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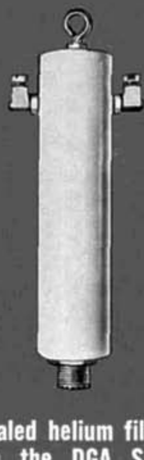

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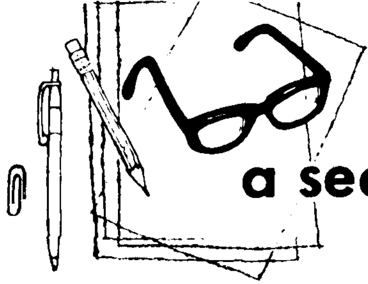

a second look

by jim fisk

The FCC has just approved some additional telephony frequencies within the amateur 80- and 40-meter bands. The Commission decided, however, not to permit any phone expansion on 20 meters, saying it would result in serious degradation to non-voice communications. The Commission also found that the 10- and 15-meter bands were not crowded enough to warrant the expansion of phone segments on those bands. The new phone segments become effective on November 22nd, 1972.

If you will remember, the FCC originally proposed to expand the telephony sub-allocations of the five amateur high-frequency bands in early 1971. Also proposed were changes to expand the operating frequencies for General and Conditional class licensees, and to provide additional phone sub-bands for Extra and Advanced class amateurs where they do not presently exist.

Numerous comments on the proposed rule changes were received from amateurs in the United States, as well as from foreign countries. A delegation from one country even made an official visit to the Commission to discuss the proposals. As can be imagined, foreign amateurs were strongly opposed to any telephony expansion in the United States, particularly on 20 meters.

Since there are no formal, internationally agreed, sub-allocation plans reserving portions of any of the high-frequency amateur bands for any one type of emission, amateurs in various parts of the world operate under informal gentlemen's agreements. Therefore, many overseas amateurs predicted, if U.S. amateurs were permitted to expand their phone operation into the sub-band between 14.1 and 14.2 MHz, that non-U.S. phone stations would retaliate by moving into the 14.0 to 14.1 MHz segment, causing a deterioration in CW and RTTY communications. Hence, the Commission decided not to expand our phone privileges on 20 meters.

The Commission decided not to authorize an expansion of 50 kHz in the 75-meter band for phone operation by Amateur Extra and Advanced class licensees, as originally proposed, but to adopt an expansion of 25 kHz, 3775 to 3800 kHz, limited to Amateur Extra class. Advanced-class operators may now operate from 3800 to 3890 kHz, and General class licensees have phone privileges from 3890 to 4000 kHz.

The 40-meter phone segment has been expanded, as originally proposed, permitting phone operation between 7150 and 7200 kHz. As a result, the 40-meter Novice band has been relocated from 7100 to 7150 kHz. Amateur Extra and Advanced licensees may now use phone on 7150 to 7225 kHz, and the General-class phone segment runs from 7225 to 7300 kHz. The Commission did not adopt a proposal to provide a phone sub-band below 7100 kHz for contacts with stations in Regions 1 and 3, but did adopt the proposal to permit phone operation between 7075 and 7100 kHz for American stations located *outside* of Region 2.

To help beginning amateurs gain experience in CW operation, a new Novice segment was adopted for 28100 to 28200 kHz. Lightly occupied Novice segments 21.2 to 21.25 MHz and 145 to 147 MHz were deleted, leaving a 15-meter Novice band that runs from 21100 to 21200 kHz. And, big news for Novices, transmitters no longer must be crystal controlled.

Jim Fisk, W1DTY
editor

Yaesu presents the great two-meter leap forward

Since Yaesu makes and sells more factory-assembled amateur rigs than any other company in the world, it follows that we'll only place dependable, fully-perfected products on the market.

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Great new features — like Auto-Scan and a special Priority-channel — place the FT-2 AUTO in a class by itself. These unique capabilities are achieved with advanced digital-logic circuits. Here's how they work:

With Auto-Scan on, the receiver scans all 8 channels at 20 channels per second, indicator lights provide a visual channel display, stopping on receipt of a signal. At the end of each transmission, the receiver continues to scan. (Just push a channel button to skip over any channels you wish eliminated from the scanning cycle.) To lock on any frequency being received, simply depress the mike button momentarily. The lock light then glows indicating that transmitter and receiver are working together. To unlock, you again hit the mike button and the receiver continues to scan.

Only Yaesu offers this type of remote, one-handed control of the scanning function.

The Priority-channel feature allows automatic monitoring of a pre-selected frequency. When the receiver stops on a frequency other than the Priority-channel, Auto-Scan will check every two seconds to determine if the Priority-channel is busy. If it is, the receiver reverts instantly to the Priority-channel. Manual or Auto-Scan mode of operation is instantly selectable on front panel. In manual mode, the push buttons function as channel selectors.

The FT-2 AUTO will operate from either 117 V AC or 12 V DC power sources.

Receiver/transmitter specifications include: selectable 10 Watt or 1 Watt power-output levels: a frequency-adjustable tone-burst generator for repeater activation: 0.3 uV sensitivity for 20 db quieting; 10.7 MHz crystal filter, in addition to a 455 kHz ceramic filter, for superb adjacent channel rejection; adjustable deviation and mike gain controls; Hi-Q slot-coupled resonators used in receiver front end; all solid-state construction, with diode-protected MOSFET input stage.

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NOTE: Both units are supplied with crystals for simplex operation on 146.76 MHz, 146.82 MHz, and 146.94 MHz. Additional crystals are $5.00 ea.

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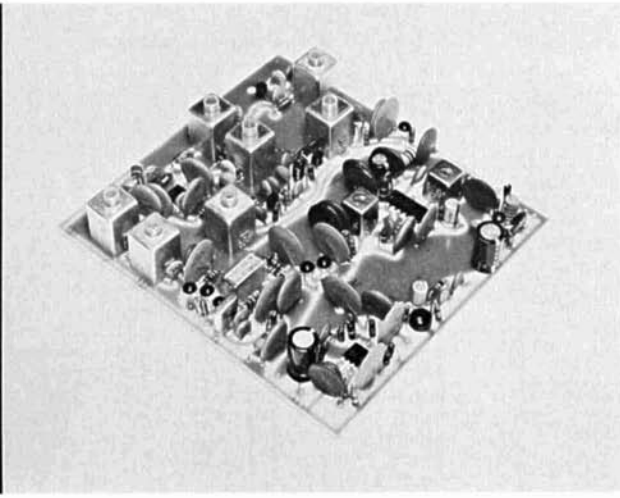


vhf fm receiver

A versatile high-band or low-band state-of-the-art vhf fm receiver

Jerry Vogt, WA2GCF, 182 Belmont Road, Rochester, New York 14612

Are you looking for a compact, low cost receiver to use with your new homebrew fm transmitter to make a good transceiver? Are you interested in trying fm without investing a lot of money for a transceiver right away? Do you need an extra receiver around the shack to monitor your local repeater or calling channel while you're off on another frequency? Do you and your wife have a private frequency for house-to-car that you would like to monitor? Would you like to build a low cost, but high quality, receiver for the commercial, marine or public safety band? Do you hate to buy something that you can build yourself, either for satisfaction or to learn what makes it tick? I might have the answer if you enjoy homebrew work! This can be an exciting winter project for you.

For several years, as I have developed numerous homebrew receivers, I had the feeling that more hams would be rolling their own if someone who had refined the art of receiver construction would show them the tricks or perhaps make a basic kit available. I had written many notes to kit manufacturers, trying to prompt them to put out module kits; thereby allowing the ham to build the difficult part of a receiver from available kits and then custom finish the receiver by adding case, speaker, controls and other peripheral goodies. Evidently, the low market volume or lack of faith in the ability of the advanced ham builder caused the idea to be scrapped. Too bad!

Then, along came fm activity amongst hamdom. I got bit, and I jumped in head first as I usually do in any new venture. I turned all my homebrew efforts into building receivers (my favorite) for two-meter fm. At the same time, I began to go all solid state. The rapid growth of integrated circuits made receiver construction more fun by injecting a bit more magic into the art.

Over a period of three years, I developed nine fm receivers, including narrowband receivers for two meters and the high public-safety band (I am also a volunteer fireman) and one for fm music (what the ICs were really intended for). The subject of this article is a receiver developed especially for readers of *Ham Radio*, the cream of the homebrew ham crowd. Unlike previous designs, this one is not tailored to my individual needs, but is designed to allow maximum flexibility consistent with low cost and ease of construction and alignment.

This is a big undertaking, since I vowed to make all the special parts available to allow anyone to build it. However, I am encouraged that it will be a big hit, because I have previously done the same thing with six- and two-meter preamps and other projects.[1] I was delighted with the response; especially the letters which followed from hams all over the world, indicating that hams do want to build, that homebrewing is not a lost art, and that all the average ham wants is a little headstart in knowing where to start and how to get parts.*

design considerations

Let me say from the outset that this design uses some of the fine goodies available to make the set reproducible, including mosfets. Anyone having read my earlier article will undoubtedly question my use of mosfets after having spoken out against them in the previous article. I am a big cascode pusher, being all in favor of its obviating the need for neutralization. The only real objection to mosfets was in their fragility, being susceptible to damage from static discharges before being soldered into the circuit. Recently, protected gate mosfets have been developed to eliminate that problem. The MPF-121 dual-gate mosfet used in this design is a homebrewer's dream; it is the answer to a "cascoder's" prayer. Besides being inexpensive, it, like other cascode devices, requires no neutralization. The noise figure is relatively low, and it is relatively immune to cross-mod overload.

features

Enough editorializing! From here on, I will discuss the circuitry and construction of the receiver. I will leave the finishing touches, such as case, controls, etc., to your imagination, and I will concentrate on the inner workings. I am sure that the average *Ham Radio* reader is above being sucked into building a project because of

*The following components are being made available in conjunction with this project. Be sure that you specify exactly what you want, including frequency bands. Complete parts kit for A1 assembly is available with undrilled circuit board for $54.95, or with pre-drilled board for $59.95. Six-channel oscillator board A2 parts kit is available with undrilled circuit board for $9.95, and with pre-drilled circuit board for $12.95.

Channel crystals are available separately. ZIP certificate for monitor crystal (shipped directly from the factory when you send the certificate) is available for $5.00. A kit containing a 3 x 5-inch, 16-ohm oval speaker and squelch and volume controls is offered as an accessory at $5.95.

Delivery on all items is subject to availability at the time of receiving your order. Every effort will be made to supply your requests as soon as possible, and you will be notified if there will be a delay in shipment. Expected time of delivery is about two weeks. Quantity prices are available on request for clubs and individuals interested in local distribution to hamfests, etc.

All prices are in US$ and include postage for domestic parcel post. Write to Hamtronics, Inc., 182 Belmont Road, Rochester, New York 14612.

a fancy panel which he probably doesn't have equipment to reproduce. Many articles have been written around finishing techniques if you are interested, and the variety of methods is endless.

The basic receiver consists of one to build and test the basic receiver first; subsequently building and substituting the multichannel board, A2, for the basic oscillator on the A1 board.

Note that construction information in later pages gives data for covering any of

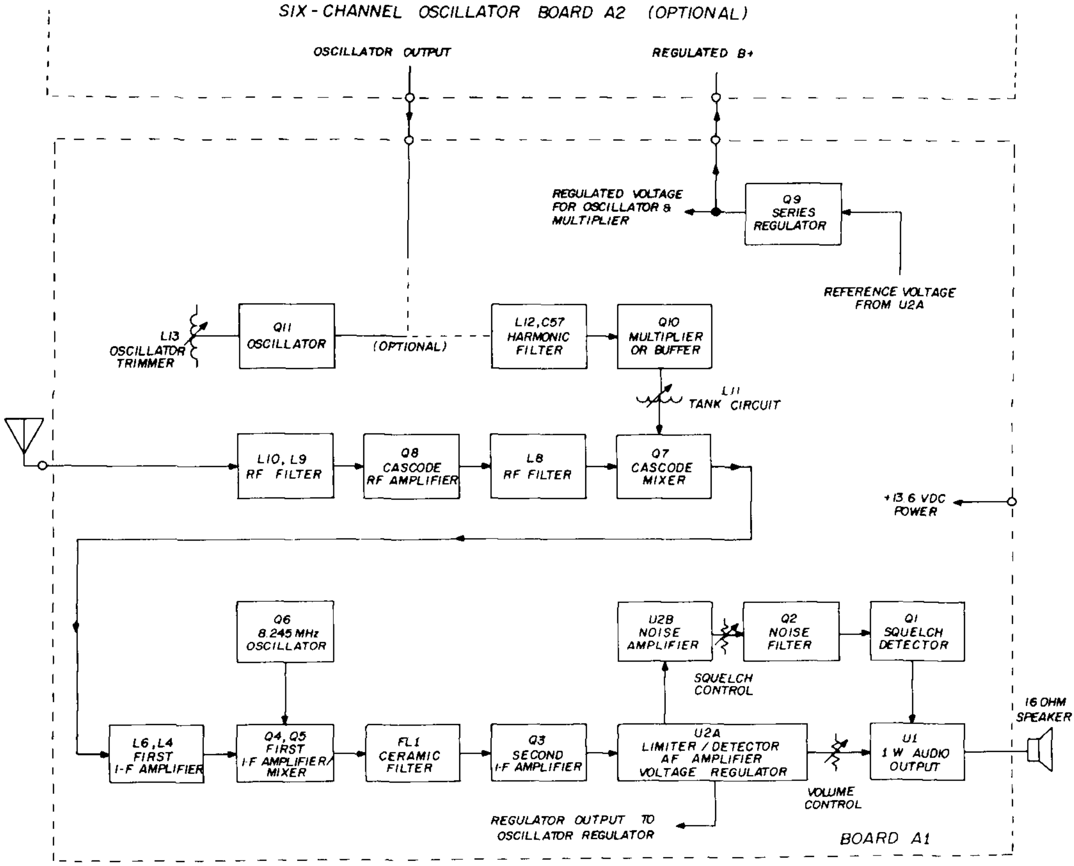


fig. 1. Functional block diagram of the vhf fm receiver.

printed-circuit board as pictured. The board, dubbed assembly A1, incorporates a one-channel oscillator, with a separate (A2) board available to allow six-channel operation, if desired. The advantage of this scheme is that if a user wishes to monitor only one channel, small size and low cost makes such an application attractive. However, for multichannel operation, it is still very easy to add the extra channels. One recommended procedure is four bands with the receiver: 6 or 2 meters or either low or high commercial band. Although a quality receiver, the cost of the parts involved allows the receiver to be very competitive with the cheapie monitors available on the market for public-safety monitoring, to say nothing about having a better one than your neighbor.

The receiver as described uses a one-watt IC audio amplifier, which should suffice even for mobile operation. However, if desired, the receiver can be used to drive a higher power audio amplifier, such as the one I wrote up previously[2]. The same holds true for sensitivity. The receiver has been designed to be a good receiver for various applications, including requirements for minimum cross-mod in the front end. If you wish, a preamp can be added to obtain slightly better sensitivity. However, this is left optional, since you may be in a high signal level area where high front-end gain and selectivity against unwanted interference are mutually exclusive.

functional description

A block diagram of the set is shown in **fig. 1.** The rf signal from the antenna passes through two tuned circuits, L10 and L9 with associated capacitors, and is amplified by dual-gate mosfet Q8. The amplified rf signal is filtered again and applied to gate 1 of dual-gate mixer Q7. The injection to mixer Q7 is applied to gate 2, and rf signal is applied to gate 1, thereby providing slightly additional gain and better isolation. The output of Q7 is applied to first i-f filter L6/L4 to select the signal-minus-injection-frequency mixer product at a frequency of 8.7 MHz. This frequency was chosen to provide good operation at either high band or low band and to provide good image rejection with a fairly simple filter scheme.

Injection for mixer Q7 is obtained from Q10 at the optimum level of approximately 1-volt rms. Q10 functions as a tripler for high-band operation and as a buffer for low-band operation. The input to Q10 is applied either from internal oscillator Q11 or from multichannel board A2 through harmonic filter L12/C57, which is a series-tuned trap. This minimizes spurious mixer injections.

The oscillator crystal is trimmed with series inductance to allow a vernier adjustment of about ±1.5 kHz for netting to channel frequency. Using a coil rather than a variable capacitor provides a much easier method of adjustment because of the multi-turn range of a slug-tuned coil as opposed to a 180-degree capacitor swing. The B+ for the oscillator(s) and multiplier/buffer is obtained from series pass transistor Q9, which uses an existing regulated voltage inherent in the detector IC for a reference.

Note that part of the magic art of receiver building is the knowhow in bypassing each circuit element to common ground. Optimum values for each frequency are chosen for frequency of resonance to provide ideal rf grounding. Likewise, the decoupling between stages must be done very carefully to prevent random transfer of rf energy between stages on the B+ line. Such measures not only ensure that oscillation will be suppressed, but provide optimum gain in each stage. In some cases, multiple bypasses were used to provide grounding at more than one frequency. The selection of coupling and tuning capacitors in the front end is also a fine art, ensuring optimum transfer of signal without overcoupling or under-Q'ing tuned circuits.

The first i-f signal from L4 is applied to Q4/Q5, a cascode mixer/amplifier. Refer to the schematic (**fig. 5**) temporarily. Oscillator injection at 8.245 MHz is generated in dc-coupled oscillator Q6. This transistor is connected directly from the base of Q6 to the base of Q4. I don't know that this trick saves anything but two resistors and a capacitor, but I thought it was cute. (Might as well tell the truth!) Regency has a scheme using an MC-1550 coupled to a discrete oscillator this way. I thought it was a good trick, but I went a step further. A friend of mine convinced me that there is no excuse for using MC-1550s for a simple amplifier or mixer, so I replaced the one previously used here with two discrete transistors and a few resistors. You might want to try this trick in other circuits you build. Bypass the second base, and you have a neat cascode amplifier.

The second i-f output of 455 kHz from Q4/Q5 is filtered by a bandpass ceramic filter. This is one of the greatest little devices going! Essentially, it is an integrated-circuit Permakay filter, hardly any bigger than a dip IC. I chose one with nine poles (nine ceramic elements) which provides a selectivity of ±7.5 kHz to allow operation on either narrow-band or quasi-narrow-band signals (as used by most hams nowdays).

The ceramic filter described is much smaller than a crystal filter and is considerably less expensive than the $30 approximate price of equivalent crystal filters. In addition, it is easy to match, requiring only a resistive 1500-ohm load at each end. Being composed of ceramic elements, no dc blocking capacitors are required either. The only drawback is that they must be imported so they are not readily available in single lots.

The filtered second i-f signal is amplified by Q3 and transformer coupled through an i-f can into U2A. Q3 is another attempt to stamp out needless ICs. An MC-1550, as originally used, adds nothing over a discrete transistor. The second i-f signal is applied to a 70-dB limiter amplifier in U2A, which consists of a series of differential amplifiers. The limited i-f signal is detected by a differential-peak detector in U2A. A separate stage in U2A provides a low-impedance audio-driver stage to feed the volume control and squelch circuit. Also incorporated in U2 is a series of voltage regulators which provide regulated +11 volts for operation of the IC. Some of the regulated voltage is tapped off to provide a reference voltage for the pass transistor in the front-end oscillator section.

Audio from the volume control is applied to an integrated circuit one-watt audio amplifier, U1. A complex series of de-emphasis networks is used in conjunction with U1 and Q2 to provide high-frequency roll off required for fm operation. The output of U1 is capacitively coupled to a 16-ohm loudspeaker provided externally. The 16-ohm load is optimum for a one-watt speaker driver amplifier such as U1, so you should strive to obtain a 16-ohm speaker and not use your old 3-ohm speakers, although they will work to some extent. They will draw more audio current than normal through U1, so the level should be held down if a low-impedance speaker is used.

An additional audio output from the preamp in U2A is provided to a separate section of U2, dubbed U2B, which is an audio amplifier normally used to drive a power transistor. Since this function was redundant to the requirements for operating U1, I used this section as a noise amplifier for the squelch circuit. Coupling circuits and a selective filter network in the emitter circuit of noise filter Q2 were designed to pass a narrow band of noise frequencies around 20 kHz. This noise component is present only in the absence of a carrier from an incoming signal, so it provides good reliable squelch operation. (This is not the case with the CA-3089, which operates on the presence of a directly detected carrier. That system allows any rise in signal level or noise level to open the squelch.)

The 20-kHz noise signal is detected in Q1 to provide a filtered dc signal to squelch trigger one input of audio amplifier U1 to provide quieting of the otherwise-present noise output when no signal is present. It is common practice to use a separate squelch gate to mute the audio path; however, my research has shown that it takes redundant components to do that with results which sometimes are not as good. Often, diode gates allow noise leakthrough when no signal is being received. Transistor gates operate fairly well, but in the same manner as squelching the IC directly.

detailed circuit descriptions

Now that your curiosity about the receiver is satisfied, let's take a look at the inner workings of the integrated circuits and their applications in the receiver.

Refer to **fig. 2**. The Motorola MFC-6070 one-watt audio amplifier is very similar to the discrete direct-coupled amplifier circuit developed by Motorola several years ago, using complimentary transistors. The primary differences are that all transistors are npn and that the input stage consists of a Darlington differential arrangement. Normally, the input signal is applied to pin 3 and negative feedback is applied to pin 2. Pin 1 is grounded, and pin 5 has B+ applied. Pin 4 has B+ applied through a bootstrap arrangement to provide clean response at high input peaks. Two diodes in series between bases of the power transistors in both sides of the circuit set the bias difference to prevent cross-over distortion.

A capacitor from pin 6 to pin 4 stabilizes the amplifier against high frequency oscillation. The output is capacitively coupled (no transformer required) to a 16-ohm speaker load. In this case, the speaker was returned to ground for convenience, although it is common practice in consumer equipment to return the speaker circuit to B+.

Biasing is applied to pins 2 and 3 in approximately equal amounts for normal operation. In this application, I returned the biasing circuit for pin 3 (not shown) to the squelch detector to provide squelch control. When no signal is present, full B+ is applied to one side of the differential input stage on the MFC-6070 to effectively cut off the audio output by saturating the amplifier.

The MC-1358PQ, shown in **fig. 3**, is a country cousin of the MC-1357 and the ULN-2111A integrated circuits which have been around for a few years. Although the former and latter are priced the same, the MC-1358 has all kinds of added goodies. One added feature is an array of voltage regulators as shown in the upper left corner. B+ is applied to pin 5 through R_S, which drops the +13.6Vdc to the +11Vdc established by the shunt regulator consisting of a pair of zener diodes. Other devices in the section supply various reduced bias voltages to the individual signal stages.

The input i-f signal is transformer fed to pins 1 and 2, which provide a differential input port. The signal is amplified

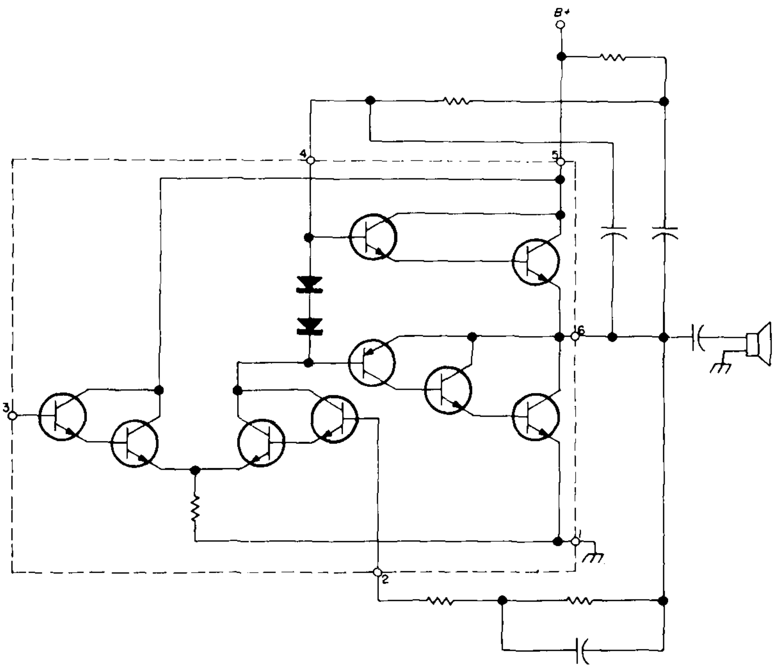
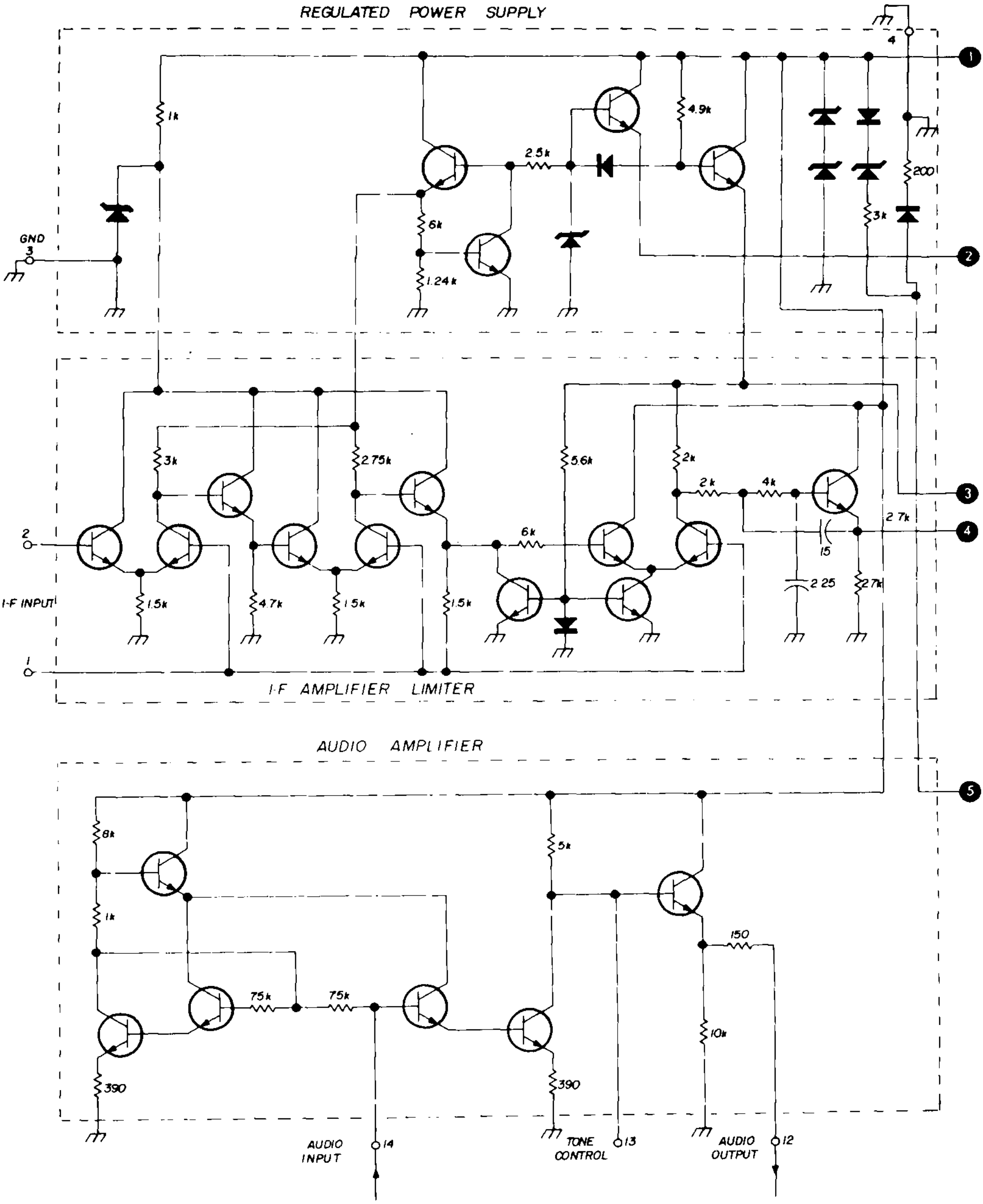


fig. 2. Basic schematic of the Motorola MFC-6070 one-watt audio amplifier.



and limited by a four-stage 70-dB amplifier arrangement and applied to the detector section. Unlike the quadrature detector used in earlier ICs, the MC-1358 uses a differential peak detector. The signal is peak detected in two sides of a differential circuit. The 15-pF capacitors incoroporated in the circuit are actually part of the peak detection process.

The signal is applied directly to one side of the detector and is applied to the other side through a tuned-circuit ar-

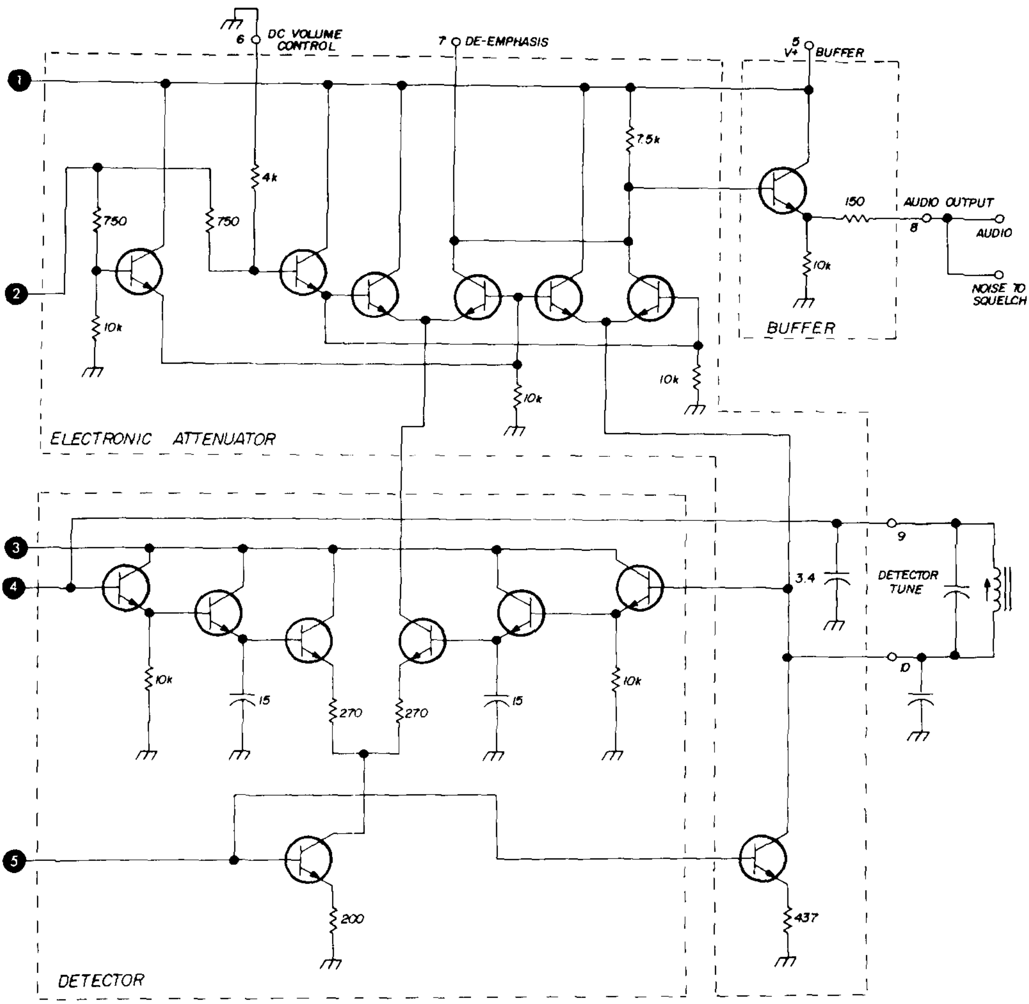


fig. 3. Basic diagram of the Motorola MC-1358PQ sound i-f circuit.

rangement to provide a frequency-sensitive component to shift the level (not the phase) of that signal. Thus, depending on instantaneous frequency, the inputs to the two sides of the detector will be different and produce an output difference. As the frequency changes, the relative difference of the two inputs changes, causing an audio output signal to be generated. The tuned circuit consists of a pi-network, employing an internal 3.4-pF capacitor on one end and an external 20-pF capacitor on the other end to provide a slight impedance transformation from pin 9 to pin 10.

The audio output from the detector is *applied to an electronic* attenuator section. In television usage, this section normally provides about 80 dB of audio attenuation variable by connection of a 50k dc potentiometer to pin 6 of the IC. In this application, though, I couldn't take advantage of this feature, since reducing the signal level at this point would also reduce the noise output to the squelch circuit. This section and the adjacent buffer do provide the desired audio output level and low-impedance output, however, and partial de-emphasis is performed at this area by connection of a capacitor from pin 7 to ground. Full de-emphasis is not done at this point, though, since you need considerable high-frequency noise output to operate the squelch circuit.

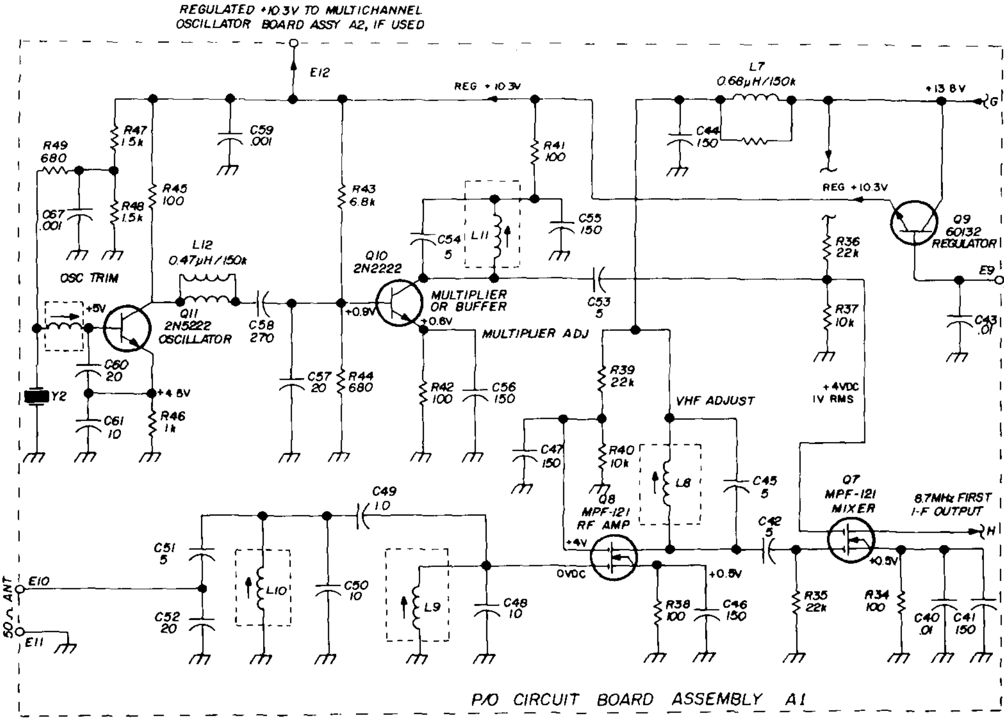


fig. 4. Front-end section of the vhf fm receiver. Coil and capacitor data is given in table 1.

The audio amplifier section at the lower left corner is intended to be used for driving the low-impedance input at the base of a power transistor. However, not needing such a low impedance and high drive level for the MFC-6070, I used this amplifier section as a noise amplifier for the squelch circuit. The three stages provide about 40 dB of gain, and small coupling capacitors were used to begin the low-frequency rejection process in feeding the noise-filter stage. Care must be taken in designing noise amplifiers to prevent high levels of low-frequency audio from driving a high-gain noise amplifier, since this would result in clipping-produced distortion which would "pump" the squelch circuit during normal voice reception.

channel crystals

Channel crystals, Y2 for A1, or Y1 through Y6 on multichannel board A2, are third-overtone, series-resonant types in HC-18/U (miniature, wire lead) holders. The formula for operation on 2 meters or the adjacent high commercial band is:

$$F_{xtal} = \left(\frac{\text{channel frequency} - 8.7\text{ MHz.}}{3}\right) - 1\text{kHz}$$

For 6 meters or the adjacent low commercial band, the formula is:

$$F_{xtal} = (\text{channel frequency} - 8.7\text{ MHz}) - 1\text{kHz.}$$

One kHz is subtracted from the final calculated frequency to allow the pulling range of the crystal to be centered at the channel frequency, since the system tends to have much more range at the high side than at the low side of the true series-resonant frequency.

Various types of crystals are available, and almost any good crystal house can supply them. The type desired depends on the use of the receiver and the wouldn't bother spending extra money for the more expensive crystals.

semiconductors

At this time, there are no direct substitutes for the integrated circuits used in this receiver, although there are a variety of different audio output ICs available which could be used with differ-

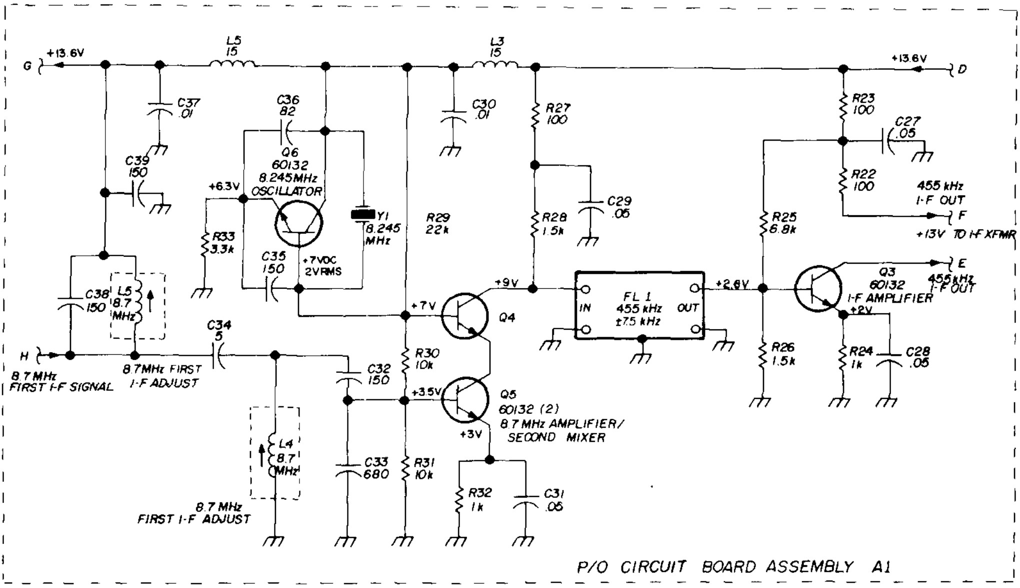
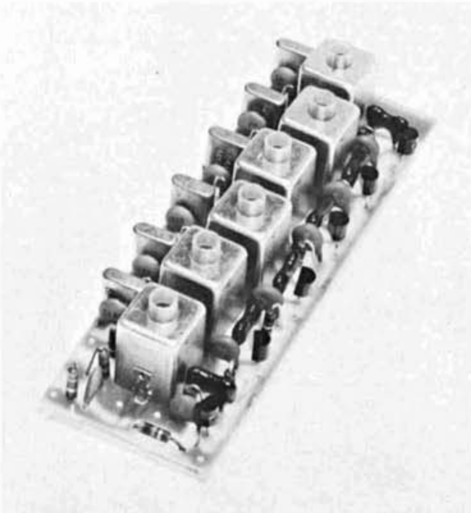


fig. 5. I-f section of the vhf fm receiver, including the first and second i-f filters. Filter FL1 is a Japanese ceramic filter with a bandwidth of 14 kHz.

environmental temperature range which will be encountered. For monitor receiver use in the shack, I would recommend monitor set crystals, available for about $5.00 from many sources. My firm, Hamtronics, sells Crystek's monitor crystals, since they are available quickly on a crystal certificate basis and are mailed directly to the customer. For operation over a wide range of temperatures, as in mobile operation, I would recommend the standard commercial type of crystal, which has a specified temperature curve. They cost around $6.50. The circuit itself is stable, so the overall stability with temperature variations will depend almost entirely on crystal quality. If you will be in the shack all of the time, though, I wouldn't bother spending extra money for the more expensive crystals.

ent connections. In discrete devices, the 60132 is our house-numbered general purpose npn high frequency silicon transistor; it can be replaced by any good 200-MHz F_T unit. The 2N5172 is a very attractively priced transistor, having a single lot price tag of about 16 cents. The 2N5222 is a 450-MHz silicon type which is specified with closer tolerances than the 2N5172, although it is a similar type with a fairly low price. The 2N3644 is a high-gain 60-MHz unit of the pnp silicon type. In the applications in this receiver, any pnp silicon type with high gain at i-f frequencies can be used.

Unless otherwise specified in the schematic diagrams or in the text, all resistors are ±10%, ¼ watt; all capacitances marked in whole numbers are in picofarads and those specified in fractional numbers are in microfarads; all coil inductances are in microhenries. Dc test voltages for various idling conditions are marked on the schematics at significant test points for troubleshooting purposes.



The six-frequency crystal deck.

coils and chokes

Before assembling the receiver circuit board(s), it is necessary to wind the rf coils, high i-f coils, and one or two rf chokes. Data for coils is given in **table 1**, and the coil winding technique is illustrated in **fig. 9**. Winding your own coils has two advantages. First and foremost, is the cost savings. Second is the fact that you can do as well as the finest inductors commercially available.

Rather than buy an expensive off-the-shelf coil form, we have ours custom made by the largest houses in the industry. We use the types basically made for commercial two-way sets. I say houses because the form is made by one manufacturer, the slugs by a second, and the shield cans by a third. Unfortunately, these people don't even like to deal with us for 10,000 pieces at a time, but we manage to have them made to our specs regardless. We do this so you don't have to struggle with fragile ceramic forms with loosely fitting slugs. The forms used, by the way, are 10-32 types of 0.8 inch length. Cans are half-inch square by three-quarters high with Berg solder lugs. The slugs are 10-32 x 3/8 inch long with a small hex slot.

Coils are wound as shown in **fig. 9**. Soldereze number 26 wire is used so that insulation is thermally stripped with your soldering iron. Carbonyl – J slugs are used for all applications except the 8.7 MHz first i-f coils, L4 and L6, which use slugs of carbonyl TH material identified by a different color. To wind a coil, insert about a half inch of wire through any of the six plastic funnels in the base of the form. Bend the wire at right angles to the base, and begin winding with turns tightly spaced. After the proper number of turns is applied, make a right angle bend in the wire, trim the end to allow a half inch protrusion, and insert the wire through the funnel opposite the starting funnel. All coils are specified in half turns, so that windings finish 180 degrees around from the starting funnels.

After the coil is checked for proper number of turns, perform the following magic. Lock a tuning tool in your bench vise, and insert the slug in the form. Slip the coil and slug over the tuning tool so that the coil is stationary with the funnel end of the base outward. Using a hot soldering iron, tin the insulated Soldereze coating on the wire, starting at the tip of the wire where there is no insulation at the end. As the wire heats up, the insulation will melt off, and the wire will tin with the solder applied to the iron.

Continue up the wire to within about 1/32 of an inch of the form. You will have to remove the iron quickly when solder reaches that point. When done, the plastic at the funnel will melt slightly and bond the wire to the form, making a neat coil assembly. The other lead should be done in the same way. The coils are eventually mounted at the bottom by the leads being soldered to the circuit board, and the coil tops are held rigid by the tops of the shield cans, which slide over

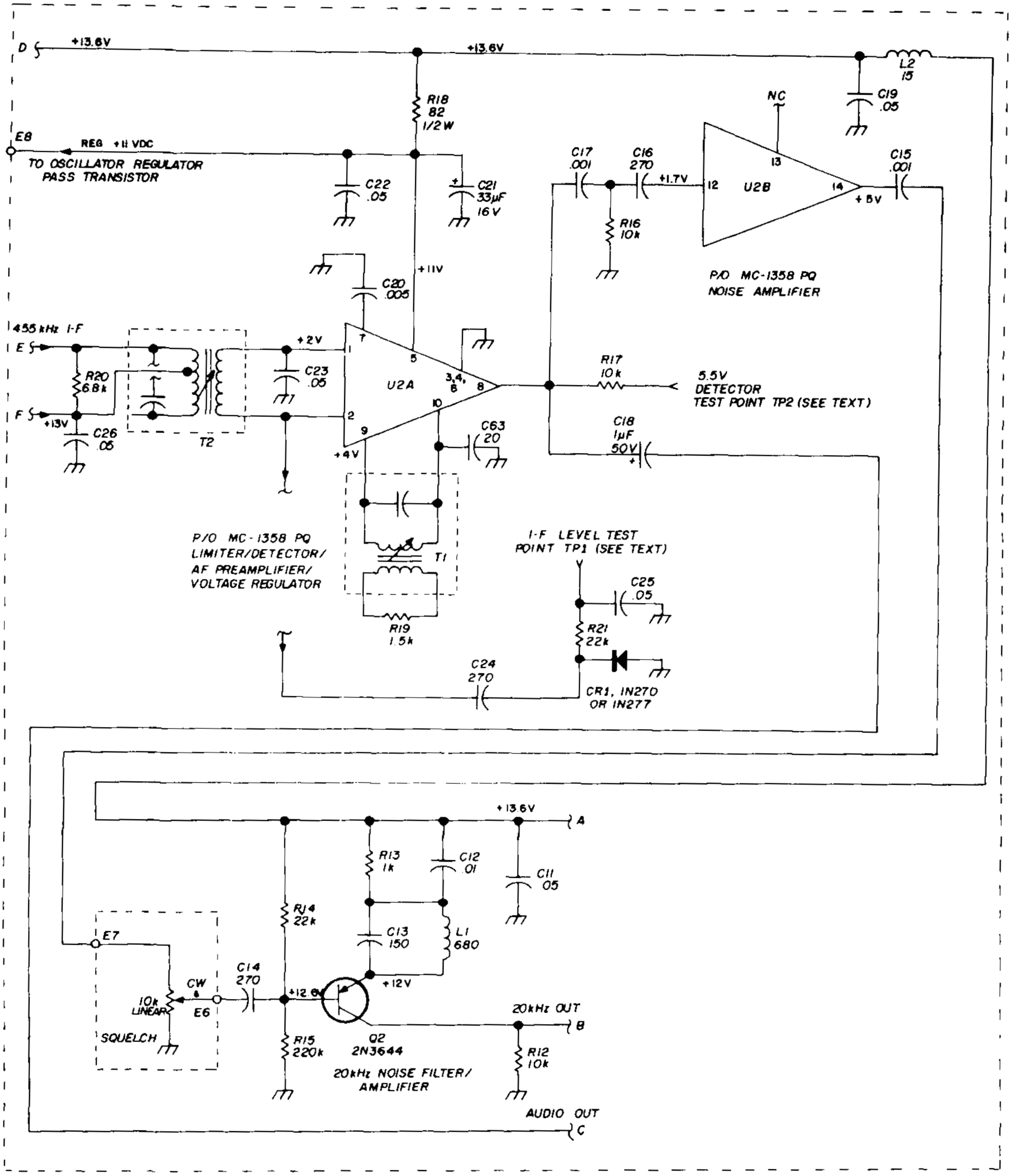


fig. 6. Limiter/detector section of the receiver. Note the test points provided for alignment. The squelch control is external to the circuit board.

the tops of the forms. This gives you a professional, modern coil assembly which will amaze you. Our preamp customers have been writing for parts so they can use these coil forms and shields in other projects.

I have started using hand-wound 0.47- and 0.68-μH rf chokes, since paying a lot of money for a part so easily made goes against the ham instinct, once you know the tricks. **Fig. 10** shows you how to make these. Chokes are wound with number 28 Soldereze wire, which is the smaller size supplied with the kit. A 150k resistor was used, although any ½-watt resistor with a high resistance will work well as a form. Wrap two or three turns around the lead near the body at one end. Wind on the 17 or 20 turns, which will fill most of the length of the resistor body, and then terminate the other end in the same manner. Twist the wire around the body tightly, and then solder away the insulation to make the connection to the resistor leads. You now have an rf choke!

For those of you interested in making other values for general use in your own projects, you can scale the turns as being in proportion to the square root of the inductances. The tricky part is that the series self-resonance must be well below the operating frequency. I use a Q-meter to check inductance and a vhf signal generator (HP-608) and an rf voltmeter to check resonance, but a good grid dipper can be used (if you can find one good over 100 MHz).

board layout

If you decide to lay out your own pc board(s), general vhf layout techniques should be used throughout. Even the integrated circuits, although operating at 455 kHz and audio, require special layout precautions due to the high impedances and high open-loop gains involved. Single-sided boards work well if layout is good and sufficient areas of ground plane are provided; however, stay away from board materials with poor dielectric properties. General layout can be seen in the photograph.

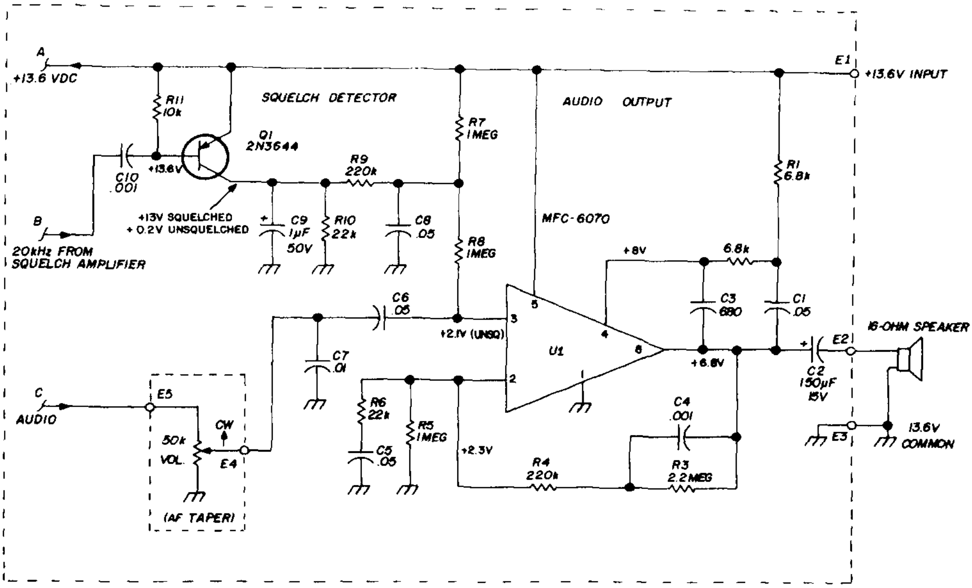


fig. 7. Squelch and audio section of the receiver. Volume control and speaker are external.

Since doing a good tape-up can take several weeks of effort, I suggest that you write if you only need one or two boards, and we can probably help you out. It is most practical to obtain the kit, however, to get the coil forms and filter as well as the board(s).

construction sequence

I have a philosophy about building a project like this which has been developed by hard knocks. In general, when building anything, I progress one or two stages at a time, testing as I complete each section. Things do go wrong: a *wrong part in a certain place, a bad solder* joint, or even a defective part. It is much easier if you build and test in sections, verifying the proper operation up to a certain point before introducing more variables. Anyone who has built some project only to find that it oscillates (assuming it shouldn't) can tell you how hard it is to narrow it down if this plan isn't followed. Also, with receivers, I find it is always best to start at the speaker and *work backward. You may have* noticed that even the component reference designators are numbered in that direction.

With the section-at-a-time approach in mind, the schematics have been carefully broken down into convenient functional sections and pc board A1 had been laid out to allow testing after building each section as shown. You should start with the audio section in **fig. 7** and work toward the antenna. In that way, the speaker and audio output stage will act as an extra test aid so that you can hear what's happening as you progress. For testing each section, a signal generator can be connected to the components at the left side of the schematic (sometimes through a blocking capacitor).

As a matter of fact, by the time you get the high i-f working, you can connect an antenna and possibly hear some short *wave stuff. (You remember what that is!)* When you get to the front-end section in **fig. 4**, you should mentally break the schematic into two smaller sections, and build and test the oscillator and multiplier (or buffer) first. If you are planning to use an A2 multichannel board, you should either build and test that first, or better, build the single-channel arrangement on the A1 board for initial testing purposes and make A2 a separate project. *Life is simpler that way!*

construction notes

Following are some practical suggestions to consider when assembling your receiver.

1. Check and double check the direction in which the various components should be installed. In particular, take care when inserting the leads of transistors, ICs, electrolytic capacitors and the ceramic filter. The filter which I used is said to operate ok when reversed but with somewhat more insertion loss. If you use the Hamtronics kit, note that resistors mounted in a stand-up arrangement may be oriented with a lead coming off the top facing a certain pad. (Drawings with the kit show preferences.) A preference may be to protect from shorting to adjacent leads, or in the case of TP1 and

table 1. Coil and capacitor data for the vhf fm receiver.

	2 meters	high-band	6 meters	low-band
L4	28½ turns	28½ turns	28½ turns	28½ turns
L6	26½ turns	26½ turns	26½ turns	26½ turns
L7	0.68 μH	0.68 μH	5.6 μH	5.6 μH
L8	3½ turns	3½ turns	9½ turns	9½ turns
L9, L10	2½ turns	2½ turns	8½ turns	8½ turns
L11	3½ turns	3½ turns	10½ turns	11½ turns
L13	11½ turns	11½ turns	11½ turns	12½ turns
C39, C41, C44, C46, C47	150 pF	150 pF	680 pF	680 pF
C42,C53,C54	5 pF	5 pF	15 pF	15 pF
C45	5 pF	5 pF	20 pF	33 pF
C48	10 pF	10 pF	20 pF	33 pF
C49	1 pF	1 pF	2.2 pF	2.2 pF
C50	10 pF	5 pF	10 pF	15 pF
C51	5 pF	5 pF	20 pF	20 pF
C52	20 pF	20 pF	50 pF	50 pF
C55, C56	150 pF	150 pF	0.001 μF	0.001 μF

TP2, the top resistor lead provides a convenient test point connection.

2. In this day and age, you needn't worry too much about heat sinking semiconductors. Just make sure you use a good, clean pencil-type soldering iron, and make your solder connections quickly.

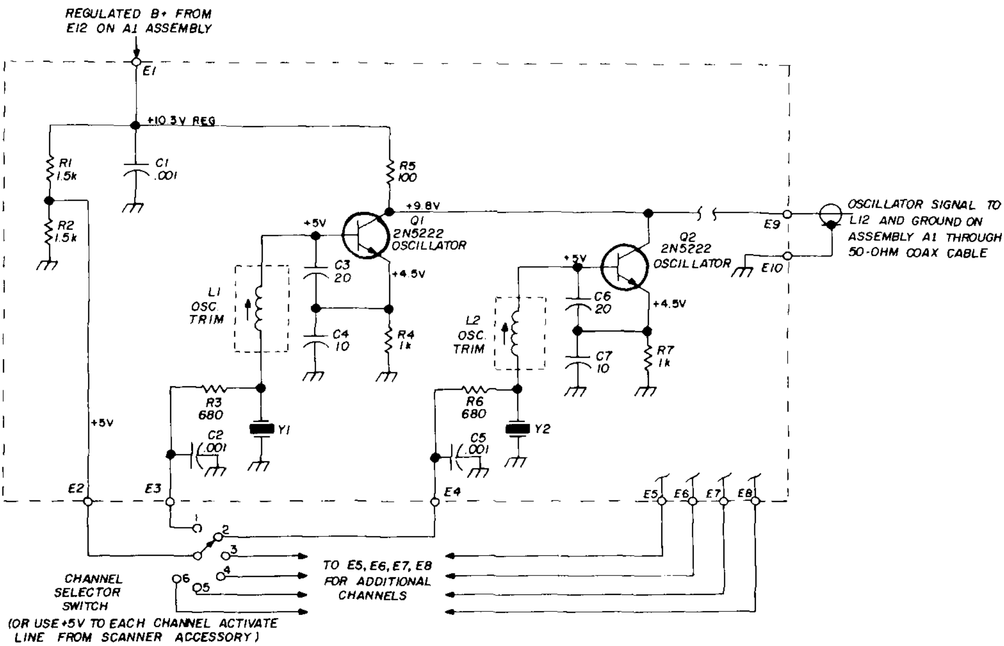


fig. 8. Circuit board A2 which may be used to provide multichannel operation of the vhf fm receiver. Six channels are included on the board, but only two are shown here.

Generally, pc board land areas can become separated from the board material long before a semiconductor device is damaged. Nowdays, most parts are made to allow flow soldering in mass production, so think accordingly. If you want to worry about your semiconductors, check the transients on your power supply and your polarity when making connections. These are the things which hams forget to check until it is too late!

3. If you wash your finished board off with solvent to remove excess flux, watch out! Plastic parts can become swollen and deformed with solvents such as trichloroethylene. Freon is probably safest. (I learned the hard way by destroying the coil forms in about 50 preamps because I wanted to wash them nicely with trichlor.) If you use good solder, you shouldn't have to worry about cleaning the board except for appearance sake. (I find that popular multi-core solder leaves the darkest, messiest flux residue, so I threw mine out.)

4. After coil forms are soldered securely in place, the shield cans should be installed over them; and the lugs should be soldered to the board, both to make good ground connections and to provide mechanical rigidity.

testing and alignment

As previously suggested, it is advisable to build and test a section at a time, beginning with the audio portion in schematic **fig. 7** and working backwards toward the antenna. The following test equipment should be available.

1. Vtvm or fetvm, preferably one which has a dc range that can indicate full scale values of about 250 mV.

2. Vhf and hf signal generators left on long enough to be fairly stable. No modulation required. An hf signal generator will suffice if harmonic frequencies can be determined fairly well.

3. Power supply, regulated or unregulated to provide +13.6 Vdc filtered fairly well with a current rating of 500 mA. Be sure the power supply has no voltage transients.

4. Rf probe for vtvm. See ARRL handbook for an easy one to build if you don't already have one. Works fine! Required for checking oscillators.

5. Frequency counter for vhf range – optional to check oscillator frequencies. Can also be done with on-the-air signal checks.

To augment alignment procedures, two test points have been designed into the receiver, including an rf level detector for measuring relative signal levels at the i-f stage. This is roughly equivalent to checking limiter current in a tube-type receiver. This is a novel feature not often found even in professional commercial radios.

A completed receiver normally draws about 75 mA (1 watt) when squelched and about the same amount unsquelched with the volume turned down. Current increases rapidly as audio level is increased, but shouldn't exceed 300-400 mA on peaks. Of course, when testing the first section by itself, current drain will be relatively low.

Begin testing the audio circuit in **fig. 7** by connecting the external speaker, volume control and power to the board as shown. Check the current drawn from the power supply to be sure that it is less than about 50 mA. At this point in construction, the squelch circuit has no drive, so the audio output stage should be operative. You should be able to hear hum if you touch your finger to the volume control at E4 or E5, and you should be able to hear an audio signal (from any radio or audio generator) patched into point C on the schematic (top of volume control).

No appreciable distortion should be evident unless you have an ac ground loop from the audio source causing superimposed ac garbage. You should be able to measure the dc voltages marked at terminals of semiconductors on the schematic. Values aren't critical and vary with component tolerances and line voltage; so don't get shook if your values vary somewhat from the ones marked on the schematics.

With respect to the MFC-6070 audio amplifier, note that Motorola states that because of the high open-loop gain, it may be necessary to install an oscillation suppressor for high frequencies if the speaker impedance or very long leads to the speaker cause a reactive load of certain types to be applied to U1. I have not encountered this problem. However, I will mention the fix just in case someone should have need for it. A series R-C network, consisting of a 10-ohm resistor and a 0.1-μF capacitor, is connected from output pin 6 of the IC to pc board common to correct an oscillation.

After completing the limiter/detector section shown in **fig. 6**, you can connect a 455-kHz signal generator through a 0.05-μF blocking capacitor to point E on the schematic with the shield connected to pc board common ground. The nominal level for testing should be about 5 mV at first. Temporarily connect the dc probe of a vtvm to pin 5 of U2. Be careful not to short to adjacent pins. Measure and record the regulated dc voltage at this point. Nominal level of +11 Vdc can vary according to the tolerance of zener diodes in U2. Divide the measured voltage by 2. The calculated voltage (about +5.5 Vdc) is roughly equivalent to zero on a discriminator meter when measuring the voltage at TP2, the top of resistor R17. The direct-coupled emitter-follower audio-output stage in U2 will present a variable dc voltage dependent on i-f signal frequency after alignment. With zero-deviation (center frequency) input signal at 455.0 kHz, the voltage is about half the regulated supply voltage.

With the 455.0-kHz signal applied, connect the vtvm probe to TP2, and adjust T1 through its range. You should observe a dc voltage variation of about ±1.5Vdc as you tune through the range. Now set T1 for a value equal to the calculated test voltage previously determined. Then, scan the signal-generator frequency through about a 30-kHz range around 455 kHz, and note the S-curve effect and the low and high voltage levels reached. Find and record the mean voltage (center of the spread), which should be close to that previously calculated. This is your new "on-frequency" reference voltage to be used for alignment in future procedures. Set the signal generator to 455.0 kHz, and adjust T1 to obtain the new test voltage at TP2. This completes detector alignment for now.

Note at this point that squelch operation and alignment of T1 cannot be checked due to high-frequency stages not being completed. The squelch can be checked later, when sufficient noise level is available from front-end on through high and low i-f stages. At that time, the squelch action should be apparent as the squelch control is rotated. Normal operation provides complete noise silencing with the control clockwise approximately 25-50%. Squelch action should be abrupt as in any good fm receiver.

After completing the portion of the receiver in the i-f section (**fig. 5**), connect the dc probe of your vtvm to i-f test point TP1 (top of R21). Set the vtvm to lowest possible positive dc voltage range, preferably in the millivolt range if you have one of the newer fetvms. The meter will indicate relative i-f signal level once the threshold of CR1 conduction is reached, which is about the same you would expect from an rf probe connected in the i-f circuit. Apply a 455.0-kHz signal through a 0.05-µF blocking capacitor to the base of Q3. Adjust the signal generator level to obtain a meter reading of about ¼ scale. Then, align T2 for maximum meter indication.

Connect the vtvm rf probe to R29 or R30 at the base of Q4, and check the Q6 oscillator level, which should be about 2 Vrms. Allow for inaccuracies in your rf probe. The important thing is to note that oscillation begins immediately as the power supply is turned on.

Reconnect the signal generator through a 0.01-µF blocking capacitor to point H on the schematic. Set it for about 1 mV output (increase later if necessary) at 8.7 MHz. Connect the dc vtvm probe to TP1, and set the meter for lowest positive dc voltage range. Adjust the signal generator to obtain partial scale deflection, and adjust frequency for a peak. Then, adjust first i-f coils L4 and L6 alternately for maximum. Keep the generator level as low as possible while still maintaining sufficient meter deflection required for tuning. (Be sure to use the correct tool, such as the small tip on most Heathkit tools, to prevent cracking the tuning slugs.)

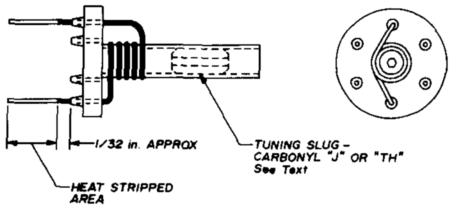


fig. 9. Rf coil winding and stripping. Data is given in table 1. Although turns are shown spaced out, they should be wound tightly together.

Note that these coil forms, with turns wound starting right at the base, will not allow you to obtain two peaks, which is the normal test to be certain that you are peaking and not just running through maximum inductance. You will get only one peak on these coils. However, if you don't get a definite peak but just run out of range as the meter is rising, you must adjust the number of coil turns to allow peaking to occur. This is not likely to be necessary with L4 or L6; however, it may be necessary with front-end coils, especially if you want to operate at a frequency far removed from the design frequencies.

You should add one turn (rewind coil, using a different pair of funnels on form) if the slug wants to be all the way at the bottom of the form, and you should take one turn off if the slug wants to be all the way out of the form. The latter is best done by heating the coil connection, under the pc board, corresponding to the highest lead on the coil form and pulling the lead out of the top of the funnel while the plastic around the lead is warm. Then, remove one turn, clip off excess wire, and reinsert insulated wire through funnel and board. The insulated lead can be heat-stripped right in place at the board's pad.

After completing the high i-f and low i-f stages, it is recommended that you build the regulator, oscillator and multiplier/buffer in **fig. 4.** Note that a jumper must be installed from pad E8 in **fig. 6** to E9 in **fig. 4** to carry the regulator base input signal. A jumper is used to eliminate the need for long bus wires printed on the board to prevent stray signal coupling along the printed wiring, and to allow maximum use of ground planes on the board. Set the oscillator coil to midrange, and connect the rf proble of your vtvm to C53 at R36 and R37.

Apply power, and adjust L11 for maximum, which should be at least 750 mVrms. If you have a frequency counter, you can observe the effect of L13 on oscillator frequency by the connecting counter at the base of Q10. Otherwise, you should wait until the front-end is completed and set the oscillator frequency with an incoming signal. Just make sure that L13 is set at a position in which the oscillator starts; a setting which should not be critical at all, since L13 has been designed to allow oscillation over the entire range with crystals of good activity.

If you have constructed the multichannel oscillator board A2, shown in **fig. 8,** it should be connected via miniature 50-ohm coax to the A1 board and tested when you decide to tie it in. Connect the center conductor and shield to A2 at pads E9 and E10 respectively. At A1, the Q11 oscillator circuit components shown at the left of the breaks in the signal and B+ lines in **fig. 4** should be removed from the board, if installed earlier, and the coax cable should be connected to the pads normally used for the collector of Q11 and one of the closer common ground pads. A number 22 hookup wire should be connected from E12 on assembly A1 to E1 on A2 to carry the regulated B+.

The desired channel control line (E3-E8) on A2 should be activated by

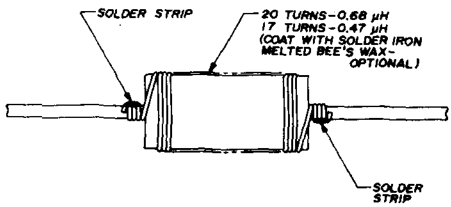


fig. 10. Rf chokes used in the receiver are wound around a ½-watt resistor.

either direct- or switch-connection to +5 Vdc terminal E2. The oscillator can then be tested as previously stated for A1-Q11. Note that the multichannel board can be used with any scanner project you wish to build which is capable of supplying about +5 Vdc to turn on the oscillator stages. Depending on the scanner circuit, you can get squelch voltage from any of a few different places on the receiver around the collector of Q1 in **fig. 7.**

The final step in construction is to assemble components for the front-end rf amplifier and mixer stages. Be sure that you install the coils in the proper positions according to **table 1.** Note, too, that certain capacitor values change when using 6 meters or the low commercial band. Values shown on the schematic are for 2 meters or high band, and alternate values are shown in **table 1.**

To test the front-end, assuming that the rest of the receiver is operative, inject a signal-generator signal at the proper frequency at E10 and E11 on A1, and tune the coils for maximum with the dc probe of a vtvm connected to TP1 (**fig. 6**). Keep the signal level as low as possible while maintaining sufficient meter indication to tune by. As stated earlier, depending on exact operating frequency with respect to design center, it may be necessary to change one or more coil windings by one turn to provide proper peaking within range of the tuning slug.

The antenna lead for the final packaged board should be connected from E10 and E11 with miniature 50-ohm coax to a connector you supply on the chassis, stripping the coax ends as short as possible. Long unshielded leads have series inductive reactance which will reduce the sensitivity of the receiver by dropping signal strength enroute to the input coil. A good method of connection is to wrap a length of number 22 bare wire around the shield and insert the end into the pad on the board. This method is neat and allows shorter center conductor connections.

The final alignment procedure consists of netting the oscillator(s) to channel frequency by monitoring at TP2 (**fig. 6**) for predetermined test voltage. Adjust oscillator coil(s) for that dc voltage while receiving or injecting a signal on-frequency. You may also do the adjustment for minimum distortion of the audio signal if desired, although it's not as accurate. You should then connect the vtvm to TP1, and adjust L11, L10, L9 and L8 in the front end and L6 and L4 in the high i-f for maximum.

T2 and T1 should be adjusted only with a signal of exactly 455.0 kHz injected into the low i-f, since both coils affect linearity of the detector response. Since these have already been adjusted, it is recommended that they not be touched. They should definitely not be used to net the receiver in lieu of the oscillator coil, since T2 and T1 must be aligned to the same center frequency as the ceramic filter to prevent distortion.

When completed, the receiver should provide 20 dB of audio noise quieting with a carrier signal level of about 0.3 μV applied, and the squelch should open with less than 0.2 μV. It is difficult to establish these levels though, as even good commercial signal generators have some leakage at these levels. It is especially difficult when the board is unshielded, although these is no real necessity to shield the board for normal operation. Boards may be mounted with small standoffs to a chassis or to the rear of a rack panel, if desired, to finish the installation.

mobile noise

A final note on mobile operation is appropriate. Ignition and alternator noise are a big headache to all concerned, but they needn't be an incurable problem as many hams seem to think. This receiver has been designed to provide adequate decoupling from moderate high frequency noise components; however, severe cases may require external filtering. If you encounter noise problems in any radio in the car, the first thing to do is to disconnect the antenna to see if the noise is radiated noise. If you have this problem, good luck! You need to give your car a good tune up. Fm receivers are relatively immune to this type of noise.

If the noise persists with antenna disconnected, it is getting into the audio circuits through the power line. You should have the positive and negative power leads connected directly to the battery, since that is the only filter component in a vehicle, and the alternator puts out rectified ac without any other filtering than that provided by the battery. Ignition noise will also generally be present on all wiring in the car except directly across the battery.

If you have taken these preventive measures and the noise still rides through on power wiring, you should install an L-C filter in the positive lead of the power wiring. A choke in series (about 1 Henry) and a capacitor (about 1000 μF) from the radio side to ground should be adequate to filter out the ac component for all but extreme cases. If you also have a solid-state transmitter, the noise will probably also get into the transmitter audio; so you should install the filter in the battery lead to both receiver and transmitter while you are doing it.

references

1. G. Francis Vogt, WA2GCF, "Improved Two-Meter Preamplifier," *ham radio*, March, 1972, page 25.

2. G. Francis Vogt, WA2GCF, "Speaker Driver Module," *ham radio*, September, 1972, page 24.

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TRANSMITTER: • **Single Sideband:** 300 watts P.E.P. input power, VOX or PTT. Two special 9 MHz crystal filters provide upper or lower sideband selection on any band, without the necessity of shifting oscillators. • **CW:** *Power input 260 watts. Carrier is shifted approximately* 1000 cycles into one sideband, and mixer and driver are keyed. Grid block keying is free from chirps and clicks. Automatic transmit/receive switching when key is operated. CW sidetone oscillator for monitoring. • **AM:** Controlled carrier AM screen modulator is built-in. 260 watts P.E.P. input. Low carrier power increases 6 times to 50 watts output at maximum modulation. This system is compatible with SSB linears. VOX or PTT. Diode detector used for receiving on this mode. Product Detector can be used by switching manually . . .

RECEIVER: • **Sensitivity:** Less than ½ microvolt for 10 dB S/N • **I.F. Selectivity:** 2.1 kHz at 6 dB, 3.6 kHz at 60 dB. • **Antenna Input:** *Nominal 50 ohms.* • ***Audio Response:*** *400 to 2500 cycles at 6 dB.* • **Audio Output Power:** 3 watts. • **Impedance:** 4 ohms.

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More Details? CHECK—OFF Page 110

performance of rf speech clippers

This article sheds new light on rf clippers, shows how to get maximum performance, and explains why results are often disappointing

Leslie A. Moxon, G6XN, Hampshire, England

For the last decade or so, spectacular claims have been made in regard to rf clipping of ssb signals. Despite many confusing, and often conflicting, statements in the literature, there seems to be general agreement that rf clipping can increase talk-power by at least as much as the average linear without infringing on license regulations or significantly affecting the speech quality; this is achieved for the cost of an extra crystal filter, plus a few diodes and resistors. These claims have not been rebutted and, when seeking reasons why the system has not come into general use you find much confused thinking, some unsolved design problems, and unexpected facts about existing transmissions!

I have used rf clipping exclusively for many years during which it has been embodied in a total of six homebrew transceivers, including several ultra-low power transistor rigs used for propagation experiments. These had to be ultra-portable for use on steep ground slopes, often without road or even footpath access, and the role of rf clipping was to increase average efficiency, reducing battery drain and weight as well as permitting the use of inexpensive output transistors. DX worked on these occasions, with less than two watts and often less than one watt PEP output, included many contacts over the long path between Europe and Australia.

At the first attempt VK2NN and VK3IP were worked with about 0.5 watt. Later, a daily schedule was operated successfully with the same two stations from GM6XN/P during a six-day vacation on the Isle of Mull. During a retirement tour of Australia and New Zealand, eight European stations were worked in a single session from VK7LM, and reports up to S8 were obtained from England while operating ZM1BJF on Stewart Island. In one session, 13 U. S. stations were worked from G6XN/P on 21 and 28 MHz. There appeared to be little or no distortion attributable to the clipping and it is estimated that most of these contacts would have been impossible with an unclipped signal.

With efficient clipping it is easy to demonstrate an advantage of the order of two S-units by reducing gain to the point where the peak rf level (by then reached only infrequently) just starts to drop. Unfortunately, anyone expecting to gain all of these two S-units in practice is likely to be disappointed because the noclipping condition described above, though strictly correct, is unrealistic. It is now obvious from an analysis of amateur ssb signals that in most cases some overdriving of the final, which is then acting as a clipper, occurs for a small percentage of the time. It is a simple fact of life that as the drive increases, interference to adjacent channels increases, slowly at first, then more rapidly, whereas talkpower does the opposite.

The dividing line between *right* and *wrong* operation is not precisely definable and it would appear that by the time splatter becomes sufficiently continuous to give rise to complaints, there is already very considerable rf clipping taking place in the transmitter. On the other hand, if the drive is nearly constant (if it consists of an rf clipped signal or a two-tone test signal), any spillover into adjacent channels will be more or less continuous, and for any given average level of out-of-band radiation (however small), much greater care must be taken to avoid overdriving.

In view of all the subjective aspects there is some doubt as to the existence of a *solid engineering* basis for determining the correct adjustment of ssb transmitters with an unprocessed speech input. The use of clipping, which determines a definite peak level, has obvious value in this regard. Existing rf clipper designs using cascaded pairs of standard filters are, however, open to criticism on the grounds of restriction of audio response, and an unnecessarily steep-sided overall response with corresponding inflation of manufacturing costs.

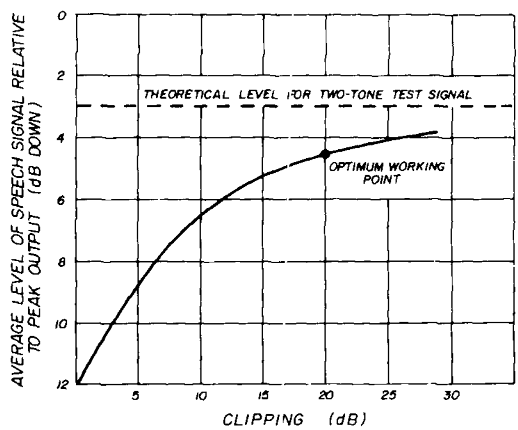

fig. 1. Variation of average signal output with clipping.

how it works

Rf clipping works in two different ways.[1] First, by providing an 8 or 9 dB increase in mean power level for a given peak power; secondly, by increasing the signal-to-noise ratio of speech sounds such as "th" which are important for intelligibility, but low in energy content, so they easily get submerged in the noise. This latter point, despite considerable discussion in reference 1, appears to have been ignored by later writers. It has been demonstrated[1,2] that, *in ordinary speech*, intelligence is conveyed entirely by frequency and not by amplitude. Unfortunately, large amplitude variations are present so that, to prevent occasional peaks of unclipped voice from exceeding the transmitter peak-power rating or the license limit (whichever comes first), the mean power level has to be held down to about 12 dB less than the peaks.

If we clip the peaks of the ssb signal so that the maximum amplitude is reduced to some small fraction of its original value, the audio gain control can be advanced by the same amount so that the peak level is restored to its previous value. When most of the amplitude variations have been removed the mean level is, of course, much higher. **Fig. 1** shows how this mean level varies with the amount of clipping as I measured it, using my voice and rig.

The weaker speech sounds (when not accompanied by louder ones) will be boosted by the amount of clipping so long as the peak power limit of the transmitter is not exceeded.

Since it is essential for the clipping to be applied to the ssb signal, two filters are needed as shown in **fig. 2**. The second filter is required to remove out-of-band signals generated by the clipper; the role of the first filter is less obvious, but without it, spectacular things could happen at the output of the second filter. This is evident if you remember that the job of a clipper is to hold the *total signal* constant, whereas the sum of two sidebands is zero at one point in the cycle, the two voltages being equal and of opposite phase. Therefore, to keep the total voltage constant the voltage of each sideband has to become infinitely large; remove one to them so that the other is left unopposed, and the sparks fly! The output of the second filter, far from being constant, would consist of a series of sharp spikes. Spikes large enough to destroy vacuum tubes and circuits were it not that practical clippers have a limited dynamic range.

Only a few harmonics in the modulation envelope actually get through the filter. Those that do get through cause some distortion and amplitude variations, but apparently the benefit of clipping before sideband-filtering is not completely neutralised, so even audio clipping remains effective to some extent.[3]

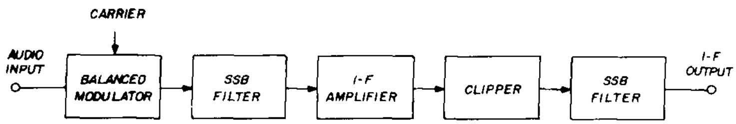

fig. 2. Essential rf clipper details.

practical advantages

Fig. 1 shows that in one typical instance the mean rf power transmitted was increased 7.4 dB by 20-dB of clipping. This agrees reasonably well with the 8-dB increase found by other writers.[2,3,4] This is less than the average difference of two S-units in signal reports which I have obtained by reducing gain so that,in effect,you slide down the curve of **fig. 1** from the 20-dB to the 0-dB point.

The difference, perhaps, may be explained by threshold effects including the enhancement of weaker speech sounds, which has been investigated elsewhere for the case of 20-dB clipping. As would be expected, the gain from this cause was found to be closely linked to the prevailing level of word intelligibility; at the 70% level, which would probably be reported as QSA5, the total benefit from both effects was found to be 11 dB. At 50% intelligibility, corresponding to a higher noise level, it rose to 13 dB.

At very poor signal-to-noise ratios, useless for ragchewing, but probably better than nothing during a contest, or when trying to work a new country, the advantage drops again; this is presumably because the high-level components of speech, unaided, convey a certain small degree of intelligibility even though the weaker sounds may have been irretrievably lost.

From **fig. 1** it appears that increasing clipping beyond 20 dB produces little further increase of mean level, and half the total enhancement is generated by a mere 6 dB clipping. This is consistent with reference 1. The linear relationship claimed by some authors ignores the rather spiky nature of speech waveforms; thus, for the first few dB of clipping the only energy lost is that of a few infrequent spikes so the mean level increases by almost the same amount. On the other hand, with 20 dB of clipping, the clipper operates well below the mean level of speech so the output is already nearly a square wave, and little further increase is possible.

The input-output relationship must be of the nonlinear form indicated by **fig. 1.** A similar result would be expected from allowing the final to overload except that in this case some of the transmitter power is radiated in adjacent channels where it causes interference. It is difficult to define precisely the point at which such interference becomes intolerable. However, legal requirements apart, it depends on many factors such as distance to the nearest neighboring ham and the quality of his receiver.

Interference caused by the first few dB of such clipping, compared with the next few, will be relatively small. For example, typical speech signals exceed 50% of the peak amplitude for only about 8% of the time. Therefore, if the final is allowed to clip the peaks by 6 dB, the adjacent channel interference will exceed that produced by a standard two-tone test for 8% of the time. International regulations allow a two-tone intermodulation products level of about 30 dB. In effect, an S9 signal is permitted to destroy an S4 signal on an adjacent channel.

In contrast, overloading by speech signals to the extent of the above example will cause some annoyance, but the weak signal will remain more or less intelligible because of gaps in the interference. As a fact-finding exercise **fig. 3** shows the amount of "clipping" measured for a random sample of 60 amateur signals on the 14-MHz band. These were deduced by measuring the ratio of peak-to-mean signal level as described later. In obtaining this data no instances were observed of adjacent channel splatter. It seems likely that ALC systems, which normally have too long a time-constant to provide satisfactory compression,[3] nevertheless reduce the frequency and duration of overloads to acceptable limits.

Any method of increasing mean power obviously must increase the amount of interference generated by cross-modulation in neighbouring receivers and rf clipping is no exception. However,

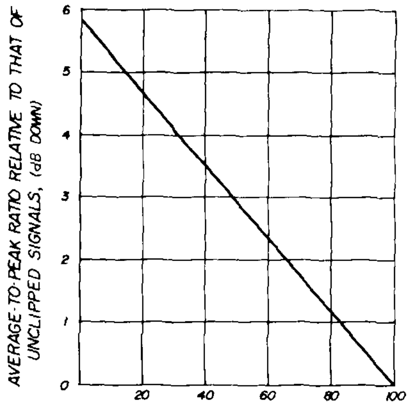

fig. 3. Average-to-peak power ratios for a typical sample of amateur ssb signals.

because of the highly nonlinear character of such effects it should be less damaging than a corresponding increase of mean power without restricting the peaks.

Most writers regard 20 dB as the optimum clipping level, and that agrees with my experience. It is possible that more clipping might be useful under very noisy conditions in order further to enhance the weaker speech sounds, but this has been difficult to prove or disprove. In general, there is a tendency with increased clipping for sibilants to become objectionable. Up to 20 dB of clipping, changes in voice characteristics appear to be small compared with other influences such as the microphone, filter response, etc., provided the system is operating correctly. However, in the absence of noise a slight alteration in the voice has been observed.[1]

Despite the general agreement between writers on an increase in mean level of 8 dB for 20 dB of clipping, there are considerable differences in values quoted for peak-to-mean amplitude ratios of unclipped speech. Defining the "peak" as the level exceeded for 1% of the time, reference 1 finds a peak-to-mean ratio of 12 dB for an unclipped audio signal, and 10 dB for the modulation envelope of the same signal converted to ssb. Other writers quote ratios of 14-16 dB for the

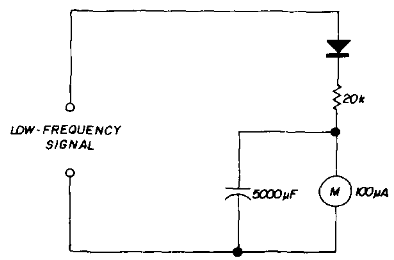

fig. 4. Long time constant, mean signal level indicator. Low-frequency signal should be 1 to 2 volts rms; resistance of meter should be approximately 700 ohms.

audio signal. **Fig. 1** shows the ratio is 12 dB for the ssb signal but this could be in error by one dB or so as the zero level was difficult to estimate precisely. This ratio is unchanged if the average level of a single tone is retained as reference, but for consistency with other writers it's necessary to relate to the peak level of the single tone. That is, to add 4 dB so the 12-dB ratio becomes 16 dB.

The data for **fig. 3** were obtained using alc with a fast attack (20 ms) and slow release (4 s) time constant to hold the peak levels constant. The mean level was observed with a voltmeter time constant of 3.5 seconds (**fig. 4**). The values recorded were the highest maxima reached during continuous speech, but with some operators there were too many pauses and about 25% of observations had to be discarded as useless.

Zero clipping was taken as the lowest of the recorded values for steady talkers on the assumption that there must be some unclipped signals around. This was also confirmed by observations on one sideband of typical broadcast signals. The zero level, 12 dB down on a continuous tone, agreed with the rf measurements. The only signal known to have rf clipping (Comdel processor) was near the top end of the range. The average signal enhancement was found to be 3 dB, corresponding to 4.8 dB of clipping, or nearly half as effective as full rf clipping. Adjacent-channel splatter was not detectable but there were no local signals available.

Reference has already been made to the need for greater linearity in the final stage when clipping is used as any tendency to saturation will generate more splatter in view of the greater time spent at high levels. Other things being equal, the rf gain control cannot be advanced quite as far. In other words, for a given peak power capability, there is something to be subtracted from the increase of mean power obtainable by clipping. On the other hand, if the license specifies the maximum peak output power, and the transmitter is operating well within its rating, full benefit is obtainable.

This point does not seem to have been considered elsewhere although reference 1 suggests class-C operation of the output stage, and presents measurements of out-of-band radiation which were found acceptable provided the final was not driven beyond 90% of saturation. However, out-of-band radiation was increased, and it is not clear that there is any significant increase of efficiency by using this mode of operation.

So far, the discussion has been directed toward improving signal-to-noise ratios or extracting more intelligence with bad signal-to-noise ratios, but the same arguments should also be valid for QRM situations.

objections of rf clipping

Rf clipping has been slow in gaining support. There are several reasons for this, including prejudice engendered by audio clippers, much of it dating back to the days of amplitude modulation. Despite distortion which takes the form of in-band harmonics, audio clipping is basically sound in the a-m case and unsound with ssb. However, in both cases the assumptions are undermined by practical considerations to the extent that some benefit is achieved from audio clipping in the ssb case. Disastrous consequences may result from its applicaton to practical a-m signals despite impressive performance in laboratory tests.

In a-m, the increase of modulation percentage due to clipping increases the importance of preserving the relative phases and amplitudes of carrier and side-bands to avoid distortion. Unfortunately, due to selective fading, these phases and amplitudes are more or less randomised, and clipping can reduce the intelligibility of an otherwise readable signal to zero. The effect is aggravated by agc which ensures that maximum distortion, caused by carrier fades, is accompanied by greatly increased volume.

These effects are not present with ssb, but frequency-distortion can still occur, causing undue emphasis of sibilants, and may account for occasional preferences for a lower clipping level when selective fading *is* present.

design considerations

The first few decibels of possible speech-processing gain are obtainable by simple methods such as alc, audio clipping or mere carelessness in adjusting the drive to the final. In contrast, the last few dB involve much larger amounts of clipping and this in turn requires careful design and monitoring. It should be apparent, from the earlier discussion, that clipping must take place only between the filters, the clipping level should be sharply defined, and subsequent amplifiers or modulators must have better-than-standard linearity at higher levels.

Furthermore, carrier suppression must be better than normal by an amount equal to the clipping; for example, with 20 dB of clipping, 20 dB of carrier suppression would add up to no carrier suppression at all during speech pauses. The second filter may provide the extra overall suppression needed, but this is not the whole story since the amount of carrier present at the clipper must be negligible compared with the clipping level. Otherwise, the beat note between the carrier and the wanted signal will appear as modulation.

To reduce this to 10% with 20 dB of clipping, 40 dB of carrier rejection is needed ahead of the clipper. This is only just within the lower specification limit for a typical IC balanced modulator such as the Plessey SL 640C plus a typical crystal filter. With 20 dB of clipping this still leaves the carrier only 20 dB below peak output, or about the same as it would be with no first filter or clipper. The second filter must provide the same amount of carrier-rejection as in a non-clipping modulator.

For maximum carrier rejection the balanced modulator should be operated at as high an audio input level as possible without risk of overloading; overloading at this point will not cause splatter or upset the action of the clipper, since out-of-band products are rejected by the first filter, but it will produce in-band, audible distortion.

Within the limits imposed by the above conditions, clipping level may be adjusted by alteration of audio gain or the i-f gain between balanced modulator and clipper. Reduction of i-f gain has the advantage of giving better carrier rejection. However, particular care must then be taken to ensure that there is no leakage of dsb signal which can bypass the clipper and filters if insufficient care is taken in layout and decoupling.

If the gain is increased too far, a point will be reached where the acoustic background noise in the shack fully modulates the transmitter; long before this point is reached the signal becomes unpleasant. The louder you speak and the quieter the shack, the more clipping can be used before this factor becomes important. Up to 10 dB of clipping is usually possible before there is any problem, and up to at least 20 dB is possible before it becomes serious. At 30 dB of clipping, there also *tends to be trouble with sibilants and* other normally-weak sounds which become unpleasant due to over-amplification. These disadvantages are not offset by any useful increase in talk-power.

The dynamic range of the clipper must obviously exceed the required amount of clipping, *and at least 26 dB is advised.* Within this range the output should be level within a small fraction of a dB since any variation tends to reduce the mean available level.

Pre-emphasis, up to as much as 6 dB per octave, is usually recommended with speech clipping, but the theory is obscure. The required amount is best found by experiment to suit the operator, microphone, degree of clipping and the carrier spacing.

Rf clipping can provide such advantages as higher efficiency and reduced splatter but the case for it usually relies on the assumption that without clipping the transmitter is peak-power limited, either by its design or because of license regulations. Until this point is reached, it is normally simpler and cheaper to increase drive than to add speech clipping. The transmitter must, of course, be capable of tolerating the increased mean power which results from clipping, a point which cannot be too strongly emphasized.

filters

Previous articles on rf clipping have specified pairs of standard filters, presumably because nothing better has been available. This is not likely to produce optimum performance because the tasks required of conventional filters, pre-clipping filters and post-clipping filters are all different. However, the requirements for carrier rejection are more or less identical in all three cases.

The basic task of the first filter is to prevent unwanted frequencies produced in or before the balanced modulator from getting through to the clipper at a high enough level to generate appreciable in-band distortion. With adequate carrier rejection, the main problem is getting rid of the unwanted sideband. Assuming, for example, 20 dB of sideband suppression, the unwanted sideband will cause 10% amplitude modulation of the wanted sideband, thereby restricting the power in the wanted signal for a given total peak signal by nearly 1 dB. The unwanted sideband is blocked by the second filter, but the desired sideband is amplitude modulated at the beat frequency and its harmonics.

Many of the resulting "sidebands of sidebands" will get through the second filter and add something to the general noise level, but the main consequence is loss of wanted signal power. Even if this is only a fraction of a dB, fractions add up, and it is only by taking care of all of them that most of the extra bonus theoretically obtainable from rf clipping can be realized.

In arriving at a specification for the sideband rejection of the second filter there is no clear distinction between right and wrong; 30 dB rejection of the unwanted sideband will reduce the power loss to 0.25 dB, which is fully acceptable, but even 10 dB is better than nothing, the potential gain from clipping being then reduced by 2.4 dB.

Rf clipping produces third-order intermodulation products in the passband. For a two-tone test signal with 20 dB of clipping the worst IM level is about −13 dB. This is an extreme case and products generated by speech signals appear to be of negligible importance provided they are at least 10 dB down.[4] Out-of-band IM will be roughly comparable with the in-band products and need to be reduced by filtering to a level which does not add appreciably to that generated in the rf stages of the transmitter. *IM* must be reduced from −13 to −30 dB to comply with international regulations, or −40 dB before an S9 +10 dB signal ceases to interfere with an S4 signal on an adjacent channel. Therefore, *adjacent-channel rejection* of − 27 dB is desirable.

The two filters have similar requirements, except that the second filter must suppress both of the adjacent channels whereas the first filter need only suppress the unwanted sideband. Suppression prior to the clipper of high, unwanted audio frequencies is also necessary, and it is probably most convenient to do this in the first filter.

Why not use two standard filters? Typically, these have a 3-dB bandwidth of 2.0 to 2.2 kHz which gives an optimum compromise between loss of speech quality and generation of too much interference. If two such filters are cascaded for transmission, and the signal passes through another one or two similar filters for reception, intelligibility will suffer; moreover, the amount of passband ripple acceptable for a single-filter system is halved for a two-filter system.

In transmitters, the amount of out-of-band radiation is usually determined by nonlinearity of rf stages rather than inadequacy of filters, and the steep-sided responses of standard filters are dictated mainly by requirements for reception. In this case, with two filters available, the individual bandwidths can be increased and the selectivity reduced so that when the two are cascaded the overall response is unchanged.

By operating the second detector at the lowest possible signal level, even further relaxation of the specification becomes possible, as proved by the adequacy of receiver performance with surplus crystal filters. This means that filters which meet the transmitting requirement will be adequate for transceivers.

I am indebted to the Yakumo Tusin Company in Tokyo for providing filters modified to my own specification, the 6-dB bandwidth being increased from 2.2 to 2.5 kHz. The 60-dB bandwidth was thereby increased slightly but overall response of the pair of filters remains more than adequate. During initial discussion with the manufacturers, it appeared likely that the cost and physical size of the individual filters could be reduced by about 30% if there was sufficient demand.

conclusions

In summary, it appears that the first few dB of gain possible by rf clipping are currently being realized with no special circuitry or deliberate intent by allowing rf stages to overload for a small percentage of the time. This has been pointed out elsewhere and condemned as unethical,[5] but there is considerable evidence, theoretical and practical, for reducing the charge to one of poor engineering.

Formal rf clipping provides the basic engineering advantage of establishing a much more definite peak signal level and is capable of providing a total increase in talk power of about two S-units with no adverse consequences. This requires about 20 dB of clipping and observance of the following conditions:

1. Use of filters designed for the job, filters correctly designed for conventional systems being unsuitable.

2. Hard limiting with a dynamic range in excess of 20 dB.

3. Adequate precautions to ensure that *all* limiting takes place between the filters.

4. Adequate carrier rejection *prior to the clipper*, as well as overall.

5. The transmitter must have adequate *mean* power handling capability.

6. Operation of the final must be highly linear, and, in general, must have a higher peak power capability.

references

1. J. Daguet, K. Gilabert, "La Parole a Niveau Constant dams Emetteurs a Bande Laterale Unique," *L'Onde Electrique,* May, 1961.
2. P. Marcou, J. Daguet, "New Methods of Speech Transmission," Information Theory (Third London Symposium), Butterworth's Scientific Publications, London, 1956.
3. E. W. Pappenfus et al, "Single Side-band Principles and Circuits," McGraw-Hill, New York, 1961.
4. J. P. Hawker, G3VA, "Technical Topics," *Radio Communication,* January, 1972.
5. J. Horwood, G3FRB, "A Clipper and Filter for Transistorized SSB Exciters," *Radio Communication,* February, 1972.

ham radio

More Details? CHECK—OFF Page 110

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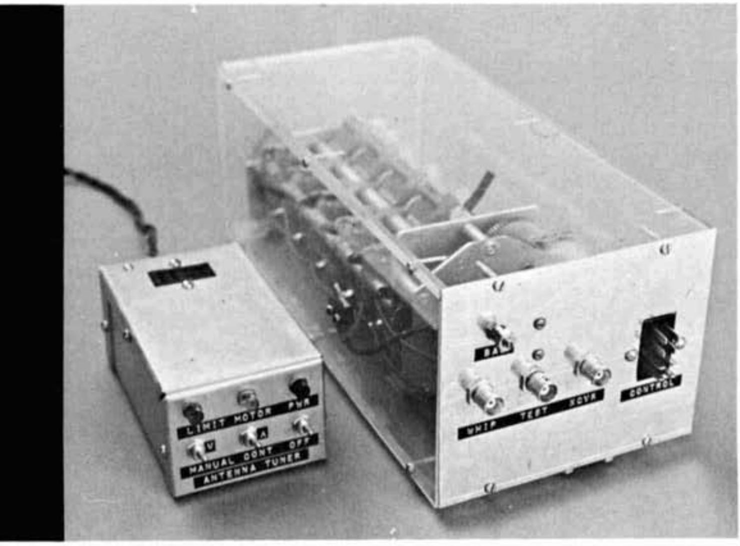


automatic solid-state antenna tuner

A complete, automatic antenna-tuning system which is designed especially for the mobile operator

Stan Johnson, WAØAQC, 215 North River, North Aurora, Illinois

Of all the problems encountered by the mobile amateur radio operator, the antenna is the most grievous. Impedance mismatches and limited bandwidths on low frequencies can cause standing-wave ratios beyond the operating limits of most transceivers.

An antenna matching device[1] can eliminate the swr problem, but without a variable element on low frequencies, the narrow bandwidth remains. The tunable coil in series with the antenna[2] used by K6DY and W6WOY provides a wider range of usable frequencies, but watching the swr meter while tuning the coil and trying to keep the car out of the ditch is a job only for the courageous, well-coordinated ham who happens to have four eyes.

The automatic mobile antenna tuner built by WØIGP[3] provides a solution to the mobile antenna problem by automatically tuning the antenna with a variable inductor until it appears resistive. The tuner described here is similar to WØIGP's design except that solid-state devices have replaced the tubes and relays, and the variable inductor is replaced by a variable capacitor. The resulting, improved swr makes the solid-state automatic antenna tuner a worthwhile addition to any mobile installation.

theory of operation

The automatic antenna tuner consists of a motor-driven variable capacitor connected in series with the mobile antenna and controlled by a phase detector. The antenna is adjusted to resonate at a frequency just below the desired frequency range. At the desired frequencies the resulting inductive reactance from the antenna is cancelled out by capacitive reactance from the variable capacitor (C1 in **fig. 1**), making the antenna appear resistive. Since the antenna is electrically longer than a quarter wavelength, the resistive component of its impedance increases, and provides a better match to 50-ohm coaxial feedline.

the phase detector

The phase detector, which is similar to the Foster-Seeley fm discriminator, determines resonance by comparing the voltage and current phase relationships at the base of the antenna. A detailed description of the phase detector theory of operation can be found in references 3 and 4.

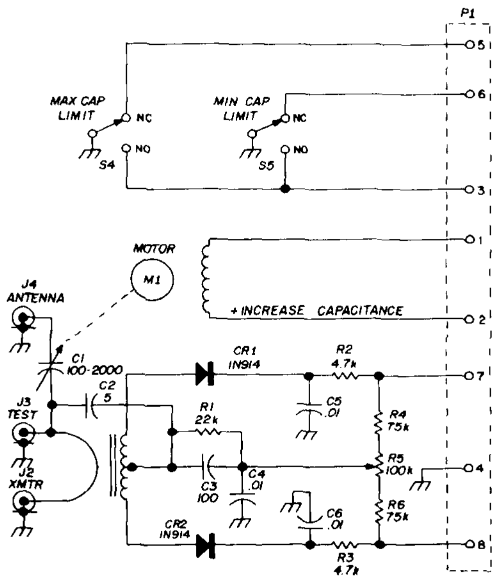
The center conductor of the coax from the transmitter is passed through a toroid to form the primary winding of T1 (see **fig. 1**). The induced voltage on the secondary of T1 is added to a reference voltage developed by the voltage divider, C2 and C3. The vector sum of the voltages is rectified and filtered to produce two opposing dc voltages on pins 7 and 8 of the output connector (P1). With a 50-ohm non-reactive load connected to test jack J3, and normal transmitter power applied, R5 should be adjusted for 0 volts between pins 7 and 8.

When the load is reactive, as in the case of an off-resonant antenna, a dc voltage will appear between pins 7 and 8, its polarity corresponding to the reactance of the load. During normal operation, the transmitter is connected to J2, the antenna to J4, and J3 is left open.

control unit

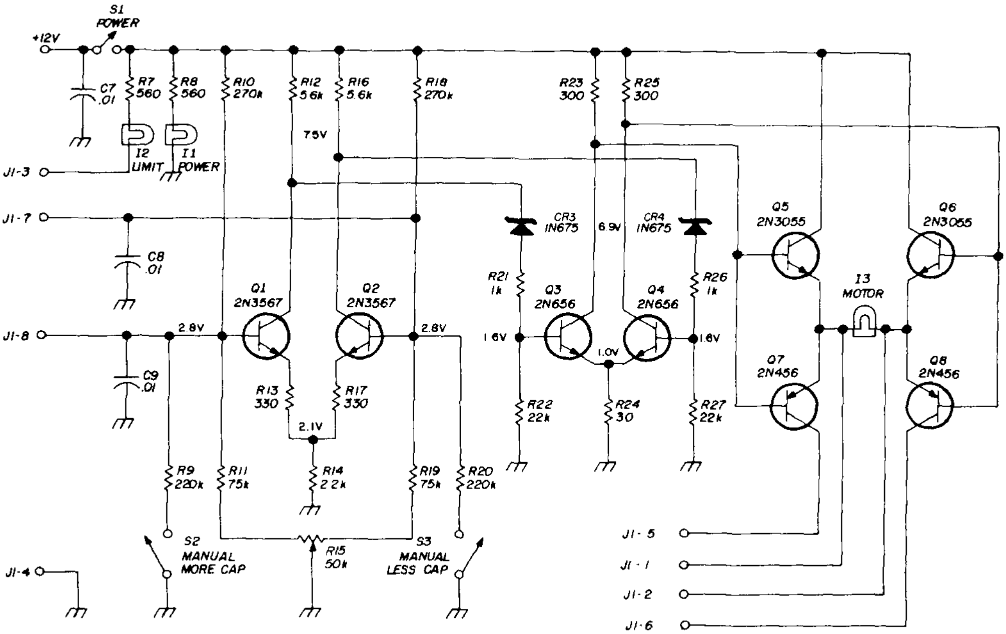
The dc voltage from the phase detector is applied to a differential amplifier, Q1 and Q2 (**fig. 2**). For manual operation, S2 or S3 can be used to unbalance the amplifier and tune the antenna. The tuning rate under manual control is determined by the value of R9 and R20 with maximum speed occurring at 90 kilohms.

Differential amplifier Q3 and Q4 further amplifies the error voltage to the level required by the motor-control



C1	100 to 2000 pf variable capacitor with a 120 to 1 gear reduction
M1	24-Vdc motor manufactured by Globe Industries, Inc., Dayton, Ohio (part number B3A1225)
S4,S5	spdt microswitch with leaf
T1	Toroid core, E type (red color code, 0.5 to 30 MHz) 0.25" ID, 0.45" OD, 0.14" high. Obtained from Tri-Rio Electronics, 2614 Lake Shore Drive, La Crosse, 2, Wisc. 54601. Primary consists of coax center conductor passing through toroid core. Secondary is 2 wires, 24 gauge, enameled, bifilar wound for 9 turns, connected to provide a center tap.

fig. 1. Tuning unit containing motor, tuning capacitor, limit switches and phase detector. Control unit is shown in fig. 2.



I1,I2,I3	15 mA, 3V lamps	Q3,Q4	matched pair of 2N656s
Q1,Q2	matched pair of 2N3567s or similar transistors with current gain of approximately 75	Q5,Q6	2N3055 or similar
		Q7,Q8	2N456 or similar

fig. 2. Schematic diagram of control unit. It is connected to tuning unit (fig. 1) through an 8-conductor cable.

bridge circuit, Q5, Q6, Q7 and Q8. The selection of the control-bridge circuit transistors is not critical. Any transistors, either silicon or germanium, capable of handling the motor current should suffice.

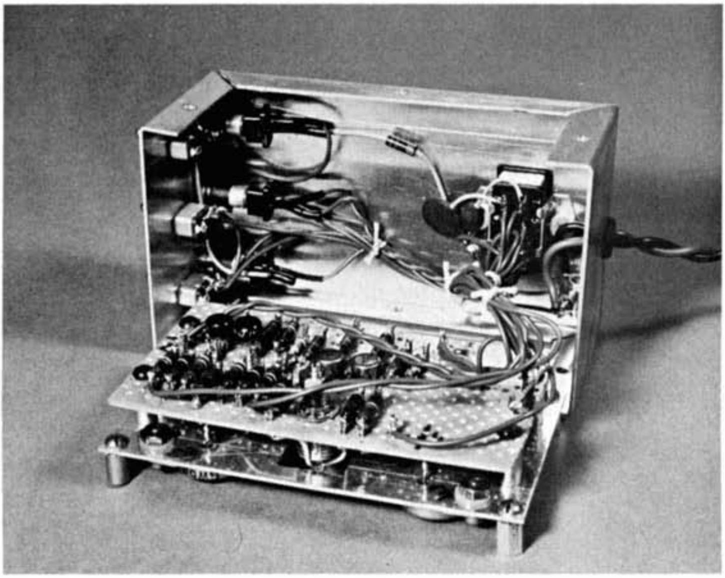
When the motor-control bridge is unbalanced, either Q5 and Q8 or Q6 and Q7 will conduct, passing current through the motor and rotating C1. If C1 has reached the limits of its rotation, limit switches are actuated, removing ground from the collector of Q7 or Q8 preventing further rotation in that direction. The control unit has three indicator lamps, I1 for power, I2 for when C1 has reached the end of its rotation, and I3 for motor voltage.

For best performance, Q1 and Q2, CR3 and CR4, and Q3 and Q4 should be matched pairs. To compensate for component differences, R15 is adjusted for zero volts between the collectors of Q3 and Q4 with no rf applied to the phase detector.

antenna tuner

Both the tuning motor and variable capacitor C1 are refugees from my junk box. A 24-Vdc motor was used. However, it does a very nice job of turning the capacitor on as little as 3 Vdc at 300 mA. The tuning capacitor from an ARN6 radio compass receiver is used for C1, but any reasonable facsimile should work.

An insulated gear is used between the motor and C1 to keep rf off the motor. Unfortunately, this gear was found huddling in a corner of the junk box without the foggiest recollection of its ancestry. Hopefully, the photographs will help identify duplicates. If an insulated gear cannot be located, perhaps an insulated coupling could be substituted. The tuning unit is housed in a plexiglass box with the limit switches attached to the sides. The

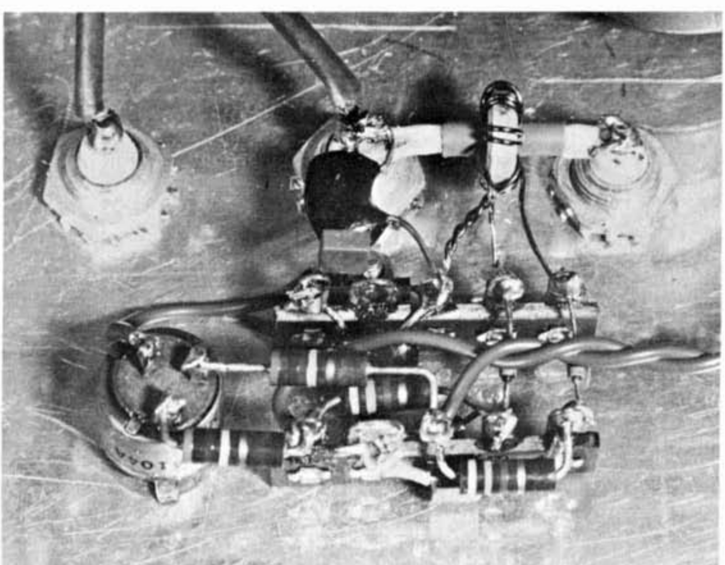


Control unit is mounted in 2" x 3" x 5¼" box.

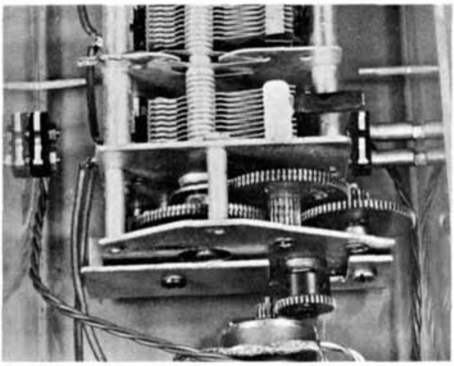
limit switches are actuated by an insulated metal strap which has been glued to the rotor of C1.

The direction of current through the motor windings determines the direction of rotation; therefore, it also determines whether C1 is rotating towards maximum or minimum capacitance. With one motor lead grounded, and voltage applied to the other lead, note the direction of rotation. The wire from the motor which, when made positive, increases the capacitance, should be connected to Q6 and Q8 via pin 2 of J1.

The other lead will cause the wrong limit switch to be activated when the capacitor reaches its rotation limit. The result will be wailing and gnashing of teeth. If the motor rotates in the wrong direction when rf is applied to the phase



Construction of phase detector in the tuning unit.



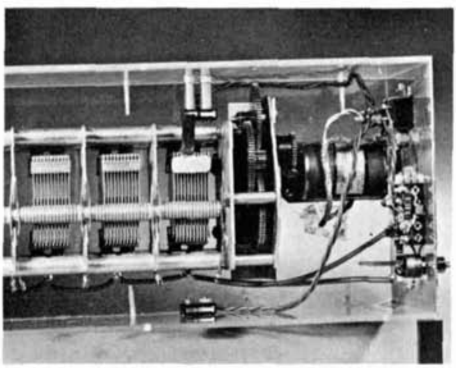
Tuning unit closeup showing limit switches and actuater.

detector, simply reverse the wires on pins 7 and 8 of P1.

The tuning unit in the car trunk is connected to the control unit with an 8-conductor rotor cable. It is recommended that the two larger wires be used for the motor leads (pins 1 and 2).

results

After installing the antenna tuner in the car the swr on 10, 15 and 20 meters was negligible. On 40 meters, the swr at 7250 kHz was 1.0:1 and rose to 1.5:1 at the edges of the phone band. Without the tuner, on 75 meters the bandwidth (swr of 2.0:1 or less) was 16 kHz, while with the tuner, the bandwidth equaled 84 kHz. On 75 meters the bandwidth is limited on the low end by the antenna's resonant frequency and on the high end by the increasingly large resistive component of the antenna's impedance.

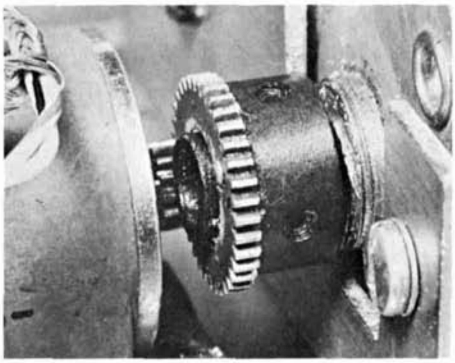


Inside the tuning unit. Note the small strap which is glued to the rotor to actuate the limit switches.

The antenna tuner also eliminated the effects of heat dissipated in the resonator which changed the resonant frequency. The most pleasant benefit derived from the tuner, however, is that the transmitter always sees a resistive load, and therefore does not require retuning after large frequency excursions. After the transmitter frequency has been changed, a short gleeful whistle into the microphone is all that's required to tune the antenna to the new frequency.

credits

I would like to express my appreciation to my friends at Bell Telephone Laboratories for their help; Bill Thelen for conversations on differential amplifiers, Jon Fistler for the photographic work, and Ron Cunningham, W9MAF, for editing assistance.



Insulated gear

references

1. Kayla Hale, W1EMV, "Variable Impedance Mobile Mount," *73 Magazine,* February, 1970, page 96.
2. J. C. Picken, Jr., K6DY, B. A. Wambsganss, W6WOY, "Remote Mobile-Antenna Resonating," ARRL Mobile Manual, 1962, page 144.
3. John A. Hargrave, WØIGP, "Automatic Mobile Antenna Tuning," ARRL Mobile Manual, 1962, page 145.
4. G. Robert Mezger, W2BLL, "A Phase Angle Detector for RF Transmission Lines," *QST,* July, 1952, page 17.

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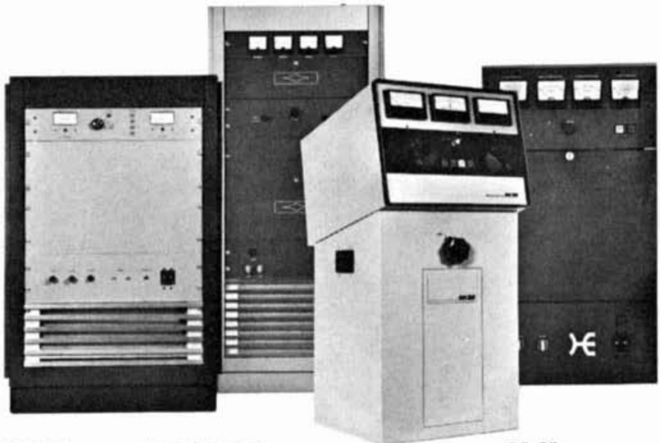


More Details? CHECK–OFF Page 110

5-MHz WWV receiver

High-performance frequency-calibration receiver uses new reciprocating detector circuit for maximum frequency stability and accuracy

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

Since the day of the "Lunch Box Frequency Meter"[1] has long since passed, the FCC frequency-measuring requirement is now met through the use of a crystal-controlled frequency standard, with appropriate marker outputs to help indicate band edges. These standards have increased in popularity to the point where most receiver manufacturers include one as part of the receiver.

A lot of interest has been directed to the accuracy of frequency measurement; this activity is due to the national contests and the MARS programs which require nets to operate within confines not previously required of amateurs. Most amateurs use the station receiver to calibrate their marker generators. few have a separate receiver for this purpose. Very few have a receiver which can be used as a "sole-source direct calibration signal."

It is the intent of this article to describe a receiver which is primarily for this purpose. It is a simple, but very effective, self contained, battery-operated solid-state unit to which a frequency standard may be calibrated very accurately.

This receiver has the single purpose of receiving WWV at 5 MHz, but it could be put on any other frequency which you want. To change the operating frequency all that is required for the most part will be a new set of coils.

circuit

The rf circuit consists of two tuned rf amplifiers and a synchronous detector. A trf configuration was chosen because the receiver is not dependent upon any frequency-determining devices other than the tuned circuits in the rf amplifiers; this eliminates errors in frequency calibration. Since the output frequency is the operating frequency it is dependent upon the received signal for its accuracy.

The receiver circuit shown in **fig. 1** can be used on many frequencies. At W1SNN it has been built for both 60 kHz and 5 MHz. At WA1NWF it has been duplicated for 10 MHz where it also used as an i-f strip for a 50-MHz receiver.

To change the inductors to new frequency ranges, information on how to wind toroidal inductors can be found in articles published in recent issues of *ham radio magazine.*[2,3,4]

The input circuits of the receiver may look a little strange, but they are built to accomodate an antenna and the output of a calibrator. Each input is isolated from the other – the reason for their existance will be described later under operation.

The first and second rf stages have tuned input and output circuits which are very loosely coupled. The loose coupling minimizes loading the toroids down and lowering the Q of the tuned circuits. The unloaded Q of each coil was 180; calculations indicate that the loaded Q is in the vicinity of 110. By loosely coupling the output of the first rf stage and the input of the rf stage preceeding the detector, an effect of critical coupling is possible which enhances the detection bandwidth. This improvement in selectivity is very necessary. Operators who think that 5 MHz is a sacred frequency used only by WWV will be chagrined to find that adjacent signals slop over from as much as 20 kHz away.

Fets are used to further preserve the high Q of the tuned circuits. The fet inputs are lightly coupled to the tuned circuits.

To insure circuit stability each rf amplifier is neutralized. The neutralization provides stabilizing feedback and insures spurious oscillations will not be present. Further, each stage is completely shielded. Seems like a lot of work? Not by a long shot; when you turn the receiver on, it all stays in the box and does not oscillate.

detector

The reciprocating detector circuit was previously described in *ham radio.*[5] This circuit has several advantages not found in other detectors. The detector is synchronous and depends upon a reference signal which is synthesized from the received signal. The reference signal is proportional to the average received signal; therefore, it is always at just the right level, eliminating noise which is generated by conventional reference oscillators.

The reference signal is synthesized through a narrowband rf filter. Because of the Q of the filter, it will not respond to impulse noises. This eliminates interference caused by short duration impulses, such as static crashes. Selective fading which is common on double-sideband transmissions is reduced, and in many cases, corrected with this detector. In the form presented here, the detector will respond to any of the modes used by amateurs (except fm) without any circuit changes. Last, but most important, this circuit provides the reference signal for calibration.

construction

The two rf stages and detector were built on pieces of copper-clad epoxy board. Each circuit was built on a separate board as I am experimenting with the circuits in other applications. A single piece of circuit board can be used. In my unit the boards are 2¼ by 4¼ inches; components were mounted with a simple technique described by W6CMQ.[6]

W6CMQ used a fly cutter to cut rings in the copper, providing an insulated tab for part mounting. This method provides an excellent mounting for small parts and semiconductors. A variation in this approach is accomplished by drilling small pilot holes so a Vector Pad cutting tool can be used. Vector terminals similar to *Flea Clips* can be inserted into the pilot holes. It is possible to mount components on the opposite side of the board which acts as a support for the coil shields; this is very effective for mounting the neutralizing capacitors.

The detector circuits and part of the audio system were mounted on a separate board, which is a printed circuit. All components in this unit were shielded with shields made from small pieces of sheet brass. The small subassemblies were fastened to a larger aluminum sheet which is the cover sheet for a chassis; controls and batteries were mounted in the chassis, which is inverted.

filter

The reciprocating detector includes a few components which need more discussion regarding their adjustment and construction. These components are found in the rf filter used to provide the reference

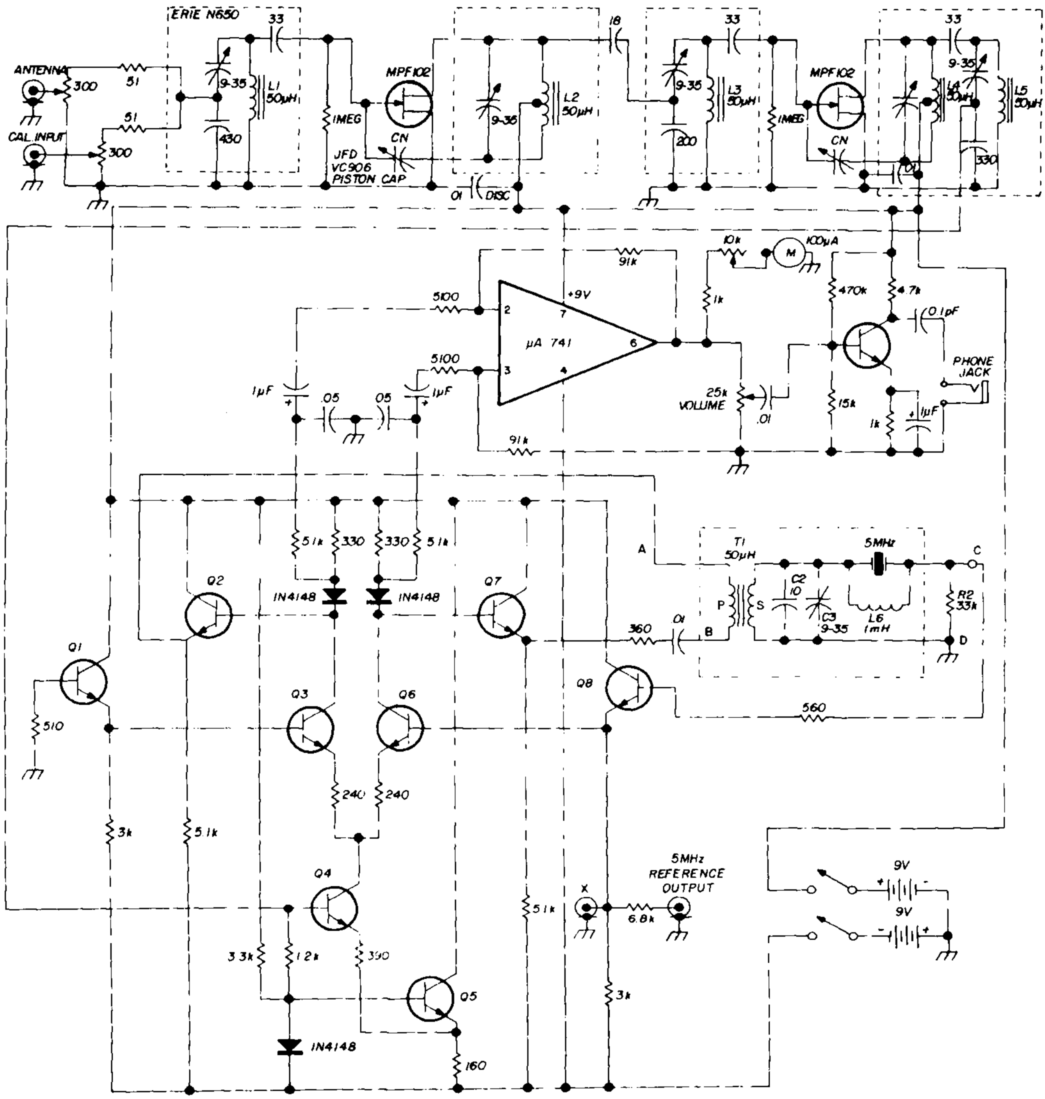


fig. 1. Circuit diagram for the 5-MHz frequency-calibration receiver.

signal from the received signal. The reference filter is narrowband, 500-Hz wide at the 3-dB points. It is not unlike the crystal filters used in early communication receivers. However, those filters were adjustable and did not attempt to maintain a uniform shape factor. More often they used the slope of the filter as a rejection point for an offending signal.

This filter has similar circuitry, but it is used to pass a signal. Therefore, the crystal must *not* be an old FT243 type, which has a high holder capacitance. In fact, almost all of the older free-plate type holders will give trouble when used in this circuit. An HC6/U crystal is very small and has about 0.5 pF holder capacitance.

To remove the loading effect which this capacitance causes, the crystal must have a parallel inductance to resonate out the holder capacitance. This is labeled L6 in **fig. 2**. The inductance is quite high, but is easily made with a toroid core.

The input transformer for the filter is shown in **fig. 2** with the two windings marked P and S. Since the filter is driven differentially, it is convenient to use a coupling loop for the input circuit. However, the output is single ended. To wind the toroid properly, make the S winding first, starting around the toroid core using up about 330 degrees of the winding surface. Then wind P into the remaining 30 degrees. Enough coupling exists to provide transformation, but it will not add additional stray capacitance to the secondary winding.

The filter has low insertion loss. A loop gain of about three can be obtained using no amplification other than that of the basic reciprocating detector circuit. To prevent loading the filter impedance should be, and is, 360 ohms, by virtue of the resistor which is connected in series with the filter and the emitter of Q7. Increasing this resistance broadens filter response and reduces its noise rejection capability.

I have only discussed crystal filters for the detector. If a low-frequency circuit is required, sufficient Q can be obtained by using pot cores.

Fig. 2 gives three frequencies in decades. By scaling these, inductances can be determined for any frequency in these ranges. By using an appropriate toroid core and crystal it should be no problem for you to design your own reciprocating detector filter. A source of filters for those of you who do not care to make your own is available from me upon request.

The choice of transistors and ICs is left to the builder. In my case I used 2N3415 transistors and 1N252 diodes because these components were readily available. The IC is a Fairchild μA741 but I originally used a Motorola MC1433G. Any of the op amps of this variety can be used as can any of the silicon transistors and diodes of similar operating characteristics. Motorola MPF102 fets were used in the rf amplifiers because I had them, but I am sure there are many others in the same price range which can be used.

The 5-MHz rf output should be brought out as directly as possible from the printed-circuit board. Do not use shielded leads to the output jack for this purpose. Plan to locate the output jack on the adjacent to the side of the board so the 6.8k resistor can be connected directly to the output jack.

The meter is a center-scale 100 microammeter which does not indicate very much until you get right down to the nitty gritty of a frequency count. A larger movement will work — it just will not swing as far. The audio amplifier is sufficient to knock the phones off your head, but is not good enough to run a speaker.

Once you have the receiver built, there are several adjustments you have to make before you can use it as a frequency calibrator. First apply the ±9-volt supplies to the reciprocating detector and audio amplifier. Through a .01 capacitor apply a 5-MHz signal to the junction point of the trimmer and 330-pF capacitor connected to L5; the signal should be modulated. With the phones plugged in, adjust the secondary of T1 until the modulation is heard.

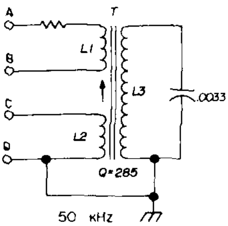
If a heterodyne is heard, it is an indication that the signal generator is not exactly on 5 MHz; it should be readjusted until you have a zero beat. To make this adjustment, turn off the modulation to the signal generator, set the sensitivity control full on for the 100-microamp meter. If the input frequency is off far enough to hear a beat signal, the meter will probably not indicate, or will quiver. Now adjust the signal generator until a zero beat is obtained. When you get close to zero beat, the meter will swing slowly around its zero center; reduce the sensitivity control to keep it on scale.

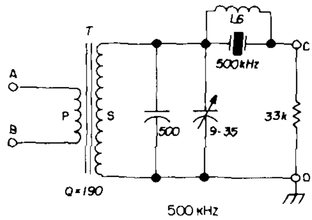
The signal generator will probably not be stable enough for further adjustment. (If the components used are those recommended there will be none required.) WWV will have to be used for the final adjustments.

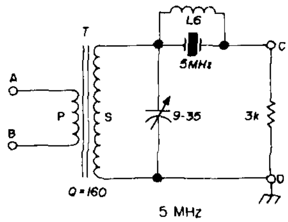
Disconnect the signal generator from the detector circuit and connect it to the antenna input. Modulate the signal generator; be sure the antenna potentiometer is full on. With a moderately high output from the generator the 9-35-pF trimmer on L5 should be adjusted until the modulation increases in amplitude in the phones. Once this L5 has been resonated, the trimmers on L4 through L1 should be adjusted for maximum signal. Decrease signal volume by turning the antenna potentiometer toward *off*.

By the time you have gone this far the capacitor for the first rf amplifier to a null, or until there is no indicated signal.

Remove the signal generator and rf probe; connect an antenna to the input jack and a crystal calibrator to the calibrator input. Be sure the antenna potentiometer is full on and the calibrator pot is near off. Do not turn on the calibrator yet; apply the voltage to the receiver. If you have tuned the receiver correctly to 5 MHz, you will hear the 5-MHz WWV signal. Observe the signal for a while and







50-kHz filters

L1 5 turns no. 32 enameled

L2 43 turns no. 32 enameled

L3 109 turns no. 32 enameled, 2.9 μH

All wound on Ferroxcube pot core, no. 1811CA250-3B7

500-kHz filters

T1 primary consists of 30 turns no. 32 enameled; secondary is 115 turns no. 32 enameled on Micrometals T44-15 toroid core.

L6 is 10 mH toroid

5-MHz filter

T1 primary consists of 10 turns no. 32 enameled; secondary is 96 turns no. 32 enameled on Micrometals T50-2 toroid core.

fig. 2. Filter table for the calibration receiver's reciprocating detector gives component values for different frequency ranges. For frequencies other than 50 kHz, 500 kHz or 5 MHz, values may be scaled as described in text.

receiver will have broken into oscillation. Turn off the power, connect the signal generator back to the capacitor junction point on L5, then to the junction point of the 9-35-pF and 200-pF capacitors connected to L3, and connect an rf probe to your vtvm.

Adjust CN, the neutralizing capacitor, until the signal goes through a null or disappears; move the signal generator to the same junction point where the vtvm rf probe was located and connect the signal generator to the antenna input. Adjust the antenna potentiometer to full on. Increase the output of the signal generator and adjust the neutralizing

note if there are any beats or heterodynes. If there are, the rf stages may still be oscillating. If all is well, when the audio tones disappear from WWV, you should hear nothing except the timing ticks. Now turn on your crystal calibrator and adjust the calibrator potentiometer to half value. If your calibrator is right on frequency, or very close to zero beat, you will hear nothing.

Careful listening will reveal a very slow beat signal, which will have a hissing sound as it goes through zero beat. Adjust the two input potentiometers alternately until the signal levels have the same strength and the slow beat note becomes more pronounced. All of this must be done during the tone-off period of WWV. Now turn up the sensitivity of the meter circuit; the meter will move very slowly through the center scale as it follows the beat, and as you adjust your calibrator trimmer, you can make the meter sweep faster or slower.

The idea is to get the meter to stand still at zero. It will probably not stay still unless you have a pretty good frequency standard, but you can listen to the time ticks from WWV and count the time it takes for a very slow excursion across the meter zero. You are now able to measure quite accurately the parts of a cycle per second at 1 MHz for which your calibrator is stable.

Now you can try the 5-MHz output reference signal. Turn off your crystal calibrator, and connect the output reference jack from the WWV receiver to the vertical plates of an oscilloscope. Connect the output of your calibrator crystal. If it is a 5-MHz crystal oscillator when the gain pots are set correctly for the oscilloscope defection plates a perfect circle will result. The circle will be stationary if the calibrator is right on, but will rotate slowly if the calibrator is slightly off frequency. The speed with which the display rotates can be timed in the same manner as described for the meter. If the calibrator crystal is 1 MHz, a chain-like Lisajou pattern will result; it will be stationary if on frequency.

references

1. "Lunch Box Frequency Meter," The Radio Amateur's Handbook, American Radio Relay League, 1933.
2. M.J. Gordon, Jr., WB9FHC, "Calculating Toroid Inductance," *ham radio,* February, 1972, page 50.
3. G.K. Shubert, WAØJYK, "Tuning Toroidal Inductors," *ham radio,* April, 1972, page 24.
4. H.D. Olson, W6GXN, "How to Use Ferrite and Powdered Iron for Inductors," *ham radio,* April, 1971, page 15.
5. S.M. Olberg, W1SNN, "Reciprocating Detector," *ham radio,* March, 1972, page 32.
6. F.T. Swift, W6CMQ, "Low-Cost Printed-Circuit Boards," *ham radio,* August, 1971, page 44.

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first steps to satellite communication

Background, definitions and suggestions for entering the fascinating field of amateur satellite communication

Alvah Buckmore, Jr., K1TMA, Main Street, Russell, Massachusetts 01071

If we, as radio amateurs, are going to involve ourselves in satellite communications, we must develop what professional engineers call systems engineering. We must have a systems engineering attitude and approach to the problems of communicating via amateur satellite. Most radio amateurs think in terms of individual components and devices. There is no longer room for this kind of technical narrowness; for satellite communications are far more demanding than the typical twenty-meter single sideband contact.

sub-systems

First steps to satellite communications involve the following sub-systems:

1. A transmitter with an output power of 25 watts in the CW mode of operation is thoroughly adequate. Though it's hard to believe, anything more than that may overload the satellite's circuitry or cause interference with adjacent channels.

2. A communications receiver with good sensitivity, selectivity and stability, and a converter to receive all of the satellite frequencies – vhf and uhf.

3. An antenna array with a forward gain of at least 10 dB and, ideally, vertical *and* horizontal directional control.

Systems engineering simply means coordinating these three sub-systems into one workable satellite communications system.

transmitting sub-system

There is nothing really very special about the transmitter requirement for the 144 to 148 MHz and 420 to 450 MHz bands. Any standard circuit in present day use should work well.

From the standpoint of design efficiency – and again, systems engineering – we should coordinate each stage to interact interdependently. This means we should use the same oscillator, doubler, control circuits and power supply for both bands. When we are using the 144 to 148 MHz circuits all other irrelevant circuits are off.

Special care is necessary to avoid certain characteristic problems. Primarily, we need proper shielding and efficient matching of the impedance of the final amplifier to the transmission line. Some radio amateurs don't like to admit it, but this is a very frequent cause of failure.

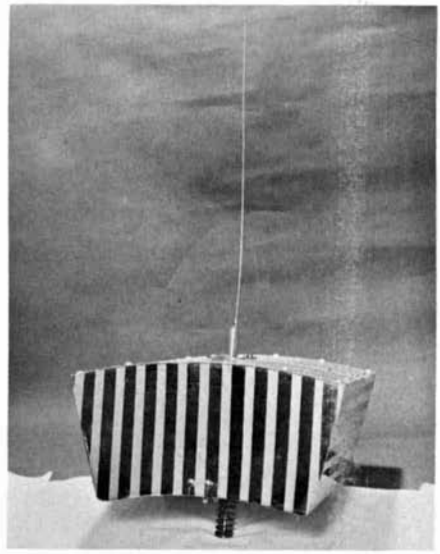
receiving

No attempt is usually made by amateurs with an interest in satellite communications to build from scratch a complete communications receiving system for vhf or uhf operation. It's very much more complex than building a transmitter and is not really necessary. Using a good quality dual-conversion superheterodyne communications receiver in conjunction with a low-noise, high-gain converter should achieve the same results. The converter's intermediate frequency output is usually either the 20- or 10-meter band.

antenna array

Using commercial equipment, antenna arrays are considerably simpler than any other sub-system. This doesn't mean an antenna isn't important – it's enormously important; but as long as we properly match the transmission line to the antenna, and the antenna's resonant frequency is close enough to the operating frequency, we should experience little difficulty.

Gain isn't necessarily important, though entirely desirable, to receive satellite telemetry transmissions. Indeed, results have shown that a vertical array with unity gain often works satisfactorily. Ground planes work. This, of course, is only for satellite telemetry reception. For reasonably reliable satellite two-way communications, with the satellite as an active relaying point in outer space, a directional array with about 10-dB gain is necessary. Vertical and horizontal directional control with computing devices to track the satellite are nice; but mounting a beam at a 25 to 45 degree angle on a television-type mast and rotator should work well much of the time. A little experimentation should tell us the optimum angle of radiation.



One of the early amateur satellites – OSCAR 2 – launched June 2, 1962. (Photo courtesy ARRL.)

Helical and parabolic arrays are extremely efficient but cumbersome to build and to operate. Yagi arrays with both vertical and horizontal elements have the advantage of switching from vertical to horizontal to circular polarization at will when using electrical remote-control coaxial switches. An antenna with an ability to change polarization is much more valuable than any other kind for amateur satellite service.

system losses

Critically important to satellite communications, the type of transmission cable and transmit-receive switch can easily determine success or failure. This and all the other variables affecting the strength of the signal, and subsequent success or failure, can be written down in what radio propagation engineers call the system loss formula.[1] This formula takes into consideration eight variables and is expressed LS = Lta + Ltp − Gt + Lp + Lrp − Gr + Lra + Laa, where LS is the total system loss,

Lta is the ohmic loss in the transmitting antenna and its transmission line, in dB,

Ltp is the polarization mismatch loss of the transmitting antenna,

Gt is the gain of the transmitting antenna in the desirable direction,

Lp is the path loss in dB,

Lrp is the polarization mismatch loss of the receiving antenna,

Gr is the gain of the receiving antenna in the desirable direction,

Lra is the ohmic loss in the receiving antenna and its transmission line, and

Laa is the antenna aperture loss.

ohmic loss

Ohmic loss in a transmission cable is the resistance the inner conductor and dielectric offers to radio frequency movement.[2] It is measured in decibels per hundred feet. On vhf, non-pressurized Alumifoam coaxial cable is applicable for this kind of service, and is made up of a low-loss polyethylene dielectric and seamless aluminum outer conductor, with a jacket of xelon polyethylene.[3] We might pressurize the cable for uhf applications under certain critical circumstances. Certainly, any coaxial cable should be in perfect physical condition. Coaxial cable installation is critical at any radio frequency for this kind of service.

A transmit-receive switch was mentioned operating under the assumption that the same antenna used for transmitting is also used for receiving. Silverplating the contacts and careful construction will cut down the insertion line-loss, which is unavoidable.

One of the more sophisticated club stations designed for moonbounce and satellite communication. Complex equipment, however, is not that much of a necessity. (Photo courtesy Talcott Mountain UHF Society and the ARRL.)

polarization mismatch

When a radio signal is transmitted from earth to a satellite and back the polarization may change many times. Leaving the antenna, the radio signal may be of a vertical polarization, but after going through earth's atmosphere, through the satellite's amplifier circuits and then re-entering earth's atmosphere, the signal may change to a horizontal polarization – or most likely something in between. If the receiving signal is of a different polarization than that of the antenna, a polarization mismatch occurs causing a further reduction in signal strength. It could be the deciding variable, so it's important for us to know the receiving polarization and to have the ability to properly match polarization with the right antenna.

gain

Some antenna arrays will in effect amplify radio frequency power in certain directions. The primary concern of the system loss formula is to know the amount of rf gain there is in a particular array in the desirable direction of transmission, relative to a half-wavelength dipole or that hypothetical antenna, the isotropic source. The unit of measurement of gain is the decibel.

antenna aperture loss

Only a certain amount of radio frequency power coming from a directional antenna array will be of use in the desirable direction of transmission. The remaining power, if the antenna array is efficient, will be relatively small. Antenna aperture loss is a measure of that percent of the total available power delivered to the antenna which is wasted in radiation in directions other than the one chosen, focused beam toward the desired target antenna. This loss is measured in decibels.

path loss

Path loss is the total attenuation of the medium between the transmitting station on earth to the satellite in space, and between the satellite in space to the receiving station on earth. Path loss is a function of the medium characteristics and radio frequency energy in time. The unit of measurement is again the decibel.

At present, amateurs are mostly using 144 to 148 MHz and 420 to 450 MHz as their operating frequency range – and getting good results. The 28-MHz band is also in use but not as efficiently as the other two, though it was a surprise to learn that "10-meter signals from a satellite can penetrate the ionosphere at all elevation angles without experiencing blockage due to ionospheric reflection at low elevation angles."[5]

The favorite band is two meters because of the relative simplicity in the design and operation of the tank circuits and shielding. Also, reasonably priced tubes and transistors operate well there. An antenna system above the two-meter band must be larger to cover the same captivity area. Transmission cable is more critical above 300 MHz and hence gives unacceptable attenuation loss figures. This can be overcome, but only with a bigger diameter cable and a larger pocketbook.

acknowledgements

I wish to thank Perry Klein, K3JTE, William Dunkerley, WA2INB, Frank Pomeroy, W1UCB, and Yaidas Simonis, UP2ON, for their cooperation in putting this article together.

references

1. Kenneth Davies, "Ionospheric Radio Propagation," U. S. Department of Commerce, National Bureau of Standards, 1965.
2. "The Radio Amateur's V. H. F. Manual," American Radio Relay League, Newington, Connecticut, 1965.
3. "RF Transmission Line: Catalog and Handbook," Times Wire and Cable Company, Wallingford, Connecticut.
4. Radio Research Laboratory Harvard University, "Very High-Frequency Techniques (Volumes 1 and 2)," McGraw-Hill, New York, New York, 1947.
5. Jan A. King and Perry I. Klein, "Radio Amateur Satellites for Education and Research," Radio Amateur Satellite Corporation, Box 27, Washington, D. C.

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carrier-operated relay

Simplicity, dependability and an end to haywire lashups are benefits of this little gem

Robert C. Heptig, KØPHF, and Robert D. Shriner, WAØUZO

When repeaters first started to become popular a few years ago, amateurs desiring to build a repeater started to wire up what is known as a carrier operated relay. However, the words carrier operated relay are actually a misnomer. All repeater designers apply the voltage derived from the squelch or the limiter to the circuitry that operates the relay. This really doesn't make any difference, as all we are after is a relay action caused by the presence of a signal into the receiver.

After constructing a COR that will key the transmitter, a time-out timer should be constructed to limit the time that the transmitter can be on the air. From one to three minutes is a common time for the time-out function.

Too often we have a bucketfull of garbage haywired into the repeater consisting of one relay operated by the incoming signal which in turn operates the relay that keys the transmitter that is released by yet another relay that is controlled by the time-out function. This is all shown in **fig. 1**.

A better concept of how to control a repeater is shown in **fig. 2**. It is obvious that the reliability will be greatly increased due to its simplicity.

Other uses for this COR can quickly be seen — such as for a remote tape log in which case the value of C3 and R13 can be changed to limit the length of time that the tape log runs on each trans-

Etched and drilled G10 epoxy circuit boards are available from Circuit Board Specialists, 3011 Norwich Avenue, Pueblo, Colorado 81008. The price is $4.50, postpaid.

mission, (10 to 15 seconds being a normal time). Another use that is becoming very popular is to connect the relay to the speaker of base or mobile receivers and adjusting the time to about 10 seconds. Then all you will hear is the first few words of a transmission, and if the call isn't for you, then you don't have to hear it. If you do want to listen, though, the feature can be disabled.

circuitry

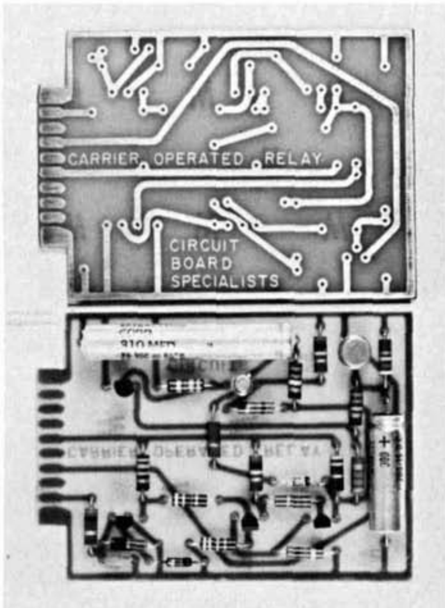
Practically any voltage and any relay can be tied to the circuit and it will go right to work. Primary power at 12 Vdc will be assumed for this discussion along with a 12-volt relay. However, keep in mind that the circuit will operate on any voltage from 6 to 36 Vdc. Almost any relay will work and the relay need not be the same voltage as the circuit uses.

The input signal to the circuit must be a negative voltage. This is common in most tube-type receivers and can be found in the squelch or limiter area of the receiver.

If the point that you desire to tie into in your receiver goes positive when receiving a signal, then simply replace Q1 with a P-channel field effect transistor such as a HEP 803 and reverse the zener diode CR1.

Now, to get down to the nitty gritty of the circuit. A negative voltage applied to the input is fed to Q1 by way of R1 which acts as a current limiter and prevents any loading of the receiver. The zener CR1 regulates the gate voltage of Q1 to a safe value. Capacitor C1 filters any rf or audio voltage from the signal.

The field effect transistor is connected as a voltage multiplier. It is normally conducting the voltage from R3 to ground causing a low voltage on the base of Q2. A negative voltage applied to the gate of Q1 will cause a pinch-off action in Q1 and consequently a rise in voltage on the base of Q2. Transistor Q2 will now start to conduct, and a rapid rise in voltage on the emitter of Q2 and a drop in base voltage of Q3 will cause Q3 to cease conducting. This action of Q2 and Q3 is known as a Schmitt trigger. When the collector of Q3 goes positive as previously noted, this voltage is fed to:



The complete COR fits easily on the small pc board. Note the generous component spacing for simplicity and ease in trouble shooting. The board fits a standard 10-pin circuit-board socket.

1. The base of Q4 which will go positive and Q4 will conduct heavily causing the relay to close.

2. The emitter and base 2 of the unijunction transistor Q5. This starts the time-out function as will be explained a little later.

3. The anode of the silicon controlled rectifier, CR4.

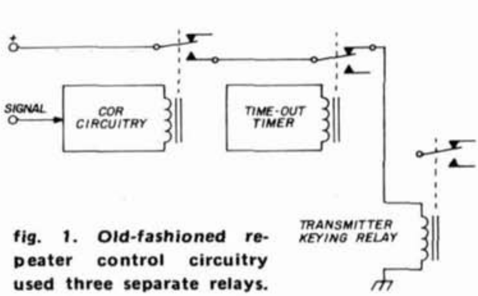


fig. 1. Old-fashioned repeater control circuitry used three separate relays.

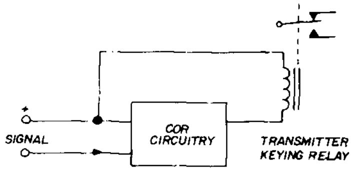


fig. 2. The updated carrier operated relay uses only one relay but offers reliable transmitter keying and built-in time-out timer.

time-out function

Now to the time-out function. As stated previously, on receipt of a signal, voltage will be applied to the emitter and base 2 of Q5. Emitter voltage, initially being very low or zero, will gradually increase, at a rate controlled by resistor R13 and capacitor C3. By juggling these values the time for the actual time-out function to take place can be set from a second to as high as several minutes. When the emitter voltage finally increases to a point where it is equal to the voltage applied at base 2, the unijunction will then conduct or fire thru base 1 and to the gate of the SCR. This gating action of the SCR will now conduct all voltage applied to the anode to ground thereby removing the base potential on Q4 and releasing the relay. The SCR will continue to conduct until its anode voltage is removed. This can only happen if the incoming signal is dropped from the receiver, at which time the COR will resume its idle state, and the voltage at the junction of R10 and R11 drops to zero thereby ungating the SCR and putting the complete system back to normal.

We have explained the action of the circuit in closing the relay and the reverse of this action will naturally open the relay with a slight delay in opening caused by the stored voltage in C2. This stored voltage prevents relay chatter on a fluttering signal and provides a tail on the repeater carrier.

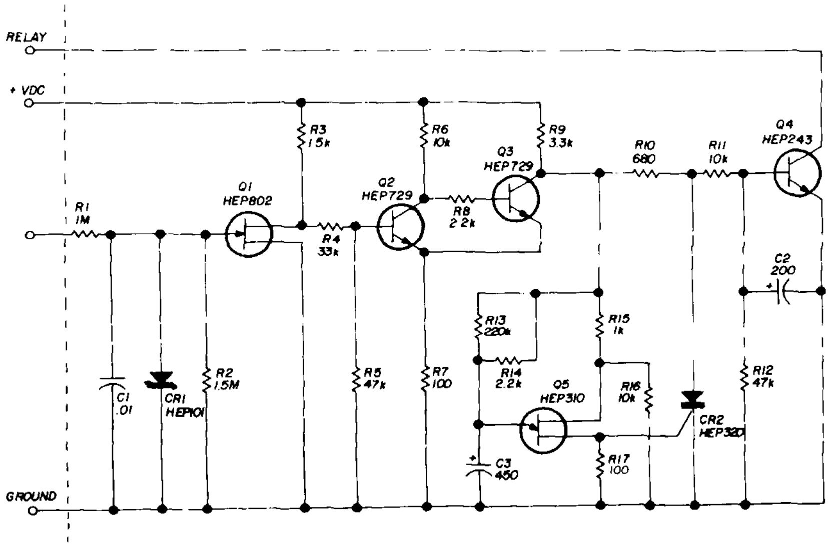


fig. 3. Schematic of the carrier operated relay.

A little added feature of this carrier operated relay is contained in CR5 and R14 which allows a slow bleed-off for the time-out function. This little jewel requires the users of the repeater to drop their carriers between each transmission for a few seconds in order to reset the timer fully. This quickly trains the repeater users to allow a little time between each transmission to allow for breaks as necessary.

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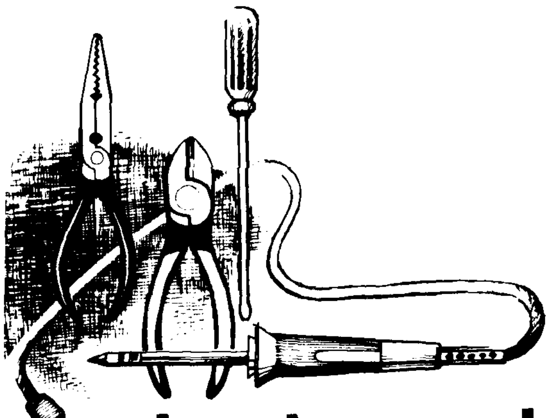

circuits and techniques

ed noll, W3FQJ

fet biasing modes

The field-effect transistor, although its operation is entirely different from that of a vacuum tube, has family characteristics quite like that of a pentode. Biasing methods are similar too.

A junction field-effect transistor consists of a channel of P- or N-type silicon semiconductor sandwiched between a region of opposite sign. Discussion is confined to an N-channel junction fet, **fig. 1**. In this case, the N-channel has its drain at one end and source at the opposite end, sandwiched by a piece of P-type semiconductor material. The N-type material has electron or negative carriers; the P-type positive carriers.

When there is zero bias between gate and source, the application of a positive voltage between drain and source causes the electron carriers of the channel to move between source and drain. As the positive voltage is increased this current rises. In effect, the channel acts as a resistor.

As this current rises a voltage gradient appears along the resistor and the junction between gate and channel becomes reverse biased. This causes a depletion area to extend outward from the gate into the channel. Its action is to decrease the effective cross-sectional area of the channel – similar to decreasing the diameter of a conductor or a resistor. The greater the potential gradient along the channel, the further the depletion area extends into the channel. Eventually a point is reached at which there is no significant increase in drain current because the extension of the depletion area balances out the influence of the increase in drain-source voltage. The current is then said to be pinched off.

The above explanation is represented by the Vgs = 0 curve of the family shown

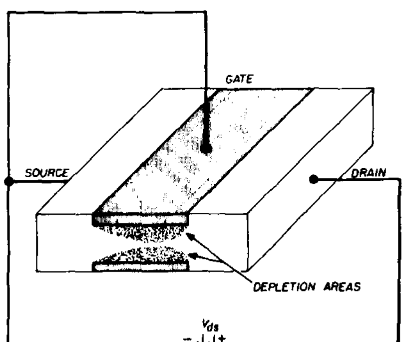

fig. 1. Simplified plan of an N-channel junction fet.

in **fig. 2**. Note how the drain current increases between drain source voltage of zero and +5 volts. The pinch-off region *occurs above a drain voltage* of 5 volts. Note how slowly the drain current now increases for a given increase in drain voltage, producing a pentode-like characteristic curve. The drain current at which pinch-off starts is known as the saturation current and is symbolized by Igss.

Note from **fig. 2** that the drain source voltage Vds corresponding to the saturation current Idss is +5 volts. The bias voltage Vgs needed to cut off the drain

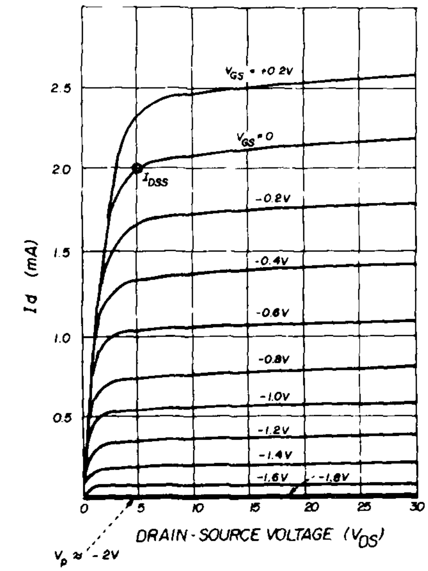

fig. 2. The family of curves for a fet.

current (one nanoampere) for this amount of drain-source voltage is known as gate-source pinch-off voltage Vp. In **fig. 2** this value would more likely fall somewhere between −1.8 and −2.0 volts Vgs.

When the gate is biased negatively relative to the source, the pinch-off occurs at a lower value of drain current because of the depletion area already set up by the gate bias. The higher the gate bias, the lower is the pinch-off drain current. A family of curves demonstrates

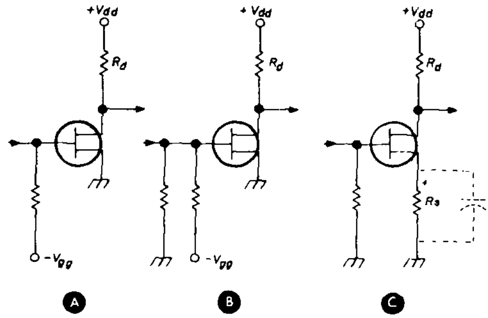

fig. 3. Simple biasing methods for fets.

the characteristics of a given fet as shown in **fig. 2**.

simple bias methods

Three simple bias systems are given in **fig. 3**. Note their *similarity to vacuum*-tube practice. The first case is biased from a battery or other bias source. The gate resistor has no influence on the bias if the stage is to be operated in a normal linear fashion. In B a two-resistor voltage divider produces the correct bias. Hence it can be derived from a higher voltage source.

The third arrangement is called source bias. Drain current in the source resistor now develops a positive voltage between source and common. The current direction, as shown, is such that the gate is made negative with respect to the source. The cathode resistor of a vacuum-tube circuit performs in the same way. A capacitor connected across the source resistor prevents degeneration and loss of gain.

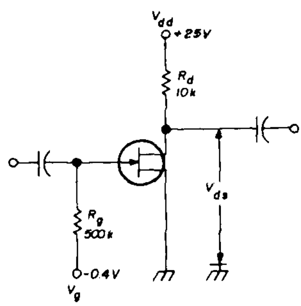

fig. 4. A circuit with external bias to meet the conditions of fig. 5.

load line

The operation of the circuit of **fig. 4** can be disclosed by drawing an appropriate load line on the family of curves, **fig. 5**. As shown the supply voltage is +25. If on the peak of the input signal, the drain current is to rise to the saturation current on the zero-bias curve, the load line must be drawn between this point and +25 on the zero drain-current axis. If the load line is continued to the zero drain voltage axis, it is possible to determine the ohmic value of the load line:

$$Rd = \frac{25}{0.0025} = 10{,}000 \text{ ohms}$$

This load line condition is matched by connecting a 10,000 ohm resistance in the drain circuit, **fig. 4**.

A suitable operating point can be found along the load line. The best gain is obtained by using a low bias provided the input signal is not great enough in amplitude to overdrive the transistor. The operating point of **fig. 5** is satisfactory for an input signal of 0.4 volts peak. Operating point bias is −0.4 volts; drain current 1.35 mA and drain voltage, about 11.25 volts. An operating-point gate bias of

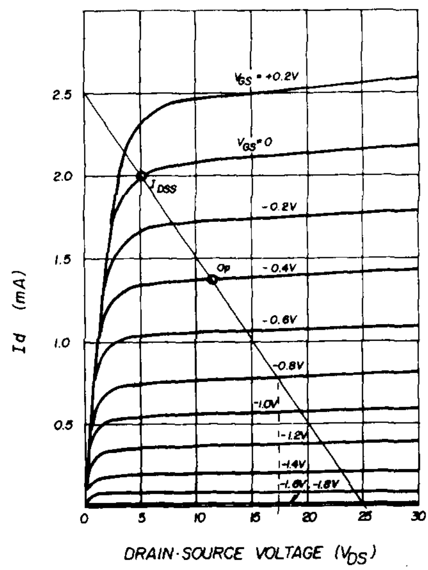

fig. 5. Fet family of curves with load line.

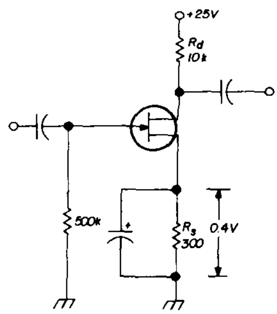

fig. 6. Self-bias circuit for the conditions of fig. 5.

−0.4 volts is applied externally in the circuit of **Fig. 4**.

If the input signal is of 0.4-volts peak, the gate voltage will swing between 0 and -0.8 volts. Hence the drain voltage swings between +5 and +17.5 volts. From this information it is possible to obtain the voltage gain of the fet stage:

$$Vg = \frac{17.5 - 5}{0.8} = 15.6$$

self-bias

Self-bias using the circuit of **fig. 6** can be used to establish the same operating conditions. Inasmuch as the operating-point drain current and gate bias are known, it is possible to determine the proper value for the source resistor. Source resistor value for the circuit of **fig. 6** and the operating conditions given in **fig. 5** is:

$$Rs = \frac{0.4}{0.00135} = 296 \text{ ohms}$$

stabilized bias

Two factors have a significant influence on bias requirements. One is the production spread which may be such that the saturation current Idss may have a ratio of 3-to-1 or higher. In the typical example of **fig. 5**, it may be that the Idss value will not be 2 mA, but may have a high of 3 mA and a low of 1 mA. Temperature drift is the second factor – both warm-up operating point drift or a shift as a result of change in ambient temperature.

The changes in operating conditions as a result of production spread and temperature are pronounced when only external gate bias is used. Self-biasing is much more self-adjusting because a shift in operating point drain current is compensated by the change in bias produced by the change of current in the source resistor. However, even better operating-point stabilization can be obtained with a further increase in the ohmic value of the source resistor. Normally this would result in an improper bias, but a combination of gate-divider bias and a higher value of sourceibias can be used to set-up the operating-point of **fig. 5**. This is done by using positive gate voltage instead of negative, however. In fact, the circuit in **fig. 7** is similar to that used in a bipolar transistor circuit but for quite a different reason as you learned.

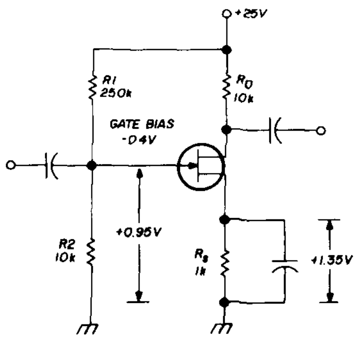

fig. 7. Compensated and stabilized bias for the conditions of fig. 5.

Good stablization is obtained by increasing the ohmic value of the source resistance three to five times. In our example, let us assume a source resistance value of 1000 ohms (an increase of +3 times). In this case the source bias would be:

$$Vs = IdRs = 0.00135 \times 1000 = 1.35 \text{ volts}$$

Note that this is substantially higher than the desired 0.4-volts bias, **fig. 5**. Hence, to obtain the proper bias, it is necessary that the gate bias be:

$$Vg = Vs - Vgs = 1.35 - 0.4 = 0.95$$

This condition requires that the voltage at the junction between resistors R1 and R2 be +0.95 volts.

The ratio for the two-resistor voltage divider then becomes:

$$\frac{Vdd}{Vg} \approx \frac{R1 + R2}{R2} \approx \frac{25}{0.95} = 26.3$$

A satisfactory ratio would be set up using standard value resistors of 250k and 10k, respectively, for resistors R1 and R2. This would set up a ratio of:

$$\text{Ratio} = \frac{R1 + R2}{R2} = \frac{260k}{10k} = 26$$

One advantage of a field-effect transistor is its high input impedance. This would be compromised by the low ohmic value of resistor R2 in certain applications. The answer to this loading of the input impedance is the circuit of **fig. 8**. In this case it is possible to use a high value gate resistor Rg. The biasing is again handled by resistors R1 and R2. However, resistor R2 will no longer load down the input impedance.

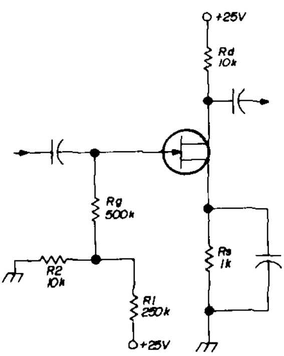

fig. 8. Circuit for the reduction of input loading.

influence of higher source bias

It is to be noted from **fig. 9** that the actual voltage between the drain and source is less than the operating point Vds value by the amount of the source bias. In the example, this is not an important amount because of the self-adjusting characteristics of the source circuit.

In some circuits in which a rather low supply voltage, Vdd, is used and the operating point is very critical, it is advisable to increase the supply voltage by the amount of the source bias. A second alternative is to draw a load line initially that includes the ohmic value of the source resistance. Load line resistance would be Rd + Rs.

pulse-duration modulation

In a pulse-duration modulation system a low-level pulse train is modulated by the desired audio. It is then built up to a high power level by a series of switching (digital) amplifiers. They permit power amplification at high efficiency. A low-pass filter, which removes the pulse train and recovers the original modulating information, follows the final power amplifier or modulator.

This technique is being used in modern a-m broadcast transmitters with the modulator being connected directly to

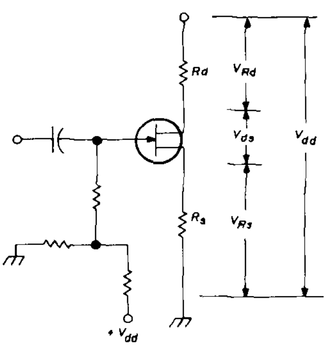

fig. 9. The figure shows the distribution of voltages in the drain circuit.

the cathode of the final modulated power amplifier through the low-pass filter. This plan eliminates the modulation transformer and associated critical high-power audio components. Here is a different method of modulation with which the a-m buffs can experiment. There are possibilities for the development of a

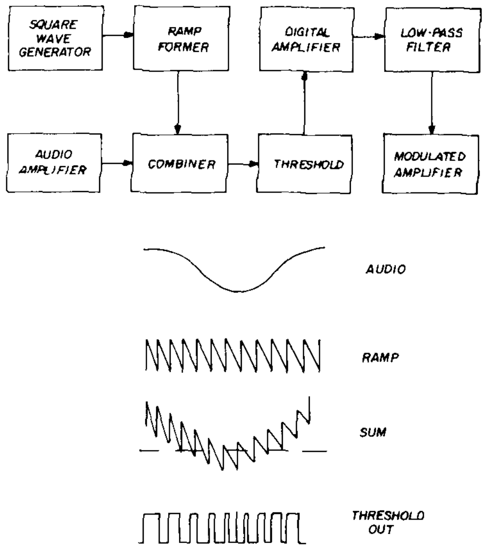

fig. 10. Block diagram and waveforms for pulse-duration modulation.

kilowatt vhf-uhf a-m transmitter with less weight and fewer critical components than is common today.

Give some thought to possible uses for pulse-duration modulation in other facets of amateur radio. Everything seems to be going digital so there should be some tie-ins. How about a digital audio amplifier and speech processor for sideband or fm?

The functional block diagram of **fig. 10** shows the process begins with a square-wave generator. This generator operates on a frequency up to five or ten times higher than the highest modulating frequency. A square wave is generated which is integrated to convert it to a ramp voltage. The waveform generator described in the last two columns could be used to generate such a sawtooth ramp voltage. The ramp voltage and the audio modulating signal are applied to a combiner stage and the waveforms of **fig. 10** show the results of this summing.

There follows a threshold stage which levels off one half of the joined waveforms. It should be noted from the waveforms that the duration of each ramp has become a function of magnitude of the original audio wave at that particular instant. Duration of the ramp for the positive peak is greater than during the trough of the modulating wave. Hence the output of the threshold stage becomes a train of pulses, the durations of which follow the amplitude change of the modulating wave. A change in frequency of the modulating wave simply changes the rate at which the pulse duration varies. In effect the amplitude variations of the modulating wave have been converted to a train of constant-amplitude pulses with durations that follow the original audio.

The pulse train has two levels, on and off. Hence the following amplifiers can be operated between cut-off and their full-on condition (digital switching). Efficient amplification is now possible without distorting the modulating information, and the signal can be increased in magnitude up to hundreds of watts, if desired. In a high-powered broadcast transmitter the average power level may be 20 to 50 kilowatts. In amateur practice the entire chain might be solid state, ending in an output of several hundred watts.

The final step is to integrate back to the original audio variation. This is done with a low-pass filter that removes the pulse frequency and its harmonics, leaving a copy of the original audio variation. Output can be at low impedance and will series modulate a high-powered rf power amplifier without the need for a modulation transformer and the large audio components and filters needed to supply high voltage to modulator and modulated amplifier.

TTL fm demodulator

Wireless World presented a circuit for an fm demodulator of high linearity using a TLL one-shot monostable, **fig. 11.**[1] Since the input of the SN74121 also includes a Schmitt trigger, no limiter is required. Muting is handled by supplying a dc component from the rectifier transistor to the inhibit inputs of the trigger. Inasmuch as the output pulse is one of constant width, the voltage developed at the output integrator is proportional to the i-f frequency. This output resistor-capacitor combination also provides de-emphasis.

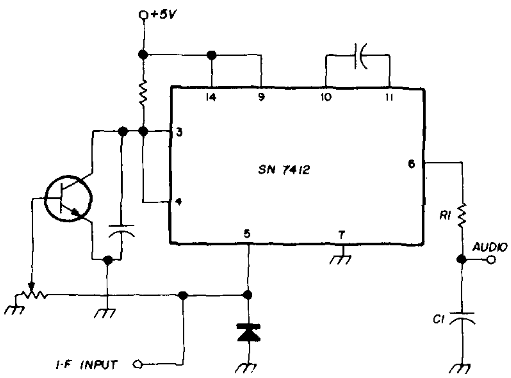

fig. 11. A TTL fm demodulator. This circuit was taken from the British electronics magazine Wireless World, **April, 1972 issue.**

ouch!

Several of the computer pros have clobbered some of my introductory digital IC coverage. Mr. E. D. Jensen of Honeywell sent them in good organization. I make amends by including his comments and corrections:

"In April, a typo in DeMorgan's theorem just before **fig. 1** erroneously claims that $X = \overline{A \cdot B} = \overline{A + B}$.

"**Figs. 1 and 2** illustrate the positive NAND function but uses the standard symbol for a positive NOR gate.

"In the June column on multivibrators, **fig. 1** has several problems. Most obvious is the NOR gate RS flip-flop which is actually made of inverters. While this FF will operate correctly for the 0, 1 and 1, 0 input cases, you have wire-ORed the outputs of the FF with those of the driving gates. If these are TTL gates, the 0, 0 and 1, 1 input conditions will now destroy one or more gates.

"Furthermore, the response of a correctly wired RS FF to the 0, 0 input will always be both outputs high, not a no-change as you stated.

"The truth table of **fig. 2A** is also wrong in that a clocked RS FF has the same reaction to a 0, 0 input as an unclocked – at least you were consistent. The **fig. 2B** truth table mistakenly uses the input convention of the RS FF for the JK FF. Q is caused to go high by a 1 on J, not a 0 as is the case for S. Also, it would be much more enlightening if the table showed the outputs for 0, 0 inputs when c = 1 instead of 0.

"While **fig. 5** is reasonable for an experiment, it should be noted that simply leaving TTL inputs floating is not a reliable means of insuring that they are high. Pins 1 and 2 ought to each be tied up to +5 V through 1k resistors.

"Finally, I must point out that experiment three fails to observe the 150-nsec maximum risetime spec of TTL. Many gates will indeed operate on sine wave inputs, but they are not guaranteed to do so (that is why the 7413 exists)."

errata

Count for the chains of B and C in **fig. 2** of the August issue should be: 50, 10, 2 and 1 kHz and 50, 10, 5 and 1 kHz.

reference

1. Circuit Ideas, "Low Distortion F-M Demodulator," *Wireless World,* April, 1972, page 185.

ham radio

the ham notebook

noisy fans

In any equipment using vacuum tubes, the removal of excessive heat becomes imperative in obtaining reasonable equipment life. Most of the equipment presently in amateur use is vacuum-tube operated. Manufacturers of communication equipment *normally fail to remove* heat on this equipment unless the heat generated causes immediate catastrophic failure to the components (in the range of three to ten hours of operation). Yet very little is done about removing the heat which is not critical. The reason is obvious: extra parts and extra engineering increase manufacturing costs, lower profits dull the firm's competitive edge.

The solution then, is left to the consumer. Since the removal of heat is important, the best way of going about it, is by just blowing it off. The easiest way to do this is to use a small fan (like Rotron, Muffin, *Sentinel, Centaur or* Whisper fans). To achieve maximum efficient electronic cooling, compromises must be made. First: the amount of air to be moved should be known – the more air you move, the greater the cooling factor (assuming a stable ambient-temperature), Second: the more air you move, the more noise (air noise, rotor noise, motor noise) you generate. I found that for most amateur communication equipment, the amount of air needed for proper cooling varies from about 65 cfm to about 110 cfm. Optimum value is generally set at 75 cfm; yet it is nice to *have the capability of going to about* 100 cfm for those long operating periods or for operation on hot summer days.

Getting a Mark 4 Muffin fan and slowing the motor, I had the capability of running the fan at 75 cfm and, when things got rough, switching to 100 cfm. Establishing the proper motor speed for this type of fan, I found that the best reference setting for about 75 cfm was about 70 to 90 Vac, depending on the type of fan. You could use a speed control for the fan, but speed controls run from five to fifteen dollars. The fan *only costs about ten* dollars so this is *an* expensive method to try. If you use a power resistor in series with the fan, you are essentially generating more heat.

The best was to slow down the fan and also make it run quietly, is by using a capacitor in series with the fan. Since a capacitor does not dissipate any power (well, very little, anyway), you are thus achieving the same result.

First, determine the power consumption of your fan. It is usually indicated on a plate on the fan body. Next, determine the resistance (simplified impedance) of your fan using $Rf=(Vt)^2/P$ where Rf is the fan's resistance, Vt is the supply voltage and P is the fan's power consumption.

In my installation, I knew P (listed as 12 W) and Vt was the standard 120 Vac. The resistance worked out to be 1200 ohms.

From **fig. 1**you can see the voltage you want across the fan. I decided to run my fan at 90 Vac. Let this be Vf in the

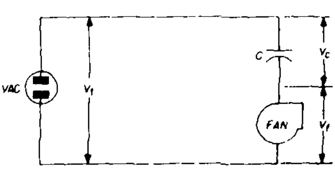

fig. 1. Voltages in the fan circuit.

figure. The total voltage, Vt, is 120 Vac. The desired voltage drop across the capacitor, Vc, is calculated simply by Vc=Vt−Vf. In my example Vc was 30 Vac.

The capacitor voltage drop, Vc, will determine the value of the capacitor needed. First calculate the necessary reactance for the capacitor: Xc=Vc/Ic. Ic is the total current through the circuit and is equal to Vf/Rf. In my case it worked out to 75 mA. By substitution, the reactance of the capacitor can be found from the new equation Xc=(VcRf)/Vf. We also know the textbook equation for reactance: $Xc=1/(2\pi fC)$.

By substitution and then solving for C, our equation becomes $C=Vf/(2\pi VcRf)$, where Vf is the voltage across the fan, Vc is the voltage across the capacitor, and Rf is the resistance of the fan at 120 Vac. My capacitor worked out to approximately 6 μF. I also placed a high-resistance carbon resistor across the capacitor to also reduce the fan speed. The switch across the capacitor allows a choice of fast or slow speed.

At 120 Vac, my Muffin Mark 4 fan moved 100 cfm with a noise level of 42 dB. At 90 Vac, the same fan moved 75 cfm with a noise level of 22 dB.

The capacitor and resistor could be mounted in a small box. Wiring is noncritical but be sure that everything is well insulated. Capacitor voltage should be 200 Vdc or better. I have tried capacitors from 1.0μF to 10μF and they all work well for different speeds. If you want more than two speeds, it is easy enough to switch in different values of capacitance.

Alfonso R. Torres, WB8IUF

s-line transceive mod

The purpose of patching the high frequency crystal oscillator signal from the S-line receiver to its companion transmitter is to assure accurate transceive operation. It is not practical to do this during manufacture with separate oscillators. However, an improved, fail-safe means of eliminating the crystal oscillator signal to the S-line transmitter from the receiver for transceive operation, together with a very simple calibration procedure, may be accomplished as follows:

1. Remove the high frequency oscillator patch cable from the receiver to the transmitter. The vfo cable remains in the jack marked *vfo input.*

2. Plug in the cable from the transmitter's own crystal oscillator to its *xtal osc input* as is normally done for split-frequency operation.

3. Set up the exciter with the frequency control switch in the normal transceive, *rec vfo* position.

4. Solder a 5- to 25-pF NPO ceramic or miniature air-variable capacitor across the appropriate crystal socket pins in the transmitter for the band segment to be corrected. In addition, a small value silver-mica padder may be necessary in some equipment.

Switch the receiver to *operate,* turn on the ptt switch in the transmitter, and adjust the new variable capacitor for a zero beat sync chirp which will be clearly audible everywhere on the dial. If the crystal frequency will not move in the right direction, interchange it with the one in the receiver.

After the modification, the receiver and transmitter high-frequency fixed oscillators are corrected to approximately the same frequency so transceive operation is accomplished in a normal fashion with split operation being unaffected. The CW offset in the CW band may be essentially eliminated by the same padding procedure. Approximately 900 Hz correction is required in CW transceive to put you very near zero beat, instead of being off by the CW beat-note frequency.

In transceive operation, with this method, you now always use the transmitter crystal oscillator. This effectively precludes out-of-band ssb operation so there are no hurried patch cables to be pulled or forgotten, especially in the 14-MHz phone band when working DX below 14.2 MHz.

Marv Gonsior, W6VFR

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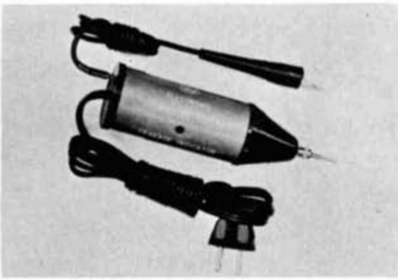

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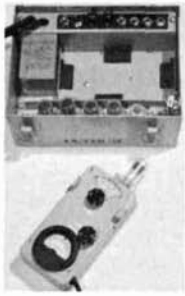

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new products

two-meter fm repeater

The new solid-state two-meter fm repeater from Standard Communications is a completely packaged repeater system including 10-watt transmitter, sensitive receiver, adjustable carrier-operated relay, time-out timer and remote control. The repeater is designed for 12-Vdc operation; current drain is 400 mA on receive and 3 amperes during transmit. Accessories include tone squelch and a 117-volt ac power supply.

The transmitter features rf output of 10 watts and frequency stability of 0.0005%. Frequency deviation is ±5 kHz, adjustable to ±15 kHz. Spurious outputs and harmonics are 55 dB below the carrier. The built-in carrier-operated relay is adjustable from noise level to 20-dB quieting sensitivity plus 10 dB. Carrier delay is adjustable from 0.1 to 10 seconds, and the time-out timer is adjustable from 0.1 to 5 minutes. An input is provided for automatic identification.

The sensitivity of the receiver is 0.5 μV minimum (20 dB quieting method). Squelch threshold sensitivity is 0.3 μV minimum. Adjacent channel selectivity at 30 kHz is 90 dB, while spurious and image rejection is -80 dB. Audio output is 5 watts; an auxiliary local speaker is available.

The new SC-RPT-1 19" rack-mounted two-meater fm repeater is priced at $640.00. For more information, write to Standard Communications Corporation, 639 North Marine Avenue, Wilmington, California 90744, or use *check-off* on page 110.

hv silicon rectifiers

A very extensive line of direct plug-in replacements for most popular mercury-vapor and vacuum glass-type high-voltage rectifiers has been introduced by Semtech. The new solid-state rectifiers are smaller and have a much longer life-expectancy than the vacuum tubes they replace. The new devices give off far less heat, require no filament power or warm-up time and are corona free. Cooling fins built into the units help conduct away heat more evenly than is possible with vacuum tubes.

Semtech calls the new rectifiers "Tubepac Silicon Rectifiers" and offers a free specifications sheet listing the PIV and maximum current ratings along with pin connection information on the complete line. The sheet facilitates direct plug-in substitution of the Tubepacs for hundreds of mercury-vapor and vacuum-tube rectifiers without any form of an adaptor.

More information is available from Semtech Corporation, 652 Mitchell Road, Newbury Park, California 91320 or by using *check-off* on page 110.

More Details? CHECK—OFF Page 110

censor-lock

The Censor-Lock is a switch which screws into the telephone handset between the carbon microphone button and the contact spring. The unit is sold to allow the telephone user to cut off audio entering a telephone line from his position *without* disconnecting the caller (as is generally done on office telephones with "hold buttons"). The unit is sold for home and office use for keeping comments, queries and confidential conversations within a room from being transmitted along the telephone lines.

The unit, however, has a particularly useful application in running phone patches by amateur radio. Often, when running a patch, there is more than enough noise and interference on frequency without having to add any more. In a normal telephone handset, noise picked up by the microphone will be heard in the speaker *along with* the caller. With the Censor-Lock in the line, stray room noises will not add to the speaker output and readability will be improved over the normal telephone noise levels.

The units come in colors to match most standard telephones. They screw in without tools and can be switched in and out instantly. They sell for $4.95. More information is available from A-Head Products, Box 817, Lomita, California 90717 or from *check-off* on page 110.

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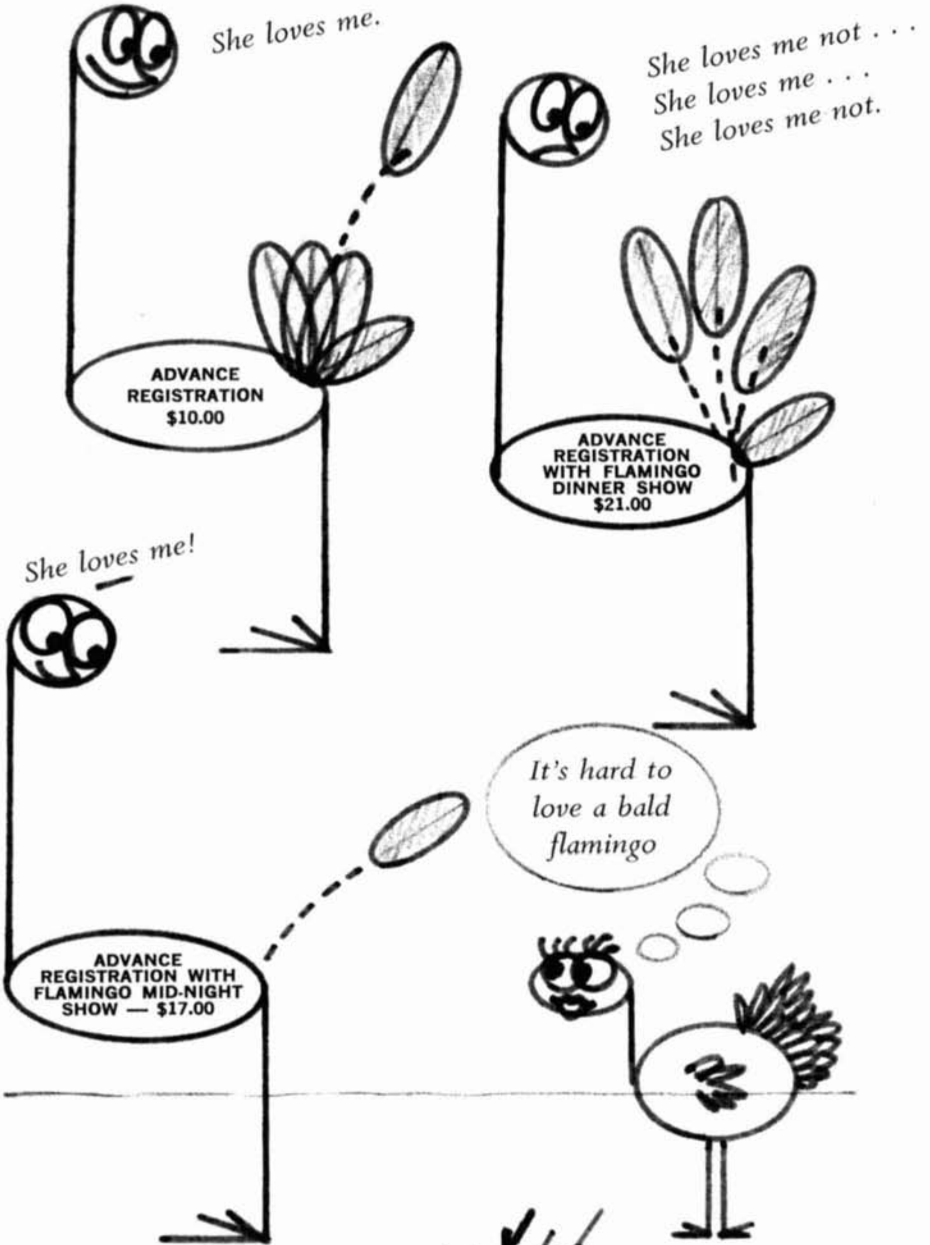

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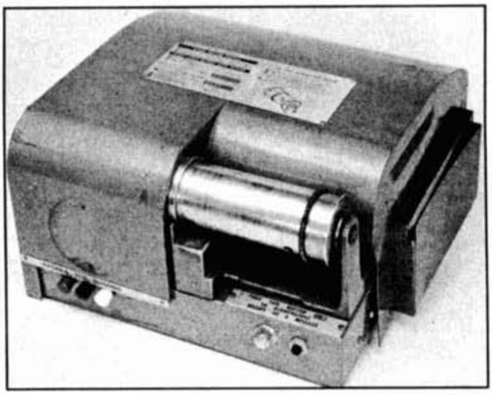

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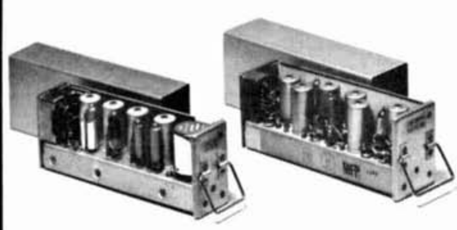

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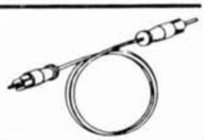

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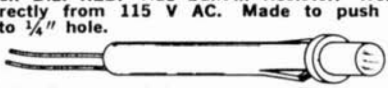
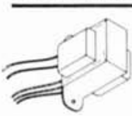


No hardware needed. 50¢ ea. ppd.



NEW NEW NEW

Low Voltage Transformer. American made. 115 VAC Primary 12-0-12 Volt 1 Amp Secondary. Very Nice. $2.40 ea. ppd.

PRINTED CIRCUIT BOARD MATERIAL

1/16 Inch G-10 Epoxy Board. 2 Ounce Copper. Factory New.

3″ x 3″	45¢ ppd.
3″ x 6″	85¢ ppd.
6″ x 9″	$2.75 ppd.
12″ x 12″	$6.00 ppd.

DIODES

PIV	TOP-HAT 1.5 AMP	EPOXY 1.5 AMP	EPOXY 3 AMP	STUD-MOUNT 6 AMP
50	.04	.06	.12	.15
100	.06	.08	.16	.20
200	.08	.10	.20	.25
400	.12	.14	.28	.50
600	.14	.16	.32	.58
800		.20	.40	.65
1000		.24	.48	.75

ZENERS

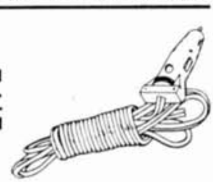
All Units Tested And Guaranteed

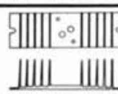
400 MILLIWATT UNITS — 3, 3.3, 3.6, 3.9, 4.3, 4.7, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1, 18, 22, 24, 27, Volts.

1 WATT UNITS — 10, 11, 12, 13, 15, 16, 18, 20, 22, 27, 30, 33, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91, 100, 110, 120, 130, 150, 160, 180, Volts. ALL UNITS 10% — 4 for $1.00 ppd. 5% — 3 for $1.00 ppd.

HIGHEST QUALITY, AMERICAN MADE POWER CORD

6 Foot Gray Cord. Good For At Least 7 Amps. Plugs Into Auto Cigarette Lighter. A Hard To Find Item. 75¢ Each or 3 For $2.00 ppd.





Part #7277151.

Black, Aluminum, Anodized, Heat Sink. Size Approximately 4¾″ x 1⅜″ h. x 1½″ w. Predrilled For TO-3 Transistors. Delco Factory New. 75¢ Each 3 for $2.00 ppd.

Rectangular 0 to 1 Mil. Meter. Panel Size Approximately 1⅜″ x ¾″ x 1¼″ Deep. Basic Movement 0-1 ma. Easily Adjusted For 0 Center With Instructions supplied. Ideal meter For RTTY Use, Etc. American Made. Price: $1.00 Each ppd.

JUST ARRIVED

250,000 American made disc ceramics. Almost all have full leads. All clearly marked with values. A bargain we may not repeat.

100 Assorted	$2.00 ppd.
500 Assorted	$7.50 ppd.
1000 Assorted	$10.50 ppd.

High quality, American Made Transformer. 115 Volt Primary. Secondary 17-0-17 Volt @ 150 ma. Tap At 6.3 Volt For Pilot Light. Ideal For Transistor Pre-Amps, VFO's, etc. Fully Shielded. $1.50 Each ppd.

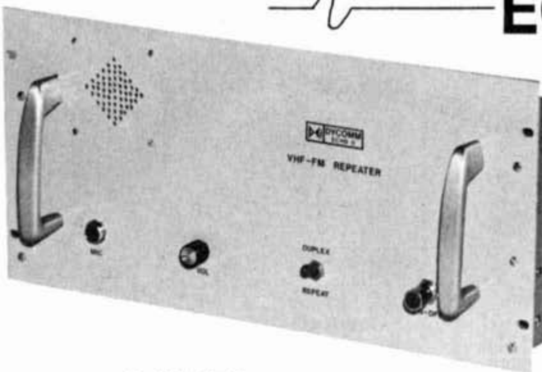
Power Transformer. 115 Volt AC Primary. Secondary #1: 32-0-32 Volt @ 1 Amp. Secondary #2: 6.3 Volts. Low Current For Pilot Lights. Size 2½″ x 2½″ x 3″. Price: $2.50 Each ppd.

6.3 Volt 1 Amp Transformer. Fully Shielded. $1.60 Each ppd.

m. weinschenker

K3DPJ BOX 353 · IRWIN, PA. 15642

ECHO II



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DYCOMM 948 AVENUE E P.O. BOX 10116
RIVIERA BEACH, FLA. 33404

250 MHz ELECTRONIC COUNTER

FREQ RANGE: 10 Hz to 250 MHz. **SENSITIVITY:** 100 mv from 2 MHz to 150 MHz, 200 mv from 150 MHz to 250 MHz. **RESOLUTION:** One-tenth Hz from 10 Hz to 10 MHz, 10 Hz from 10 MHz to 250 MHz. Has built-in prescaler for freqs above 10 MHz. **ACCURACY:** Two versions available, .0005% or .0002%, see below. **FEATURES:** Six digit incandescant readout with memory, two digit overrange for eight digit capability; six ranges; thru-line function measures transmitters up to 50 watts directly; self test; 1 MHz output jack; dual power supply, line or 12vdc for mobile use; polaroid filter; handle, bail, and cord holder. One year warranty. Prices are fob Reseda, Calif. Weight - 7 lbs.

Model 6-VHF-A with room temp xtal, .0005%, 15 to 30 degrees C **$350.00**

Model 6-VHF-A with temp comp xtal (TCXO, .0002%, 10 to 40 degrees C **$390.00**

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6742-C TAMPA AVENUE
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SPACE-AGE TV CAMERA KITS & PLANS

BE A PIONEER IN HOME TELECASTING! Build your own TV CAMERA. Model XT-1A, Series D, $116.95 pp. Solid-State. Step-by-step construction manual. High quality. Connects to any TV without modification. Ideal for hams, experimenters, education, industry, etc.

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DIAL 402-987-3771

Many other kits, parts and plans available including starter kits, focus/defl. coils, vidicon tubes, const. plans, etc.

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IDENTIFIER FOR FM REPEATERS
ID-403

- AUTOMATIC TIMING
- PLUG–IN MEMORY
- ALL SOLID STATE
- 117Vac POWER SUPPLY
- TONE BURST ENTRY OPTION

Complete, ready to go. . . .
$199.50
$239.50 (with tone burst option)

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READOUTS $3.00
7-SEGMENT 5 VDC

Long life incandescent tube ½ inch high character. Drive with 7447 IC. Write for complete list including polarizing filters, complete counter modules, many more items.

Display Electronics P.O. BOX 1044
LITTLETON, CO 80120

SUPER COUNTER — $349
TO 160 MHz (as shown with scaler) 5 digits, w/display storage very compact, 4.5 lbs, AC/DC Sens 50mV, Stblty. 1 pt 10^6/wk full wrnt. immediate delivery. Order yours now or SASE for more info. 206-747-8421.

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15112 S. E. 44TH
BELLEVUE, WA. 98006

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SIGNAL/ONE CX7A — $2,395.00
IN STOCK FOR IMMEDIATE SHIPMENT.
REALISTIC, GOOD TRADE-INS WELCOME

DRAKE

T4XB	new,	$495.00
R4B	new,	$475.00
TR4/C	new,	$599.95
AC4	new,	$ 99.95
MS4	new,	$ 22.00
MN4	new,	$ 99.00
729SRD	new,	$ 17.00
W4	new,	$ 61.95
WV4	new,	$ 73.50
TR22	new,	$199.95
ML2	new,	$299.95
SW4A	good,	$220.00
TV 1000 - LP		$ 18.75
AA-10 10 Watt FM Amplifier	new,	$ 49.95
AC-10 Power Supply		$ 39.95

The above items are just those that are in stock. We can order any others needed.

TEN TEC

ARGONAUT	new,	$288.00
210 POWER SUPPLY	new,	$ 24.95
TX100	new,	$109.95
RX10	new,	$ 59.95
AC4	new,	$ 14.95
KR1	new,	$ 18.95
KR2	new,	$ 12.95
KR5	new,	$ 34.95
KR20	new,	$ 59.95
KR40	new,	$ 89.95
Microphone		$ 17.00
PM2B		$ 64.95
PM3A		$ 79.95

COLLINS

75S3C	orig. box — unused,	write
KWM2 with 516F2	good,	$625.00
MP1 mobile supply	xlnt,	$125.00
351D2 mobile mount	fair,	$ 75.00
180U3 Antenna Tuner, Collins, military		$ 49.95
DL1 Dummy Load	good,	$ 49.95
R388/URR	looks new,	$425.00
30L1 spare parts kit less chassis/cab. etc.		$ 99.95
KWM-1 w/516-F1		$350.00

INSTRUMENTS

HP 415CR SWR METER	good,	$ 65.00
HP 430CR POWER METER	good,	$ 65.00
DIGIPET 60MHz COUNTER	new,	$299.00
DIGIPET SCALER	new,	$ 50.00
HP 130C 200uV SCOPE	mint,	$225.00
GR 1001A SIGNAL GEN	mint,	$595.00
TEKTRONIX P6006 PROBE	new,	$ 14.95
HEATH IO-18 SCOPE	good,	$ 85.00
DUMONT 304H DUAL BEAM SCOPE	ok,	$150.00
HEATH IP-17 POWER SUPPLY	ok,	$ 64.95
HEATH IG-82 GENERATOR	good,	$ 40.00
HICKOK 455 VOM	good,	$ 39.00
BOONTON AM/FM GEN	good,	$225.00
HP 355C ATTENUATOR	good,	$ 75.00
HP 355D ATTENUATOR	good,	$ 75.00
HP DY5003 XBAND TEST SET	ok,	$450.00
HP 540B TRANSFER OSC	good,	$275.00
HEATH IP-32 POWER SUP	good,	$ 40.00
HP 685A H BAND OSC	good,	$275.00
GR 1208A UNIT OSC	good,	$ 95.00
MEASUREMENTS 78E GEN	fair,	$ 75.00
HP 416A RATIOMETER	good,	$250.00
HP 492A TWT AMPLIFIER	good,	$125.00
FR-114U COUNTER, FREQ	good,	$225.00
HP KS19353 TEST OSC	mint,	$225.00

12 VOLT DC POWER SUPPLIES: 110 AC INPUT

MODEL 102, is a 4 amp overload protected power supply that automatically resets itself when the overload is removed .... new, $24.95

MODEL 104R, is a regulated power supply with the same electronic overload protection as the model 102. MODEL 104R .... new, $34.95

MODEL 107M is a heavier duty supply with the same features as the 10w but puts out 6 amps .... new, $27.95

INVERTER/CONVERTER:

MODEL 612 is a special purpose unit to provide 12 VDC negative ground power in automobiles with either 6 volt negative ground or 12 volt positive ground. 10 amp surge, 3 amp continuous .... new, $22.95

HONEYWELL

0-25 VDC Voltmeter .... new, $3.95

MISC.

AUTRONIC KEYER	new,	$ 79.50
SBE SB-36 TRANSCEIVER	new,	$895.00
JOHNSON KW MATCHBOX*	mint,	$105.00
JOHNSON 250W MATCHBOX	mint,	$ 90.00

*without coupler (swr)

2 METER VHF DUMMY LOAD/WATTMETER Good up to 15 watts — w/SO-239 CONNECTOR $19.95

ANTENNAS

2M MAGNETIC MOUNT w/RG58 & PL259	$ 9.95
AR-2 RINGO	$ 13.50
AR-25 RINGO (KW RINGO)	$ 17.00
DI-2 DIPLOMAT	$ 13.35
12AVQ VERTICAL	$ 29.95
14AVQ/WB VERTICAL	$ 47.95
18AVT/WB VERTICAL	$ 69.95
TH3Mk3 10/20/40 BEAM	$144.95
A144-7 2 METER BEAM	$ 13.95

All of the above antennas are in stock here. In addition, we can order any antenna made by Antenna Specialists, Cush Craft, Hy Gain, Mosley or Newtronics.

DX ENGINEERING SPEECH COMPRESSORS

DIRECT PLUG-IN FOR COLLINS 32S $79.50
DIRECT PLUG-IN FOR KWM — 2 .... $79.50
DIRECT PLUG-IN FOR DRAKE TR3 OR DRAKE TR4 .... $98.50
C.D HAM "M" ROTATORS, new, complete $99.95
HAM "M" CABLE .... @ 12¢/ft.
RG8A/U — 65 feet with PL-259 CONNECTORS ON EACH END $9.50
C.D. TR-44 ROTATORS, new, complete $63.95
CABLE FOR TR-44 .... 6¢/ft.

BIRD

4350 80-10M 2KW Ham Mate	$ 79.00
4351 80-10M 1KW Ham Mate	$ 79.00
4352 6- 2M 400W Ham Mate	$ 79.00
43 Wattmeter	$100.00

(Write for quote on slugs)

81 50 W Dummy Load	Fair	$ 49.95
74 Coaxwitch SP6T	New Surplus	$ 37.50
72-R Reversing Switch	New Surplus	$ 37.50

Mor-Gain Antenna Distributor .... Write for Details

Overseas friends. Barry can demonstrate and help you with the purchase of **ROBOT** SSTV Gear. Write or drop in when you are in NYC.

500 PIV 12 Amp Diodes .... 75¢

CASH PAID . . . FAST! For your unused TUBES, Semiconductors, RECEIVERS, VAC. VARIABLES, Test Equipment, ETC. Write or call Now! Barry, W2LNI. We Buy!

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512 BROADWAY, NEW YORK, N. Y. 10012

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flea market

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

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WORKED ALL EL PASO CONTEST. 2200 GMT November 4 to 2200 GMT November 5, Ten Meters Only. Contest to promote WAE certificate. Amateurs out of El Paso County must work fifteen stations in El Paso to qualify for the WAE Certificate. This can be any mode or modes of operation and on any band or combination of bands. No time limit. Past, present or future QSO's in any combination are permissible. All requests for WAE certificates must list the 15 stations, date and time worked, not QSL's, and be mailed to W5ES, 1501 Golden Hill Terrace, El Paso, Tex. 79902.

RECIPROCATING DETECTOR KIT. Send SASE to Peter Meacham Associates, 19 Loretta Road, Waltham, Mass. 02154.

DISCOUNTS! Standard, Sonar, Clegg, Robyn, Mosley, Cush Craft, Rohn, Gladding, others. Also Marine and CB. Arena Communications, Dept. H, 1163 N. Military Hwy., Norfolk, Va. 23502.

WORLD QSL — See ad page 108.

COLLINS 204H-1 LINEAR. Autotune 2-30. 2.5 KW peak, average. Like new, $1500.00. H. G. Husbands, 6626 Talmadge, Dallas, 75230.

FREE "WANT" ADS! Details, plus 4 big issues $1. HAM ADS, P. O. Box 46-653H, L. A., Calif. 90046.

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

P.C's FOR MOST CONSTRUCTION ARTICLES seen in Ham Periodicals. Also P.C's from your artwork. Write: D. L. McClaren, 19721 Maplewood Ave., Cleveland, Ohio 44135.

RTTY PICTURE TAPES. Stamp for list. John Sheetz, 5 Hansell, New Providence, NJ 07974.

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MILLEN 3" C.R.T. BEZELS $2.00 ea. postpaid. While they last. J. D. Page, 422 18th N.E., Salem, Ore. 97301.

WANTED: COLLINS 516F-2 AC Supply, will ship. Ship UPS. Tom Webb, WA9AFM/VE8, ITT/ASI (Cambridge Bay), PO 6200 Winnipeg, Manitoba, Canada R3C 3A4.

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SAVE MONEY on parts and transmitting-receiving tubes. Foreign-Domestic. Send 25¢ for giant catalog. Refunded first order. United Radio Company, 56-HR Ferry Street, Newark, N.J. 07105.

FILTERS — Panasonic Ceramic ladder type 455 kHz, bandwidth 15 kHz @ 6 db. $5.00 each. Post paid. Pace Electronic Products, Box 161, Ontario Center, New York 14520.

WANTED: HAM RADIO, All 68 and 69. Also Aug., Dec. 1970. K8JBL12, 901 Floyd Ave., Rome, N. Y. 13440.

WANTED: HP 340B; Models 343A & 349A. Noises sources. WA0JDU, Mel Overdieck, 130 Harrison Ave., So. Hopkins, Minnesota 55343.

"RTTY SPEED CONVERTER" A drilled, fiberglass 4" x 6½" printed circuit board now available for the WA6JYJ speed converter in the Dec. 71 issue of Ham Radio. $6.00 post paid. Complete parts kit including PCB $40.00, post paid. P & M Electronics, 519 South Austin, Seattle, WA 98108.

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.

QSLS. Second to none. Same day service. Samples 25¢.· Ray, K7HLR, Box 331, Clearfield, Utah 84015.

WANTED — M15 and M32 TELEPRINTERS in any quantity in good condition for use by deaf people . . . will accept donations or for fair prices . . . can be picked up anywhere . . . write Lee Brody, New York-New Jersey Phone-TTY for the Deaf, 15-06 Radburn Rd., Fair Lawn, New Jersey 07410 or call 201-796-5414 evenings.

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"AFSK GENERATOR" — PCB and all components except input output jacks, power supply and chassis. $6.60. P & M Electronics, 519 South Austin, Seattle, WA 98108.

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

SB301, SB401 — good condition, with all cables and manuals, $4.00. Barken, 274 E. Mt. Pleasant Ave., Livingston, N. J. 07039.

DX'ERS — Dig then out of the Mud. New low noise Dual Gate Mosfet Preamplifier. Nominal 20 db gain. 10-30 MHz. Complete in cabinet. $29.96. Dynacomm, 1183 Wall Street, Webster, N.Y. 14580.

TELL YOUR FRIENDS about Ham Radio Magazine.

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"DON AND BOB" GOODIES. SBE SSTV system-monitor, camera (999.90L) 849.00; SBE144 209.00; Gladding 25 212.50; with AC 255.00; SBE450 339.00; Hygain TH6DXX 139.00; Hyquad (139.95L) 109.00; 400 Rotor (229.95L) 179.00; 204BA 129.00; Mosley CL33 124.00; MCQ3B Quad 91.00; Ham-M 99.00; TR44 59.95; CDE Rotor Parts; Belden Rotor Cable 10¢/ft.; Belden 8214 RG8 Foam 16¢/ft.; Motorola HEP170 epoxy diode 2.5A/1000PIV 39¢; Rohn 15% off dealer price package tower; low quote Triex, Drake, Hallicrafters; KY65 Code ID 5.95; RG22B/U 12¢/ft.; used guaranteed Collins 75A4 345.00; write quotes, list. Prices fob Houston, subject to change without notice. Mastercharge, BAC. Warranty guaranteed, Madison Electronics, 1508 McKinney, Houston, Tex. 77002 (713) 224-2668.

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

URGENTLY NEEDED: solid state VLF receiver, RAK, AN/URM-6, Rustrak recorder and/or tape, professional weather instruments, for research programs by children. Dr. R. B. Ammons, 411 Keith, Missoula, Montana. 59801. Or call collect evenings.

WANTED: Coils G, H, and J for HRO Sixty. W51BS 820 Solano NE., Albuquerque, N. M. 87110.

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NEW FROM COMTEC! Ameco books cover all grades of amateur and commercial licenses. Also code practice records. Write for full details. Comtec, Greenville, NH 03048.

EXPERIMENTERS — Make etched dual-in-line printed circuit patterns on your board at home. Quick! Easy! Inexpensive! No taping! Details: Stamp-a-circuit, Box 113H, Westchester, Ohio 45069.

PEARCE SIMPSON — Gladding 25's, $219.95 — with 117vac Power Supply, $264.90 — HiSkan monitor incl. one xtal, $105.00. Antenna Specialists. Bill's Radio, South Rd., Wading River, N. Y. 11792. (516) 929-6118.

JOHNSON 1.5 - 5.1 pf. trimmers 3/$1.00; .0015 mfd feedthru capacitors 5/$1.00; Ceramic piston trimmers - .3 - 3 pf. 5/$1.00, .5 - 10 pf. 4/$1.00; Glass piston trimmers - .6 - 5.5 pf. 5/$1.00, 1.5 - 10 pf. 4/$1.00. Eimac SK-620 Socket $10.00. 7 pin socket for 5894, 829B etc. w/mica bypasses $2.00. Assorted terminal strips 50/$1.00. JFD piston trimmers - s.a.s.e. for list. All parts listed are unused, limited quantity, and postpaid. CPO Surplus, Box 189, Braintree, Mass. 02184.

RESISTORS: Carbon Composition brand new. All standard values stocked. ½ watt 10% 50/$1.00; ¼ watt 10% 40/$1.00. 10 resistors per value please. Minimum order $5.00. Post paid. Pace Electronic Products, Box 161-H, Ontario Center, New York 14520

QUICK GAIN PREAMP. R. F. design division of Amateur Sales and Service introduces the fool-proof way to improve your receiver sensitivity without any internal connections to your present 2-meter FM rig. Simply hook the quick gain preamp in the antenna line, apply 12 VDC, and hear the difference. The preamp features a 3N140 low noise fet, instantaneous in or out mode, 15db receiver gain, 20db rejection at 150 MHz, and small size 4"W, 2"D, 1½"H. Our low price of $39.95 includes prepaid shipping. Write or call collect, Amateur Sales and Service, 111 Rand Mill Road, Garner, North Carolina 27529, tel. 1-919-772-6044.

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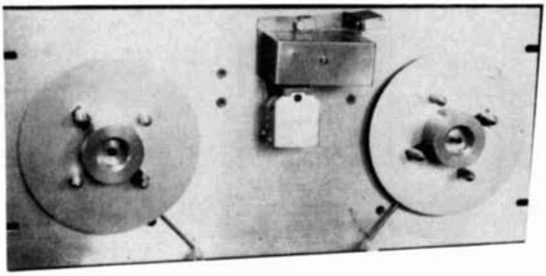

8 LEVEL PUNCH TAPE READER $50

8 Level punched tape reader with motor drive. Made by TALLY CORP. 115 volt 60 cycle AC motor. Appearance like new. $50 postpaid in the United States.

Alpha-numeric keyboards. Excellent to new in condition. Styles may vary slightly from picture. Two models available, one with ASCII encoder in base $55.00 postpaid in the U.S. Keyboard with no encoder in base $35.00 postpaid in U.S.

KEY BOARDS $35 & $50

COMPUTER KEYBOARD W/ENCODER $35
Another shipment just received. Alpha-numerics keyboard excellent condition. Once again we expect an early sellout. Price of $35 includes prepaid shipment in the US and shipment made within 24 hours of receipt of order.

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Another fantastic bargain for the builder. We have brand new bounce-less micro switch keys, spares from the above units, less key-tops. Make up your own keyboards. Made for PC mount. Package of 48 brand new key-switches only $12.00 postpaid.

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Similar to MA-4060, used in doublers, triplers, amplifiers, etc. Fully guaranteed, with specs and some circuits. $5 each or 6 for $25 ppd.

MAGNO STRICTIVE MEMORY
Good for 7116.5 Bits Storage **Like New $10**

LASER DIODE 3 WATT
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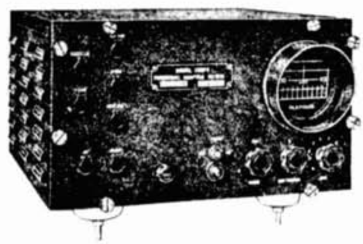

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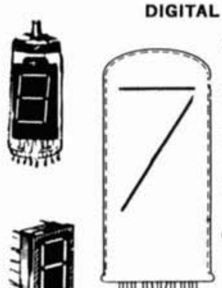

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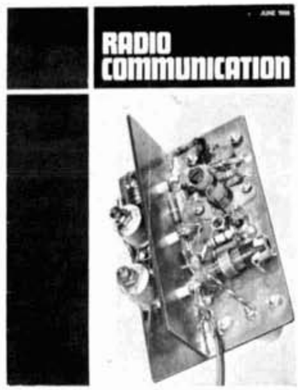

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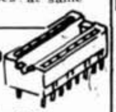

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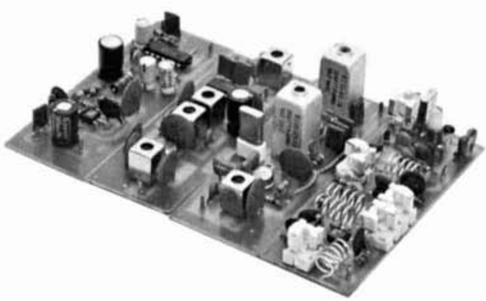

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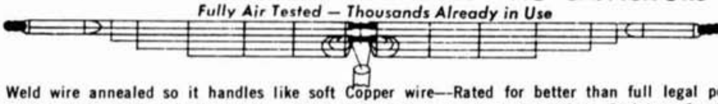

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