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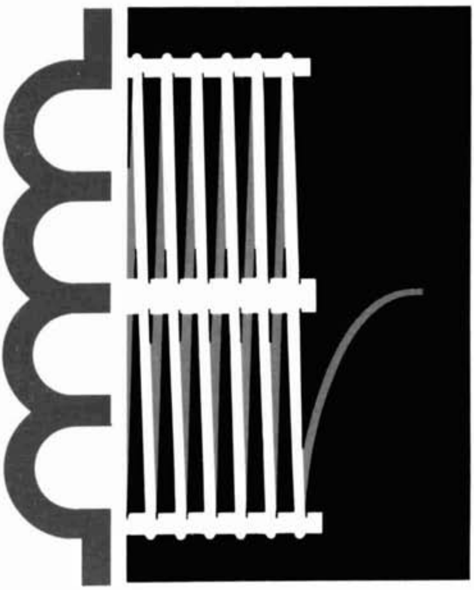
AUGUST 1975

500-WATT POWER AMPLIFIER FOR 160 METERS



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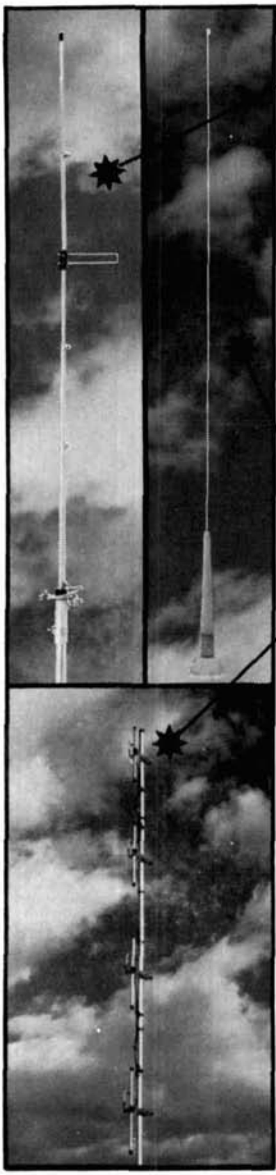

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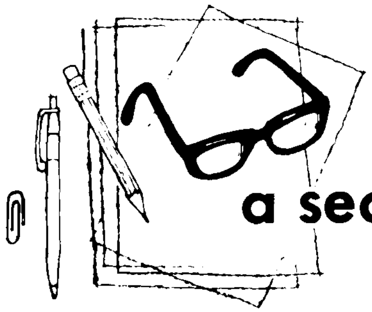

a second look

by jim fisk

It doesn't seem possible, but it was only ten years ago that the price of field-effect transistors finally dropped to the point where it became possible to use them in amateur radio projects. Those early fets, which were limited to audio frequencies, were soon replaced by devices which worked well into the high-frequency range, and later, to vhf and uhf. Now, advances in gallium arsenide (GaAs) technology have produced field-effect transistors which exhibit an *available* gain of 18 dB and minimum noise figure of 4 dB at, get this, 10,000 MHz.

If this sounds like science fiction, consider the fact that these 10-GHz fets are only the tip of a much larger iceberg – by the end of the year it's expected that advanced devices will move into the 15-GHz region, and in several years, possibly to 25 or 30 GHz. Although practical circuit experience is still somewhat limited, many researchers feel that these new devices combine the best characteristics of Schottky and tunnel diodes, but without the isolation problems inherent in two-terminal devices.

Although these fets are usually thought of as small-signal devices, cellular GaAs fets have been combined to form very efficient linear amplifiers which rival the best bipolar linears down to about 4 GHz (gain is so high at lower frequencies it's practically impossible to build unconditionally stable amplifiers).

Most of the research so far has been devoted to single-gate fets, but dual-gate structures have been built and they show great promise. Their noise figure is a bit higher than the single-gate fet, but the dual-gate version has higher gain. Furthermore, the dual-gate GaAs fet has a large gain modulation range so it's suitable for use with agc.

In addition to their use as linear amplifiers, these fets are finding applications as oscillators and mixers for integrated microwave receiver front ends. Since the GaAs fet exhibits a large dynamic range with conversion gain, it may eventually replace diode mixers at microwave frequencies. As an example of an fet mixer, scientists at Raytheon recently showed an 8-GHz GaAs fet mixer with a 7.8 dB noise figure and third-order intercept point at +18 dBm. Low-level tunnel-diode mixers for this same frequency have a noise figure which is about 1 dB lower, but gain is also lower and the third-order intercept point is only +5 dBm. However, other researchers have shown that the noise figure of the fets can be reduced considerably by cooling and predict that 1 to 2 dB noise figures will eventually be possible at 10 GHz.

So we come *full circle* . . . ten years ago a 1 or 2 dB noise figure at 144 MHz was just barely possible, but only if you were willing to use a complex parametric *amplifier*.

Jim Fisk, W1DTY
editor-in-chief

presstop

REPEATER LINKING (Docket 20073) okayed by the FCC, will be permitted after July 11th. Limitations are that linked repeaters must operate on the same band (cross-banding linked repeaters will be covered later with Docket 20113), licensee of each repeater in a linked system must submit a new system network diagram showing all stations in the system.

Repeater Automatic Control (Docket 20112) also approved, requires that repeaters operated without a control operator must record their transmissions for later review, incorporate procedures to shut the system down for "malfunctions or improprieties." No modification of existing repeater licenses is required by the terms of the Report and Order, which goes into effect July 28th.

"Closed Repeaters" (defined as "repeaters used only by persons specifically authorized by the control operator") are exempted from the requirements for recording and review — such systems typically require some form of coded access.

HIRAN DOCKET is definitely warming up as FCC's Office of Chief Engineer has asked Amateur And Citizen's Division for its list of coast area frequency coordinators. Lab and/or field testing to determine interference potential is a strong possibility, and if such tests get complicated they could further delay any decision on whether HIRAN will end up in the 420-450 MHz Amateur band.

WARC 1979's last open slot, chairmanship of 1296 MHz and up Task Force, has been filled by Chuck Dorian, W3JPT. Initial work of some WARC groups has begun with mailings and telephone discussions.

MID-CONTINENT AMSAT NET is moving from 3850 to 7280 kHz for its regular 9:00 PM Tuesday night (0200Z Wednesday morning) sessions, at least for the summer. This should reduce QRN and propagation problems, may encourage some additional participation from AMSAT members not on 75 meters.

Another Mode Jump occurred in OSCAR 7 on June 22nd. Any listener who heard the satellite go from Mode A to Mode B or simply didn't find it on the scheduled mode as expected could help AMSAT by dropping a note to Box 27, Washington, D.C. 20044.

New Satellite Amateur Band proposed by Bob Haviland, W4MB, head of the WARC '79 Task Force on 27-1296 MHz amateur allocations. A "propagation optimum" exists in the 900-MHz region, so Bob proposes a secondary amateur allocation for space communications only in the 33cm area. He also proposed that satellite allocations in other amateur bands be broadened.

Another AMSAT Project Leader is sought, this time to oversee design and construction of low cost 2- or 10-to-BC band converters (with bfo) for use in schools with AMSAT's educational program.

SEVERE RESTRICTIONS ON TRANSMITTERS proposed for Texans. A set of regulations restricting all rf electromagnetic radiation has been written up by the Texas State Department of Health Division of Occupational Health and Radiation Control. They would effectively prohibit hand-held or even mobile transmitter use in the state because of their unreasonably low levels of permitted exposure. In addition, the proposed regulations would severely limit the power output of fixed stations — and would, of course, cover public service and broadcast as well as Amateur and CB.

Whether A State even has the power to make such restrictions is questionable — the Communications Act of 1934 gives the Federal government jurisdiction over radio communications — but if the proposal should be adopted anyway, a lengthy (and expensive to the taxpayer) court battle would undoubtedly result.

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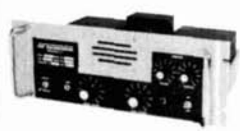

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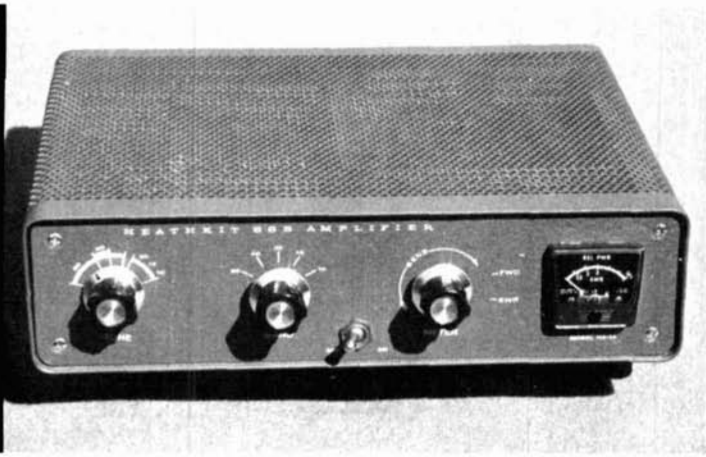


500-watt power amplifier for 160 meters

Modifying the Heath HA-14 or SB-200 for top-band operation

Albert Segen, W2BP, 101 Collins Avenue, Pleasantville, New Jersey

With the recent decrease in sunspot activity and fewer DX openings on 10 and 15 meters, interest in the 160-meter band operations has increased markedly. And, in the future, with Loran A vacating the band, we can expect full use of 160 meters with restoration of full power.

I first got on 160 in late 1968, completed my 160-meter WAC in 1973 and my 160-meter country total now stands at 74 with nearly half on ssb. The 160-meter band is now my primary amateur interest and in April, 1972, I went on a one-operator, seven-country, 160-meter DXpedition into the eastern Caribbean.[1]

Amateur stations in the states and provinces along the Atlantic and Pacific coasts are generally restricted to 100 watts input power at night and 500 watts during the day. The idea of 500 watts of daytime power is very appealing, particularly for use during those short periods around sunrise and sunset when long-range DX contacts can be made on occasion.

Sometime ago I picked up a Heath HA-14 linear rf power amplifier for use on 10 through 80 meters. The HA-14, known as the "Kompact KW," was originally designed for mobile use although separate ac and dc power supplies were available. It appeared that the HA-14 could be modified for operation on 160 meters, so another was obtained. The HA-14 is no longer in production but units invariably turn up at amateur flea markets and auctions. The current pro-

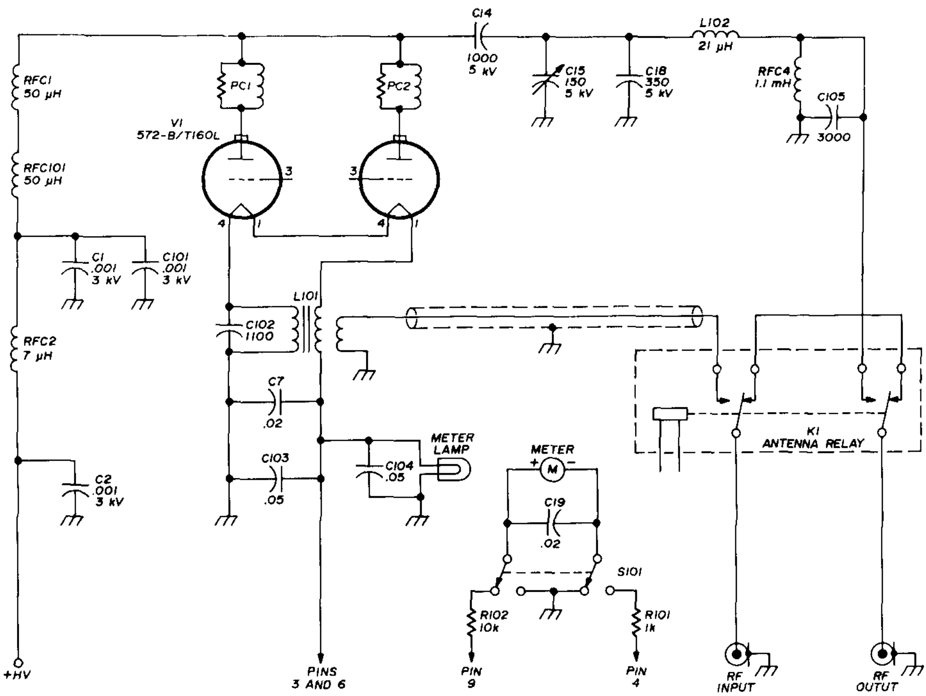


fig. 1. Schematic of the Heath HA-14 modified for operation on 160 meters. Components with 100-series part number (R101, C101, etc.), are added.

duction Heath SB-200 is much like the HA-14 rf circuit; modifications unique to the SB-200 will be treated later in this article.

The modifications described are for a 1 kW ssb amplifier operating over the range from 1800 to 2000 kHz. Some performance will be compromised when the amplifier is used at a CW level of 500 watts input.

design factors

Before modifying a proven unit like the HA-14, I felt it was appropriate to go through some of the basic design calculations for the output pi-network. Using a plate supply voltage of 2100 volts and an input of 1 kW peak ssb in class-B linear operation, the plate load impedance was calculated to be about 2800 ohms. This plate impedance requires a pi inductance of about 21 μH and a tuning capacitance around 440 pF.[2] Happily, these values could be accommodated in the space available within the HA-14.

With the HA-14 operating at 500 watts input on CW, the plate load impedance is essentially doubled, requiring an inductance far larger than the room available in the HA-14. Therefore, using component values calculated for 1 kW ssb input, amplifier efficiency is somewhat lower at 500 watts CW but there still is a worthwhile power increase.

modifications

A schematic diagram for the 160-meter HA-14 power amplifier is shown in **fig. 1**. As there are no changes required in the grid circuit, that portion of the amplifier is not included in the diagram. The values of the original plate choke, RFC1, and bypass capacitor, C1, are not high enough for operation on 160 meters. The addition of choke

RFC101 in series with RFC1 and capacitor C101 in parallel with C1 solve this problem. The location of these parts is shown in **fig. 2**.

All components in the plate circuit tank compartment are removed except the variable capacitor and the wiring harness. I chose not to destroy the original coil and was able, with care, to disassemble the multideck bandswitch by loosening all the assembly screws. This allowed the original coil to be removed without cutting any coil connections to the deck switch.

The output capacitor, C105, consists of three capacitors in parallel which are mounted on the rear wall of the compartment. One is a husky 2000 pF mica while the others are 500 pF postage-stamp micas (see **fig. 3**). Do not skimp on the quality or size of these capacitors as considerable rf current flows at this point.

The pi network inductance, L102, has 37¼ turns, the quarter turn used to provide mechanical support as can be seen in **fig. 3**. When initially cut from a B&W 3026 air inductor (2 inch [51 mm] diameter, 8 turns per inch, [3.1 turns per cm], 10 inches [25cm] long), 39 turns were used. Almost two turns were unwound at the antenna end of the coil to permit the use of the polystyrene support rods as short standoff insulators for support at the left side of the compartment. A ceramic standoff insulator at the antenna end provides further mechanical support.

The 350 pF capacitor (C18 in the original circuit) is used as part of the plate tuning circuit and is mounted on a piece of aluminum strip along with the coupling capacitor, C14. Capacitor C18 is installed on the right side of the compartment and acts as a support for the hot end of inductor L102.

All the input coils and capacitors are removed at the same time the original tank circuit is removed. I was not successful in designing an input pi-network with essentially flat vswr over the range of 1800 to 2000 kHz without some sort of retuning at each end of the band. The circuit I finally worked out proved to be simple, effective and used a minimum of parts – inductive coupling of the exciter into the bifilar filament choke. The bifilar choke remains in place as in the original HA-14 except that a third winding is carefully wound onto the bottom end (see **fig. 4**).

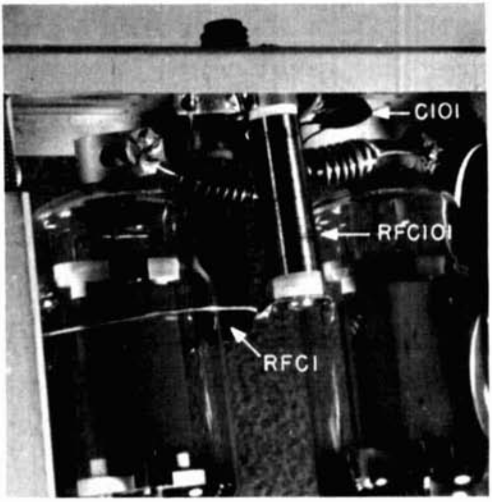


fig. 2. High-voltage compartment of the HA-14 showing the added plate choke and bypass capacitor.

This input assembly, which is labeled L101 in **fig. 1**, is resonated to 160 meters by capacitor C102 (three 300-pF and one 200-pF mica capacitors in parallel). Do not try to get away with too few capacitors here as there is an appreciable rf current flow. The third winding on the bifilar choke consists of 6½ turns of number-20 (0.8mm) stranded, insulated wire, held in place by Duco cement.

measuring dc power input

The HA-14 has no provision for measuring either plate voltage or plate current, but this is easily corrected. Whatever the merits the vswr bridge may have had when the HA-14 was used in an automobile, for fixed-base operations everyone should have a decent vswr bridge. The HA-14 meter has six divisions which readily permits full-scale readings of 6000 volts and 600 mA. The *vswr function was abandoned.*

The vswr switch and variable resistor were removed, a new rotary two-pole two-position deck switch was installed, and a meter circuit arranged for monitoring dc power input. Since another wire is to be added to the power cable to measure plate current with the amplifier meter, a new cable is needed. I used a cable four-feet (1.2m) long with number-14 (1.6mm) wires for the ac and filament lines.

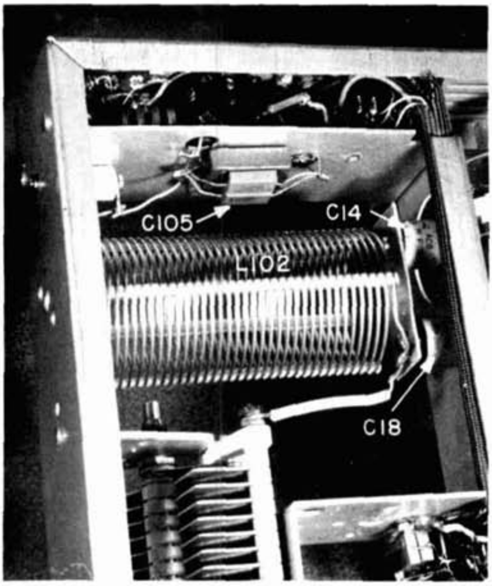


fig. 3. Pi-network compartment of the 160-meter Heathkit HA-14.

Plate current is measured by inserting a one-ohm resistor in the high-voltage ground return in the Heath HP-24 power supply and using the amplifier panel meter as a voltmeter to measure the voltage drop across the resistor. Open the ground return lead of diode CR14 and insert the one-ohm resistor. Since I didn't have a one-ohm resistor, I used ten 10-ohm resistors in parallel. **Fig. 5** shows the location of the resistor bank, R201, in the circuit. The hot end of the resistor is then wired to pin 1 of the HP-24 octal power socket and then through the new power cable to pin 4 of the HA-14 connector. Within the HA-14 a wire is run from pin 4 on the power socket through the cable bundle to R101 and then to *S101.*

The HA-14 ALC threshold level is set by a resistive voltage divider across the high-voltage line (R1 thru R7) in the HP-24 power supply. A level of approximately 6 volts dc is brought through pin 9 to the right-hand terminal of the strip seen in **fig. 4** and makes an ideal point to use for measuring plate voltage. From that point a 10k resistor, R102, goes to switch S101; S101 is used to switch between plate voltage and plate current readings. While a dpdt toggle switch could be used for S101, I used a rotary switch so the front panel of the HA-14 would retain its original appearance.

Blinking of the pilot light during modulation or keying is cured by the addition of capacitor C104. More effective rf bypassing at the bifilar choke was accomplished by adding C103. To retain the panel's original appearance, an old variable resistor from my junk box was used to fill the hole left by the removal of the bandswitch.

test procedure

The initial testing of an rf amplifier of this power level requires a good 50-ohm dummy load capable of handling the power. Vswr bridges at both the input and output are essential. It is highly recommended that an rf power output meter be used if overall performance and efficiency are to be determined.

With minimum power output from the exciter, turn on the HA-14. There should be no mistaking the closure of the HA-14 antenna relay when you key the exciter. Rapidly turn the tank capacitor, C15, to resonance as indicated by maximum power output. C15 should be about two-thirds meshed at the 1800-kHz end of the band and near minimum at the 2000-kHz end.

Next test the dc power metering. Because of the high voltage involved, these tests can be extremely dangerous and should never be made without a responsible and knowledgeable person in the shack with you. From Heath specifications and my own tests, the no-load voltage on the power supply is

Next test the input circuit. A vswr bridge between the exciter and the HA-14 should indicate a vswr of 1:1 when the exciter is keyed and the HA-14 is putting out power. If this is not the case, temporarily solder another 100 pF capacitor across C102. If the vswr improves, it means that C102 is not large enough; if the vswr worsens, it means C102 is too large and the 200 pF should be reduced 100 pF. If you find you cannot bring the input vswr to 1:1 by

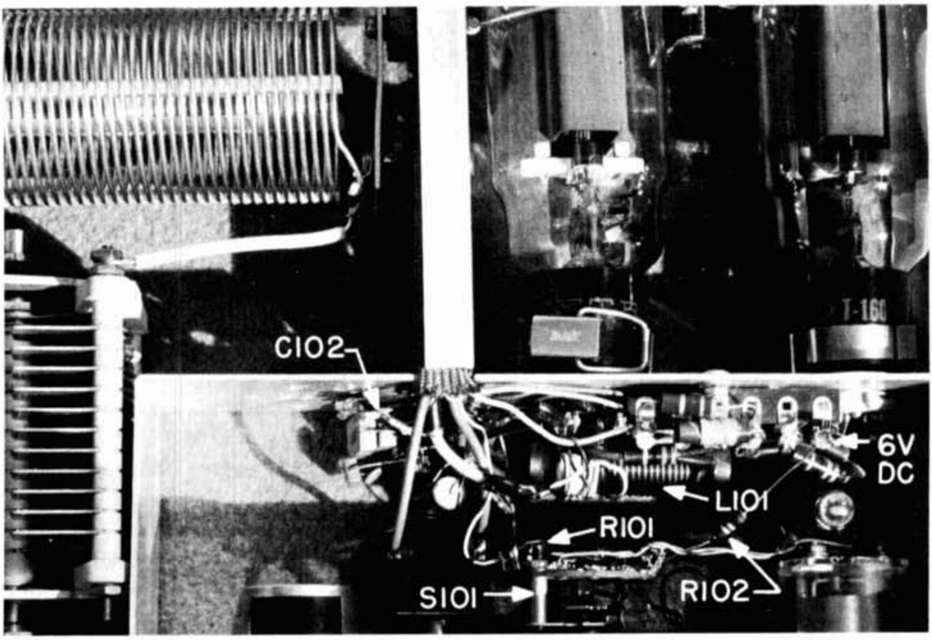


fig. 4. Input network and metering circuit.

about 2500 volts dc. Slight changes in the value of R102 may be necessary to bring the panel meter to a 2500 volt reading (2.5 on the swr scale).

With a reasonably accurate 500 mA meter in series with the high-voltage cable, increase the drive from the exciter to produce 200 mA current flow in the HA-14. The HA-14 panel should indicate 200 mA (2 on the swr scale). A slight adjustment in the value of R101 may be necessary to bring the HA-14 meter into agreement.

adjusting the value of C102, use that value at C102 which brings the vswr to a minimum and work on the third winding of L101, adjusting the number of turns until the vswr is 1:1.

When the input vswr is satisfactory and the output circuit is tuned to resonance, increase exciter drive until the HA-14 plate current is 250 mA; this is 500 watts input. Output power is about 260 watts for an efficiency of about 52 per cent. Amplifier power gain is about 6.7 dB (55 watts drive for 260 watts output). Increasing exciter drive until the HA-14 plate current is 400 mA produces approximately 800 watts input (the key should be held down no more than 5 seconds). Power output is 450 watts for an efficiency of about 56 per cent. Power gain is about 7 dB (90 watts drive required for 450 watts output).

Now you can connect your antenna. However, the antenna should have reasonably good vswr. If your antenna is not reasonably flat, you are going to run into problems. The variable tank capacitor, C15, because of its limited range, may not be able to bring the tank circuit into resonance if the amplifier load is too far off from 50 ohms resistive.

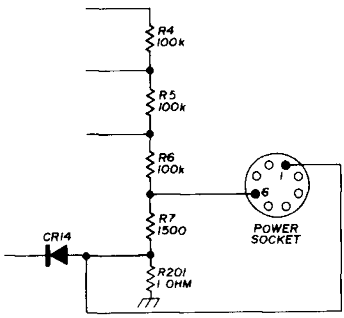


fig. 5. Partial schematic of the Heath HP-24 power supply showing the addition of resistor R201 to permit plate-current monitoring.

Heath SB-200 modifications

The rf circuits in the HA-14 and SB-200 are almost identical. While the HA-14 has C18 (a 350 pF, 5 kV capacitor), the SB-200 has no such capacitor. It can be obtained from a regular parts supplier. Heath is the source of the choke RFC101 (Heath part 45-61, 50 μH rf choke) used in both the HA-14 and the SB-200 160-meter modifications.

Because of the extensive metering in the SB-200, the metering changes described for the HA-14 are not required. This saves time and parts when modifying the SB-200. In addition, the vswr bridge is retained.

A variable pi-network output capacitor is used in the SB-200. While a fixed 2000 pF mica capacitor must be added to the output network as in the HA-14, the variable capacitor in the SB-200 should give some added control over antenna loading.

I have not modified a SB-200 but an inspection indicates the following items should be considered: C11 and C19 (bifilar choke bypasses) should be increased to 0.05 μF. Capacitor C12 may have to be removed. While C102 in the HA-14 has one side grounded, in the SB-200 this 1100 pF capacitor should be placed directly across one of the windings of the bifilar choke.

The bench checks of amplifier gain were substantiated on the air. There were not many reports as daytime activity on 160 meters is quite low. Nevertheless, during one major contest an ssb contact with Hawaii occurred at sunrise with the amplifier in use – my signal was not readable while I was running barefoot.

I estimate that no more than six hours are required to make the modifications to the HA-14 and less for the SB-200. Except for the plate choke RFC101 (which is available from Heath) all parts are quite standard. Parts cost is less than $15 if all parts are purchased new, the most expensive item being the tank coil, L102. For the SB-200 modification only the 350 pF, 5 kV, capacitor needs to be obtained. No attempt should be made to run the HA-14 at 1000 watts input on CW – the tubes would probably collapse.

references

1. Douglas Stivison, WA1KWJ, "Caribbean 160-meter DXpedition," *Worldradio News*, August, 1972, page 8.
2. Irvin M. Hoff, W6FFC, "High-Frequency Power Amplifier Pi-Network Design," *ham radio*, September, 1972, page 6.

ham radio

vhf fm receiver alignment techniques

Complete discussion of alignment techniques for the three most popular vhf fm receiver circuits

Joe Carr, K4IPV, 225 North Glebe Road #3, Arlington, Virginia 22203

There are two seemingly complementary diseases which afflict large numbers of amateurs: "alignaphobia" and "alignatosis". The first of these is characterized by an absolute terror of making any attempt to align any electronic circuit. The etiology of the disease probably lies in a very conservative (e.g. *don't touch*!) early education in electronics reinforced by a lack of self confidence, the kind nurtured best by some mystical commodity usually called "experience." The latter disease, on the other hand, causes the victim to inexplicably twist, turn and adjust everything in sight with neither rhyme, reason nor clearly defined purpose. Which is to be most feared is best left to the philosophers. The purpose of this article is to offer a little insight which will help both sufferers along; at least where fm receivers are concerned.

typical fm receivers

Knowledge has a way of alleviating both forms of alignment syndrome provided it is supplied in big enough doses. This need not be frightening as the proper dosage is surprisingly close to that level required to pass the technician/general class examination. Toward that end let us consider first a couple of the more popular fm superheterodyne designs.

Fig. 1 shows the block diagram of one typical superheterodyne fm receiver. The front end converts the 146-MHz vhf fm signals to a lower, more manageable intermediate frequency through a process of heterodyning the rf signal against that from a local oscillator. Most amateur receivers or transceivers use three to five transistorized i-f amplifier stages and, sometimes, a limiter. Another popular alternative, providing at least as much gain, is the use of one or two very high-gain IC *gain blocks* of which there are several readily available.

The final stage, prior to the audio section, is the fm demodulator. This stage processes the frequency-modulated i-f signal to extract the original audio information. In some receivers it also serves to supply the dc feedback control voltage used to drive any automatic frequency control (afc) circuits which might be used in the receiver.

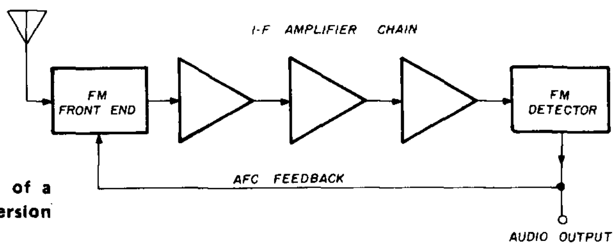


fig. 1. Block diagram of a typical single-conversion fm receiver.

Many fm receivers are actually dual-conversion jobs such as shown in the block diagram of **fig. 2**. In this system the front end converts the rf signal to the same high i-f (usually 10.7 MHz although other frequencies are sometimes used) as used in single-conversion designs. This signal is then heterodyned against the output of a crystal oscillator to produce a low i-f in the vlf range (typically 455 kHz).

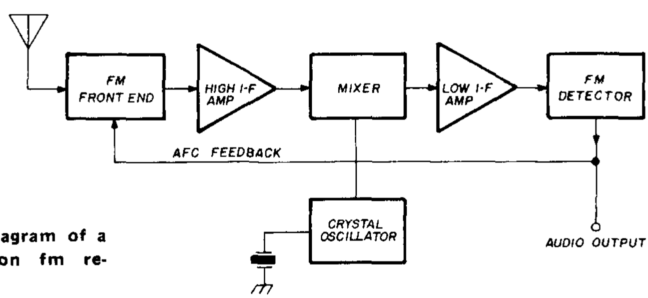


fig. 2. Block diagram of a double-conversion fm receiver.

The problem of aligning an fm receiver is primarily in learning to recognize detector types and knowing the proper procedure for that type with which you are confronted. There are three basic types of fm detectors in general use: discriminator (Foster-Seeley), ratio detector, and quadrature detector. I recognize that others exist but not in sufficient incidence to warrant coverage here.

Fig. 3 shows a simplified but essentially complete version of the Foster-Seeley fm discriminator. In this circuit signal voltages from the primary of T1 are added to signal voltages in the secondary. When the signal frequency is exactly equal to the frequency to which the secondary is tuned the output voltage will be zero. Deviation, whether caused by a shift in carrier frequency or by the process of frequency modulation, will produce a positive or negative output voltage depending upon the direction of frequency shift. This varying output voltage is the audio signal.

Another traditional fm detector is the ratio circuit of **fig. 4**. There are two immediate characteristics of this circuit which distinguish it from the Foster-Seeley discriminator: the diodes point in opposite directions and the circuit *includes an electrolytic capacitor* (C3). The capacitor is sometimes referred to as an a-m suppression capacitor as it bypasses amplitude variations sufficiently to reduce the need for a limiter. In the ratio circuit the relative charges on capacitors C1 and C2 will have a 2:1 ratio when the i-f frequency is precisely equal to the resonant frequency of the secondary of the transformer. Frequency deviation causes the ratio to change, resulting in an audio output signal.

quadrature detectors

The last type of detector to be considered here is an old friend which has been given a nominal re-birth by the advent of integrated-circuit technology: the quadrature detector. This circuit gets its name from the fact that it

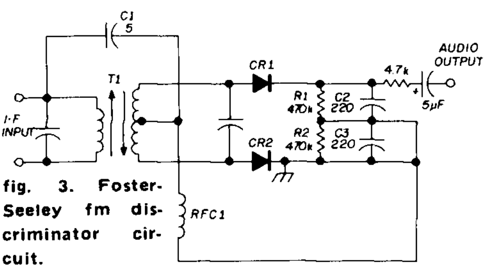


fig. 3. Foster-Seeley fm discriminator circuit.

demodulates an fm signal by combining two versions of the i-f which have a phase difference of 90° (that is, the signals are "in quadrature"). An example of the IC Quadrature Detector (ICQD) is shown in block form in **fig. 5** and as a schematic in **fig. 6**.

The input stages to the quadrature detector circuit are wideband, high-gain amplifiers which serve to limit the amplitude variations of the input signal. This eliminates a-m components such as

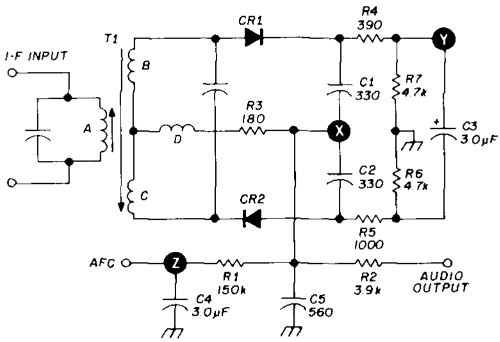


fig. 4. Fm ratio detector is found in many fm receivers.

noise and converts the signal to a series of squarewaves. These square waves have varying periods and durations, the actual value of which depends upon the input frequency and the nature of the modulation.

The square waves from the limiting amplifiers are fed to a splitter section which separates them into two channels. One is fed directly to the synchronous-gated detector while the other is fed to an external (see **fig. 6**) 90° phase shift network. The shifted version is then fed to the alternate input of the gated detector.

One process of the gated detector is to integrate the detector output pulses *to extract the audio signal. Be aware* that the use of an IC in the detector does not automatically indicate the use of a quadrature circuit. The real telling feature is the phase coil in place of the transformer. There are many types of ICs used in fm i-f stages which also include the detector diodes. An example of such a device is the popular RCA CA3043. These devices are given away by the use of a transformer.

alignment instruments

Fm alignment procedures all require some sort of controlled signal source as the standard. Some amateurs may have a complete fm alignment laboratory

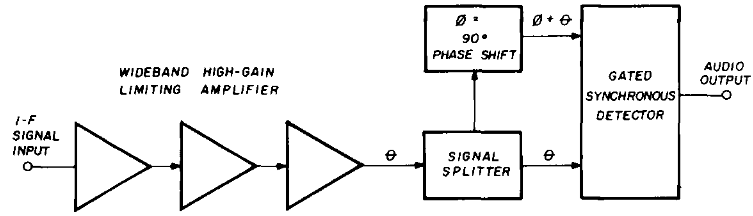


fig. 5. Block diagram of the MC1357P IC fm quadrature detector.

that would make the GE and Motorola two-way radio R&D labs jealous, but such resources are not needed, as will be demonstrated. However, if you have the resources to select a reasonably high grade instrument there are several factors to look for:

1. Low residual signal leakage. It is not very helpful if the signal level leaking around the attenuator or through the

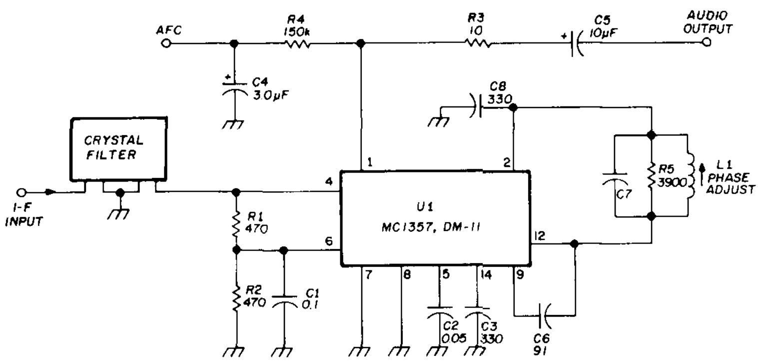


fig. 6. Typical circuitry used with the fm IC quadrature detector.

cabinet flanges can drive your receiver into hard limiting.

2. Reasonably accurate frequency dial or a means of setting to accurate points (i.e. crystal calibrator or a high-level output for a frequency counter).

3. Calibrated output level. The usual method is to have a meter with a known *set point* preceding the attenuator. The attenuator is then calibrated in microvolts or dBm.

4. Control over modulation level and some means of indicating amounts. If an a-m only signal generator is being considered, a means is needed for turning off the modulation.

5. Reasonable short-term stability and rugged construction.

There are a number of signal generators available which will suit the needs of the amateur. Some are available at attractive prices on the surplus market and include the venerable Measurements series (models 60, 80, etc), the surplus TS-497 (military version of the Measurements 80), and the old Boonton 202. **Fig. 7** shows an updated version of the model 202 now offered by the Boonton division of Hewlett-Packard as their model 202H. The main signal generator produces a high quality vhf fm signal at a calibrated output level.

The *Univerter* in **fig. 8** takes the

fig. 7. Hewlett-Packard model 202H fm signal generator (photo courtesy Hewlett-Packard).

output of the 202H and heterodynes it down to lower frequencies for use in i-f alignment. One feature of the Univerter is that it produces a low signal with the same deviation (because it heterodynes rather than divides) and output level as the 202H. This allows the calibrated output to be controlled by the 202H attenuator.

Fig. 9, the Measurements model 800, is an updated fm signal generator. A block diagram of the model 800 is shown in **fig. 10**. This instrument has proven popular with the commercial vhf fm mobile-radio crowd as it is reasonably portable for installation in a crowded service truck.

As amateurs on limited budgets we often find it necessary and advisable to have available certain contingencies which allow a goal to be realized. While I will readily concede that a kilobuck signal generator might be the *best* way to align an fm receiver, I think it is necessary to offer a viable alternative to those whose resources are limited to a vtvm or vom and a junk box full of parts. If you fall into this category, as most of us do, the signal generators shown in **fig. 11** and **fig. 12** are for you.

Fig. 11 is a simple two-transistor crystal oscillator which should oscillate between 1 and 13 MHz or so, depending upon what type of transistor you use. The transistors can be almost any small-signal type offering good gain at the frequency range of interest. One oscillator I built used some vhf pnp Germanium types salvaged from an old Delco car radio. The crystal, Y1, should be chosen to produce either the desired frequency (in the case of the i-f) or a sub-harmonic of the front-end rf frequency. For example, a 10.7-MHz crystal for the i-f and either 6- or 12-MHz crystals which are sub-harmonics of the receiver frequency. The trimmer C_T can be used to zero the crystal frequency. This can be done with a crystal calibrator and a receiver, external counter or another fm receiver known to be correctly tuned to local repeater frequency.

The low cost of TTL IC logic devices means that the calibrator of **fig. 12** can be built for practically peanuts. If the crystal is a 500-kHz type the output can be used as 5-kHz markers in a sweep alignment procedure. If you eliminate the two SN7490P decade dividers and plug in a 455-kHz crystal, the circuit can be used to supply the low i-f frequency used by some receivers. This circuit will oscillate, when selected TTL devices are used, up to frequencies of several MHz.

fig. 8. Hewlett-Packard 207H Univerter i-f converter for the model 202H signal generator (photo courtesy Hewlett-Packard).

Please note that the procedures described here, while being reasonably universal, are fairly generalized. They are not an end-all for all receivers. Some radio manufacturers might toss in a few wrinkles of their own just for fun. If you have a service manual or other source which promotes a certain technique as best, bow to their wisdom and follow it if possible. In the absence of manuals, or where resources do not permit, following the procedure prescribed here should prove successful.

A typical sweep alignment set-up is shown in **fig. 13**. The signal generator provides a calibrated, controlled source which is supposed to effectively simulate the input from the antenna. In some manuals a dummy antenna will be specified for interconnection between the generator and the receiver. The marker is a crystal oscillator which is used to provide pips on the oscilloscope trace to aid in identifying specific frequency points. The adder is an isolator which allows interconnection of all the instruments without undue interactions which might tend to make the job impossible. When the audio output from the receiver is added to the detected output from the other sources the oscilloscope will display what is essentially a calibrated frequency response curve for that receiver.

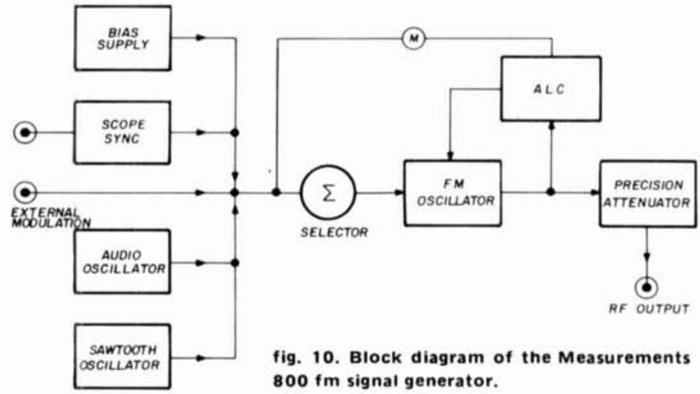


fig. 10. Block diagram of the Measurements 800 fm signal generator.

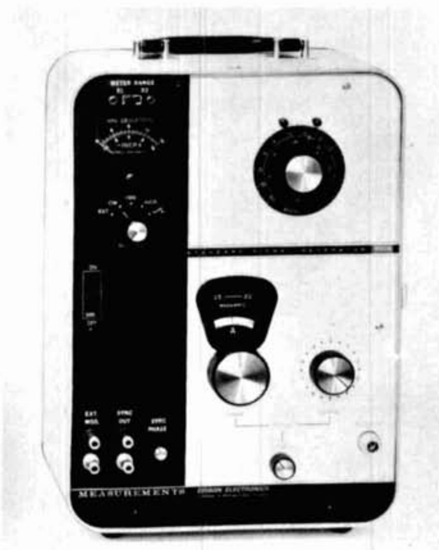


fig. 9. Measurements model 800A fm signal generator (photo courtesy Measurements Division, Edison Electronics).

Fig. 14 and **15** show the various curves associated with sweep alignment. The trace in **fig. 14A** is an i-f response curve. The dip at the top end of the curve will be especially noticeable in wideband equipment. Authorities usually claim that the dip should have a depth of ten percent of the overall amplitude. Let that be a maximum. Do not try what one serviceman acquaintance of mine did, and create the dip from what was essentially an almost ideal flat response!

Fig. 14B shows the discriminator output curve. Note that the output

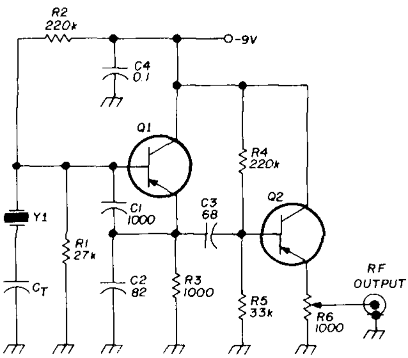


fig. 11. Simple two-transistor alignment oscillator.

voltage goes through zero when the input signal frequency is equal to the resonant frequency of the discriminator transformer secondary. This should give you some ideas as to how an fm deviation meter operates. The curve in **fig. 15** is a fairly typical response curve showing a marker pip at the center frequency.

Most receiver manufacturers clearly state in their literature exactly where they want the i-f alignment signal injected. This might be a jack or test point in the tuner or in the input section of the i-f amplifier strip. Follow their advice if the point is known. In the absence of good data connect the signal generator output to either a capacitor connected to the mixer input or a "gimmick" dropped inside the first i-f transformer. The gimmick, in this context, is simply a short length of *insulated* hook-up wire. About ¼-inch (6-mm) is bared on one end to make contact with the generator output cable.

One common procedure calls for a zero-center voltmeter (most vtvms and fet voltmeters can be made zero center by adjusting the zero control) to a point such as Z in **fig. 4**. Apply an fm signal to the input and adjust the secondary of the detector transformer to zero volt. The meter will shift positive on one side of the correct setting and negative on the other side. Now adjust the i-f tuning to produce a curve such as that shown in **fig. 15**. During this operation keep the input signal level well below the limiting point but above the noise to eliminate any ambiguity. Overdriving the receiver (driving it into limiting) has a tendency to broaden the response and obscure the true peak.

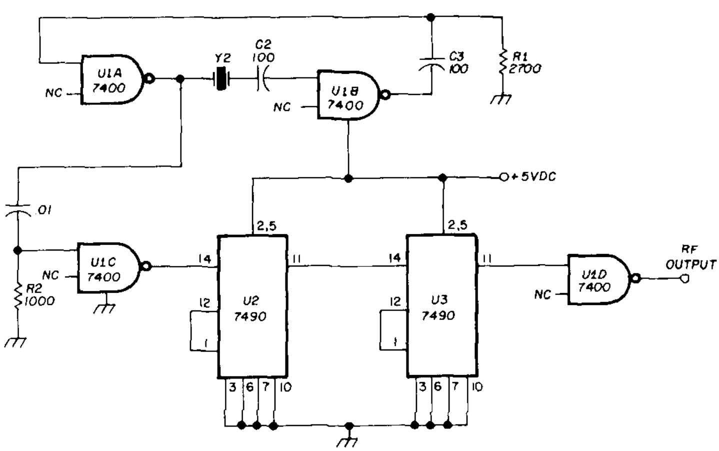


fig. 12. Simple TTL digital logic IC alignment oscillator.

One aspect of the procedure for aligning the secondary of the transformer is that the correct point is established with the least total harmonic distortion. Although that is not the best way to go (unless the proper THD analyzer is available) I have known professional servicemen who could rough in an alignment off the air to an extent that the operator would not know the difference.

The local oscillator in the front end can be set by adjusting the trimmer capacitor across each channel crystal for a zero at point Z when a precisely known input signal is applied to the input. The signal can be from a multi-kilodollar synthesizer/frequency meter, a close-at-hand transmitter, simple crystal oscillator as shown earlier (provided it is accurate) or from your local repeater. In my Heath HW-202 the transmitter oscillator is used for this purpose. Again, this assumes that some other means was used to verify the transmitter's correctness.

Peak the rf amplifier tuning to either a channel specified by the radio manufacturer or a channel approximately mid-way in the group of channels used. Of course, if the rig is a single-channel affair peak it to that channel. Rf amplifiers will typically have two adjustments. For both it is necessary to keep the input signal level down to a barely audible level. If the input is a common base or gate design one adjustment will be noticeably broader than the other.

non-swept alignment

The use of the transmitter oscillator applied to the receiver alignment in at least one model transceiver implies that it is not absolutely necessary to use a sweep generator. In fact, the non-swept technique, properly applied, will yield comparable results. However, it must be noted that sweep alignment is preferred by high-fidelity buffs because of the interaction of the i-f alignment and the channel bandwidth. In lower grade fm broadcast receivers and narrow-band equipment the need is less acute.

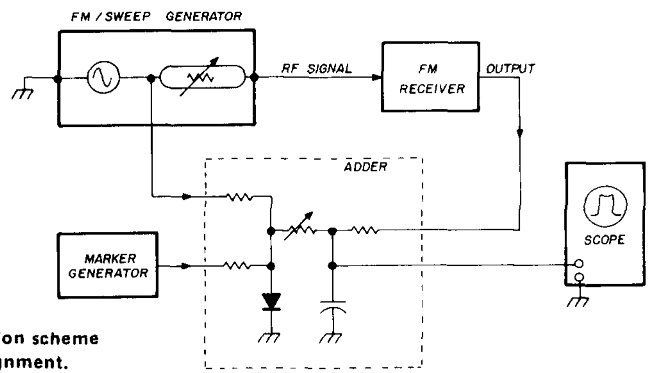


fig. 13. Connection scheme for fm sweep alignment.

It is important to note, however, that the signal source must be unmodulated. If your source is an a-m signal generator, turn the modulation off. This can be done by turning the modulation control switch to *off* or *external*. Do not depend upon the modulation level or percentage control to sufficiently reduce the level.

As was true in the swept technique, adjust the detector transformer secondary to null when the unmodulated signal, at the i-f of a channel frequency, is present at the input. Coupling to the i-f strip is the same as for the swept technique. Connect a high-impedance dc voltmeter to a point in the receiver

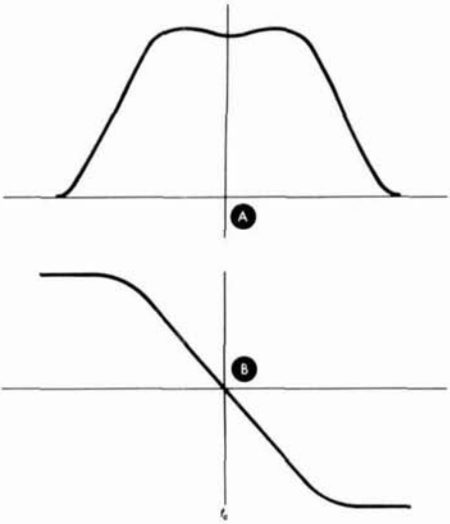


fig. 14. Typical alignment curves from sweep alignment of fm receiver.

which produces a voltage proportional to the strength of the input signal. Point Y in **fig. 4** is such a point. In vacuum-tube sets the grid of the limiter does nicely while in transistorized types the emitter resistor of the limiter is good.

Another method uses an rf detector probe at the limiter input although care must be exercised not to detune the output i-f transformer. It is necessary that the input signal level be kept low. In some cases it is a good idea to disable the agc system to prevent interaction with the alignment. No good advice can be given on this point. In some receivers you merely ground the agc line. In others you must apply a fixed bias of one polarity or the other, while in still others it is best to physically interrupt the agc line (some receivers have removable jumpers specifically for this purpose). *Do not* attempt to use your ears as a monitor of the quieting level as it will probably be inaccurate.

In both the swept and non-swept alignment procedures start at the detector and work toward the front-end. Go through the procedure several times looking for a slight improvement each time. This optimization is needed because there will be a slight interaction between adjustments.

One admonition: *Don't overtighten i-f slugs and trimmer screws.* Many ferrite slugs will become seized if they are tightened against either the top or bottom stops. Additional force will tend to make them break. One sure sign that this has occurred is a "crumbly" feel as you adjust. Stuck slugs can often be freed by application of a slight amount of heat.

I-f transformers which do not tune usually indicate one of two conditions: the transformer is defective and requires repair or replacement, or that coil is actually in the transmitter circuitry (identify *all* parts before making any adjustments). Note that many a good rig has had to make a trip to the repairman because of misguided alignment attempts. Believe me, the service guy can almost always tell a set that has been tinkered with.

quadrature detector alignment

Aligning circuits using the MC1357P or Delco DM-11 ICQD detectors requires a special technique. If a swept generator is available the job is simpler. Connect an ac vtvm across the output (in the absence of an ac vtvm a rectified dc type or an oscilloscope will be adequate) and adjust the 90° phase coil

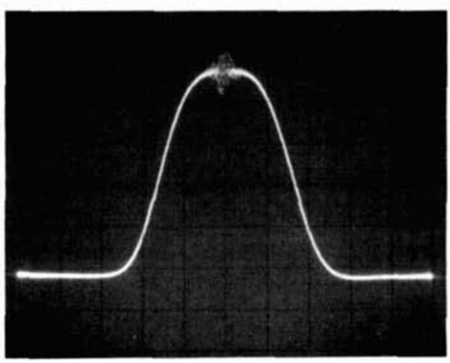


fig. 15. Oscilloscope trace of i-f passband curve with frequency marker.

for maximum output signal level. Connect a dc vtvm through an rf detector probe such as the RCA WG-301 to pin 10 of the MC1357 or DM-11 detector (it is worth noting that if you need a MC1357P replacement and can't locate one, drop into the nearest authorized Delco car radio shop and buy a DM-11 or DM-31). Now you can peak the i-f coils for maximum.

When using an unmodulated signal generator you can approximate the pro-

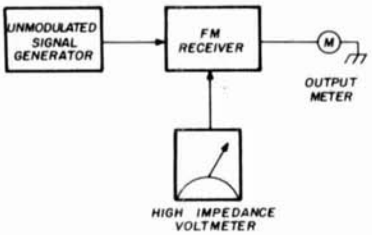


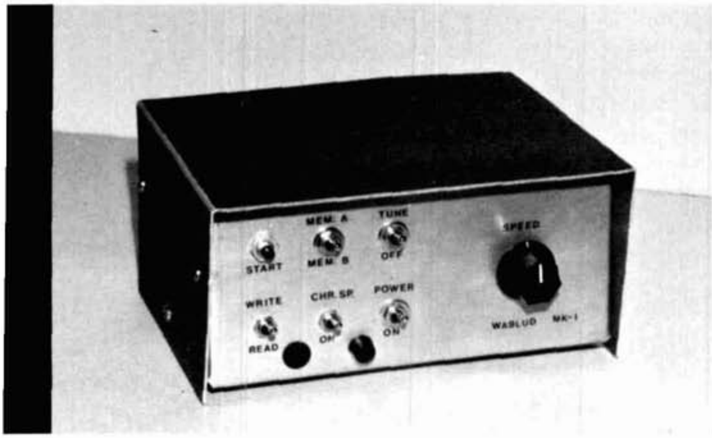
fig. 16. Test equipment arrangement for non-swept alignment of fm receivers.

per phase-coil adjustment by nulling the noise level. The phase coil is correctly adjusted when it is tuned to a null located between two relatively high amplitude noise peaks. However, this is only an approximation as the null tends to be rather broad.

summary

As stated earlier these techniques are rather generalized. They will suffice, however, for most jobs without serious performance loss. One parting word of caution: *Do not align anything as a troubleshooting method*. The first and foremost sign of the novice troubleshooter is the galloping "diddle stick." Remember that alignment doesn't change within short spans of time. If your rig suddenly stops working the fault is *not* alignment. Find the fault first. If it is an alignable component, align *only* the replacement part or the repaired original.

ham radio



Photos by WB9DZI

programmable memory accessory for electronic keyers

Design of an expandable, programmable random-access memory system for use with electronic keyers

Andrew B. White, WA9LUD, 102 Franklin Street, Urbana, Illinois

During the past few years, several circuits have been published for CW keyers, both with and without programmable memories. Most designers, however, seem to either combine memory capability with a mediocre keyer circuit or design a good keyer with no memory. With the inexpensive TTL ICs and mos memories that are now available, I felt there was room for a better design which incorporated a good iambic keyer with a programmable memory.

Riley[1] had an interesting application of recirculating memories, but the programming seemed awkward, the messages (if more than one) were stored in series, and I felt separate speed controls for the keyer and the memory should be avoided. Gordon[2] used two mos random-access memories to provide two selectable message stores, but the associated keyer was not acceptable. The other drawback I saw in both these approaches was the inability to re-start the read or write sequence until the current message was completed. The design presented here combines an excellent keyer circuit with two programmable memories.

I chose to use the very popular Accu-Keyer circuit described by Garrett[3] as the basic keyer because it features dot and dash memories, iambic operation, automatic character spacing and low cost. The memory accessory, however, could easily be adapted to many other keyer circuits. For the mos memories, I used the readily available National 1101 (or Signetics 2501) static mos RAM. These memories have a three-state output that enables two or more memory outputs to be connected in parallel with no additional circuitry.

places a zero (TTL positive logic) on the CS input of the desired memory. To read the memory, the *read* line is allowed to float high by switch S3 which enables U7C, gating the data output from the memories to the output keying circuit and sidetone. To write data into a memory, S3 takes the read line to zero, enabling a 500 ns write command pulse triggered by the trailing edge of the clock pulse (see timing diagram, **fig. 2**).

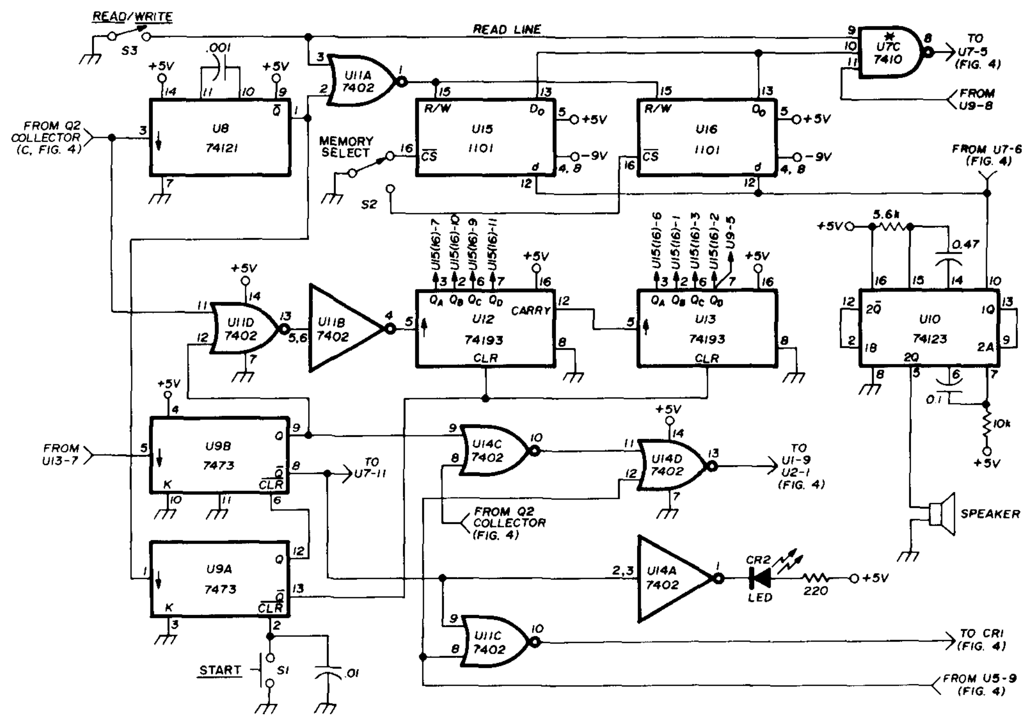


fig. 1. Programmable memory for electronic keyers uses two 256-bit random-access memory ICs, U15 and U16. Timing diagram for this circuit is shown in fig. 2.

memory circuit

Operation of the basic keyer will not be covered here because WB4VVF provided a complete discussion in his original article. Only the operation of the memory circuit itself will be examined. **Fig. 1** is a logic diagram of the memory circuit. A memory is selected for either reading or writing by switch S2 which

Both the read and write cycles are initiated by closing S1, a normally-open spst switch, which resets U9A, the start/stop flip-flop U9B, and the counters U12 and U13. When S1 opens, the synchronous four-bit counters count up on the leading edge of the clock pulse from 000 to 255 providing the proper addresses to cycle access to the RAM.

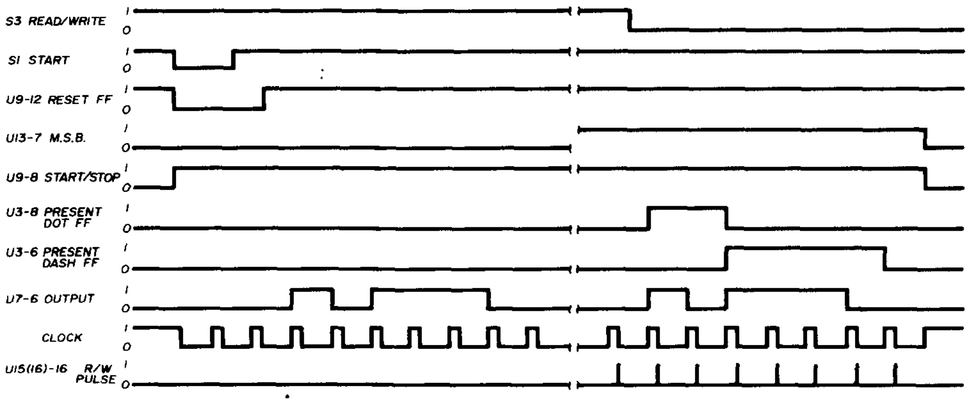


fig. 2. Timing diagram for the programmable CW memory shown in fig. 1.

When the most significant bit of the address goes from 1 to zero, indicating 256 has been attained, U9B toggles, disabling further counting and returning the keyer to normal asynchronous operation.

The start/stop flip-flop, U9B, turns on an LED to signal the user when the keyer is cycling the memory. In addition, a dual monostable, U10, has been included as a sidetone oscillator for programming the memories and use as a code monitor.

Two circuit modifications are necessary to connect the memory accessory to the Accu-Keyer, as shown in **fig. 3**. The connection between diode CR1, input gate inputs U1, pin 9, and U2, pin 1, and the missing-character flip-flop, U5, pin 8, has to be broken. Since the oscillator must run free during the read and write cycles, the anode of CR1 is connected to U11, pin 10, which is low during the memory sequence. U5, pin 9, (the complement of U5, pin 8) is connected to U11, pin 8, to provide normal operation when not using the memory.

The gate inputs U1, pin 9, and U2, pin 1, are connected to U14, pin 13, so that during the memory write cycle the dot/dash inputs are sampled only when

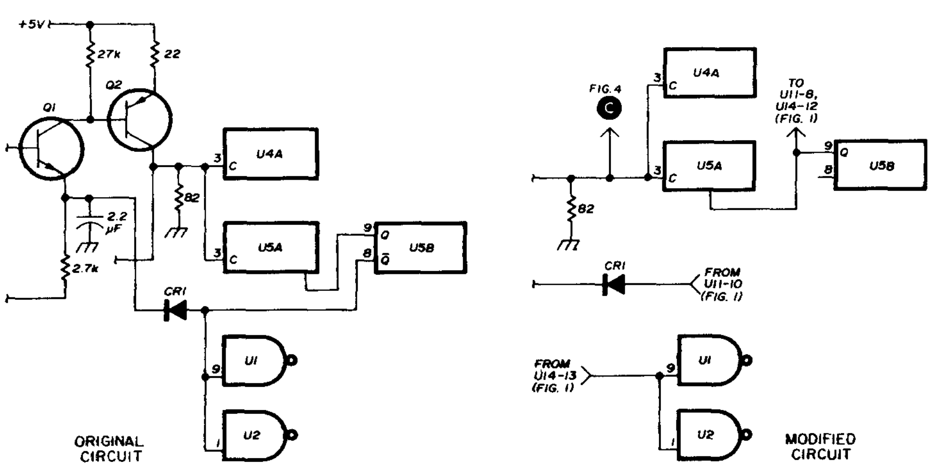


fig. 3. Modifications required to the WB4VVF Accu-Keyer for use with the programmable memory accessory. Complete schematic is shown in fig. 4.

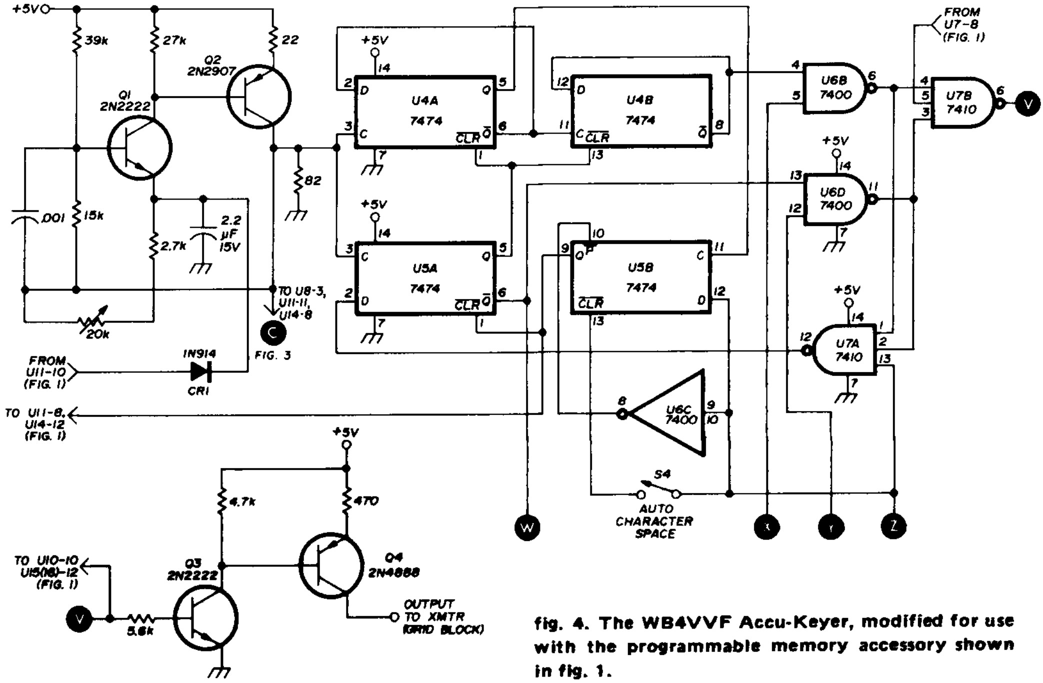
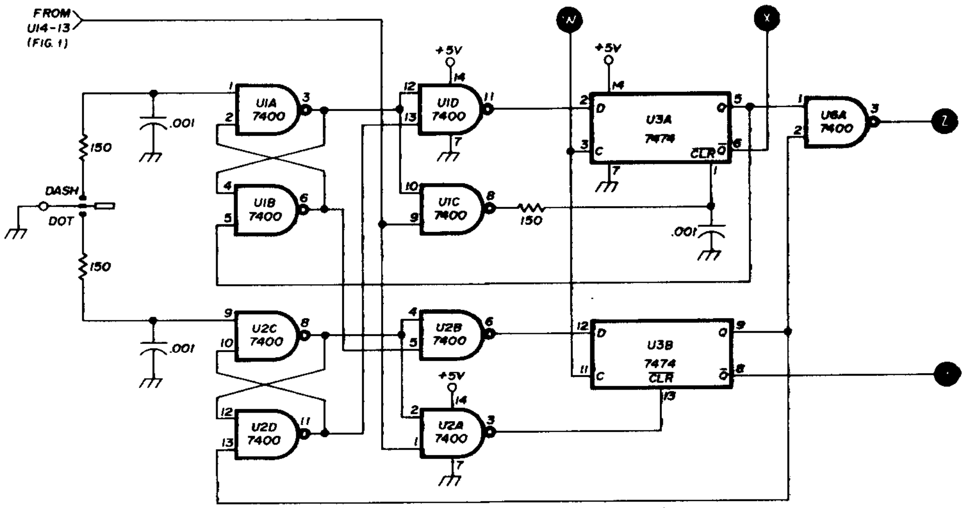


fig. 4. The WB4VVF Accu-Keyer, modified for use with the programmable memory accessory shown in fig. 1.



the clock pulse is high, thus preserving proper dot/dash timing. These inputs are effectively connected to U5, pin 8, otherwise, resulting in normal keyer operation when not using the memory.

The clock in the Accu-Keyer provides the clock pulses for the memory circuit (taken from the collector of Q2). The previously unused section of U7 is wired to inhibit data transfer out of the memory except during the read cycle. Finally, U7, pin 6, is taken to the memory circuit to key the sidetone and input data to the memories.

construction

I built the memory circuit and keyer on two 3-inch (76mm) square pieces of single-clad Vector board using breadboard-type fabrication because wiring errors are much easier to repair. Any other method of construction would work equally as well so long as the usual rf bypass techniques are used. **Fig. 5** shows the power supply I used for both the keyer and the memory circuit.

operation

Operation of this memory accessory is quite simple. The operator selects the desired memory with S2. To write data into the memory, S3 is closed, the start button, S1, is pressed, and, when released any data being sent will also be written into the selected memory. If a mistake is made, simply depress the start button again and start over. Even if the previous cycle is not complete, the counters will be reset to 000.

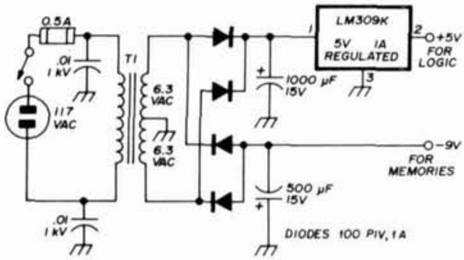


fig. 5. Simple power supply circuit provides regulated +5 volts for the TTL ICs and −9 volts for the random-access memories.

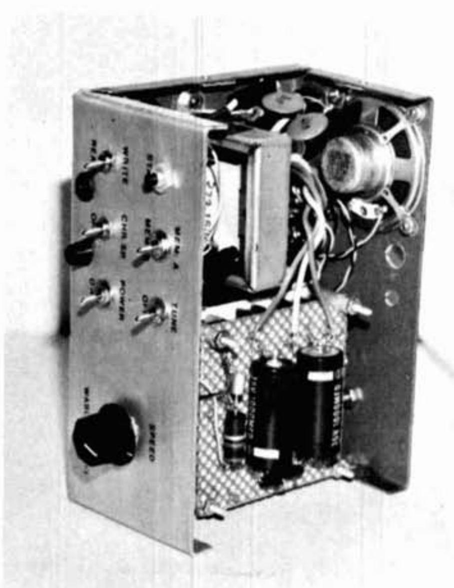
To read the data in storage, open S3 and press the start button, S1. When S1 is released the memory will cycle through the 256 bits. Two separate messages can be stored and selected by S2. Again, the start button may be repressed at any time to restart the message.

Approximately 30 characters can be stored in a 256-bit RAM. This is enough for the typical Sweepstakes exchange:

B DE WA9LUD/9 64 ILL BK

However, the basic circuit can be expanded to a cascade of individual memories for any desired character length.

The entire keyer package cost about $25 to build, but the memory accessory alone can be built for under $10. I have been very pleased with the performance of the unit. The memory replaces a clumsy tape recorder device I used to use during CW contests, resulting in a more relaxed and smooth operation. It has been a welcome addition to a crowded operating table.



Inside view of the memory keyer showing the circuit board stack. Accu-Keyer is on bottom board, memory accessory is on the middle board, and power supply rectifiers and filter capacitors are on top. The +5 volt regulator IC is mounted on heatsink on rear panel.

references

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2. Michael Gordon, WB9FHC, "Electronic Keyer with Memory," *ham radio*, October, 1973, page 6.
3. James Garrett, WB4VVF, "The WB4VVF Accu-Keyer," *QST*, August, 1973, page 19.

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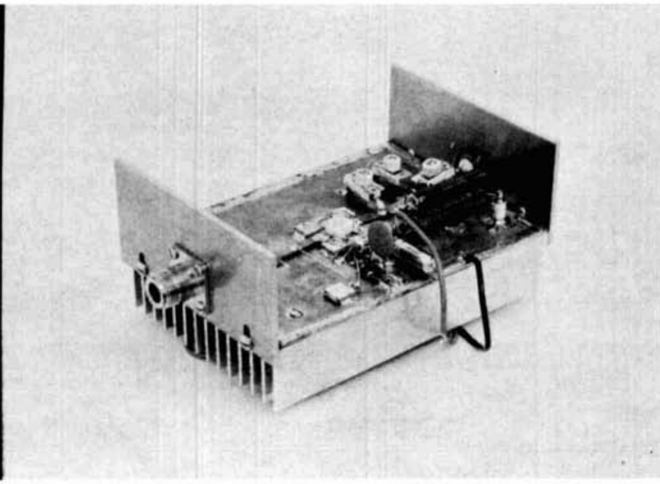

solid-state linear power amplifier for 432 MHz

Construction details for a solid-state linear amplifier that provides 10 watts PEP output at 432 MHz

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Until recently, amateur use of semiconductors on 432 MHz was limited to low-noise preamplifiers, mixers and low-level transmitter stages. Now, with rf power devices developed for the uhf land-mobile service, it is possible to build rf power amplifiers for this band without breaking the bank. The linear amplifier described in this article delivers 10 watts PEP *output* with 10 dB or better power gain, operates from a 12-volt power supply, and is comparable in price to vacuum-tube linears operating at similar power levels. One of the goals in designing this amplifier was to develop a circuit that was rugged with respect to load vswr as well as being easy to build and align — the amplifier presented here meets those goals.

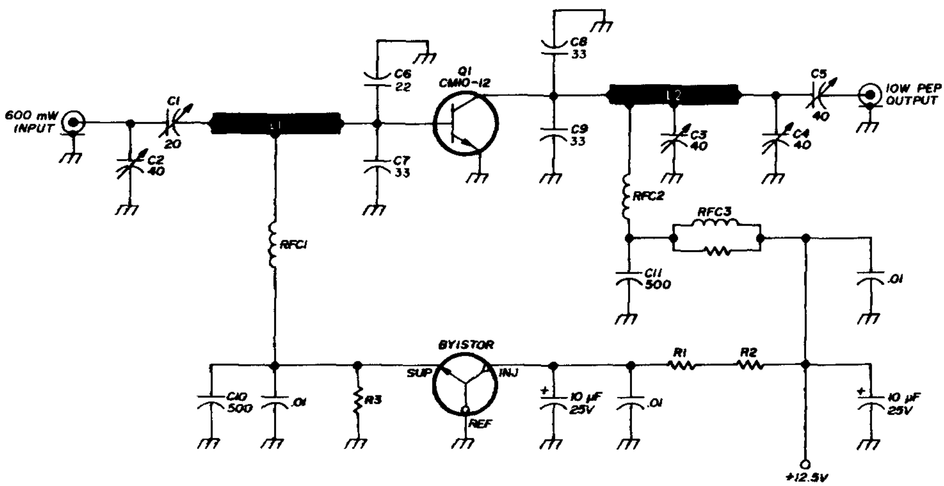
When designing an rf power amplifier, the first task is to select a suitable power transistor. The device I selected is the CTC CM10-12. This device, originally developed for the land-mobile service, is both inexpensive and rugged.* Most solid-state linears for vhf and uhf use 28-volt transistors, but 28-volt devices have two important disadvantages: cost (these parts are always more expensive than 12-volt devices) and power supply

*The CTC CM10-12 is $13.50 in small quantities from Communications Transistor Corporation, 301 Industrial Way, San Carlos, California 94070. The BYI-1 byistor is $7.50. Since the minimum order is $50, this amplifier would make an excellent club project.

availability. Although most amateurs have access to a medium-current 12-volt power supply, 28-volt power presents more of a problem.

Many amateurs find solid-state uhf power amplifiers difficult, if not impossible, to build. Uhf stripline circuits perform exceptionally well, but the Teflon-glass or *duroid* circuit board necessary for their construction is very expensive and difficult to obtain. Furthermore, many amateurs have very little experience with printed-circuit boards. After reviewing this problem, I decided to use *lumped constants* (*mica compression trimmers* and conventional inductors). A main consideration in the design of this amplifier was to make it reproducible.

The circuit, shown in **fig. 1**, is fairly straightforward. An L-network is used for the input match and a pi-L network for the output. To operate in linear service the CM 10-12 must be forward biased. This is accomplished through the use of a CTC *byistor*. The byistor consists of a diode and a silicon resistor in one package which is coupled to the amplifier heatsink. The byistor thermally tracks the power amplifier and assures that problems with thermal runaway are minimized. A previous article describes this device in detail.[1]



C1	2-20 pF mica trimmer (ARCO T51113-1)
C2,C3 C4,C5	4-40 pF mica trimmer (ARCO T21213-1)
C6	22 pF Underwood metal-clad mica
C7,C8 C9	33 pF Underwood metal-clad mica
C10,11	500 pF Underwood metal-clad mica
L1	0.175" (4.5mm) wide copper strip, 1.1" (28mm) long, including bend at input end; RFC1 attached at center
L2	0.175" (4.5mm) wide copper strip, 1.2" (30.5mm) long, including bend at output end; RFC2 and C3 attached at center
R1,R2	approximate total series resistance, 37 ohms (10 watts); adjust for correct byistor current (see text)
R3	adjust for correct idling current (6.8 ohms in parallel with 47 ohms, ½ watt, used in amplifier shown in photograph)
RFC1	no. 20 (0.8mm) wire, 1.5" (38mm) long
RFC2	2 turns no. 20 (0.8mm), airwound, 0.3" (7.5mm) diameter, 0.3" (7.5mm) long
RFC3	5 turns no. 20 (0.8mm) wound around 0.5" (12.5mm) Amidon T-50-6 toroid, in parallel with 15 ohm, ½ watt resistor

fig. 1. Solid-state 432-MHz linear amplifier. Do not substitute for the Underwood metal-clad mica capacitors; dipped micas or disc ceramics will not work.

construction

The amplifier is built on a 6x4.375 inch (15.2x11.1cm) finned aluminum heatsink (Thermalloy 6157). A smaller heatsink can be used, but I don't recommend it as parts placement becomes cramped and the CM10-12 power transistor will obviously run hotter. With the heatsink described a barely discernable heat rise is noticeable after several hours of operation.

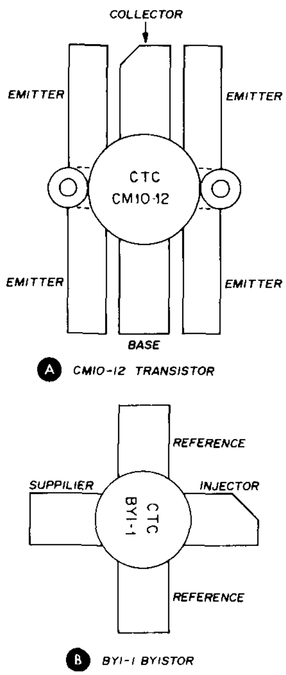


fig. 2. Lead layout for the CTC CM10-12 power transistor and BYI-1 byistor.

The end pieces are 1/8-inch (3mm) thick aluminum which are attached to the ends of the heatsink with 6-32 screws. The holes for the screws are drilled into the heatsink ends and then tapped.

The first step in building the amplifier is to prepare the printed-circuit board. The circuit board is standard double-clad 1/16 inch (1.5mm) thick fiberglass-epoxy board. The thickness is not really critical, but if the printed-circuit material is too thin the board may buckle when it is fastened to the heatsink. The CM10-12 power transistor is located at the exact center of the board. A 33/64 inch (0.516" or 13mm) hole is punched or drilled in the center of the board and the transistor is temporarily placed in the hole and used as a template to mark the locations for the two CM10-12 mounting screws. These holes are drilled (or punched) with a 17/64 inch (0.266" or 6.7mm) drill. The extra material is then filed away until the transistor mounting flange fits through the hole with about 0.015 inch (0.4mm) clearance all around (see **fig. 3**). Don't file away too much of the circuit board or it will be impossible to obtain short emitter leads – a must at uhf.

The 5/16 inch (8mm) hole for the byistor is next drilled 1.25 inch (32mm) from the center of the CM10-12. For best thermal tracking the byistor should be as close to the power transistor as is practical.

A good ground is a must in uhf power amplifiers and most problems with unstable amplifiers can be traced back to poor grounding. In this amplifier copper foil is soldered from the top to bottom ground planes around the entire outside edge of the board as shown in **fig. 4**. Similarly, short pieces of foil are soldered at the four edges of the CM10-12 mounting hole. Make sure

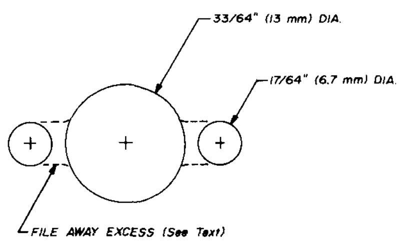


fig. 3. The CM10-12 transistor mounting hole is placed in the center of the circuit board (fig. 4).

these fit snugly or the transistor may not fit. These copper strips are about 0.125 inch (32mm) wide.

The board is then placed on the heatsink and secured with four 4-40 machine screws which are threaded into corresponding holes drilled and tapped into capacitor leads overlap one another (see **fig. 5**). This will provide the points for the base and collector connections.

The leads of the transistor are then trimmed as shown in the photograph. Put Silicone heatsink compound on the CM10-12 mounting flange and fasten

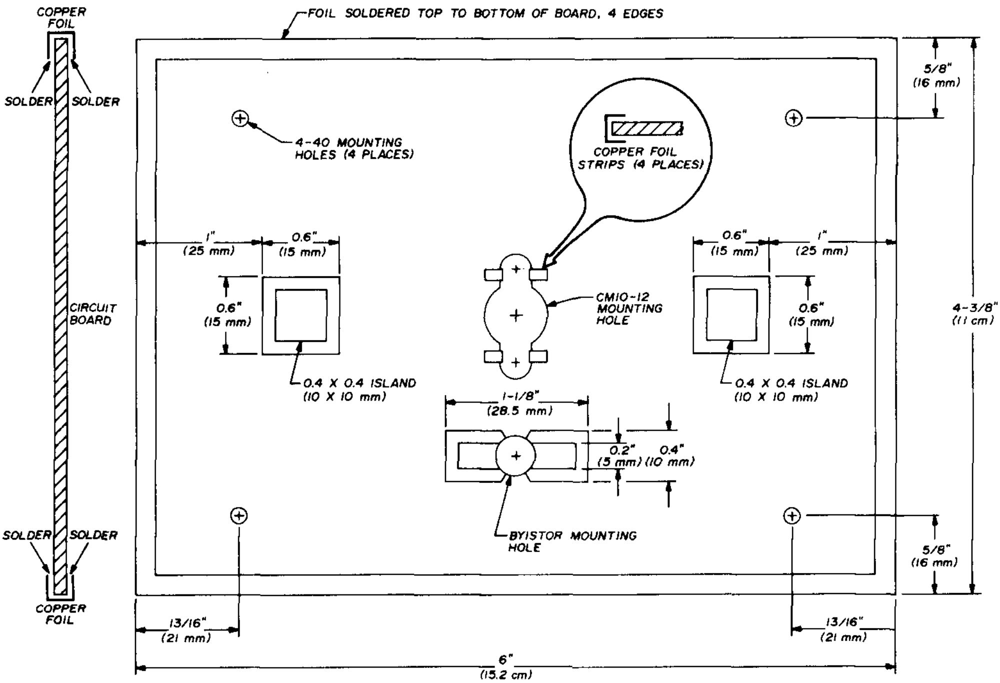


fig. 4. Layout of the circuit board used for the 432-MHz linear amplifier. Good grounding is provided by copper foil around outside edge of the board. Input and output islands and byistor circuit pads are cut out with an Xacto knife.

the heatsink. Temporarily remove the board and, with a milling bit or large diameter drill, prepare a space for the byistor mounting stud on the finned side of the heatsink. Be careful not to drill all the way through the heatsink.

The circuit board may now be secured to the heatsink with the 4-40 screws. Install the four Underwood capacitors* on the board as close as possible to the CM10-12 mounting holes. Solder the metal cases of the capacitors to the circuit board and let the the transistor to the heatsink. (*Do not* solder the transistor into circuit before securely fastening it to the heatsink with the two mounting screws — doing so may fracture the ceramic transistor case.) When the transistor leads have been soldered in place, small islands are cut out with an Xacto knife for the byistor supplier and injector and the transistor base and collector lines, L1

*Do not substitute for the Underwood metal-clad mica capacitors; dipped mica or disc ceramic capacitors will not work.

and L2. The remaining components are then installed as shown in the photographs.

Small turret terminals are used for the byistor power resistor connections and the 12-volt supply voltage, V_{CC}. It is suggested that the layout shown be followed if you have not had experience with uhf solid-state amplifiers.

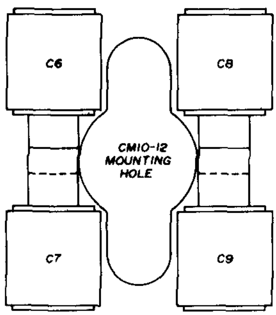


fig. 5. Installation of the Underwood mica capacitors, C6, C7, C8 and C9. Transistor base and collector connections are made at the overlap points.

tuneup

Do not operate the amplifier without resistor R3 connected; that will damage the power transistor.

Temporarily disconnect the collector dc feed choke, RFC2, gradually apply +12 volts to the byistor and make sure injector current is 300 and 350 mA. If this current level is not achieved, the values of resistors R1 and R2 must be adjusted until it is. Remove V_{CC} and reconnect the collector choke, RFC2.

Now install about 1 ohm at resistor R3, apply V_{CC} and check the total current drain. A milliammeter in series with the 12-volt supply line will read the byistor current plus the quiescent current of the power amplifier:

$$\text{Indicated current} = \frac{\text{byistor}}{\text{current}} + \frac{\text{CM10-12}}{\text{idling current}}$$

If the byistor current is 300 mA, for example, and the total indicated current is 350 mA, the idling current of the CM10-12 is 50 mA. Increase resistor R3 in one-half ohm steps until an idling current of 50 to 60 mA is reached. It may be necessary to *parallel* two resistors to obtain the correct idling current.

Basic tuneup of the amplifier can be done with a uhf vswr bridge, power meter and dummy load as shown in **fig. 6.** However, an accurate power meter and non-reactive 50-ohm load are required for proper circuit adjustment.

Apply V_{CC} and check to see that the power meter reads zero with no drive applied. This will indicate if the amplifier is oscillating. (No oscillation was detected in any of the four units I built.) Apply about 200 mW of drive and tune capacitors C3, C4 and C5 for maximum output. Tune C1 and C2 for minimum input vswr. Now increase drive to 600 mW and repeat the above process. The power meter should read approximately 10 watts.

If two-tone measurements are to be made and you're using an average-reading meter such as a Bird model 43, remember that the power meter indication will be one-half the actual rf output. For example, if the Bird wattmeter reads 5 watts, actual PEP output is 10 watts.

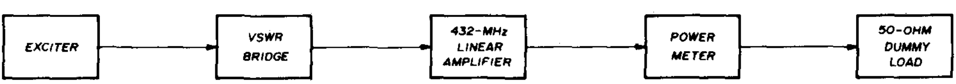
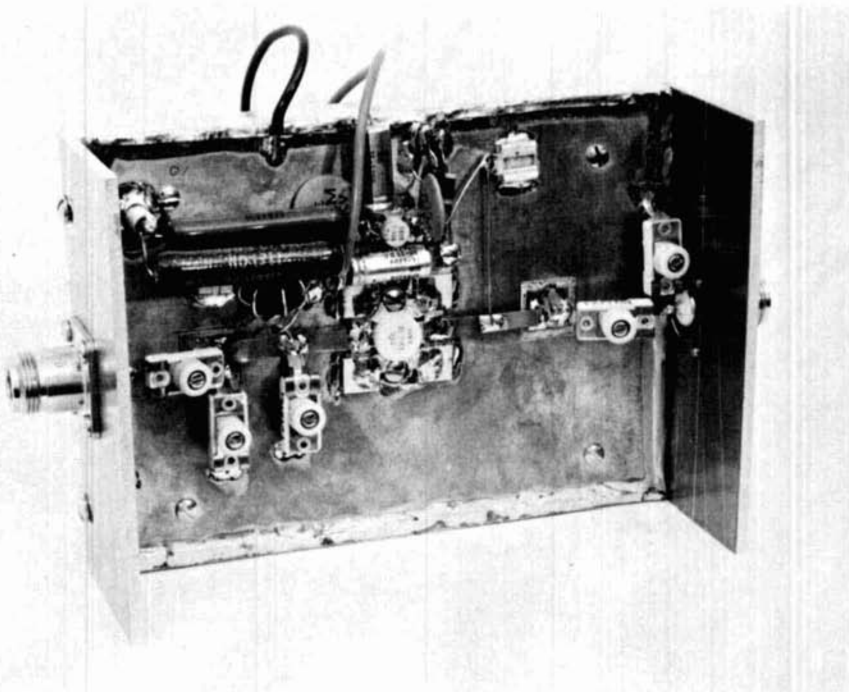


fig. 6. Equipment setup required for tuning up the 432-MHz amplifier. For correct adjustment the power meter must be accurate and the 50-ohm must be non-reactive.

operation

A well-regulated 12-volt supply is necessary for linear operation. Since current drain is less than 2.0 amps, a simple series regulator will work fine. Most current handbooks describe such circuits.

600 mA will put you in the safe area (remember that the meter will read 300 mA high because of the byistor current). Make sure the amplifier works into a good load. Although the CM10-12 device will survive an infinite vswr, sustained operation into such loads will damage it.



Solid-state 432-MHz power amplifier built by WB6QXF. In this photograph output is at left, input on right. Large wirewound resistors are in the byistor circuit.

Since voice characteristics vary from one operator to another, if possible an oscilloscope should be used to check for flattopping. If a scope isn't available, talking collector current up to 500 to 600 mA will put you in the safe area.

table 1. Performance of the 10-watt, 432-MHz solid-state linear power amplifier. Second harmonic is more than 35 dB down.

single tone		two tone	
V_{cc}	= +12.5 Vdc	V_{cc}	= +12.5 Vdc
P_{in}	= 15 Wdc	P_{in}	= 600 mW PEP
P_o	= 10 W	P_{out}	= 10 W PEP
I_c	= 1.2 A	I_c	= 750 mA
		IMD	= −29 dB at 10 W PEP

Every effort was made to make the construction of this amplifier as easy as possible. Inexpensive components were used throughout and the results have been very gratifying. The total cost of the amplifier is less than that of a comparable vacuum-tube unit and it is a lot less trouble.

reference

1. Robert Stein, W6NBI, "Solid-State Transmitting Converter for 144-MHz SSB," *ham radio*, February, 1974, page 6.

ham radio

adjustable voltage-regulator ICs

Circuit applications for the new Fairchild 78MG and 79MG adjustable positive and negative voltage-regulator ICs

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The 7800 series of fixed, three-terminal IC voltage regulators has greatly simplified the design of well regulated power supplies.[1] The only drawback of this series of ICs is that variable output voltages cannot be obtained without sacrificing performance or circuit simplicity. Fairchild Semiconductor has developed two new devices which fill the need for a low cost, adjustable voltage regulator: The 78MG positive regulator and the 79MG negative regulator.

Both of these IC regulators are rated for 500 mA output current, are protected against short-circuits and thermal overloads, and feature infinitely variable output voltages between V_{ref} and V_{in} (minus a few volts). Brief specifications are listed in **table 1**.

positive voltage regulator

A basic, positive adjustable regulator using the 78MG IC is shown in **fig. 1**. The internal reference voltage for the 78MG is 5.0 volts, so this sets the lowest possible output voltage with this device. As is true with the 7800 series voltage-regulator ICs, a 0.33 μF capacitor is required from the input of the device to ground if the regulator is located more than a few inches from the power supply filter capacitor. A small capacitor from the output to ground will improve transient response.

The output voltage of this circuit is predicted by

$$V_{out} = V_{ref}\left(\frac{R1 + R2}{R2}\right)$$

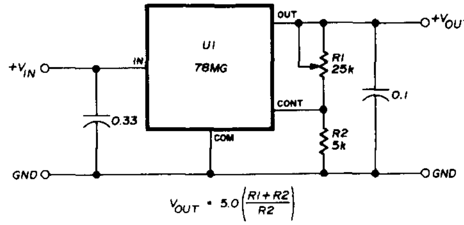

fig. 1. Basic, adjustable positive voltage regulator using the Fairchild 78MG. Unregulated input voltage must be 2 volts greater than desired maximum output.

where V_{ref} = 5.0 volts. If 1 mA is used as the control current, then R2 = 5k ohms and V_{out} = 0.001 (R1 + R2). With the values shown in **fig. 1** and V_{in} >32 volts, V_{out} is adjustable from +5 to +30 volts.

The 78MG may be used in higher current applications by using a series pass transistor, Q2, as shown in **fig. 2**.

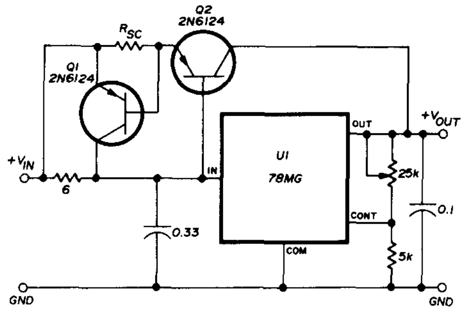

fig. 2. High-current, short-circuit protected adjustable positive voltage-regulator circuit using the Fairchild 78MG.

table 1. Electrical parameters of the Fairchild 78MG and 79MG adjustable positive and negative voltage regulators.

78 MG positive regulator	
Input voltage, V_{in}	+40 volts max
Output voltage, V_{out}	+5 to +30 volts
Voltage reference, V_{ref}	+5.0 volts
Reference current, I_{ref}	1.0 μA
Dropout voltage	2 volts
Quiescent current	2.5 mA
Line regulation	1%
Load regulation	2%
Dissipation (internally limited)	≈ 6 watts
Thermal shutdown temperature	≈ 170°C
Thermal resistance, junction-case	8°C/watt
Thermal resistance, junction-ambient	70°C/watt
79MG negative regulator	
Input voltage, V_{in}	−40 volts max
Output voltage, V_{out}	−2 to −30 volts
Voltage reference, V_{ref}	−2.23 volts
Reference current, I_{ref}	0.3 μA
Dropout voltage	2 volts
Quiescent current	0.5 mA
Line regulation	1%
Load regulation	2%
Dissipation (internally limited)	≈ 6 watts
Thermal shutdown temperature	≈ 175°C
Thermal resistance, junction-case	8°C/watt
Thermal resistance, junction-ambient	70°C/watt

The short-circuit sensing resistor, R_{sc}, is equal to V_{be}/I_{sc}, or about 0.6 ohm for 1.5 amp output current. Transistor Q1 is another 2N6124 or equivalent. The sensing resistor, R_{sc}, turns Q1 on at high output current conditions and since $V_{ce(sat)}$ of Q1 is less than the voltage drop across R_{sc} plus the base-emitter voltage of Q2, the current through Q2 will decrease, protecting the transistor.

negative voltage regulator

A basic negative adjustable regulator is shown in **fig. 3**. The reference voltage for the 79MG is 2.23 volts and, as in the 78MG, this reference determines the minimum possible output voltage available from the device. Again, 1 mA should be selected for the control current; therefore, R2 is 2.2k ohms and V_{out} = 0.001 (R1 + R2). R1 may be a 25k ohm pot as was used in the circuit of **fig. 1**.

A dual tracking regulator with 500 mA output capability is shown in **fig. 4**. This circuit features dual 10 volt outputs with the use of only two ICs and seven external components.

packaging

Obviously, a four-terminal package is now required due to the addition of the control pin. **Fig. 5** shows the basic

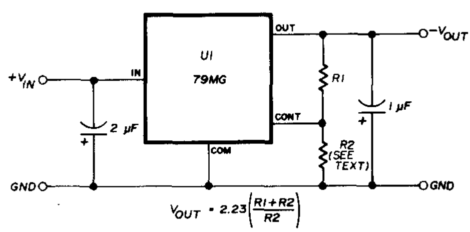

fig. 3. Basic, adjustable negative voltage regulator using the Fairchild 79MG. Unregulated input voltage must be 2 volts greater than desired maximum output.

configuration and connection diagram of both regulators, while **fig. 6** shows mounting techniques for two of the package options which are available. Package size and pin spacing are similar to the familiar mini-DIP package. For low power dissipation applications, the cooling wings may be bent upwards for natural convection cooling, or a heatsink may be added for higher power applications. Refer to **table 1** for thermal resistance and maximum junction temperature values for the package.

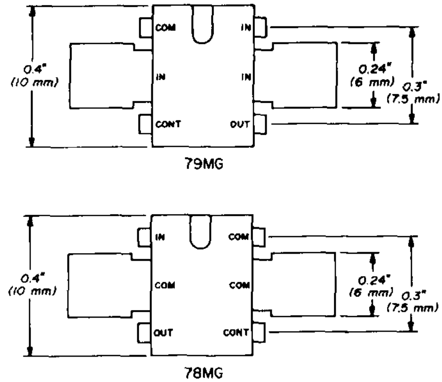

fig. 5. Connection diagrams for the 78MG and 79MG adjustable voltage-regulator ICs.

conclusion

These new adjustable voltage regulators fill the need for easy to use, high performance, minimum component count, variable-voltage regulators. Both electrically and thermally, the 78MG and the 79MG perform well in all medium-current applications and as drivers for higher current regulators. The 78MG and the 79MG and their related data sheets may be obtained from franchised Fairchild distributors.

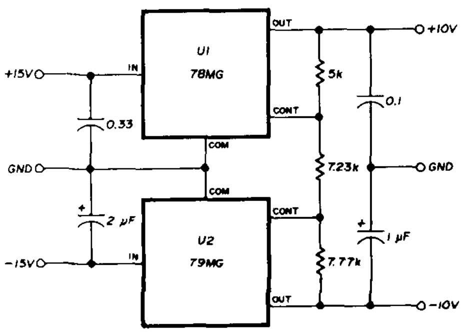

fig. 4. Dual tracking regulator for up to 500 mA output at ±10 volts.

reference

1. James Trulove, WB5EMI, "Three-Terminal Voltage-Regulator ICs," *ham radio*, December, 1973, page 26.

ham radio

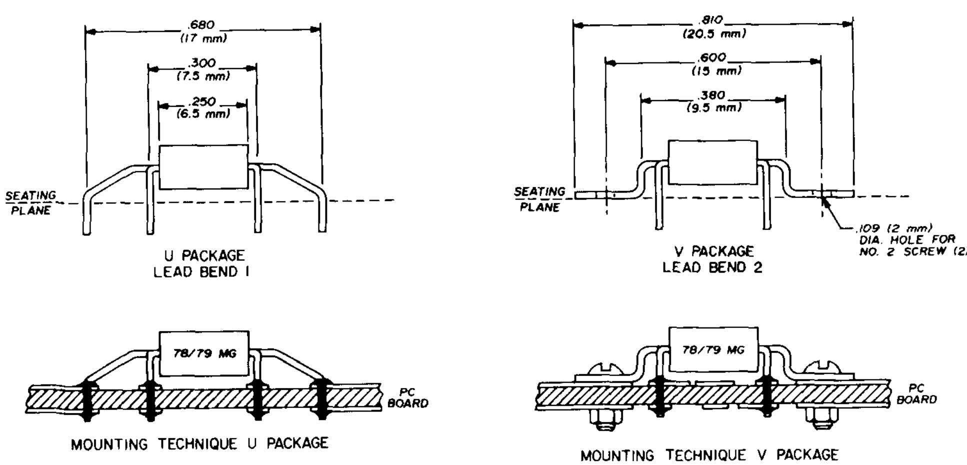

fig. 6. Dimensions and mounting techniques for the two package options which are available for the 78MG and 79MG adjustable voltage regulators.

calibrated electronic keyer time base

Description of a novel electronic time base that provides direct readout of keyer speed

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It is desirable to be able to set the speed of an electronic keyer before you start sending. This is difficult if the keyer has a single uncalibrated knob and the variable resistor it controls is not linear and gives a large change in speed for a small rotation. Three solutions to this minor problem will be discussed in this article: speed selection with toggle switches or a thumbwheel switch, a digital counter, and a simple analog frequency meter which will display keyer speed on a meter. The last two systems require the time-base oscillator to run continuously. However, by running the oscillator at a high frequency and dividing down, the normal disadvantages of a continuously *running oscillator can be avoided.*

switch selection

It is well known that the time delay of an RC circuit is proportional to the RC product. The frequency of an RC oscillator, therefore, is proportional to 1/RC, or G/C where G is the conductance (1/R) of the resistor. When resistors are connected in parallel the conductances add. Resistors can easily be switched in parallel with toggle switches or thumbwheel switches, and when this is done the frequencies associated with the individual resistors add directly.

In the keyer time base shown in **fig. 1**, a 560k resistor (R5) is permanently wired in to give a speed of 5 wpm. Another 560k, 270k or 150k resistor can be switched in to add 5, 10 or 20 wpm to the speed. With three switches any speed from 5 to 40 wpm can be selected in steps of 5 wpm. The 1000-ohm vernier adjustment pot, R1, can be mounted on the front panel if continuous speed adjustment is desired. This pot can also be screwdriver adjusted (or even omitted if the timing capacitor is carefully selected).

Fig. 2 shows how a single thumbwheel switch can be used to provide keyer speeds of 5 through 45 wpm. **Fig. 3** shows how a two-section thumbwheel

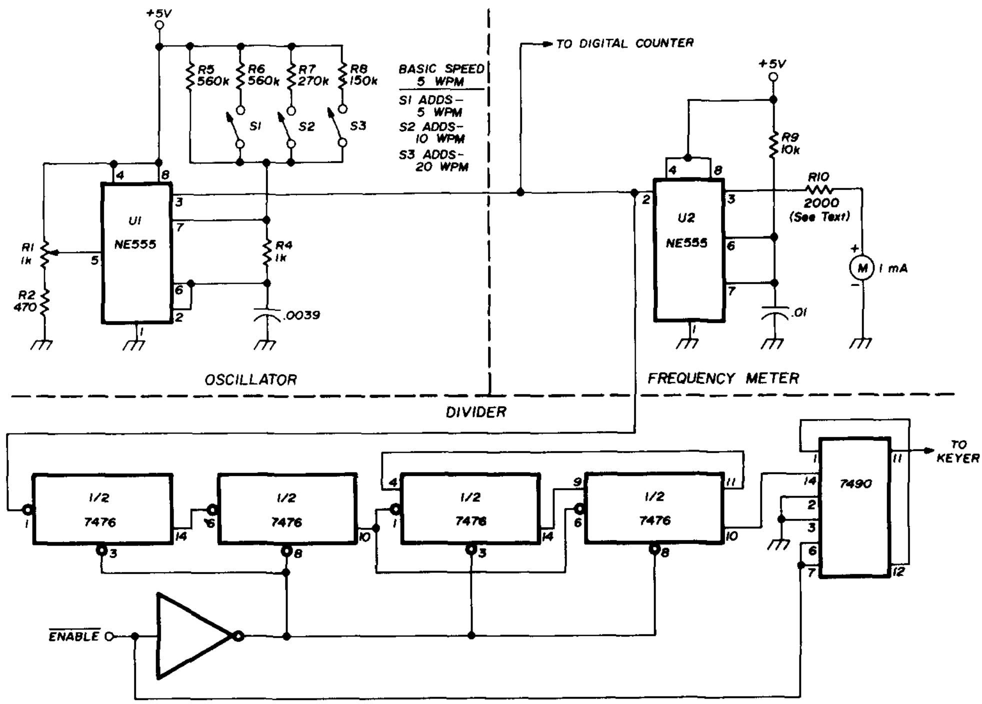


fig. 1. Electronic keyer time base with switch selection of speed. Analog frequency meter indicates keyer speed directly.

switch can be wired for speeds of 1 through 99 wpm in 1 wpm steps. The principle of paralleling resistors is very simple and can be applied to any keyer whose speed is determined by a single resistor and capacitor.

digital speed readout

A formula in the ARRL *Radio Amateur's Handbook* states that the speed of an electronic keyer is 1.2 times the clock frequency in Hz. In the time base shown in **fig. 1** the frequency of the basic NE555 oscillator is 100 times the keyer speed. The keyer clock is obtained by dividing the oscillator frequency by 120. For a 24 wpm keyer speed, for example, the oscillator runs at 2400 Hz. This can easily be read on a digital counter. If the counter is set to its 100 Hz range (dropping the tens and units digits), the speed can be read directly. The time-base divider would supply a clock frequency of 20 Hz, the correct clock frequency for 24 wpm keying.

Normally an electronic key with a continuously running oscillator does not have a good "feel" because you have to wait up to one-half the length of a dot for the keyer to start after pressing the paddle. With the time base shown in **fig. 1**, however, you only have to wait 1/240 the length of a dot, which is hardly noticeable (only 2 milliseconds

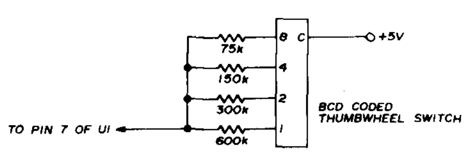
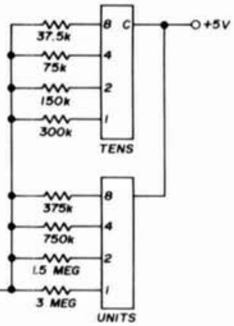


fig. 2. Using a thumbwheel switch to set electronic keyer speed. This arrangement provides speeds of 5 to 45 wpm in 5-wpm steps.

at 5 wpm). This is because when the keyer is not enabled the dividers are poised with all outputs high, ready to give a negative transition as soon as the next oscillator pulse comes along after the keyer is enabled. This system has all the advantages of a continuously running oscillator with none of the disadvantages.

fig. 3. Thumbwheel switch selection of electronic keyer speed from 1 to 99 wpm in 1-wpm steps.



The signal marked "to keyer" should go to a JK flip-flop such as the 7473 or 7476 which responds to negative transitions. The input to the inverter should be high when not sending and low when sending or self-completing a character.

keyer speed meter

It's doubtful that anyone would build a digital counter especially for his electronic keyer, and switching another counter to the keyer is not as convenient as simply looking at a panel meter which indicates keyer speed. The simple analog frequency meter shown in **fig. 1** uses few components and has all the accuracy that is needed. The meter is a 0-1 milliammeter with a 0-5 scale such as the Lafayette 99F26270. Resistor R10 should be trimmed to give a full-scale reading at 50 wpm using a digital counter to set the speed to 50 wpm (oscillator at 5000 Hz). The meter in my keyer, calibrated at 50 wpm, agrees with my digital counter over the entire scale.

ham radio

dc latch circuit

Modern dc latch for transmitter PTT control uses cmos circuits for low current drain

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A dc latch circuit or flip-flop is a handy circuit to have around if you operate PTT but don't want to hold down the microphone switch. One circuit described by W2EEY[1] used a form of latch for PTT-PTL (push-to-talk, push-to-listen) control of a radio system.

Fig. 1 shows a fairly typical latch circuit of the 1960s which used four bipolar transistors and one unijunction to drive a relay circuit. Applying a +12 volt pulse to diode CR1 caused the circuit to be *set*. Applying a +12 volt pulse to diode CR2 *resets* the circuit. However, during the set cycle the 180-ohm resistor in Q2's emitter circuit dissipates almost 800 mW of power. Not counting the relay, this circuit requires almost 100 mA (1.2 watt) to function – with modern cmos circuits this excessive power drain can be reduced by a factor of 200.

updated latch

The latch circuit shown in **fig. 2** is made for today. Disregarding the transistors Q3, Q4 and Q5 and the two relays for a moment, when the push-button switch, S1, is depressed, the circuit draws slightly more than 500 microamps. When switch S1 is not activated current drain is in the region of 100 μA. This very low power requirement is one of the advantages of using modern cmos ICs. This is not to say that cmos doesn't have its problems. It does: handling, static discharge and drive ability, but for ultra low power consumption cmos is the answer.

In the circuit of **fig. 2** integrated circuit U2A is a dual type-D cmos flip-flop. When the incoming clock signal makes a transition from zero to 1, the signal on the data input (D) is gated through to the Q output. When switch S1 is depressed, the input to the cmos inverter, U1A, goes low and its output goes high. The RC network consisting of the 100k resistor and 0.01 μF capacitor add roll-off to the leading edge of the zero to 1 transition, eliminating any contact bounce caused by S1. It has been found by experimentation that the RC time constant should approximate (or be slightly longer) than the contact bounce of your particular switch; more about this later.

During the zero to 1 transition, if the Q output of U2A is high, $\overline{Q}$ by definition is low. Since this low is also present on the data input as the clock makes the transition from zero to 1, Q goes to zero and $\overline{Q}$ goes to logic 1. At the next zero to 1 clock transition the output states will change.

When the Q output of U2A is low, it is inverted in U1B, turning on transistor Q2 and enabling relay K1. The $\overline{Q}$ output, which is high, is inverted in U1C, turning off Q1 and relay K2. The 4700-ohm resistors in series with the inverter outputs are determined by the transistor collector loads. Do not try to use a higher value or the transistor will not turn on. A lower value will most likely burn out the cmos inverter. Note that the series resistor R2 is 10k because Q3's collector load is greater than the loads seen by Q1 or Q2.

The main function of transistors Q3, Q4 and Q5 is as a power switch. When transistor Q3 is turned by a logic 1 at the $\bar{Q}$ output of U2A, it allows +24 volts (or what is on the Q5 emitter) to be seen at Q5's collector. Several hundred milliamperes of current can be switched in this way using a 2N2222A. More current can be switched by using a Darlington connection at Q5.

When working with this circuit just remember that a logic zero at the base of Q3 turns on transistors Q4 and Q5. A logic 1 turns on Q3, pulling the base of Q4 to ground, which shuts off power switch Q5. If you don't mind relay noise, you can use a relay. However, if you like silent operation and no wasted relay power, use the solid-state arrangement.

If you consider transistor Q3 by itself (forgetting Q4, Q5 and the three 10k resistors for a moment), you can tie the collector of Q3 to your speaker output for muting. This arrangement can't be used, however, if your speaker is driven directly by a complementary bipolar or IC output device; it can only be used where an output transformer is used (no dc component). Otherwise connect the Q3's collector across the volume control for an audio signal without a dc component.

cmos levels

The graph of **fig. 3** shows a large intermediate region in the operating characteristics of cmos logic that expands as the supply voltage, V_{DD}, is

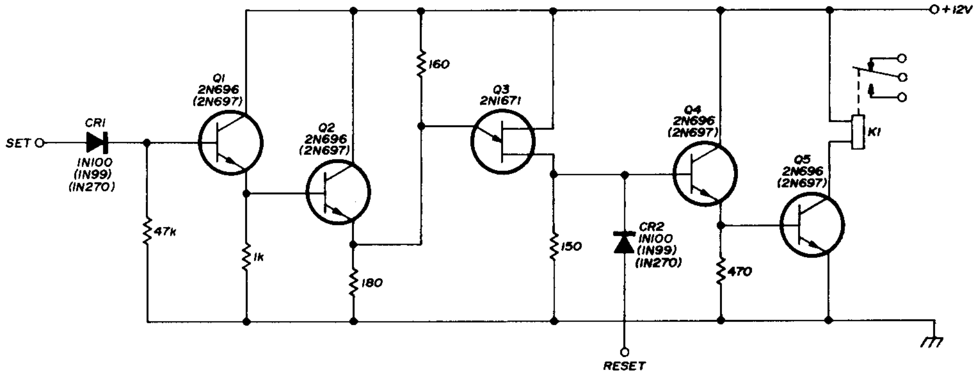

fig. 1. Dc latch circuit using bipolar transistors requires up to 1.2 watt of power. In this circuit a +12 volt pulse at set input latches relay K1; +12 volt pulse at reset input resets K1.

increased. This is where cmos really shines — noise immunity. The maximum acceptable input level for a cmos device in a low-level input state, V_{IL}, is 30 per cent of V_{DD}, or 4.5 volts when V_{DD} = 15 volts. This means that a logic zero can be from 0.01 to 4.5 volts.

At the other end of the scale, the minimum acceptable input level for a cmos device in a high-level input state, V_{IH}, is 70 per cent of V_{DD} or 10.5 volts when V_{DD} = 15 volts. This means that a logic 1 can be 10.5 to 14.99 volts. The intermediate region (or noise margin) is from 30 to 70 per cent of V_{DD}.

Referring back to **fig. 2**, to effectively combat contact bounce the RC time constant at one time constant (63.2%) should approximate or be slightly longer than the switch's contact

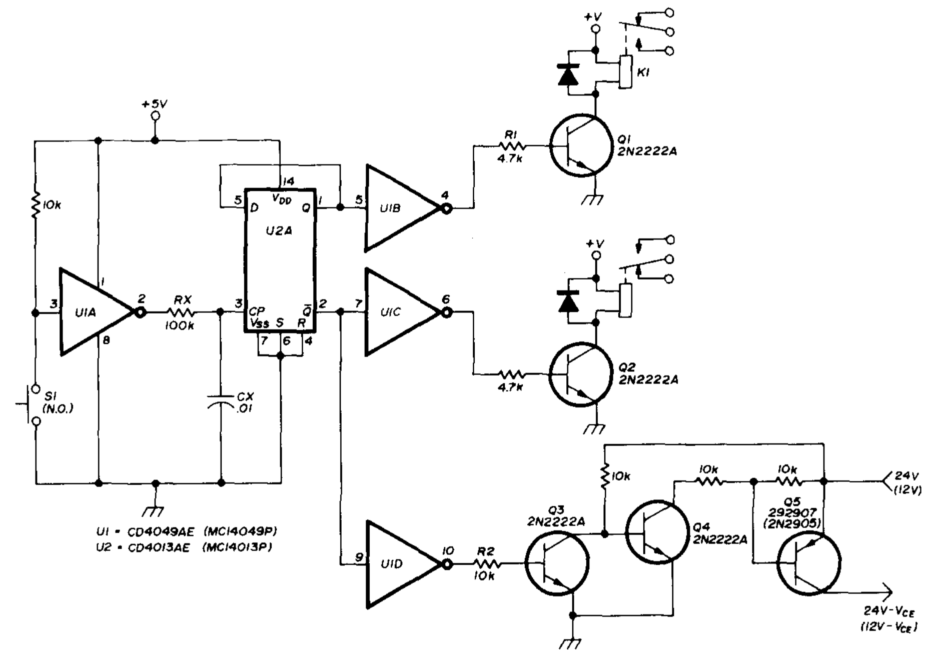

fig. 2. Modern dc latch uses cmos ICs for minimum current drain. Either relay switching (Q1, K1 or Q2, K2) or solid-state switching (Q3, Q4 and Q5) may be used.

bounce, and should approximate 70 per cent of the supply voltage, V_{DD}.

When using cmos devices be sure you look at the manufacturers' specifications.[2] If you are not using an input, tie it to ground or to V_{DD} whichever is appropriate. Do not use cmos NAND or NOR gates to drive transistors – inverting or non-inverting buffers are designed to do this job. Be careful when handling cmos devices as the static burnout problem is very severe. In addition, do not use plastic bags or polyethylene snow for packaging cmos devices – this stuff has zapped more than one device.

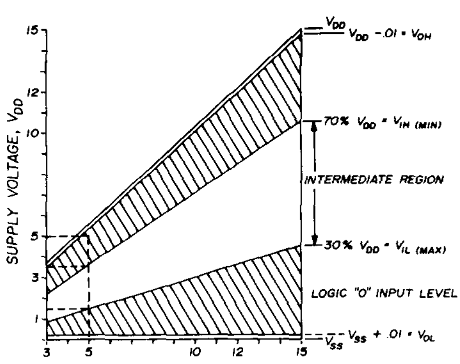

fig. 3. Graph of cmos logic levels shows how intermediate region with high noise immunity expands as the supply voltage is increased. Dashed lines show operation with +5 volt supply (see text).

Reference 3 has much more information on the use of cmos devices which should enable experimentally inclined amateurs to learn much more about these very useful devices. Just obey the rules and you can gain as much as a 1000:1 reduction in circuit current drain.

references

1. John Schultz, W2EEY, "Solid-State Transmitter Switching," *ham radio*, June, 1968, page 44.
2. *COS/MOS Digital Integrated Circuits*, RCA Solid-State Data Book SSD-203B, RCA Solid State, Somerville, New Jersey 08876.
3. M. Stiglianese, "Interface CMOS Logic with Switches," *Electronic Design*, August 16, 1974, page 80.

ham radio

More Details? CHECK—OFF Page 94

fet-controlled charger

for small nicad batteries

A novel use of the fet produces this simple constant-current nicad charger

G. Kent Shubert, WAØJYK, 1308 Leeview Drive, Olathe, Kansas 66061

Rechargeable nickel-cadmium batteries have become very popular over the last few years, not only for hand-held fm transceivers, but also for powering test equipment. Several ideas for inexpensive chargers have been tried, but maintaining a constant rate of charge has been a problem.[1]

The Regency HRT-2 uses the Regency MA-50, Eveready N64, Gould CD64, or the Alexander R64 rechargeable nicad battery, which is representative of the batteries used in most hand-held units. Regency recommends a charge rate of 50 mA and a trickle or "float" rate of 15 mA. It is detrimental to the nicad if the voltage across the battery rises too high. This particular battery is fully charged at 14.4 volts, so a 15-volt zener diode was chosen to provide over-voltage protection.

constant current charger

Junction field-effect transistors can be used as constant-current sources simply by shorting the gate to the source. The current which results is the I_{dss} rating given in the data sheets. Type 2N3819 fets were used in the circuit in **fig. 1** simply because there was an abundance of them on hand. Practically any n-channel junction fet will work, but only devices that have an I_{dss} of 8 to 15 mA should be used. There are special power fets available, but most of the inexpensive plastic devices will strain to dissipate a quarter of a watt at room temperature — so don't crowd them. The six fets used were actually graded by connecting them as shown in **fig. 2** and grouped to supply the 15 mA or 50 mA as selected by the switch.

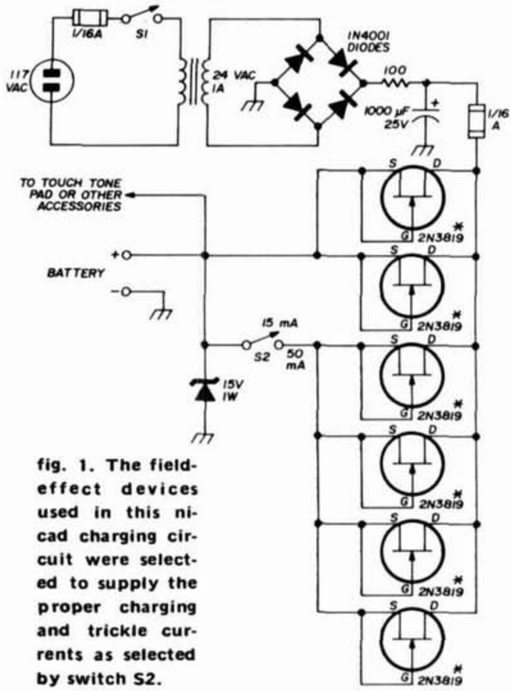

fig. 1. The field-effect devices used in this ni-cad charging circuit were selected to supply the proper charging and trickle currents as selected by switch S2.

The photograph shows a few other frills that were added to the basic charger to make life on two meters a little more enjoyable. The hand-held portable becomes a low-power base station when placed in the charger. The HRT-2 has both antenna and battery terminals in the base, so placing the unit on the charger connects the external antenna and places the battery on charge. The external microphone and PTT keying is connected to the top of the HRT-2 to enable the hand microphone and the Touch-Tone encoder to function. The ac power is switched by a microswitch mounted so the weight of the transceiver turns it on. The unit is held firmly to the charger with a black elastic garter, a difficult item to locate nowadays.

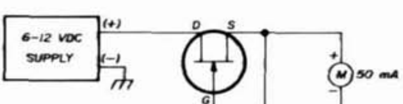

fig. 2. Setup for testing fets for the drain-to-source current, I_{dss}, measured with the gate shorted to the source.

As an added bonus, the unit can be used far from ac power lines just for the Touch-Tone encoder function. It is necessary to use an external antenna, but at least the charger serves as an adapter from the mini-phone plug to the more popular UHF or BNC connectors.

The hookup of the Touch-Tone pad is standard with fm operators so no details are included here. The 1/16th amp fuse is not necessary but is added life insurance against a semiconductor failure.

reference

1. R. D. Shriner, WAØUZO, "Charging Nickel-Cadmium Walkie-Talkie Batteries," *QST*, August, 1973, page 44.

ham radio

The Regency HRT-2 sits atop the charger overlooking the ever popular Touch-Tone pad.

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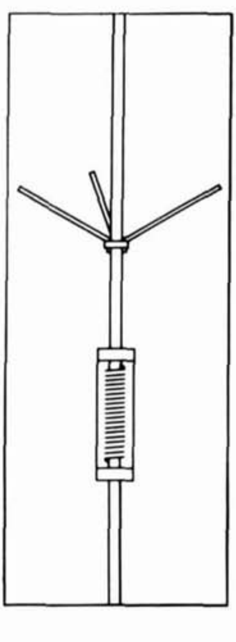

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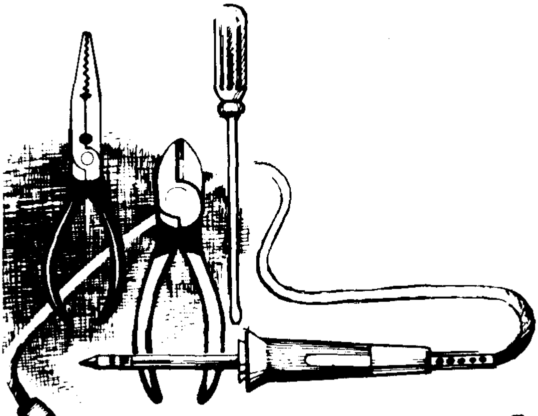


circuits and techniques

ed noll, W3FQJ

QRP fet transmitter

The Siliconix 2N3970 switching fet performs well in low-powered transmitter circuits such as crystal oscillators, modulators, rf amplifiers and frequency multipliers. Circuit simplicity is an fet advantage and many circuits are identical to vacuum-tube arrangements except that no filament power is required. The two-stage crystal oscillator and amplifier, **fig. 1**, requires approximately 500 mW dc input to the final and can be operated from two 12-volt lantern batteries in series. At W3FQJ it operates from the solar power supply detailed in the November, 1974, issue of *ham radio*.[1] A 12-volt motorcycle battery has also been added to the installation, providing 24-volt capability.

The oscillator is a Pierce-type and requires no resonant output circuit. The signal is capacitively coupled to the gate of the amplifier with an rf choke serving as a means of applying the drain supply voltage. A 1-mA meter can be connected across the low-value gate-circuit resistor to provide an indication of gate current and, therefore, the strength of the oscillator signal arriving at the gate. The meter can be connected and disconnected without any influence on the operation of the transmitter because the value of R4 is very low in comparison to the value of the gate resistor, R3. The

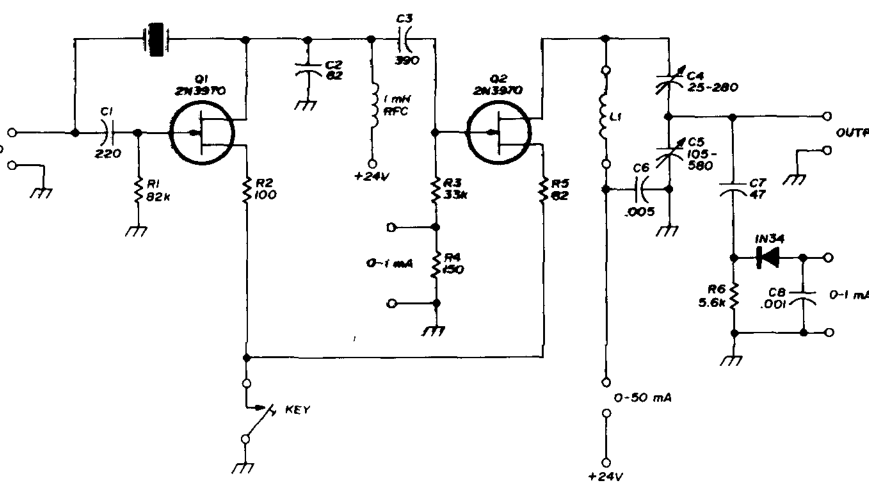


fig. 1. Two-stage fet QRP transmitter uses crystal oscillator stage, Q1, and power amplifier, Q2. Dc power input is about 500 mW. A vfo may be used if desired. For 80 meters L1 is 50 close-spaced turns no. 24 on 13/16" (20mm) toroid core.

low-value capacitor C2 aids crystal starting when operating at low frequencies. Parts values and information are given for operation on the 80-meter band.

The resonant circuit of the rf amplifier consists of a toroid coil and two series-connected trimmer capacitors. These capacitors are used both for tuning and for obtaining an impedance match to a low-impedance load. Capacitor C4 influences primarily the resonant tuning; capacitor C5 is for the impedance match. The amplifier drain current can be measured with a 50-mA meter or an appropriate vom current scale. The product of drain current and supply voltage represents the dc input power to the amplifier. As in vacuum-tube practice, when the resonant circuit is tuned through the resonant point, there is a dip in drain current.

A 1N34 diode and resistor-capacitor filter are used as an rf output indicator. The dc current indicated on the 1-mA meter is a relative measure of the level of the rf output voltage. This meter can also be connected and disconnected without affecting the output power level.

The simple two-stage QRP transmitter is mounted on a Vector board, **fig. 2**. This is micro-vector board type 84P44-062; the 0.042-inch (1-mm) hole size and 0.1 inch (2.5mm) spacing are ideal for mounting transistor and IC sockets. The Vector T42-1 micro-clips can be inserted conveniently into the holes to provide terminals. This method of construction will be used throughout the *Expro* projects. Binding posts are convenient for making tests and interconnections. Stick-on protector pads (available at hardware stores) provide support and permit the bulk of the wiring to be done underneath the Vector board.

The toroid core is the 13/16-inch (20-mm) type. The winding consists of

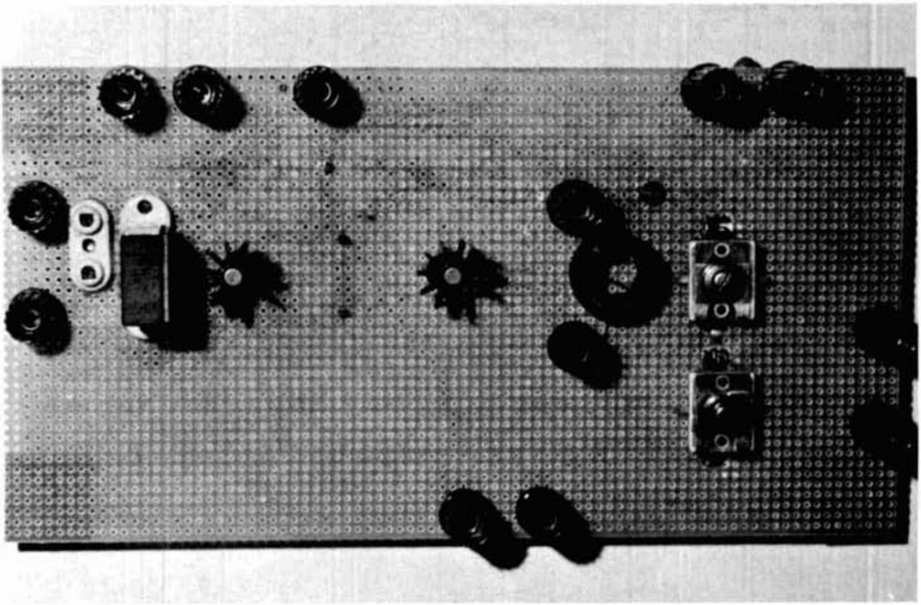


fig. 2. Two stage fet QRP transmitter is built on piece of Vector perfboard as shown here.

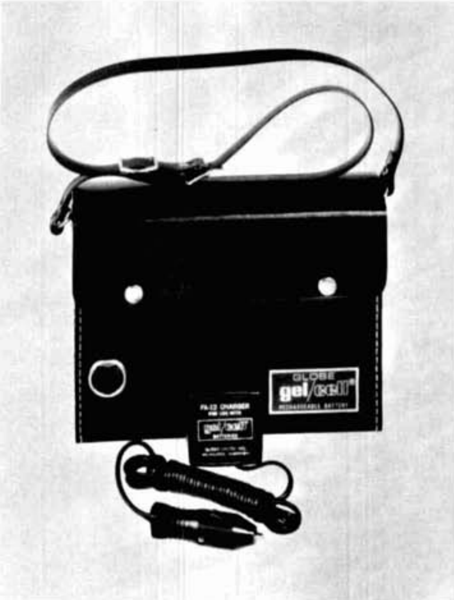


fig. 3. For portable use you may want to use a rechargeable Gel/Cel battery made by Globe Battery, Milwaukee, Wisconsin.

50 close-spaced turns of number-24 enameled copper wire. There are two binding posts positioned on each side of the toroid. Later you may wish to operate on other bands and they provide an easy means of changing coils for multiband operation. The two trimmer capacitors are mounted near the coil so they can be easily adjusted while observing the readings on the output indicator.

You may wish to drive the two-stage transmitter with a variable-frequency oscillator connected to the vfo input binding posts, **fig. 1**. For this mode of operation you need only remove the crystal from its socket.

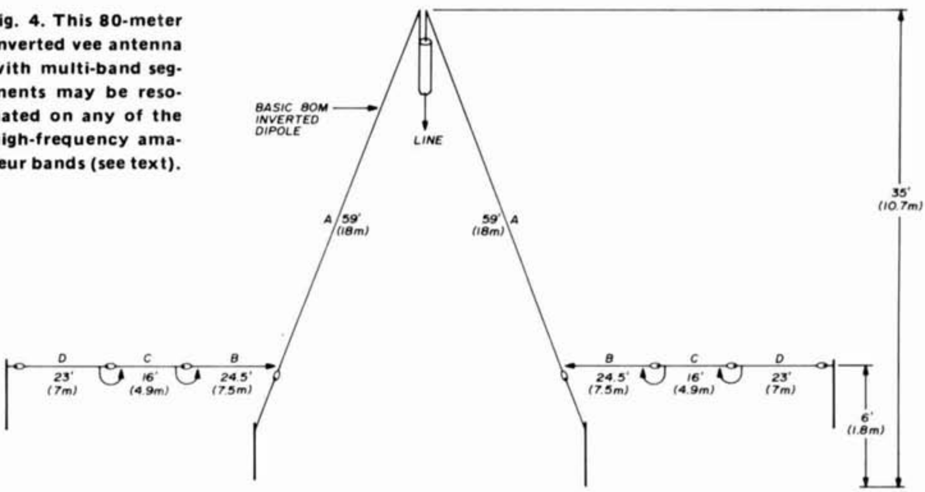
tuneup

To check out the transmitter, first insert the crystal and the two fets. Arrange the supply voltage so as to apply power, initially, to the oscillator only. Connect the 1-mA meter across the gate resistor R4.

Turn on the oscillator stage. Note that there is an indication on the meter. This indicates that the oscillator is operating and there is adequate drive to the amplifier, enough to draw gate current. Meter reading is low and approximately 0.1 mA. Note that if the crystal is removed from its socket, the current reading falls to zero. Also, if the amplifier fet is removed from its socket the meter reading falls to zero.

Insert the 50 mA meter in the supply line to the drain of the amplifier. Adjust capacitor C5 for near maximum setting. Apply power to both stages. Now tune capacitor C4 through its range. Note the

fig. 4. This 80-meter inverted vee antenna with multi-band segments may be resonated on any of the high-frequency amateur bands (see text).



dip in the drain current as the output circuit is tuned through resonance.

Transfer the 1-mA meter to the indicator circuit (across capacitor C8), connect a 68-ohm resistor across the amplifier output, and turn on the transmitter. Adjust capacitor C4 for maximum meter reading. Now adjust capacitor C5 for best output. Jockey back and forth between C4 and C5 until maximum output is obtained.

Jot down the output meter readings and the drain current reading, and calculate the dc power input to the amplifier

$$P_{IN} = V_{DD}\ I_D$$

Typical dc input power is 480 milliwatts (24 V x 20 mA).

Now connect an oscilloscope across the output. Note the good quality of the generated 80-meter sinewave. Key the transmitter, noting the influence on the oscilloscope pattern and the drain and output current meter readings. Tune the transmitter in on your receiver. Check out the keying quality of the CW signal.

Remove the 68-ohm resistor which is across the output, disconnect the oscilloscope, and connect your 80-meter dipole antenna across the output. Retune

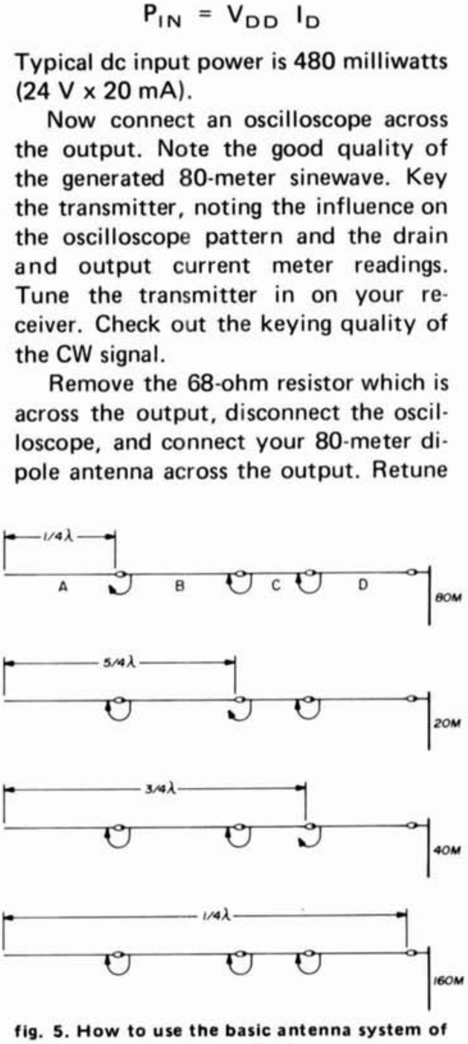


fig. 5. How to use the basic antenna system of fig. 4 on four bands by using jumpers.

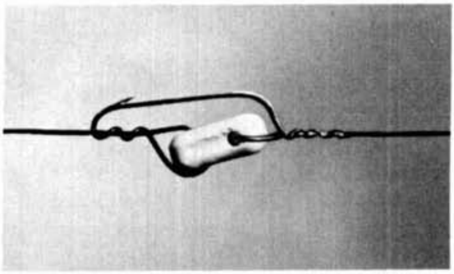


fig. 6. Installing a simple jumper wire across the antenna insulator to adjust resonance.

the transmitter. If your antenna system matches properly there should be very little change in drain current or the output meter reading. If your antenna is not resonant to exactly the crystal frequency the meter readings might not be the same. You are now ready to operate your fet QRP transmitter. Initial W3FQJ contacts with this little rig were with W2UEZ and W2UUV/1.

The rig can also be operated portable using the Globe Gel/Cel 4.5AH 12-volt battery. This convenient battery can be supplied with its own charger or it can be charged from a small solar energy converter, **fig. 3**.

single antenna — four bands

In my solid-state and QRP experiments I needed a single good performing, one-transmission-line test antenna for the 20-, 40-, 80- and 160-meter bands. In addition, it should be possible to resonate the antenna to any frequency in any band. For good performance there should be a current loop at the top of the antenna for each band. For convenience it is helpful to make all resonant frequency and band changes from the ground level and without letting a mast down or putting it back up. A bit of walking to make changes was welcome rather than frowned upon.

The Inverted-Vee antenna was selected because current maxima could be positioned at the apex for each band by proper selection of leg length. At the same time all changes in resonant leg length could be made from ground level. This is accomplished by making each leg length some odd multiple of an electrical quarter wavelength, reflecting a low impedance to the feedpoint at the apex. The final antenna operated as an inverted dipole on 80 and 160; a 3/2λ Inverted-Vee on 40; and 5/2λ on 20.

A general plan of the antenna is shown in **fig. 4**. The 80-meter segment is a conventional inverted dipole with its apex about 35 feet (11m) up at W3FQJ, with wire ends reaching down to 4 to 5 feet (1 to 1.5m) above ground level. From these accessible ends the legs of the antenna span out horizontally at the same level.

Segment B, approximately 25-feet (7.6m) long, when added to segment A with a jumper in each leg sets up the 5/2λ antenna on 20 meters. Additional 15-foot (4.5m) segments jumpered onto leg ends establishes a 3/2λ on 40. Finally, about 25 additional feet (7.6m) provide a half-wavelength antenna on 160 meters. The legs do not necessarily have to run straight away. When necessary they can be tilted away from the plane of the Inverted-Vee by as much as 40 to 60° to permit accommodation to the mounting site.

The arrangement of each leg of this antenna is shown in **fig. 5**, showing the jumper open or closed plan for four-band operation. All of this can be done conveniently from ground level. The photograph of **fig. 6** shows how a jumper is closed across a standard ceramic insulator.

table 1. Free-space dimensions (f in MHz).

1/2 wavelength	492/f (feet)	150/f (meters)
3/2 wavelength	1496/f (feet)	450/f (meters)
5/2 wavelength	2460/f (feet)	750/f (meters)
7/2 wavelength	3444/f (feet)	1050/f (meters)

Free-space dimensions for a sequence of odd quarter-wavelength segments is shown in **table 1**. These free-space lengths must be shortened to obtain an electrical resonance with a wire antenna. The following formulas are normally used to find the length of a quarter-wavelength dipole leg:

$$\text{leg length (feet)} = \frac{234}{f_{MHz}}$$

$$\text{leg length (meters)} = \frac{71.3}{f_{MHz}}$$

This works for most amateur bands. However, when building a 160-meter antenna recently I found the leg length was more closely given by $228/f_{MHz}$ (feet) or $69.5/f_{MHz}$ (meters), possibly showing the close-to-ground influence.

table 2. Design equations and resonant points for inverted-vee antenna shown in fig. 4.

band	antenna	equations		measured resonance
160 M	1/4 wavelength	228/MHz (feet)	69.5/MHz (meters)	1850 kHz
80 M	1/4 wavelength	234/MHz (feet)	71.3/MHz (meters)	3930 kHz
40 M	3/4 wavelength	725/MHz (feet)	221/MHz (meters)	7290 kHz
20 M	5/4 wavelength	1210/MHz (feet)	369/MHz (meters)	14340 kHz

By experiment I have found that the leg-length equations for 3/4 wavelength are $752/f_{MHz}$ (feet) and $221/f_{MHz}$ (meters); for 5/4 wavelength the equations are $1210/f_{MHz}$ (feet) and $369/f_{MHz}$ (meters). These equations should get you into each of the desired bands. However, some length ad-

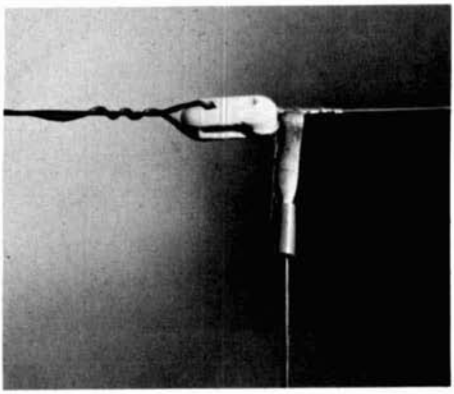


fig. 7. Resonating to a spot frequency in any band may be accomplished with short clip-on sections.

justments will undoubtedly be necessary for resonance at your preferred frequency as variables inevitably creep into any antenna installation.

Resonating to a spot frequency within any one band can be handled with clip-on sections, **fig. 7**. In using the idea of the clip-on section, dimension the antenna segments to the high end of each band. For example, the 80-meter inverted dipole is resonated near 3.95 MHz. Two clip-on sections of proper length can then be used to resonate the dipole to any lower frequency in the same band. For the case in point clip-on lengths of 4 feet (1.2 meter) tune the antenna to resonance at 3.6 MHz.

The dimensions given in **fig. 4** are the final practical values. Data for them are given in **table 2**. Of course, you may wish to cut the antenna segments for resonance at the center of the phone segment of each of the bands. If you decide to do this, a single pair of clip-ons for each band can then be used to lower antenna resonance into the CW band.

reference

1. Ed Noll, W3FQJ, "Solar Power," *ham radio*, November, 1974, page 52.

ham radio

simple audio-frequency keyer for RTTY

This easily-duplicated afsk unit produces a stable, smoothly-switched, sine-wave output from a minimum of components

W.H. King, W2LTJ, 5 Midwood Drive, Florham Park, New Jersey 07932

With a minimum of parts and a bit of electronic serendipity, I designed and constructed the audio-frequency-shift-keyer described herein. I received excellent and gratifying reports as well as queries on its circuitry from experts on the air and friends who have used my "spare" on both afsk a-m on two meters and fsk via ssb-afsk on the low bands. Most don't believe me when I tell them that it uses only one transistor and no filter or other complication. The device, however, doesn't know that, so it continues to function and to enjoy the flattery of its more complicated counterparts. Consult the circuit diagram (**fig. 1**) and you'll see immediately that it is a gutless thing, with only a few parts.* I almost forgot to mention that it also puts out a pure sine wave!

circuit description

The power supply is derived from the loop current (*typically 60 mA*), and when the loop current disappears during spacing, the electrolytic supplies the 4 mA required by the oscillator. Since the device is insensitive to voltage changes, the small drop in supply voltage is not detectable.

As will be developed in the data tables to follow, power supply voltage changes from 15 to 30 volts have less than 6 Hz effect on the frequency and only a 5 per cent effect on the audio frequency output voltage. The oscillator is a Hartley type, using a resistance loaded inductor with a Q of ten. The "grid-leak" has no capacitor across it. These points, in addition to the current regulating nature of the jfet, are what allows transient-free frequency-shift keying.

The opto-electric coupler keys a diode-switched capacitor to change from mark to space frequencies. The coupler is required for isolation and to obtain the very high impedance needed for good switching.

**A printed-circuit board and the components for the afsk can be obtained from Varco Devices, Drawer 8, Stirling, New Jersey 07980.*

Note that you could get away with one logic diode in lieu of the diode bridge if you connect the RTTY loop up with the proper polarity. The bridge arrangement is better, as anybody can wire it up and get the correct polarity on the circuit, thus providing protection at the same time!

It is no surprise that the 88-mH toroid and the capacitors aren't "on the button" items; thus, you will have to tune the circuit to the appropriate frequencies by trial and error. For 850-Hz shift keying between 2125-Hz mark and 2975-Hz space, the values for C1 and C2 are 0.0317 μF and 0.0330 μF, respectively. For 170-Hz shift the values are 0.0555 μF and 0.0092 μF. Please note that the toroid in this case had an inductance of 86.7 mH. You could never be so lucky as to get an identical one, but you can come close if you start with a capacitor of about 0.033 μF and tune to the 2975-Hz space frequency by unwinding turns from the toroid.

You can tune the unit on the RTTY loop, or you can use an equivalent source of power of 18 volts, current limited with a resistor to 60 mA. Whatever you use, I suggest that you connect a temporary short across the LED in the MOC1002 (pins 1 and 2). This will put the unit in the spacing condition and you can now tune C1. Next, remove the short and tune C2 to the mark frequency. Since there may be a little interaction, recheck it, and when you are satisfied solder the capacitors in place. If you desire both shifts, you can add a dpdt switch and the two additional capacitors.

The only other adjustment depends upon your audio output requirements. Each turn of output secondary you wind on the toroid gives about 20 mV of audio output for your microphone

table 1. Audio frequency and rms voltage at top of toroid as a function of supply voltage. Above 15 volts both frequency and audio output are independent of supply voltage.

	850 Hz shift tones				170 Hz shift tones			
	marking		spacing		marking		spacing	
power supply volts	freq Hz	audio volts	freq Hz	audio volts	freq Hz	audio volts	freq Hz	audio volts
10.0	2100	13.3	2900	13.5	2096	13.3	2264	13.3
15.0	2125	18.5	2966	18.7	2121	18.7	2294	18.5
20.0	2134	19.7	2983	20.5	2128	20.1	2302	20.1
25.0	2133	20.1	2986	20.3	2128	20.3	2303	20.0
30.0	2131	19.6	2987	19.6	2130	20.1	2304	19.3

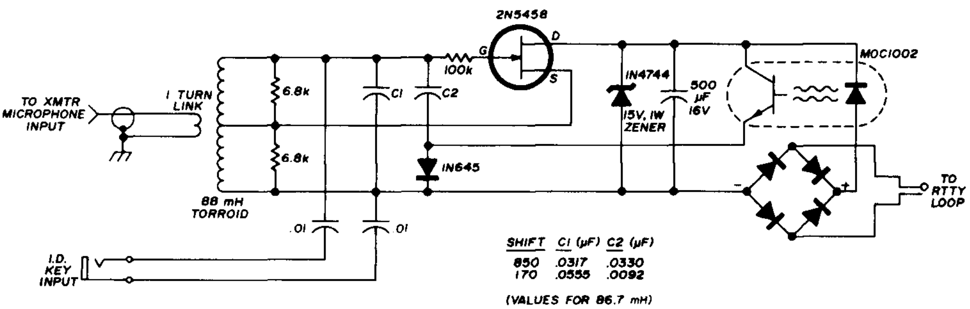


fig. 1. Schematic diagram of the afsk Keyer. Values for C1 and C2 are approximate; oscillator must be tuned to frequency by removal of turns from the 88 mH toroid.

table 2. Audio frequency as a function of shift, loop current and supply voltage.

power supply volts	spacing zero mA 850	170	marking 50 mA 850	170	marking 70 mA 850	170
5.0	2784	2209	2503	2053	2050	2047
7.5	2891	2260	2093	2090	2094	2090
10.0	2934	2280	2112	2107	2111	2109
12.5	2957	2291	2130	2118	2120	2117
15.0	2967	2296	2140	2122	2125	2122
17.5	2974	2298	2140	2124	2127	2124
20.0	2975	2299	2139	2124	2128	2125
22.5	2976	2300	2138	2125	2128	2124
25.0	2977	2300	2136	2125	2128	2125
27.5	2978	2300	2135	2125	2127	2125
30.0	2978	2300	2133	2125	2128	2126
ideal	2975	2295	2125	2125	2125	2125

Note: Frequencies at 60 mA are within a few Hz of those shown at 70 mA.

input. In my case one turn was enough, so you can be accordingly cautious.

performance

I don't intend to defend my design with great amounts of data which may prove difficult for you to verify. But let me say this: on 170-Hz shift you can't find any defect or transient problem as determined by scope, ear, or RTTY expert; on 850-Hz shift there is a bit.

Recently, I borrowed a Western Electric Telegraph Transmission Measuring Set (model 164C2) and used it to check the above conclusions. I played a test tape into the TD to key the loop and thus the afsk. The tones were simultaneously demodulated with a terminal unit which keyed a second loop containing the distortion meter and a printer. The 170-Hz shift was — as advertised — perfect, and the 850-Hz shift mode showed about one percent distortion that could be blamed on the afsk.

The data in **tables 1** and **2** quantify my statements about the frequency stability and constant-amplitude audio output of the circuit. In order to make these tests, the circuit was altered by applying static voltages, then measuring the resulting frequencies and voltages.

ham radio

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the ham notebook

TTL crystal oscillators

Since building a frequency counter, I've been intrigued by TTL crystal oscillators because of their simplicity. Previously I had not been able to obtain reliable performance at frequencies above a few MHz, but I recently ran across a circuit that purrs like a kitten at 14.833 MHz, the highest frequency crystal in my junk box. While checking out this circuit, the possibility of frequency modulating a TTL oscillator came to mind. The circuit is shown in **fig. 1**.

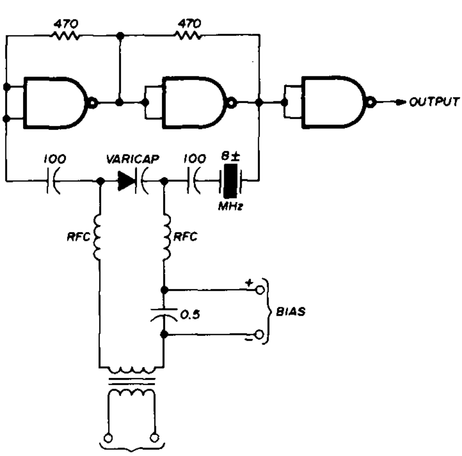


fig. 1. Frequency-modulated crystal oscillator uses TTL gates and varicap diode. Performance curves are shown in fig. 2.

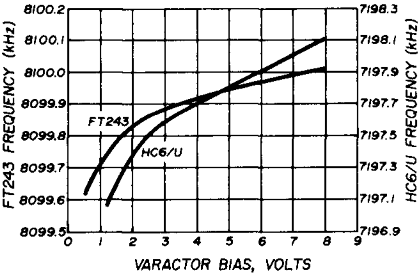
The varicap I used was one of Radio Shack's specials, since that was what was in the junk box. With no audio, the bias was varied to obtain voltage/deviation curves with two available crystals, an FT243 at 8.1 MHz and an HC6/U at about 7.2 MHz. The two curves are shown in **fig. 2**. A bias of 4 volts was chosen.

Since I hadn't been bitten by the 2-meter fm bug at the time I first built this circuit, there was nothing in the house to monitor the output except a six-band general-coverage receiver which covered the 2-meter band along with police and other frequencies. The 18th harmonic of the oscillator was strong and the audio quality seemed to be surprisingly good. I had KØPHF's Heath Twoer on the bench, and with one connection change (and a different crystal) the output of the oscillator was plugged into the Twoer's crystal socket. It drove the Twoer nicely, and to keep it in the sphere of amateur radio, a contact was made through the local 34/94 repeater.

The Twoer first stage, a tripler, seemed to flourish on the harmonic content of the TTL oscillator. Succeeding stages should do a fair job of curtailing final harmonic output. However, this must be carefully checked before any long-term 2-meter operation as additional filtering may be required.

George Chynoweth, WØJVA

fig. 2. Deviation of frequency-modulated TTL oscillator shown in fig. 1.



filter alignment

Moore covers a lot of territory in his recent article[1], but he couldn't include everything. However, one point does need to be expanded: using the spectrum analyzer and noise generator for matching and aligning filters. I have been using this method for several years.

I first used the noise generator in my Omega-T antenna bridge in lieu of a good sweep generator that would cover the i-f frequencies. A Heath SB620 Scanalyzer was connected behind or ahead of the filters under test. Unfortunately, the SB620 covers only the i-f it is built for. I was interested in an i-f of 5645 kHz and the SB620 was equipped with those coils (various frequency coils are supplied in the SB620 kit).

The object of all this was to properly match and align a Drake R4B receiver after installing an 8-pole, 3.7 kHz filter in place of the original, rather wide, 4-pole, 8 kHz filter. More recently the 8 kHz filter was removed from an R4C and replaced with a 5 kHz filter.

To align the filter I coupled the noise bridge into the antenna terminal of the receiver, and the AVC was turned off. The SB620 is coupled very loosely to the grid of the first tube after the filter which is being adjusted. Observe the lower corners of the bandpass curve. You will probably see something like **fig. 3**, curve A. But what you want, and can get by adjusting the coupling components, is curve B.

What you may not suspect is that the SB620 can be placed ahead of the filter to display the "suck-out" of the filter (its low-impedance swamping of the incoming noise). This curve, **fig. 4**, is just about the reciprocal of **fig. 3**. The area between the solid and broken lines is what you have gained by proper matching and isolation.

The curve in **fig. 4** also illustrates what happens when the SB620 is connected as a pan adapter in front of a good filter which has a fairly low impedance. This results in off-frequency signals appearing stronger than those within the passband of the filter. This is rather disconcerting when you wish to check the frequency to which you are tuned: it will look like a clear spot and a good place for a CQ when, in fact, there may be signals there.

Arthur E. Lux, W7UC

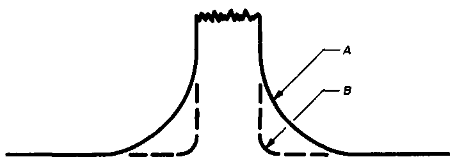


fig. 3. Display of filter response with noise generator input and SB620 installed after the filter. Curve B can be obtained with careful matching and tuning.

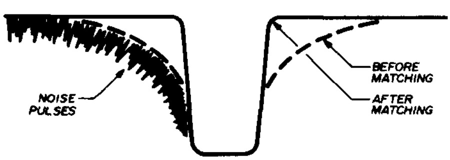
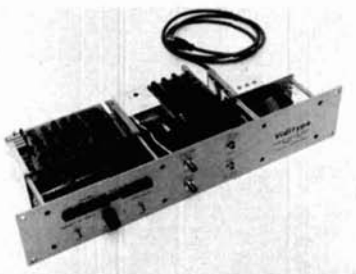


fig. 4. Display of filter "suck-out" with SB620 installed in front of the filter. This curve is nearly a reciprocal of that shown in fig. 3.

1. Ray Moore, "Designing Communications Receivers for Good Strong-Signal Performance," *ham radio*, February, 1973, page 6.

new products

RTTY video display unit



Leland Associates has announced a new RTTY video display unit, the model 872 Viditype, which will provide a video display of RTTY signals on *any* standard television receiver's unused channel. No modifications are required to the TV receiver – simply connect the unit to the antenna terminals. The model 872 is directly compatible with all common RTTY terminal units and features CR-LF on line feed signal, automatic CR-LF on 40th character or a space in positions 36 to 40, automatic page unshift at the end of the 25th line, manual clear (starts print at upper left screen), selectable down-shift on space, manual letters key, and print suppression on all nonprinting functions. Character format is 40 characters per line, 25 lines of display and 1000 character display capacity. The video system uses a crystal-controlled sync generator with a video bandwidth of 3 MHz and 30 Hz refresh rate. Output is 2000 microvolts at 50 ohms on TV channels 3 to 6.

The model 872 video display unit is priced at $450 in kit form ($550 assembled and tested) plus $3.00 shipping and insurance. Specify Baudot or ASCII input. For more information, write to Leland Associates, 18704 Glastonbury Road, Detroit, Michigan, 48219, or use *check-off* on page 94.

triad catalog

Triad-Utrad's new *1975-76 Replacement Catalog and Television Guide for Transformers* is now available. The 70-page catalog features several hundred replacement transformers including color TV components, deflection yokes, flybacks, vertical outputs and filter chokes, as well as power, filament and audio transformers. Copies of the catalog are available on request from Steve Fisher, General Manager, Triad Utrad Distributor Services, 305 North Briant Street, Huntington, Indiana 46750, or use *check-off* on page 94.

450-MHz fm transmitter and power amplifier

VHF Engineering has recently announced the availability of a new 450-MHz fm transmitter and companion 10-watt, 450-MHz power amplifier. For the first time, simple kits are available to permit fm operators to get on 450 MHz without relying on expensive new or surplus equipment. Previously, the uhf fmer had to purchase surplus tube-type uhf fm equipment which was expensive (and difficult to maintain), or

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he had to purchase new fm gear designed for the amateur market. The new gear is much more reliable than the older surplus, but it is very expensive.

VHF Engineering has announced the availability of a simple 1-watt, 450-MHz transmitter kit and a 10-watt 450-MHz amplifier kit designed for construction by the average amateur. These kits are relatively easy to build and do not require sophisticated test equipment. The kits are fully solid state and use readily available components. An experimenter who builds these kits will be able to maintain them himself, a distinct advantage over purchasing a wired and tested unit.

The 450-MHz transmitter consists of five simple stages starting with a varactor-modulated crystal oscillator using crystals in the 18-MHz range. The oscillator quadruples to 55 MHz and drives the first of three doublers. The first two doublers use 2N3866 transistors in a standard doubling configuration. The last doubler uses a 2N3553 and delivers output to the final on 450 MHz. The final amplifier transistor is a 2N5913 operating straight through at 450 MHz, delivering 1 watt output out on the 450 MHz fm band.

While one watt may be sufficient for some applications, additional power really helps in rough terrain when using a repeater and is an absolute must when operating direct on 450 MHz. The VHF Engineering 450-MHz, 10-watt amplifier will supply this extra power at nominal cost. The power amplifier is well designed and very easy to build. Most experimenters should be able to complete it in less than two evenings. The power amplifier uses two balanced-emitter uhf transistors and delivers slightly more than 10 dB gain. For one watt input, the minimum output is 10 watts.

Each VHF Engineering kit consists of top quality components and epoxy-glass circuit boards. The instructions are

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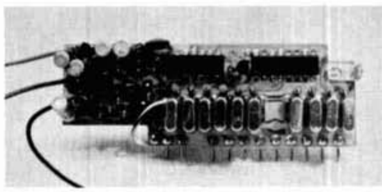
straight forward and include sections on theory, construction, operation, and trouble-shooting. Also available from VHF Engineering are a companion solid-state 450 MHz receiver and a solid-state 450 MHz repeater.

The VHF Engineering 450-MHz transmitter kit sells for $39.95, and the 10-watt amplifier sells for $39.95. VHF Engineering kits are available from dealers or direct from the manufacturer at 320 Water Street, Binghamton, New York 13902. For more information, use *check-off* on page 94.

fm scanner



Topeka FM Communications has just released a ten-channel scanner designed for use with Regency's HR-2 series radios. This unit will also work on Regency marine radios MT-15, MT-25 and Aquaphone, and is designed to rapidly scan ten channels and lock on any frequency which has a strong enough signal to open the receiver's squelch circuit. A scan-lock feature prevents continued scan due to a momentary signal loss.

The scanner features a priority channel which is selected by the channel selector switch. While receiving on any frequency, the scanner periodically checks the priority channel and returns to it if a signal is present. This feature is ideal for the receivers that must monitor emergency frequencies. Delayed scan after transmit allows time for an answer before the scan is resumed. A simple modification allows selective channel bypass. The scanner is priced at $52.50. Order from Topeka FM Communications, Inc., 125 Jackson, Topeka, Kansas, 66603.

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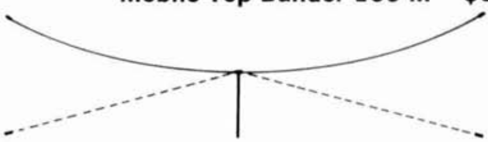

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LM340K 24	1.95	LM747H	.79	CA3046	1.15
LM340T 5	1.75	LM747N	.79	CA3059	2.46
LM340T 6	1.75	LM748H	.39	CA3060	2.80
LM340T 12	1.75	LM748N	.39	CA3080	.85
LM340T 15	1.75	LM1303N	.90	CA3083	1.60
LM340T 24	1.75	LM1304N	1.19	CA3086	.59
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8130	2.19	8280	.75	8830	2.59
8200	2.59	8281	.85	8831	2.59
8210	3.49	8288	1.15	8836	.49
8214	1.69	8520	1.29	8864	2.00
8220	1.69	8551	1.65	8880	1.35

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ASST. 3	5 ea:	470 OHM 1.2K	560 OHM 1.5K	680 OHM 1.8K	820 OHM 2.2K	1K 2.7K	1/4 WATT 5% = 50 PCS.
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ASST. 5	5 ea:	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	1/4 WATT 5% = 50 PCS.
ASST. 6	5 ea:	150K 390K	180K 470K	220K 560K	270K 680K	330K 820K	1/4 WATT 5% = 50 PCS.
ASST. 7	5 ea:	1M 2.7M	1.2M 3.3M	1.5M 3.9M	1.8M 4.7M	2.2M 5.6M	1/4 WATT 5% = 50 PCS.

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2102 1024 RAM	5.50	2518	7.00	MC1741	4.00
AY5 1013 UART	9.95	2519	4.00	MC4044	4.50
RC4194 TK	5.95	2524*	3.50	CA3130S	1.49
8101	18.00	2525	7.00	40410	1.75
8263	7.00	2533	11.85	40673	1.75

DIODES

TYPE	(Zener) VOLTS	W	PRICE	TYPE	(Rectifier) VOLTS	W	PRICE
IN746	3.3	400m	4/1.00	IN4003	200 PIV	1 AMP	.10
IN751A	5.1	400m	4/1.00	IN4004	400 PIV	1 AMP	.10
IN752	5.6	400m	4/1.00	IN3600	50	200m	6/1.00
IN753	6.2	400m	4/1.00	IN4148	75	10m	15/1.00
IN754	6.8	400m	4/1.00	IN4154	35	10m	12/1.00
IN965B	15	400m	4/1.00	IN4734	5.6	1w	.28
IN5232	5.6	500m	.28	IN4735	6.2	1w	.28
IN5234	6.2	500m	.28	IN4736	6.8	1w	.28
IN5235	6.8	500m	.28	IN4738	8.2	1w	.28
IN5236	7.5	500m	.28	IN4742	12	1w	.28
IN456	25	40m	6/1.00	IN4744	15	1w	.28
IN458	150	7m	6/1.00	IN1183	50 PIV	35 AMP	1.60
IN485A	180	10m	5/1.00	IN1184	100 PIV	35 AMP	1.70
IN4001	50 PIV	1 AMP	.09	IN1186	200 PIV	35 AMP	1.80
IN4002	100 PIV	1 AMP	.10	IN1188	400 PIV	35 AMP	3.00

TRANSISTORS

MPS-A05	5/$1			2N3905	4/$1
2N918	.25	2N2906A	4/$1	2N3906	4/$1
2N2219A	3/$1	2N2907A	5/$1	PN4249	4/$1
2N2221	4/$1	2N3053	2/$1	PN4250	4/$1
2N2222A	5/$1	2N3055	.95	2N4409	5/$1
2N2369	5/$1	2N3725A	2/$1	2N5129	.19
2N2369A	4/$1	2N3903	5/$1	2N5139	.19
2N2484	4/$1	2N3904	4/$1	C106B1 SCR	2/$1

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10pf	.05	.04	.03	.001	.05	.04	.035
22 pf	.05	.04	.03	.0047	.05	.04	.035
47 pf	.05	.04	.03	.01	.05	.04	.035
100 pf	.05	.04	.03	.022	.06	.05	.04
220 pf	.05	.04	.03	.047	.06	.05	.04
470 pf	.05	.04	.035	.1	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

± 20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1	35V	.28	.23	.17	1.5	35V	.30	.26	.21
.15	35V	.28	.23	.17	2.2	25V	.31	.27	.22
.22	35V	.28	.23	.17	3.3	25V	.31	.27	.22
.33	35V	.28	.23	.17	4.7	25V	.32	.28	.23
.47	35V	.28	.23	.17	6.8	25V	.36	.31	.25
.68	35V	.28	.23	.17	10	25V	.40	.35	.29
1.0	35V	.28	.23	.17	15	25V	.63	.50	.40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead					Radial Lead				
.47	50	.15	.13	.10	.47	25	.15	.13	.10
1	50	.16	.14	.11	.47	50	.16	.14	.11
3.3	50	.15	.13	.10	1	16	.15	.13	.10
4.7	25	.16	.14	.12	1	25	.16	.14	.11
10	25	.15	.13	.10	1	50	.16	.14	.11
10	50	.16	.14	.12	4.7	16	.15	.13	.10
22	25	.17	.15	.12	4.7	25	.15	.13	.10
22	50	.24	.20	.18	4.7	50	.16	.14	.11
47	25	.19	.17	.15	10	16	.14	.12	.09
47	50	.25	.21	.19	10	25	.15	.13	.10
100	25	.24	.20	.18	10	50	.16	.14	.12
100	50	.35	.30	.28	47	50	.24	.21	.19
220	25	.32	.28	.25	100	16	.19	.15	.14
220	50	.45	.41	.38	100	25	.24	.20	.18
470	25	.33	.29	.27	100	50	.35	.30	.28
1000	16	.55	.50	.45	220	16	.23	.17	.16
2200	16	.70	.62	.55	470	25	.31	.28	.26

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WE'RE STILL "THE FM PEOPLE" BUT . . .

IN ORDER TO HELP YOU FILL ALL YOUR AMATEUR NEEDS WE'VE JUST ADDED THE QUALITY, DRAKE LINE OF AMATEUR PRODUCTS. INCLUDING:

THE FABULOUS "C" LINE

R4C | **T4XC** | **MS4/AC4** | **TR4C**

PLUS FOR FM

TR22C | **TR72**

FOR US THIS IS A BIG STEP . . . AND WE'RE TAKING IT SERIOUSLY. OUR STAFF CAN OFFER YOU OVER 25 YEARS OF H.F. EXPERIENCE INCLUDING DXCC, WAZ, CONTESTS AND WHAT HAVE YOU. WE ALSO STOCK ANTENNAS BY HYGAIN AND HUSTLER TO COMPLETE YOUR STATION NEEDS.

AS ALWAYS WE WILL CONTINUE TO OFFER YOU THE BEST IN FM WHETHER IT BE USED MOTOROLA RADIOS AND PARTS OR ANY OF 38 QUALITY BRAND NAMES IN STOCK. SO WHATEVER YOUR NEEDS BE, GIVE US A CALL OR WRITE . . . YOU'LL BE GLAD YOU DID.

TERMS OF SALE: Sales to licensed Radio Amateurs for use on Amateur freqs only. All prices FOB Oak Park, IL. Check with order, COD or you can charge to your BankAmericard or Master Charge.
STORE HOURS: Mon.-Thurs. 9:30-6:00, Fri. 9:30-8:00, Sat. 9:30-3:00. Closed Sun. & Holidays
INQUIRIES WITHOUT ZIP CODE OR CALL . . . NO ANSWER
WANTED: Good used FM & test equipment. No quantity too large or small. Finders fees too.

SPECTRONICS INC.
1009 GARFIELD STREET
OAK PARK, ILL. 60304
(312) 848-6778

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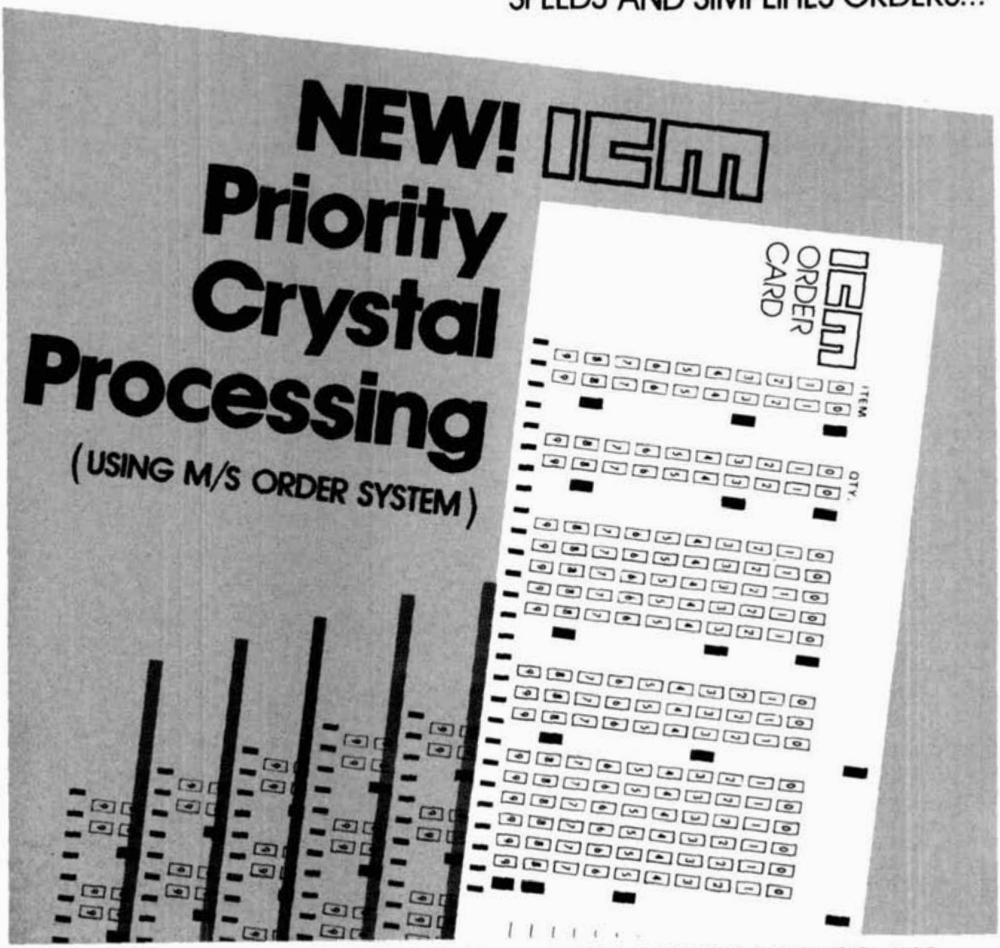
Our new priority crystal processing, using a mark sensing order system, is designed to expedite orders for International Crystals and EX Kits. It's another effort to improve our order processing and make a proven reliable system even better. Your order in the future will be processed by using mark sensing order cards and prepunched name and address cards. Complete and return the coupon and we will mail you a special kit containing instructions, order cards and a prepunched name and address card. This is the first step in our new "no delay" order processing.

For International Crystals, EX Oscillators and Amplifiers

SPEEDS AND SIMPLIFIES ORDERS...



INTERNATIONAL CRYSTAL MFG. CO., INC.
EX Dept., P.O. Box 32497, Oklahoma City, Ok. 73132

Send Special Kit to . . .

NAME ______________________________

ADDRESS ______________________________

CITY ______________ STATE ______________ ZIP ______________

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Wilson Electronics Corp.

ANNOUNCES ITS

NEWEST EDITION

WILSON 1405SM HAND HELD 5 WATT FM TRANSCEIVER

- ✶ NEW SLIMLINE UNBREAKABLE LEXAN® CASE
- ✶ SWITCHABLE 1 or 5 WATT OUTPUT
- ✶ EXTERNAL EARPHONE MIC JACK
- ✶ EXTERNAL POWER JACK

✶ **FACTORY DIRECT AUGUST SALE INCLUDES:**
Rubber Flex Antenna, NiCad Batteries, Leather Case, 52/52 Crystals, Plus Your Choice of 2 Extra Pairs of Common Frequency Crystals. Extra Common Pairs, $9.00 pr.

$390 VALUE ALL FOR JUST **$269.95**

- 6 Channel Operation, Individual Trimmers on all TX and RX Xtals. All Xtals Plug In.
- S Meter Battery Indicator.
- 10.7 IF and 455 KC IF. 12 KHz Ceramic Filter.
- .3 Microvolt Sensitivity For 20dB QT.
- 5 Watts Nominal Output 12 VDC.
- Microswitch Mike Button.
- Size 8-7/8 x 1-3/4 x 2-7/8 Inches.
- Weight 1 lb. 4 ounces, Less Battery.
- Current Drain RX 14MA TX 800 MA.

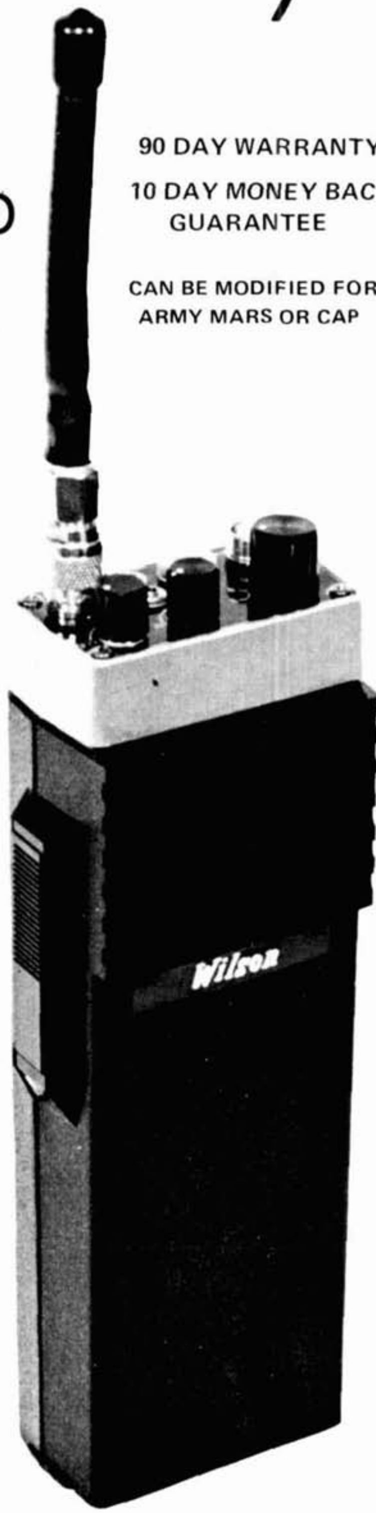
ACCESSORIES:

- SM2 Speaker Mike $24.00
- BC2 Battery Charger $29.95
- XF-1 10.7 MHz monolithic IF filter (installed) $10.00
- TE-1 Continuous Sub-Audible Tone Encoder (installed) $39.95

To: *Wilson Electronics Corp.*
P.O. Box 794
Henderson, Nevada 89015
(702) 451-5791

Ship_____ 1405 August Packages
Plus ☐ SM2 ☐ BC2 ☐ XF-1 ☐ TE-1
Enclosed is $__________ ☐ Check ☐ Money Order
☐ Master Charge ☐ Bank Americard
Expiration Date________ M/C Interbank #________
Card #________________
Xtals_____ _____ _____ _____ _____
Name________________
Address________________
City and State____________ Zip______
Signature________ ____________

All orders will be shipped Parcel Post within 48 hours after receipt of order (excluding weekends). Enclose additional $4.00 for prepaid shipping & handling. Nevada residents add sales tax. Sale ends August 31, 1975.



90 DAY WARRANTY

10 DAY MONEY BACK GUARANTEE

CAN BE MODIFIED FOR ARMY MARS OR CAP

More Details? CHECK—OFF Page 94

Wilson Electronics Corp.

FACTORY DIRECT

SPECIAL AUGUST SALE!!!

WILSON 1402SM HAND HELD 2.5 WATT FM TRANSCEIVER

* Rubber Flex Antenna
* Complete Set NiCad Batteries
* Leather Case
* Three Sets of Crystals, 52-52,

Plus Your Choice of 2 Pair of Common Frequencies
Extra Crystals, $4.50 ea., Common Frequencies Only

$320 VALUE ALL FOR JUST **$199.95**

- 6 Channel Operation, Individual Trimmers On All TX and RX Xtals. All Xtals Plug In.
- S Meter Battery Indicator.
- 10.7 IF and 455 KC IF. 12 KHz Ceramic Filter.
- .3 Microvolt Sensitivity For 20dB QT.
- 2.5 Watts. Nominal Output 12 VDC.
- Microswitch Mike Button.
- Size 8-7/8 x 1-7/8 x 2-7/8 Inches.
- Weight 1 lb. 4 ounces. Less Battery.
- Current Drain RX 14MA TX 450 MA.

COMING SOON !!!
220 & 420 MHz
HAND HELD
TRANSCEIVERS

ACCESSORIES:

SMI Speaker Mike $24.00
BCI Battery Charger $29.95
1410A Amplifier Mobile Mount $99.00
XF-1 10.7 MHz monolithic IF filter (installed) $10.00
TE-1 Continuous sub-audible tone encoder (installed) $39.95

To: Wilson Electronics Corp.
P.O. Box 794
Henderson, Nevada 89015
(702) 451-5791

Ship_____1402 August Packages
Plus ☐ SM1 ☐ 1410A ☐ BC1 ☐ XF-1 ☐ TE-1

Enclosed is $__________ ☐ Check ☐ Money Order
☐ Master Charge ☐ Bank Americard
Expiration Date________ M/C Interbank #________
Card #________________
Xtals______ ______ ______ ______ ______
Name________________
Address________________
City and State____________ Zip______
Signature________________

All orders will be shipped Parcel Post within 48 hours after receipt of order (excluding weekends). Enclose additional $4.00 for prepaid shipping & handling. Nevada residents add sales tax.

Sale ends August 31, 1975.

90 DAY WARRANTY
10 DAY MONEY BACK GUARANTEE
CAN BE MODIFIED FOR ARMY MARS OR CAP

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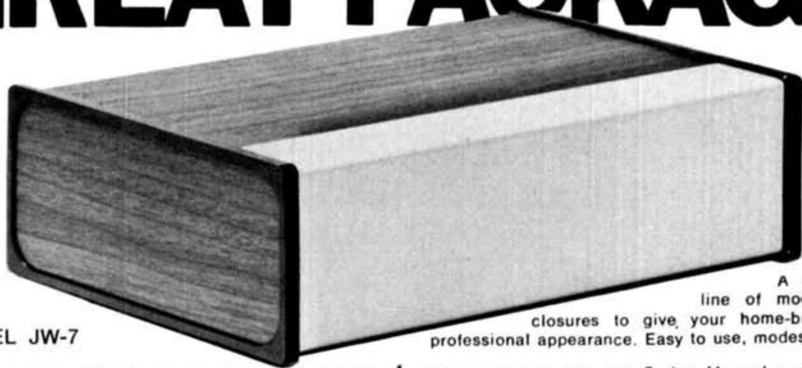
GREAT PACKAGE



MODEL JW-7

A complete line of modern enclosures to give your home-brew gear professional appearance. Easy to use, modest in cost.

SERIES "D"

Series D is our largest enclosure style providing a low profile decorative case. DW types have walnut grain vinyl tops and side panel trim, and eggshell white front panels. DG models are styled in grey tops and front panels with black pebble side panels. Both have Cycolac molded side panels and .062" aluminum cases.

Model	H"	W"	D"	Weight	Price
DG-8	4-3/16	7-3/4	10-7/32	2 lb- 0 oz	$15.50
DG-10		9-3/4		2 lb- 5 oz	16.50
DG-12		11-3/4		2 lb-12 oz	18.00
DG-14		13-3/4		3 lb- 0 oz	19.50
DW-8		7-3/4		2 lb- 0 oz	16.50
DW-10		9-3/4		2 lb- 5 oz	18.00
DW-12		11-3/4		2 lb-12 oz	20.00
DW-14		13-3/4		3 lb- 0 oz	23.00

SERIES "M"

Series M enclosures provide styling and finishes similar to the D series, but in a somewhat shorter depth. They are also available in models down to five inches in width.

Model	H"	W"	D"	Weight	Price
MG-5	4-3/16	4-3/4	6-5/16	1 lb- 0 oz	$ 5.50
MG-6		5/3-4		1 lb- 0 oz	6.50
MG-7		6-3/4		1 lb- 4 oz	7.75
MG-8		7-13/16		1 lb- 6 oz	8.75
MG-10		9-15/16		1 lb-11 oz	11.00
MG-12		11-15/16		2 lb- 0 oz	13.50
MW-5		4-3/4		1 lb- 0 oz	6.50
MW-6		5-3/4		1 lb- 2 oz	7.75
MW-7		6-3/4		1 lb- 4 oz	8.75
MW-8		7-13/16		1 lb- 6 oz	10.00
MW-10		9-15/16		1 lb-11 oz	12.00
MW-12		11-15/16		2 lb- 0 oz	14.25

SERIES "J"

Series J is a low profile, decorative enclosure designed for small, fine equipment. Basic construction features and styling similar to the D and M series. Molded Cycolac side panels and .062" aluminum housing.

Model	H"	W"	D"	Weight	Price
JG-4	2-1/8	3-5/8	5-9/16	11 oz	$ 4.25
JG-5		4-11/16		13 oz	5.00
JG-6		5-11/16		15 oz	5.75
JG-7		6-11/16		1 lb- 0 oz	6.50
JG-8		7-3/4		1 lb- 2 oz	7.25
JG-10		9-7/8		1 lb- 5 oz	9.25
JW-4		3-5/8		11 oz	5.00
JW-5		4-11/16		13 oz	5.75
JW-6		5-11/16		15 oz	6.50
JW-7		6-11/16		1 lb- 0 oz	7.25
JW-8		7-3/4		1 lb- 2 oz	8.25
JW-10		9-7/8		1 lb- 5 oz	10.50

SERIES "T"

Series T is a new series that brings the beauty of TEN-TEC enclosures to the low priced market. Constructed of two formed .062" aluminum sections. Finished in (W) wood grain walnut vinyl and egg shell white, or (G) instrument grey and black pebble vinyl.

Model	H"	W"	D"	Weight	Price
TG-24	1-7/8	4-1/4	4-1/8	6 oz	$2.00
TG-26	1-7/8	6-1/4		8 oz	2.50
TG-34	3	4-1/4		8 oz	2.50
TG-36	3	6-1/4		10 oz	3.25
TW-24	1-7/8	4-1/4		6 oz	2.00
TW-26	1-7/8	6-1/4		8 oz	2.50
TW-34	3	4-1/4		8 oz	2.50
TW-36	3	6-1/4		10 oz	3.25

AVAILABLE FROM YOUR DEALER OR DIRECT

NAME ________________ STREET ________________

CITY/STATE ________________ ZIP ________

Estimate shipping charges at $1.00 for each enclosure of D and M series, 50¢ each for J and T series.

QUANTITY	MODEL	UNIT PRICE	AMOUNT
		Sales Tax if Applicable	
		Shipping & Handling	
		Total Enclosed	

TEN-TEC INCORPORATED
SEVIERVILLE, TENNESSEE 37862

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flea market

RATES Non-commercial ads 10¢ per word; commercial ads 35¢ per word both payable in advance. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing). Repeat insertions of hamfest ads pay the non-commercial rate.

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 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

MODEL 32 ASR LIKE NEW, for sale, $300 or best offer over that, shipping extra. B. Rowan W2GKP, 55 Runnymeade Rd., Berkeley Heights, N. J. 07922.

RADIO MUSEUM NOW OPEN. Free admission. 25,000 pieces of equipment from 1850 telegraph instruments to amateur and commercial transmitters of the 1920's. Amateur Station W2AN. Write for information. Antique Wireless Association, Main St., Holcomb, N. Y. 14469.

F.R.R.L. HAMFEST — August 17th. U.S. Rt. #30 east of Aurora, Ill. Phillips Park — Picnic — Zoo — Family Fun. Advance donation $1,00, $1.50 at park. S.A.S.E. to P. O. Box 443, Aurora, 60507. Two grand prizes and many others.

FINDLAY HAMFEST — Sept. 7 — Riverside Park, Findlay, Ohio. For advance drawing tickets write Clark Foltz, W8UN, 122 W. Hobart, Findlay, 45840.

FLEA MARKET, HAMFEST & AUCTION. Hilliard, Ohio, Franklin County Fairgrounds. Sunday, August 10, 1975, 8 a.m. to 6 p.m. rain or shine. Details from CORC, Box 23, Delaware, Ohio 43015.

FIGHT TVI with the RSO Low Pass Filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada. MIS 3B4.

23rd ANNUAL NORTHWEST DX CONVENTION, August 2-3. Double Tree Inn just south of Seattle. Details from W9IRH/7, 14041 - 159th NE, Woodinville, Wash. 98072.

SURPLUS TEST EQUIPMENT, VHF and microwave gear; write for bulletins. David Edsall, 2843 St. Paul, Baltimore, Md. 21218.

DANE COUNTY SWAPFEST. Dane Co. Expo Center, Madison, Wis. Sept. 28, 8 a.m. Box 3403, Madison, Wisc. 53704 for information.

RTTY — NS-1 PLL TU (HR 2/75). Undrilled board $4.75 ppd. Wired/tested $29.95 ppd. Nat Stinnette Electronics, Tavares, FL 32778.

CLAMBAKE HAMFEST, Sept. 21, 10 a.m. to sunset. Tewksbury (Mass.) Rod & Gun Club, 11 Chandler St. Tickets & program — Box 221, Malden, Mass. 02148.

RADIO ARCHIVES, amateur ancedotes solicited for (SASE subscription) monthly PR newsletter. Electronic Avocations, 3207 4th St. N., Minneapolis, Minn. 55412.

50 FREE INTERNATIONAL QSL EXCHANGE COUPONS — Send large self addressed stamped envelope, or 2 stamps. Swaney, Box 54, Goose Creek, SC. 29445.

TELETYPEWRITER PARTS, gears, manuals, supplies, tape, toroids. SASE list. Typetronics, Box 8873, Ft. Lauderdale, Fl. 33310. Buy parts, late machines.

SWAN 350 with 117C PS/Spkr, DC PS, ext. osc. for MARS, etc. Mint condition. $275 FOB my QTH. R. Davis, W9KK, RR 1, Box 12, Colfax, In. 46035.

MANUALS for most ham gear made 1940/65, some earlier. Send SASE for specific quote. Hobby Industry, WØJJK, Box H-864, Council Bluffs, Iowa 51501.

TOWER, 75 ft. crankover with HAM-M rotator, 4-element 10-40M beam antenna, new hardware incl. mounting hardware. $750 FOB my QTH. R. Davis, W9KK, RR 1, Box 12, Colfax, In. 46035.

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

SELL YAESU FT101, $525, 2 meter H.T. Tempo FMH, 2 watts, 6 channel, touchtone pad, nicads, 12 xtals, 2 antennas, charger, cost $350 — mint only $245. Dycom E40 2 meter amplifier, $50.00, 2 in 40-50 out. Call Marty, 215-884-6010, WA3IFQ.

EXCLUSIVELY HAM TELETYPE 21st year, RTTY Journal, articles, news, DX, VHF, classified ads. Sample 30¢. $3.00 per year. Box 837, Royal Oak, Michigan 48068.

NOBARC HAMFEST, Aug. 16 and 17th at the Middlefield Fairgrounds, Middlefield, Mass. Talk ins on 31-91, 43-03, 34-94, 52 simplex, 52.525 and 223.50. Admission fee $3.00 per adult or $5.00 per family. Flea market parking $1.00 per car. Free camping. Activities both days starting Aug. 16th, at 12 noon.

PC's, Send large S.A.S.E. for list. Semtronics, Rt. #3, Box 1, Bellaire, Ohio 43906.

"HAM BUY LINES". Send name and address for literature. Iacopelli, 1720 77 St., Brooklyn, N. Y. 11214.

CANADIAN JUMBO SURPLUS and Parts Catalogs. Bargains Galore. Send $1. ETCO-HR, Box 741, Montreal "A" H3c 2V2.

CINCINNATI HAMFEST: 38th annual — Sunday, September 21, 1975 at the New Stricker's Grove on State Route 128, one mile west of Ross (Venice), Ohio. Flea market, contests, model aircraft flying, food and beverages all day. Advanced Tickets $7.00, covers everything; $8.00 at gate. For tickets or further information: Carl J. Dettmar, W8NCV, 8630 Cavalier Drive, Cincinnati, Ohio 45231.

SELL — Quality nylon cable ties 6 inch for $2.75 pp/hundred. New Manuals for AN/ARC-3, AN/ARC-12, AN/TRC-1 for $5.00 pp. W4VQD/Ø, 106 Sheridan Ct., Leavenworth, Ks. 66048.

MT. BEACON A.R.C. 3rd Annual Hamfest, Aug. 16, 1975, 8 a.m. to 6 p.m. at Stewart Airport, Newburgh, N. Y. Hangar E. Flea market and auction, door prizes, talk-in 37/97, 94 and 52, rain or shine. Free parking, admission $1.00, tailgating $1.00, under 12 free. For advance tickets write: Marty Irons, WB2TBI, 46 Magic Circle Drive, Goshen, N. Y. 10924.

THE ORIGINAL FM HAMFEST, August 3, 1975, near Angola, Indiana. Free flea market, picnic grounds, swimming, boating available. Talk-in on 146.16/76, 146.94. For information contact Ft. Wayne Rept. Assn., Box 6022, Fort Wayne, Indiana 46806.

More Details? CHECK—OFF Page 94

RECIPROCATING DETECTOR, write Peter Meacham Associates, 19 Loretta Road, Waltham, Mass. 02154.

LAPORTE COUNTY HAMFEST, 24 August, at the County Fairgrounds in LaPorte, Indiana. Paved midway or inside tables for sellers. On-site camping. Advance tickets $1.00 each, $1.50 at gate. Cold drinks and food available. Contact WB9AOU, RR 7, Box 275, Valparaiso, Ind. 46383.

OSCAR SLIDES, set of 5, $1.25. Launch and spacecraft. Proceeds AMSAT. K6PGX, P. O. Box 463, Pasadena, CA 91102.

MELBOURNE, FLORIDA — PCARs 10th anuual Hamfest at Melbourne Auditorium, September 6 & 7. Prizes galore, exhibits, swap-tables, auction, Floridora's, QCWA, etc. First prize 40′ crank-up tower, tri-band beam, rotator & coax-complete! For info - Box 1004HR, Melbourne, FL 32901.

RECONDITIONED TEST EQUIPMENT for sale. Catalog $.50. Walter, 2697 Nickel, San Pablo, Ca. 94806.

MILITARY QUALITY FIELD STRENGTH METER Instruments for industry model EFS-1. New condition w/manuals. $475 new — selling for $225 or trade for ? K. Schreiber, Route 2, New Concord, Ohio 43762.

MANUFACTURERS, Distributors! The Memphis Hamfest will be bigger than ever. The dates are Saturday and Sunday, October 4 and 5. Best location possible — State Technical Institute, Interstate 40 at Macon Road. Security. Contact Chairman, Harry Simpson W4SCF, Box 27015, Memphis, TN 38127, phone 901 358-5707.

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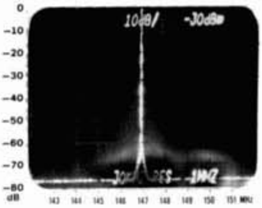

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