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JULY 1975



## UHF DOUBLE- BALANCED MIXERS

### *this month*

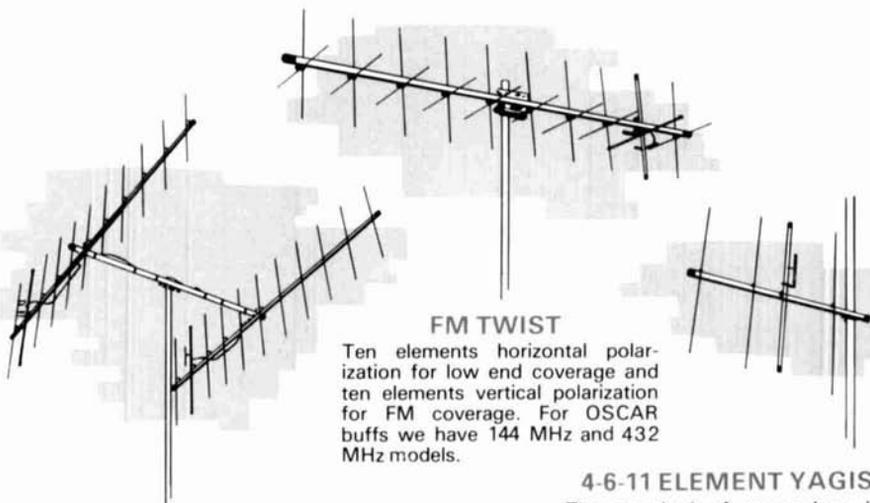
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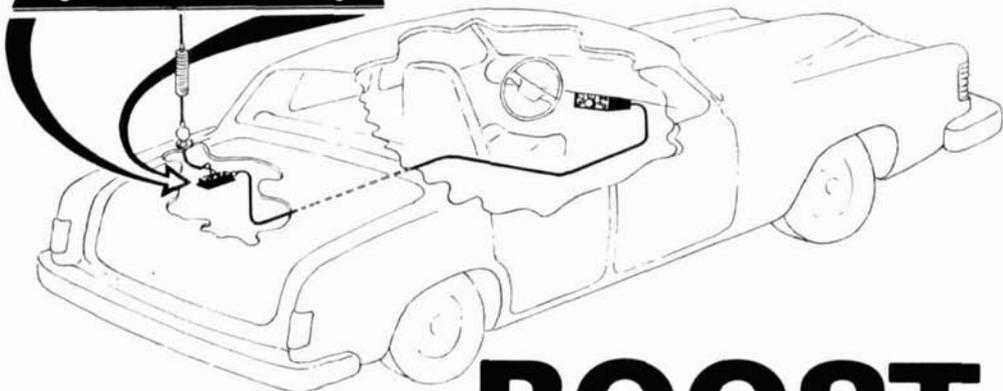
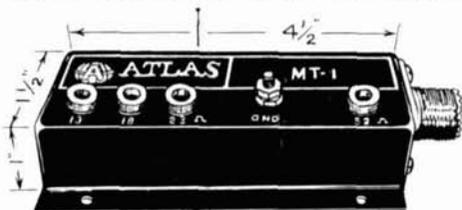
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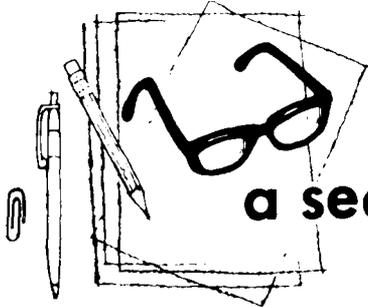
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## a second look

by Jim  
fisk

In our modern day world of solid-state electronic gadgets and centralized urban living, it's the rare amateur who hasn't been troubled at one time or another by interference complaints. As often as not the interference is being generated by some other source, but if you have a tower in your backyard, you're a likely suspect and the first one to whom they turn when the local taxicabs (or whatever) come booming through their quadraphonic stereo systems.

As I pointed out in this column last year, the problem can be effectively cured only by proper design and construction at the manufacturing level. The home-entertainment business is highly competitive, however, and with today's staggering economy the manufacturers are reluctant to add filtering and lead bypassing that would increase the price tags on their equipment. Until recently, in fact, they contended that only 1% of home entertainment equipment operates in an rf environment which necessitates special attention. However, with the proliferation of two-way radio systems, as well as higher power a-m and fm broadcasting stations and high-speed digital systems which can cause interference, I doubt that many consumers would agree.

The answer to this problem may now be in sight. On May 15th, Rep. Charles A. Vanik of Ohio introduced a Bill to the House of Representatives which, if it becomes law, will give the FCC the right to regulate the manufacture of electronic home-entertainment devices to reduce their susceptibility to interference from nearby radio transmitters.

That Bill, H.R. 7052, has been referred to the Committee on Interstate and Foreign Commerce, and specifically to the Subcommittee on Communications. The Bill must receive a hearing there before it can be sent to the House for action. If the Bill is to receive a hearing, however, the Congress must be made aware of our support for such legislation — support which you can demonstrate by writing to the Chairman of the Subcommittee on Communications, The Honorable Torbert H. Macdonald.\*

The letters do not have to be long, although background information on your (or your neighbors') RFI problems could be important. Even a note to the effect that you support H.R. 7052 and respectfully request an early hearing would be a valuable contribution. It would also be a good idea to send a short letter to your own Congressman, indicating your desire that he support H.R. 7052. Remember that previously introduced RFI legislation never made it through Congress — don't let that happen this time.

Consumers are becoming increasingly aware of the RFI problem, so the time is right for legislation such as that proposed by Rep. Vanick. Amateurs have known for a long time that the majority of RFI problems are not due to interference *per se*, but are due to the interception of signals by devices which were not designed to operate in today's rf environment. The only way to eliminate 90% of the RFI problems is through legislation such as H.R. 7052 which could eventually require the manufacturers to correct those design deficiencies which lead to unnecessary interference.

Now is the time to lend your support to this vital effort. Write today, and make your voice heard.

**Jim Fisk, W1DTY**  
editor-in-chief

\*The Honorable Torbert H. Macdonald, Chairman, Subcommittee on Communications, Room R331, Rayburn House Office Building, U.S. House of Representatives, Washington, D.C. 20515.

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FIRST WORKING GROUP MEETING in preparation for the 1979 World Administrative Radio Conference (WARC) went very well with nine "Task Forces" now set up and operating: ITU Rules and Regulations and Technical Criteria (W3FU), Military Liaison (W4FZ), Liaison with Other Services (W4ZC), Basis and Purpose (W6APW), 0-4 MHz Spectrum (W2QD), 4-27 MHz Spectrum (W30KN), 27-1296 Spectrum (KH6IJ), and 1296 and Up Spectrum (Task Force Chairman shown in parenthesis).

Task Force Rosters were made up from those present, with additional membership still solicited from anyone willing and able to contribute time and expertise to this important effort. Contact Task Force leaders of the groups to which you wish to contribute. Task Force meetings will be held during the next few months, and a second meeting of the entire Working Group has been scheduled during the ARRL National Convention in Reston, Virginia in September.

Proposed New HF Amateur Bands got some encouragement during the general discussion, as preliminary views were expressed that the fixed services will likely be giving up enough frequencies in the HF range to accommodate the increased desires of international broadcasters plus at least some of the proposed new ham bands. However, the problem may very well not be finding the frequencies, but be one of marshalling sufficient support for the amateur service among the many new ITU members!

"DUAL LADDER" WAS REJECTED as ARRL Directors met to prepare League response to FCC's amateur restructuring docket. In a lengthy meeting in which the membership poll played a prominent part, the League leadership also came out against the loss of privileges proposed in Docket 20282 and recommended that present Conditionals and Technicians be permitted to renew their licenses indefinitely without re-examination. Although they supported the Communicator (they prefer "Basic" Amateur) class, they would include CW "recognition" in its requirements.

Member Survey Results, broken down in several ways, had been provided to the Directors for study well before the meeting. Of the approximately 56000 ARRL members who participated in the poll, about 20% also provided their Directors with written comments and few expressed any enthusiasm for either the dual ladder or loss of privileges.

AMATEUR DOCKETS starting to move at the FCC. Repeater Linking (Docket 20073) is reported on its way to the Commissioner's agenda, and Repeater Crossbanding (Docket 20113) is not far behind it. Action on Extra Class requesting specific call signs (Docket 20092) is also expected soon.

Still Pending are RACES (19723), HIRAN (20147) and Repeater Automatic Control (20112). At least one new docket — "exotic emissions" — is in preparation.

Docket Moving Unlicensed Hand-Helds from 27 MHz to just below six meters may be decided soon. Docket 20119 proposed putting the under-100 mW portables on discrete channels that alternate with already assigned MARS channels in the same range and as yet MARS authorities seem to have raised no objection.

FCC's Amateur and Citizens Division has been looking out for amateur interests, however — they've urged that superregen receivers be prohibited because of their potential interference to amateur operations on the low end of the 50-MHz band.

HAM RADIO, QST CHANGING FORMAT to 8½x11-inch page size effective with January, 1976 issues. Much justification for the change is economic — most periodicals, including practically all in the electronic field except for amateur radio, are in the larger format so printing, paper, handling, and the like should all be less expensive. Hopefully, the savings from these changes can delay future subscription rate increases.

OSCAR 7 is still suffering from occasional unexplained mode jumping. Any OSCAR user observing such a switch when it actually occurs should note the exact time and date and report them to AMSAT. Non-amateur satellites have had similar problems and AMSAT is attempting to correlate OSCAR 7's problem with theirs.

Russian Participation in OSCAR programs being discussed — two Russians, one a ham, spent two days with AMSAT representatives recently reviewing possible cooperative activities.

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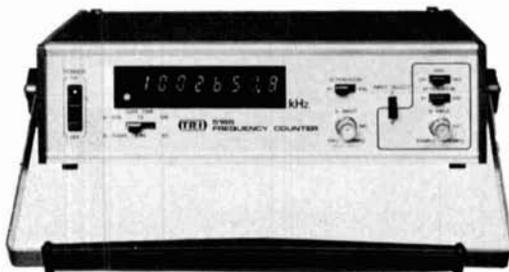
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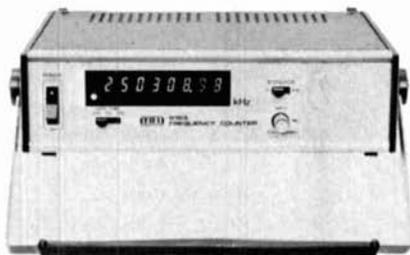
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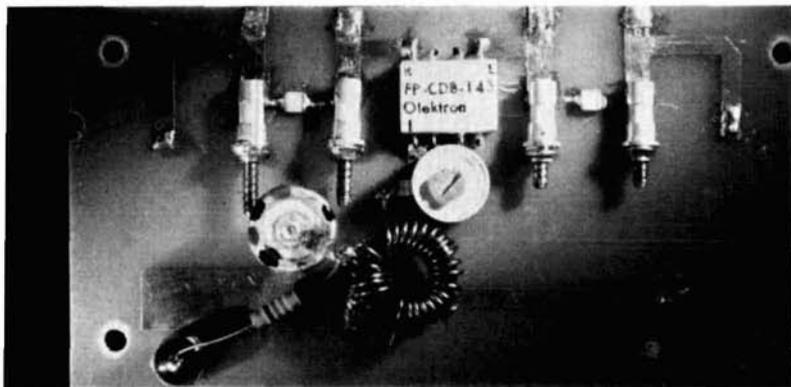


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## how to use double-balanced mixers on 1296 MHz

Modern commercial  
uhf double-balanced  
mixer modules  
improve the performance  
of 1296-MHz converters

Diode balanced mixers have received considerable attention as bilateral mixers for transceive converter applications. In a previous article,<sup>1</sup> I outlined a transceive converter for 1296-MHz ssb including construction details for two suitable homebrew single balanced-mixers. Recent price breakthroughs have now brought within the reach of the serious experimenter several commercial double-balanced mixers which are adaptable for transmit, receive and transceive conversion well into the microwave region. This article describes the use of such mixers in the 23 cm band.

### mixer modules

Since a number of manufacturers offer flatpack double-balanced mixers with identical lead arrangements, a circuit board can be designed which will accommodate a variety of mixer modules. These mixers, some of which are listed in table 1, vary primarily in conversion loss and power handling capabil-

Paul Shuch, WA6UAM, San Jose, California 95124

ity. All of the mixers listed here will withstand the injection levels used in the 1296-MHz ssb transceiver converter (i.e., 40 mW of local-oscillator injection and 12 mW PEP of applied i-f power in the transmit mode).

functionally equivalent to a popular design which many amateurs have built for lower frequency applications.<sup>2</sup> In theory, all that is necessary to use the mixers is to mount the flatpack device on a circuit board containing connectors

**table 1. Partial listing of flatpack double-balanced mixers suitable for use on the 1296-MHz band. Conversion loss shown is worst cast for the specified frequency range; it may be less at spot frequencies within the overall range. Mixers are listed in order of ascending single-quantity price. Manufacturer's addresses are listed below.**

manufacturer	model	frequency range	conversion loss	approximate price
Olektron Corporation	FP-CDB-145	0.5-1350 MHz	9.0 dB	\$29
Merrimac Industries	DMF-2A-750	50-1500 MHz	9.0 dB	\$40
Vari-L Company	DBM-158	500-1500 MHz	7.5 dB	\$50
Lorch Electronics	FC-200ZF15	10-1500 MHz	8.5 dB	\$59
Watkins-Johnson	M4A	10-1500 MHz	8.5 dB	\$60
Anzac Electronics	MD-614	600-2000 MHz	7.5 dB	\$75

Anzac Electronics, 39 Green Street, Waltham, Massachusetts 02154

Lorch Electronics, 105 Cedar Lane, Englewood, New Jersey 07631

Merrimac Industries, 41 Fairfield Place, W. Caldwell, New Jersey 07006

Olektron Corp., 6 Chase Avenue, Dudley, Massachusetts 01570

Vari-L Company, 3883 Monaco Parkway, Denver, Colorado 80207

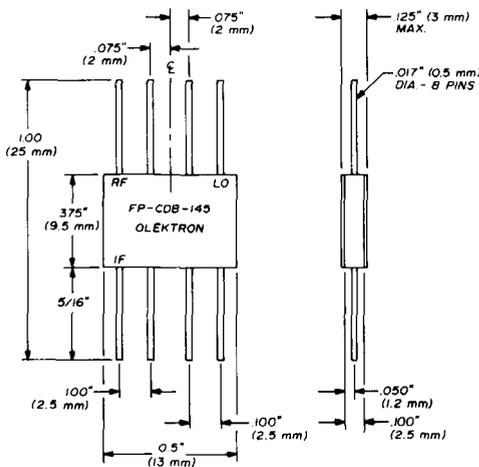
Watkins-Johnson Company, 3333 Hillview Avenue, Palo Alto, California 94304

The commercial flatpack double-balanced mixers all contain a ring of four hot-carrier diodes, typically in a beam-lead pill package, along with two wideband balun transformers. They are

(to each of the three ports) and provide a good ground path for those terminals which must be grounded. Other features can be added to the circuit board to enhance its performance in a particular application.

The circuit board presented in this article is designed to permit transceiver conversion to the 23 cm band while providing image filtering at the rf port, spurious response filtering at the local-oscillator port, and resonating the i-f port to 28 MHz.\* Provisions are also made for monitoring mixer current in the dc return to the i-f port.

The prototype of this assembly uses an Olektron model FP-CDB-145 flatpack mixer. Its physical configuration (which is typical of all the flatpack mixer modules) is shown in fig. 1. The Olektron device is the least expensive of the



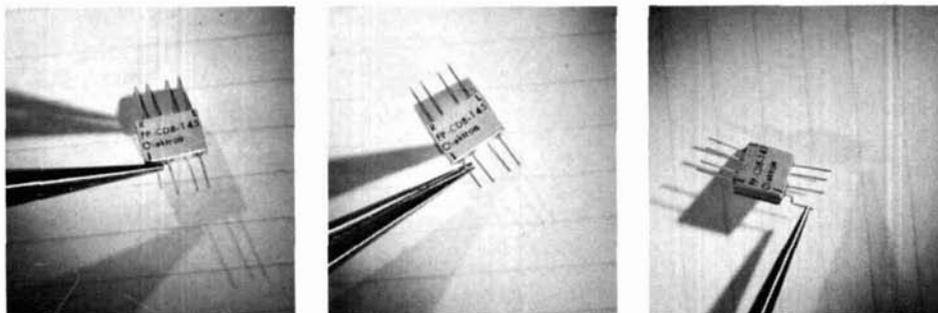
**fig. 1. Physical dimensions and pin layout of typical flatpack double-balanced mixer module.**

\*Other intermediate frequencies may be used by suitable modification of components L5, L6 and C7 in fig. 2.

mixers listed in **table 1**, and offers electrical characteristics which are completely satisfactory for the 1296-MHz transceiver application (see **table 2**). Should lower conversion loss be required, you may wish to substitute one of the more expensive mixers listed in **table 1**. However, as you might expect, each 1 dB of improvement in conversion

with connectors, this filtering is readily incorporated on the circuit board on which the mixer is mounted. In **fig. 2**, components L1 through L6 and C1 through C7 serve this purpose.

As was mentioned previously, it is possible to use any of the flatpack mixers simply by mounting them on a board containing the appropriate con-



To bend the leads on the delicate double-balanced mixer package, first grasp the pins with long-nose pliers very close to the package and bend the lead downward at 90 degrees (left). Then grasp the lead at the bend and form the lead straight out from the package (center). The desired lead configuration is shown on the right.

loss is offset by a corresponding 1 dB increase in cost.

### bandwidth considerations

When applying any of the readily available commercial mixers to narrow-band service, you should be aware of their inherently broad frequency response. The Olektron unit, for example, is designed for operation from 500 kHz to 1350 MHz. The very bandwidth which is so beneficial in many applications may well prove a detriment here as an absence of selectivity at the rf and local-oscillator ports invites out-of-band spurious responses. My homebrew mixer designs have incorporated frequency-selective circuitry at the various ports. To alleviate interference problems related to unnecessary bandwidth, such filtering should be added externally to any of the commercial mixers. Unless the mixer module is already provided

connectors for interfacing to the three ports. Upon attempting this simplistic approach in a 1296-MHz transceiver converter, however, I found myself with more birdies than the Audubon Society, and enough image to run for office. Only upon incorporating the filtering provisions of **fig. 2** did the melange of signals emanating from the mixer become manageable.

### diode current monitoring

Often it is desirable to monitor mixer diode current during converter operation. This is especially useful while tuning local-oscillator chains, or for determining the adequacy of the i-f injection applied in the transmit mode. Unfortunately, most commercial mixers make no direct provision for monitoring diode current. Again, this feature may be added to the board on which the mixer is mounted.

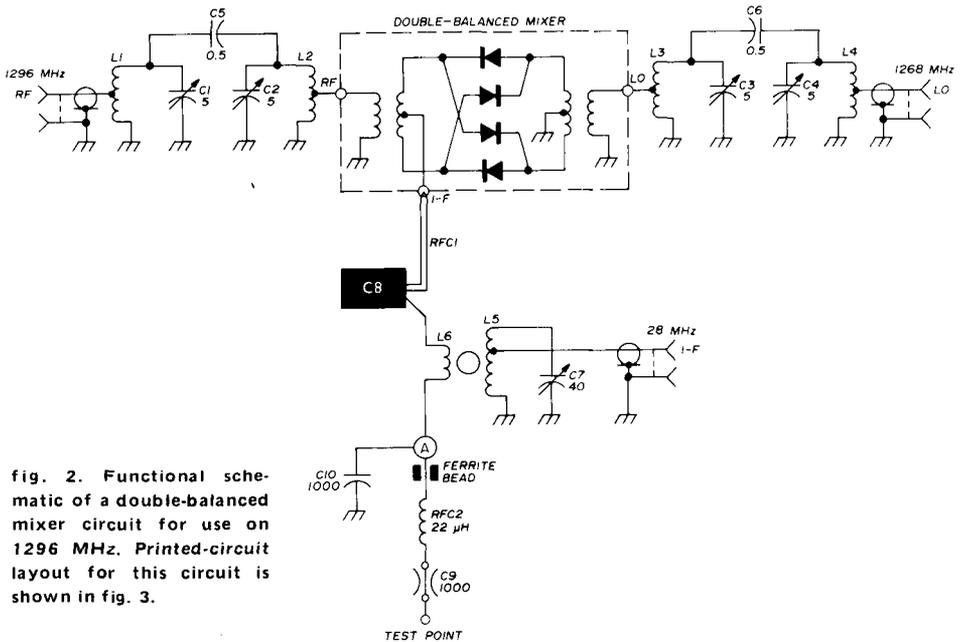


fig. 2. Functional schematic of a double-balanced mixer circuit for use on 1296 MHz. Printed-circuit layout for this circuit is shown in fig. 3.

- |       |   |       |  |
|-------|---|-------|--|
| C1-C4 | 1.5 pF ceramic piston trimmer (Triko 201-01M or equivalent)                                   | L1-L4 | 44-ohm 0.1 wavelength shorted microstripline, 0.125" (3mm) wide, 0.5" (13mm) long, tapped 0.2" (5mm) from grounded end |
| C5,C6 | 0.5 pF chip capacitor (ATC-100 or equivalent)   | L5    | 1.2 μH. 19 turns no. 22 AWG on Amidon T50-10 toroid core, tapped 5 turns from cold end                                 |
| C7    | 10-40 pF ceramic trimmer  | L6    | 5 turns no. 22 AWG on same core as L6  |
| C8    | 25-ohm quarter-wavelength open-circuited microstripline, 0.3" (7.5mm) wide, 1.14" (29mm) long | RFC1  | 50-ohm microstripline, 0.1" (2.5mm) wide, 1.20" (30.5mm) long  |
| C9    | 1000 pF feedthrough capacitor   | RFC2  | 22 μH molded inductor  |
| C10   | 1000 pF standoff capacitor  |       |  |
| DBM   | double-balanced mixer module (Olektron FP-CDB-145 or similar, see table 1)                    |       |  |

The circuit of fig. 2 incorporates a current monitoring provision. Point A is normally connected directly to ground. If the ground is omitted, rectification by the diode quad results in a dc component; relative current may be monitored by measuring the voltage drop with a sensitive vtm connected between point A and ground. Additionally, proper operation of the mixer requires point A to be at rf ground. Therefore, effective bypassing of all rf components must be provided. Bear in mind that the local-oscillator to i-f isolation is only on

the order of 16 dB. Thus, with 40 mW of local-oscillator injection, and without adequate bypassing, a disruptive 1 mW of local-oscillator energy will appear on the bias test point.

In my application the local-oscillator and rf frequencies are sufficiently close (1268 and 1296 MHz, respectively) to be adequately bypassed by capacitor C8, an open-circuited quarter-wavelength microstripline of low characteristic impedance. Grounding the i-f component (28 MHz in this case) is accomplished with bypass capacitor C10. In

addition to the bypassing components, an rf choke and ferrite bead are used to isolate the bias test point from any remaining i-f, local-oscillator or rf signals.

tors of the BNC, TNC or SMA variety. Fig. 6 details the fabrication of these launchers and shows a method for mounting them to the circuit board.

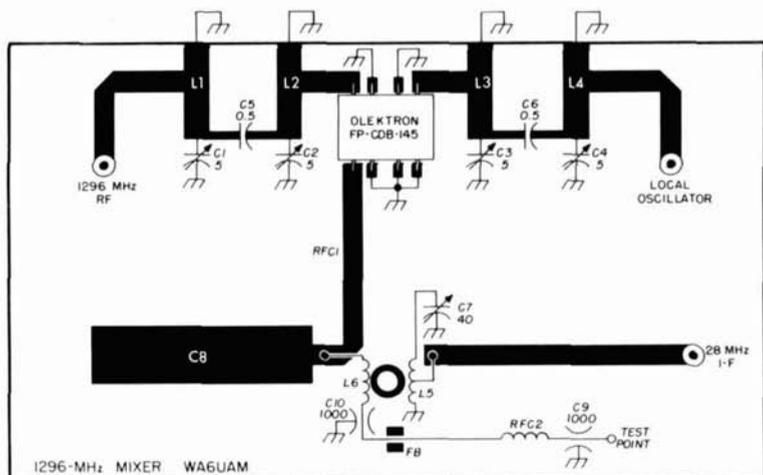


fig. 3. Double-balanced mixer circuit for 1296 MHz which uses microstripline construction. Component details are listed under fig. 2. Full-size printed-circuit board is shown in fig. 4.

### construction

Construction of the printed-circuit mixer assembly is shown in fig. 3. Full-sized artwork for the circuit board is shown in fig. 4. The microstripline dimensions are for use with 1/16 inch (1.5mm) thick G-10 fiberglass-epoxy board, double clad with 1 ounce copper. When building the board be sure to leave an unetched ground plane on the opposite side of the board.

Microstripline inductors L1, L2, L3 and L4 are grounded by pieces of copper foil which are wrapped around the board edge to the ground plane as shown in fig. 5. Holes are drilled in the board so the tuning-screw terminals of capacitors C1, C2, C3 and C4 can be connected directly to the ground plane. Minimum lead lengths are imperative.

Interfacing of the rf, i-f and local-oscillator ports is accomplished by microstripline launchers which can be built from flange-type coaxial connec-

tioning of the fragile double-balanced mixer module should be deferred until all other components are in place. Holes are then drilled to permit direct through-the-board grounding of all mixer pins not connected to micro-



Double-balanced mixer layout for 1296 MHz, showing component placement on the printed-circuit board (see fig. 3).

**table 2. Electrical specifications for the Olektron model FP-CDB-145 double-balanced mixer module.**

Frequency response	RF port	0.5 to 1350 MHz		
	LO port	0.5 to 1350 MHz		
Conversion loss, typical	500 MHz	6.5 dB		
	1000 MHz	7.5 dB		
	0.5 to			
	1350 MHz	9.0 dB		
Isolation, minimum	LO/RF	RF/IF	LO/IF	
	500 MHz	30 dB	20 dB	20 dB
	1000 MHz	20 dB	15 dB	15 dB
Local-oscillator power	+7 to +13 dBm (5 to 20 mW)			
Diodes used	hot carrier			
Temperature	-54°C to +100°C			

striplines. The leads to the rf, local-oscillator and i-f terminals are bent down at right angles to the plane of the substrate, then out at 90 degrees so they lie on top of the microstriplines to which they are soldered.

When you're bending the leads of the mixer module, use extreme care so you do not fracture the delicate metal-glass lead seal. It is advisable to grip each lead with a pair of small needle-nosed pliers at the point where the lead just exits the flatpack; then bend the lead down on

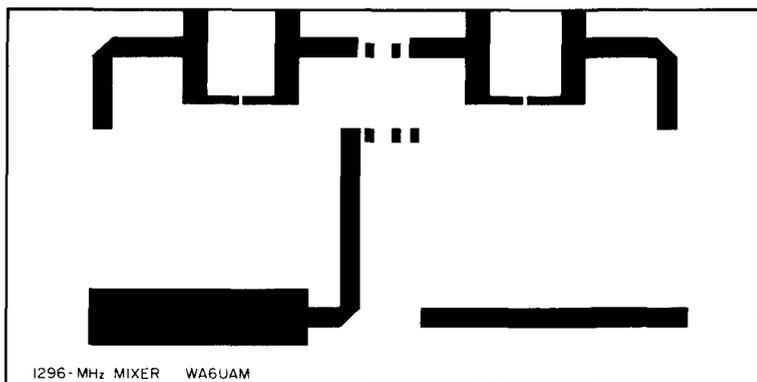
the far side of the pliers. For the local-oscillator, rf and i-f leads use the pliers to grip each lead just below the first bend when making the second bend. See the accompanying photograph for clarification (page 10).

## tuneup and operation

In addition to bandpass filtering, proper adjustment of the resonators at each port of the double-balanced mixer assembly will provide the required impedance matching. An excellent technical note from Anzac Electronics<sup>3</sup> describes the disastrous side effects of improperly terminating the various ports of a double-balanced mixer. As can be seen from **table 3**, a worst-case combination of reactive mismatches to all three ports can result in an overall degradation in mixer conversion loss of 3.5 dB, with a corresponding increase in third-order intermodulation products up to 30 dB.

When tuning the mixer assembly it is imperative to adjust each tuned circuit so that its associated mixer port sees a nonreactive 50-ohm termination. This is accomplished by adjusting the local-oscillator filter for maximum diode current, and adjusting the rf and i-f filters for minimum single-sideband conversion loss.

Initial adjustment of the local-oscillator port is most easily accomplished



**fig. 4. Full-size printed circuit board for the 1296-MHz double-balanced mixer. Material is 1/16" (1.5mm) G-10 fiberglass-epoxy board, double clad with 1 ounce copper.**

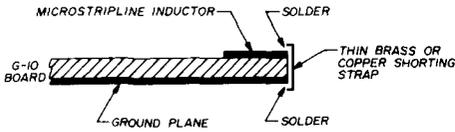


fig. 5. Method of properly grounding inductors L1, L2, L3 and L4 with thin shorting straps to the ground plane on the reverse side of the board.

by coupling in a +5 to +13 dBm local-oscillator signal (3 to 20 mW) and adjusting trimmers C1 and C2 alternately for maximum relative diode current, as indicated on a sensitive vtvm at the bias test point. Preliminary adjustments of the rf filter, to assure that the mixer is not tuned up on the image frequency, should be performed by coupling 10 milliwatts or so of 1296-MHz energy from a signal generator into the rf port and adjusting C3 and C4 for a maximum reading at the test point with *no* local-

oscillator injection. If a grid-dip oscillator, tuned to 28 MHz, is link-coupled through a coax cable to the mixer's i-f connector, the i-f tank circuit can be tuned for a dip with C7.

Final adjustments to C3, C4 and C7 can be made by connecting the mixer to a local-oscillator chain, i-f receiver and weak signal source, and tweaking for optimum signal-to-noise ratio. *Do not* adjust C1 and C2 at this time as optimizing diode current with the local oscillator connected has the effect of impedance-matching the local-oscillator port. While it is true that the mixer's conversion loss will vary with local-oscillator injection level (see fig. 7), to minimize third-order intermodulation products, changes in the local-oscillator injection level should be accomplished by padding the output of the oscillator, *not* by mismatching the mixer's local-oscillator port.

table 3. Effect of reactive terminations on double-balanced mixer performance. Mixer terms are defined below. (Data courtesy the Engineering Department, Anzac Electronics.)

termination condition	conversion loss	rf compression level	rf desensitization level	harmonic modulation products	third-order IM products
RF Port = 50 ohms IF Port = reactive load LO Port = 50 ohms	can vary ±3 dB	can vary ±3 dB	can vary ±3 dB	can vary ±20 dB	can vary ±20 dB
RF Port = 50 ohms IF Port = 50 ohms LO Port = reactive source	no effect if LO drive adequate	no effect if LO drive adequate	no effect if LO drive adequate	can vary ±10 dB	can vary ±10 dB
RF Port = reactive source IF Port = 50 ohms LO port = 50 ohms	typically ±0.5 dB for 2:1 vswr*	±0.5 dB	±0.5 dB	no first order effect	no first order effect

\*Increases proportional to mismatch.

**Harmonic modulation products:** Output responses caused by harmonics of the local-oscillator and rf signal and their mixing products.

**RF compression level:** The rf input power level that causes the conversion loss to increase by 1 dB.

**RF desensitization level:** The rf input power of an interfering signal that causes the small-signal conversion loss to increase by 1 dB.

**Intermodulation products:** Harmonically related distortion products caused by multiple rf signals and their harmonics mixing with each other and the LO producing signals at new frequencies.

The most elegant method of adjusting this mixer, of course, is to tune all ports for minimum indicated noise figure on an automatic noise meter system. However, those amateurs blessed with access to such equipment are cautioned to verify their results with a crystal-controlled weak-signal source to guard against resonating the rf port's filter at the image frequency. When properly adjusted, this mixer's image rejection is on the order of 18 dB.

My prototype mixer assembly, shown in the photographs, indicates a ssb noise figure of 10.5 dB, measured with a Hewlett-Packard 340 B Automatic Noise Meter and an AIL 7010 argon discharge noise head. Local-oscillator injection at optimum noise figure is +10.5 dBm. The measured noise figure of the dual-gate mosfet i-f amplifier which followed this mixer during noise measurements is 1.0 dB. There-

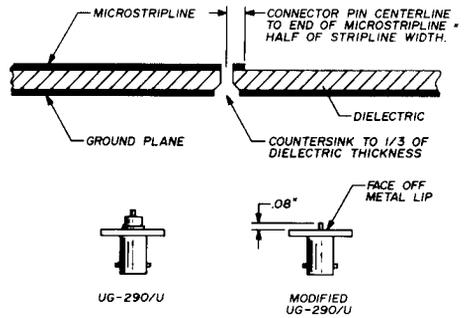


fig. 6. Technique for modifying flange-type coaxial connectors for microstripline launchers. Same method can be used with BNC, TNC or SMA coaxial connectors.

fore, if you accept the published figure of 9.0 dB for the conversion loss of the flatpack mixer module, the filter loss at the rf port is on the order of 0.5 dB.

The 9.5 dB conversion loss of this mixer assembly is on a par with my homemade mixer designs while offering the improved isolation and reduced harmonic modulation product density characteristic of the double-balanced arrangement. Performance of this mixer in the receive mode is wholly satisfactory for line-of-sight communications on the 23 cm band. Should beyond-the-horizon communications be desired, a single stage of low-cost preamplification<sup>4</sup> will reduce overall system noise figure below 5 dB. With the addition of a low-noise stage I have brought my system noise figure down to 2.2 dB.

#### references

1. H. Paul Shuch, WA6UAM, "1296 MHz SSB Transceiver," *ham radio*, September, 1974, page 8.
2. William J. Ress, WA6NCT, "Broadband Double-Balanced Modulator," *ham radio*, March, 1970, page 8.
3. "Reactive Loads - The Big Mixer Menace," Technical note, Anzac Electronics, 39 Green Street, Waltham, Massachusetts 02154.
4. H. Paul Shuch, WA6UAM, "Microstripline Preamps for 1296 MHz," *ham radio*, April, 1975, page 12.

ham radio

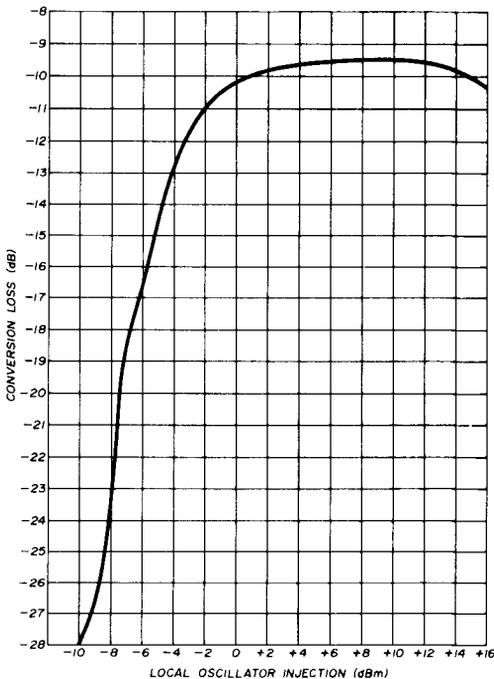


fig. 7. Measured conversion loss of the 1296-MHz double-balanced mixer circuit as a function of local-oscillator injection level.



## universal tone encoder for vhf fm

A straight-forward  
tone encoder  
which provides both  
Touch-Tone signaling and  
tone-burst operation

Larry McDavid, W6FUB, Anaheim, California

The availability of low cost Touch-Tone\* decoders, autopatch and tone-burst-operated repeaters has resulted in renewed interest in tone encoders. However, much confusion exists as to how tone pads and burst oscillators can be built and interfaced with vhf fm transceivers. The unit described here provides both Touch-Tone and tone burst, yet is stable and easily constructed. Three types of audio outputs are provided as well as automatic PTT hold during Touch-Tone dialing. The unit can be operated from internal batteries or from automotive or other 12-volt systems. All components are commonly available and construction is simplified by the use of a printed-circuit board.

\*Touch-Tone is a registered trademark of the Western Electric Company.

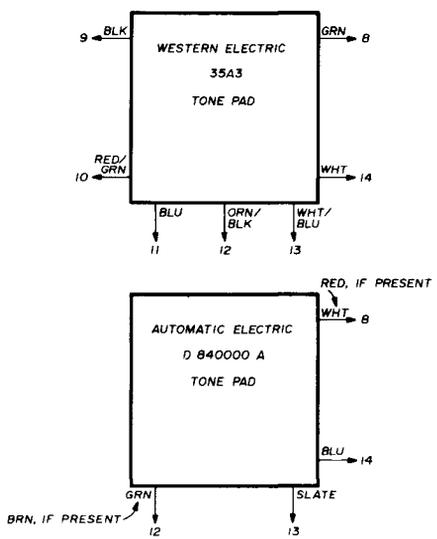
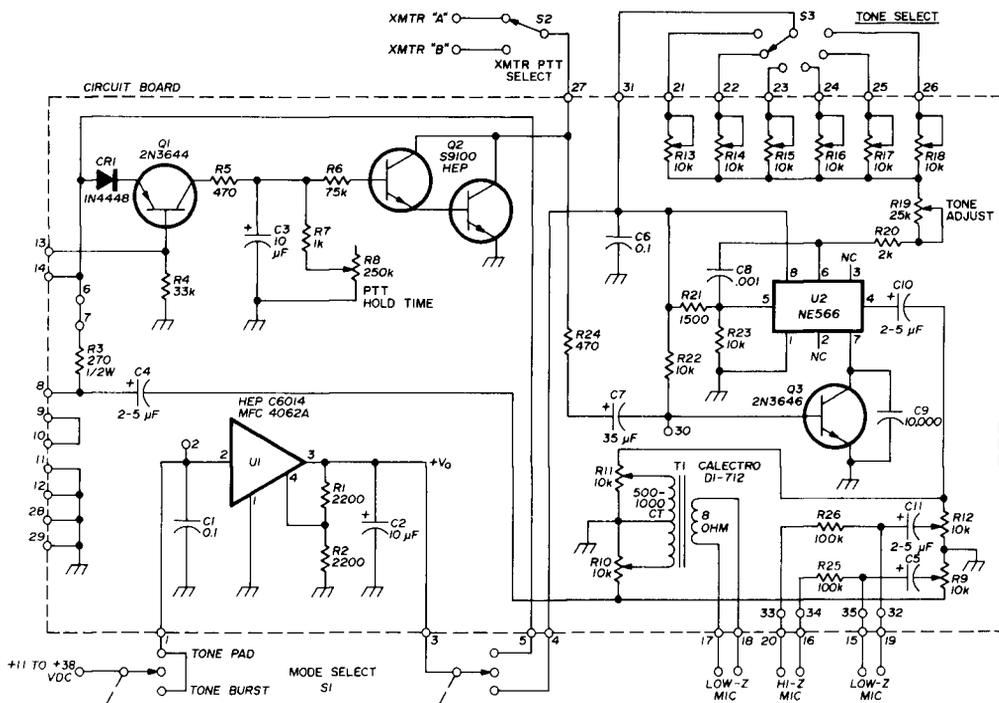


fig. 1. Circuit of the universal tone encoder. This circuit provides both high- and low-impedance microphone outputs, and may be used with more than one transmitter. Before using either of the tone pads, remove the 5100-ohm resistor (see text). Resistor R1 is selected to set the regulated voltage,  $V_0$ , at +8.5 volts. Resistors are 1/4 watt unless otherwise noted.

### output coupling

Two sets of independent level controls allow operation with two different transceivers without readjustment. One high-impedance and two types of low-impedance outputs are provided. Independent Touch-Tone and tone-burst outputs may be combined by jumpering terminals 33 to 34 and 32 to 35 (see fig. 1).

High-impedance inputs may be driven by connecting terminal 16 or 20 directly to the microphone line. Resistors R9 and R12 adjust the output levels for Touch-Tone and tone burst, respectively. If the drive level is too low the value of R25 or R26 may be reduced.

Low-impedance inputs may be driven by connecting terminals 17 and 18 in series with the microphone line. Resistors R10 and R11 adjust the output levels; no change in microphone audio quality or deviation will result. This has

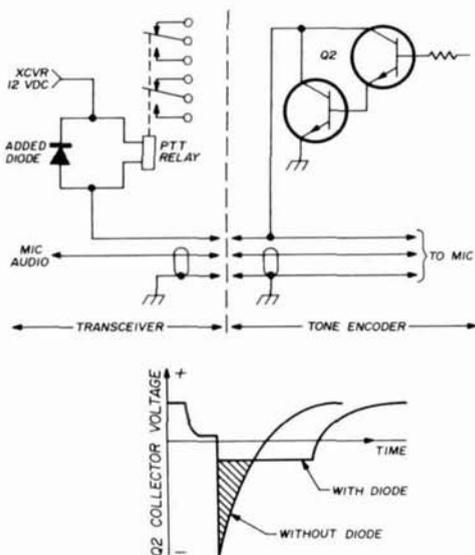


fig. 2. Correct wiring for the PTT relay in your fm transceiver. Proper waveform on the collector of transistor Q2 is shown below the schematic.

an advantage in many transceivers: a microphone shorted by the PTT switch

will not pick up background noise during Touch-Tone signaling. A shorting type microphone is not required for operation, however. The microphone may be plugged into the tone encoder enclosure and a shielded cable run to the transceiver. Another low-impedance output is available at terminal 15 or 19 if transformer coupling is not desired. This output should be connected directly to the microphone line. Unused outputs may have the associated components omitted.

### tone pad encoder

Wiring for Western Electric and Automatic Electric tone pads is shown in fig. 1. One modification is required to the pad: the removal of the 5100-ohm resistor used for reducing the local handset tone signaling volume. One end may be clipped or the resistor may be entirely removed. This provides a pair of normally-shortcd contacts that are open when any button is depressed.

Some Automatic Electric tone pads have an internal diode bridge to allow

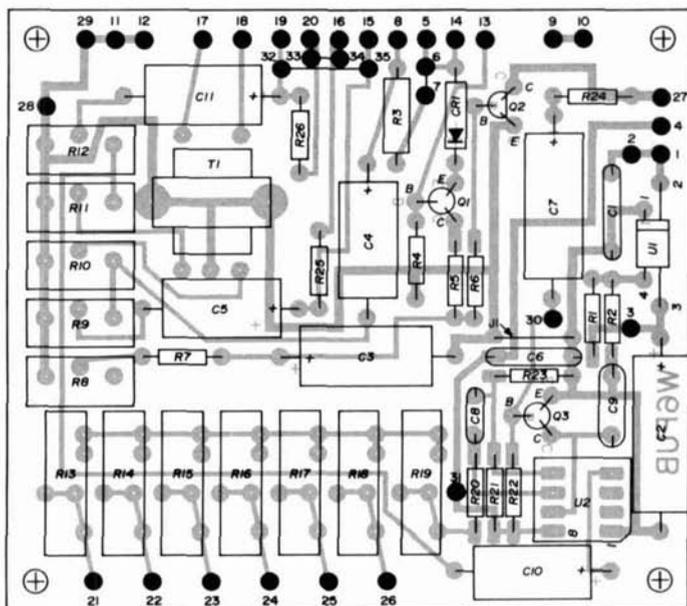
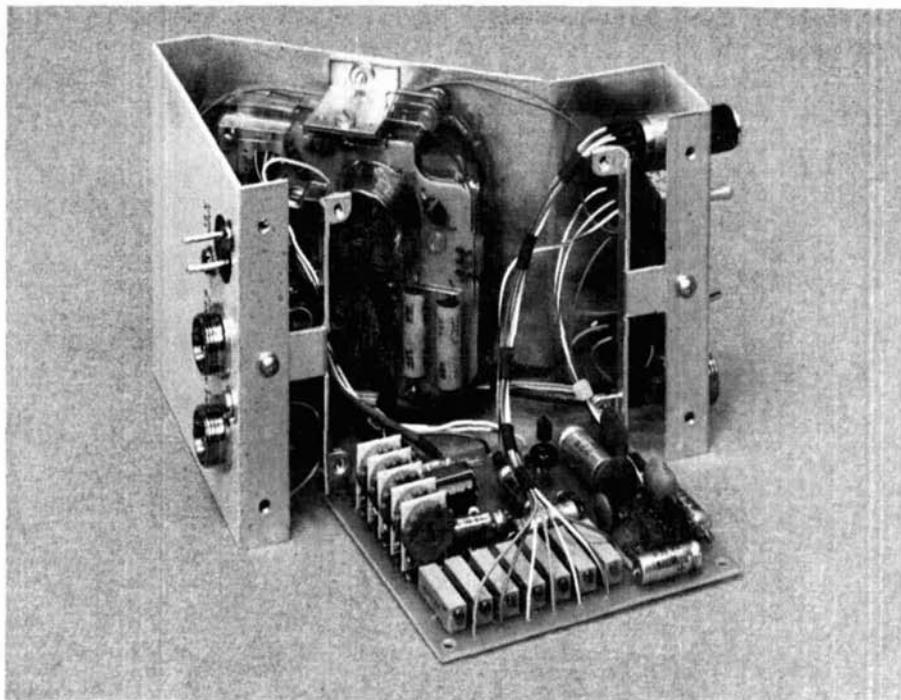


fig. 3. Component layout for the tone encoder circuit board. Full-size printed-circuit board is shown in fig. 4.

operation with either polarity input voltage. These wires, red and brown, may be used rather than the green and white. Any unused wires from either pad should be cut off or taped to prevent shorting.

of C3 will yield longer delays. This approach is not new and has been tested for some time with no problems.<sup>1</sup> The delay interval should be set just long enough to dial a tone sequence without rushing.



Construction of the universal tone encoder. The printed-circuit board is shown in the foreground.

Transistor Q1 is normally biased off by CR1, and the regulated supply voltage,  $V_o$ , is applied to the base through terminals 13 and 14. When any tone button is depressed, terminal 13 is opened, turning on Q1 and Q2 and charging C3. The PTT relay is operated by ground return through transistor Q2.

When the tone button is released, Q1 is again turned off. Transistor Q2, however, is held on until the charge on C3 is bled off through R6, R7 and R8. The PTT hold time is adjusted by R8. Delays up to two seconds are possible with the components shown. Increasing the value

Operation of this circuit assumes that the transceiver PTT relay is wired as shown in fig. 2. The collapsing field of the relay coil will cause the voltage spike on the PTT line when the relay is opened. Although no trouble has been experienced by several users, damage to Q2 could result. The spike can be eliminated by installing a diode across the relay coil; although relay drop-out time will increase, it should not be noticeable. Maximum relay current must be less than 300 mA.

Transceivers which use diode PTT switching will generally work with this

circuit without change. If any switching difficulty is experienced, a small reed relay could be used to switch the transceiver; Q2 would operate this relay coil.

Switch S2 allows the encoder to be used with two transceivers by selecting the appropriate PTT line. CR1 may be any silicon diode; Q2 should not be substituted. The other components are not critical.

R19 for approximately 2500 Hz, using a counter connected at the junction of C10 and R11. Then adjust R13 through R18 for the desired burst frequencies selected by switch S3. Tone-burst duration is about 0.4 second, but may be varied by changing the value of C7. The oscillator has been used for MCW by connecting a key between terminal 30 and ground.

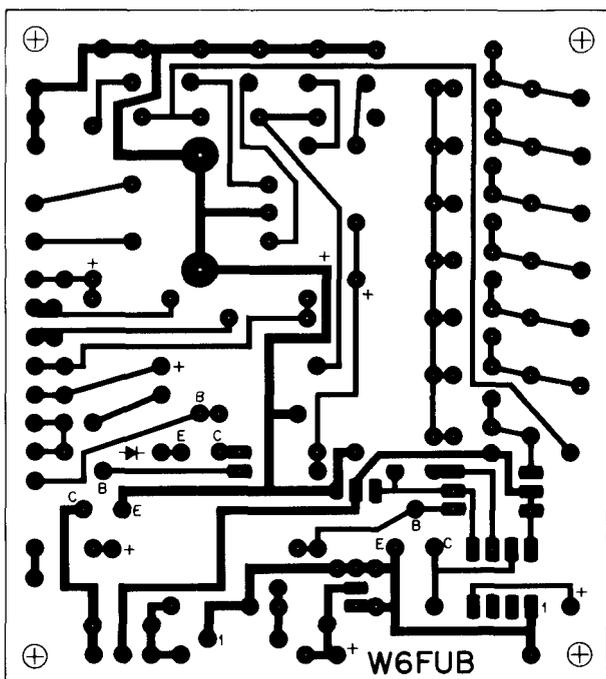


fig. 4. Full-size printed-circuit board for the universal tone encoder. Component layout is shown in fig. 3.

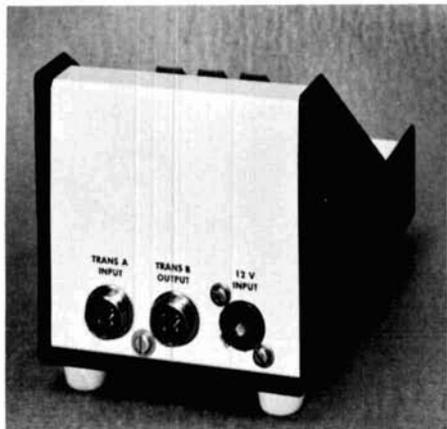
### tone-burst oscillator

This circuit was first described elsewhere and has proven stable and reliable.<sup>2</sup> A polystyrene capacitor is selected for C9; a mylar or disc may be substituted with some loss of temperature stability of burst tone frequency. Resistor R20 prevents accidental damage to U2 if all the tone adjust pots are set to minimum resistance.

The oscillator frequency is set by grounding terminal 30. Set R13 through R18 to minimum resistance and adjust

The burst oscillator, in particular, requires a well regulated power supply. To minimize the current drain, a low-cost IC regulator, U1, was selected. Input voltage variations do not cause excessive current drain as with a zener regulator. Inputs between 11 and 38 volts are satisfactory, allowing operation with either an auto battery or two internal 9-volt batteries in series.

Total current required is 11 mA for tone burst and 20 mA during tone pad signaling. A further advantage of the IC regulator is the elimination of generator



Rear view of the universal tone decoder showing the input and output connectors.

or alternator noise on the encoder output. Switch S1, a center-off dpdt, selects the mode of operation. Resistor R1 may be selected if required to set the regulated voltage  $V_o$  to 8.5 volts.

### construction

The internal packaging of the encoder is shown in the photographs. A LMB-007-446 cabinet was used. All components except switches and connectors mount on the 3.1x3.5-inch (79x89mm) printed-circuit board.\* Fifteen-turn trim pots are shown for the tone-burst frequency adjustments. However, the board will also accept single-turn pots. A socket is used for U2; all other components are soldered in place. If only internal batteries are used, the 12-volt input connector on the rear panel may be omitted.

### references

1. Roy Hejhall, K7QWR, "Solid-State Mobile Touch-Tone Circuit," *ham radio*, March, 1973, page 50.
2. Glen Dickson, WB5BAF, "A Tone-Burst Generator for Repeater Access," *QST*, April, 1974, page 30.

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\*Drilled and plated printed-circuit boards are available from the author for \$5.50, postpaid.

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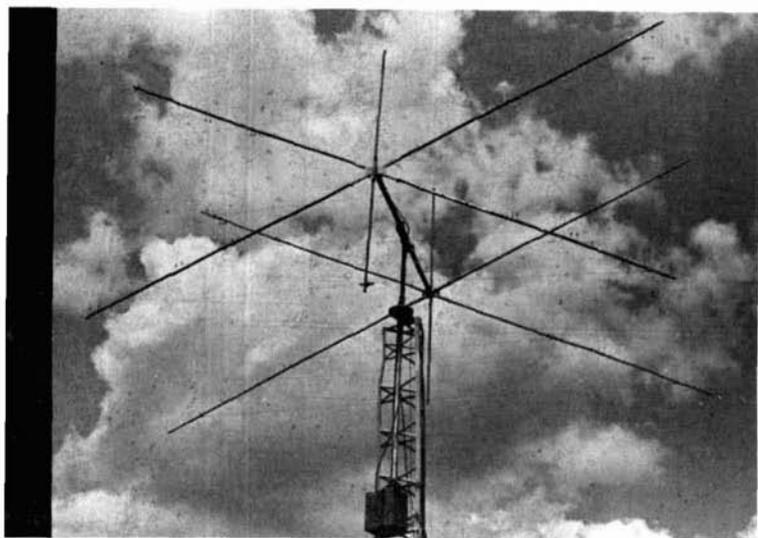
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## low profile three-band quad

The low profile quad  
offers several  
mechanical advantages  
over the usual  
three-band design

**Multiband coverage** with a compact beam antenna is a necessity with most amateur operators and complements the modern station contained in a single cubic foot of space. After having achieved excellent quad performance with the LPQ 20-meter monobander,<sup>1</sup> an excursion to the 10 and 15 meter arena with this same type of antenna seemed mandatory. At the same time,

some structural and electrical improvements were to be implemented.

The casualty rate among quads is rather high, and although my bamboo spreaders survived last winter's ice storm, it probably would have finished off a tri-bander with its additional surface area. Static load tests revealed the quad's inherent weakness when built with small diameter spreaders. The easiest solution seemed to be the addition of a vertical king post to each spider; the horizontal wires of each loop could then be attached to them to provide some useful load bearing. To accomplish this, a 1-foot (30.5cm) length of 1x1 inch (25x25mm) angle iron was bolted to the outer side of each spider and a wood king post 1-1/8 inch (28mm) OD by 9 feet, 4 inches (2.84m) long was installed. Number-8 (4mm) panhead sheet metal screws at appropriate points along the king post provided anchor points for the wire.

An aluminum or metal king post would provide even greater rigidity.

John P. Tyskewicz, W1HXU, Hartford, Connecticut 06112



and taken to a welding shop for finishing. Close attention to dimensions will take care of the necessary 54 degree spreader angle. To attain good radiator-reflector alignment once the individual spiders are assembled, the following procedure is recommended: First, insert one spider (without spreaders) in the boom and drill through both boom and spider with a 1/8 inch (3mm) drill. Then follow with a number-7 (5.1mm) drill, and finish by tapping both pieces together with a 1/4-20 (M7) tap. Fasten them with a machine screw, and continue to drill-tap the other holes.

When one spider is completed, insert the opposite spider into the boom and lay the entire assembly on a flat surface. Check the top of the spider arms with a level, and repeat the drill-tap operation. Before dismantling, index and identify the spider-boom positions with a center punch or small chisel marks.

The spreader clamps, **fig. 3**, are made from 20 gauge (1mm thick) stainless or galvanized iron stock, and they should be formed so as to leave a gap of approximately 1/8 inch (3mm) when fully tightened. The bamboo spreaders should be weatherized by spiral wrapping them with PVC electrical tape. I also wrapped one set of spreaders with 3/4 inch (19mm) wide paper masking tape, wiped them off with naphtha, and coated them with latex paint. To date the paper covering has not deteriorated, is cheaper, and can color match the sky or your house.

## elements

**Fig. 1** shows in detail the driven element and its shorting bars. In building this "monster," you're confronted with the unpleasant task of locating and providing a large number of anchor points along the spreaders. Begin by matching up the bamboo poles and selecting the stronger pair for the upper set. Then you can either fasten a spreader to the proper spider arm and measure off the given radii, or measure

from the butt end and allow for the difference. Wrap three layers of PVC tape at all anchor points.

**The wire-loop anchors** are formed as shown in **fig. 2**. The approximately 1/8 inch (3mm) ID two-turn loop is made by wrapping the number-16 (1.3mm diameter) galvanized iron wire around a suitable nail held in a bench vise. First make up one sample and try it for size at the 10-meter section. To secure the anchor to the spreader, make two turns around the anchor point and then twist the remaining ends into a pigtail. After that step, insert a nail through the loop ID and apply an additional half turn more twist. The critical anchors are those holding the number-14 (1.6mm) horizontal wires. To prevent slippage, number-6 (3.5mm) panhead screws are driven alongside of the wrapped wire; a number-39 drill (0.1 inch or 2.5mm) is used to start them in the bamboo.

**Wire stringing** is started with the outer number-18 (1.0mm) copperweld vertical sections. Fashion a 9 foot, 2 inch (2.79m) gauge stick from 1x2 inch (25x50mm) wood, and insert it between the inner side of the end anchors before installing the wires and insulators. Leave several inches of pigtail on these wires for connection to the others; do not rely on the anchors for continuity! Transfer the gauge stick to the other side and repeat the procedure.

Next, attach the number-14 (1.6mm) twenty-meter lower wire to the mounted insulator, followed by the upper wire. Pull them up taut, but before securing, sight along the diagonal spreaders and make any corrections necessary. Follow with the number-14 (1.6mm) wires for 10 and 15 meters and the remaining number-18 (1mm) vertical runs, all of which are separate wires to permit proper tension adjustment. The shorting bar and jumper positions can be interchanged for best accessibility. The reflector element shown in

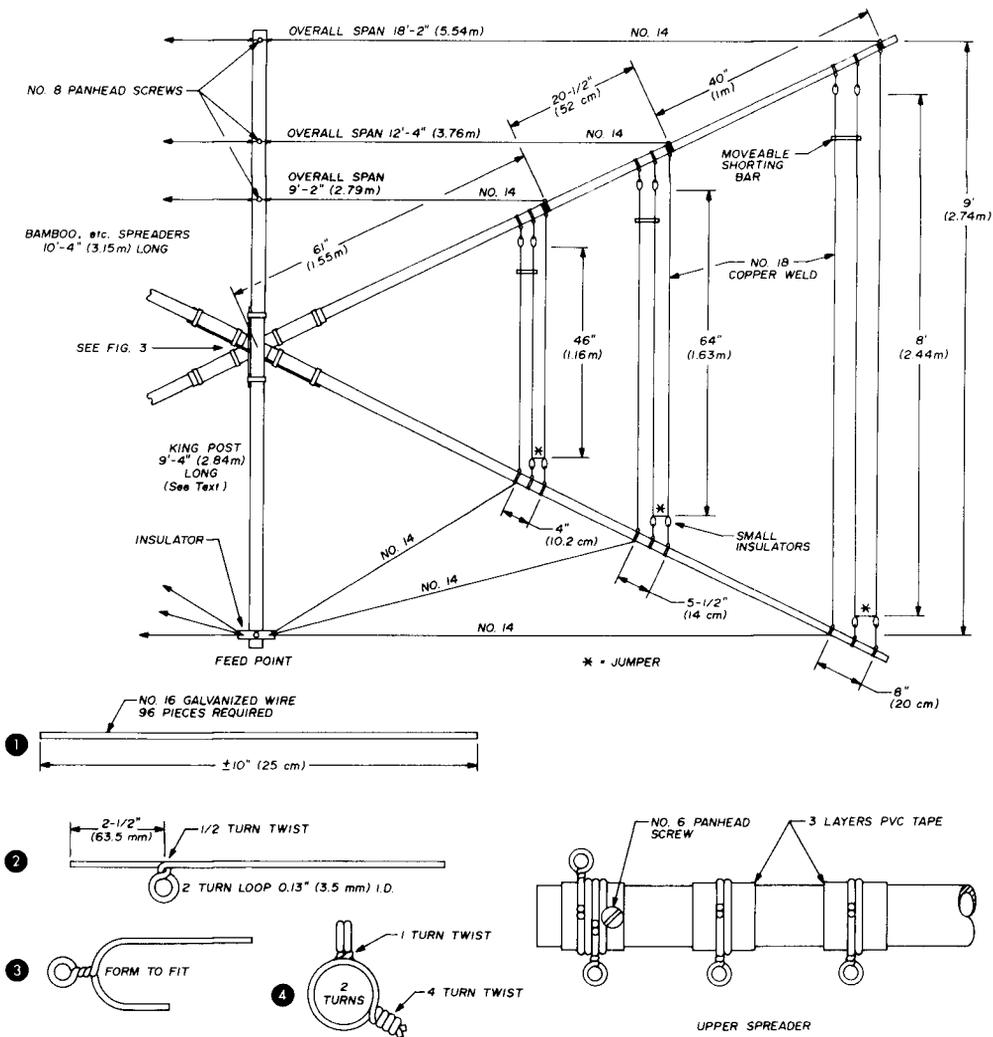


fig. 2. Construction of the reflector and wire loop anchors used in the three-band quad.

fig. 2 is assembled in the same way but without the insulators and shorting bars. To retard corrosion at the anchor loop connectors, dab on a bit of axle grease.

### feeding and adjustment

The present direct feed with a single RG-8/U 50-ohm coaxial line is a quick and easy way to get going, but it is probably not the ultimate matching method. A triple gamma match is now feasible since there is now a convenient

mast to support the required components. Some improvement was also noted when the original feedline length was extended from 80 feet (24.4m) to 91 feet (27.7m), a length which corresponds closely to multiple of a half wavelength on all three bands. Two other good choices for feedline length are 45 feet (13.7m) and 137 feet (41.8m). Adding the 10- and 15-meter elements to the original 20-meter LPQ lowered its resonant frequency by a

substantial amount, and it required re-tuning. Tuning is accomplished by adjustment of the shorting bars.

As shown in fig. 1, moving the shorting bars upward increases the loop length and lowers the resonant frequency while moving them downward will raise the resonant frequency. Initial

Front-to-back ratio and comparative field strength were checked with a simple detector consisting of a short dipole and a 1N34 diode connected via twisted pair to a 1 mA indicator in the shack. When you are satisfied with the tuning, a fixed jumper should be soldered just below every shorting bar for insurance.

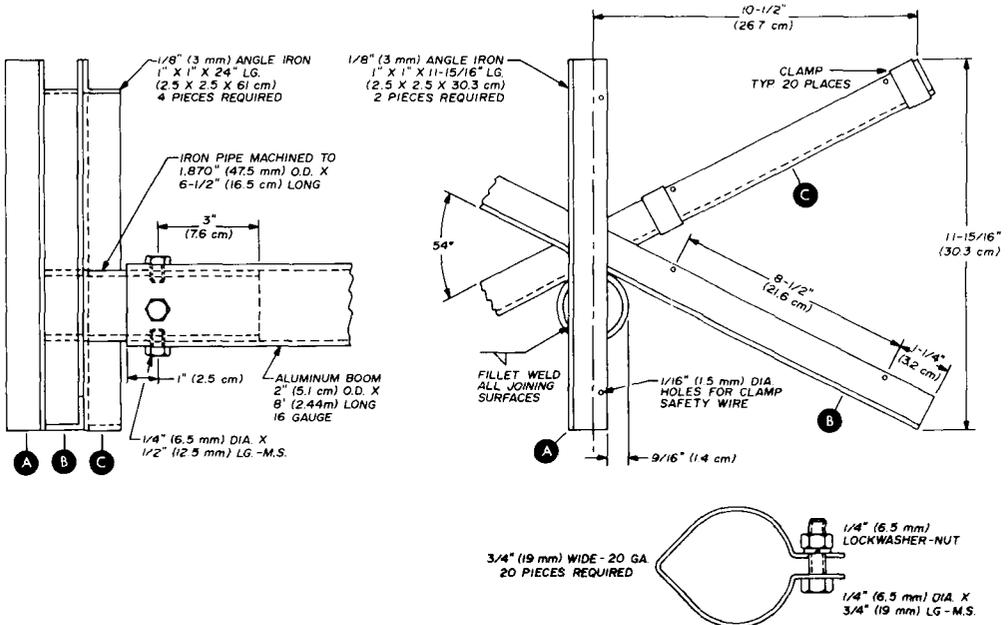


fig. 3. Spider and spreader clamp construction for the low-profile quad.

changes can be made in 5 inch (13cm) increments until the best swr is bracketed. The procedure I used was to raise the antenna, apply low power, and take swr readings across all three bands. At first do not concentrate on trying to obtain the optimum match for any one band. Since three antennas are connected to a common feedline, it may be necessary to make changes to all antennas and repeat the swr checks several times. An antenna impedance bridge will also show frequency changes and may be useful in the tune-up process. The reflector should not require any attention since it is broadly tuned.

After finishing this antenna, another modification to improve the mechanical rigidity of the quad occurred to me: Why not have the 10- and 15-meter loops on the radiator and reflector fastened to the king post at the same point as the 20-meter loops? The elements would then assume a hexagonal shape and the assembly should be even more rigid.

**reference**

1. J.P. Tyskewicz, W1HXU, "The Low-Profile Quad Antenna," *CQ*, February, 1974, page 24.

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# phase modulation

## principles and techniques

When phase modulators are used in vhf fm systems, frequency-shaping circuits must be tailored for maximum intelligibility

In discussions with other radio amateurs, and in reading such references as the ARRL *Radio Amateur's Handbook* and *FM and Repeaters* manual, I have found that considerable confusion exists concerning modulation standards for vhf-fm. Both of these books explain the difference between fm and phase modulation (pm), but neither point out that it is pm that is normally used on vhf. If homebrew receivers and transmitters are used which do not take this into account, intelligibility will suffer greatly.

### fm vs pm

In practice the most obvious difference between fm and pm is in the audio-frequency response. In a pm signal the deviation is proportional to the modulating frequency while in an fm signal it is not. When analyzed

mathematically a phase modulator differentiates the audio signal. A pm signal, therefore, has a deviation which rises at 6 dB per octave, so a pm receiver must have a frequency response which falls at 6 dB per octave or the audio will have excessive treble response and be "tinny" sounding. An fm signal received on such a receiver will sound very muffled.

The methods for achieving the desired response are simple and have been reported before,<sup>1</sup> but perhaps a recap is in order. If a phase modulator is used on a multiplier stage of the transmitter (the usual commercial practice in vacuum-tube rigs), the audio response will automatically be correct; hence the only processing necessary is to limit the audio bandwidth and maximum deviation, as described later.

### pre-emphasis

The usual practice in homebrew fm equipment is to modulate a crystal oscillator with a varactor diode — a process which is simple but which results in a flat rather than a rising frequency response. Measurements on my Pip-Squeak<sup>2</sup> with an audio generator fed directly into the varactor decoupling network (bypassing the audio stages) show that response is flat from dc to over 20 kHz. Using the original audio circuits, the audio sounds very muffled

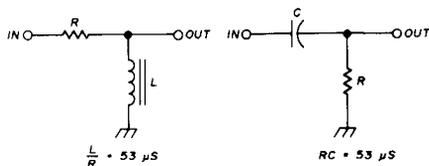


fig. 1. Pre-emphasis networks. For communications circuits with 3 dB rolloff at 3000 Hz the time constant should be 53 microseconds.

Ian Hodgson, VE2BEN, 296 Malcolm Circle, Dorval, Quebec, Canada H9S 1T7

unless an inexpensive microphone with peaky high frequency response is used. A simple RC or RL pre-emphasis network, as shown in fig. 1, will cause the audio response to rise at the desired rate.

In this network R and C may have any value provided that their time constant (product) is 53 microseconds. This value is chosen to give 3 dB rolloff at 3000Hz ( $R = X_C$  at 3000 Hz). In the RC network shown, R must include the input resistance of the following stage as a parallel component. Similarly, in the RL circuit, R must include the output resistance of the preceding stage as a series component. (The 75-microsecond time constant mentioned in the ARRL books applies to broadcast fm and is used for noise reduction.)

The response curve for the pre-emphasis network and formulas for its

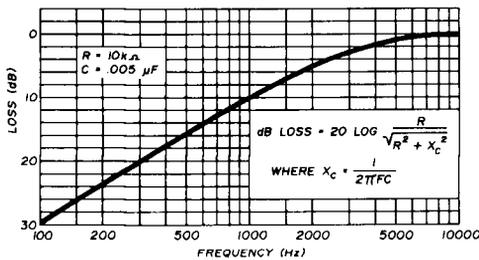


fig. 2. Response of pre-emphasis network. Changing the RC product moves the curve to the left or right but does not change its shape.

calculation are shown in fig. 2. Changing the RC product simply moves the entire curve to the left or to the right but does not change its shape or slope. The curve for the RL network is identical.

### clipping and filtering

Good amateur practice (and regulations) require that maximum deviation be limited to  $\pm 5$  kHz,  $\pm 7.5$  kHz, or  $\pm 15$  kHz, depending on the system. Values exceeding these amounts will cause distortion, squelch closing on voice peaks, and unnecessary bandwidth. Since pm deviation increases with both frequency

and modulation amplitude, it is necessary to restrict both peak amplitude and high-frequency response in pm systems.

A simple shunt clipper is shown in fig. 3. In this circuit resistor R may be simply the output impedance of the driver, but it should be very high compared to the forward resistance of the

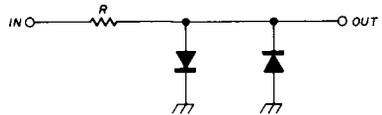
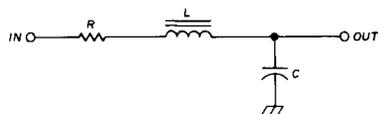


fig. 3. Simple shunt clipper circuit for limiting peak amplitude response of pm systems.

diodes. The diodes may be either germanium or silicon, depending on the audio level. Since the clipping circuit will produce harmonics of the modulating frequency, it should be followed by a lowpass filter.

Level controls should be located on both sides of the clipper. The input control is called a *modulation* control and sets the amount of clipping present on the signal. The output control is a *deviation* control and sets maximum deviation. Insufficient clipping will result in a low audio level; any attempt to correct this by turning up the deviation control will result in excessive peak deviation.

Many commercially built rigs lack a modulation control and depend on carefully matched microphones and audio circuits to set the correct level into the clipper. When designed for mobile use, they often have insufficient gain for normal speech in a quiet fixed station. If your rig suffers from low audio with



$$X_L = X_C = R \text{ AT CUTOFF FREQUENCY}$$

fig. 4. Lowpass LCR filter provides roll-off of 12 dB per octave. Response is plotted in fig. 5.

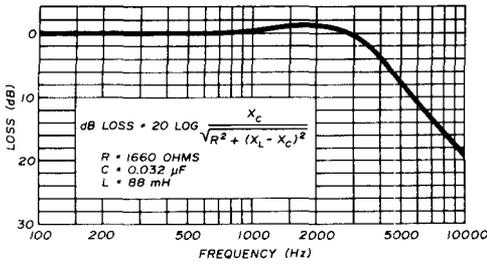


fig. 5. Response of lowpass filter (fig. 4) where  $R = 1.66k$ ,  $C = 0.032 \mu F$  and  $L = 88$  mH. Roll-off is 12 dB per octave.

the deviation properly set, add a variable gain microphone preamp, don't turn up the deviation.

While a simple RC lowpass filter could be used after the clipper, twice as much roll-off (12 dB per octave) is possible with an LCR filter such as that shown in fig. 4. The R, L and C components may be selected by noting that at the cutoff frequency,  $X_C = X_L = R$ . If L is an 88-mH toroid and the cutoff frequency is 3000 Hz, then  $C = 0.032 \mu F$  and  $R = 1659$  ohms (either 1.5k or 1.8k should be satisfactory).

If R is too high, a peak will develop in the response at the cutoff frequency; if it is too low the high-frequency response will suffer. R includes the output resistance of the preceding stage, and since it must have quite a low value, an emitter follower is suggested.

Since the input impedance of the LCR filter varies widely with frequency, it should not be used to terminate the pre-emphasis network. The stage follow-

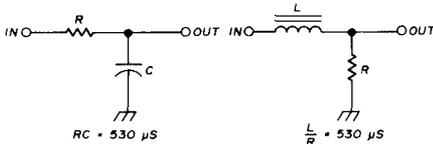


fig. 6. De-emphasis networks are used in phase-modulation receivers to provide 6 dB per octave roll-off. For communications circuits with a low-frequency cutoff of 300 Hz, a 530 microsecond time constant is chosen. Frequency response of the de-emphasis circuit is plotted in fig. 7.

ing the filter must have an input resistance much higher than  $X_C$  at the cut-off frequency, say 100k in this case.

## receiving

In the receiver in a pm system the discriminator must be followed by a network giving 6 dB per octave roll-off above 300 Hz. Such a circuit is called a de-emphasis network, and examples are shown in fig. 6. If  $R = X_C$  (or  $R = X_L$ ) at 300 Hz, a time constant of 530 microseconds results, and the frequency response is that shown in fig. 7. Again, changing RC will move the plot to the

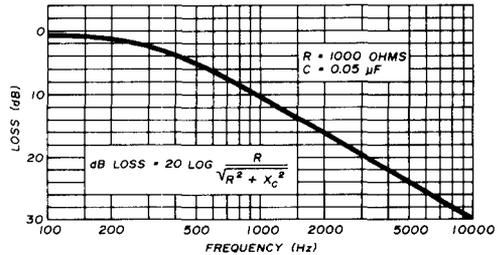


fig. 7. Frequency response of an RC de-emphasis network with  $R = 10k$  and  $C = 0.05 \mu F$ .

left or right, but will not change its shape. In mathematical terms, the de-emphasis network integrates the audio signal.

The block diagrams shown in figs. 8 and 9 illustrate how the principles discussed may be included in transmitters using either a phase modulator (fig. 8) or a frequency modulator (fig. 9) to give pm in either case. Clipping is always done after pre-emphasis so that frequencies below 3000 Hz may achieve higher deviation levels than would otherwise be possible.<sup>1</sup>

## other techniques

Operational amplifiers may be used as differentiators and integrators, and they have the advantage over passive networks of very low output impedance and a gain of unity or greater rather

than 10 dB loss at 1 kHz. In addition, the frequency response curves are quite linear. A differentiator will serve as a pre-emphasis circuit, and an integrator as a de-emphasis circuit. Suitable circuits are shown in fig. 10. Internally compensated op amps such as the  $\mu$ A741 should be used. The circuit of fig. 10A may be used in a transmitter and that of fig. 10B for a receiver. Parts

resistor. Some receivers, such as the Motorola Sensicon series, have the test point heavily bypassed for both audio and rf. Such bypassing should be reduced sufficiently to allow audio signals to pass. Calibrate the scope by feeding in signals of  $-10$  kHz, on frequency, and  $+10$  kHz. Peak deviation may now be read by simply looking at the audio waveform.

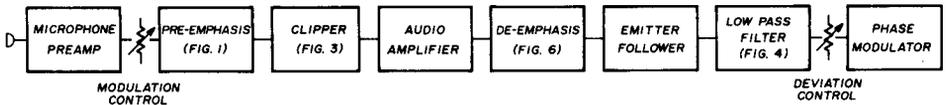


fig. 8. Basic phase modulator system. This is the system most often used in vhf communications equipment.

values are fairly critical to assure correct frequency response. The response curves of these circuits are shown in fig. 11 (these circuits originally appeared in reference 3).

### measurements

Checking frequency response and distortion on an fm or pm transmitter is easily done if you have access to a few items of test equipment. You will need a good quality wideband fm receiver capable of receiving the transmitted frequency, a dc oscilloscope, and an accu-

In a pm system, only a sine wave is transmitted unchanged; a square wave is sent as a series of positive and negative spikes which would be infinite if not filtered. When clipping begins, therefore, large spikes will appear on the waveform. The peaks of these spikes represent peak deviation and must be set to  $\pm 5$  kHz,  $\pm 7.5$  kHz, or  $\pm 15$  kHz. If they seem out of proportion, the lowpass filter isn't doing its job.

These terrible looking waveforms are restored to their original shape by the de-emphasis network in the receiver. If

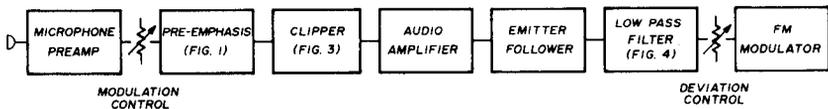


fig. 9. Frequency modulator is similar to pm system but does not require a de-emphasis network.

rate, stable signal generator (a BC-221 is ideal).

First align the discriminator of the receiver very carefully so as to obtain a linear curve of voltage vs frequency. Connect the oscilloscope to the discriminator test point. If no test point is provided, connect the scope directly to the discriminator through a 1 megohm

you are not convinced, either put a de-emphasis circuit on the input of the scope, or connect the scope to the speaker terminals instead of the discriminator.

Using this method will show up one fault of a varactor diode modulator: the modulation will be asymmetrical, going more in one direction than the other.

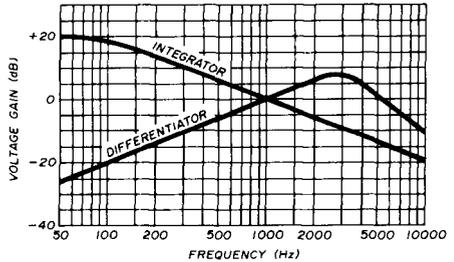
This is partly because the capacitance-vs-voltage curve of such a diode is not a straight line. Fortunately, most voice modulation is below the level at which the distortion becomes obvious, so it usually sounds all right.

### repeaters

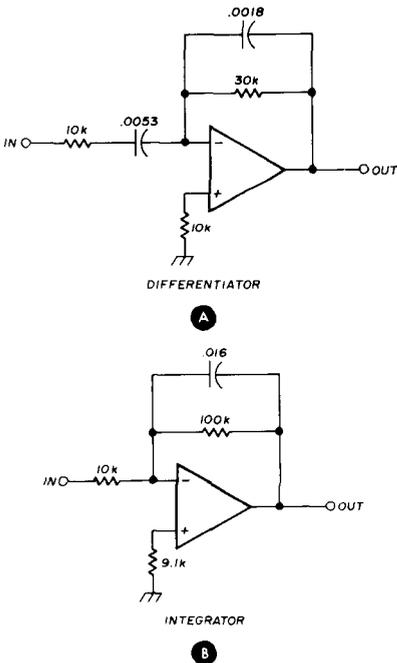
The frequency response of a repeater should be as flat as possible over the desired bandwidth of 300 to 3000 Hz. In fact, it may be desirable to extend the low-frequency response to 100 Hz or so if the use of sub-audible tones is contemplated. This may be accomplished by increasing the time constant, RC, in **fig. 6** to 1.6 milliseconds. No attempt should be made to tailor the response for better "communication quality" at the repeater, since the users' rigs will already include such provisions and doing it twice will make things

worse. Ideally, the repeater output should be identical to its input in all respects within the limits of audio bandwidth and deviation.

The frequency response of some commercial rigs is less than ideal, and before using them as a repeater they could benefit from the application of



**fig. 11.** Frequency response of op-amp integrator and differentiator circuits shown in **fig. 10**.



**fig. 10.** Operational amplifiers may be used as differentiators (pre-emphasis) or integrators (de-emphasis) as shown here. Frequency response of these circuits is shown in **fig. 11**.

some of the points mentioned in this article. When the repeater is installed, a careful set of measurements should be made to ensure that the following conditions are satisfied:

1. The input and output deviations must be identical up to the maximum chosen by the system.
2. Inputs with greater deviations than this maximum should be clipped to the maximum.
3. The frequency response should be flat within  $\pm 2$  dB from 300 to 3000 Hz for signals below the clipping level.
4. There should be little distortion on signals below the clipping level.

Here is the method I use to make these tests: The equipment is set up as shown in **fig. 12**. The receiver must be switchable between the repeater input and output frequencies, and separate receive and transmit antennas must be used (unless you have the facilities to work duplex on one antenna). If low power is used, and the repeater signal is

fairly strong, full duplex operation should be possible. Turn your transmitter deviation all the way up to essentially remove the clipper from the circuit. Calibrate the scope as described earlier. Set the repeater deviation and modulation controls at maximum. The following steps are shown for a  $\pm 5$  kHz system, but may be scaled for any desired deviation.

5. Feed a 1-kHz tone to the transmitter and adjust the audio level for  $\pm 7.5$  kHz deviation using the receiver and scope on your own frequency. Switch the receiver to the repeater frequency and have the repeater deviation reduced to  $\pm 5$  kHz.

6. Feed a 1-kHz tone into the transmitter and set the deviation to a low value, say  $\pm 2.5$  kHz. Have the repeater modulation control adjusted for an output deviation of  $\pm 2.5$  kHz. Make sure that the audio waveshape on the scope is an undistorted sine wave.

7. Repeat the above checks at different levels and frequencies to make sure that conditions 1 and 2 above are met.

8. Feed in tones from 300 to 3000 Hz, setting the transmitter deviation to  $\pm 2.5$  kHz each time, and see that the output deviation does not vary by more than  $\pm 2$  dB (use an audio vtm in parallel with the scope if desired).

Note that the repeater receiver and transmitter may both be fm instead of pm if desired, as the system frequency response will be flat in either case. Fig. 13 shows the overall frequency response using the pre-emphasis and de-emphasis circuits mentioned earlier. If a flatter

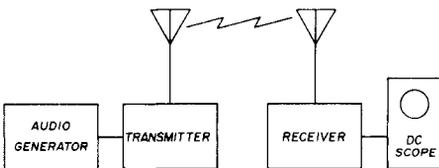


fig. 12. Suggested test setup for measuring frequency response of a repeater (see text).

response curve is required, consideration should be given to using the op-amp integrator and differentiator circuits described previously.

### conclusions

The fm systems used on vhf are actually pm, not fm. Many homebrew

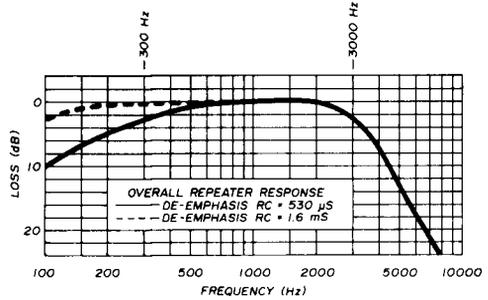


fig. 13. Overall frequency response of a repeater using the pre-emphasis and de-emphasis circuits shown in figs. 1 and 6.

transmitters produce fm, not pm, but the required conversion can be effected by simple RC networks. Modulation and deviation are not the same thing.

If care and attention are paid to audio circuit design for vhf fm transmitters and receivers, the resulting voice quality is almost good enough to be called hi-fi while still retaining full communications effectiveness, and a well designed repeater can re-transmit a signal with no noticeable change in this good quality. First-class audio is not hard to obtain — let's hear more of it.

### references

1. Les Cobb, W6TEE, "Modulation Standards for VHF FM," *ham radio*, June, 1970, page 16.
2. Doug DeMaw, W1CER, "An FM Pip-Squeak for 2 Meters," *QST*, March, 1971, page 21.
3. "An Applications Guide for Operational Amplifiers," Application Note AN-20, National Semiconductor Corp., Santa Clara, California, February, 1969.

ham radio

# high performance sync generator for amateur television

High performance  
television sync generator  
uses National MM5320 IC  
to provide  
all pulse signals  
needed for both  
black-and-white  
and color TV

Most amateur television installations tend at first to be derived from low-cost surveillance TV cameras. These cameras use a random interlace system and often combine both blanking and sync as a single pulse. Professional TV systems, however, use a very stable sync generator which will interlace the scan pattern for maximum definition. They also provide a separate blanking pulse group

which will give a clean picture with sharp edges and no retrace problems. The final addition to a professional sync generator is color synchronizing capability. Now you can get all this by using one special purpose integrated circuit plus some peripheral ICs and other parts.

## circuit

The new National Semiconductor MM5320 mosfet circuit is the heart of this sync generator, and it will do everything required of an amateur TV sync generator and more. You start by generating a crystal controlled 14318-kHz signal and divide it by seven to give 2045 kHz. This is the basic clock frequency which drives the MM5320 and in turn produces all the correct sync pulses, both horizontal and vertical, equalization and serration pulses, blanking, drive signals and color gate plus a few other things you may be interested in if you own a video tape recorder and other exotics.

I expect that some amateurs will want to try color television now that the one-tube color camera has been developed. Thus I have included the color parts of the sync generator in the schematic. If you don't need them, just leave them out. Basically the color sub-carrier frequency of 3579 kHz is generated by dividing the crystal frequency down 4 times. If you do use color, you may want to add a trimmer capacitor to the crystal oscillator so you can adjust this signal to the exact frequency. I have

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also included a color-burst output which can be added to your signal just for fun even if you are using black and white (please use a switch so you can remove the signal and keep peace with the guys with color monitors). A color gate signal is also there if you need it.

Notice that all circuits connected to the IC are buffered to protect the chip. In addition, the outputs are driven hard with discrete transistors to provide solid signals for a 72-ohm line.\* All signals are negative going (for true) at the outputs.

### construction

The transistors I used were all epoxy types, high-speed switches with a voltage rating of 30 volts or better. About five different low-cost types were tried and all worked okay. I did have a MM5320 fail, so I recommend that you use a 16-pin socket for the chip and build everything else on perfboard with number-28 tinned wire and Teflon spaghetti before plugging in the chip. When all the wiring is completed and checked, ground yourself to the chassis and the IC holder to your fingers, then remove the IC from the holder and plug it in. Remember to keep yourself grounded to the chassis with one hand. Don't stroke the top of the IC or you may build up enough static charge to turn the circuit off. Also, if you put a heat dissipator on the IC, ground it too as any charge on it may impede circuit action.

The schematic also shows some vertical sync-locking circuits which may be connected to your video tape recorder to keep the picture from rolling as you switch from camera to recorder. If you don't need this, just connect pin 6 of the MM5320 to +5 volts and forget that part of the circuit leading up to pin 6.

\*If coaxial cable is used to carry the signal from the sync generator to other equipment, add resistors in series with each output point shown in the schematic. Use 68-ohm resistors for 70-ohm coax and 47-ohm resistors for 52-ohm coax.

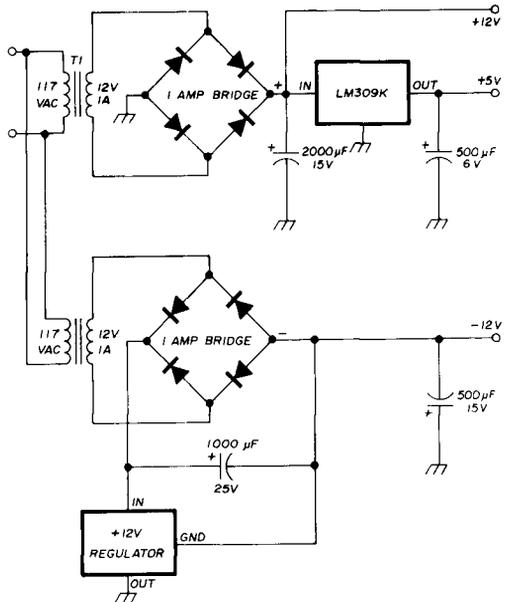


fig. 2. Power supply for the television sync generator uses voltage-regulator ICs.

Now that you have a sync generator right up to network standards (almost anyway), you are ready to convert your old camera over to full 2:1 interlace scan with correct blanking and a stable sync frequency. You will have to figure out the actual interconnections but let me suggest using some high-voltage HEP (or similar) transistors to drive your vacuum-tube sync circuits and get rid of those old free-running oscillators.

As for testing the unit, a frequency check is nice, but is only required for color. Connecting each output to my old Tektronix 310 scope provided nice sharp +5 volt signals which looked just like those out of the \$2000 sync generator down at the local TV station. Quarter- or half-watt resistors work well everywhere and only the MM5320 got warm. This was solved by adding about two square inches of aluminum (in the form of an L) to the top of the IC with some five-minute epoxy (and grounding the heatsink).

ham radio

# multiplexed seven-segment readouts

Surplus calculator  
digital readouts  
may be easily adapted  
for other uses

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The tremendous volume of low-cost, hand-held digital calculators has led to the appearance of a number of solid-state digital readouts in the bargain lists. Many of these units are internally wired with common cathodes for each digit and all like segment anodes tied together. The units are quite small, but this doesn't seem to be a problem in calculators so they should be usable in frequency counters as well.

The internal connections necessitate multiplexing the readout system. This means that each digit is activated in turn and is only on a small part of the time. In the case of a nine-digit readout, each numeral will be on only one-ninth of the time. If this action is repeated 30 or more times a second, the entire row of nine digits will appear to be on at once.

## multiplex circuit

To accomplish the multiplexing, each individual digit's cathode lead is grounded in turn and, at the same time, the common seven-segment anodes are tied to the proper decade through a decoder-driver. The circuit shown in fig. 1 will do this using easily obtained parts.

Briefly, the circuit works as follows; a 7441 BCD-to-decimal decoder is driven by a 7490 counter operating with a 1kHz input from the frequency stan-

standard countdown chain of the counter. This causes the ten outputs of the 7441 to go low in sequence. Each open collector is "pulled up" by a resistor to the +5 volt supply. As each output goes low, it

outputs are connected through diodes to the ABCD inputs of the single 7448 decoder which drives the segment anodes of all the digits thru current limiting resistors.

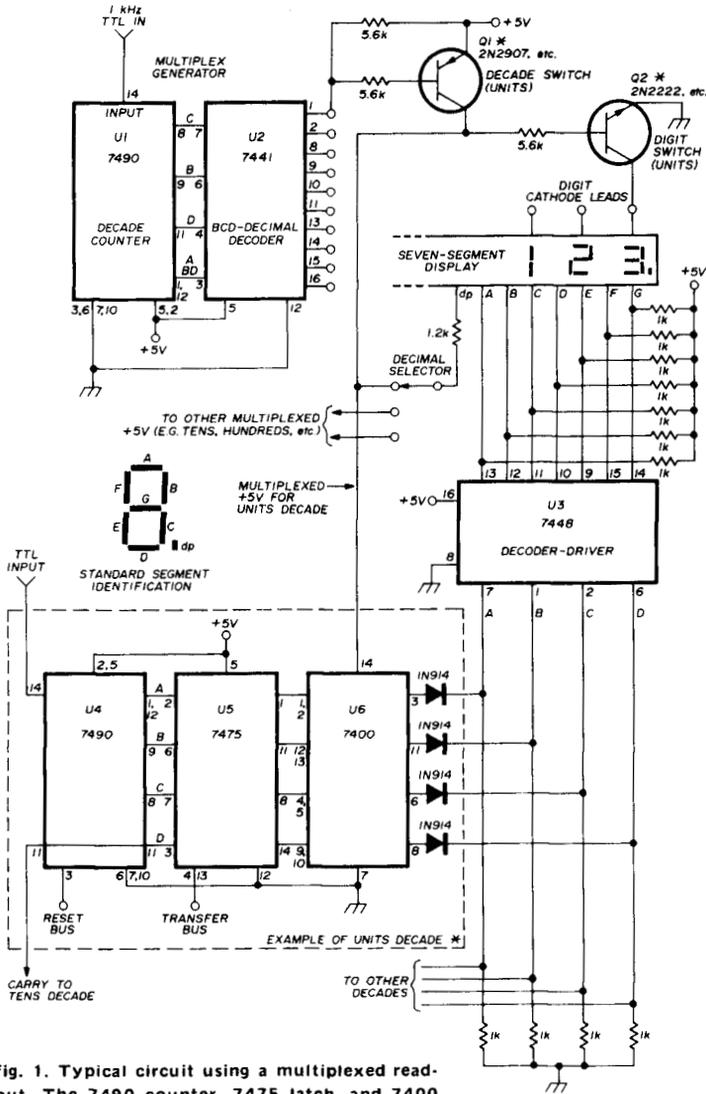


fig. 1. Typical circuit using a multiplexed read-out. The 7490 counter, 7475 latch, and 7400 driver ICs and circuitry marked with an asterisk are repeated for each decade.

causes a pnp transistor to switch the five-volt supply voltage of a 7400 tied to the ABCD complements ( $\bar{O}$ ) of the 7475 latch in one decade. The 7400's

The 7448's inputs are grounded through resistors which hold these inputs low in the absence of high outputs from the 7400. In other words, the

7400 can only send high signals to the 7448. This allows all the decades to be tied to the same decoder-driver without problems occurring when other 7400 outputs are low since only one 7400 has supply voltage at any given time and is capable of producing a high. The switched supply voltage is also applied to an npn transistor which grounds the common cathode lead of the proper digit.

The 7441 multiplex generator can supply up to ten digits. In the unit I built no attention was paid to the sequence of activated digits, and this was left to be determined for convenience of circuit-board layout.

The readouts I used were advertised as similar to the DL-33 and have a 5 mA per segment rating. Surprisingly, these units have been operating at about 1.6 mA per segment with adequate brightness except when under direct illumination by the light over my workbench. Current measurement was made with the multiplexing off and without the 1000-ohm resistors. Needless to say, this results in very low current drain for the nine digits. Segment current rose to 4.5 mA with the resistors in the circuit, and the brightness increased considerably. With multiplexing, readout brightness and dissipation are reduced because of the low duty cycle, and this should insure long life.

The rest of the circuitry for frequency counters or other applications may follow any of the usual techniques without the display method necessitating any changes.

### summary

Although the multiplex system is perhaps more complex, it actually has less circuit repetition. As the number of digits increases, this approach becomes more attractive. Its use should encourage construction of frequency counters with sufficient readout to directly display high-frequency signals with 1-Hz resolution.

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# low-noise uhf preamplifier and converter

A simple,  
easy-to-build  
converter and  
low-noise preamplifier  
for the 450-MHz  
amateur band

The latest in the Hamtronics series of receiver-related projects was quite a challenge. I set out to develop a low-noise receiving preamp and companion converter for the 432 and 450 MHz amateur bands and adjacent commercial bands. This article describes the results of several months work. As anyone who has attempted to build solid-state uhf gear knows, layout and construction technique is vital — not only to come up with a good basic design, but to make one which even works!

My goal was to design units which could be duplicated easily, with no special metal-working facilities. I was determined it could be done with a single-sided, printed-circuit board chassis and simple shielding components. In the several months it took, I researched dozens of old magazine articles, handbooks and manufacturer's application notes. I designed and breadboarded at least four different converters and about a dozen preamps. At one point, I even soldered the metal can of an fet directly to the metalization on a feedthrough capacitor to try to reduce lead inductance. That

gives you an idea how critical lead lengths are at uhf.

Having tried many semiconductor devices, the one I finally settled on is the new Siliconix J308 super-fet. This is an n-channel device similar to two E300 fets in a monolithic parallel combination. It has a very high transconductance (about 13000  $\mu$ mhos at 450 MHz) and a low noise figure (about 3.4 dB at 450 MHz if correctly matched).

## uhf converter

The converter shown in fig. 1 uses a low-noise jfet mixer, Q1, with a high-Q, two-pole filter input which may be tuned to any frequency in the 400 to 500 MHz range. It is designed to provide optimum performance at low cost for use with receivers operating as an i-f in the range from 30 to 170 MHz. Possible uses include 432-MHz CW, TV, ssb, 450-MHz fm and 450 to 470 MHz commercial fm. The passband of the front end is wide enough to allow operation on amateur TV.

Channel selection, for channelized operation, may be accomplished either at the i-f or by using a multichannel adapter in place of the built-in local oscillator. The converter may be used for scanner operation by switching oscillator frequencies or by using a scanning receiver at the i-f.

Because the converter has a low inherent noise figure, for best results it is recommended that it be used with a sensitive, low-noise receiver. Generally, due to the low-noise design of the converter, the sensitivity will be determined by the sensitivity of the i-f receiver. Note that the converter is not designed to provide additional gain to the i-f receiver. It is accepted practice, in mod-

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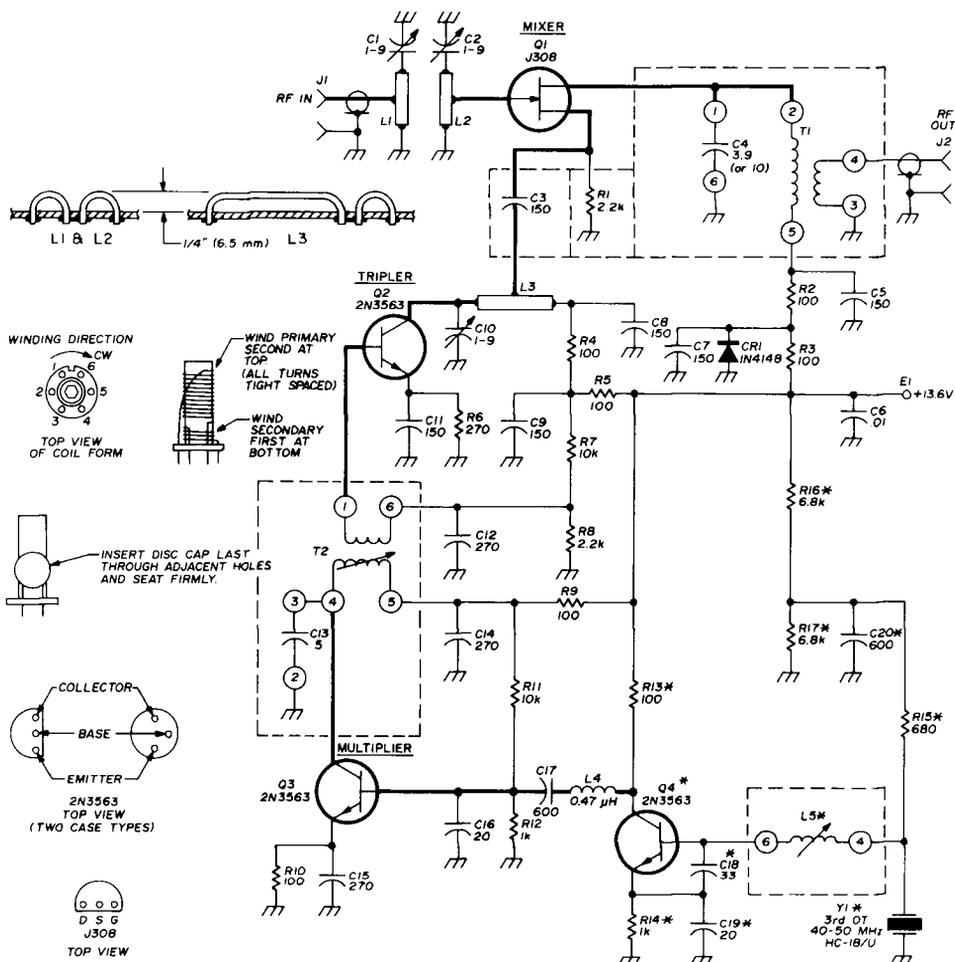


fig. 1. Schematic diagram of the uhf converter. Components marked with an asterisk are not required if the multi-channel oscillator (fig. 7) is used. Inductor L5 is 11-2/3 turns no. 22 (0.6mm) on 1/4" (6.5mm) diameter, slug-tuned coil form (carbonyl-J slug). Windings of other inductors depend upon operating frequency and are described in the text. Printed-circuit layout is shown in fig. 2.

ern uhf design, to mix down as soon as possible and use only enough converter gain to offset losses in the tuned filter. This minimizes front-end overload in urban areas with high level, adjacent-band signals. A pre-amplifier may be used between the converter and the i-f receiver if the receiver has insufficient gain. If desired, a uhf preamp such as the one described later in this article can be used.\*

\*The following kits are being made available in conjunction with this article: U20-450 uhf converter kit, \$20; P15-450 uhf preamplifier kit, \$15; P25-450 uhf preamplifier, wired and tested, \$30; A13-45 uhf six-channel oscillator adapter, \$12.95; AS10 scanner adapter with LEDs, \$10. Kits are complete except for crystals and include predrilled G-10 printed-circuit boards. Crystal certificates are available for \$5.50 each. For more information, send a self-addressed, stamped envelope to Hamtronics, Inc., 182 Belmont Road, Rochester, New York 14612.

## crystals

The crystals in the converter local oscillator (or in the accessory six-channel adapter) are series-resonant, third-overtone, 0.002% HC-18/U types. The required crystal frequency is equal to the channel frequency minus the i-f frequency divided by six. One kHz is subtracted from the calculated crystal frequency to center the crystal in the

choose one of the less popular frequencies.

## converter construction

All the vhf coils are wound clockwise, using the solderable wire supplied with the kit (other coil forms and winding techniques may be substituted if you elect to build with your own components. All turns are close spaced. The

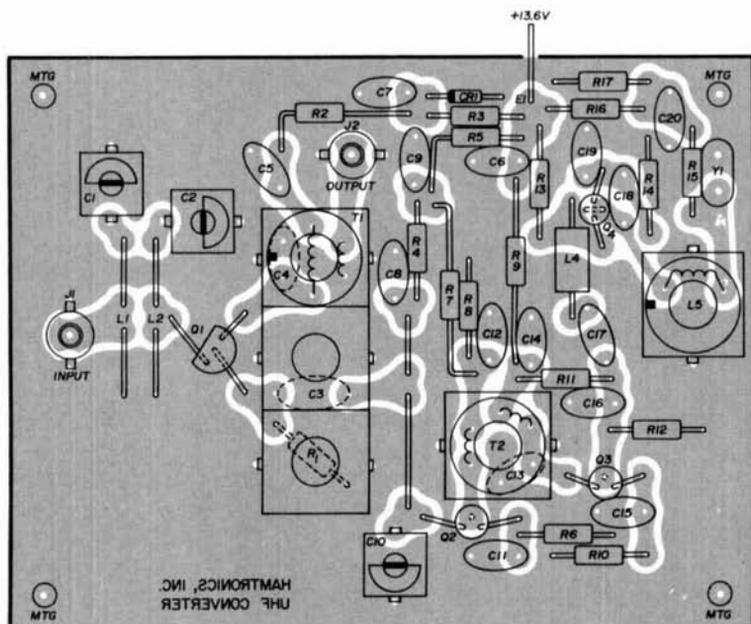


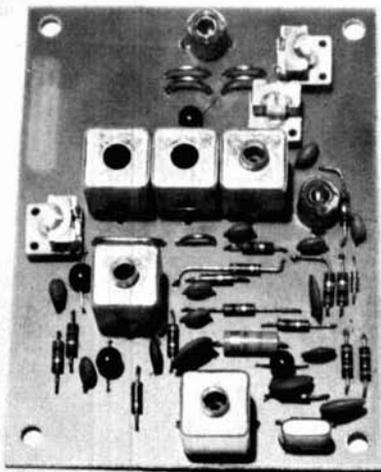
fig. 2. Component layout for the uhf converter. Circuit board is shown in fig. 3.

trimming range of the oscillator circuit. When the local-oscillator frequency is in the 400-MHz range instead of the 300-MHz range, as used for a high-band i-f, the division factor is nine instead of six. This is necessary to place the crystal frequency in the 40 to 55 MHz range.

When selecting the intermediate frequency, be sure to consider the effects of vhf feedthrough. I did some testing with 146.94 MHz as an i-f, and a few local amateurs had signals strong enough that they could be heard with the vhf antenna disconnected. If you want to use a receiver on an existing channel,

detail in fig. 1 is exaggerated for clarity, but all leads should be pulled tight. No fancy bends are required. Holes in the base of the coil form are numbered as shown. Thus, coils can be prewound and then installed on the board with the keyway oriented toward the mixer end of the board. Secondaries should be wound first, followed by primaries, followed by insertion of the disc capacitor, if any.

The leads should be inserted through the circuit board while the coil form is spaced slightly away from the board; then the coil form is seated into place.



Basic uhf converter covers the range from 420 to 470 MHz. Printed-circuit layout is shown in fig. 5.

Do not attempt to insert the leads with the coil form flush against board. After all the coils are installed, application of heat from a very hot soldering iron for

10 to 15 seconds (with solder applied) will automatically strip the *Solderon* wire and provide a good solder bond. If you prefer, all leads may be stripped before the coil form is installed on the board. Do not solder-strip the leads unless the coil form is mounted on the board as the leads may migrate into the plastic form.

Coil L5 is always 11-2/3 turns number 22 (0.6mm), with the winding starting at terminal 4 and ending at terminal 6. Construction of transformer T2 depends upon the oscillator injection frequency. For injection in the 300-MHz range the first multiplier doubles to the 90 to 110 MHz range and the secondary of T2 consists of 1-5/6 turn number 22 (0.6mm) from terminal 6 to terminal 1; the primary consists of 4-1/6 turns number 22 (0.6mm) from terminal 5 to terminal 4. A 5-pF capacitor is installed in holes 2 and 3. For mixer injection in the 400-MHz range (low i-f), the primary of T2 consists of 3-1/6 turns number 22 (0.6mm) to allow the multiplier to triple to the 120 to 150 MHz range. The secondary is the same as

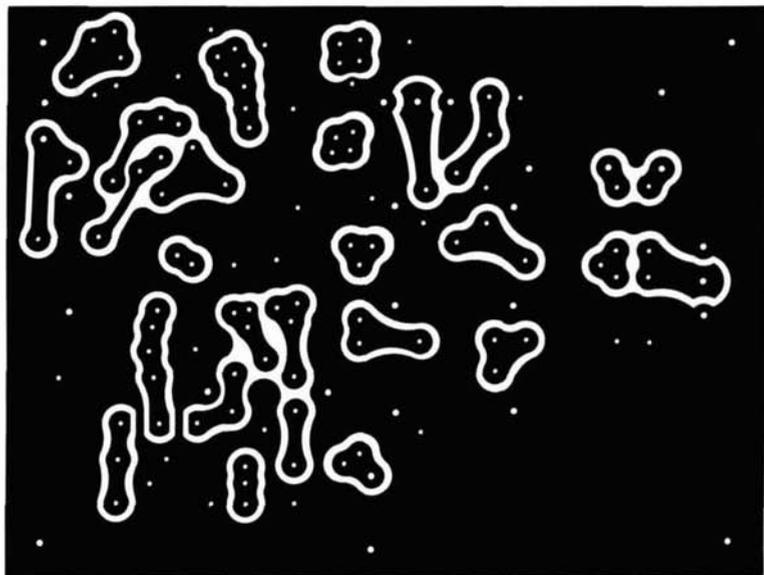


fig. 3. Full-sized printed-circuit board for the uhf converter. Component layout is shown in fig. 2.

above. Other capacitors or numbers of turns may be used to provide resonance for other local-oscillator injection frequencies.

The secondary of transformer T1 is wound from terminal 4 to terminal 3. The primary is then wound from terminal 2 to terminal 5 (all windings number 22 [0.6mm] wire). The capacitor is installed between 6 and 1. For an i-f in the range of 140 to 170 MHz, the

connection to the board. The variable capacitors will tune over a wide range to compensate for coil variations. Excess leads should be trimmed on the foil side of the board after soldering the number-18 (1mm) wires to the board.

### connectors

The popular RCA style phono connectors are used for coaxial cable connections to the circuit board. However,

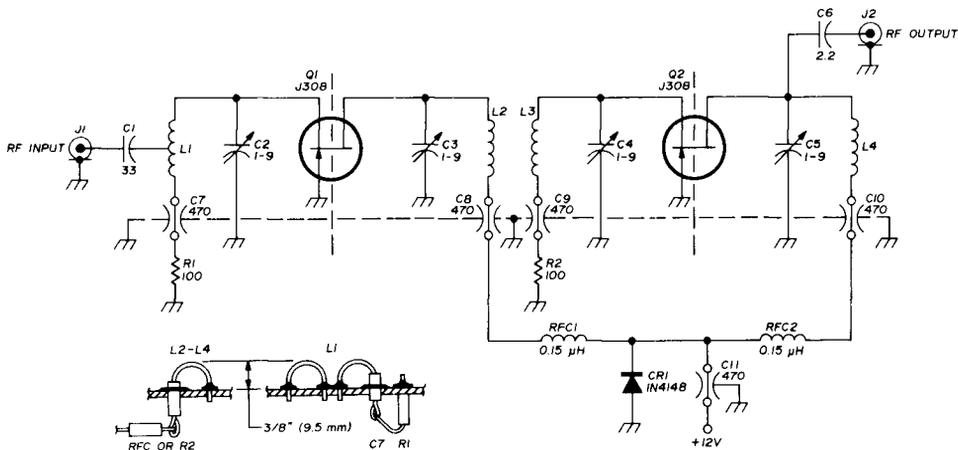


fig. 4. Two-stage uhf preamplifier provides 15 to 25 dB gain. Capacitors C2-C5 are vertically-mounted E. F. Johnson 9-pF air variables. Printed-circuit layout is shown in fig. 5.

secondary should be 1-1/6 turn; primary, 5½ turns; and capacitor, 3.9 pF. For an i-f in the range of 40 to 60 MHz, the secondary is 3-1/6 turns; primary, 15½ turns; and capacitor, 10 pF. For an i-f of 20 to 30 MHz, secondary is 4-1/6 turns; primary, 21½ turns; and capacitor, 10 pF. Note that further adjustment of the number of primary turns may be necessary for other frequencies. Smaller wire sizes may be desired at large numbers of primary turns so that this winding is near the lower half of the coil form.

Coils L1, L2 and L3 are formed as shown in fig. 1, using number-18 (1mm) tinned bus wire. Forming is not critical because the coils are essentially straight pieces of wire which are bent to allow

any connectors used in the line at uhf should be a constant-impedance type (such as type-N) for low loss; phono connectors and uhf-type coaxial connectors put a "bump" in the line in such applications. Likewise, the coaxial cable type should be carefully chosen for low loss at uhf. RG-58/U coax, for example, has too high loss for long runs (it may be okay for short runs in mobile operation or for monitor applications with strong signals). If a transmitter is involved, a good coaxial relay should be used, both to minimize signal loss and to prevent coupling of large amounts of rf into the front end of the converter.

### converter alignment

The most difficult part of the align-

ment process is obtaining a stable test signal. Even my HP-608 signal generator takes several hours to settle down enough to stay within a 5-kHz passband at uhf. The best solution is to use a weak-signal source such as one of those described in the amateur magazines.<sup>1,2</sup> An on-the-air test is an alternative if you can find an appropriate signal.

Start with all adjustments at about mid-range. Tune in the test signal and

during the crystal calculation centers the oscillator adjustment range.

The dc voltages shown on the schematic diagram are a guide, and are based on using a 13.5 volt power supply. Probably the most common trouble, based on my experience with vhf preamps, is a burned-out fet caused by excessive rf from a transmitter or transients on the B+ line from relay coils, etc. Diode CR1 provides protection from reverse transients, but forward voltage spikes from faulty power supplies may still get through. Remember, if you encounter problems during initial tests, it is very easy to install components in the wrong places or to make a cold solder joint. Double check every connection!

### uhf preamplifier

The uhf preamp shown in fig. 4 is a two-stage grounded-gate device which provides a gain of 15 to 25 dB. Although designed primarily for use on the 432 and 450 MHz amateur bands, the preamp may also be built for use on the 300-MHz aircraft band, the 470-MHz commercial band, or the lower vhf TV channels. Its passband is sufficiently wide for amateur TV or selected commercial TV channels.

The preamp components are mounted on both sides of the circuit board to provide the high degree of shielding required at uhf. Critical components are installed on the copper side of the board with absolutely minimum lead lengths. Feedthrough capacitors interconnect components on the other side of the board to provide thorough bypassing. When construction is almost finished, shield plates are installed between the input and output of each stage to prevent feedback. Following is a step-by-step summary of construction:

1. Install the coaxial connectors from the fiberglass side of board by gently rocking them into place. Spot solder the four tabs on the copper side.

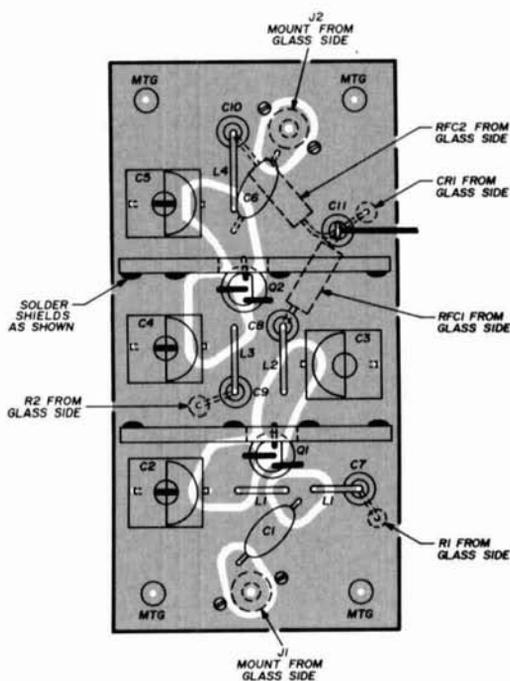


fig. 5. Component layout for the uhf preamplifier. Circuit board is shown in fig. 6.

peak all adjustments. If T1 or T2 do not peak within the range of their tuning slugs, an adjustment in the number of primary turns may be necessary. Then adjust the oscillator trimmer coil, L5, to net the converter to the channel frequency by monitoring the receiver discriminator or S-meter. Note that the crystal may be pulled enough to adjust over a range of about 10 kHz at uhf. The extra 1 kHz which is subtracted

2. Spot solder the feedthrough capacitors and variable capacitors in place as shown in the pictorial, **fig. 5**.

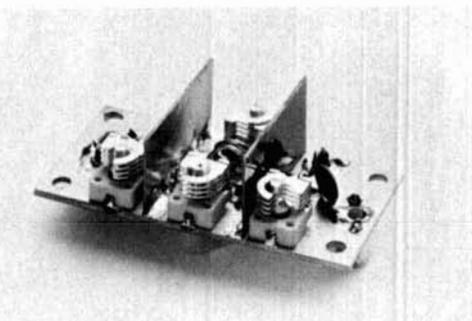
3. Cut number-18 (1mm) wires, form as shown in **fig. 4**, and spot solder them to the feedthrough capacitors and the circuit board. Loops on feedthrough can be cut off and solder can be applied directly to metalization on the ceramic. For each coil, first apply solder to the feedthrough or one pad of the board. Then solder that side of coil in place while holding the coil loop with pliers. Straighten as required and then solder the other end of the loop. Coils L2 and L3 should lean toward each other for tight coupling, about 1/8-inch (3mm) apart at top of loop (not shown).

4. Bend the leads of the disc capacitors away from the body of the capacitor and trim as shown. Solder short remaining leads to strip pads on the circuit board.

5. Spot solder the shields (made of 1½x1 inch [38x25mm] G-10 board material) to ground areas, centering a



**fig. 6.** Full-sized printed-circuit board for the uhf preamplifier. Component layout is shown in **fig. 5**.



**Uhf preamplifier for 432 and 450 MHz uses two low-noise, grounded-gate fet stages.**

small notch over drain lead pad area. This notch must be very small to prevent feedback. Realign the shield after tacking it in one place with solder; then solder the shield firmly in place.

6. Form the fet leads, and trim the leads to within 1/16 inch (6.5mm) from edge of transistor case. Slide the drain lead under the shield notch and seat the transistor in the hole in the circuit board. Carefully tack solder the leads close to the case, but do it quickly to avoid overheating the fet.

7. On the fiberglass side of board install the two rf chokes between C8, C10 and C12, leaving room between RFC2 and J2. Install R1 and R2 from C7 and C9 to the board. Then install diode CR1 with the cathode to feedthrough capacitor C11 and anode to ground.

Diode CR1 is used to protect the fets from reverse transients on the power wiring. However, diodes should also be installed across relay coils and other inductive components sharing the B+ line to prevent fet damage from voltage spikes which are generated by collapsing magnetic fields.

The preamp may be aligned either in conjunction with a receiver or with a 50-ohm load and an rf detector and sensitive vtvm. The best signal source is a signal generator with a variable attenu-

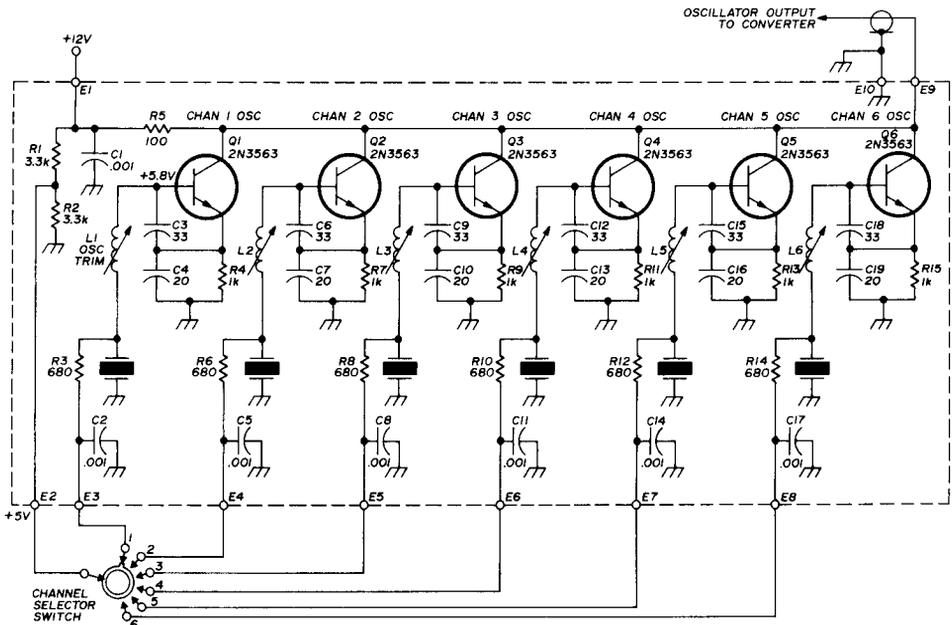


fig. 7. Schematic diagram of the six-channel oscillator for use with the uhf converter. Inductors L1-L6 consist of 11½ turns no. 26 (0.4mm) wire on ¼" (6.5mm) diameter forms with carbonyl-J slugs.

ator; however, a strong transmitted signal may also be used. An insulated tuning tool should be used for tuning.

Capacitor C2 will tune broadly while C3 and C5 tune sharply. In addition to resonating L3 to the desired frequency, C4 also establishes loading of the first stage to some extent. If there is a tendency for the preamp to oscillate, either the load on J2 is greater than 50 ohms or C4 needs to be increased to place a heavier load on Q1. Capacitors C3 and C5 should always be tuned last, because they tune fairly sharply. If one of the capacitors peaks at maximum capacitance, the coil should be enlarged (and vice-versa). Some allowance can be made when the preamp is first built if the frequency is far removed from the 440-MHz design center.

### multichannel operation

If a multichannel oscillator, such as the one shown in fig. 7, is used in place of the built-in oscillator on the converter board, the components marked

with an asterisk in fig. 1 should be removed from the converter. The output cable from the multichannel oscillator should be connected to L4 (Q4 collector connection in fig. 1), and the shield should be connected to a nearby ground. The six-channel adapter (or as many as you want to use) consists of independent oscillators similar to the one on the converter board. Five volts are applied to individual oscillators to turn them on at appropriate times. DC switching can be done either with an electromechanical switch or with a scanner adapter.<sup>3</sup>

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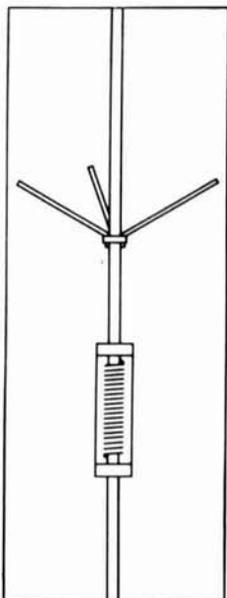
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# parabolic reflector gain

Graphical method  
for determining  
gain and beamwidth  
in terms of frequency  
for dish diameters  
up to 100 feet

Walter E. Pfeister, Jr., W2TQK, 1 Skadden Terrace, Tully, New York 13159

The **parabolic reflector**, used in conjunction with an efficient feed, is probably the best antenna available today for use at frequencies over 300 MHz. Many articles have been written on the construction<sup>1-4</sup> and feed systems<sup>5,6</sup> for proper illumination of the dish; however, few have examined the gain from a mathematical point of view. The interrelationships of antenna gain, beamwidth, and dish size are discussed in this article and represented graphically on an easy-to-use linearized nomogram.

## antenna gain and beamwidth

The equation usually used to describe the available gain from a parabolic reflector, well known to all microwave engineers, is:<sup>7</sup>

$$G_a = 7.5 + 20 \log D + 20 \log F \quad (1)$$

where  $G_a$  = gain above isotropic (dB)  
 $D$  = diameter of the dish (feet)  
 $F$  = frequency (GHz)

When the diameter of the dish is given in metric terms, the gain is given by:

$$G_a = 17.82 + 20 \log D + 20 \log F \quad (2)$$

where D is the diameter of dish (meters), the other terms the same as in eq. 1.

Interrelated with the gain equation is the beamwidth of the main lobe, which is approximated by:

$$\theta = \frac{70}{D \times F} \quad (3)$$

where  $\theta$  = total half power or 3 dB bandwidth (degrees)

D = diameter of the dish (feet)

F = frequency (GHz)

Again, when the diameter of the dish is given in metric terms, the beamwidth of the main lobe is approximated by:

$$\theta = \frac{21.3}{D \times F} \quad (4)$$

where D is the diameter of the dish (meters), the other terms the same as in eq. 3.

These equations assume that the antenna has 55 percent efficiency and tapered illumination such that the illumination on the outer rim of the dish is 10 dB down from the illumination at its center or bore site. For example, what is the theoretical gain and half-power beamwidth of a 30-foot parabolic reflector on 432 MHz?\* From eq. 1 the gain is

$$\begin{aligned} G_a &= 7.5 + 20 \log 30 + 20 \log 0.432 \\ &= 7.5 + 20(1.48) + 20(9.64 - 10) \\ &= 7.5 + 29.54 - 7.29 = 29.75 \text{ dBi} \end{aligned}$$

The half-power beamwidth from eq. 3 is

$$\theta = \frac{70}{30 \times 0.432} = 5.4 \text{ degrees}$$

These equations are obviously unwieldy, even with slide rules built specifically for this purpose,<sup>8-10</sup> especially in those cases where you are trying to compare the various factors which are

involved. Fig. 1 is a graphical solution to these equations. The diameter of the dish, from 1 foot (30cm) to 100 feet (30.5 meters), is plotted along the horizontal axis of the graph. Along the vertical axis, on the left-hand side, is the gain of the antenna in dBi (for gain above a reference dipole, subtract 2.15 dB from the value shown on the graph). Values are represented from zero to +70 dBi.

The right-hand vertical axis represents the antenna beamwidth (main lobe) in degrees at the half-power points. Values from 128 to 0.06 degrees are shown. The family of curves shown by the diagonal lines cover frequencies over the range from 100 MHz to 32 GHz. The graph is constructed so that values not shown are easily interpolated and may be drawn on the graph with a straight edge.

### using the nomograph

Assuming a recent acquisition of a surplus 6-foot (1.8m) dish, what can you expect from this dish at 432 and 1296 MHz? Draw a vertical line from the 6-foot (1.8m) point of the horizontal axis to the 432 and 1296 MHz curves (interpolated on fig. 1). Draw horizontal lines from these points to both the left and right axis. At 432 MHz, the nomograph shows that it's possible to get 15.5 dBi gain with a beamwidth of 30 degrees. At 1296 MHz, this same dish will deliver 24.5 dBi gain with a beamwidth of 9 degrees.

\*Using metric dimensions, what is the gain and half-power beamwidth of a 9.14-meter (30-foot) parabolic reflector at 432 MHz? From eq. 2 the gain is

$$\begin{aligned} G_a &= 17.82 + 20 \log 9.14 + 20 \log 0.432 \\ &= 17.82 + 20(0.96) + 20(9.64 - 10) \\ &= 17.82 + 19.22 - 7.29 = 29.75 \text{ dBi} \end{aligned}$$

From eq. 4 the half-power beamwidth is

$$\theta = \frac{21.3}{9.14 \times 0.432} = 5.4 \text{ degrees}$$



fig. 1. Antenna gain and beamwidth versus dish diameter. Dashed lines are examples discussed in the text.

These gain figures are practical and reliable, having been attained by other than professionals in the microwave field. Through judicious use of this chart tradeoffs may be made easily

among beamwidth, gain, and size, with real-world values resulting. I'd appreciate hearing from those having any trouble with the use of this chart and would appreciate comments on its use.

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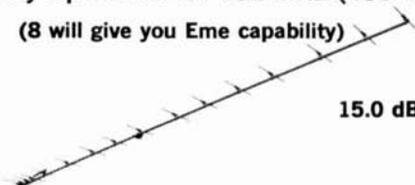
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WB6QVW is the  
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The sixth annual *Ham Radio Sweepstakes* is over. After many busy weeks, both at our local post office and in our Greenville office, the many hours of opening and reading your sweepstakes entries are finally over.

Much as we like all of the Sweepstakes excitement it was quite a relief when May first finally rolled around and we knew that it was over for another year. There was an excellent crop of entries this year, and they were matched with more equipment prizes than we have ever offered before.

This year's prizes centered around two basic choices. Four winners received their choice of Atlas Radio's exciting 210 or 215 solid-state single-sideband transceivers while another four

Skip Tenney, W1NLB, Publisher, Ham Radio Magazine



Fred Moller, WN1USO, Ham Radio Advertising Manager, contemplates the combination of an Atlas 210 and a General Class license.



Ham Radio receptionist Rose Jenkins picks the lucky winner, WB6QVW.

winning tickets entitled their owners to the very much sought after Icom IC-230 synthesized two-meter transceivers.

The luckiest guy of all was Andy Ellis, WB6QVW, who won our grand prize. He received both an Atlas and an Icom transceiver. Andy can now boast of having the very latest, both in single-sideband and in fm equipment. He is particularly excited about his prizes and plans to use his new Atlas 210 as a downlink receiver for Oscar work and the IC-230 to compliment the Icom IC-21 he already owns to give himself both mobile and base capability on two-meter fm.

Bob Hueberger, W2NWE; George Pastilla, W6RRC; Con Weigand, WA8SCA; and David Kochendarfer, K4DC were the fortunate winners of the new ultra-compact Atlas transceivers. These 200-watt rigs feature broadband tuning and a solid signal on either ssb or CW. They operate on five bands; the model 210 handles 80, 40, 20, 15 and 10 meters while the model 215 covers 160 meters in place of 10 meters.

These rigs feature the smallest physical size and one of the hottest receivers in amateur radio today. Operating from 12 Vdc they certainly represent one of

the outstanding mobile high frequency transceivers ever offered to the radio amateur. These rigs turned the eyes of all the radio amateurs on our staff while they were here waiting for their new owners.

Icom's fabulous IC-230 PLL synthesized two-meter transceivers were the perfect prizes for Mike Bardon, WA7ZGI; Earl Cunningham, W5RTQ; Ira Cohn, K2CTK; and Charlie Spencer, K4RXX.

This is the rig that has really been setting the pace in two-meter circles. Covering all of the standard 30-kHz fm repeater pairs with its own easy-to-use, built-in synthesizer, these rigs can also cover a number of the new 15-kHz channels with merely the addition of appropriate crystals.

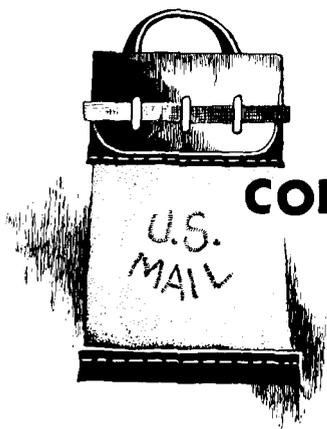
The IC-230 also boasts a very sensitive receiver front end which will match the performance of virtually any amateur fm installation. All of this convenience and performance is put in a compact package no larger than most of the crystal-type rigs now on the market.



Ham Radio publisher, W1NLB, checks in on a local repeater with one of the Icom IC-230s given away in this year's sweepstakes.

We had a lot of fun bringing you this year's Sweepstakes and a large vote of thanks is due to the many thousands of you who entered. Let's hope *you* win next year.

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## comments

### wind loading on antennas

Dear HR:

The recent article by John Nagle, K4KJ,<sup>1</sup> is a very excellent educational article on the wind loading of towers and gives data and recommended design coefficients which I have been searching for. However, on the subject of wind loading calculations for antennas, I have a question. Author Nagle would merely choose the largest calculated area looking end-on to the boom or end-on to the elements. Unlike the case for the guyed tower with the wind blowing at an angle with respect to the guy wires, he ignores this possibility when calculating the wind loading of beam antennas. I should also mention that he is not the only author who has used this simplified approach.<sup>2</sup>

Let's take a specific case: a five-element, 20-meter Yagi. To simplify the arithmetic, assume a 3-inch (7.6cm) diameter boom 48-feet (14.6m) long with 1-inch (2.5cm) diameter elements,

1. John Nagle, K4KJ, "How to Calculate Wind Loading on Towers and Antenna Structures," *ham radio*, August, 1974, page 16.

2. Richard Ludwig, W3GNK, "Wind Force on a Yagi Antenna," *QST*, July, 1974, page 46.

all 33 feet (10.1m) long. Using Nagle's approach for the boom case (wind blowing perpendicular to the boom), the antenna area is

$$\begin{aligned} 3/12 \times 48 \times 0.66 &= \\ 7.92 \text{ square feet (0.736m}^2) \end{aligned}$$

The author would choose 9.075 square feet (0.843m<sup>2</sup>) as the projected area to be used in calculating the wind loading. However, the wind may not be so accommodating. Suppose that the wind is blowing at 45° with respect to the boom and elements. This would result in a force equivalent to the vector sum of *both* projected areas:

$$\begin{aligned} (7.92 \sin 45^\circ) + (9.075 \cos 45^\circ) &= \\ (7.92 \times 0.707) + (9.075 \times 0.707) &= \\ 12.015 \text{ square feet (1.117m}^2) \end{aligned}$$

Since designs should always be for the worst case, I maintain that this approach should be used for antenna wind-loading calculations. As the referenced *QST* article points out, gusty winds can often act in concert with the natural oscillation of the tower/antenna system to produce deflections which are many times those expected of a steady wind. If we kid ourselves about how much antenna area we have on the top of our towers, the result could be painful. I, for one, am accepting no more manufacturers' ratings in this category without first performing my own calculations.

I have heard it said that the case I pose results in an overstated wind load

because the boom would "shadow" the elements behind it. A year of observing wind velocity and direction, with sensors located at the top of my tower, has shown that neither wind velocity nor direction shows any consistency for durations longer than 3 or 4 seconds. This is anything but laminar flow and I would not count on any shielding effect of the boom in lessening wind load on the antenna elements.

**Forrest E. Gehrke, K2BT  
Mt. Lakes, New Jersey**

*Mr. Gehrke is, of course, quite correct in his statement that one should take the vector sum of all forces acting on the antenna just as for the tower case. For the boom and element diameters assumed by reader Gehrke, the maximum effective area is 12.045 square feet (1.119m<sup>2</sup>) and occurs at an angle of 41.11 degrees.*

*Using differential calculus and the terminology given in fig. 1, the wind angle that sees the maximum area, and hence will develop the maximum force, is given by*

$$\theta = \arctan (A_b/A_e)$$

*The maximum effective area,  $A_{\text{eff}}$ , is given by the Pythagorean theorem as*

$$A_{\text{eff}} = \sqrt{A_b^2 + A_e^2}$$

*The reason Mr. Gehrke came as close to the maximum force as he did in assuming a wind angle of 45 degrees is because his element and boom areas are almost equal and the actual maximum wind force angle of 41.11 degrees is close to the 45 degree angle he assumed. In the more general case, however, the two areas will not be equal and the equations given above should be used.*

*If one does not have an inclination for mathematics and wants an easy, conservative approach, the boom and element areas can be added arithmetically. Since the arithmetical sum will*

*always be greater than the vector sum, this will lead to a conservative design.*

*As to K2BT's doubts concerning the shadowing effect of the larger diameter boom on the smaller diameter elements, I concur. Even with laminar air flow (non-turbulent) where some shadowing may exist, I doubt that the shadowing*

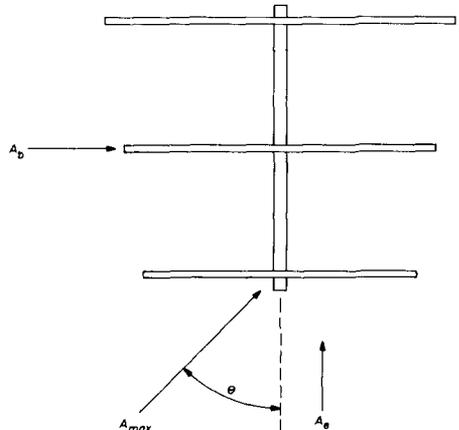


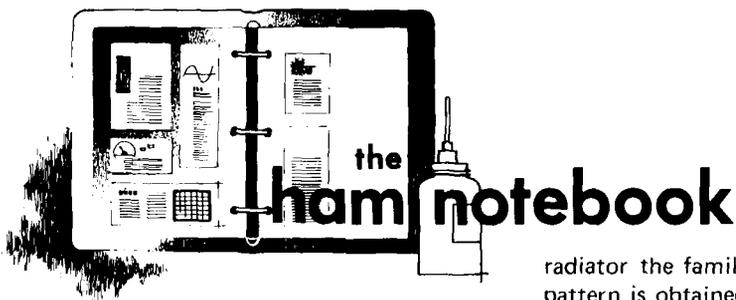
fig. 1. The angle at which the maximum area is presented to the wind is given by  $\theta = \arctan A_b/A_e$ .

*extends further than about one boom diameter behind (on the lee side) of the boom. When dealing with element lengths that may extend 5, 10 or even 20 feet (1.5, 3 or 6m) on each side of the boom, the shadowing, if it does exist, will be negligible and can be neglected for all practical purposes.*

*Regarding Mr. Gehrke's statement that he is no longer accepting manufacturers' antenna wind-loading ratings but will make his own calculations, I would like to quote one of Murphy's lesser known laws:*

*"Manufacturer's spec sheets will be incorrect by a factor of 0.5 or 2.0, depending upon which multiplier gives the most optimistic value. For salesman's claims, these factors will be 0.1 or 10.0."*

**John J. Nagle, K4KJ  
Herndon, Virginia**

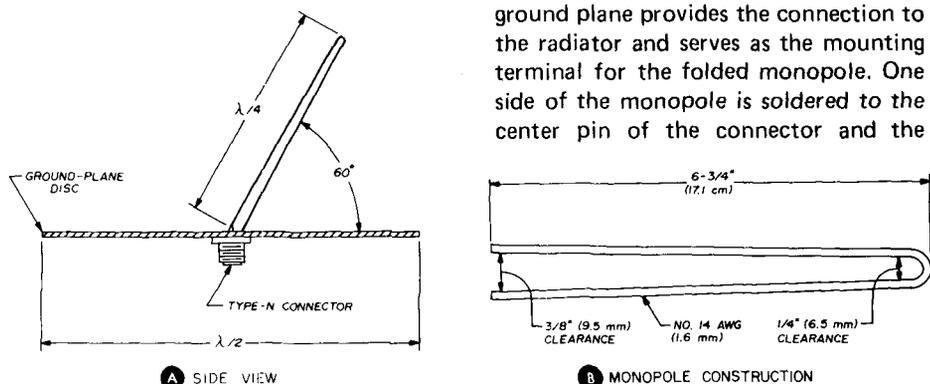


## 432-MHz OSCAR antenna

The antenna described here is a simple approach for 432-MHz stations who want to operate on the OSCAR 7 uplink and have high output power (100 watts or greater). It is similar to the slanted ground-plane antenna discussed by

radiator the familiar distorted radiation pattern is obtained. The use of a folded monopole provides protection from electrical discharge and also results in a very low *vswr* — typically 1.2:1 — without any special matching schemes.

Construction details for the slanted 432-MHz monopole are shown in **fig. 1**. The ground plane is easily made from a piece of sheet aluminum (such as the Reynolds *Do-It-Yourself* material found in many hardware stores). A type-N connector mounted at the center of the ground plane provides the connection to the radiator and serves as the mounting terminal for the folded monopole. One side of the monopole is soldered to the center pin of the connector and the



**fig. 1.** Ground-plane antenna with slanted folded-monopole radiator for use on the OSCAR 7 432-MHz uplink. Ground-plane disc is 13 to 15 inches (33 to 38 cm) in diameter (not critical), 1/16" (1.5mm) or thicker aluminum. Construction of the monopole radiator is shown at B.

K4GSX<sup>1</sup> but does not use complex impedance matching networks or tuned lines.

The antenna, shown in **fig. 1**, consists of a ground plane and folded monopole radiator. By tilting the angle of the

other side is soldered to a grounding lug which is held in place by one of the connector-mounting screws. A dab of RTV (or similar sealant) over the connector provides weatherproofing and completes the construction.

While this simple antenna is not comparable to a fully steerable array, it provides good omni-directional coverage whenever the satellite is above 10 to 20

1. Dale Covington, K4GSX, "Simple Antennas for Satellite Communications," *ham radio*, May, 1974, page 24.

degrees elevation. Below that elevation, the normal high-gain 432-MHz antenna can be switched in for the real DX.

Joe Reisert, W1JAA

## audio transducer

The audio transducer shown in the photograph (fig. 2) with all the other gear is a modified permanent-magnet speaker with its voice coil removed and its diaphragm intact. It is a tactile aid. Mine was made from an old PA system, but it can be made from any loudspeaker. The core is magnetic and vibrates strongly at a low audio frequency.



fig. 2. Gayle Sabonaitis, WA1OPN, can copy CW up to 25 wpm using the audio transducer she is using in this photograph.

Building the transducer is quite simple — all that is needed is a discarded loudspeaker. When the coil is removed, it is advisable to enclose it in a metal box so it will not get crushed (the plastic cone is easily broken). It is a good idea to use an 8-ohm speaker as deaf persons respond best to low-impedance speakers because the vibrations are stronger.

Gayle Sabonaitis, WA1OPN, a student at the Perkins School for the Blind in Watertown, Massachusetts, is both blind and deaf and has been licensed for three years. She is presently preparing to take the Advanced class exam.

I have used an audio transducer for five years and find it much easier than headphones. I do not have any hearing left — it all disappeared a few years ago and headphones can be very confusing — it is difficult to copy CW with only a little hearing left. I can copy CW at 25 wpm and send at 18 wpm. These speeds may appear to be an overstatement when said by a deaf amateur who has only been on the air three years, but they are not an exaggeration and are possible with the help of an audio transducer. However, I usually copy about 18 wpm when there is too much interference. Some deaf-blind hams can copy faster than this because they have had much more practice.

Gayle Sabonaitis, WA1OPN

## gated oscillator

The circuit shown in fig. 3 is a versatile, minimum-cost oscillator using a minimum of components. It can be made to operate from less than 100 kHz to over 80 MHz by selecting a 74S00 for any operating frequency above 20 MHz. The output is a square wave swinging between about 0.4 volt and 4.5 volts. The oscillator can be started and stopped by switching the oscillator gating input between zero and 5 volts. If this feature is not desired, the NAND gates may be replaced by three sections of a 7404 hex inverter, resulting in a package count savings of one fourth. All external components are the same as those shown.

Doug Schmieksors, WB9KEY

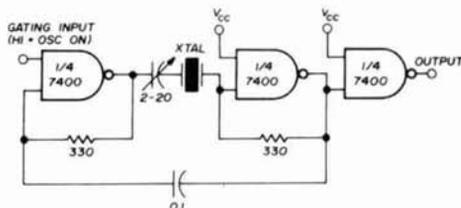


fig. 3. Simple gated oscillator circuit can be used from 100 kHz to 80 MHz. For use above 20 MHz, select higher speed 74S00 ICs.

# new products

## code-teaching keyer



Code practice has suddenly become more efficient and interesting because of a new development from Curtis Electro Devices. Their new IK-440 Instructokeyer provides an infinite variety of code groups allowing unlimited practice for higher proficiency. In addition, the IK-440 is a state-of-the-art keyer which uses the new 8043 keyer-on-a-chip IC. It uses no motors or tapes.

The all solid-state unit sends random groups of Morse letters, numbers, punctuation and word spaces in an ever changing sequence which never exactly repeats. Code speed is adjustable from 4 to 50 wpm. Code groups are of varying lengths but average five characters per

group. A rear panel switch selects alphabet only or full alphanumeric.

The keyer portion of the IK-440 provides self-completing dots, dashes and spaces, instant start, dot memory, weight control, iambic mode and built in sidetone. Front panel controls are provided for volume, pitch, weight, speed, on-off, tune, self-test and "keyer-code practice." The IK-440 will key  $\pm 300$  Vdc at 200 mA in either the keyer or code practice mode. Output switching is solid state. Price of the IK-440 is \$224.95.

For further information, contact Curtis Electro Devices, Inc., Box 4090, Mountain View, California 94040, or use *check-off* on page 94.

## 500 MHz prescaler

Levy Associates has broken the frequency-measurement barrier with a prescaler that will count to 500 MHz. Requiring only 150 millivolts to operate, this prescaler is guaranteed to respond to 500 MHz minimum, and will typically operate to 550 MHz. Division by ten and one hundred is provided, and the TTL compatible outputs provide adequate drive for all commercial and home-built counters.

The combination of high input impedance (500 ohms) and high sensitivity makes possible easy measurement of low-power transmitters. The frequency of a one-watt transmitter can be measured at four to six feet using only a  $\frac{1}{4}$ -wave whip antenna to drive the prescaler. Overload protection is provided up to 2 volts input.

The prescaler is complete including 117-Vac power supply on a 3x4-inch (7.6x10.1-cm) circuit board, small enough to fit inside many counters. Available from stock as a kit, with all

parts, drilled circuit board and instructions, \$89.00; or completely assembled and tested, \$109.00 (plus \$.85 postage and California sales tax if applicable). For more information write to Levy Associates, Post Office Box 961R, Temple City, California 91780.

## ameco equipment

The popular line of Ameco amateur equipment is now available directly from the manufacturer. Included in the line are lowpass transmitting filters, highpass TV filters, all-band preamplifiers, a standing wave bridge and bridge indicator unit, code practice oscillators, and a novice CW transmitter kit. Also available are heavy duty 572B/T160L power triodes (replace 811As), type-UHF rf connectors and economy slide switches. For a copy of their latest catalog, write to Ameco Equipment Company, 314 Hillside Avenue, Williston Park, New York 11596, or use *check-off* on page 94.

## MFJ catalog

The new MFJ catalog of amateur radio equipment describes many *new* products, including CW and ssb audio filters, electronic keyers, frequency standards, audio amplifiers, active filters, printed-circuit boards and electronic components. Copies of the catalog and additional information are available from MFJ Enterprises, Post Office Box 494, Mississippi State, Mississippi 39762, or use *check-off* on page 94.

## short circuit

The new Jackson Brothers high-precision trimmer capacitor described on page 65 of the March, 1975, issue of *ham radio* is known in this country as the *N.R.P.* capacitor. *Trimline*, the name used in England, cannot be used in this country as it is a trade name owned by another firm.



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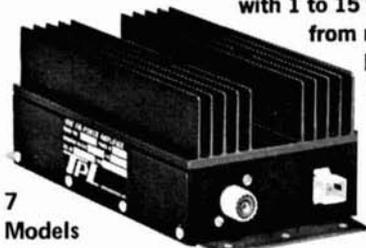
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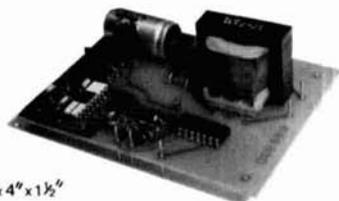
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VOLTS	W	VOLTS	W	TYPE	W
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IN751AH	36.0	400m	4.1	100	1.0
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IN751AJ	38.0	400m	4.1	100	1.0
IN751AK	39.0	400m	4.1	100	1.0
IN751AL	40.0	400m	4.1	100	1.0
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IN751AW	51.0	400m	4.1	100	1.0
IN751AX	52.0	400m	4.1	100	1.0
IN751AY	53.0	400m	4.1	100	1.0
IN751AZ	54.0	400m	4.1	100	1.0
IN751BA	55.0	400m	4.1	100	1.0
IN751BB	56.0	400m	4.1	100	1.0
IN751BC	57.0	400m	4.1	100	1.0
IN751BD	58.0	400m	4.1	100	1.0
IN751BE	59.0	400m	4.1	100	1.0
IN751BF	60.0	400m	4.1	100	1.0
IN751BG	61.0	400m	4.1	100	1.0
IN751BH	62.0	400m	4.1	100	1.0
IN751BI	63.0	400m	4.1	100	1.0
IN751BJ	64.0	400m	4.1	100	1.0
IN751BK	65.0	400m	4.1	100	1.0
IN751BL	66.0	400m	4.1	100	1.0
IN751BM	67.0	400m	4.1	100	1.0
IN751BN	68.0	400m	4.1	100	1.0
IN751BO	69.0	400m	4.1	100	1.0
IN751BP	70.0	400m	4.1	100	1.0
IN751BQ	71.0	400m	4.1	100	1.0
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IN751BU	75.0	400m	4.1	100	1.0
IN751BV	76.0	400m	4.1	100	1.0
IN751BW	77.0	400m	4.1	100	1.0
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IN751CD	84.0	400m	4.1	100	1.0
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IN751CG	87.0	400m	4.1	100	1.0
IN751CH	88.0	400m	4.1	100	1.0
IN751CI	89.0	400m	4.1	100	1.0
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IN751CL	92.0	400m	4.1	100	1.0
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IN751DH	114.0	400m	4.1	100	1.0
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IN751DJ	116.0	400m	4.1	100	1.0
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IN751DM	119.0	400m	4.1	100	1.0
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IN751DO	121.0	400m	4.1	100	1.0
IN751DP	122.0	400m	4.1	100	1.0
IN751DQ	123.0	400m	4.1	100	1.0
IN751DR	124.0	400m	4.1	100	1.0
IN751DS	125.0	400m	4.1	100	1.0
IN751DT	126.0	400m	4.1	100	1.0
IN751DU	127.0	400m	4.1	100	1.0
IN751DV	128.0	400m	4.1	100	1.0
IN751DW	129.0	400m	4.1	100	1.0
IN751DX	130.0	400m	4.1	100	1.0
IN751DY	131.0	400m	4.1	100	1.0
IN751DZ	132.0	400m	4.1	100	1.0
IN751EA	133.0	400m	4.1	100	1.0
IN751EB	134.0	400m	4.1	100	1.0
IN751EC	135.0	400m	4.1	100	1.0
IN751ED	136.0	400m	4.1	100	1.0
IN751EE	137.0	400m	4.1	100	1.0
IN751EF	138.0	400m	4.1	100	1.0
IN751EG	139.0	400m	4.1	100	1.0
IN751EH	140.0	400m	4.1	100	1.0
IN751EI	141.0	400m	4.1	100	1.0
IN751EJ	142.0	400m	4.1	100	1.0
IN751EK	143.0	400m	4.1	100	1.0
IN751EL	144.0	400m	4.1	100	1.0
IN751EM	145.0	400m	4.1	100	1.0
IN751EN	146.0	400m	4.1	100	1.0
IN751EO	147.0	400m	4.1	100	1.0
IN751EP	148.0	400m	4.1	100	1.0
IN751EQ	149.0	400m	4.1	100	1.0
IN751ER	150.0	400m	4.1	100	1.0
IN751ES	151.0	400m	4.1	100	1.0
IN751ET	152.0	400m	4.1	100	1.0
IN751EU	153.0	400m	4.1	100	1.0
IN751EV	154.0	400m	4.1	100	1.0
IN751EW	155.0	400m	4.1	100	1.0
IN751EX	156.0	400m	4.1	100	1.0
IN751EY	157.0	400m	4.1	100	1.0
IN751EZ	158.0	400m	4.1	100	1.0
IN751FA	159.0	400m	4.1	100	1.0
IN751FB	160.0	400m	4.1	100	1.0
IN751FC	161.0	400m	4.1	100	1.0
IN751FD	162.0	400m	4.1	100	1.0
IN751FE	163.0	400m	4.1	100	1.0
IN751FF	164.0	400m	4.1	100	1.0
IN751FG	165.0	400m	4.1	100	1.0
IN751FH	166.0	400m	4.1	100	1.0
IN751FI	167.0	400m	4.1	100	1.0
IN751FJ	168.0	400m	4.1	100	1.0
IN751FK	169.0	400m	4.1	100	1.0
IN751FL	170.0	400m	4.1	100	1.0
IN751FM	171.0	400m	4.1	100	1.0
IN751FN	172.0	400m	4.1	100	1.0
IN751FO	173.0	400m	4.1	100	1.0
IN751FP	174.0	400m	4.1	100	1.0
IN751FQ	175.0	400m	4.1	100	1.0
IN751FR	176.0	400m	4.1	100	1.0
IN751FS	177.0	400m	4.1	100	1.0
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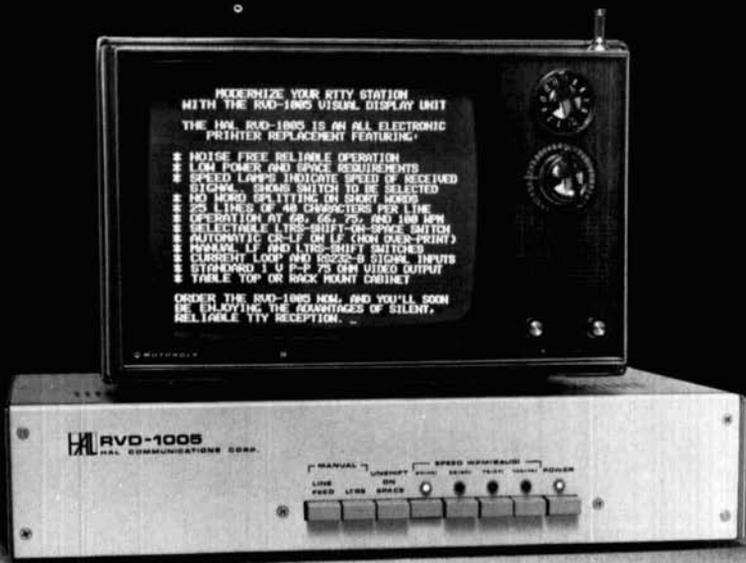
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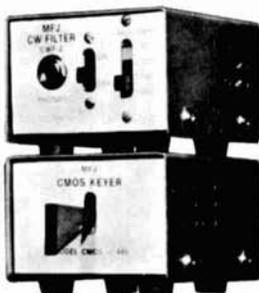
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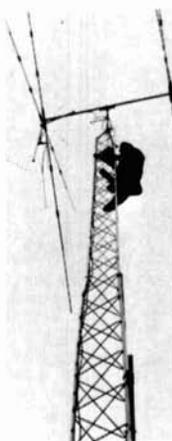
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| <input type="checkbox"/> |  | <b>GTX-100</b><br>1 1/4-meter FM, 100 channels. 12 watts<br>was \$309.95 (Incl. 223.5 MHz) | NOW                        | <b>\$219<sup>95</sup></b> |
| <input type="checkbox"/> |  | <b>GTX-10</b><br>2-meter FM, 10 channels. 10 watts<br>was \$239.95 (Incl. 146.94 MHz)      | NOW                        | <b>\$169<sup>95</sup></b> |
| <input type="checkbox"/> |  | <b>GTX-2</b><br>2-meter FM, 10 channels. 30 watts<br>was \$239.95 (Incl. 146.94 MHz)       | NOW                        | <b>\$189<sup>95</sup></b> |
| <input type="checkbox"/> |  | <b>GTX-600</b><br>6-meter FM, 100 channels. 35 watts<br>was \$309.95 (Incl. 52.525 MHz)    | NOW                        | <b>\$219<sup>95</sup></b> |

- |                          |   |   |                  |
|--------------------------|---|---|------------------|
| <input type="checkbox"/> | <b>ARX-2 2-M Base Antenna</b>                     | @ | \$ _____         |
| <input type="checkbox"/> | <b>Lambda/30 2-M Base Antenna</b>                 | @ | \$29.95 \$ _____ |
| <input type="checkbox"/> | <b>Lambda/4 2-M Trunk Antenna</b>                 | @ | \$39.95 \$ _____ |
| <input type="checkbox"/> | <b>TE-I Tone Encoder Pad</b>                      | @ | \$29.95 \$ _____ |
| <input type="checkbox"/> | <b>TE-II Tone Encoder Pad</b>                     | @ | \$59.95 \$ _____ |
| <input type="checkbox"/> | <b>PSI-9 Port. Power Package (less batteries)</b> | @ | \$44.50 \$ _____ |
| <input type="checkbox"/> | <b>PS-1 AC Power Supply</b>                       | @ | \$29.95 \$ _____ |
|                          |   | @ | \$59.95 \$ _____ |

and the following **standard** crystals @ \$4.25 each: \_\_\_\_\_ \$ \_\_\_\_\_

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(allow 8 weeks delivery.)

For factory crystal installation add \$8.50 per transceiver.

IN residents add 4% sales tax:

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Prices and specifications subject to change without notice.

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*Due to several acts of vandalism and an office fire, many inquiries were lost. If you have not had a reply, please place your inquiry again.*



## Glade Valley School Radio Session

16th Year — July 26 thru August 8, 1975

**Restructuring is coming!  
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**JANUARY 8-11, 1976**

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## TOUCH TONE ENCODERS

### SOLID STATE CRYSTAL CONTROL TONE ENCODERS

- 12 or 16 Touch Tone digits
- Ideal for hand held units
- Choice of 4 keyboard styles
- RF proof
- Temperature, -20° to 150°F
- CMOS IC Encoder

- Bell System Compatibility
- Easy Installation
- Sub-miniature size
- Crystal Controlled
- Single Tone capability
- Low cost



Style A



Style B



Style C



Style D

### SELF-CONTAINED KEYBOARD ENCODERS

Complete 12 or 16 digit Touch Tone keyboard encoders for mounting directly to side of hand-held transceivers. All electronics included WITHIN keyboard, nothing to add inside of transceiver. Only 1/4" thick. Ready for easy installation, just add three connections to unit. RF proof. Select keyboard style when ordering.

DTM ..... \$49.50

### SUB-MINIATURE TOUCH TONE ENCODER AND KEYBOARD

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SME ..... \$29.50

### DO IT YOURSELF ENCODERS

Now, buy all the major parts — "ala-carte" and build your own Touch Tone Encoder. All you need is a Keyboard, Digital Touch Tone Encoder, a 1-MHz crystal, and P.C. board. Parts come with complete set of application notes, schematics and instructions.

Keyboard, your choice of keyboard style .....

Digital T. T. Encoder with 1-MHz HC-6 Crystal .....

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P.C. board 0.8" x 1.2" .....

All resistors, capacitors, and P.C. board .....

(With purchase of keyboard, encoder and crystal)

### AUTOMATIC TOUCH TONE DIALER

Automatic mobile telephone dialing is now available. By the push of a single button you can automatically dial up to six separate 7-digit numbers. All solid-state micro-power CMOS design. Automatic PTT operation. Programmable to send telephone number only, access code plus telephone number or telephone number plus an identification number. Low profile dash mount, easy installation. Compatible with most radio equipment. Available with keyboard for manual dialing of numbers. Manual operation provides automatic PTT operation with 1 1/2 second transmitter hold.

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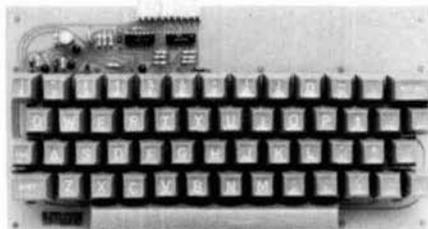
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- \* 53 Keys
- \* One Chip MOS Encoder
- \* Upper and Lower Case
- \* Standard ASCII Output
- \* Two Key Lockout

We are happy to announce a new addition to our keyboard and encoder line. Our new KBD-3 uses a one chip MOS encoder system to give you maximum possible features with a minimum number of parts.

This keyboard produces a standard ASCII coded output that is compatible with TTL, DTL, RTL and MOS logic systems. You have the option of wiring the kit for normal typewriter style output in both upper and lower case letter, or all upper case format. All common machine control commands such as "line feed", "return", "control", etc. are provided on the keyboard. Four uncommitted or extra keys are available for your specific use requirements. Two of these have isolated output lines to the connector for special functions such as "here is".

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<b>Crystals for 2-Meter, Marine, Scanners, etc. Send for Catalog.</b>	

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Sale ends July 31, 1975



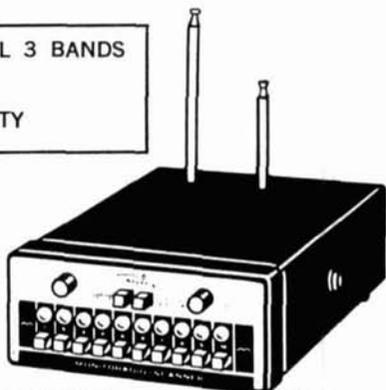
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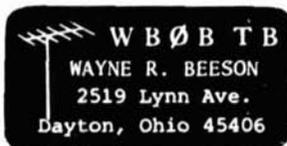
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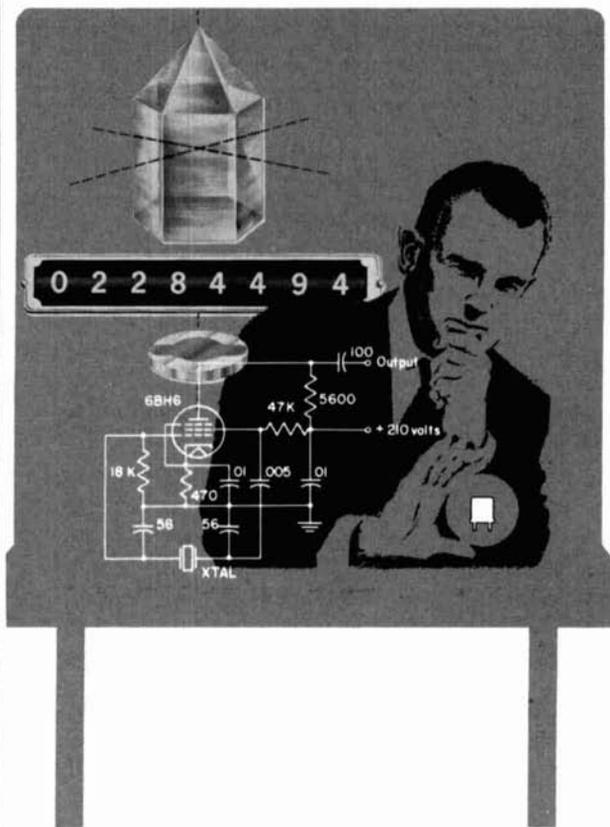
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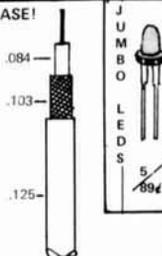
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3DB Bandwidth: 220 KHZ  
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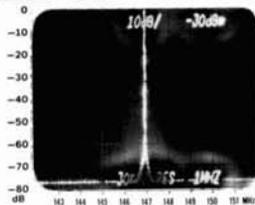


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- Dual tone decoder decodes one Touch-Tone digit.
- Available for 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, #, \* and other dual tones 700-3000 Hz.
- Latch and reset capability built-in.

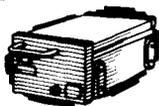
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T-2 Touch-Tone Decoder ... \$39.95 PPD.  
Specify digit or tone frequencies.  
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DURING OUR 2 FOR 1 SUMMER SALE  
2 for \$75.00 + SHIPPING**



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INQUIRIES WITHOUT ZIP CODE OR CALL . . . NO ANSWER

**WANTED:** Good used FM & test equipment. No quantity too large or small. Finders fees too.



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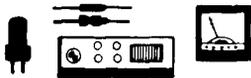
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**QSL'S — BROWNIE W3CJI** — 3035B Lehigh, Allentown, Pa. 18103. Samples with cut catalog 35¢.

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**VHF COMMUNICATIONS SOUTH,** Alan Bridges, WB4VXP, is now representing VHF COMMUNICATIONS, the quarterly magazine for amateurs interested in VHF/UHF technology and equipment construction. This is the English version of the well-known German publication UKW-BERICHTE. VHF COMMUNICATIONS provides modern, practical construction articles, such as receivers, transmitters, converters, antennas, test equipment, etc. reflecting current technology. Kits are available providing P.C. boards, solid state devices, etc. All mechanical and electrical data are provided. Subscription rate: \$6.75 per year. Back issues available \$1.75 each. Binders including issues 1972-1974 plus 1975 subscription \$24.50. VHF COMMUNICATIONS SOUTH also has VHF Engineering, Hamtronics, Regency, Emergency Beacon Corporation, KLM, J-Beam, Texas Instruments, Microwave Modules, Larsen, M-Tech, & more including Swan, Drake, Atlas, & Collins. Write for information, VHF COMMUNICATIONS SOUTH, 2881 S. Main, Kennesaw, Georgia 30144.

**OKLAHOMA** — The Oklahoma Ham Holiday and State ARRL Convention will be held, August 2 and 3 in Oklahoma City, OK. In addition to flea market, the program will include special programs, technical seminars, equipment displays, MARS meetings, unique activities for the XYL. Write Oklahoma Ham Holiday, P.O. Box 20567, Oklahoma City, OK. 73120.

**Buying or Selling ham gear? — BUYERS & SELLERS HAM RADIO BROKERAGE** — See our ad.

**TRAVERSE CITY, MICHIGAN:** The Cherryland ARC family picnic and swap shop welcomes all hams July 27 at Whitewater Township Park in Williamsburg (just outside of Traverse City). Bring your wife and kids, your food and drinks. Good old fashioned picnic with boating, fishing, swimming, etc. Picnic tables and grills, a pavillion and a place to park a trailer overnight. It's a freebee — for details write W8GI, Box 176, Kingsley, Michigan 49649.

**COMING TO FLORIDA?** Use our Club station or your own rig and our all-band antennas to work DX or your home town. All hams welcome. Details — H. E. Saxton, W4QED, c/o Spanish River Inn, Delray Beach, Fla. 33444.

**THE OAK RIDGE ARC Annual Crossville Ham Fest** is July 19-20 at Crossville, Tenn. July 19 highlights are technical forums and banquet; July 20 a picnic, flea market and a raffle. At the local Holiday Inn and at nearby Cumberland Mountain State Park.

**MONTREAL HAMFEST 75,** Aug. 3, MacDonald College Farm, Ste. Anne de Bellevue. Prizes, giant flea market, technical sessions, family fun, \$2.50/adult. Info contact — Montreal Hamfest, Box 201, Pointe Claire-Dorval, Quebec H9R 4N9.

**OKANAGAN INTERNATIONAL HAMFEST,** July 26th and 27th. Gallagher Lake KOA Campsite, 8 miles N. of Oliver, B. C., Canada. Grand Prize raffle draw: IC-22A. Prizes, entertainment. Call-in: 3800, 34/94, 76/76. Registration: 9:00 a.m. PDT, Sat., July 26th. Activities: 1:00 p.m. PDT Sat., 2:00 p.m. PDT Sun. Information: VE7DV or VE7DKL.

**PRINTED CIRCUIT TECHNIQUES** for the hobbyist. Booklet: \$2.00. H. S. steel and carbide drill bits and PC artwork. Send SASE for flyer. Trumbull, 833 Balra Dr., El Cerrito, Ca. 94530.

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**THE INTERNATIONAL HAMFEST** will be held July 12 and 13 at the International Peace Gardens between Dunseith, N. D. and Boissevain, Manitoba, in the American Lodge. Camping, party, contest, free pancake breakfast, meetings and prizes. For information contact John McCann, 1234 Valley View Dr., Minot, N. D. 58701 or Dave Syndal, 25 Queens Crescent Brandon, Manitoba R7B 1G1.

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

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**WANTED:** Instruction manual for Sonar Radio Model SSB Four Bander. W2YEZ, 29 Walton Ave., New Providence, N. J. 07974.

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

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**QSL's**, Sample catalog 20¢. N & S Print, P. O. Box 11184, Phoenix, Ariz. 85061.

**ARIZONA FT. TUTHILL HAMFEST**, July 25, 26 and 27th. Grand Prize FT-101B. Flea market, social activities, contests. Location: South of Flagstaff on Highway I-17 across from airport.

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**ANNUAL FAMILY DAY & PICNIC,** August 10, (rain date August 17th) at the Fort Washington State Park, Flourtown, Pa. All Hams and their families are invited. Games, entertainment, free prizes to the kiddies, free soda. Talk in on 52.525, 146.52, 222.98/224.58. Registration \$2.00 per family.

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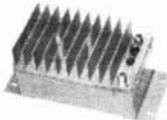
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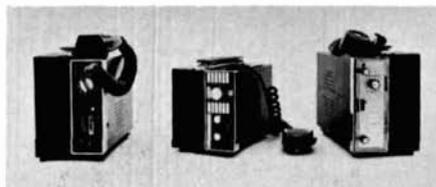
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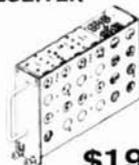
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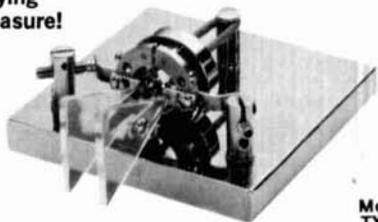
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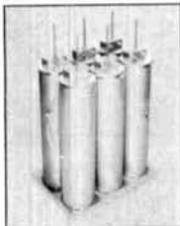
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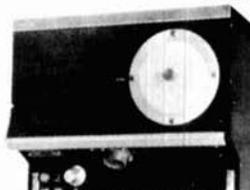


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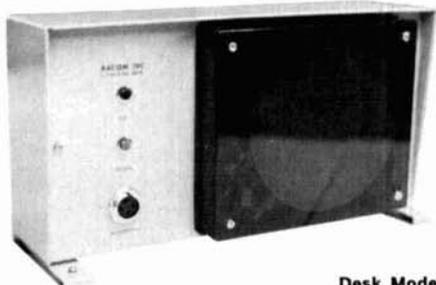
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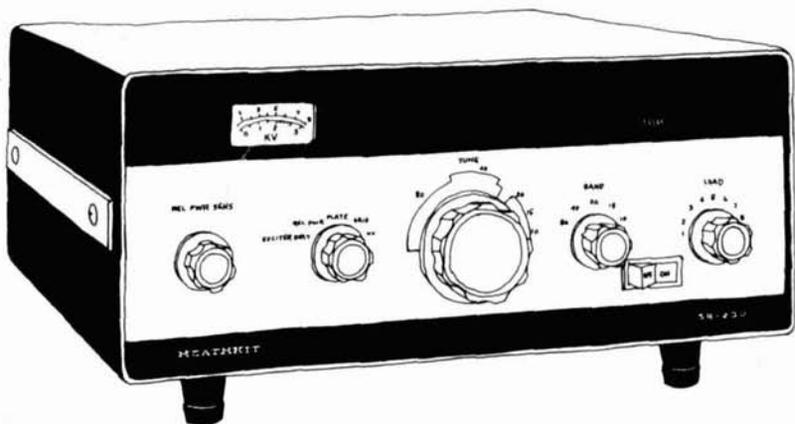
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