked loop function generator, the Signetics 566. This little device puts out both triangle and square waves up to about 1 MHz. The frequency of the 566 is programmable by a resistor (R8), capacitor (C1), and voltage or current at pin 5.

In this application, the AFSK frequency is set to 2125 Hz (mark) by R1-R5 and R10. Then the voltage at the modulation input is changed sufficiently to move the frequency up to space (2295 or 2975 Hz), or to 2225 Hz for narrow-shift CW identification. This is accomplished by feeding the FSK keying voltage from the RTTY terminal unit to a transistor inverter stage which keys the phase-locked loop.

The keying transistor, Q1, is cut off in mark, allowing R1-R5 and R10 to set the frequency. In space, the keying transistor is biased on, pulling current through either R2-R6 or R3, lowering the voltage at pin 5; this raises the output frequency to space. If the key is closed, the frequency is similarly raised through R4 and R7.

Since the ST-5 and ST-6 both have plus and minus power supplies, and the 566 IC is designed to operate that way, the pair are a natural for each other. Although the 566 will operate with up to...
24 volts, this is its maximum rating, so 4.7-volt zeners were used to drop the voltage to the device. The circuit will also work with a single +12 volt supply by grounding the minus terminal, feeding +12 volts to the positive supply, and juggling the frequency-setting resistors.

No problems were experienced with the triangular output voltage, since the bandpass circuits of any rig used with this AFSK generator will remove the high-frequency component of the oscillator.

alignment

To set up the generator, use a frequency counter or well-aligned terminal unit, and follow the following steps:

1. With the terminal unit in mark, or a negative or zero voltage at the keying input and CW key open, adjust R1 for 2125 Hz at the output.

2. With CW key closed, adjust R4 to provide 2225 Hz at the output.

3. With the terminal unit in space, or +10 volts or so at the keying input,

4. With the mode switch at 850 shift, adjust R3 for 2975 Hz at the output.

5. With the rig that will be used, adjust R9 to the proper operating level.

You will note the odd resistor values in the circuit; I used surplus precision resistors for thermal stability. However, carbon resistors would probably suffice. I used 10-turn wirewound pots for the...
adjustable resistors (except level). It might pay to experiment with fixed resistors in parallel with the pots to narrow the adjustment range and alleviate the problem of the pot slider hitting two wires, each of which may be to either side of the desired frequency.

This AFSK generator was designed to use the FSK voltage output of the ST-5 and ST-6. This is -10 volts on mark, and +10 volts on space. I initially used the alternate keying circuit (fig. 2) with the RTTY keyboard itself keying the transistor, but this system didn’t work too well due to the unstable keyboard resistance and the requirement for two separate loop circuits.

I built the generator on perfboard the same size as the ST-6 boards, using copper-foil tape. The layout is not critical, but mount the pots so they can be easily adjusted. My copper-foil layout is very similar to the schematic diagram.

I have used this circuit for over a year and have not had to readjust it after it was set initially. I use this circuit on both vhf fm as AFSK, and on low bands by just feeding the output signal into the microphone jack.

My thanks to Al Crapo for doing the complex math needed to come up with the resistance values and circuitry required. Without that, I would still be diddling with resistor values!

references

*ham radio*
Radio frequency interference (RFI) is often a problem in amateur radio communications. Getting into a neighbor’s TV set or telephone line does little to improve your popularity and on occasion has resulted in fisticuffs. In such cases, diplomacy is the order of the day. Stray signals have even appeared in hi-fi sets having no rf circuits at all!

RFI sources

Let’s say you have an ordinary a-m radio connected to an inverted L antenna. It works fine. Now, take a small diode such as a galena crystal used in a crystal set, or a solid-state diode such as the 1N34, and connect it in series with the antenna. The result will be a mismash and cross-modulation, or RFI. If a signal source is connected to a pure resistive load, and the harmonic content of the source is very low, a signal at the frequency of the generator can be measured (fig. 1). Put a nonlinear impedance such as a diode in series and the result will be sum and difference frequencies. This action is useful in a detector, such as the first detector of a superheterodyne, but it is decidedly not useful in an antenna system. Suggestion: if you use an swr bridge with diodes in the antenna circuit, remove the bridge after making swr measurements. Otherwise, you may generate spurious radiation.

Any corroded joint may, in effect, form a diode and permit rectification and the generation of RFI. (The theoretical principles and mathematics are given in texts such as Everitt’s Communication Engineering.) Even a coax relay can cause such troubles and, in some cases, it’s best to eliminate the relay and connect the transmitter directly to the coaxial line and antenna. The reason for this is that a discontinuity in the relay/line combination can cause reflections and standing waves on the line. When you have standing waves, you have radiation. A sloppy job of fitting a coaxial connector on the line can cause troubles, such as high swr.*

In some older transmitters, the tank circuit LC ratio on the higher frequencies is not what it should be: too much L and not enough C — harmonics tend to be shunted by high C. On the 75-meter band things may be fine; on 10 meters troublesome harmonic radiation, due to an im-

*The braid on RG-8/U coax, for example, leaves much to be desired as an rf shield. Double-braided coax (e.g., RG-9/U) is preferable.
proper LC ratio in the amplifier tank, may occur. In such cases, an antenna that attenuates harmonics is highly desirable. Usually, this will be a sharply tuned resonant antenna (fig. 2), and the addition of an antenna tuner will help. If the system is matched properly, a low-pass filter may help.

**antenna installations**

Coax cable can radiate like a bearcat. If the antenna mast is placed at the side of the house, is hollow, grounded, and the coaxial cable is run inside it, radiation will be reduced greatly. Radiation is then in the horizontal plane, assuming a dipole or beam is used. If a balun is used at the antenna feed point, a better balance and less trouble may be expected. Such an installation may give as much as 30 dB discrimination when referred to the vertical downlead of a TV receiver antenna installation using 300-ohm twin lead. A trap at the TV receiver or a high-pass filter at the TV set will help (fig. 2). It helps public relations if you pay for it, but let a TV serviceman install it. Otherwise, if anything goes wrong with the TV set, you will be the culprit and will be expected to fix it or foot the bill.

The troubles are usually bad on 6 and 10 meters, and sometimes on 15. It can happen on any band, but I think sometimes the reason amateurs use 75 meters so much is because of the relative freedom from RFI on this band. With a-m, you are easily identified. With ssb or CW identification is more difficult, but a mast in your backyard is a dead giveaway. An inconspicuous antenna in crowded communities is highly desirable.

Running coaxial cable in the ground will help reduce stray radiation. The antenna should be sharply tuned and resonant at a single frequency rather than a multi-band type. With the coax shield grounded, the cable tends to act like a low-pass filter. Running the cable in a piece of galvanized pipe will also help reduce RFI (fig. 3).

**power-circuit coupling**

Inside the home, coupling between ordinary lampcords and power wiring

**fig. 1.** A signal source connected to a pure resistive load produces no harmonics. A diode connected in series with the load produces harmonics and harmonics plus cross modulation.

**fig. 2.** Selective circuits in the transmitter output reduce harmonics. A high-pass filter between a TV set and the tuner input is effective in attenuating strong amateur signals at the transmitter fundamental frequency.

**Editor's note:**

Despite the vast improvement in electronic communications equipment design over the past few years, the problem of amateur transmitter interference with home-entertainment devices is still much in evidence. Thanks to the efforts of industry in this country and concerned amateur groups, TVI isn't nearly as serious as it was 20-25 years ago. Today, TVI has been replaced by a bugaboo known as TXI, which includes interference from ham transmitters with equipment such as f-m broadcast receivers, stereo record players, and even hearing aids. Amateur transmitter interference with public telephone equipment is very much a problem. These interference modes may be lumped under an all-inclusive category known as RFI — radio-frequency interference. This article presents some suggestions for handling the problem. WA3NFU doesn't pretend to provide solutions for every type of RFI. Rather, a compendium of basic RFI causes and cures is given; and the knowledgeable amateur, armed with this information, should be able to resolve his particular RFI problem.
should be minimized. Placing the transmitter near a window, and having a short direct run for the antenna cable to the outside of the building, will tend to minimize stray coupling to power circuits. Of course, if the wiring of the outside power system is open, on poles, and not buried, and you radiate toward it from the antenna, the rf will feed right back into the house and may also get into telephone circuits. Installing the antenna on a high mast and using horizontally polarized radiation may help. Since the power wires are horizontal and may run for miles, a vertical antenna may actually be a better RFI solution because of reduced coupling. The base of the vertical can be at ground level, making adjustments and tuning more convenient. Each case is unique and experiments are necessary to find the best solution. Using a vertical ground plane on a mast is likely to be the worst case.

A neglected part of the transmitter installation is the power cord from the transmitter to the electric outlet. Preferably, this cord should have an rf filter and the wiring should be shielded and grounded. A ground may be made to the BX cable in the house wiring and also to a ground rod. A heavy, low-resistance conductor should be used. If the house wiring is old, connections and joints should be examined for corrosion. Corroded joints form diode rectifiers, and you know what that can cause, especially with strong rf currents.

If the transmitter runs high power, switching it on may cause the lamps in lighting fixtures to dim because of poor line-voltage regulation. If this problem occurs with low or medium power, rf may be in the power circuit. If the lamps, especially fluorescents, light without being switched on you’d better check for rf in the power system. If a neon lamp or fluorescent lamp glows when placed near an rf line, the presence of rf and standing waves on the line is assured. Often this means RFI.

transmitter problems

Let’s now examine what is probably the most predominant cause of RFI – the transmitter. The sketches in figs. 4 and 5 illustrate some of the more obvious problems, which are discussed below.

Some amateurs have a habit of not using all the screws when reinstalling a bottom plate or cover of a transmitter. This may reduce shielding effectiveness and cause stray radiation. The screws should be in and reasonably tight. A ground conductor should be run from the ground connection of the transmitter to a solid ground rod buried at least six feet deep, preferably in moist soil. This is important from a safety standpoint as well as for minimizing RFI.

If the antenna and ground system are all right and RFI troubles still persist, the fault may be due to a misadjustment of the transmitter or a defect in it. Over-

![Diagram](image-url)
modulation, for example, can cause a host of troubles. Modulation can be checked on a scope or a simple carrier-shift indicator. If the final amplifier is a class-C stage and is not neutralized properly, RFI may result. How many amateurs check the neutralization? Techniques are covered in the ARRL Handbook and elsewhere. Usually this is the last thing to be done and might well be the first.

If the drive for the final stage is marginal due to poor transmitter design, misadjustment, or a fault in a preceding stage, the final may be struggling so hard that its output waveform is highly distorted. A class-C stage by its very nature is a harmonic generator. Many transmitters use a single-ended final, whereas a push-pull final would help to reduce harmonic output. With a single-ended stage it's especially important that the final be tuned properly. An antenna tuner is a definite advantage since it increases the output circuit selectivity.

Proper LC ratio is also important, not only from the standpoint of tube efficiency, but from the standpoint of reducing harmonic output. With the transmitter output fed to a shielded dummy load, harmonic output can be checked on a receiver or other suitable device.

If you buy the transmitter or transceiver, you're stuck with the original design. However, if you build your own, you can design circuits that will minimize RFI. All the design data is in the ARRL Handbook and numerous other standard texts. At one time, for example, link coupling between rf circuits was widely used. Now the final amplifier is coupled to the antenna circuit through a pi network. This system is simple but not too good from an RFI standpoint. An electrostatic shield placed between primary and secondary circuits eliminates capacitive coupling, but it is difficult to implement.

keying

When CW is used, the tendency to generate RFI is even worse than with a-m or ssb. With CW you have a step-function signal, or transient, similar to a radar pulse. To minimize such interference, key-click filters are highly desirable as well as push-pull final stages.

Grid-block keying uses the keyed tube as a switch. Using a shielded keying relay is effective in RFI reduction. If a low-power keyed oscillator is used, followed by several stages of rf amplification, RFI will be less than if a high-power final is keyed. With the key up, in any case, there should be negligible radiated rf.

filters

In general, a series LC filter should be used where the load impedance is low, such as with a 50-75 ohm receiver input. The high-Z circuit should be used in series with low Z (fig. 6). If the receiver input Z is high, the shunt across it should be low Z. Passive filters may give poor attenuation because of mismatching. A shunt high-Z filter may consist of a small capacitor that bypasses rf at the input to a high-gain audio amplifier. Such a filter will eliminate rf rectification or greatly reduce it. A quarter-wave transmission line, which acts as a short circuit across the input of an rf or af amplifier, is often used.

ham radio
how to use ferrite beads

How to choose ferrite beads so they do the job you intend them to

This is dedicated to those home builders who may have gotten into trouble while using ferrite beads in an attempt to stabilize a troublesome circuit. Many times the problem was not resolved, and occasionally it even got worse when the bead was installed. This has led to a lot of head scratching by the hams involved.

Ferrite beads can be a great aid when they are understood and properly used. This seems to be the problem. Most of us merrily install them in the circuit without being certain of their effect or of what we really expect the bead to do for us. Thus, when the desired signal is greatly attenuated or the undesired one not nearly enough, we try another type bead, more beads (or less), until the circuit seems to be working right. If we can’t make the circuit work, we remove the beads and try other measures; or we live with the original problem.

What has happened? Did we use a bead with too much or too little attenuation, or one having incorrect characteristics for our circuit? All of these must be considered if we expect equipment performance to match our expectations.

bead characteristics

A ferrite bead is not a simple device but a rather complex one consisting of both resistive and reactive elements. In fact, the simple equivalent circuit of the bead shows a resistor in series with an inductance as shown in fig. 1. The impedance of the bead at any frequency is found by solving the equation

\[ Z_b = \sqrt{R^2 + X^2} \]  

(1)

Since you are dealing with reactive devices, they must be handled with care—otherwise you may get into real trouble.

Can a logical plan of action be established to determine how and where to use beads? I think so. Let’s take a typical circuit problem and develop a method for selecting and using the proper bead to do the job. The circuit is shown in fig. 2A.

The source impedance, \( Z_s \), is 50 ohms

\[ -6 \text{ dB} = 20 \log_{10} \left( \frac{50 + 50}{50 + 50 + Z_b} \right) \]

Dividing by 20 gives

\[ -0.3 = \log_{10} \left( \frac{100}{100 + Z_b} \right) \]

Taking the antilog of -0.3, we have

\[ 0.5012 = \frac{100}{100 + Z_b} \]

therefore

\[ 50.12 + 0.5012Z_b = 100 \]

so

\[ Z_b = \frac{(100 \cdot 50.12)}{0.5012} = \frac{49.88}{0.5012} = 100 \text{ ohms} \]
and the load impedance, \( Z_L \), is also 50 ohms. You are experiencing a parasitic oscillation at 100 MHz that is reaching the load. However, it can do no harm if it is reduced by one-half (6 dB). Therefore, you need to add a bead to the circuit that will reduce the undesired signal by this amount. The new circuit is shown in fig. 2B.

**choosing a ferrite bead**

With a ferrite bead in the circuit, circuit losses are increased. Cowdell has shown how to determine this insertion loss by using the ratio of load voltage with \( (v_0) \) and without \( (v_1) \) the new impedance.\(^1\)

Insertion Loss Ratio \((ILR) = \frac{(E_0)}{(E_1)} = \frac{v_0}{v_1} = \frac{(Z_s + Z_L)}{(Z_s + Z_L + Z_b)} \) \( (2) \)

\[
ILR \ (dB) = 20 \log_{10} \left( \frac{(Z_s + Z_L)}{Z_s + Z_L + Z_b} \right) \quad (3)
\]

In fig. 2 \( Z_s = 50 \) ohms, \( Z_L = 50 \) ohms and the desired loss ratio is 6 dB. You are looking for \( Z_b \), the bead impedance to add to the circuit to attenuate the 100 MHz signal by 6 dB.

Solving for \( Z_b \) gives \( -6 \) \( dB = 20 \log_{10} \left( \frac{50 + 50}{50 + 50 + Z_b} \right) = 100 \) ohms.\(^*\)

The task now is to select one or more beads having a total impedance at 100 MHz of approximately 100 ohms.

If the bead characteristics are given in terms of impedance versus frequency, there is no problem. Look at the graph in fig. 3 and see that four beads will present 100 ohms impedance at 100 MHz. Keep in mind that the desired signal will also be reduced somewhat unless it is at a very low frequency.

For example, if the circuit is working at 7 MHz, the graph indicates that one bead has an impedance of 9.5 ohms at that frequency. Hence, the total impedance of four beads would equal 38 ohms. The object is to find a bead (or combination of beads) that will give the desired attenuation of the spurious signal while at the same time giving minimum attenuation to the desired signal.

If the bead characteristics are given in terms of resistance and inductance then you must resort to some elementary mathematics to convert these to impedance values. Looking at fig. 4 you can see that the resistance is 24 ohms at 100 MHz and the inductance is 0.01 \( \mu \)H.

First, solve for \( X_L \). This can be done by using a reactance chart\(^2\) or you may elect to work the problem mathematically. In any case, \( X_L = 6.28 \) ohms; therefore, from eq. 1, \( Z = 25 \) ohms.

Fig. 5 gives the values of resistance and inductance for Ceramag 7D material\(^*\) of a certain bead size. Impedance vs frequency for the same bead is shown in the graph of fig. 3.

For those of you who have come this far, the graph in fig. 4 based on eq. 3 may

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*\( \text{Ceramag Engineering Department, Stackpole Carbon Company, St. Marys, Pennsylvania 15857.} \)
be useful. It allows you to quickly read the impedance required to get bead insertion losses from 1 to 40 dB.

In this graph the source impedance plus load impedance \((Z_S + Z_L)\) was assumed to be 50 ohms. If \(Z_S + Z_L\) equals another value, the bead impedance, \(Z_b\), read along the horizontal axis may correctly be changed the same amount.

For example, if you want the impedance required for an insertion loss of 6 dB in a circuit having \(Z_S + Z_L\) equal to 100 ohms, double the figure of \(Z_b\) at the 6 dB point (50 ohms to 100 ohms). This is because the value used for \(Z_S + Z_L\) in this example (100 ohms) is twice that used for calculating the curve on the chart (50 ohms). If \(Z_S + Z_L\) equals 200 ohms, multiply the \(Z_b\) value by 4.

Suppose you have a circuit with \(Z_S + Z_L = 100\) ohms and want bead attenuation in the circuit of 10 dB. From fig. 4 \(Z_b = 108\) ohms. Double that to 216 ohms which is the value to use for 10-dB signal reduction. Now you can select a bead or combination of beads that will provide 10 dB of rejection at the frequency of interest.

**summary**

To summarize, you must define the problem before deciding what measures to take. First of all, do you have a problem that a bead can solve? If the answer is yes, then how much attenuation is required, and at what frequencies?

fig. 4. Graph of insertion loss ratio (ILR) vs bead impedance for 50-ohm systems \((Z_S + Z_L = 50\) ohms). Graph may be used for other system impedance values by use of a simple factor, see text.

Bead characteristics are then reviewed to determine which ones will give the desired results. It is generally wise to use the smallest size and the fewest in number that will get the job done.

For those readers who may be interested in pursuing the subject of ferrites and ferrite beads, references 1 and 3 through 6 are suggested for additional reading.

**references**


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Two simple electronic keyer circuits based on the new Signetic NE555 timer IC in numerous applications requiring high stability over time periods from microseconds to one hour.

The most interesting feature about the device is its price, currently about a buck. The NE555 consists of a flip-flop controlled by two comparators. The flip-flop drives two outputs. One is the output which is used to control external circuits; the other is used to control charging and discharging current on a timing capacitor. Fig. 1 shows the basic pin connections of the NE555 and external components used for astable multivibrator operation.

operation

Free-running oscillation of the NE555 occurs when pins 2 and 6 are connected and pin 4 voltage is higher than 0.7 V. If the voltage on the capacitor is less than 1/3 Vcc, the comparator connected to the trigger toggles the flip-flop, causing the output, pin 3, to go to logic high, and causing discharge, pin 7, to go to a virtually open circuit. The capacitor now charges from Vcc through Ra and Rb. When the threshold voltage, pin 6, reaches 2/3 Vcc, the second comparator toggles the flip-flop causing the output to go to logic low and discharge to go to
ground. The capacitor now discharges through \( R_b \) to pin 7 until the voltage at pin 2 drops to 1/3 \( V_{cc} \). At that time, the flip-flop retoggles and a new cycle begins: From the Signetics data sheet, the time the output is high is described by

\[
T_{\text{high}} = 0.685(R_a + R_b)C \quad \text{(seconds)}
\]

The time the output is low is

\[
T_{\text{low}} = 0.685(R_b)C \quad \text{(seconds)}
\]

The total time period is

\[
T_{\text{high}} + T_{\text{low}} = 0.685(R_a + 2R_b)C \quad \text{(seconds)}
\]

**Morse code generation**

If the circuit of fig. 1 is constructed with \( R_a \) small compared to \( R_b \), the output will be a square wave of 50% duty cycle. This is the requirement for dots. The only problem with keying the circuit up from quiescent with the available control ports is that the voltage on pin 6 must rise from nearly zero to 2/3 \( V_{cc} \) on the first dot and rise from 1/3 \( V_{cc} \) to 2/3 \( V_{cc} \) on the succeeding dots. Therefore, the first dot is 40 or 50 percent longer than its successors.

The bias arrangement of fig. 2 is used to hold the voltage on pin 6 slightly higher than 1/3 \( V_{cc} \) during rest, allowing it to fall below the required threshold during key down and form an almost perfect first dot.

The control, \( R_2 \), is used to adjust the threshold voltage slightly higher than the internal threshold voltage and allow for the voltage drop of the diode. \( R_2 \) should be approximately equal to the value of \( R_1 \) to allow sufficient adjustment range. \( R_1 \) should be included to limit the current drain on the power supply when the key is closed and \( R_2 \) is inadvertently adjusted to maximum voltage. Diode CR1 is included so that the bias circuitry

![fig. 1. Astable multivibrator circuit using a Signetics NE555 IC.](image)

won't disturb operation of the timer during the charge-discharge cycle.

**Dash-dot ratio**

The generation of dashes can be accomplished by various methods, of which two are described here. The first, which is generally used with digital logic circuits, is to frequency divide the dot pulse train by two and add the results to the dot pulse train as shown in fig. 3. The length of the dash formed by this technique is always equal to three times the length of one dot. The method also provides a dash space equal to one dot-length, which is correct.

This method is used in the solid-state keyer described in the ARRL Radio Amateur Handbook using RTL devices. With a little juggling of components, the more modern and less power-consuming TTL devices can be used. The circuit of fig. 4 results from a desire to minimize parts. The JK flip-flop, a 7470 IC, was selected to perform the dividing because it has a built-in inverting amplifier on one of the J inputs (as well as on one of the K inputs) which allows grounding of, rather
than supplying logic high to, the J input to activate the divider. Adding the flip-flop output and dot output is accomplished by diodes CR2 and CR3.

Closing the dash key grounds the timer control through CR4 and initiates a dot. At the same time the timer is initiated, the J is brought to logic low which readies Q to go high on the rise of the clock pulse. It is important that J be low before the clock pulse goes high. This is normally accomplished by the slight time lag caused by discharge of the timer capacitor, C1, fig. 2, down to the trigger voltage where the output toggles high.

If the bias voltage set by R2 is too close to the trigger voltage, there may be insufficient time between grounding of J and the arrival of a clock pulse. The result is a dot followed by a dash. The remedy is to increase bias voltage by adjustment of R2 until reliable dash operation is accomplished without excessive delay in initiation of characters after key closure.

After the dash starts the key can be opened because Q, in the low state, will keep the timer running through the second dot initiation by virtue of CR5. At the end of the first dot the Q output of U2 is left high. The leading edge of the second dot resets Q low but the dash continues for the duration of the dot. The timer cannot start another dot (or dash) until the time lapse of a space has occurred. Also, a dot cannot be changed into a dash while the clock pulse on U2 is high. Therefore, the keyer is self completing.

**keying speed control**

The speed range of the keyer with the components shown is four to twenty-five words per minute. It may be perferable, to suit the builder, to use values of 250k and 33k for R3 and R4 respectively (fig. 2). This will give a speed range of 6 to 50 wpm. Use a reverse log taper control for R3 if it is available. If not, an audio taper control can be wired backwards (CCW rotation increases speed) to help linearize speed vs shaft rotation.

**variable dot-dash length**

A second keyer circuit which was built to explore the use of logic control circuits and exploit the capabilities of the NE555 timer is shown in fig. 5. In this circuit, when no character is being formed both inputs of gate A are high, forcing the output low. Gate B, wired as an inverter,
has a high output. R1, acting as a voltage divider, places a bias on pin 6 of U2 which prevents the internal flip-flop from toggling, leaving it in its last state which is low on output, pin 3. The low imposed on one of the inputs of gate C forces it high. This high is placed on one of the inputs of gate D. The other input of gate D is also high so the output is low. This latches gate C output high.

When the dot key is closed the output of U2, if it is low, is impressed on one voltage. Since the output of gate C is high, there is very little voltage drop through R2, so pin 7 assumes nearly Vcc potential. The rate of charge is thus dependent on the values of R4 and R3. When the voltage on pin 6 reaches 2/3 Vcc, the flip-flop toggles, causing pin 7 to go to ground and pin 3 to go to logic low. The current through R2 is increased because of grounded pin 7. C2 now discharges through R3 and R4.

If the dot key is still closed, gates A

![Diagram of the Variable dash length keyer circuit.](image)

**fig. 5.** Variable dash length keyer circuit. Relay K1 is a 1A5AH, manufactured by Electronics Application Company, 2213 Edwards Avenue, S. Elmonte, California 91733.

input of gate A, causing its output to go high. Gate B inverts this to a low which allows the bias on pin 2 of U2 to be removed. The charge on C2 is bled through R3 and R4 to pin 7 of U2, which is grounded. When the voltage on pin 2 drops to 1/3 Vcc, the internal flip-flop toggles, opening the ground on pin 7 and presenting a high state to pin 3, the output.

The states of gates A and B reverse but U2 is not affected by the bias change because C2 is charging above the bias and B would have again changed state at the beginning of the space, removing the bias from CR3 and allowing pin 2 to go to 1/3 Vcc, which would restart the cycle and initiate another dot. If the dot key is opened after the dot is initiated, the bias from R1 will remain on CR3 preventing pin 2 of U2 from dropping to 1/3 Vcc and leaving U2 in an off state.

If the output of U2 is low when the dash key is closed one of the inputs of gate A is forced low, which causes the outputs of gate A to go high and gate B

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Variable dot- and dash-length keyer has built-in sidetone monitor. Variable controls in center of front panel control dot and dash length.

to go low. U2 triggers and the output goes high. C1 delays the high signal to the dash paddle for a sufficient length of time to allow gate C to switch low, latching the combination of gates C and D for the duration of the dash. The output of gate C, which is low, causes current flow through R2 and CR1 and a resulting low condition on CR2.

CR2 now charges through R3, R4, R5 and R6 until pin 6 of U2 reaches 2/3 Vcc. At that time the flip-flop toggles, ending the dash and beginning the discharge of C2. C2 discharges through R3, R4 and pin 7 of U2, resulting in the length of the dash being a function of the values of R3, R4, R5 and R6, and the length of the space being a function of the values of R3 and R4.

If the dash key has been kept closed another dash will be initiated at the end of the space when the output goes high. It is impressed on one of the inputs of gate C, latching it for the duration of the second dash. If the dash key is opened after dash initiation, gates C and D will reset when the output of U2 goes low.

adjustment

The standard duration of a dash is three times the duration of a dot. Duration of a space equals that of one dot. Adjustment of the keyer is best accomplished by setting the dot speed first and then the dash length. Close the dot key and count the dots generated in 2½ seconds (or 5 seconds, dividing by 2). This will be close to the words per minute rate. Set R3 to the desired speed. Now, close the dash key and adjust R5 until the number of dashes generated in 5 seconds equals the number of dots generated in 2½ seconds. (One dash plus one space equals 2 dots plus 2 spaces.) The keyer is now set correctly. If, at extremely low or high speeds, it is desired to vary the dot-dash length ratio from the standard to improve readability, controls R3 and R5 can be adjusted to suit the individual operator's taste.

sidetone generator

On either keyer it is desirable to include a tone generator to allow tuning up without keying the transmitter sidetone to allow code practice with the keyer or to simply enable “show and tell” demonstrations. There is nothing exciting about a tone generator, but the one I used in these keyers is about as simple (and cheap) as one can be.

Fig. 6 shows the tone generator circuit using, you guessed it, another NE555 timer. In this circuit, the NE555 is wired as an astable multivibrator (which means oscillator) the same as the dot generator on the keyers. Refer to the operation of U1 on either keyer for description of why it oscillates. The only difference in hook-up is pin 4 of U3. This is a reset pin. Grounding of this pin (less than 0.7 volt) forces pins 7 and 3 to logic low, regardless of what else is going on. When the keyer is making a dot or dash, the reset pin is high and the timer is allowed to cycle and generate a tone. Normally, the

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output of pin 3 would be a square wave but because of reactive loading by the 8-ohm speaker, the output looks like a sloppy sawtooth. However, the resulting tone is satisfactory.

Frequency is adjusted by R1 to suit the user. Since the timing calculations are upset by the speaker load the value of R1 was determined experimentally. R2 is only included to prevent pin 7 from drawing unnecessary current when it is grounded. C2 was included to limit the current which would flow each cycle after the initial voltage rise has thumped the speaker cone and done its job. The value of C2 can be varied to achieve the desired volume level.

construction

I chose to use prepunched, unclad circuit board with holes on 0.1-inch centers. Conductor paths and solder connections were made by combining adhesive backed conductors (Circuit-Stik or equivalent) and bus wire insulated with teflon spaghetti. The integrated circuits were plugged into Molex connectors.

When using this method of construction, first decide on your layout, then stick on the conductors for the IC and other components. When this is done install the Molex connectors and solder them in place. Then break off the tie strip between connectors, install the ICs and start wiring.

The ICs are installed before wiring so the Molex connectors don’t fall out of the perf board when you’re soldering nearby. The tie strip could be left intact until the wiring is finished, but to test for small solder bridges between pins the tie strip must be removed to check for short-circuits with an ohmmeter.

power supply

I prefer a power supply that doesn’t have to be plugged into the wall, does not require recharging or battery replacement, and doesn’t run down when it’s accidently left on—unfortunately, it hasn’t been invented yet. Therefore, I ran one keyer with four penlight batteries and the other with a regulated power supply.
The fixed-ratio keyer was battery powered and ran satisfactorily between 4.5 and 7 volts, the range to be expected from batteries. The bias voltage on U1 was adjusted on the threshold of free running with the speed control set to maximum and supply voltage at the minimum which would operate the relay. This should be around 4.5 to 4.7 volts, depending on the relay and ICs obtained.

The keyer, thus adjusted, has a built-in warning that the battery is getting low. While making a character, current drain is 46 mA with sidetone on, 35 mA with it off. Quiescent current is 27 mA.

I tried a timer circuit which interrupted the power if the keyer was left idle for ten minutes, but it drew valuable battery power and added unnecessary complexity to the keyer. The regulated power supply in fig. 7 is good for up to 200 mA if the transformer and filter capacitor are stout enough. R1 and R2 establish regulated output voltage and the values may have to be determined experimentally. The reason for experimenting is the manufacturing tolerance of an internal voltage reference in the MFC6030. The published specifications state a range of 3.8 to 4.8 volts. Every one of several I have used measured 4.2 volts.

This can be measured by wiring the rectifier and filter circuits, installing C2, and connecting pins 2 and 5 to V+ and ground, respectively. Temporarily connect pins 6 and 3 together and measure the voltage from this connection to ground. This is the internal reference voltage. The supply voltage must be at least three volts above this for the circuit to function properly. In fact, the input voltage for five volts output should be at least eight volts. The maximum is limited by package dissipation of watt. (Volt-

![fig. 7. Regulated 5-volt power supply for the NE555 electronic keyers. Diodes CR1-CR4 are 500 mA, 50 PIV. See text for computing values of R1 and R2.](image)

The formulas for computing R1 and R2 are

\[ R1 = \frac{R2 \times (V_{\text{reg}} - V_{\text{ref}})}{V_{\text{ref}}} \]

\[ R2 = \frac{V_{\text{ref}}}{I_{\text{ref}}} \]

Where \( V_{\text{reg}} \) is the desired regulated voltage, \( V_{\text{ref}} \) is the desired reference voltage on pin 6, and \( I_{\text{ref}} \) is the current flow through R1 and R2 (2 mA minimum).

For example, with a 5-volt regulated output and 4.2-volt reference

\[ R2 = \frac{4.2 \text{ volts}}{2 \text{ mA}} = \frac{2100 \text{ ohms}}{4.2} \]

\[ R1 = \frac{2100 \times (5.0 - 4.2)}{4.2} = 400 \text{ ohms} \]

Since 400 ohms is not a standard value,

*EI Instruments, Inc., 61 First Street, Derby, Connecticut 06418.

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choose the next lower value, 390 ohms. Normal component tolerances should cause no problems. However, the output voltage should be checked to make sure it falls between 4.8 and 5.2 volts.

final comments

Within the pages of this magazine are the means to generate the thrill of discovery in anyone with a little curiosity and even less money. The cost of the parts is certainly nominal; the 7400 quad two input NAND gate cost me 26c, the 7470 JK flip-flop, 42c, and the NE555, 98c. At those prices I'm not afraid of blowing something up. The devices must be pretty sturdy because I make a lot of mistakes and haven't burned up an IC yet. I would recommend, for the sake of spontaneity, the use of a breadboard such as the one manufactured by El Instruments, Inc.* I have wasted a lot of perf board before I got smart. Now I can wire up any of the circuits described here in less than fifteen minutes (including mistake corrections).

I feared that rf would create many problems without shielding and bypassing these circuits. Actually, there was no problem around my equipment with the transmitter on but there was a problem with stray, power-line field-generated voltage, and transients carried by the power line to my home. A large metallic tool held in the hand and touched to the circuitry would trigger the timer. I could not duplicate the condition in the lab where a storage oscilloscope was to be used to track down the method of spurious triggering. The final solution, on my radio bench at least, is to refrain from touching the live circuitry with large metallic tools!

references

2. Signetics Data Sheet, Timer NE555, Signetics, 811 East Arques Avenue, Sunnyvale, California 94086.

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crystal test oscillator and signal generator

This stable crystal test oscillator uses one low-cost IC to provide a stable rf test signal from 1 to 10 MHz about $1.00, but will oscillate with any crystal from approximately 1 MHz to 10 MHz. The basic circuit is stable and has been used with a frequency counter, but slightly smaller capacitor values have been used here to insure that less active crystals will oscillate. The circuit provides 32 pF crystal loading; a small E.F. Johnson variable trimmer capacitor may be used to adjust the crystal to the exact frequency. This capacitor may be omitted if you don’t need this feature.

The circuit is not critical so use the parts you have on hand. It will even oscillate with 450-kHz crystals if the 22-pF series capacitor is increased in value. The variable bias pot is broadly adjustable to compensate for battery voltage.

construction

The oscillator is built inside a 2½ x 2¼ x 12-inch Minibox with crystal sockets submounted so that some shielding is provided by the surrounding box. If the generator were to be primarily used at low output levels, it might be advisable to provide a cover plate over the crystal socket area. Two sockets for HC6U and FT-243 will provide for most types in use today.
The six attenuator pads are constructed with standard resistor values and mounted on dpdt slide switches obtained from Weinschenker.* Shields fabricated from scrap aluminum are closely fitted between switch sections to control leakage across the pads, and the interior coax fitting is shielded to prevent leakage around the assembly.

The inexpensive Japanese 50-microampere meter serves as a battery tester and gives instant indication of crystal activity. The output level may be set for half-scale on the meter to monitor the input to the attenuators.

After construction, my supply of surplus FT-243 crystals was checked and several were rejected. It was found that crystals defective in this checker would not oscillate in tube oscillators either. A few could be salvaged by careful cleaning.

reference

* M. Weinschenker, Box 353, Irwin, Pennsylvania 15642. Slide switches are priced at six for $1.00, dpdt, red or black.
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solid-state
mobile
touch-tone circuit

This all solid-state Touch-Tone circuit provides automatic, mobile fm operation

Since joining the growing crowd of two-meter fm repeater enthusiasts over a year ago, I have observed a variety of telephone Touch-Tone pad interface circuits for connecting the pad to the transmitter. Most have had various features which I felt could be improved upon by an all solid-state version. Thus, I launched the design effort which resulted in the circuit described in this article.

background

One of the better circuits to come to my attention is the one described in an excellent article by W0LPQ. This circuit has several advantages over other Touch-Tone interface circuits commonly in use: automatic keying of transmitter with delayed drop-out, automatic connect-disconnect of Touch-Tone audio output to transmitter audio system, and no transformer or battery required.

It was decided that the new design would incorporate the above features while replacing the relay with an all solid-state circuit. This approach has the advantage of all electronic circuitry (no
moving parts). Total cost of all four transistors is only $1.56.

I also decided to inject the audio signal someplace downstream in the transmitter speech amplifier, instead of at the super-sensitive, high-impedance microphone input. There is adequate signal level available to do this. Making connection to a higher signal level, lower impedance point in the speech amplifier minimizes hum worries and eliminates the level control R1, unity gain amplifier Q2, and on to the transmitter.

Transistor Q3 is a dc switch and Q4 is both a dc and signal path switch. Q1, a Darlington-connected transistor pair in a single package, performs the function of the transmitter push-to-talk switch.

All four transistors are normally off. When any button on the 35A3 Touch-Tone pad is depressed, Q1, Q3 and Q4 become essentially short circuits while

![fig. 1. Schematic diagram of the mobile Touch-Tone circuit. The 5.1k resistor connected between the blue and white/blue leads inside the 35A3 must be removed.]

need for shielded wire to carry the audio signal to the transmitter.

the circuit

Fig. 1 shows the schematic of the Touch-Tone interface. The Touch-Tone pad I used is a Western Electric Model 35A3. All wires on the 35A3 are color coded and the schematic indicates the connections by wire color.

One modification of the 35A3 is required. Remove the 5.1k resistor which is connected to the white and white-blue leads. This is easily located and snipped out.

The green wire is the audio output lead of the 35A3. The signal goes through Q2 is biased on to perform its amplifier function.

The automatic audio disconnect is accomplished by turning transistors Q2 and Q4 off. Under these conditions, essentially an open circuit is presented to the point of signal connection inside the transmitter. Transistor Q3 performs the function of turning Q1 and Q2 on and off. The dc input filter R11-C5 was added to reduce spikes (or ac ripple when operating from an ac supply).

I liked WØ LPQ's automatic keying and delayed drop-out features, and incorporated similar functions in this circuit. This results in the transmitter being keyed automatically when any 35A3 button is

march 1973
depressed. It remains keyed until after the last digit of the phone number is dialed, instead of switching back to receive between each digit. This delay is accomplished by the gradual discharge of C3 through R3, R4, Q2, R5 and Q1 after Q3 is switched off. Resistor R6 limits the turn-on charging current through Q3 to a safe value.

There is nothing critical at all about the circuit, and layout is left to the constructor. In fact, as one who works with rf most of the time, building a noncritical audio circuit is a refreshing change of pace. A printed-circuit is available to those who are interested.* Level control R1 should be a “set it and forget it” control, so it may be an internal screwdriver adjustment.

**connection and checkout**

The dc feedline is connected directly to the automobile electrical system with no voltage regulation or additional filtering beyond that shown in fig. 1. The circuit also functions very well when connected to an ac supply with 1.2 volts peak-to-peak ripple when the transmitter is keyed. If your car is noisy, the value of capacitor C5 may have to be increased.

The lion's share of total current drain is the 16 mA or so drawn by the 35A3 Touch-Tone pad. The remainder of the circuit draws less than 2 mA when on and less than 0.5 mA when off.

The automatic transmitter keying circuit is designed to be connected in parallel with the PTT mike switch in the Regency HR-2A. Before making connection to the PTT line of other rigs, the following must be determined:

1. The PTT circuit must be similar to that shown in fig. 2.

2. The PTT line current must be less than 300 mA with up to 16 Vdc input to the rig.

*Printed-circuit boards are now available from Contact, Inc., 35 West Fairmont, Tempe, Arizona 85281, for $3.00 for the board only, or $11.50 fully wired and tested, plus 25 cents postage and handling. Please direct all correspondence regarding the board to this address and not to the author.
cause the interface circuit to malfunction. To prevent this I bypassed the PTT and dc supply lines inside the HR-2A. This was accomplished by connecting 0.001-pF disc ceramic capacitors between the lines and ground at the point where the lines leave the HR-2A cabinet to go to the Touch-Tone circuit.

The only adjustment is R1. If deviation measuring equipment is available, set it for the deviation specified for your local auto-patch system. Otherwise, set R1 for reliable operation of the patch.

![fig. 2. Push-to-talk circuit for the Regency HR-2A vhf fm transceiver.](image)

circuit variations

The time that the transmitter remains keyed after release of the last button is determined by the capacitance value of C3. To shorten the time, decrease the capacitance; to lengthen it, increase the capacitance.

A temporary disabling mode for the automatic keying feature may be included by adding a switch from the base of Q1 to ground. Closing this switch will prevent automatic keying of the transmitter without affecting the operation of the remainder of the circuit.

acknowledgment

Special thanks are due to Dick Evans, W7BBW, who constructed and field tested the prototype unit.

reference


*ham radio*

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**CAPACITORS**

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<th>Voltage</th>
<th>Quantity</th>
<th>Price</th>
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<td>25 Volts</td>
<td>5 for $1.00</td>
<td></td>
</tr>
<tr>
<td>3 Mfd</td>
<td>6 Volts</td>
<td>5 for $1.00</td>
<td></td>
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<tr>
<td>1000 Mfd</td>
<td>12 Volts</td>
<td>3 for $1.00</td>
<td></td>
</tr>
</tbody>
</table>

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**6.3 Volt 1 Amp Transformer, Fully Shielded** $1.60 Each ppd.
The Heath HW16 transceiver is very popular with many Novice-class hams. However, the HW16 transmitting frequency is crystal controlled, so the owner of this equipment will probably be buying a new rig or a vfo now that the FCC has lifted the crystal-control restriction for the Novice-class licensee.

The HW16 can be easily modified to incorporate vfo capability. This and other desirable features are described, which will enhance the versatility of the HW16. The vfo mod alone will cost about $5, and the options will cost another $9 or so, even if all parts must be bought new.

**modifications**

The modifications are indicated with heavy lines on the block diagram, fig. 1. I believe this is a simple and logical way to receive and transmit on frequencies controlled by the vfo built inside the rig.

The HW16 heterodynes the incoming signal with three oscillator frequencies to produce the audio output when receiving. So let’s up-convert these oscillator frequencies when transmitting and answer that CQ right on frequency! This “reversed double conversion” is accomplish-
ed using the oscillators and tuned circuits already in the HW16 for all bands. The rf signal thus generated is at the frequency to which the receiver is tuned (minus the audio frequency, to be exact). It is then amplified through the three stages of the transmitter.

**construction**

Heavy lines and symbols in the schematic, fig. 2, show all the additions and changes needed for the modification. The transistor mixers work well when their base-current limiting resistors are chosen for the collectors to operate at about +4 Vdc. Other type transistors with equivalent current gain and cutoff frequency should also make good mixers. Power and voltage requirements are extremely low. The mixers and ON switch are on a 1 x

New components are mounted on a Vector board located between V2 and V5. Existing Heath components have been mounted on the other side of the existing circuit board to provide clearance for modifications.
3-inch Vector board mounted between V2 and V5, where existing components have been mounted upside down on the other side of the printed circuit board to clear the area. The change of R24 resistance value is to increase the receiver sensitivity, and the R28 change is to improve oscillation stability of V2B. A frequency change is about ±10 kHz per ±2-pF change of the 6-pF variable capacitor. The switch is placed in NORM position when this mode is not used.

Other optional features are supply voltage regulation for the oscillator tubes to prevent possible chirping and the noise limiter to eliminate key clicks in the side tone. The zener diode shown in the schematic is actually the collector-base portion of a silicon power transistor on a good heat sink. Tube-type voltage regulators and different transistors can be used, but all the parts for the modification are from junk boxes in my case. Tubes (6C86 for Q3 and 6U8 for Q4) were used initially and successfully except for much greater heat dissipation.

small amount of retuning of tank circuits may be necessary.

**other improvements**

Incremental tuning is an optional feature to provide an extra tunable receiving capability around a transmitting frequency, or vice versa. The switch and variable capacitor for incremental tuning are mounted on the front panel — the only externally visible modification. Frequency change is about ±10 kHz per ±2-pF change of the 6-pF variable capacitor. The switch is placed in NORM position when this mode is not used.

Other optional features are supply voltage regulation for the oscillator tubes to prevent possible chirping and the noise limiter to eliminate key clicks in the side tone. The zener diode shown in the schematic is actually the collector-base portion of a silicon power transistor on a good heat sink. Tube-type voltage regulators and different transistors can be used, but all the parts for the modification are from junk boxes in my case. Tubes (6C86 for Q3 and 6U8 for Q4) were used initially and successfully except for much greater heat dissipation.

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WRITE FOR FREE 1973 CATALOGUE

march 1973
tone-burst generator

The tone-burst generator circuit shown in fig. 1 uses a new, low-cost Signetics IC, the NE555. Although this circuit was designed specifically for the HR2 vhf fm transmitter, the circuit could be easily adapted to other vhf fm equipment. The 5-megohm audio pot in the U1 circuit provides a nice scale expansion of burst length in the 0.3- to 1-second range. Tone frequency is controlled by the 25k linear pot in the circuit of U2; output frequency is from approximately 1300 Hz to 2500 Hz.

There are many other circuit possibilities for the new Signetic NE555 IC, including tone generators, timers, repeater control, AFSK modulators, code oscillators, pulse detectors, clock generators and electronic keyers.

Phil Elrod, K4COF

zulu time

Frequently, someone makes a remark over the air when using Z after Greenwich Mean Time, wondering why that letter is used. For many years, the Military services have used letters, except for the letter J (nobody seemed to want Jig Time), to designate time zones. Eastward from Greenwich, the zones are lettered A through M (except J). Westward, the letters N through Y apply.

Thus, within the United States, the following apply for 0000Z (GMT):

<table>
<thead>
<tr>
<th>Time Zone</th>
<th>Time</th>
</tr>
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<tbody>
<tr>
<td>EDST</td>
<td>2000Q</td>
</tr>
<tr>
<td>EST and CDST</td>
<td>1900R</td>
</tr>
<tr>
<td>CST and MDST</td>
<td>1800S</td>
</tr>
<tr>
<td>MST and PDST</td>
<td>1700T</td>
</tr>
<tr>
<td>PST</td>
<td>1600U</td>
</tr>
</tbody>
</table>

Note that M and Y both apply to the zone across the International Date Line; the time is the same, but the date is different. M applies to the west side of the date line whereas Y applies to the east side.

Bill Conklin, K6KA

simple timer

The article in the September, 1972, issue of ham radio, on simple repeater-control timers prompts me to point out a useful integrated circuit which I have used in several construction projects — the Signetics NE555V timer module.

The NE555V is an 8-pin, half DIP package selling for about $1.00 that can be used as a monostable or a stable multivibrator with a timing period from 2 microseconds to an hour. Further applications include missing pulse detection, pulse-width modulation, pulse-position modulation or voltage-controlled multivibrator.

A chief advantage of the NE555V over other IC one-shots is the ease in obtaining long time delays. The 74 series IC one-
shots provide time delays given by $T = 0.32 \text{ RD}$, where $R$ is restricted to 30 to 50 Kilohms. The NE555V provides time delays given by $T = 1.1 \text{ RC}$, where $R$ can be as high as 10 megohms. Thus, with the same RC values, the NE555V gives a supply approximately 9 volts dc. This is connected to an NPN emitter-follower voltage-regulator circuit. A 4-volt zener in the base of this transistor provides a regulated 3.3 volts at the emitter.

The 120-volt loop supply is added by connecting another 6.3-volt transformer back-to-back with the one used in the 3.3-Vdc supply. This provides 110 Vac, isolated from the power line, which is rectified to provide the 120-Vdc loop voltage. A 2500-ohm adjustable resistor permits setting loop current to 60 mA. Two closed-circuit phone jacks are connected in series with the loop supply. With the printer plug in one jack, loop current can be monitored with a milliammeter plugged into the other jack. Local copy can be generated by plugging the keyboard into the second jack and, of course, when the RY generator is active the loop is keyed to give local RY copy.

The clutch circuit is wired in this unit to a normally-closed momentary-contact switch. This provides a steady 60 mA of magnet current which may be keyed by the keyboard for local copy. Depressing the momentary contact switch will cause the loop to be keyed with a stream of RYs until the switch is released.

**RTTY test generator**

The RTTY RY generator described in the March, 1971, issue of *ham radio* can be made into a compact test unit, including a 120-volt loop supply and 3.3 volt Vcc for the generator board, and housed in a 2-1/8 x 3 x 5¾-inch Minibox. The supply for the generator board is obtained by using a 6.3-volt transformer (Radio Shack 273-050) and bridge to

![Circuit Diagram]

fig. 2. Circuit for the RTTY test generator. Diodes CR1-CR5 are 50 PIV, 100-mA diodes. S1 is a normally closed, momentary contact switch. Phone jacks J1 and J2 must be insulated from the chassis.

(factor of three advantage in delay time, while the large allowable resistance provides delays up to an hour.

A word of caution is in order when using large capacitor values. If poor quality capacitors are used, the leakage current should be considered in computing the time delay since it acts as a parallel resistance. I have used 1-meg resistors and 150-microfarad tantalums for 3-minute delays with no problems.

Elmer Mooring, W3CIX

Tom Gibson, W3EAG
The introduction of a new 10-channel 2-meter FM transceiver has been announced by General Aviation Electronics (Genave). The advanced GTX-2 is a lightweight, all-solid-state unit manufactured by a leader in the field of navigation and communications electronics equipment for the aircraft and marine industries. It comes complete with quick disconnect power cable, plug-in microphone, SO-239 antenna connector and mobile mounting bracket, and retails for $249.95.

Push-button frequency selection is a major feature of the innovative GTX-2. It comes equipped with a 146.94 MHz communications channel. The remaining nine channels are available for installation at the factory or by the owner. Crystals are available for $6.50 each.

The high performance capability of the compact and lightweight instrument (5 lbs) is made possible through fully transistorized and integrated circuitry. The extensive use of integrated circuits results in decreased size and weight, and significantly reduced power consumption, while providing maximal power output and reliability. The use of ICs also results in more economical manufacturing processes, which contribute to the extraordinarily low cost of the unit.

The new unit features characteristics usually found only in more expensive radios, including a surprising 30 watts of output power. It is readily adaptable for fixed or mobile operation. A multi-position switch allows setting for long-time low power drain operation. Thus, the radio can be operated for extended periods of time with minimal current usage.

In the receive mode sensitivity is less than 0.5 microvolts for 12 dB SINAD. Images are suppressed more than 45 dB and spurious responses are down more than 50 dB. Selectivity is ±8 kHz. Squelch threshold is 0.5 μV maximum.

The transmitter covers the frequency range from 144 to 148 MHz, and features nominal output power of 30 watts. The output matches standard 50-ohm amateur antennas. Frequency deviation is adjustable to 10 kHz maximum. For more information, write to General Aviation Electronics, Inc., 4141 Kingman Drive, Indianapolis, Indiana 46226, or use check-off on page 94.

Lithic Systems has announced a milestone in monolithic integrated circuits — the world’s first radio transmitter on a chip.

Designated the LP2000 Microtransmitter, the device produces 100 mW pulse modulated, or 50 mW amplitude modulated at 27 MHz from a high stability, regulated monolithic oscillator using external crystal control. A unique transformerless modulating circuit has been created, with buffering between oscillator and modulated output stages. RF output power and power drain are externally controlled. The IC also includes a low-level modulation preamplifier/tone-coding generator, internal power supply regulation, and a latching power supply switch which draws zero power from batteries in the “off” condition.
The circuit operates from +15- down to +3-volt supplies.

Intended applications include hand-held, mobile, airborne and marine two-way radio; remote controls, and short-range telemetry. Small size, low weight and high reliability make it attractive for biomedical monitoring and security alarms.

The LP2000 is available in a 10-pin hermetic TO-100 package. Small quantity distribution to amateurs and experimenters is through Circuit Specialists, P.O. Box 3047, Scottsdale, Arizona 85257. For more information use check-off on page 94.

base-station
colinear antenna

The Antenna Engineering B-series base-station colinear antenna is a triple-skirted design operating with a decoupling ground plane. The antenna consists of seven quarter-wavelengths, and is available for all amateur and commercial frequencies in the 140-175 MHz, 220-225 MHz and 420-470 MHz bands. Unlike many antennas of this type, the B-series antenna is at dc ground for positive lightning protection, and the gamma-type feed is located on the radiating structure for symmetrical current distribution. The feed system will match 25 to 100 ohms for use with various transmission lines.
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and in phased-arrays.

The supporting mast is heavy-wall aluminum alloy, and the radials are spring-tempered stainless steel. A mounting receptacle is provided for 1-inch NPT pipe. The unit is quite rugged for its light weight. Prices range from $39.95 for the 140-175 MHz version to $29.95 for the 420-470 MHz version.

For more information on the B-series base-station colinear, write to Antenna Engineering Company, Inc., Box 19449, Indianapolis, Indiana 46219, or use check-off on page 94.

high-power balun

The new Ultra-Bal 2000 balun from K.E. Electronics is available in either 1:1 or 1:4 ratio models, covers the frequency range from 3 to 30 MHz and features a 2000-watt average power rating. The Ultra-Bal 2000 is weatherproofed by encapsulation in low-loss resin. Unlike other baluns the Ultra-Bal 2000 is totally sealed; there are no drain holes to let moisture enter and cause problems with rf arc-over. The Ultra-Bal 2000 is wound with heavy silver-plated wire for low insertion loss and Teflon-insulated wire provides superior resistance to voltage damage under high swr conditions. The use of Delrin plastic for the center-of-dipole insulator eliminates hardware corrosion, and solid brass output terminals remove dissimilar metal contacts in the amateur antenna system.

The Ultra-Bal 2000 is priced at $8.95 postpaid in the U.S.A., and is supplied complete with instructions, including detailed examples of the various impedance-matching techniques which may be used with the unit. Specify 1:1 or 1:4 impedance ratio. For more information, write to K.E. Electronics, Box 1279, Tustin, California 92680, or use check-off on page 94.
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- 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 2¾"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
- Frequency deviation: adjustable to ±15 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.

$299.95

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

For complete details contact:

R. L. DRAKE COMPANY

AC-10 POWER SUPPLY

for 115 VAC operation

$39.95

540 Richard St., Miamisburg, Ohio 45342
Phone: (513) 866-2421 Telex: 288-017

march 1973
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 5 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 ±.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 • OKLAHOMA CITY, OKLAHOMA 73102

More Details? CHECK-OFF Page 94
**DIGITAL READOUT**

At a price everyone can afford $3.20

- Operates from 5 VDC
- Same as TTL and DTL
- Will last 250,000 hours.

The MiniTron readout is a miniature direct viewed incandescent filament (7-segment) display in a 16-pin DIP with a hermetically sealed front lens. Size, and appearance are very similar to LED readouts. The big difference is in the price. Any color filter can be used.

**POPULAR IC’s**

<table>
<thead>
<tr>
<th>IC</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC1550</td>
<td>Motorola RF amp</td>
<td>$1.80</td>
</tr>
<tr>
<td>CA3020</td>
<td>RCA 1/2 W audio</td>
<td>$3.07</td>
</tr>
<tr>
<td>CA3020A</td>
<td>RCA 1 audio</td>
<td>$3.92</td>
</tr>
<tr>
<td>CA3028A</td>
<td>RCA RF amp</td>
<td>$1.77</td>
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<tr>
<td>CA3001</td>
<td>RCA</td>
<td>$6.66</td>
</tr>
<tr>
<td>MC1306P</td>
<td>Motorola 1/2 W audio</td>
<td>$1.10</td>
</tr>
<tr>
<td>MC1350P</td>
<td>High gain RF amp/IF amp</td>
<td>$1.15</td>
</tr>
<tr>
<td>MC1357P</td>
<td>FM IF amp Quadrature det</td>
<td>$2.25</td>
</tr>
<tr>
<td>MC1496</td>
<td>Hard to find Bal. Mod.</td>
<td>$3.25</td>
</tr>
<tr>
<td>MFC9020</td>
<td>Motorola 2-Watt audio</td>
<td>$2.50</td>
</tr>
<tr>
<td>MFC4010</td>
<td>Multi-purpose wide-band amp</td>
<td>$1.25</td>
</tr>
<tr>
<td>MFC8040</td>
<td>Low noise preamp</td>
<td>$1.50</td>
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<tr>
<td>MC1303P</td>
<td>Dual Stereo preamp</td>
<td>$2.75</td>
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<tr>
<td>MC1304P</td>
<td>FM multiplexer stereo demod</td>
<td>$4.95</td>
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**FET’s**

<table>
<thead>
<tr>
<th>FET</th>
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<tbody>
<tr>
<td>MPF102</td>
<td>$0.60</td>
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<tr>
<td>MPF105/2N5459</td>
<td>$0.96</td>
</tr>
<tr>
<td>MPF107/2N5486</td>
<td>$1.26</td>
</tr>
<tr>
<td>MPF121</td>
<td>$0.85</td>
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<tr>
<td>MFE3007</td>
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<td>40673</td>
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<tr>
<td>3N140</td>
<td>$1.95</td>
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<tr>
<td>3N141</td>
<td>$1.86</td>
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**MOTOROLA DIGITAL**

<table>
<thead>
<tr>
<th>IC</th>
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<tbody>
<tr>
<td>MC724</td>
<td>$1.00</td>
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<tr>
<td>MC788P</td>
<td>$1.00</td>
</tr>
<tr>
<td>MC789P</td>
<td>$1.00</td>
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<tr>
<td>MC790P</td>
<td>$2.00</td>
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<tr>
<td>MC799P</td>
<td>$1.00</td>
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<tr>
<td>MC780/880</td>
<td>$3.00</td>
</tr>
<tr>
<td>MC1013P</td>
<td>$3.25</td>
</tr>
</tbody>
</table>

**INTRODUCING NEW DEVICES AT NEW LOW PRICES**

- LA3018 (replaces CA3018) $1.60
- LA3046 (replaces CA3046) $1.60
- LS370 (replaces LM370) $4.00
- LS1496 (Improved MC1496) $2.00
- LS3028A (replaces CA3028) $1.60
- LP1000 (a new fun-type device to make LED flashers, audio osc, timer, etc.) $1.60

Coming soon the LP2000 Micro-transmitter in a 10-pin IC package.

**NATIONAL DEVICES**

- LM370 AGC/Squelch amp $4.85
- LM373 AM/FM/SSB IF strip/Det $4.85
- LM309K 5V 1A regulator. If you are using TTL you need this one. $3.00

**MOTOROLA TUNING DIODES**

Silicon voltage variable capacitance diodes in TO92 plastic case like plastic transistors. Both standard Motorola and HEP numbers are listed. Capacitance value is typical at -4 VDC. Tuning ratio is approx. 3:1.

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>MV2101/R2500 6.8</td>
<td>pF</td>
<td>$1.10</td>
</tr>
<tr>
<td>MV2103/R2501 10</td>
<td>pF</td>
<td>$1.10</td>
</tr>
<tr>
<td>MV2105/R2502 15</td>
<td>pF</td>
<td>$1.10</td>
</tr>
<tr>
<td>MV2109/R2503 33</td>
<td>pF</td>
<td>$1.10</td>
</tr>
<tr>
<td>MV2112/R2504 56</td>
<td>pF</td>
<td>$1.10</td>
</tr>
<tr>
<td>MV2115/R2505 100</td>
<td>pF</td>
<td>$1.10</td>
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</table>

**MORE RCA IC’s**

<table>
<thead>
<tr>
<th>IC</th>
<th>Description</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>CA3088E</td>
<td>AM rcvr subsystem</td>
<td>$2.50</td>
</tr>
<tr>
<td>CA3089E</td>
<td>FM IF system with circuits for IF amp., Det., AFC, Squelch, &amp; tuning meter</td>
<td>$3.90</td>
</tr>
<tr>
<td>CA3018</td>
<td>Transistor array</td>
<td>$1.55</td>
</tr>
</tbody>
</table>

**NEW FAIRCHILD ECL HIGH SPEED DIGITAL IC’s**

- 9528 Dual “D” FF toggles beyond 160 MHz $4.65
- 9582 Multi-function gate & amplifier $3.15
- 95H90 300 MHz decade counter $16.00
- A 95H90 & 9582 makes an excellent prescaler to extend low frequency counters to VHF or use two 9528s for a 160 MHz prescaler.

Box 3047H, Scottsdale, AZ 85257

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Please add 35¢ for shipping

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SWAN ELECTRONICS offers you superb craftsmanship you can see, feel, and hear. Inside, these units are uniquely designed. Progressive, proven engineering state-of-the-art techniques are enriched by the most practical advanced components available. Externally, Swan has designed these new transceivers to be appreciated by every ham, and the XYL, because it was hams who told us what they wanted. It's all here... up-to-the-minute in styling and convenience... easy to operate.

ENJOY CLEAR, CLEAN TRANSMISSIONS — The finest quality on the air. Signals are strong, stable and easy to read. Select from your choice of 3 models:

| SWAN SS-15 (15 Watts P.E.P.) | $579.00 |
| SWAN SS-100 (100 Watts P.E.P.) | $699.00 |
| SWAN SS-200 (200 Watts P.E.P.) | $779.00 |

ACCESSORIES INCLUDE:

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWAN PS-10 (115V AC power supply for SS-15/SS-100)</td>
<td>$89.00</td>
</tr>
<tr>
<td>SWAN PS-20 (115V AC power supply for SS-200/SS-100/SS-15)</td>
<td>$139.00</td>
</tr>
<tr>
<td>SWAN SS-1200 (1200 Watt P.E.P., tube type, Linear Amplifier)</td>
<td>$299.00</td>
</tr>
<tr>
<td>SWAN SS-208 (External VFO)</td>
<td>$159.00</td>
</tr>
<tr>
<td>SWAN SS-18B (Super Selective Filter)</td>
<td>$79.95</td>
</tr>
<tr>
<td>SWAN 610X (Crystal Controlled Oscillator)</td>
<td>$53.95</td>
</tr>
</tbody>
</table>

Just 10% down is all that is needed, if you use your Swan Credit Service account, to put an all-solid-state rig in your ham shack. Why wait? Order yours now!!
For the most powerful antennas under the sun

Go all the way into the REPEATER

There’s nothing half-way about the new Hy-Gain REPEATER LINE. Designed for the man who demands professional standards in 2 meter mobile equipment, the REPEATER LINE is the 2 meter HAM’s dream come true. It’s got everything you need for top performance…toughness, efficiency and the muscle to gain access to distant repeaters with ease. Reaches more stations, fixed or mobile, direct, without a repeater.

The right antennas for the new FM transceivers…or any 2 meter mobile rig.

Rugged, high riding mobiles. Ready to go where you go, take what you dish out…and deliver every bit of performance your rig is capable of.

261 Commercial duty 1/4 wave, claw mounted roof top whip. Precision tunable to any discrete frequency 108 thru 470 MHz. Complete with 18' of coax and connector. 17-7 ph stainless steel whip.

260 Same as above. Furnished without coax.

262 Rugged, magnetic mount whip. 108 thru 470 MHz. Great for temporary or semi-permanent no-hole installation. Holds secure to 100 mph. Complete with coax and connector. Base matching coil for 52 ohm match. 17-7 ph stainless steel whip.

263 Special no-hole trunk lip mount. 3 db gain. 130 thru 174 MHz. 5/8 wave. Complete with 16' coax. Operates at DC ground. Base matching coil for 52 ohm match. 17-7 ph stainless steel whip.

264 High efficiency, vertically polarized omnidirectional roof top whip. 3 db gain. Perfect 52 ohm match provided by base matching coil with DC ground. Coax and connector furnished.

265 Special magnetic mount. 3 db gain. Performance equal to permanent mounts. Holds at 90 mph plus. 12' of coax and connector. Base matching coil for 52 ohm match. 17-7 ph stainless steel whip. DC ground.

269 Rugged, durable, continuously loaded flexible VHF antenna for portables and walkie talkies. Completely insulated with special vinyl coating. Bends at all angles without breaking or cracking finish. Cannot be accidentally shorted out. Furnished with 5/16-32 base. Fits Motorola HT; Johnson; RCA Personalfone; Federal Sign & Signal; and certain KAAR, Aerotron, Comco and Repco units.
2 meter mobile! with

Top performance for 2 meter mobiles
THE REPEATER LINE
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BOX 5407-WC LINCOLN, NEBRASKA 68505
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GIANT B-7971 NIXIES (2) with 2 sockets and driver board containing hi voltage transistors. Complete plug-in board as removed from operational equipment. Schematics included. Unbelievable but true...just $2.50 for the complete package. #725-10 $2.50

15¢ IC BONANZA
Brand new DTL dual inline (DIP) package, factory marked ceramic type. The price is too good to be true. Fully guaranteed and with specs.
930 Dual 4 input NAND gate similar to 7420
931 Clocked flip flop similar to 74110
932 Dual 4 input Expand Buff similar to 7440
933 Dual 4 input expander similar to 7460
936 Hex Inverter similar to 7405
945 JK Flip Flop similar to 74110
946 Quad 2 input gate similar to 7400
962 Triple 3 input gate similar to 7410 $15¢ each
Buy $100 worth and deduct 10%
24 hour delivery guaranteed

RCA MEMORY CORE STACK $50.00
32x32x9 9 frames with 1024 cores/frame and diode matrix attached. 1024 Memory Area measures only 2x2 inches. Full stack of 9 planes $50.00 only $50.00
1024 Core Memory Frames cut from above core stack $6.00 ea. postpaid.

Please add postage for above.

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MEMORY-MATIC 8000 Deluxe Keyer
The unquestioned leader in the keyer field. Up to 8000 bit easy-to-use memory capacity allows storage of up to eight complete message sequences. More features than you've ever imagined. The contestor's and traffic handler's dream keyer.
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Easy-to-use 500 or 800 bit read/write memory offers complete flexibility to automate your CW station the modern Data Eng. way. Keep up with the winners with this exciting keyer. Send for full details.
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with 800 bit memory $219.50

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The Switchable Keyer. It's up to eight-keyers-in-one. Use the switches to make this your very own personal keyer, both today and tomorrow. Add such features as dot dash memory or adjust spacing with the turn of a switch. Completely versatile, completely perfect with everything you will ever want. Full details in our catalog.
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At last — a popularly priced IC keyer with more features for your dollar than all others in its price range. Fatigue-free sending with clean, crisp CW at all speeds.
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Replace that mechanical key with our new electronic key. Go modern with Feather Touch the electronic key that detects the mere touch of your finger. Develop a truly professional fist.
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adapted to MM-8000 & MM-500B $27.95

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Synchronize your Meteor, Tropo, or Moon Bounce communications with WWV for transmission at 15, 20, 30 and 60 second intervals with this precision Meteoric Scatter Timer.
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FMS-3
The frequency marker that gives you more. Just right for band edge markers for 160 to 10 meter bands.
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Designed specifically for the FM'er. This deluxe frequency standard allows precise calibration of all receive and transmit crystals in the 10, 6, 2 and 1¼ meter FM bands. No more off frequency operation with the FMS-5.
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Specially made for both OLD and NEW receivers. The smallest and most powerful preamp available. Provides 20dB gain to bring in the weakest signals.
Sh. wt. 4 oz. $9.50 kit $12.50 wired

BROADBAND PREAMP
Unable to hear those weak signals? Been missing that rare DX? If so, it's time for our DX "getter". Give your receiver a boost. 1-30 MHz, 36dB gain 160-40 meters, dropping to 19dB on 10 meters.
Sh. wt. 6 oz. $17.95

More Details? CHECK—OFF Page 94

March 1973
144/220 MODULAR RECEIVER KIT

COMPLETE WITH DRILLED BOARD

Companion 1 watt transmitter kit complete, now only $29.95

Complete receiver parts kit including drilled and etched circuit board $59.95. $65.95 with optional ceramic filter. Ten watt power amplifier kit $29.95. Prices do not include crystals. 146.34, 146.52, 146.94, 220.98 or 224.98 receive or transmit crystals $4.00 each. (N. Y. residents add sales tax.)

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PHONE – (305) 686-8553

RESISTORS – 1/2W. Factory Fresh, all standard values, 10% $3.50/100 $5.00/100

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600 OHM CT: 600 OHM CT TRANSFORMER
Miniature Only – 3/8 inch cube @ 1 db 50Hz – 26Khz. 20mw. Good for phone patches and lots of other audio uses, fits inside any phone. Broadcast engineers love this one. 5/$4.95

ROTRAN WHISPER FAN – Brand New, 115V. The quiet one that pays for itself in longer tube life. $10.00

RG-174/U MINI 50 ohm coax – $2.00/100 Ft.

1N4007 1000V, 1A $2.00/10 – $18/100

1N4004 400V, 1A $1.50/10 – $13/100

WRITE FOR FREE SPEC SHEETS! (DEALERS INVITED)

KW BALUN KIT STILL ONLY $5!

The AMIDON Torsoid Balun Kit makes a modern, compact antenna transformer that can be wired for either 4:1 or 1:1 impedance ratio. The balun is ideal for use between a coaxial feedline and a balanced antenna. It reduces coax radiation and properly balances the energy for application to the antenna's feedpoint. The balun also acts as an isolation device and removes the capacity of the coax from the antenna which extends the low SWR frequency range of the array. Baluns made from this kit can be used to advantage on these antenna types Dipole, Quad, Beam, Inverted Vee, Windom and Folded Dipole.

SEND FOR FREE FLYER!

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Active Audio Filters

CW: IC's for Super High Performance

Get razor sharp selectivity
No impedance matching BW (selectable) 100 Hz and 60 Hz Center frequency . . .
F = 750 Hz Skirts 60 db down at 1/2 F and 2F 4 op amps.
24 x 3" PC Board $12.95, wired, tested, guaranteed

LOW PASS:
Resistors set cutoff. 5 to 20 kHz. Set cut off for 2.5 kHz. Input Imp 1M .
Load 2K; Gain = 1 .
Rollof max 48db/oct, min 45 5 op amps, 24 x 3" PC Board $13.95, wired, tested, guaranteed

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MW GUARANTEE WHAT WE SELL!!

We ship UPS whenever possible. Give street address. Include enough for postage, excess refunded in cash. Florida residents include 4% Tax.
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3K-A

COOL AND EASY MAX.
LEGAL POWER • SSB
CW, RTTY or SSTV
THROUGH COMMER-
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30M Hz. • CONTINUOUS
DUTY. • SILVER PLATED
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SERVICE • THE FINEST COMMERCIAL GRADE
AMATEUR LINEAR AMPLIFIER AVAILABLE ANY-
WHERE IN THE WORLD AT ANY PRICE FOR
ONLY $995. THE HENRY 3K-A. THE
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until YOU write or phone us and let
us know the trade in deal YOU WANT.
We usually say yes! NO ONE ANY-
WHERE BEATS OUR DEAL.

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14th year - July 28th - Aug. 10th

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bama, New Hampshire, Iowa, District of Columbia,
Vermont, Arizona, Indiana, Ohio, New Jersey,
New York, Massachusetts, Maryland, Virginia, Illi-
nois, Michigan, Georgia, Kansas, Mississippi, Ne-
braska, Maine, Kentucky, California, New Mexico,
Arkansas, Texas, Wisconsin, Louisiana, Oregon,
Connecticut, Minnesota, Pennsylvania.

OUT OF STATE:
Puerto Rico: Saskatchewan, Canada; Ontario, Can-
da; Quebec, Canada; Granada, Spain; London,
England; Geneva, Switzerland; Netherlands, Ant-
tilles; St. Croix, Virgin Islands.

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Gilvin Roth Y.M.C.A., Elkin, North Carolina 28621
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Address
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THE NEW DELUXE DIGITAL
SYNTHESIZER!! FROM R

MFA-22 DUAL VERSION
Also Available MFA-2 SINGLE VERSION

• Transmit and Receive Operation: All units
have both Simplex and Repeater Modes
• Accurate Frequency Control: .0005% ac-
curacy
• Stable Low Drift Outputs: 20 Hz per degree C typical
• Full 2 Meter Band Coverage: 144.00 to 147.99
MHz in 10 KC steps
• Fast Acting Circuit: 0.15 second typical set-
ing time
• Low Impedance (50 ohm) Outputs: Allow long
cable runs for mobiles
• Low Spurious Output Level: similar to crystal output

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FREE DETAILS
ALSO: PARTS, ETC., BOX 1201H
COMPLETE STATIONS — CHAMPAIGN, ILL.
ALL CHANNELS SYNTH. 61820
**DIGITAL CLOCK KIT**

By Scientific Devices

**$44.00 WITH CASE**

- Smaller & more compact
- 8" x 5 1/2" x 3" case

The lowest price digital clock kit (with cabinet) as far as we can see in U.S.A.

- Includes BCD outputs for use with times.
- Options, may be wired for 12 or 24 hour display.
- Indicates HOURS, MINUTES, SECONDS.

- 3 for $35

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**11 TRANSISTOR PHILCO AM RADIO CHASSIS**

**BUY 2 FOR**

- **STEREO**
  - Mike amplifier
  - 200Ks
  - Tape amplifier
  - 1500 Kca Broadcast band
  - 90-120VDC

Original design for portable phone systems, and tape cassettes!

- One of the most versatile AM Radio and multi-purpose amplifiers we have seen at Poly Paks famous "Economy" price.
- Measures only 4 3/8" x 3 1/4" x 2" high.
- With tuning capacitor, IF circuitry, loopstick, 3 stage switch, AC and phono-mike jacks.
- Separate switch for changing from AM radio to amplifier.
- Uses 110V plug-in adapter (not with unit) and a 9-volt battery. 116VAC. 200 MAH. No dropouts.

- Buy 3 - Take 10%

---

**BURROUGHS 8-DIGIT "UNIVERSAL" NEON READOUTS**

PC Board Included!

- **Only $19.95**
- **WORTH $50.00**

- Designed for use with LSI, digital clocks, calculators, frequency counters, DVM's, & other chronometers.
- Eight individual Burroughs B5750's mounted on a universal 4 1/2" x 2" neon MUX chassis to hold pin outs for digital drivers & segment.
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by K.V.G.

9.0 MHz FILTERS

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency</th>
<th>Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>X9F-A</td>
<td>2.5 kHz</td>
<td>SSB TX</td>
<td>$25.40</td>
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<tr>
<td>X9F-B</td>
<td>2.4 kHz</td>
<td>SSB RX</td>
<td>$36.15</td>
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<tr>
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<td>12.0 kHz</td>
<td>CW</td>
<td>$27.90</td>
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<td>X9F-M</td>
<td>0.5 kHz</td>
<td>CW</td>
<td>$69.50</td>
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<tr>
<td>XL10-M*</td>
<td>0.5 kHz</td>
<td>CW</td>
<td>*10 Pole Gaussian</td>
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</table>

*10 Pole Gaussian

VHF CONVERTERS

<table>
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<tr>
<th>Model</th>
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<th>Price</th>
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<tr>
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<tr>
<td>MM 220</td>
<td>432-436 kHz</td>
<td></td>
</tr>
<tr>
<td>MM 432</td>
<td>COMING</td>
<td></td>
</tr>
<tr>
<td>MM 1296</td>
<td>SOON</td>
<td></td>
</tr>
</tbody>
</table>

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HP150A-10 MHz Scope w/152B 185

HP160B(USM105)-14MHz dual trace scope 385

HP1858-D.C-1.0GHz samp. scope w/186B 335

HP3308-Audio Gen.-50MHz-1.0-10V 75

HP321A-Pulse Gen. var. width and rate 30dB 152

HP330C-Dist. Anal. 20Hz-20kHz 225

HP522B-Freq. Counter-100Hz-200kHz digital 45

HP840-B.Trans. Osc. for counter-to 12GHz 185

HP6108-Sig.Gen.-450-1200MHz, calib. attn. 365

HP686A-Sweep Gen.-8.2-12.4GHz 625

HP803A VHF Imp. Bridge 50-500MHz 195

HP2590B-Phase-locked Acc. 10MHz-400MHz, PARALLEL 12VDC 325

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M26D/HP(HP108B) VTM-to 700 MHz 85

SG24/TRM3 Sweep Gen. 15-4000 MHz CW, AM, FM Xtal markers, scope-Dev. to 20% 395

TS-403A-Sig. Gen. (HP616) 1.5-4GHz 385

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More Details? CHECK—OFF Page 94

76 March 1973
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- 74HC25 $0.25 74HC22 $0.50 74HC53 $0.40 74HC83 $1.15
- 74HC23 $0.25 74HC30 $0.25 74HC54 $0.30 74HC86 $0.65
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**march 1973**

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- All IC's and Transistors plug into sockets on 1 plug-in glass-epoxy circuit board.
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- Built-in power supply for 115 or 220 v., 50/60 Hz.
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<tr>
<th>Frequency</th>
<th>NF</th>
<th>Price</th>
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<tbody>
<tr>
<td>50 MHz</td>
<td>2.0 db</td>
<td>$74.95</td>
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<tr>
<td>144 MHz</td>
<td>2.5 db NF</td>
<td>$74.95</td>
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<td>220 MHz</td>
<td>3.0 db NF</td>
<td>$79.95</td>
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<tr>
<td>432 MHz</td>
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INSTALLED STANDOFF TERMINALS: Teltron, 15 $1.00; Ceramic, 20 @ $1.00; Phenolic, 25 @ $1.00. Teltron pressfit Terminals - standoffs - feedthrus - testjacks - your choice, 50 @ $1.00. 1-10 pf. Ass'd 30c. 11-25 60c. 2670 $1.00. Germanium diodes (1N34 specs) 50 @ $1.00. Postpaid. S.A.S.E. brings component list.

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TH-MIDLAND AMATEUR RADIO CLUB, Midland, Texas, will hold their first Spring Swapfest on Sunday, March 18, 1973. The Swapfest will be preceded by the usual social events the afternoon and evening of March 17th. For details contact WA5HOI.

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1. A slow scan television picture is similar to that projected on TV.
2. Motion can be portrayed on slow scan television.
3. To broadcast slow scan television just add a Robot monitor and camera to your present station. No other equipment is necessary.
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ANSWERS:
1. False. The slow scan television picture is a greenish-yellow color which takes 8 seconds to transmit. Like radar, the image should be viewed in a darkened room for best results. Also like radar, as the picture progresses it has the appearance of being painted onto the screen by a bright writing line except that the line moves from top to bottom. 2. False. Motion results in a blurred picture. 3. True. Robot equipment is compatible with all brands of amateur radio equipment and antenna systems. 4. True. The SSTV signal contains frequencies ranging from 1200 Hz to 2300 Hz. Therefore, it is comparable to an audio signal.

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