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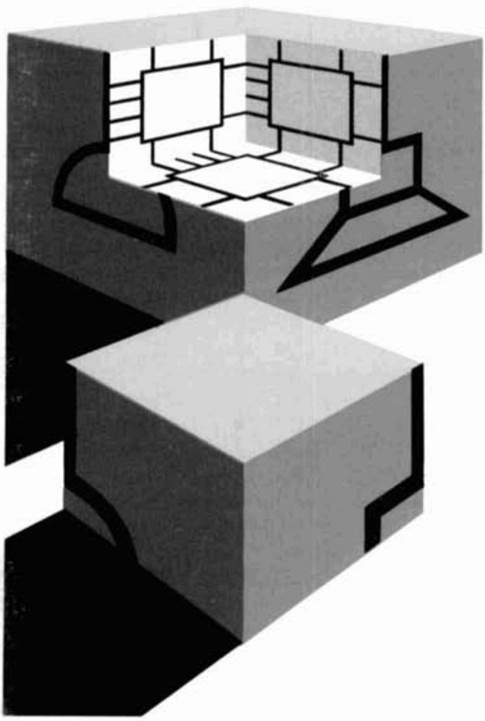
MARCH 1973

solid-state 80-meter SSB TRANSCEIVER



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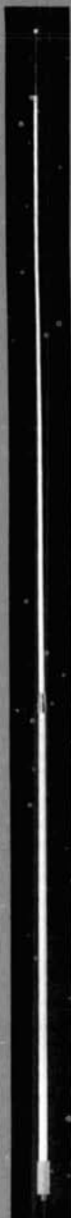

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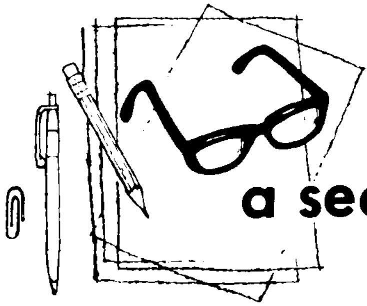

a second look

by jim fisk

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 worthwhile 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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More Details? CHECK—OFF Page 94

solid-state 80-meter ssb transceiver

Complete circuit details for an all solid-state 10-watt ssb transceiver — building-block construction simplifies future circuit revisions

Dave Hembling, VE6ABX, Box 728, Pincher Creek, Alberta, Canada

This single-band 80-meter ssb transceiver was built using a combination of solid-state building-blocks in crucial circuitry, as well as descrete 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-

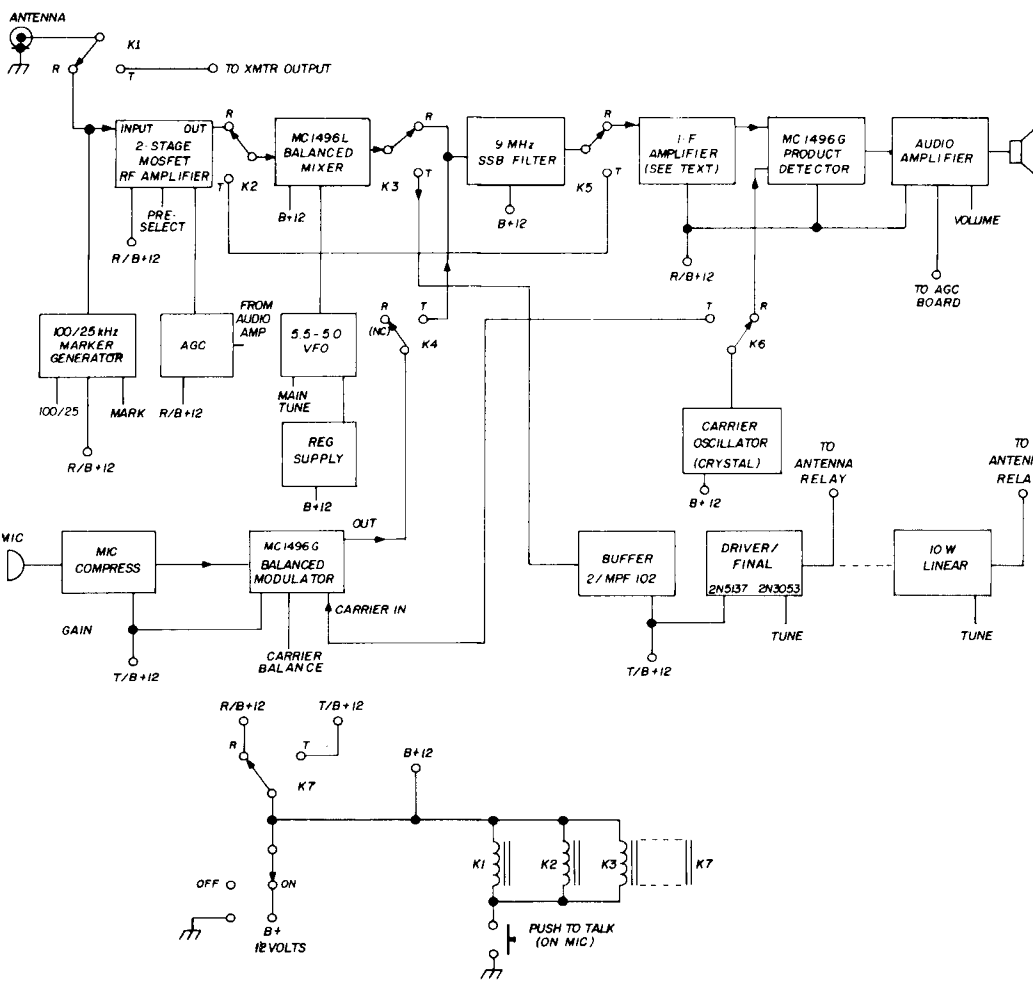


fig. 1. Block diagram of the 80-meter ssb transceiver. Relays are used for the bulk of the transmit-receive switching.

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-

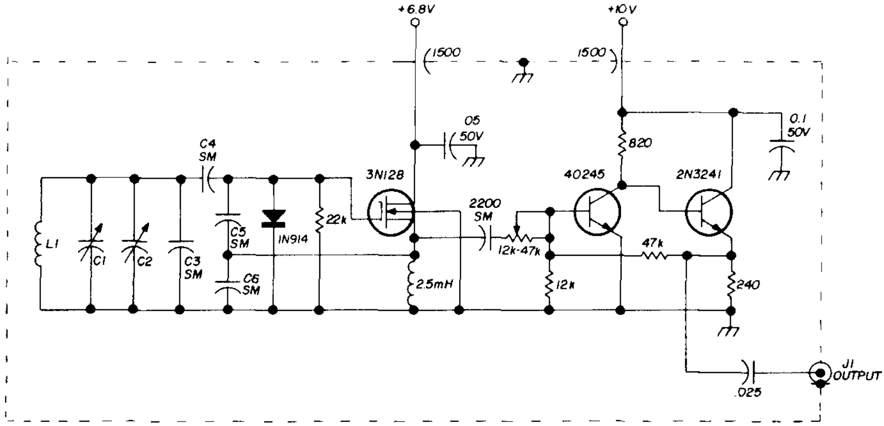
fier which offers exceptionally attractive characteristics as a balanced modulator, double-balanced mixer and product detector. As a balanced modulator, when

*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.



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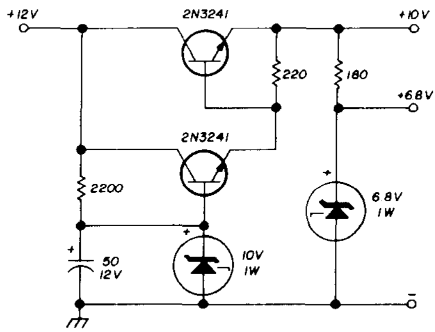


B

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 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 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.

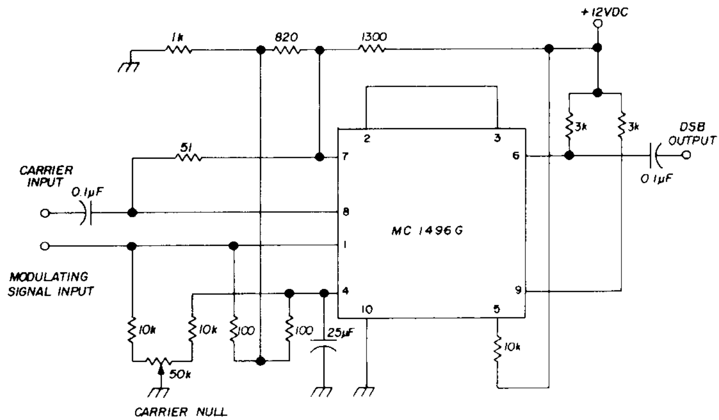


fig. 3. High-performance balanced modulator circuit uses Motorola MC1596 or MC1496 IC.

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 1. Recommended signal levels for the MC1496.

function	input at pin 8	input at pin 1
balanced modulator	carrier oscillator, 60 mV rms	audio, 3 - 300 mV rms
double balanced mixer	vfo 100 mV rms	ssb signal
product detector	carrier oscillator, 300 mV rms	ssb signal

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

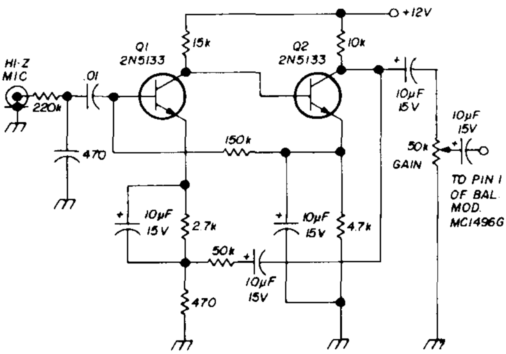


fig. 4. Simple speech compressor circuit designed by VE6BB.

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.

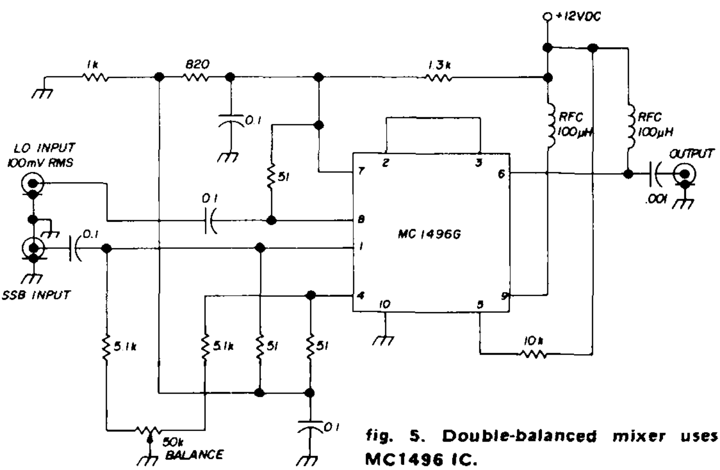


fig. 5. Double-balanced mixer uses MC1496 IC.

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

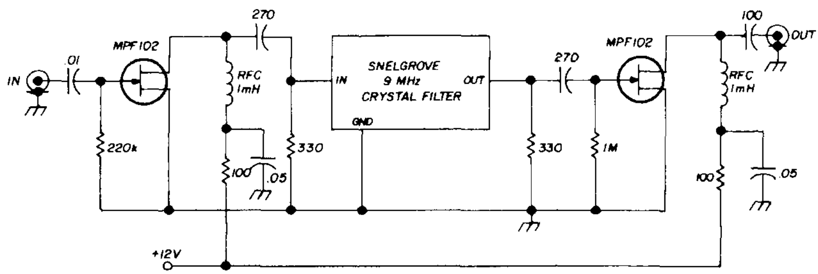


fig. 7. Field-effect transistors are used to match the input and output impedances of the Snelgrove 9-MHz crystal filter. The 1-mH rf chokes are Hammond miniature powdered iron core types; capacitors are 50-volt ceramic discs.

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 Minibox 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

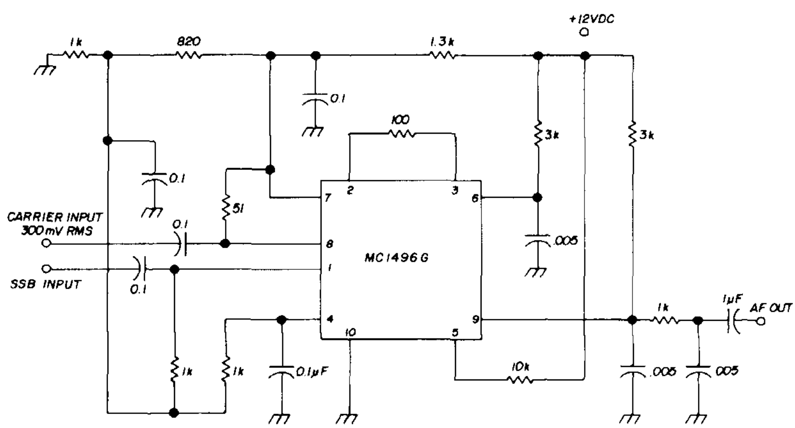


fig. 6. Product detector circuit.

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.

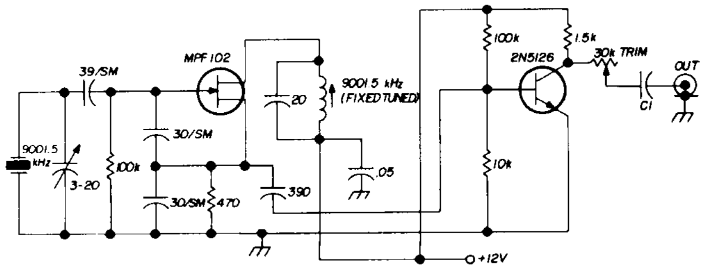


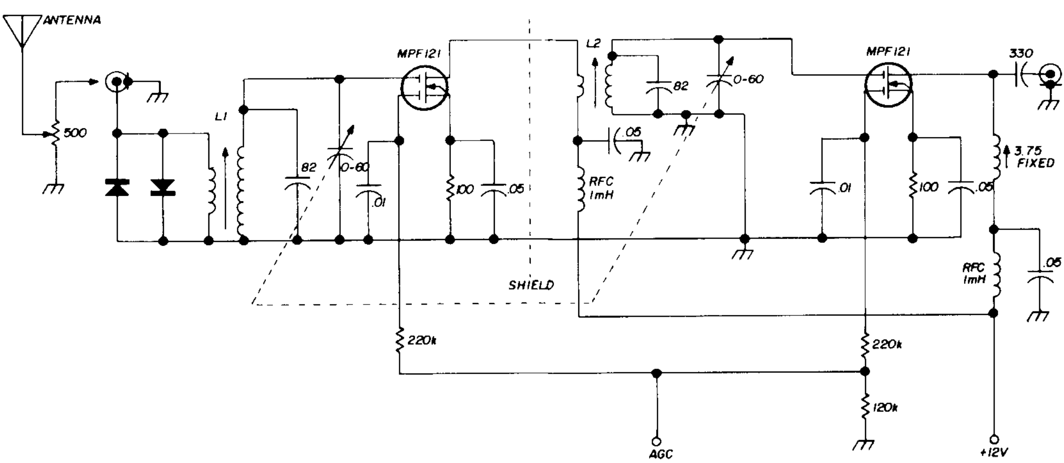
fig. 8. Circuit for the crystal-controlled carrier oscillator. The value of C1, 50 to 330 pF, is chosen for desired output range.

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 1/4" 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 1/4" slug-tuned coil form. Input link is 15 turns no. 30 on ground end of gate coil, two windings isolated as with L1

fig. 9. Receiver rf amplifier uses two MPF121 mosfets. The two back-to-back diodes across the antenna terminals are small-signal silicon switching types. Rf gain control is simple 500-ohm potentiometer voltage divider in the antenna lead.

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.

either 25- or 100 kHz markers. A momentary-contact pushbutton, S1, activates the circuit by completing the source circuit of the fet. Two inexpensive μL923 J-K flip-flops were used to divide the 100-kHz

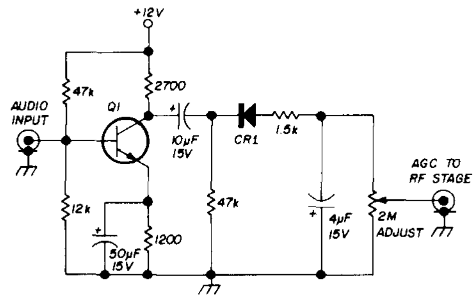


fig. 10. Simple hang agc circuit. Audio input must be picked up before the volume control (see fig. 15). Transistor Q1 is 2N5137, 2N2222, etc. CR1 is any small-signal silicon switching diode.

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

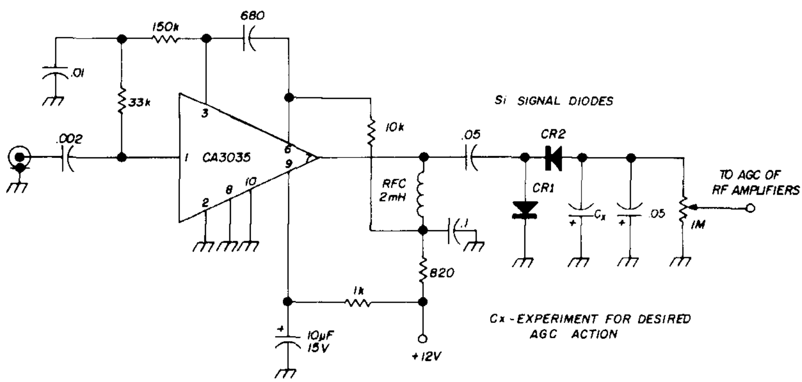


fig. 11. Integrated-circuit agc system. CR1 and CR2 are silicon signal diodes. The value of Cx is chosen for desired agc action.

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

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 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.

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

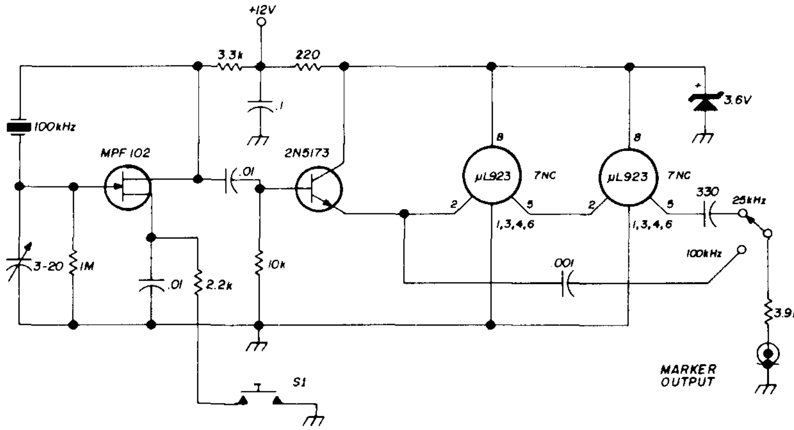


fig. 12. Crystal marker generator provides 25- and 100-kHz markers.

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.** 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

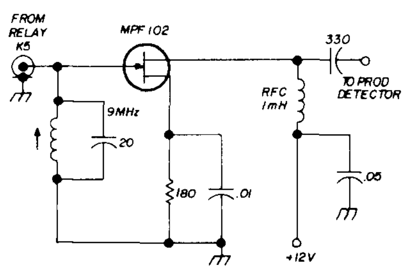


fig. 13. Simple one-stage, unity-gain 9-MHz i-f amplifier uses one fixed-tuned circuit.

considerable insight from W3TLN's experience with biasing QRP transistor finals to obtain linear operation.[4] 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 circuit uses a Fairchild SE9081 which has a power limitation of 42 watts and a frequency cutoff of 70 MHz. Cost of the SE9081 is less than $2.00.

The 2-inch heatsink of the SE9081 is 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.

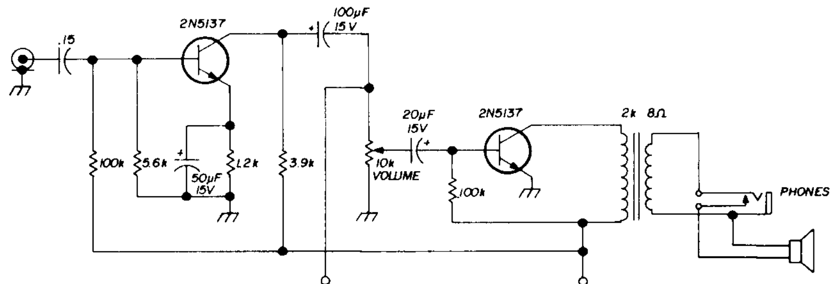


fig. 15. Audio output stage.

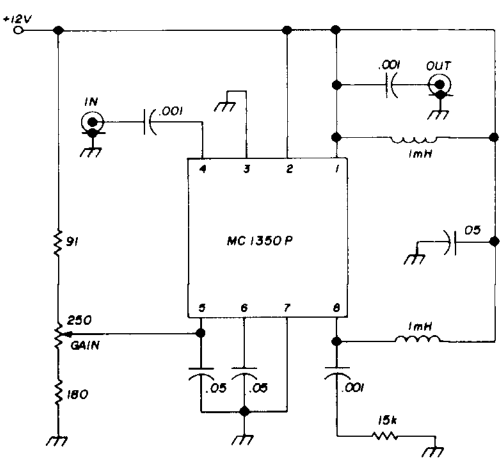


fig. 14. IC i-f amplifier which is suggested by the author for somewhat better performance.

power supply

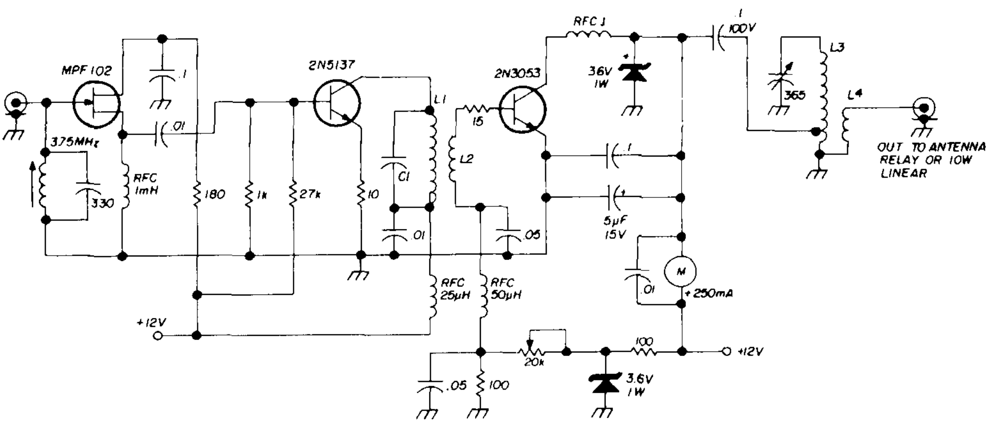
For portable operation, I use a 7 amp/hour rechargeable lead-acid motorcycle battery. This provides a very stable supply voltage over extended operating conditions. For mobile operating I plug a cord into the car's cigarette lighter. The rig requires about 150 mA on receive, and 1.5 amps on transmit. 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 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



L1	25 turns no. 24 enamelled on Amidon T-68-2 toroid core. (Use entire core surface)	L4	6 turns no. 22 insulated hookup wire wound over tapped portion of L3
L2	7 turns no. 24 enamelled, spaced evenly over L1	RFC1	3 Amidon ferrite beads on 3/8" length of no. 22 wire mounted as close as possible to the transistor
L3	7 mH. 34 turns no. 24 wound on Amidon T-68-2 toroid core, tapped 4 turns from ground end	RFC2	25 mH rf choke (James Millen J-300-25)

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.

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,[2] 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 6¼-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 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

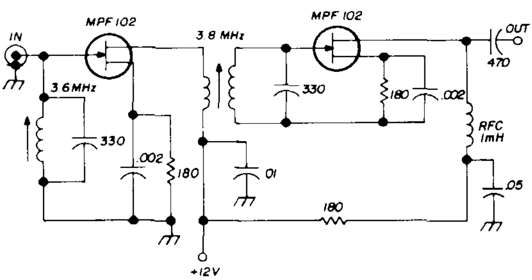


fig. 16. Two-stage transmitter buffer circuit is stagger tuned to cover the Canadian phone band (first stage tuned to 3.6 MHz, second stage to 3.8 MHz).

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 several larger boards. However, the point of the building-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 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 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.

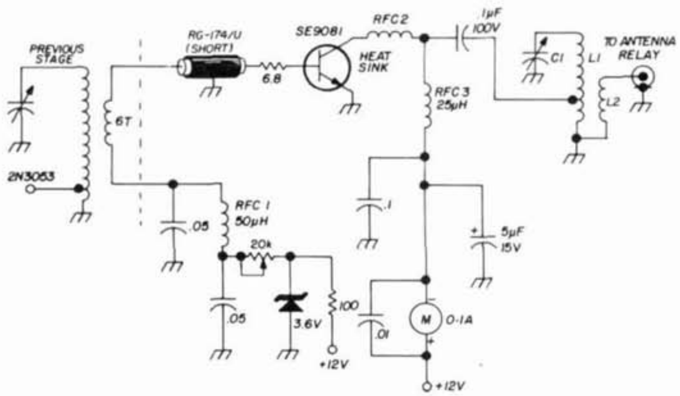
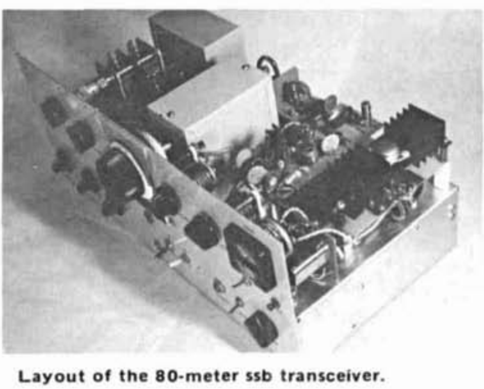


fig. 18. Ten-watt linear amplifier. Idle current is set by 20k trim-pot. RFC3 is home-made, to carry 1 amp; see text.

C1	165-pF variable in parallel with 100- to 330-pF fixed ceramic
L1	34 turns no. 19 on Amidon T-80-2 toroid core, tapped 4 turns from ground. Antenna link is 6 turns no. 22 insulated hookup wire, wound over 4-turn tapped section
RFC1	94 turns no. 31 on Amidon T-50-2 toroid core
RFC2	2 ferrite beads on no. 19 wire, close to SE9081 socket
RFC3	67 turns no. 22 enamelled on Amidon T-50-2 toroid core



Layout of the 80-meter ssb transceiver.

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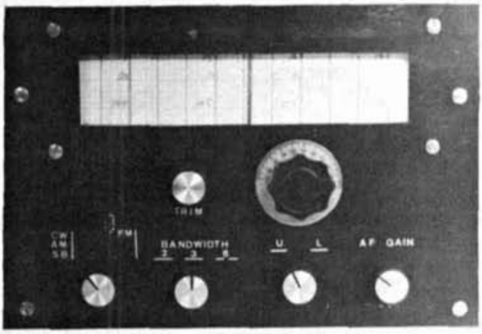


all-mode companion receiver

The reciprocating detector makes its debut as an fm discriminator in this receiver design

Stirling M. Olberg, W1SNN, Waltham, Massachusetts 02154

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.[1] This circuit works extremely well as an fm discriminator and as a synchronous detector for a-m and CW. In a nonsynchronous mode, it's an excellent detector for ssb. 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 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 on 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 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.

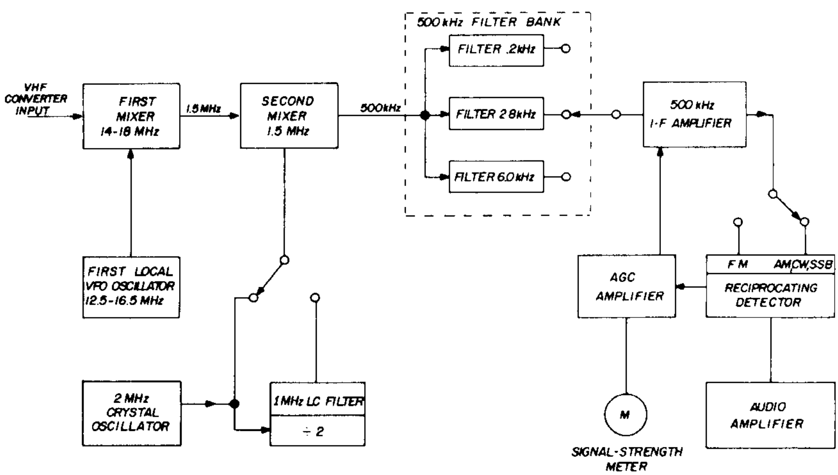


fig. 1. Receiver block diagram. Set is designed for use with 2- and 6-meter converters whose outputs are between 14-18 MHz.

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.

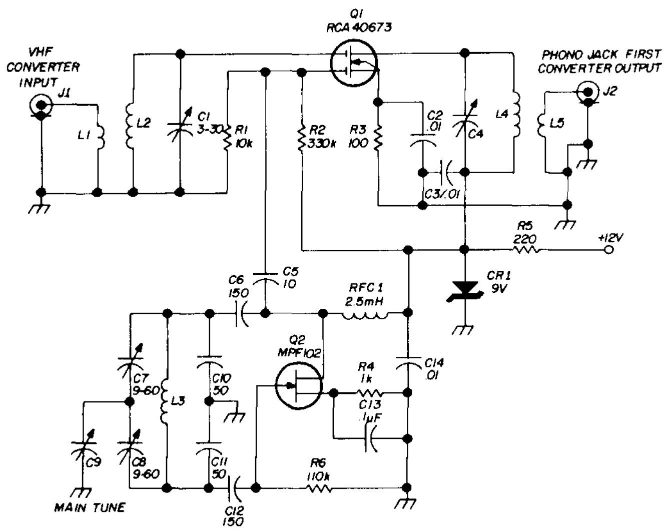


fig. 2. First converter schematic. L1: 2 turns no. 22E. L2: 12 turns no. 22E. Both coils wound on Amidon T-22-2 core. L3: 14 turns no. 26E wound on Amidon T-25-2 core. L4: Miller A123A coil with 6 turns added at bottom end of coil form for link L5.

first converter

The first conversion i-f transformer is located on the same board with the components described above. The input curcuit 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.

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.

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 4¼-inch standoff bushings within the cover of a 2¼ x 1¼-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.

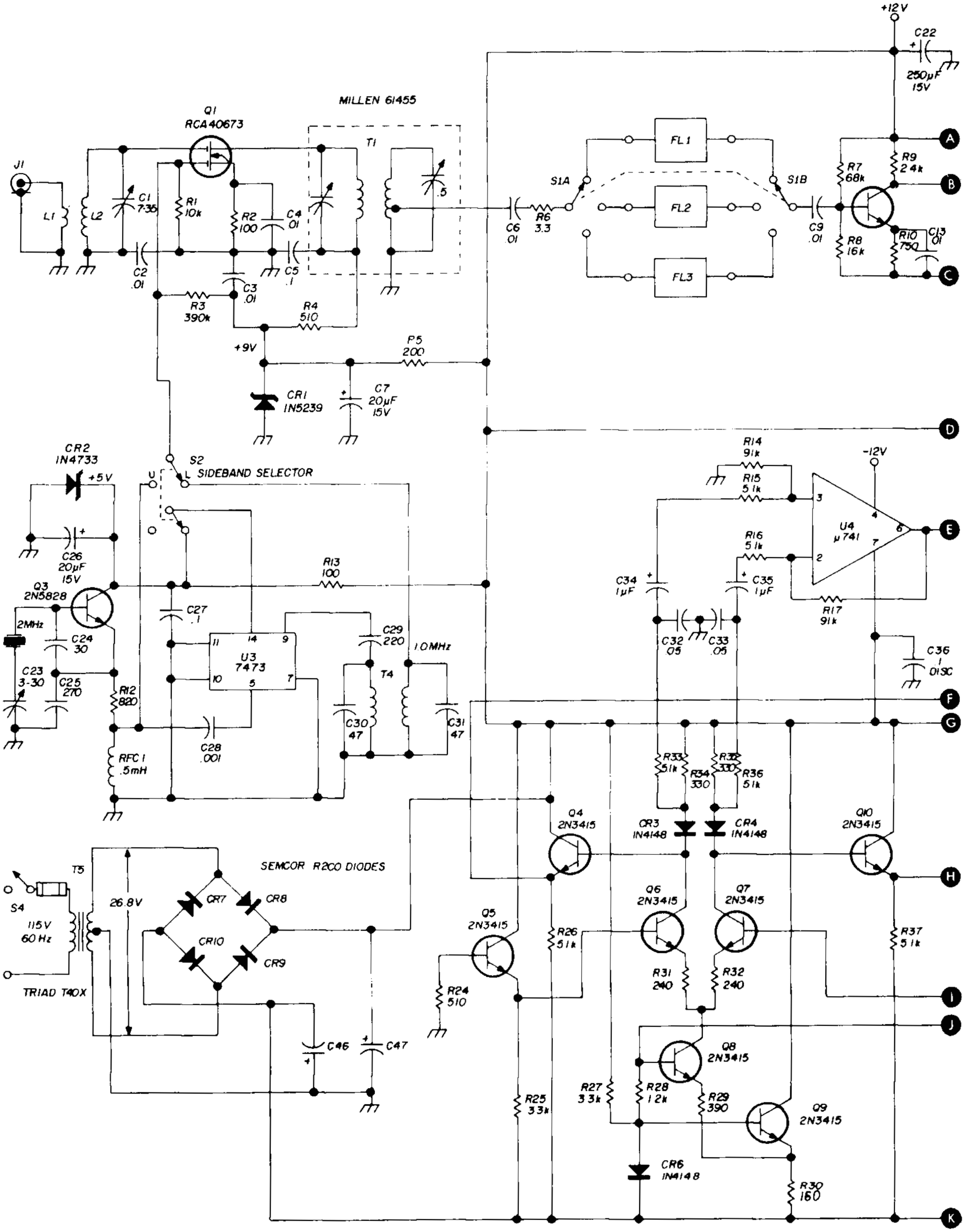
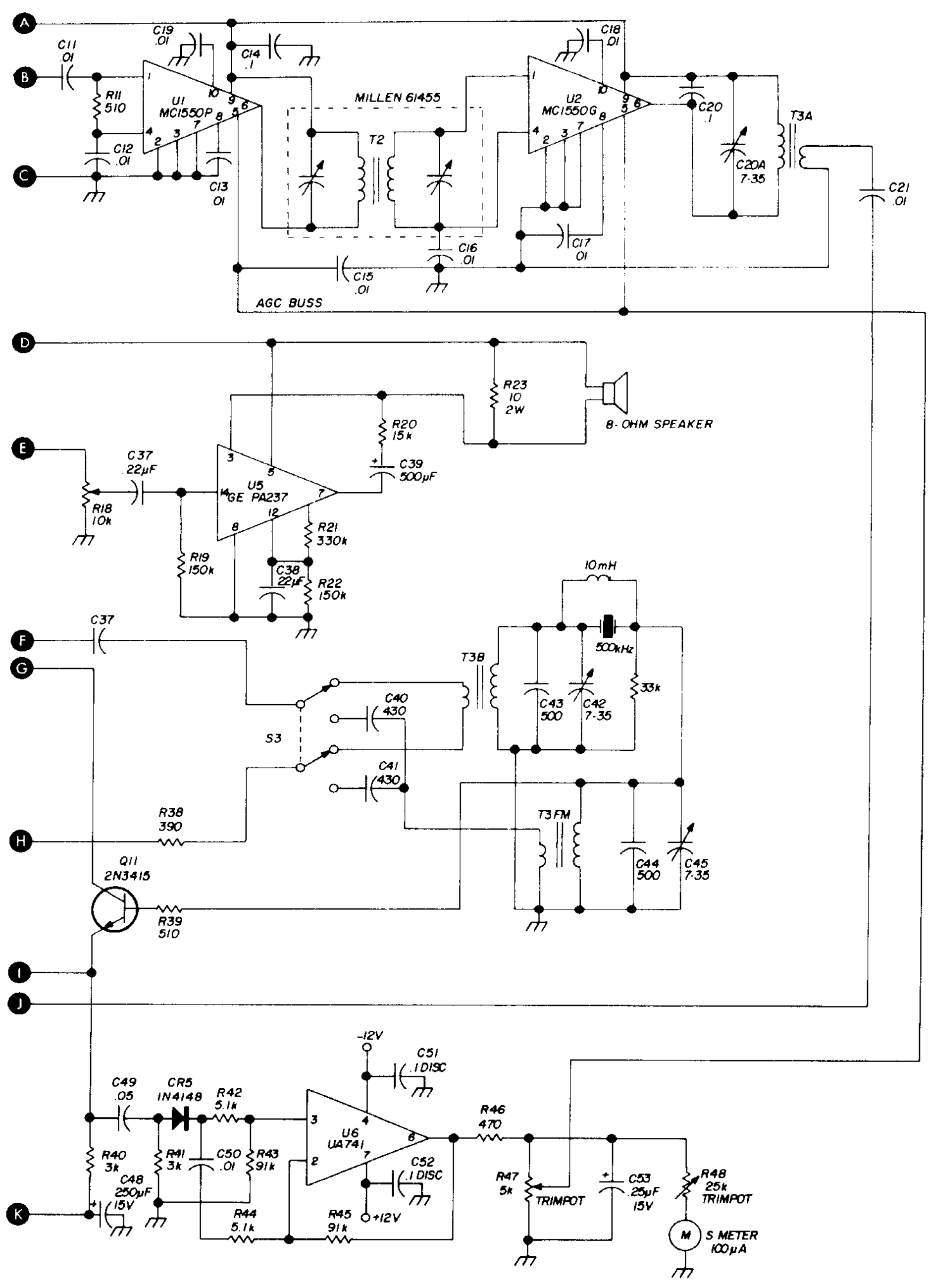


fig. 3. Schematic of 500-kHz i-f strip. L2: 74 turns no. 32E on Amidon T-144-15 core. L1: add 6 turns no. 32E over L2. T3A, T3B, T3FM: primary 14 turns no. 34E; secondary 92 turns no. 34E. All three coils wound on Amidon T-144-15 core. T4: Miller 12W1 i-f transformer.



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 narrowband 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 ½-inch bushings fastened to the main chassis next to the mode selector switch. A shield for the detector circuits, made of a 1¼ 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.

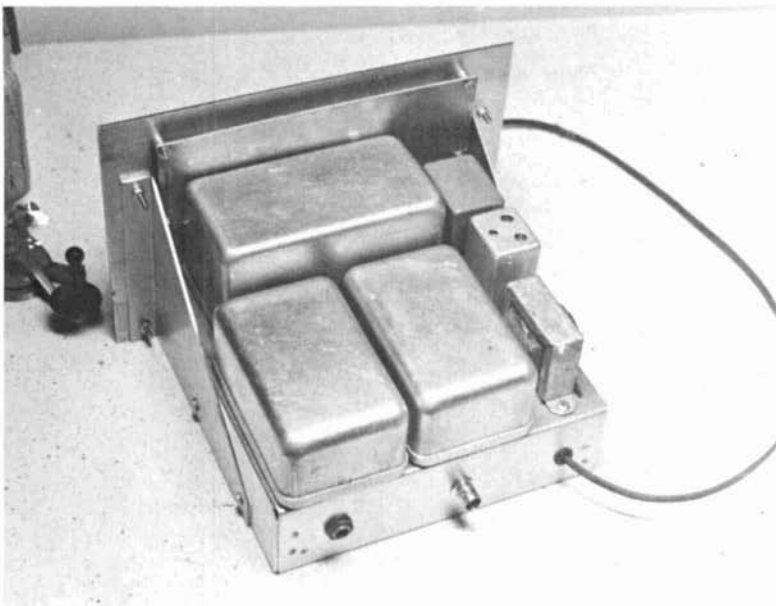
Connect the first converter output to the 1.5-MHz input jack. Tune the main tuning dial to the point determined to be 12.5 MHz when the first converter was aligned. Remove the second converter shield and connect a small piece of wire to the first converter input jack. Adjust the second converter input 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 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 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 companion receiver chassis. Battleship construction and shielding make for superior mechanical and electrical stability.

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.

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ham radio

phase-locked loop AFSK generator

This integrated-circuit phase-locked loop AFSK generator provides excellent long-term frequency stability

Daryl J. Duffin, K7ZOF, 255 Iowa, Ogden, Utah 84404

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.

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,

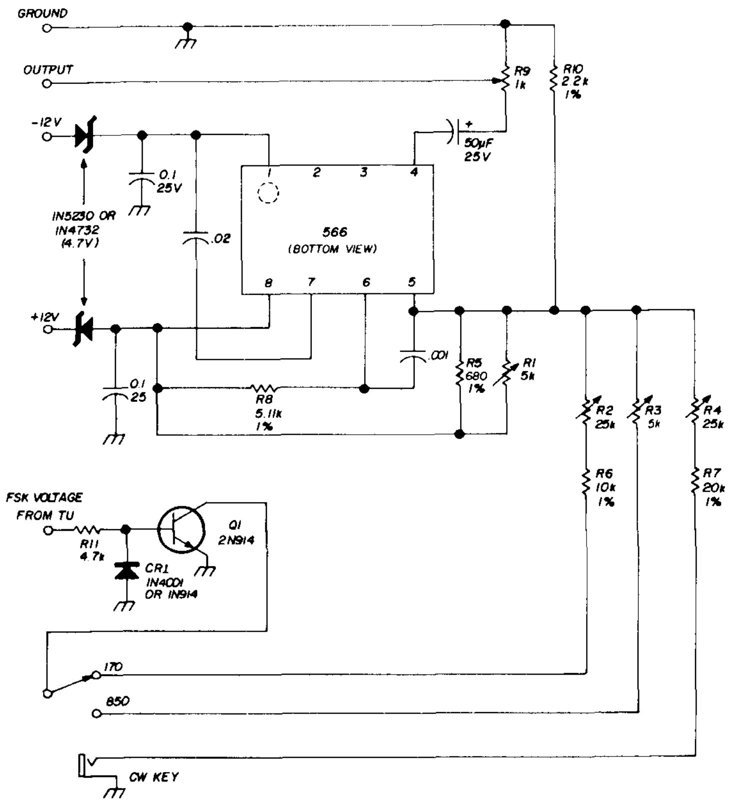

fig. 1. Circuit for the phase-locked loop AFSK generator. The IC is a Signetics 566. An alternate keying circuit is shown in fig. 2.

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

and the mode switch in the 170 shift position, adjust R2 for 2295 Hz at the output.

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.

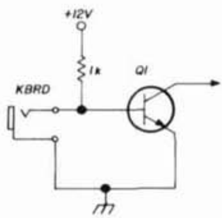

fig. 2. Alternate keying circuit for the phase-locked loop AFSK generator.

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!

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ham radio

radio-frequency interference

A review of RFI, its causes, and what to do about it

W. R. Moody, WA3NFW, 5231 Kenilworth Avenue, Apartment 201, Hyattsville, Maryland 20781

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. **editor.**

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

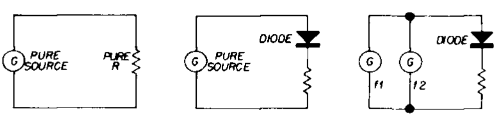

fig. 1. A signal source connected to a pure resistive load produces no harmonics. A diode connected in series with the load produces harmonics and harmonics plus cross modulation.

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

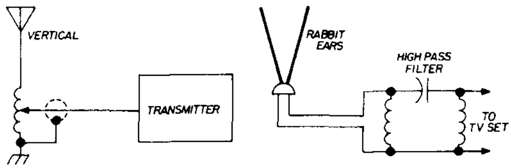

fig. 2. Selective circuits in the transmitter output reduce harmonics. A high-pass filter between a TV set and the tuner input is effective in attenuating strong amateur signals at the transmitter fundamental frequency.

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

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

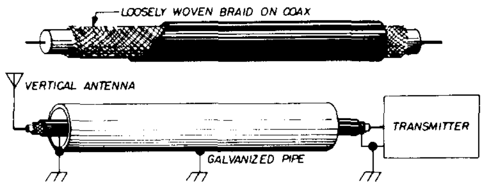

fig. 3. The braid in most coax cable does a poor job of RFI shielding. Burying the coax in the ground or installing it in a pipe provides effective shielding for RFI.

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

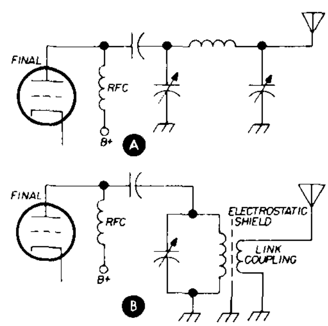

fig. 4. Typical pi network is effective in attenuating harmonic radiation only if reactance is low or zero. An electrostatic shield is useful with link-coupled output circuits but presents mechanical problems.

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-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.

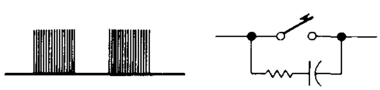

fig. 5. Pulses from CW modulation may be shaped by a simple RC filter.

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.

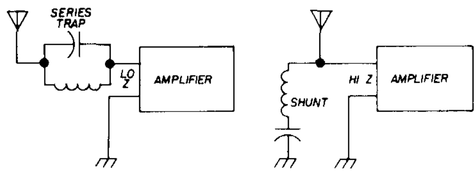

fig. 6. Application of filters for use with low- and high-impedance-input amplifiers.

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

M. A. Ellis, K1ORV, 61 Marlboro Road, Sudbury, Massachusetts 01776

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.

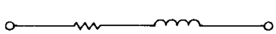

fig. 1. Equivalent circuit of a ferrite bead includes both series resistance and series inductance.

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

$$Z_b = \sqrt{R^2 + X^2} \qquad (1)$$

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 dB = $20 \log_{10} (50 + 50)/(50 + 50 + Z_b)$
Dividing by 20 gives
$-0.3 = \log_{10} (100)/(100 + Z_b)$
Taking the antilog of -0.3, we have
$0.5012 = 100/100 + Z_b$, therefore
$50.12 + 0.5012 Z_b = 100$ so
$Z_b = (100 - 50.12)/0.5012 =$
$49.88/0.5012 = 100$ 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 (vo) and without (v1) the new impedance.[1]

Insertion Loss Ratio (ILR) = (E/vo)/(E/vl)

$$= vo/vl = (Z_s + Z_L)/(Z_s + Z_L + Z_b) \quad (2)$$

$$ILR\ (dB) = 20 \log_{10}\ (Z_s + Z_L)/Z_s + Z_L + Z_b) \quad (3)$$

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 = $20 \log_{10} (50 + 50)/(50 + 50 + Z_b)$ = 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.

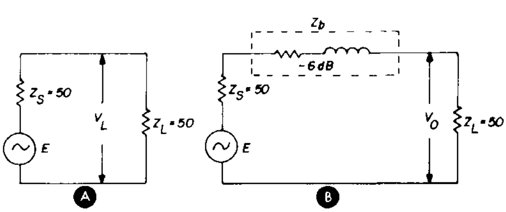

fig. 2. Typical circuit impedances without ferrite beads is shown in (A). When a ferrite bead is used (B), the normal circuit impedances, Z_S and Z_L, are increased by the impedances of the bead, Z_b.

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

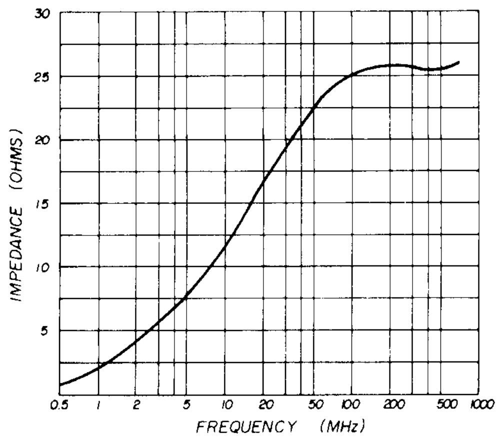

fig. 3. Characteristics of a Ceramag 7D ferrite bead plotted in terms of impedance vs frequency.

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 μH.

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

*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?

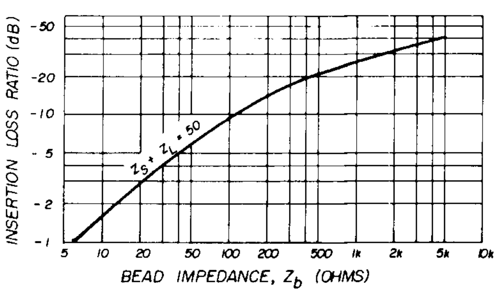

fig. 4. Graph of insertion loss ratio (ILR) vs bead impedance for 50-ohm systems ($Z_S + Z_L$ = 50 ohms). Graph may be used for other system impedance values by use of a simple factor, see text.

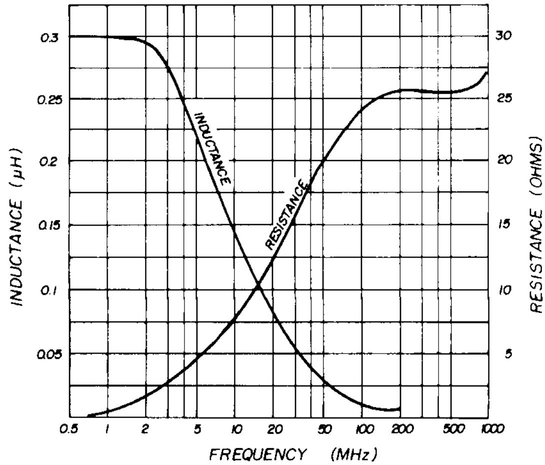

fig. 5. Bead characteristics plotted in terms of resistance and inductance vs frequency. This type of graph is very useful when choosing ferrite beads for your own circuits.

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.

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More Details? CHECK—OFF Page 94

simple integrated-circuit electronic keyers

Two simple electronic keyer circuits based on the new Signetic NE555 timer IC

Joe Buswell, WA5TRS, Post Office Box 10674, Midwest City, Oklahoma

For some time I have been intending to learn how digital integrated circuits are used and what their characteristics are. Rereading a series of articles in *ham radio*[1] aroused my curiosity and the discovery of a new device pushed me off dead center and got me started. The new device is the Signetics NE555 timer integrated circuit. The NE555 can be used 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 Rb to pin 7 until the voltage at pin 2 drops to 1/3 Vcc. At that time, the flip-flop retoggles and a new cycle begins: From the Signetics data sheet,[2] the time the output is high is described by

$$T_{high} = 0.685(Ra + Rb)C \text{ (seconds)}$$

The time the output is low is

$$T_{low} = 0.685(RB)C \text{ (seconds)}$$

The total time period is

$$T_{high} + T_{low} = 0.685(Ra + 2Rb)C \text{ (seconds)}$$

morse code generation

If the circuit of **fig. 1** is constructed with Ra small compared to Rb, 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 Vcc on the first dot and rise from 1/3 Vcc to 2/3 Vcc 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 Vcc during rest, allowing it to fall below the required threshold during key down and form an almost perfect first dot.

The control, R2, is used to adjust the threshold voltage slightly higher than the internal threshold voltage and allow for the voltage drop of the diode. R2 should be approximately equal to the value of R1 to allow sufficient adjustment range. R1 should be included to limit the current drain on the power supply when the key is closed and R2 is inadvertently adjusted to maximum voltage. Diode CR1 is included so that the bias circuitry won't disturb operation of the timer during the charge-discharge cycle.

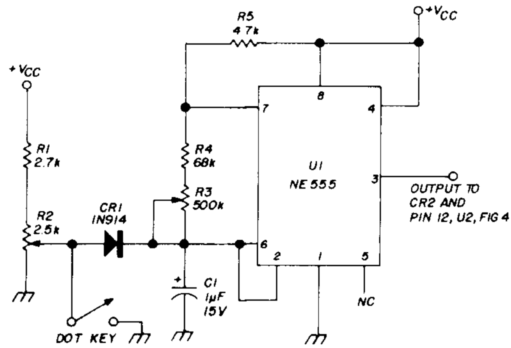


fig. 2. Dot generator using the NE555 IC. Potentiometers R2 and R3 should have linear taper (see text).

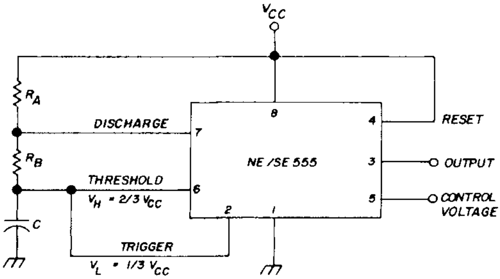


fig. 1. Astable multivibrator circuit using a Signetics NE555 IC.

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.[3] 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

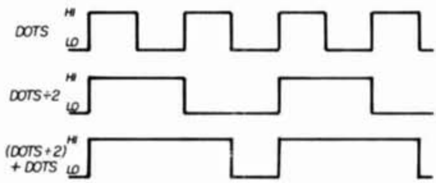


fig. 3. Timing diagram showing formation of dash length that is three times the length of one dot.

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 $\overline{J}$ is brought to logic low which readies Q to go high on the rise of the clock pulse. It is important that $\overline{J}$ 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 $\overline{J}$ 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 $\overline{Q}$, 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.

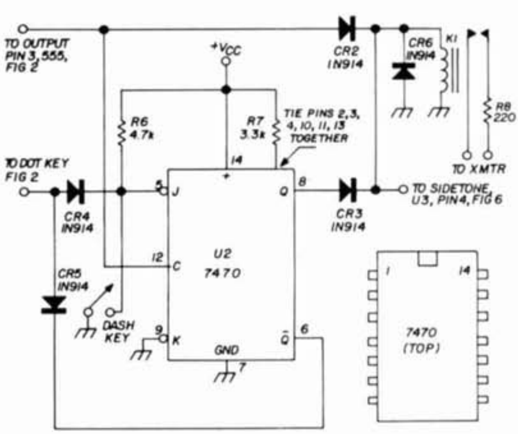


fig. 4. Dash generator circuit. Relay K1 is a 1A5AH, manufactured by the Electronics Application Company, 2213 Edwards Avenue, S. Elmonte, California 91733.

Simple electronic keyer has speed range from 4 to 26 words per minute and has built-in sidetone monitor.

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

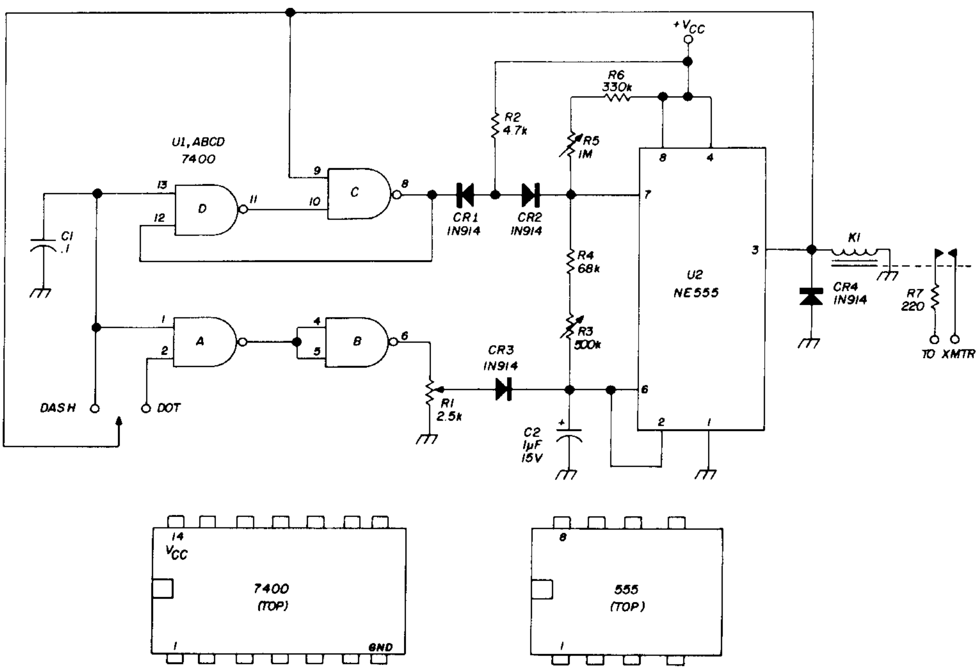


fig. 5. Variable dash length keyer circuit. Relay K1 is a 1A5AH, manufactured by Electronics Application Company, 2213 Edwards Avenue, S. Elmonte, California 91733.

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

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 readibility, 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 tune 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 hookup 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

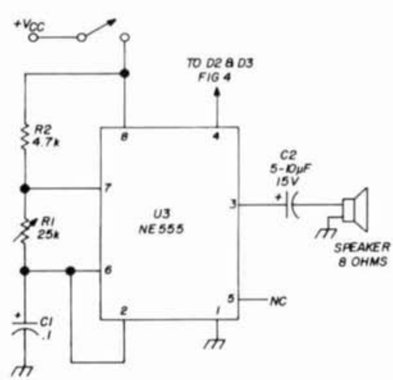


fig. 6. Sidetone generator circuit. Adjust value of C2 for suitable volume.

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.

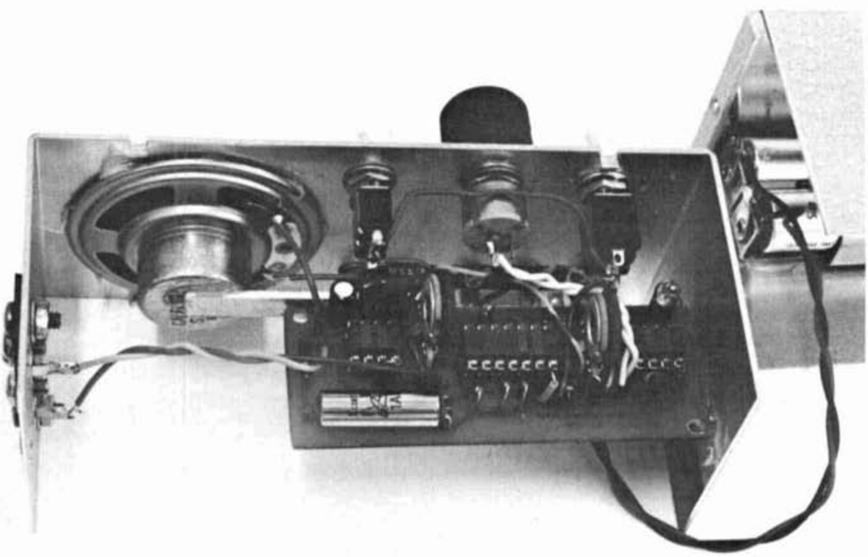
Frequency is adjusted by R1 to suit the user. Since the timing calculations are upset by the speaker load the value of R1 was determined experimentally. R2 is only included to prevent pin 7 from drawing unnecessary current when it is grounded. C2 was included to limit the current which would flow each 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.



Construction of the simple IC electronic keyer. A reed relay is used to key the transmitter.

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.

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-

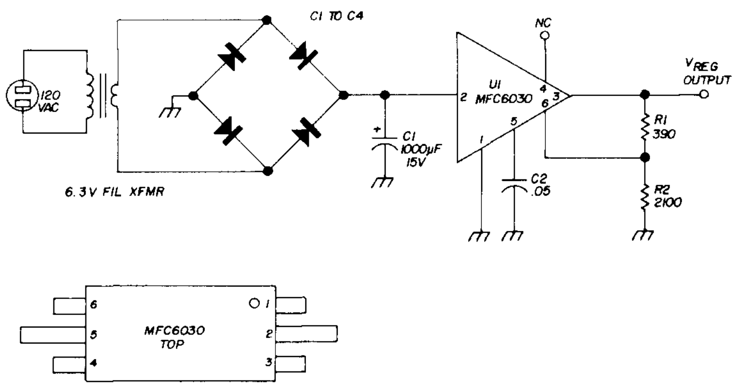


fig. 7. Regulated 5-volt power supply for the NE555 electronic keyers. Diodes CR1-CR4 are 500 mA, 50 PIV. See text for computing values of R1 and R2.

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

age drop X load current). The formulas for computing R1 and R2 are

$$R1 = \frac{R2\,(V_{reg} - V_{ref})}{V_{ref}}$$

$$R2 = \frac{V_{ref}}{I_{ref}}$$

Where V_{reg} is the desired regulated voltage, V_{ref} is the desired reference voltage on pin 6, and I_{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

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

$$R1 = \frac{2100\,(5.0 - 4.2)}{4.2} = 400 \text{ ohms}$$

Since 400 ohms is not a standard value,

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

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!

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1. Ed Noll, W3FQJ, "Circuits and Techniques," *ham radio,* March, April, June and July, 1972.
2. Signetics Data Sheet, Timer NE555, Signetics, 811 East Arques Avenue, Sunnyvale, California 94086.
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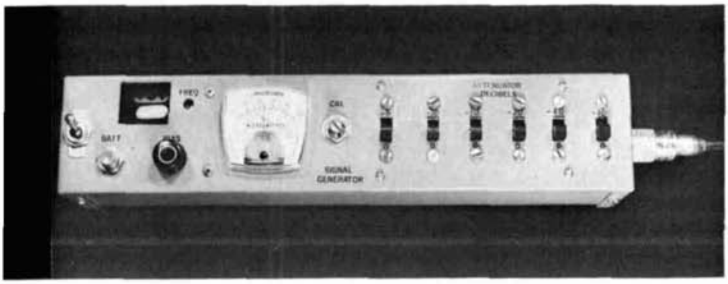

crystal test oscillator and signal generator

A.A. Kelley, K4EEU, 2307 South Clark Avenue, Tampa, Florida 33609

This stable crystal test oscillator uses one low-cost IC to provide a stable rf test signal from 1 to 10 MHz

This test oscillator was built to fill the need for a stable, resettable test signal source for aligning communications receivers. A handful of crystals gives several accurate marker frequencies with no tuning adjustments. The unit also serves as a handy crystal tester with a built-in meter to indicate relative activity.

The circuit uses a single Motorola MC799P integrated circuit that costs 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,[1] 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.

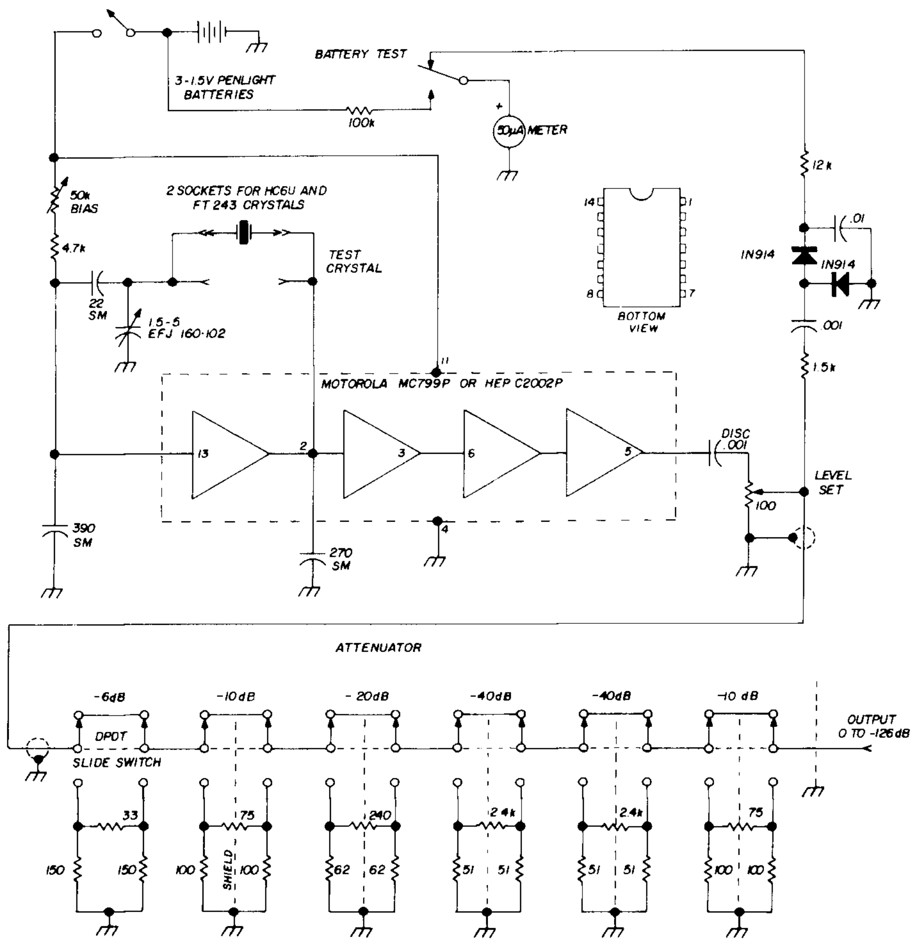

fig. 1. Circuit diagram for the crystal test oscillator and signal generator. MC799P IC will oscillate with any crystal from 1 to 10 MHz. Output attenuator uses standard resistor values to provide up to 126 dB of output signal control.

*M. Weinschenker, Box 353, Irwin, Pennsylvania 15642. Slide switches are priced at six for $1.00, dpdt, red or black.

reference

1. A.A. Kelley, K4EEU, "Compact Frequency Counter," *ham radio*, July, 1970, page 16.

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More Details? CHECK—OFF Page 94

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solid-state mobile touch-tone circuit

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

Roy C. Hejhall, K7QWR, Motorola Semiconductor Products, Inc.

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 WØLPQ.[1] 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

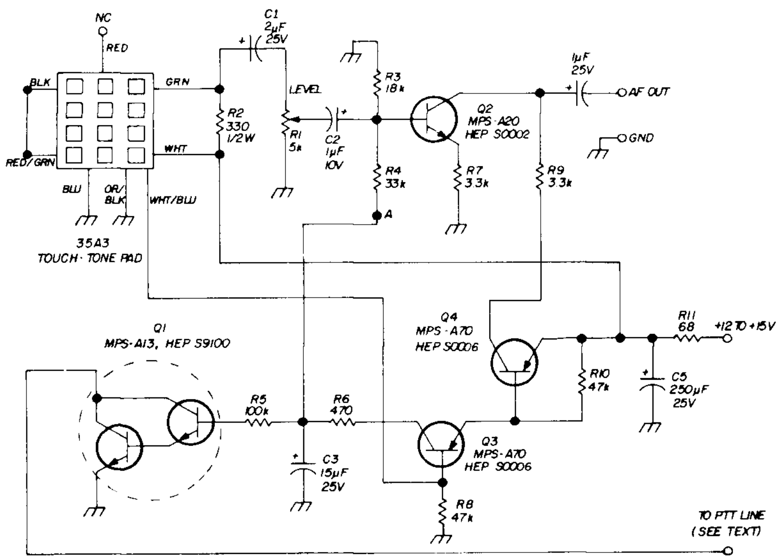


fig. 1. Schematic diagram of the mobile Touch-Tone circuit. The 5.1k resistor connected between the blue and white/blue leads inside the 35A3 must be removed.

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 WØLPQ'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 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

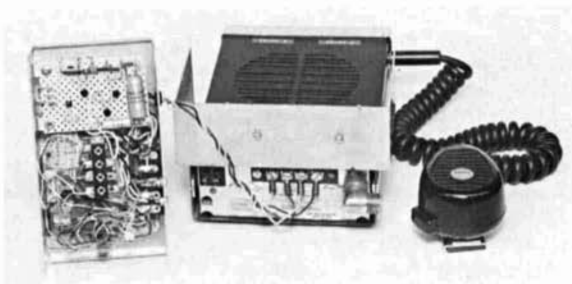
The dc feedline is connected directly to the automobile electrical system with no voltage regulation or additional filtering beyond that shown in **fig. 1.** The circuit also functions very well when connected to an ac supply with 1.2 volts peak-to-peak ripple when the transmitter is keyed. If your car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



Bottom view of the Touch-Tone circuit. At top is the circuit, mounted on a 2 x 3" piece of Vector perf-board. Touch-Tone pad is below. The four terminals on the back of the HR-2A were modified to permit connection to the solid-state Touch-Tone circuit.

If your rig does not meet these requirements, the automatic keying portion of the interface circuit must be redesigned, not connected, or eliminated.

Not connecting this function simply means leaving the collector of Q1 open. To eliminate this portion of the circuit, delete Q1, R5, C3 and R6; connect the collector of Q3 to the lower end of R4 (point A). Neither of these options will have any effect on the operation of the remainder of the interface circuit.

Advantages of connecting the audio output someplace downstream in the transmitter speech amplifier were discussed earlier. However, for the builder who prefers making the connection to the microphone input, the circuit should function just as well that way with no modifications. In the HR-2A I connected the audio output of the circuit to the junction of C226 and R223 between the second and third stages of the speech amplifier.

Excessive rf from the transmitter can

*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-μF 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.

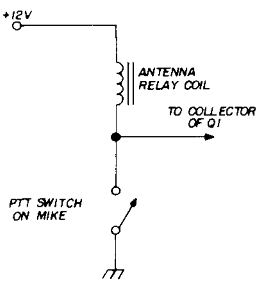


fig. 2. Push-to-talk circuit for the Regency HR-2A vhf fm transceiver.

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

1. William P. Lambing, WØLPQ, "Mobile Operation with the Touch-Tone Pad," *ham radio,* August, 1972, page 58.

ham radio

HW16 modifications

for vfo operation

Easily made mods to enhance the versatility of this popular rig

James T. Takashima, WB6MZN, 19104 Wadley Avenue, Carson, California

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-

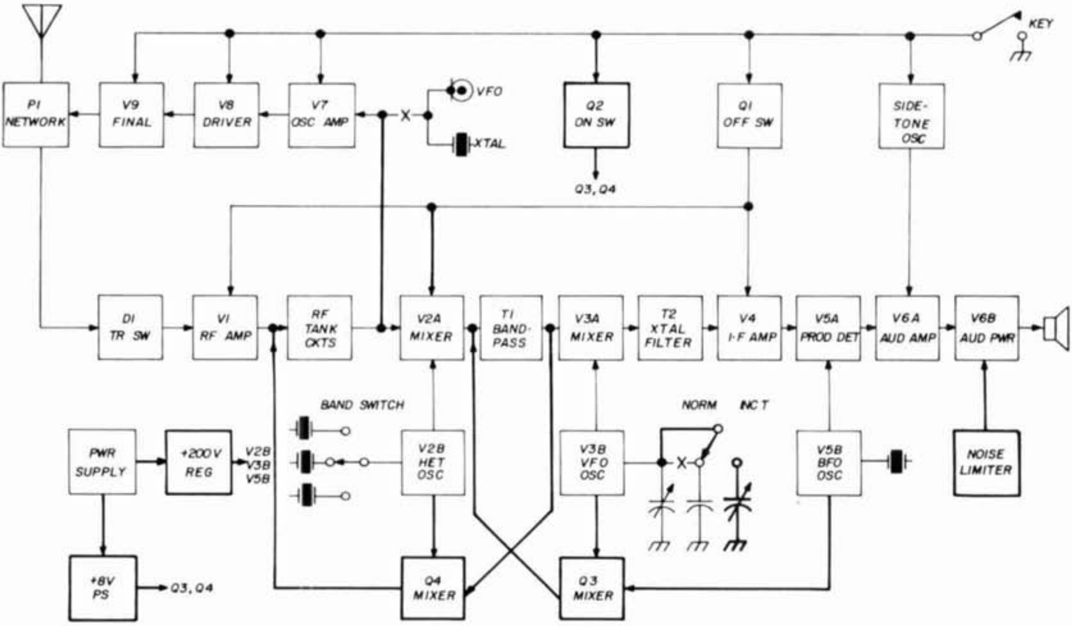
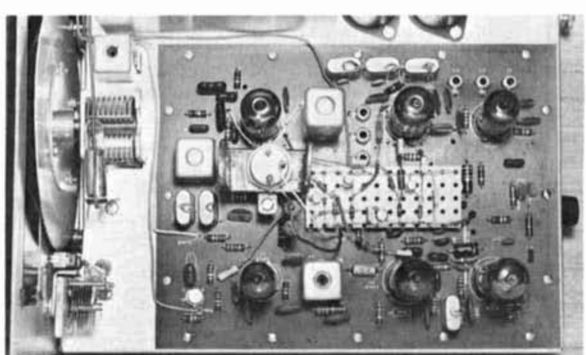


fig. 1. HW16 modifications for improved versatility. Modifications are shown in heavy lines in this diagram and in the schematic, fig. 2.

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 quency 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

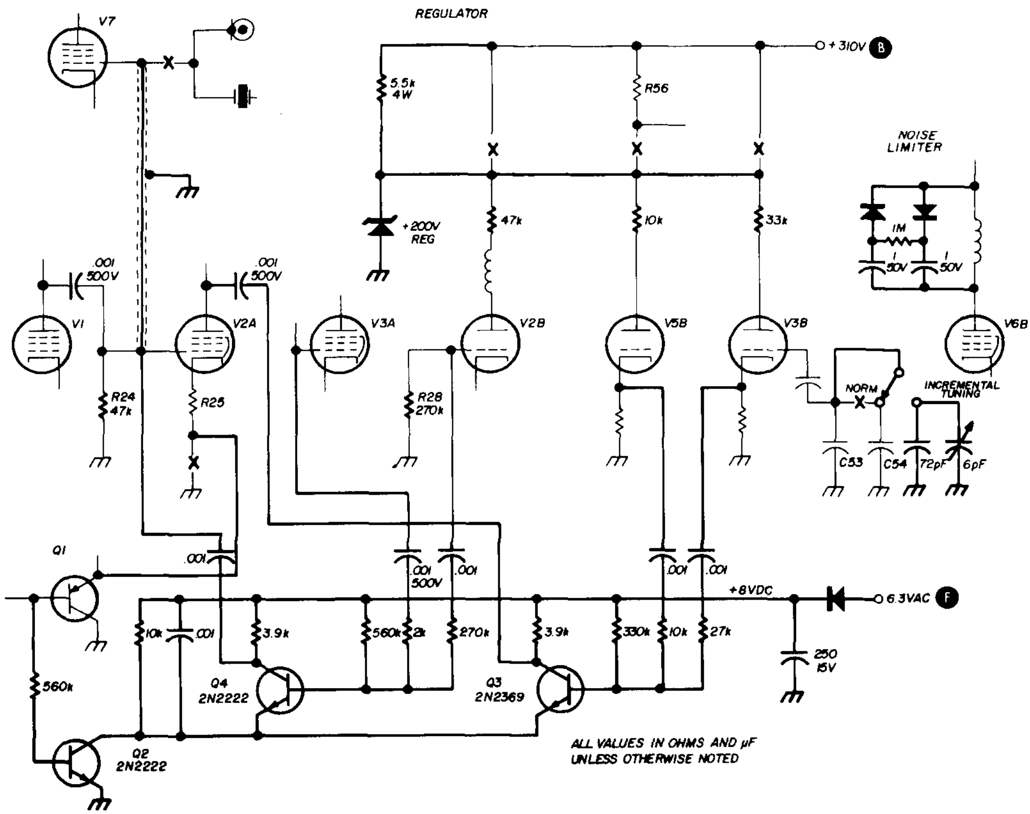


fig. 2. HW16 schematic showing modifications. Features include transmit vfo, incremental tuning, power-supply regulation for the oscillator tubes, and side-tone key click filter.

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. Fre-

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 (6CB6 for Q3 and 6U8 for Q4) were used initially and successfully except for much greater heat dissipation.

ham radio

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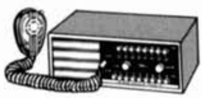

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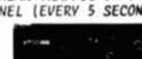

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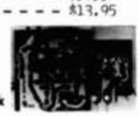

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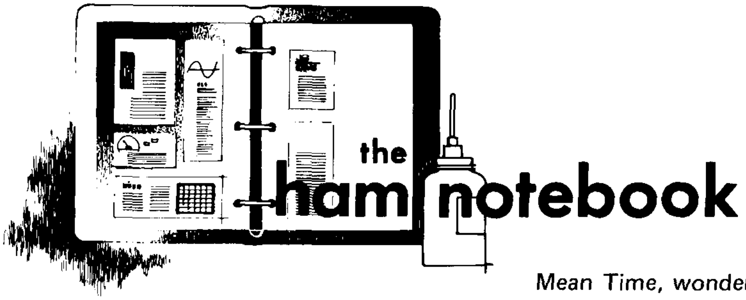


tone-burst generator

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.

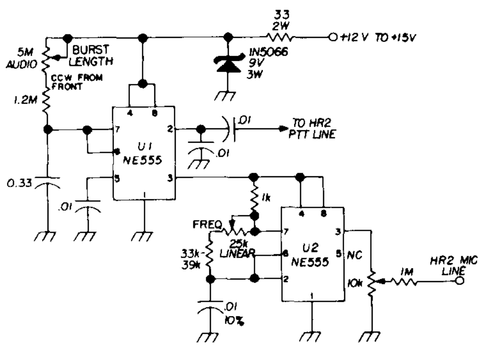


fig. 1. Circuit for the IC tone-burst generator.

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):

EDST	2000Q
EST and CDST	1900R
CST and MDST	1800S
MST and PDST	1700T
PST	1600U

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 RD, where R is restricted to 30 to 50 Kilohms. The NE555V provides time delays given by T = 1.1 RC, where R can be as high as 10 megohms. Thus, with the same RC values, the NE555V gives a 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

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 5¼-inch Minibox. The supply for the generator board is obtained by using a 6.3-volt transformer (Radio Shack 273-050) and bridge to 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.

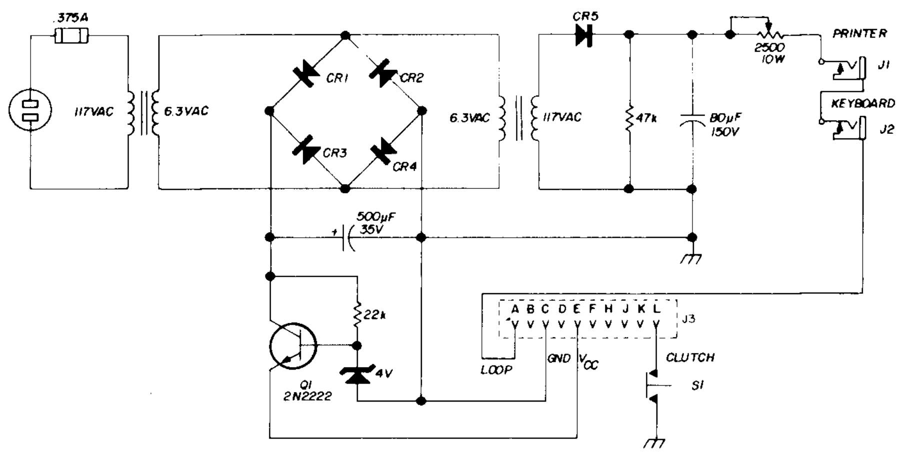


fig. 2. Circuit for the RTTY test generator. Diodes CR1-CR5 are 50 PIV, 100-mA diodes. S1 is a normally closed, momentary contact switch. Phone jacks J1 and J2 must be insulated from the chassis.

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.

Tom Gibson, W3EAG

new products

vhf fm transceiver

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 multiposition 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.

microtransmitter

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.

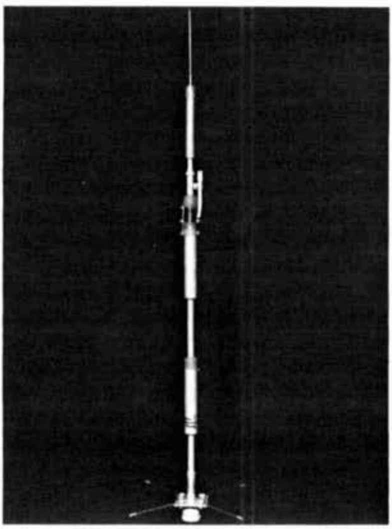
More Details? CHECK—OFF Page 94

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 and in phased-arrays.

The supporting mast is heavy-wall aluminum alloy, and the radials are spring-tempered stainless steel. A mounting receptable 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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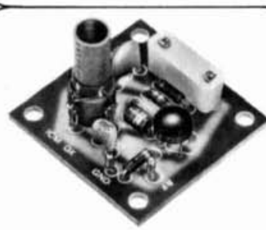

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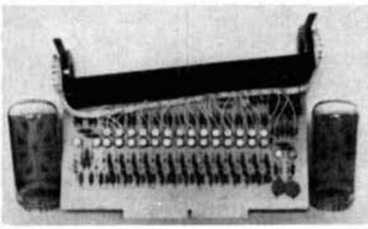

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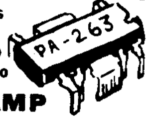
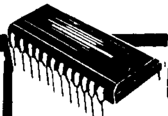


Delivers 3. watts continuous, 10 watts peak. With heat sinks; micro-mini size: ¾x½x½". 9 to 30V supply. High sensitivity, 8 to 16 ohms. For mono and stereo phonos, tape, FM, AM, TV, servo.



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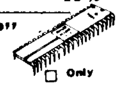
SD-5314 direct substitute to famous U.S. maker. 24-Pin DIP — IMAGINE! ONE CHIP ELIMINATING 15 and other parts. Space Saver! Money saver! Latest in clock design. Features 12 or 24-hr. operation, 4 or 6 digits, 40 or 60 Hz operation. Internal digit multiplex oscillator, leading zero blanking, high output current for simple readout interface. Single power supply operation. Digit blanking for reduced current drain. 11 thru 19 volt range. Full MOS LSI. Spec sheets included.

12-DIGIT "CALCULATOR ON A CHIP"



Similar to Mostek 5001. Outperforms Texas 8-digit TMS1802. A 40-pin DIP. Adds, multiplies, subtracts, and divides. Use with 7-segment readouts, Nixies, and LED's. We include schematics, instructions from factory to build calculator. 3 for $35

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- 8" x 5½" x 3" case

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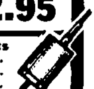
1 WATT "FLANGELESS" TOP HAT ZENERS

Type TK, Metal Case! ☐ 5 for $1

Volts	Volts	Volts
4.7	10.	15.
6.3	11.	30.
8.2	12.	33.
9.1	13.	



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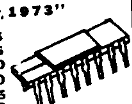

NIXIE COUNTING SYSTEM

Includes SN7490, decade counter, SN7475 latch, SN7441 BCD decoder driver, 0-to-9 Nixie tube, instructions.

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LED READOUTS

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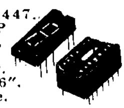

LED

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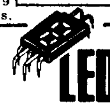

This display is excellent for small portable electronics, such as DVM's, calculators, etc. Equivalent to Monsanto MAN 3A. Operates from 5V, 20 milliamperes, with 47 ohm dropping resistor.

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☐ DM8830	Dual Diff. Line Driver	1.00
☐ DM8845	Same as SN7445	1.45
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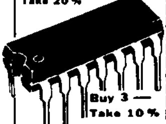

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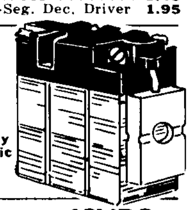

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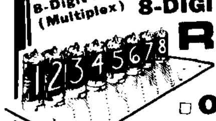

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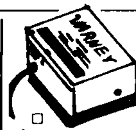

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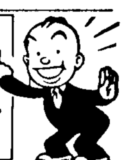

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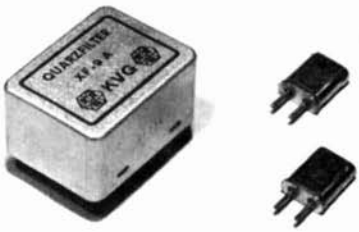

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HP150A - 10 MHz Scope w/152B 185
HP160B(USM105)-14MHz dual trace scope 385
HP185B-DC-1gHz samp. scope w/186B 335
HP202B-Audio Gen.-5Hz-50kHz-.1-10v 75
HP212A-Pulse Gen. var. width and rate 65
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More Details? CHECK—OFF Page 94

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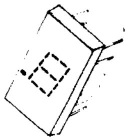

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7400	.25	74H11	.50	7451	.25	74H74	.85
74L00	.35	7413	1.75	74L51	.35	7475	1.15
74H00	.35	7420	.25	74H51	.35	7476	.55
7401	.25	74L20	.35	74H52	.40	74L78	1.00
74H01	.35	74H20	.35	7453	.25	7480	.50
7402	.25	74H22	.50	74H53	.40	7483	1.15
7403	.25	7430	.25	7454	.30	7486	.65
7404	.25	74L30	.35	74L54	.35	7489	3.00
74L04	.35	7440	.25	74L55	.35	7490	1.00
74H04	.35	74H40	.40	7460	.25	7491	1.15
7405	.25	7441	1.30	74L71	.50	7492	.90
74H05	.35	7442	1.00	7472	.40	7493	.9C
7406	1.00	7446	1.50	74L72	.50	7495	1.15
7408	.40	7447	1.50	7473	.55	74L95	2.00
74H08	.50	7448	1.25	74L73	.80	74107	.55
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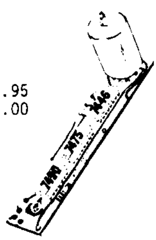

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8210	8 line to 1 line selector	1.40
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8233	2 input 4 bit multiplexer	1.75
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8261	fast carry extender	2.00
8266	2 input 4 bit multiplexer	1.50
8270	4 bit PI, SI, PO, SO	2.00
8271	4 bit shift register	2.00
8273	10 bit SI,PO register	3.00
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8290	presetable dec. counter 75MC	3.50
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NE555	prec. timer MINI	1.25
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LM100	positive DC regulator TO-5	.80
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NE561	phase lock loop DIP	3.25
NE565	phase lock loop TO-5 or MINI	3.25
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711	dual comparator DIP	.75
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flea market

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WANT: Impedance bridge GR 916A, 1601, 1602, 1603, or equal. Nagle, 12330 Lawyers, Herndon, Va. 22070.

SAVE $100.00. Brand new Hallicrafters FPM 300 solid state transceiver in original packaging. James T. Thompson, W5KRD, New Hebron, Miss. 39140.

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22nd ANNUAL DAYTON HAMVENTION will be held on April 28, 1973 at Wampler's Dayton Hara Arena. Technical sessions, exhibits, hidden transmitter hunt, flea market, and special program for the XYL. For info write Dayton Hamvention, Dept. H, Box 44, Dayton, Ohio 45401.

WORLD QSL — See ad page 92

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

HEATH 2er complete $32; Heath CB lunchbox $15; Heath HW16, like new $95. Need paddle SWR key power meter. List available. W2FNT, 18 Hillcrest Ter., Linden, N. J. 07036.

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HEY LOOK! The Charleston Hamfest II is going to be held again this year on the third Sunday in March. March 18, 1973 in Charleston, S. C.

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

ROCHESTER, N. Y. is the place to go for the largest Hamfest, VHF meet and flea market in the northeast, May 12th. Write WNY Hamfest, Box 1388, Rochester, N. Y. 14603.

FANTASTIC GAIN, low distortion transistorized preamplifier for use with low-output microphones. Stamp for specifications. USAT Box 3051B, Trenton, New Jersey 08619.

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WA8TMR DECEASED. Wife must sell Swan 500CX single sideband transceiver and power supply 117XC. Excellent condition. Mrs. John Sercia, Box 144, Brookfield, Ohio 44403.

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

WANTED: JULY 1969, Ham Radio magazine. Andy Kalayta, 7645 N. Crawford, Skokie, Illinois 60076.

SELL: PP-987U pwr sply, I-193-C test set, AM-103B/U line ampl., COQ-23403-A line cont unit, model 14 typing unit on stand, $100.00; BC-453 $17.00; T-19/ARC-5 $12.00; T-21/ARC $9.00. FOB Dick Stansbury W5SCS, 5704 Alta Monte N.E., Albuquerque, New Mexico 87110.

LINEAR BUILDERS — Model DS-12 2.5A/12,000 PIV diode rectifier, replaces 866, 3B28, and 872. R-C suppressors, $9.95. At your dealer or order direct ppd. HEP-170 2.5A/1000 PIV diodes 30¢ each, direct only. K. E. Electronics, Box 1279, Tustin, California 92680. Send SASE for information on plate chokes, filament chokes, and pi-networks.

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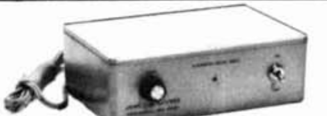

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TO SELL YOUR HAM GEAR or to purchase new or used or to receive our monthly mailer of reconditioned equipment contact, Associated Radio, 8012 Conser, Overland Park, Kansas 66204. 913-381-5900.

INSULATED STANDOFF TERMINALS: Teflon, 15 @ $1.00; Ceramic, 20 @ $1.00; Phenolic, 25 @ $1.00. Teflon pressfit Terminals - standoffs - feedthrus - testjacks - your choice, 50 @ $1.00. 1-10 pf. glass piston trimmers, 4 @ $1.00. 1N914 diodes 20 @ $1.00. Germanium diodes (1N34 specs) 50 @ $1.00. Postpaid. S.A.S.E. brings component list. CPO Surplus, Box 189, Braintree, Mass. 02184.

THE MIDLAND AMATEUR RADIO CLUB, Midland, Texas, will hold their Saint Patricks Day Swapfest on Sunday, March 18, 1973. The Swapfest will be preceeded by the usual social events the afternoon and evening of March 17th. For details contact WA5HOI.

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SELL: Kenwood (Trio) R-599 w/50Mc & 144Mc preamps, T-599, MC-50 dynamic mike, SP-599 spkr, all only two months old, original cartons, complete $650. Yaesu FT-200 w/AC supply/spkr, DC supply, excellent condition $375. W7UR, tel.: 503 643-1460.

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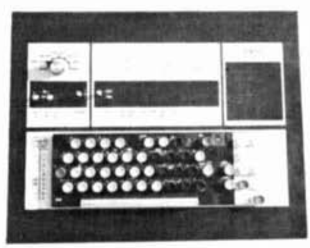

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TEKTRONIC 545A mainframe; B, CA, S plugins, manuals, $1100. Heathkit Q meter, $50; IO-10 DC XY scope, $60. Lafayette CR Analyzer, $25. Sears #2140N lathe & accessories, $225. All like new condition. Jim Ashe, P. O. Box 6, Cambridge, Mass. 02138. (617) 926-4189.

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RTTY SPEED CONVERTER. A drilled 4" x 6½" PCB and all components except input ouput jacks, power supply and chassis. See Dec. '71 and Oct. '72 issue of Ham Radio. $40.00 postpaid. PCB only $6.00. P & M Electronics, Inc., 519 South Austin, Seattle, Washington 98108.

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BROWARD AUCTIONFEST, March 10, 1973 at Broward Community College, 3501 S.W. Davie Road, Ft. Lauderdale, Fla. Hours 9:00 a.m. to 5:00 p.m. Refreshments and unlimited parking. Donation $1.50. Free coffee. XYL's admitted free. No sales commissions. Convert your used equipment into cash. Public welcome.

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6939'S 5 WATTS, 500 MHz. Guaranteed good, $2.50 each. Jack, W6TNR, 15718 Mayall, Sepulveda, Calif. 91340.

3RD ANNUAL NORTH FLORIDA SWAPFEST. March 25, 1973, Fort Walton Beach, Florida at the Community Center on Highway 98 from 8 a.m. to 4 p.m. Tickets and details are available from the Playground Amateur Radio Club, P. O. Box 873, Fort Walton Beach, Florida 32548.

G.E. POCKETMATE, NICADS, leather case $140. W4GBB, 801 Duckview, Winston Salem, N.C. 27106.

HAMFEST — Wabash County ARC Fifth Annual Hamfest, Sunday May 20, rain or shine. Admission is still only $1. Flea market, food, tech talks and much more. For information write Bob Mitting, 663 Spring, Wabash, In. 46992.

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FIGHT TVI with the RSO Low Pass Filter — p115 March 73 — write for brochure — Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada.

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

R390/URR COLLINS digital tuning receiver, .5 to 32 MHz. Operating condition, sacrifice for best offer over $475. Fleming, 1327 Prairie Road, Colorado Springs, Colo. 80909.

HAVE 4-PAGE LISTING of Ham items — can't list all here — bargain prices, big variety, some GR, H-P, etc. SASE appreciated. WA9DYE, 114 Lakeview, Milwaukee, Wis. 53217.

DX'ERS — Dig Them Out of the Mud. New low noise Dual Gate MOSFET preamplifier. Nominal 20db gain. 10-30 MHz. Complete in cabinet $29.96. Dynacomm, 1183 Wall Road, Webster, NY 14580.

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THE GREATER BALTIMORE HAMBOREE will be held at Calvert Hall College, Putty Hill and Goucher Boulevard, Towson, Maryland (one mile south of Exit 28 of Beltway-Interstate 695), on Sunday, April 8, 1973 at 10 a.m. Food service, Flea market, prizes. Registration: $2.00. No table or percentage charges. Info.: Joe Lochte, 5400 Roland Avenue, Baltimore, Maryland 21210.

75A4 FOR SALE, 2 filters, manual, like new condition, serial 5153, $350. Bayard Rowan, W2GKF, 55 Runnymeade Road, Berkeley Heights, N. J.

VHF NOISE BLANKER — See Westcom ad in Dec. '70 and Mar. '71 Ham Radio.

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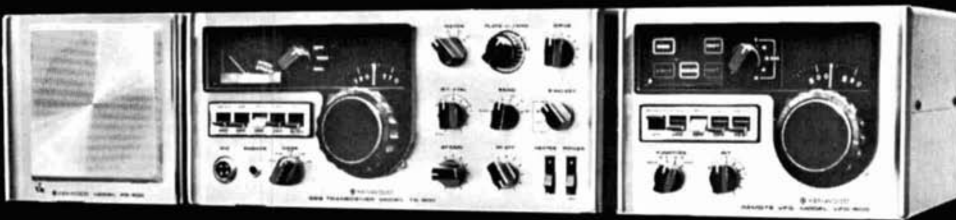

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