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USING and IMPROVING the TEN-TEC TRANSCEIVER MODULES

*A detail discussion of module circuitry,
circuit improvements, transceiver packaging
and operating experiences.*

When the Ten-Tec series of low-power transceiver modules appeared on the market, I purchased them more out of curiosity than with any great expectations that they would be very useful. This thinking goes back to about 1950 when my "large" 100W rig became inoperative, leaving only a 3W vfo—exciter available for QSOs. I had so much fun with the 3W rig on 40 and 20 CW that there followed over the years a continuous desire and search for the circuitry and components to build a truly portable low-power CW transmitter/receiver.

Of course, with tubes, one problem followed the other of trying to keep the battery drain low while still achieving a

reasonable power output, trying to extract stable performance from a regenerative receiver on the higher-frequency bands, compromising on crystal-controlled transmitter operation instead of vfo because of oscillator stability problems, etc. The result was never very satisfying, nor economical. Even some of the best "spy" type HF transmitter/receivers built in WWII never resolved all the problems involved, as became apparent later when some of the more widely produced types found their way to the surplus market or into museums.

So, with this background in mind it was very surprising to experiment with the simple and inexpensive Ten-Tec modules in

MX-1 modules simultaneously. The original interconnection instructions called for a 50 pF capacitor from the VO-1 output (terminal F) to the TX-1 (base of the MPS6514 via the lower contact on the crystal socket). Latter instructions call instead for only a 3.3 k Ω resistor since the TX-1 when keyed was found to pull the frequency of the VO-1 quite a bit. The manufacturer now recommends this change. The antenna used is switched back and forth between the TX-1 and MX-1. No tone can be heard in the headphones during transmit because the product detector is always tuned to the same frequency as the transmitter. However, to eliminate the annoying thumps heard, terminal E on the AA-1 can be grounded during transmit. Switching of the 12V supply to the AA-1 to quiet it, does not work well because the large capacitors used cause a time delay when the unit is switched on before the gain comes up.

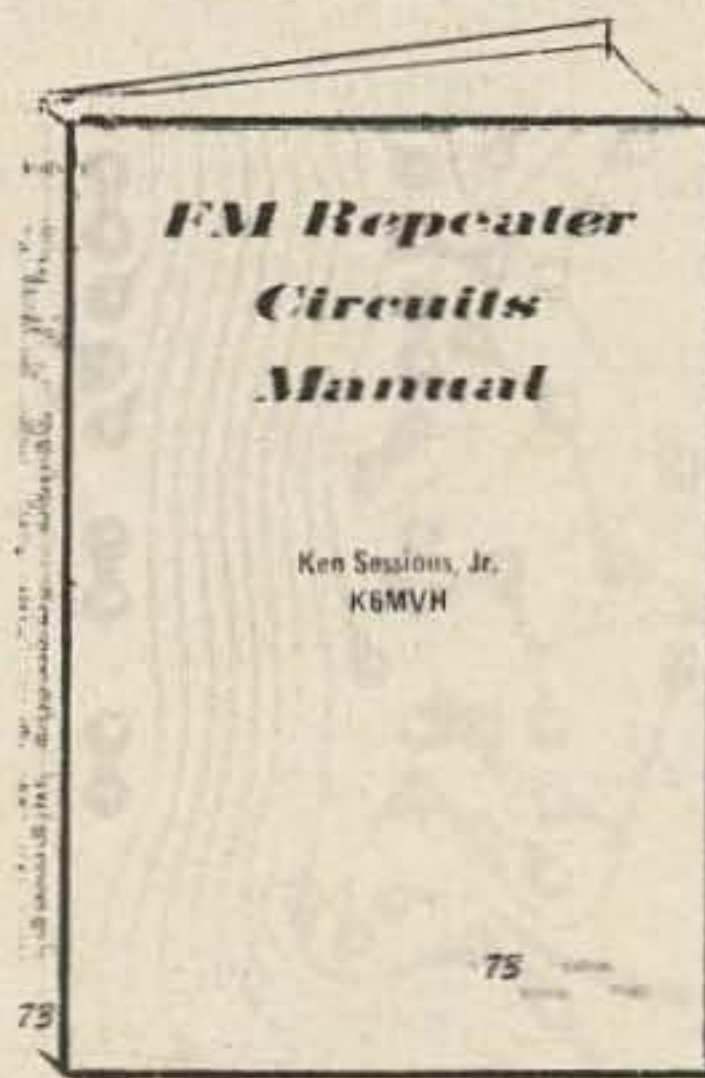
One of the most immediately noticeable difficulties in operation is the limited bandspread provided by the VO-1 module.

It covers far more than the entire 80 and 40 meter bands in one half-turn of the vfo capacitor. It is unlikely that most users will require this sort of coverage if they are interested in just the CW portions of the band. The solution is quite simple. The 430 pF vfo variable capacitor is replaced by a 150 pF capacitor fully meshed, the slug of the 80 meter vfo coil (bottom slug in coil can) is adjusted to place the vfo output at 3500 kHz and the slug of the 40 meter vfo coil (top slug in the coil can) is used to place the vfo output at 7 MHz. In this manner, just the CW portions of either band is covered and the ease of tuning is greatly improved. If one were to also add a 6:1 gear reduction drive to the tuning, such as that provided by the inexpensive (\$1.50) Jackson Bros. reduction drives, a really excellent tuning system would result. A further modification to the VO-1 would be to regulate the supply voltage to the unit. Although regulation is not required when using fresh batteries to power the transceiver, after some hours of operation the internal resistance of two series-connected 6V batteries, or three series-connected

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Fig. 2. Simple zener regulator improves transceiver stability greatly when battery supply starts to become "soft" after several hours use.

4.5V batteries, does build up and vfo chirp during keying becomes apparent. The simple solution is a 9V zener regulator for the VO-1 module, as shown in Fig. 2. Reducing the operating voltage of the VO-1 to 9V from its nominal 12V did not produce any noted reduction in output of the TX-1 module, nor in the receiving sensitivity of the MX-1 module.

Another simple addition to the modules when they are used on either 80 or 40 meters is a keying monitor and a transmitter rf output level indicator. The manufacturer does produce a keying monitor in two forms. The AC-2 module is just a keying monitor, but it is a bit elaborate and expensive as compared to the other modules for the purpose of providing just basic sidetone.

The AC6 module is a better value since it contains for about the same price not only a sidetone oscillator, but a VO-1 doubler (discussed later). However, the doubler circuit is not needed for basic 80/40 meter operation. The AC-6 keying monitor is also of the phase-shift type which produces a very good sine wave output, but is a bit superfluous when only

basic sidetone is required for a portable transceiver. The use of a 300 mA meter in the battery supply lead for tuning purposes, as recommended by the manufacturer, is certainly easy to use and does give a continuous indication of the input level to the TX-1 module. However, when dealing with such a low-power unit, it does appear advantageous to instead have a tuning indicator which shows that the maximum possible power output is being obtained.

Figure 3 shows the CW monitor developed by the author, as well as a simple rf level output monitoring circuit. The CW monitor, if one disregards the 2N706A, is seen to be a very simple unijunction sawtooth oscillator. The output is fed to the AA-1 module, but beyond the point where the volume control for the AA-1 module has effect. Thus, the sidetone volume will remain constant regardless of how the AA-1 volume control is changed during receiving. The 2N706A stage operates as a switch controlled by the TX-1 keying terminal voltage. Under key-open conditions, about 3V is developed across the key terminals. This voltage applied to the base of the 2N706A causes the transistor to "short" the .1 μ F capacitor in the 2N4616 emitter lead and that stage cannot oscillate. Under key-down conditions, the 2N4616 stage is free to oscillate. The monitor circuit produces a very cleanly keyed sidetone because of the 2N706A switch. The output frequency is adjustable by varying the 20 k Ω potentiometer in the emitter lead and the output level by varying the 2.5 k Ω potentiometer in the base 1 lead. The rf output level circuit is simply a series rectifier circuit employing a sensitive 200 μ A meter connected across the link output of the TX-1. The high series resistance used insures that the circuit will have no effect upon the low impedance output loading of the TX-1. It is used the same as any rf output level circuit, with the tuning capacitors in the TX-1 both simply being adjusted for maximum output level on the meter.

The performance of the transceiver on 80 and 40 meters, once the above modifications have been made, is very satisfac-

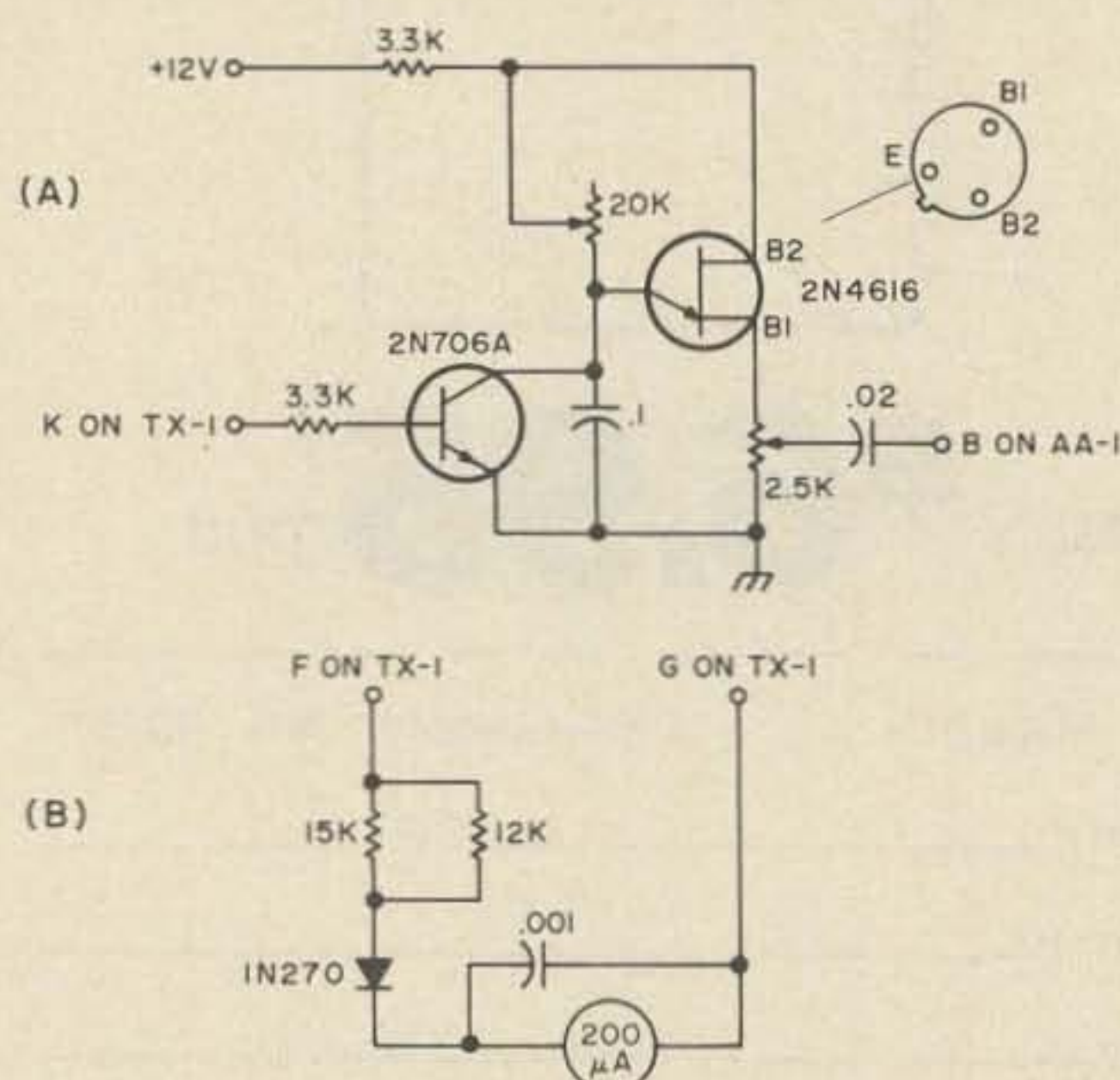


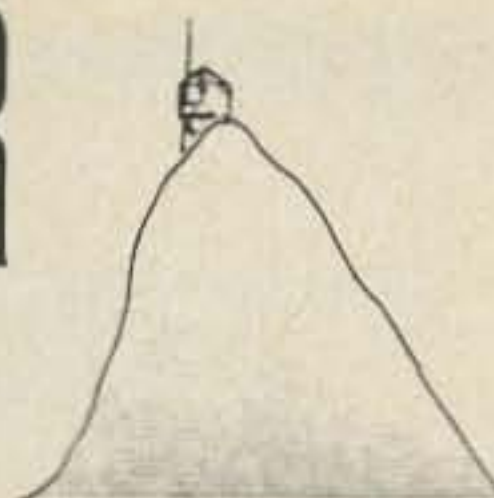
Fig. 3. CW monitor (A) with adjustable tone and volume and rf output level circuit (B).

tory. Keying is good and the stability during receive is excellent. SSB reception can be done quite easily with the expanded bandspread tuning. The CW reception is really surprising and one wonders how so many signals can be heard with even the simplest of antennas using such a simple receiver. The answer is perhaps not hard to find when one considers the high conversion efficiency and low noise factor of the MOSFET used in the MX-1 module, plus the extremely high gain of the AA-1 module. The mating of the MX-1 and AA-1 modules is very well designed. A 1.0 μ V or less signal on CW can be copied quite easily. A comparison of the MX-1 and AA-1 combination to any expensive communications receiver will, of course, demonstrate the superiority of the latter. However, the comparison of the modules to several of the medium price range receivers, or receiver portions of inexpensive transceivers, is rather disturbing. Not only does the module combination seem to perform just as well on CW but the freedom from spurious mixer responses, images, etc. provided by the module combination is really refreshing on the extremely crowded, BC infested lower frequency bands. It is a rather new experience to again be confident that what one is hearing is really on the frequency being received, rather than the creation of poor receiver design. The CW selectivity of the modules is not adjustable since it is determined by the audio filter in the output of the MX-1 module. However, one can adjust the slug in the large inductor (L2) of the MX-1 to vary slightly the audio frequency filter bandpass to a setting more suitable to individual preference. The audio gain of the AA-1 is so great that a sharp audio filter such as the surplus and inexpensive FL-8 can easily be added between the MX-1 and AA-1 when space is available to provide extreme audio selectivity without any additional circuitry.

Operation on 20 and 15 Meters

The first inclination when one investigates the usage of the modules on 20 meters is to be a bit critical of the manufacturer. The TX-1 and MX-1

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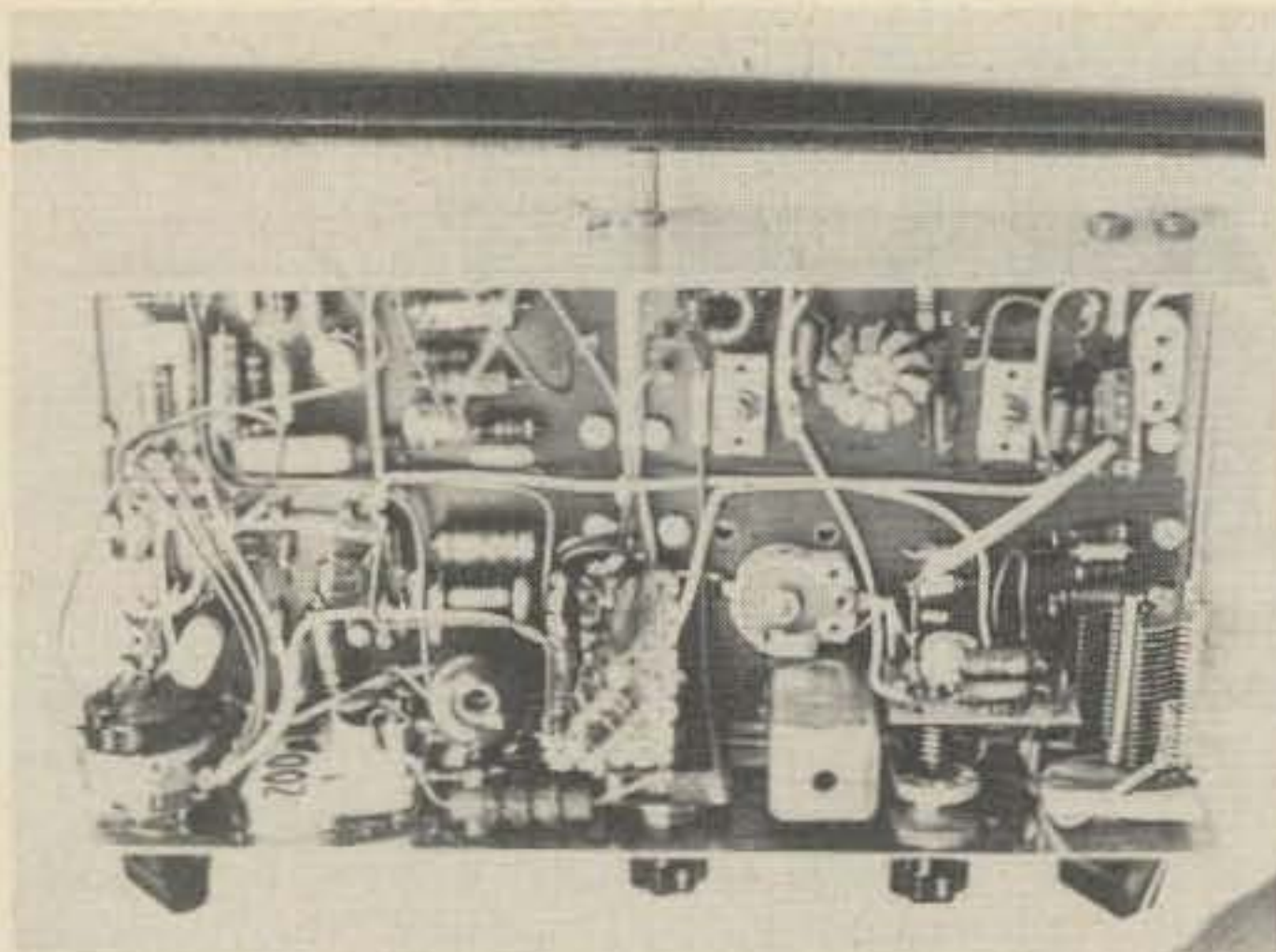
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Top view of the four basic modules as packaged by the author into a single band transceiver. Details of modifications made are discussed in the text.

modules cover 20 meters with their tuned circuits but the VO-1 module output must be doubled to provide drive to the TX-1 and an injection voltage for the MX-1. It would seem that better design of the VO-1 could have provided this simple feature. However, some consideration of the modest cost of the modules must also be included.

The manufacturer does provide a module (AC-6) which contains a frequency doubler for the 40 meter output of the VO-1, plus a CW monitor. However, a simple frequency doubler can be constructed, as shown in Fig. 4, which will also

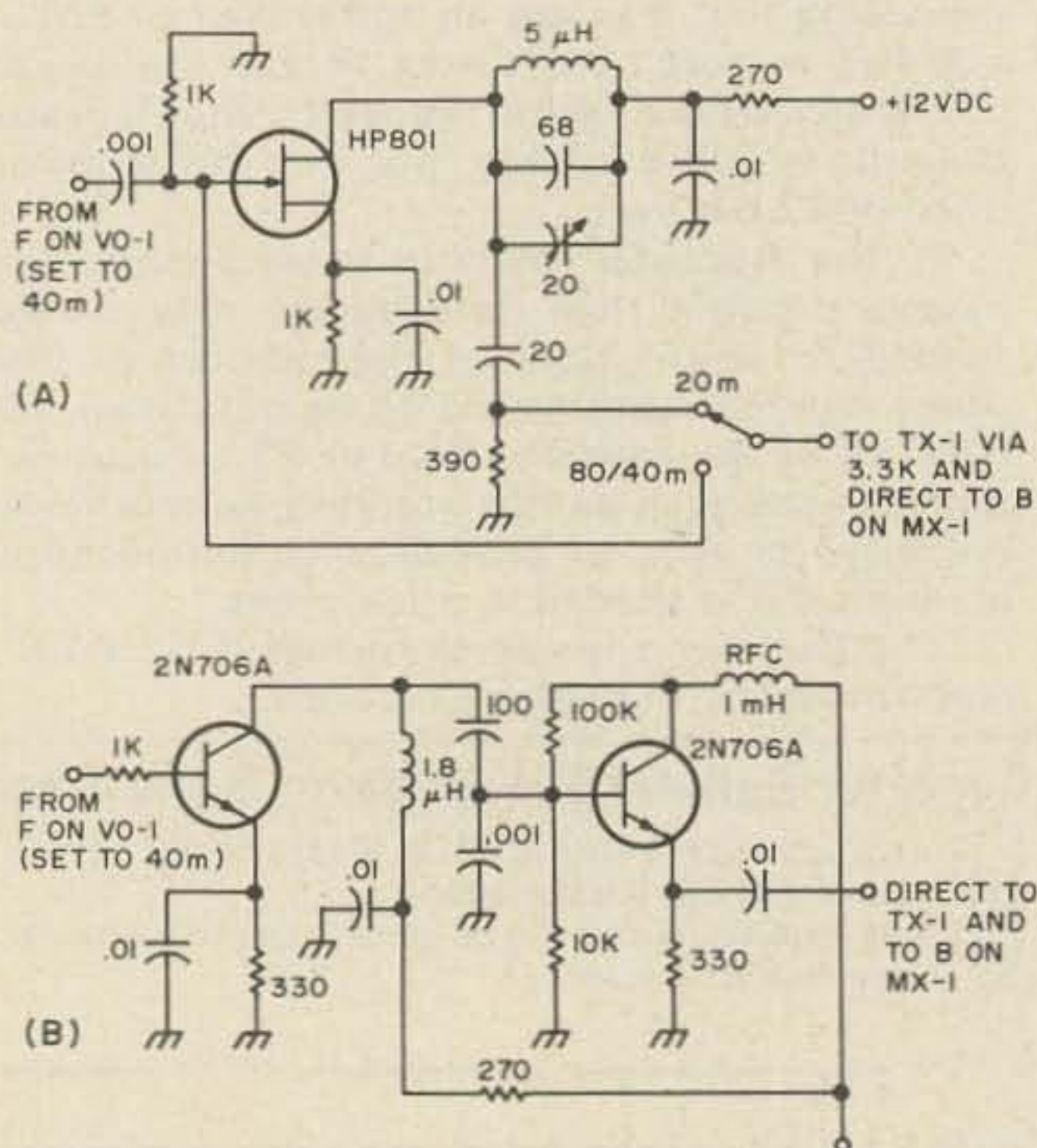


Fig. 4. FET doubler circuit (A) to convert 40 meter VO-1 output to 20 meters. Dual stage circuit (B) provides better vfo isolation and can also be used as tripler for 15 meter operation.



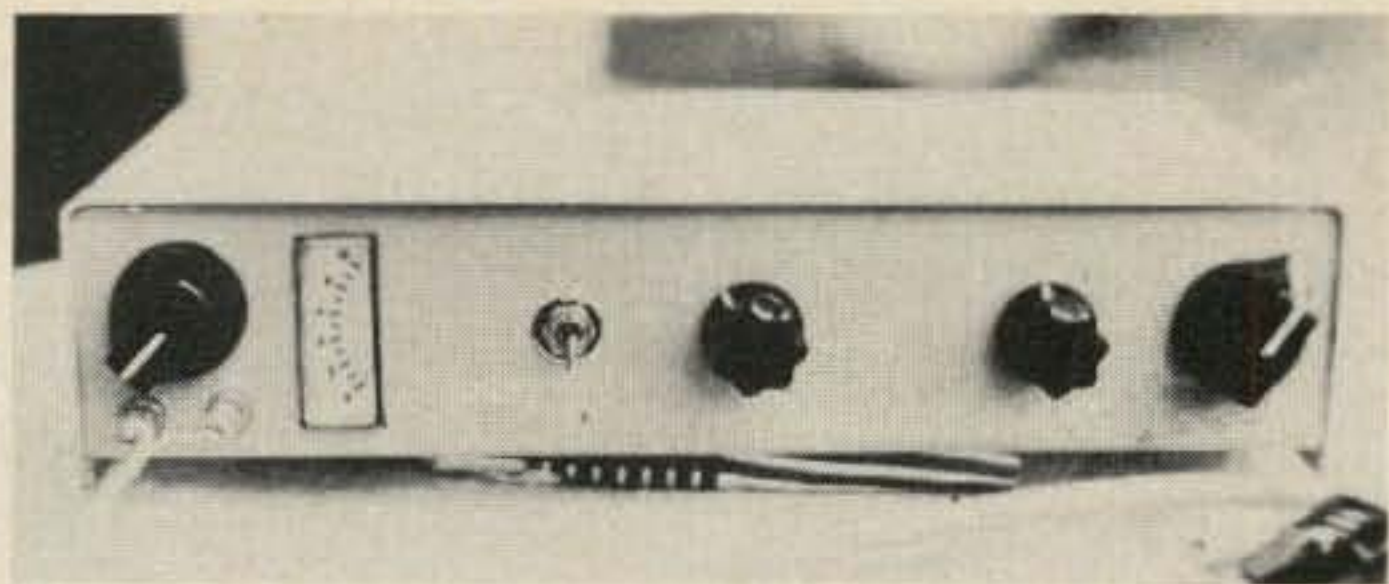
The power supply for the author's portable transceiver consists of three 4.5V flat batteries held in the top cover of the transceiver enclosure.

serve the purpose. The FET doubler shown in Fig. 4(A) provides about 2V at 14 MHz which is more than adequate for the TX-1 and MX-1 modules. However, even when using this FET circuit there was found to be noticeable "pull" on the frequency of the VO-1 unless the drain circuit of the FET was carefully tuned so that the output frequency of the TX-1 remained the same under key-down conditions and under key-up conditions when only the feed-through of the VO-1 and the doubler could be heard in a receiver. A less critical circuit is shown in Fig. 4(B). This two-stage doubler provides a broadband doubler, plus a buffer stage, so pull on the VO-1 is eliminated when the frequency of the latter is doubled from 7 to 14 MHz.

Operation of the modules on 15m becomes a bit more complicated in that if vfo operation is desired, the 7 MHz output of the VO-1 has to be tripled, but the MX-1 cannot operate on 15m and requires a down-converter to translate 15m to 40m. Of course, the necessary circuitry can be provided and one can use the circuit of Fig. 4(B) as a tripler by changing the value of the inductor in the 2N706A collector lead. The manufacturer recommends crystal controlled TX-1 operation on 15m. A rough check indicated that the TX-1 output dropped at least 50% on 15m as compared to its 40m output.

Packaging the Modules

After experimenting with the modules on various bands, I decided to package



Front view of the complete book-size transceiver package. Controls on front (left to right) are volume with headphone sockets underneath, meter, send/receive switch, final tuning, bandspread tuning, and main tuning.

them into a truly self-contained, compact and portable single-band transceiver. I decided on 20 meters as the best compromise band for reasonable performance, portable antenna size, DX possibilities, etc. However, the construction described can certainly be applied to usage of the modules of any other band, or even for multiband usage.

The first photo shows the placement of the four basic modules in the bottom section of an 8 x 4 x 2 in. enclosure (similar to BUD CU-592). The modules are all mounted on the enclosure bottom plate with the standoff hardware provided with the modules. The VO-1 module is at top left, the MX-1 module at top right, the TX-1 module at bottom left and the AA-1 module at bottom right. The placement of the modules in this fashion was deliberately done so the low-profile modules would be to the rear. This allowed the accommodation of the battery supply in the rear upper half of the enclosure, as shown in the photos. In the first photo, you can see the main tuning capacitor (150 pF) at the upper left hand corner. This capacitor was used to replace the 430 pF variable removed from the VO-1 module. Next to it is a 25 pF variable wired in parallel to the 150 pF variable and used as bandspread tuning. The bandspread tuning was added because no reduction drive was used for the main tuning capacitor. It allows far easier tuning to be done over a narrow frequency range, especially under heavy QRM conditions. The VO-1 doubler circuit is mounted on perforated board stock immediately to the rear of the bandspread capacitor and to the left of the

VO-1 inductor can. The CW monitor circuit is mounted on board stock and visible in the top center between the VO-1 and MX-1 modules. The tone and volume potentiometers are PC board types and are not brought out as front panel controls. Once adjusted, they can be left as set. Somewhat hidden behind this board is a 500 pF paper variable capacitor of the transistor radio type. It is used for peaking the 2N4427 output and is connected between ground and terminal L on the TX-1 board for 20m. Terminal E on the TX-1 board is then left unconnected. It was found not to be necessary to tune the MPS6514 stage, nor the input circuit of the MX-1 via front panel controls when operating over a 100 to 150 kHz band segment. These stages are peaked with the components already provided on their PC boards. The 200 μ A meter is clearly visible and next to it is the 25 k Ω volume control with on/off switch.

The transmit/receive switching circuitry is a bit more elaborate as that previously described and is detailed in Fig. 5. The circuitry allows battery level monitoring and rf output level monitoring, as well as the usual transmit/receive transfer functions.

Operation of the transceiver on 20m has been both rewarding and challenging. There is little more to do with the transceiver in operation except to peak the front panel final tuning capacitor for maximum rf output level on the meter. A 20m dipole cut to frequency provides excellent loading.

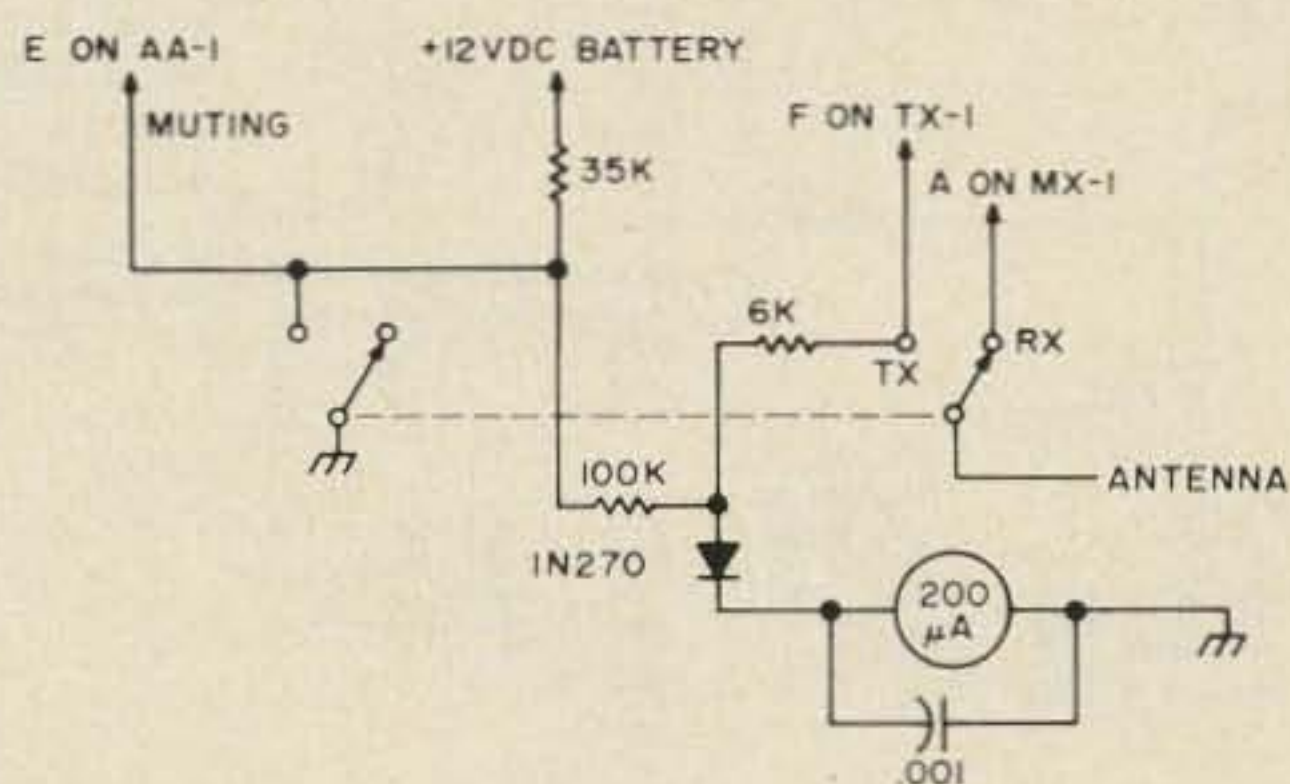


Fig. 5. A more elaborate send-receive switching circuit which provides antenna switchover, receiver muting during transmit, meter indication of battery level during receive, and meter indication of rf output level during transmit.

The operating rules for a transceiver of this power class can probably be expressed in two phrases:

1. *Never* call CQ as it is a complete waste of time.

2. When answering a CQ, wait first to hear if any strong sounding station replies also. If so, do not attempt to call the station, unless he later sends a QRZ and cannot apparently establish contact with the first station who called. The rules are simple to state and difficult to follow. But, QSOs will result instead of discarding low-power operation as a waste of time.

Further Improving Performance

The modules themselves work so nicely for their intended purpose that there inevitably follows the desire to use them as the basis for more elaborate equipment. Particularly in the case of the MX-1, there is considerable value to this idea as with some additional circuitry the MX-1 can be transformed into an excellent and inexpensive CW receiver that could rival any of the cheap-to-moderate priced receivers on the market.

Figure 6 shows an FET preamplifier stage that provides a good boost to the MX-1 sensitivity by complementing its existing low-noise FET characteristics. It is not recommended that other types of transistorized preamplifiers be used before the MX-1 since very few will have the noise characteristics necessary. Broadband,

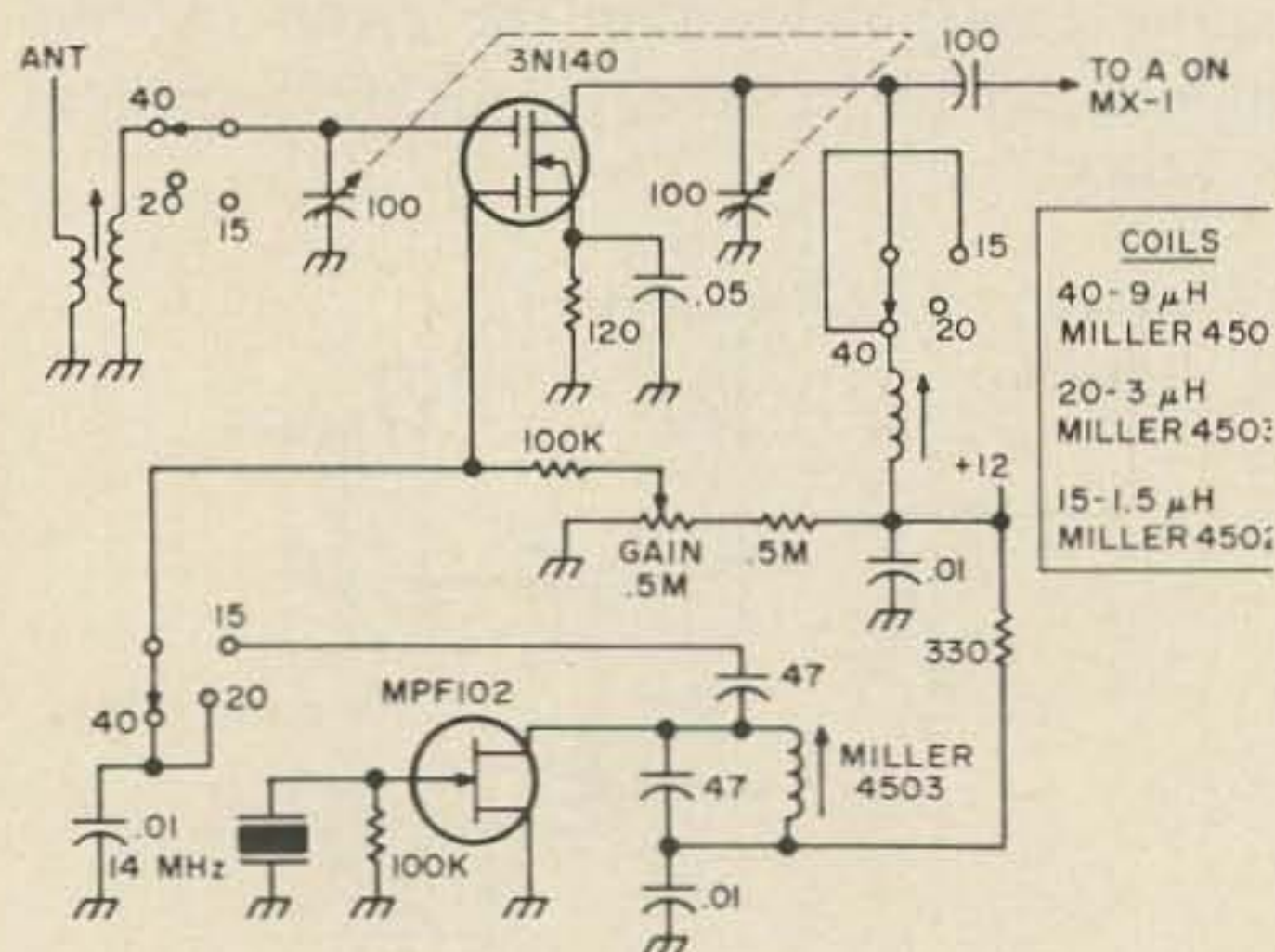


Fig. 6. Improved receiver performance can be achieved by a simple MOSFET preamp. Circuit shown can be built as a single band preamp if desired. As shown, it functions as preamp on 40 and 20m and as a down-converter to 40m for 15m input signals.

untuned amplifiers are particularly unsuitable. The circuit shown provides two additional tuned circuits before the MX-1 for added front-end selectivity. In fact, one could carry this sequence further by adding more preamplifier stages with high-Q tuned circuits in the style of the old trf receivers with 2 to 4 rf amplifier stages. One additional preamplifier stage increases the sensitivity to about 0.1 μ V on CW. The circuit of Fig. 6 can function also as a mixer on 15m to down-convert 15m into the MX-1. Used in this manner, it will perform very well as a complement to the TX-1 on 15m. If one wanted to increase the 15m sensitivity further, however, an additional 3N140 amplifier stage should be used ahead of the circuit shown with 15m coils used in both the gate and drain tuned circuits. As was mentioned before, the AA-1 module provides so much gain that an additional audio filter can be used between the MX-1 and AA-1 units. A surplus FL-8 type is very suitable and L2 on MX-1 should be shorted out for this purpose. Another approach is to use a transistorized notch filter between the MX-1 and AA-1 without disturbing the audio filter on the MX-1 board.

Even if one totals up the cost of the components necessary to provide preamplification, improved audio selectivity and vernier oscillator tuning for the MX-1/VO-1 combination on 80, 40, or 20 meters, it will be far less than the expense of any commercial superheterodyne receiver. However, "clean" reception due to the lack of spurious responses and the superior overload characteristics of the FET MX-1 and FET preamplifier will make reception much more enjoyable.

The TX-1 performance can be improved by the addition of another transistor PA stage. However, there is probably not too much value to increasing the power level for portable operation to the 5-20W category. Successful operation at these levels is almost 90% a question of operator techniques. The minimum power level which probably should be aimed for if one wants to boost the TX-1 level to a really useful value is 50-70W.

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