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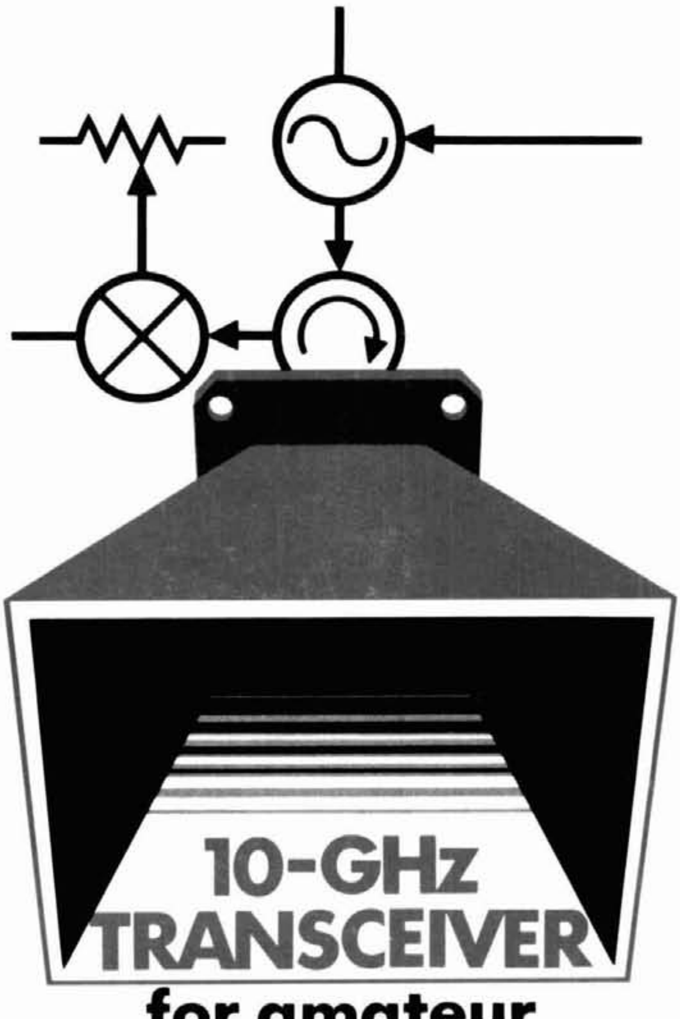
ham radio magazine

AUGUST 1978



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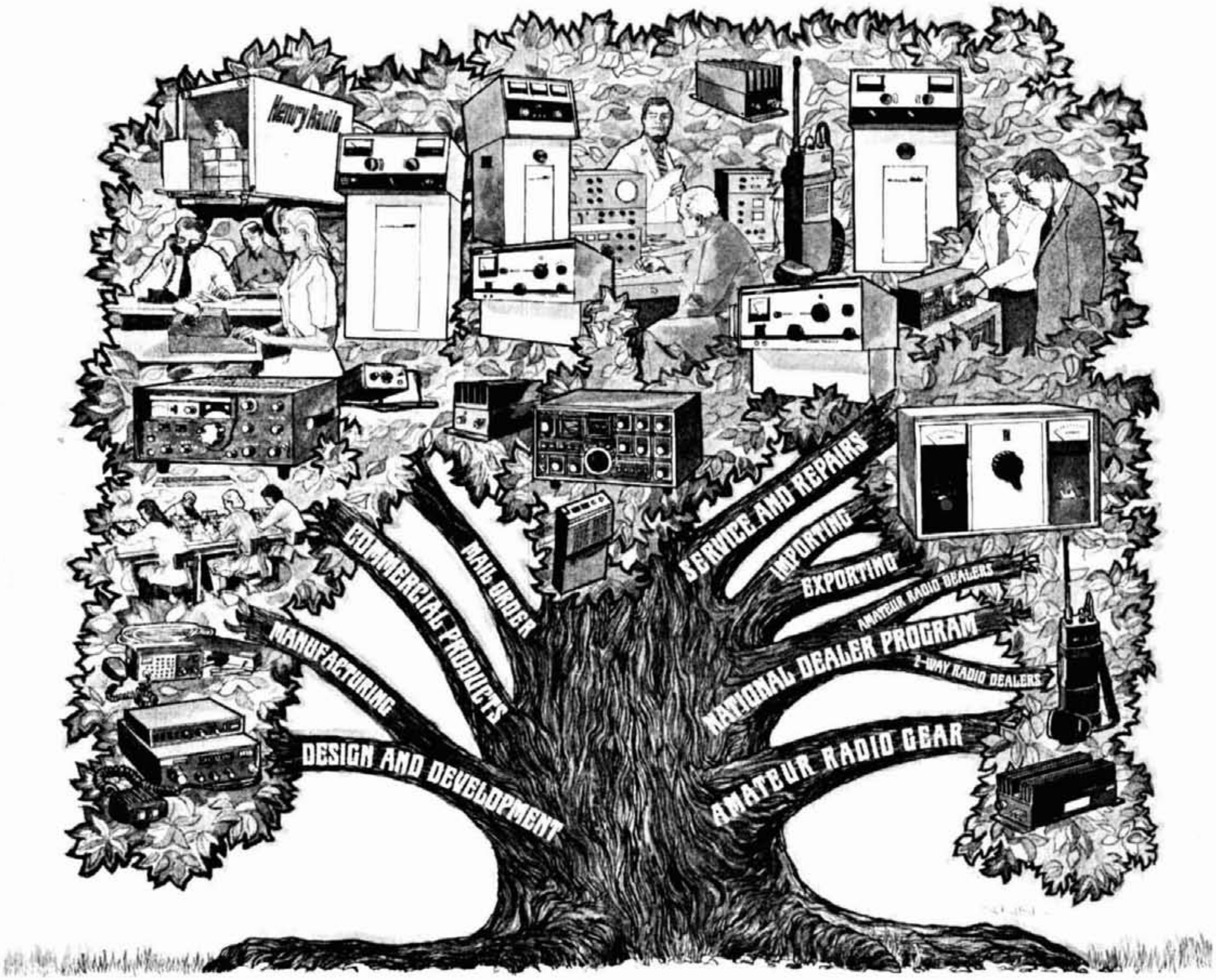
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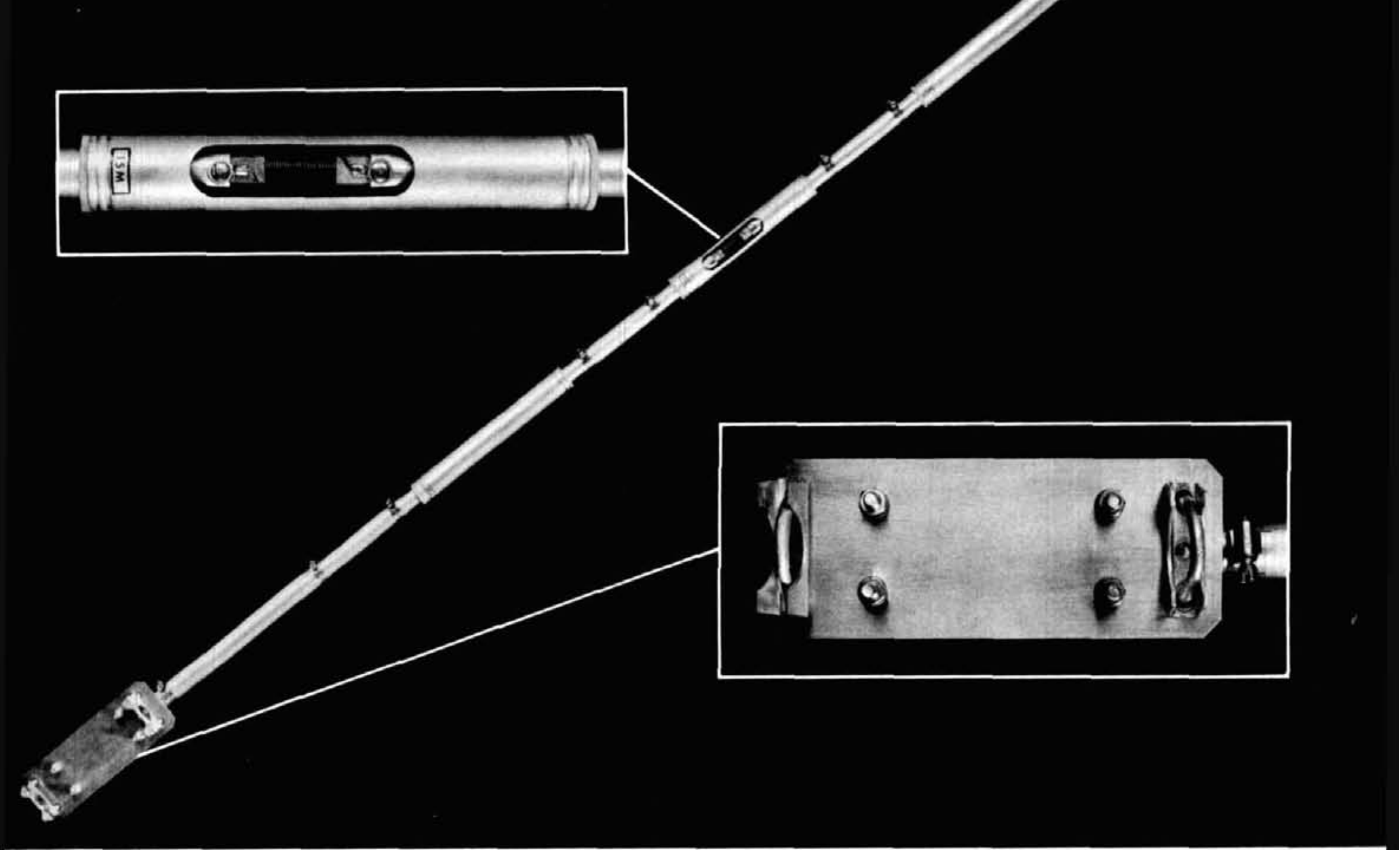

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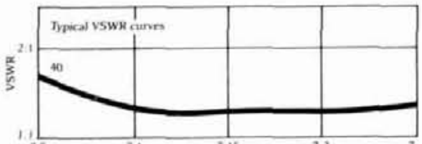

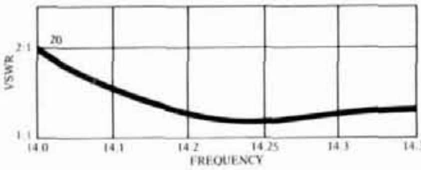

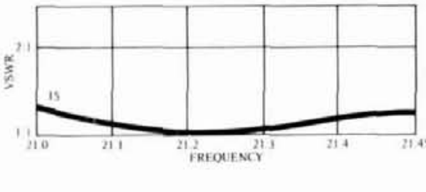

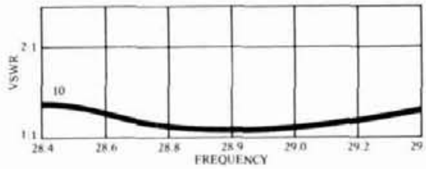

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HAM 8/78

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More Details? CHECK—OFF Page 126

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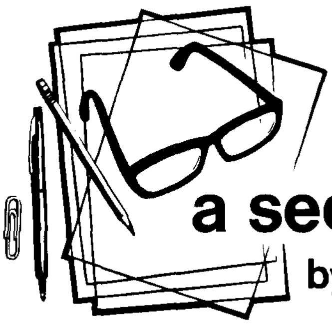


a second look

by Jim Fisk

In recent months there has been rising concern about the possible harmful effects to living tissue due to heating by radio-frequency energy at 10 MHz and above. The weekly CBS TV news magazine, *60 Minutes*, devoted a segment to this topic several months ago, numerous "rf radiation" stories have been published in newspapers and magazines, and now there is a best-selling book on the subject: *The Zapping of America*, by Paul Brodeur. Although much of Brodeur's book is devoted to what he calls the "deadly risk of microwave radiation" and its "cover-up" by the government, he apparently doesn't know the difference between high-power radar or TV transmitters and high-frequency amateur and CB equipment. He would have you believe that little or no research has been done on the dangers of electromagnetic radiation; if your neighbors believe him, you may find your radio activities squelched by local citizens who are afraid of being "zapped" by your amateur transmitting equipment.

Contrary to what Brodeur says, microwave engineers have been aware of rf radiation hazards for 30 years or more, and the scientific community has spent thousands of man hours investigating its effects and establishing safety standards. It is known, for example, that the internal body organs are susceptible to damage from heating caused by high-power radio energy in the range from 150 to 1200 MHz, and that the eye is especially prone to damage from radiation above 1000 MHz. More importantly, it is known that power levels which cause damage are much higher than those found in the average ham shack. Kilowatt transmitters on the amateur uhf bands (432 MHz and above) are potentially hazardous, but if they are completely shielded they are not dangerous to your health. On the lower frequencies there is practically no danger, even if you're running 2000 watts PEP.

Based on present knowledge, which is extensive, various government agencies have established rf radiation safety standards with recommended exposure limits referred to as Radiation Protection Guide Numbers (RPGN). The accepted RPGN value is 10 milliwatts per square centimeter of body area, the standard set by the Occupational Safety and Health Administration (OSHA). Although there are some scientists who disagree with this standard, most agree that rf power levels one-half the OSHA standard (5 mW/cm^2) have little effect on the human body, and practically no one objects to a standard of 1 mW/cm^2. Note that this is based on *continuous* exposure.

If your transmitter is well shielded, and you use coaxial transmission line, the only possible danger is radiation from your antenna. Assuming a kilowatt linear with 65% efficiency and no feedline loss places about 650 watts at the antenna; what is the minimum safe distance? This depends on the directivity of your antenna, but for a half-wavelength dipole it equates to a distance of about 3 meters (10 feet) for a power density of 5 mW/cm^2. If you're running less than a kilowatt, of course, the safe distance is less. Since most amateur dipoles are installed at least 8 meters (25 feet) above the ground, they obviously pose no radiation threat.

What about multi-element Yagi beams and stacked arrays? Since most of the power is concentrated in front of the beam, there is little danger above or below the antenna. Even with 650 watts input, the beam must have at least 15 dBd gain before the power density reaches 5 mW/cm^2 in the center of the forward lobe, 10 meters (30 feet) in front of the antenna. Few amateur antennas have this much gain, and those that do are used on uhf where it's impossible to generate 650 watts into the antenna and stay within the legal power limit.

On the high-frequency bands, if your beam is on a tower at least 10 meters (30 feet) high and not pointed into a building less than 10 meters away, there is absolutely no hazard at *legal* amateur power levels. Keep this in mind if you start getting grief from your neighbors.

Jim Fisk, W1HR
editor-in-chief

comments

microstripline impedance

Dear HR:

The formula W1HR deduced for microstrip impedance in the December, 1977, issue is interesting because it can be rewritten in the following way:

$$Z = \frac{376.7}{\sqrt{E_r}} \cdot \frac{h}{w+h} \ ohms \qquad \textbf{(1)}$$

where Z = stripline impedance (ohms)
h = height of stripline
w = width of stripline (in same units as h)
E_r = relative permittivity of dielectric

The number 376.7 ohms (per square) is the intrinsic impedance of free space which by coincidence is nearly equal to 120π.

If there were no fringing of the electric field at the edges of the stripline the characteristic impedance of the line would be given *exactly* by

$$Z = \frac{376.7}{\sqrt{E_r}} \cdot \frac{h}{w} \ ohms \qquad \textbf{(2)}$$

In **eq. 1** the $w+h$ in the denominator takes account of the fringing effect by considering that the stripline is *effectively* wider than its actual width w by the amount of the height h. As the ratio of the width to height becomes larger, the effect of the fringing becomes less significant and for a very wide stripline its characteristic impedance would approach that of **eq. 2**.

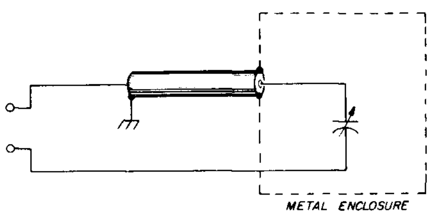
The above discussion is derived directly from a consideration of the field cell concept and of field maps for the transmission lines. It also follows that a line of *any shape* can be either calculated from a map or measured very simply with an ohmmeter and resistance paper as described on page 492 of *Electromagnetics* by J. D. Kraus and K. R. Carver (McGraw-Hill, New York, 1973).

John Kraus, W8JK
Director, The Ohio State University Radio Observatory

bandspreading techniques

Dear HR:

I read with interest Mr. Leonard Anderson's excellent article on bandspreading techniques in February, 1977, *ham radio*. I would like to propose an alternate to his standard capacitor. By using a 3-wire *guarded* circuit, as shown in **fig. 1**, the cable



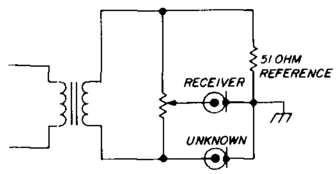
length will not cause the standard to read in error. This is due to the shield of the coax acting as a shield between the two leads from the capacitor. This method is used quite frequently by GenRad and other companies when measuring very accurate capacitance values. The main disadvantage of the guard circuit is that the capacitor must be isolated from ground.

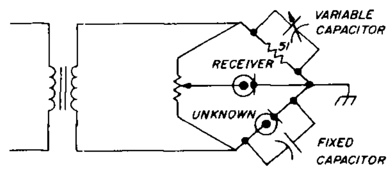
Robert Heider, WØEJO
Glendale, Missouri

antenna noise bridges

Dear HR:

I found the recent article on RX noise bridge measurements very interesting. As the developer of the original antenna noise bridge I would like to point out that two basic models were developed. The TE701 used a similar output circuit to the one shown in the article and worked well to over 100 MHz. The Model TE702 used a variation and worked to over 250 MHz. The bridge circuit was as follows:





Note that the transformer does not need to be accurately center tapped and that it can be bifilar wound. Also, with a 100-ohm variable pot the calibration range is zero to infinity. To make a reactance bridge, place a fixed capacitor across the unknown terminal and a variable capacitor across the reference resistor. With less effort a lot more accuracy is available with this network over a wider frequency range.

Ted Hart, W5QJR*
Richardson, Texas

*W5QJR is the inventor of the Antenna Noise Bridge, and holds the patent on this very useful device. Readers who are interested can obtain copies of the patent (number 3,531,717, dated September 29, 1970) for 50 cents from the Commissioner of Patents, Washington, DC 20231. **Editor**

(Continued on page 82.)

The evolution of the MLA

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CB'S THREAT TO 220 MHZ is far from dead, as indicated by an in-depth study just published by the FCC. "Alternatives for Future Personal Radio Services" is a two-volume set produced by the Commission's Office of Plans and Policy following a 20-month study by the Personal Radio Planning Group. After weighing all possible factors, the study concludes that 220-225 and the 900-MHz land mobile reserve bands **are** the best spots for a new CB service, and economics, performance, timing, and possible medical considerations all lean toward 220 MHz.

One Factor That Shouldn't be overlooked is that this study was done when Carlos Roberts headed the Office of Plans and Policy — and he's now head of the Safety and Special Services Bureau which includes Personal Radio Services (Amateur Radio and CB) among its Divisions.

THE FCC'S BAN ON 10-METER LINEARS was upheld in June by the Commissioners by a 5-1 vote despite a significant shift in FCC staff support. This time the Safety and Special Services Bureau joined the Chief Engineer's office in opposing the ban on legitimate Amateur linears, but the Field Bureau stated they found the ban to be very effective and the Commissioners went along.

AMATEUR RADIO WASN'T involved in FCC's discussion of interconnects (Docket 20846) in June, but the tone of the meeting was that commercial systems resembling Amateur autopatch repeaters were "dangerously close" to being common carriers and would be undergoing careful scrutiny in the near future. The implications for Amateur Radio are far from clear at this time, but Amateur repeater users and operators alike would be wise to be very careful in the operation of their systems.

AMATEURS REQUESTING CALLSIGNS not currently available (1x2s for Extras or "counterpart" 1x3s for oldtimers switching call areas, for example) may find themselves stuck with a new callsign they really didn't want. So many Amateurs have been making improper requests that it's caused a serious backlog, about 8500 at last count. So, in the future, such applicants won't be asked whether they want one of the new callsigns, instead of what they'd requested, but will simply be issued one.

Amateurs Who Upgrade must request a callsign change in the FCC Field Office at the time of the exam — later requests for a new callsign (except by Extras) will be returned without action.

FCC'S EX PARTE COMMUNICATIONS rules, which severely limit Commission people's ability to discuss pending Notices of Proposed Rule Making, is now the subject of a Notice of Inquiry (General Docket 78-167). Until it acts on that NOI, the Commission has adopted an interim policy requiring outsiders planning to discuss a pending issue with the Commission to submit beforehand a memo for the record describing what they plan to discuss (according to current interpretations, the limitations on informal discussions do not apply to Petitions for Rule Making or Notices of Inquiry).

Comments On The NOI are due August 9, and Reply Comments by August 23.

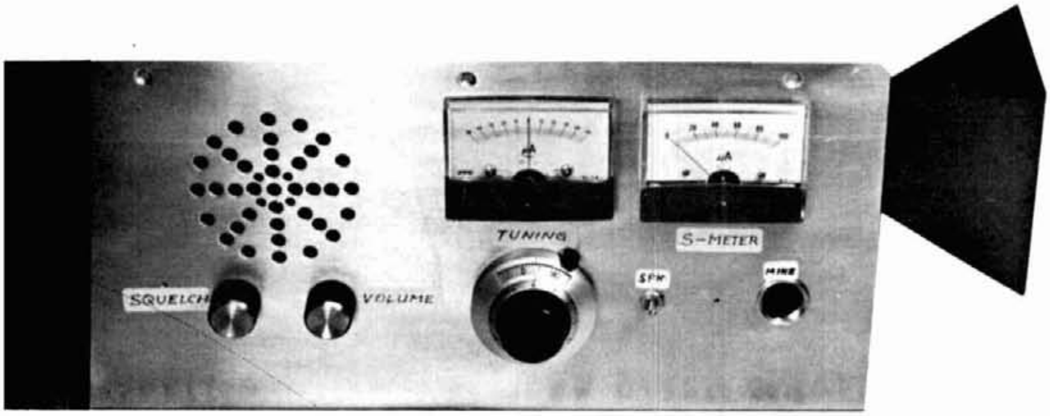
"MEDIUM BANDWIDTH" ATV on 10 meters has been okayed by the FCC for a two-year test period starting June 16. The five stations receiving the Special Temporary Authority will be permitted the use of A5 or F5 with a maximum bandwidth of 35 kHz from 29.0 to 29.3 MHz. The five involved are W9NTP, W3EFG, WØLMD, W6MXV, and WB9LVI — the STA was in response to a request from the ARRL.

THE PROPOSED REVISION OF THE 1934 Communications Act unveiled in June held no surprises for Amateur Radio, though it would abolish the FCC in favor of a "Communications Regulatory Commission" and delegate frequency allocation to the "National Telecommunications Agency." The only obvious effect on Amateurs would be the increase in license terms to 10 years, and reintroduction of license fees. Passage of the revised act is a long way off, however.

ALIEN AMATEURS SEEKING permission to operate in the United States should now send their Form 610-A applications direct to Gettysburg (FCC, Box 1020, Gettysburg, Pennsylvania 17325) instead of to Washington as in the past. Part 97.305 (b) of the Rules has just been revised to permit the change, which accelerates processing.

420-450 MHZ BAND USERS may be in for severe interference problems when the Air Force's "PAVE PAWS" radar goes into operation in the next year or so. The very-long-range system has an average ERP of about a billion watts, and one estimate says that when it's aimed at the moon the reflected signal would illuminate an entire hemisphere of the earth with a 10-20 microvolt signal. The main beam could also burn up a receiver front end 15 km away.

First Operational Site for PAVE PAWS is Cape Cod (Massachusetts) and a second installation is slated for Beale Air Force Base in California. PAVE PAWS has the potential for doing real damage to the Amateur satellite program as well as other weak-signal work on the 70 cm band. Both AMSAT and the ARRL are carefully studying the problem.



10-GHz transceiver

for amateur microwave communications

Construction of a complete 10-GHz Gunnplexer transceiver with 30-MHz i-f and automatic frequency control

A little over a year ago Microwave Associates introduced a new component for amateurs which greatly simplifies the construction of a 10-GHz transceiver for operators who are interested in microwave communications but don't have experience with microwave construction techniques. Without special knowledge or an extensive test setup amateurs can now use a Microwave Associates MA-87127 Gunnplexer to operate on the 3 cm (10 GHz) amateur band. No special mechanical work is required. The Gunnplexer is a complete transceiver which consists of a varactor-tuned Gunn diode rf source, a ferrite circulator which decouples the transmit and receive functions, and a Schottky mixer diode for the receiver signal.[1] A diagram of the basic Gunnplexer system is shown in **fig. 1**; a block diagram of the complete transceiver is shown in **fig. 2**.

The Gunn diode oscillator requires a regulated 10 Vdc source which is capable of supplying 200 mA. The rf output power is approximately 20 mW;* a 17 dB gain horn antenna is available from Microwave Associates. The frequency of the Gunn diode can be tuned with the built-in varactor diode over a frequency range of 60 MHz minimum (100 MHz typical). The required varactor bias is +1 volt to +20 volts and should be controlled by a good quality multi-turn potentiometer.

The Gunnplexer can be easily frequency modulated with a small modulating voltage (mV range) which is superimposed on the varactor's dc bias supply. Since a very small modulating voltage is required, the

*Three models are available: the 15-mW MA-87127-1, the 25-mW MA-87127-2, and the 40-mW MA-87127-3. Units are stocked by Glen Whitehouse, Newbury Drive, Amherst, New Hampshire 03031, and in Europe by Microwave Associates, Munich.

This article was translated from German by Konrad Benz, Microwave Associates, Inc., Burlington, Massachusetts 01803

By Klaus H. Hirschelmann, DJ7OO, Reger Strasse 4, 6500 Mainz 31, West Germany

amplification factor of a single-transistor microphone amplifier is sufficient.

i-f amplifier

To complete the 10-GHz transceiver, an i-f amplifier is required. Because the antenna and Gunnplexer and its antennas are normally physically separated from the operating position (for roof or tower mounting), an i-f amplifier with a low noise figure should be connected directly to the Gunnplexer's mixer diode. A noise figure of 1.5 dB or less and a good impedance match ($Z = 200\ ohms$ at 30 MHz) is requried to obtain an overall system noise figure of 12 dB or better. With careful design, a system noise figure of less than 10 dB can be achieved.

The coaxial connection between the i-f preamplifier and the post amplifier/receiver at the operating position is not critical; a proven design is presented later in this article. When considering the noise figure of a Gunnplexer system it's important to remember that the receiver has no preselection so the two receiver sidebands (carrier plus *and* minus the i-f) contribute equally to the overall noise figure.

Standardization of a single i-f system is essential for the operation of a 10-GHz system among a large group of amateur microwave enthusiasts. A 100-

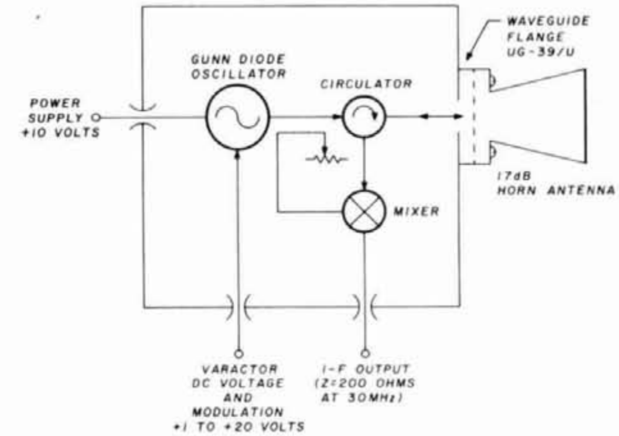


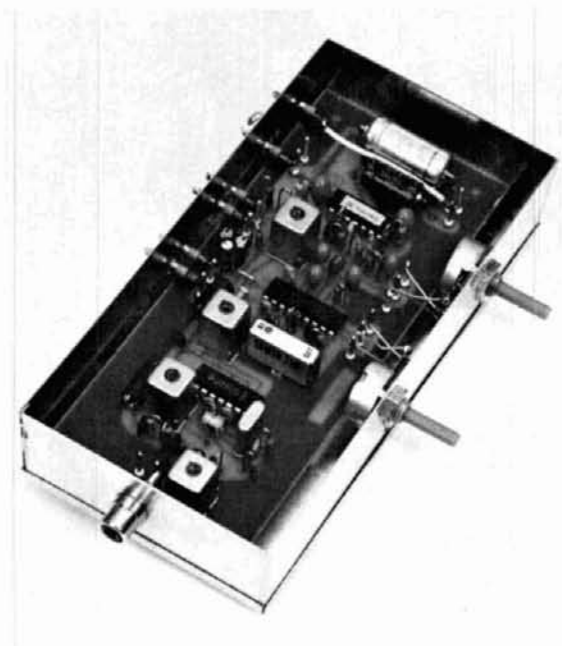
fig. 1. Basic Gunnplexer system showing the varactor-tuned Gunn-diode oscillator, ferrite circulator, and Schottky mixer diode. A portion of the rf power from the oscillator is coupled to the mixer through the circulator. The i-f output impedance at 30 MHz is 200 ohms; a 4:1 transformer is required to provide a good match to 50 ohms (see fig. 2).

MHz i-f has been recommended by several German amateurs,[2] but this is useful only if communications between two fixed stations is all that you want. The result is a full duplex system without transmit-receive switching where the Gunn oscillator operates simultaneously as a receiver local oscillator and frequency-modulated transmitter. Each partner operates at a different frequency, which results in the intermediate frequency as shown in **fig. 3**.

In most cases, however, amateurs want to contact as many other 10-GHz stations as possible. This requires that each station must be able to transmit and receive on either frequency. Since the varactor diode provides a maximum frequency tuning range of only 60 MHz, the use of a 100-MHz i-f would require mechanical tuning of the Gunn oscillator. Mechanical tuning of the Gunnplexer provides a tuning range of ± 100 MHz minimum, but this would unduly complicate a two-way communications set-up. By choosing a 30-MHz i-f, however, you can switch frequencies with a simple voltage change on the varactor diode.

In the Rhein-Main area in West Germany various Gunnplexers are operated at 10350 MHz (transmit) with +4 volts of varactor bias; with +10 volts on the varactor the transmit frequency is 30 MHz higher at 10380 MHz. If an operator knows whether the other station is using the lower (10350 MHz) or higher (10380 MHz) frequency, it is only necessary to tune the receiver over a small range of frequencies.

The instability of the self-oscillating Gunn diode requires wideband frequency modulation; a transmit bandwidth of 75 kHz and an i-f bandwidth of 200 kHz gives satisfactory results.



Construction of the 30-MHz receiver designed by DJ7OO. At the bottom left is the mosfet input stage, followed by the 40.7 MHz local oscillator and mixer, TDA1047 fm i-f strip, and TAA611 audio power amplifier. The two potentiometers are for squelch and audio gain.

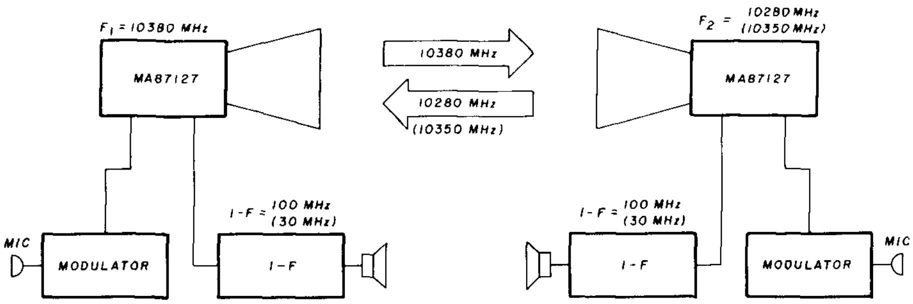


fig. 3. Duplex operation of the 10-GHz Gunnplexer system, showing the oscillator frequencies for 100-MHz and 30-MHz intermediate frequencies. As discussed in the text, a 30-MHz i-f is preferred because of the 60-MHz tuning range provided by the varactor; the use of a 100-MHz i-f would require mechanical tuning of the Gunnplexer.

i-f post-amplifier

The 30-MHz i-f post-amplifier and receiver shown in **fig. 4** was developed by the Zweite Deutsches Fernsehen amateur group. More than fifty of these receivers have been built and used on the air, and all operate well.*

The first 30-MHz amplifier stage uses a dual-gate BF900 MOSFET transistor (similar to the RCA 40673). The self-oscillating mixer is based on a Siemens SO42P IC and translates the 30-MHz input signal down to the 10.7-MHz i-f. The parallel tuned circuit (L1-C1) resonates at 40.7 MHz, the frequency of the third-overtone crystal. Without inductor L1 in the circuit the oscillator has a tendency to run at the crystal's fundamental at approximately 13.56 MHz; this can result in unwanted modulation products $(13.56+10.7=24.26\ MHz)$.

The Murata SFW10.7MA ceramic filter determines the i-f response characteristics of the receiver; the 3 dB bandwidth is 220 ± 40 kHz. The Siemens TDA1047 IC, which was developed for fm broadcast radios, is used as an amplifier and fm demodulator; it has excellent limiter capabilities and includes a built-in squelch circuit — its symmetry guarantees trouble-free operation.

An S-meter is connected to pin 14 of the TDA1047

*Kits to build your own 30-MHz post-amplifier are available from Elektronik Laden, Wilhelm-Mellies-Strasse 88, D4930 Detmold 18, West Germany; the price is 89 DM ($45) postpaid.

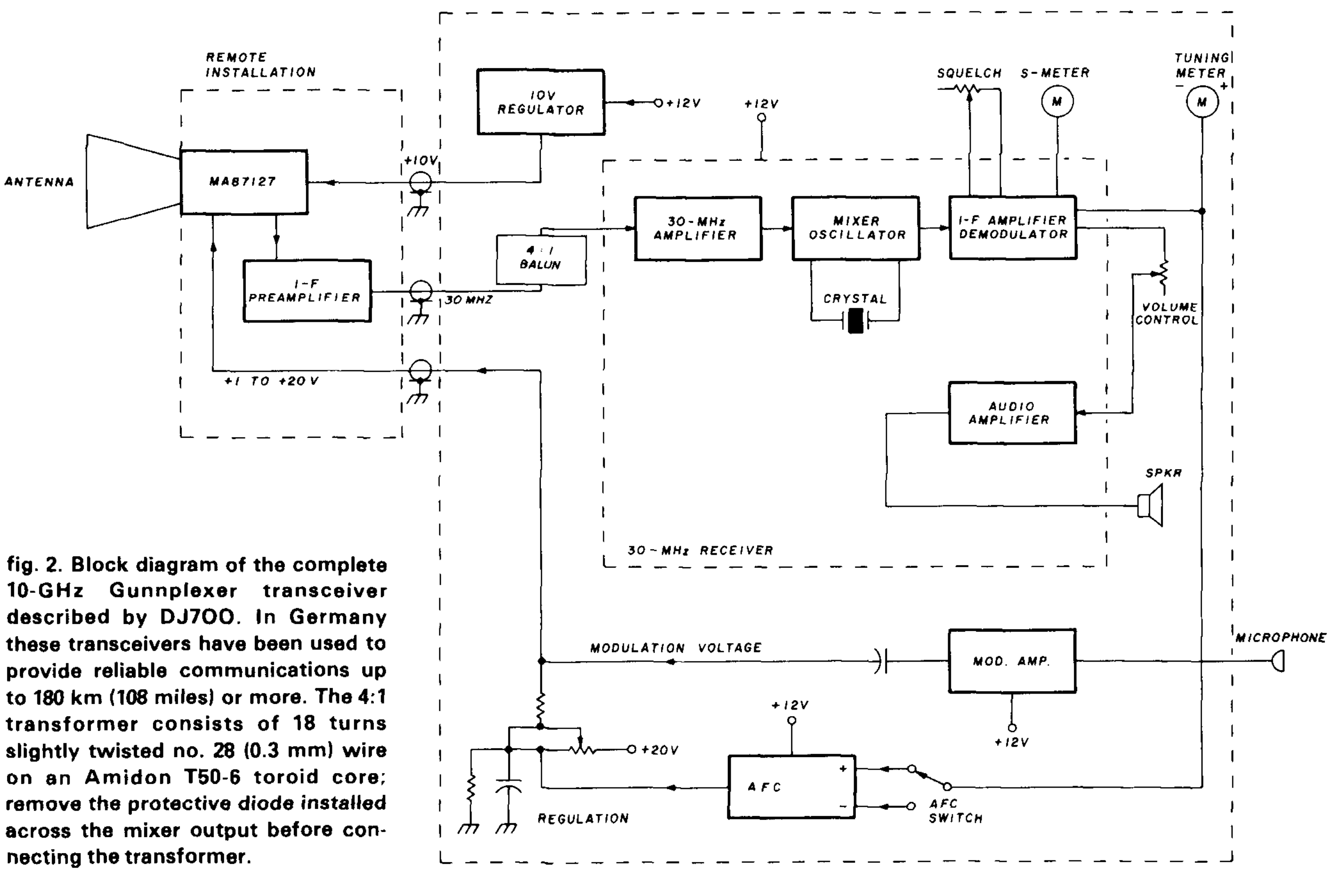
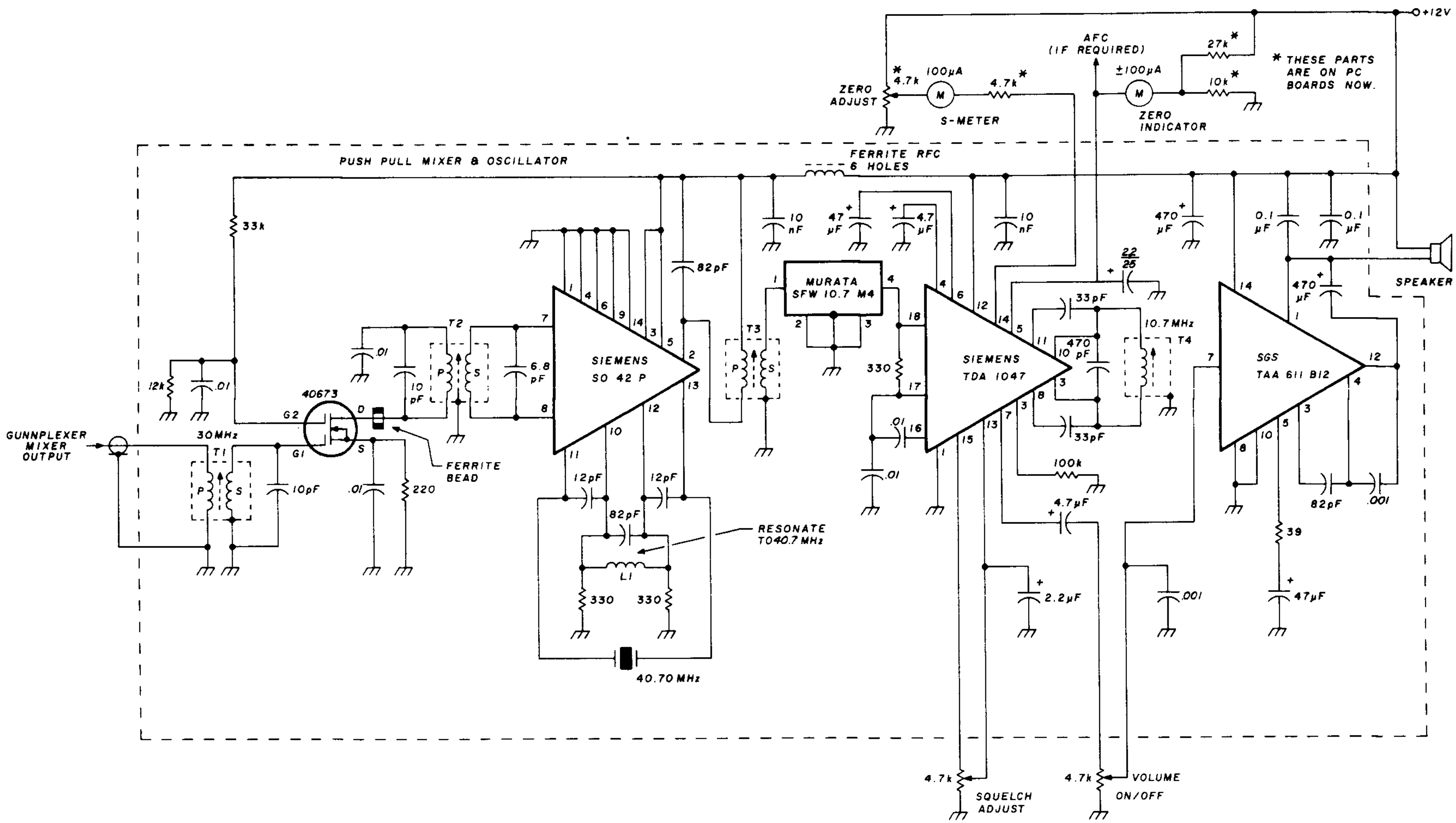


fig. 2. Block diagram of the complete 10-GHz Gunnplexer transceiver described by DJ7OO. In Germany these transceivers have been used to provide reliable communications up to 180 km (108 miles) or more. The 4:1 transformer consists of 18 turns slightly twisted no. 28 (0.3 mm) wire on an Amidon T50-6 toroid core; remove the protective diode installed across the mixer output before connecting the transformer.



L1 15 turns no. 28 AWG (0.3mm) unsupported, closewound on 4 mm (5/32 inch) diameter mandrel

T1 Primary, 3 turns; secondary, 18 turns

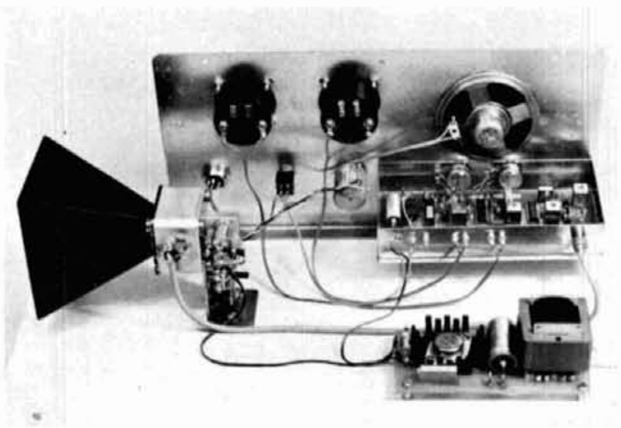
T2 Primary, 18 turns; secondary, 5 turns

T3 Primary, 18 turns; secondary, 5 turns

T4 8 turns

All transformers wound with no. 32 AWG (0.2mm) wire on Vogt D41-2520 forms.

fig. 4. Schematic diagram of a broadband 30-MHz i-f post-amplifier/receiver which features a MOSFET input stage, SO42P self-oscillating mixer, 10.7-MHz ceramic filter, TDA1047 amplifier/demodulator, and TAA611 audio power amplifier. The complete receiver is built into a package measuring 14.7 cm long, 7.4 cm deep, and 2.9 cm high (5.8 x 2.9 x 1.1 inches). A kit is available.



Layout of DJ3KM's 10-GHz Gunnplexer system, as set up for display at a German club meeting. The 30-MHz receiver is mounted on the front panel, under the speaker; the avc circuitry is built on a small board mounted next to the Gunnplexer. An ac power supply for the system is in the right foreground (photo by DB3PR).

amplifier/demodulator. This is a big help when aligning antennas for maximum received signal. The inherent noise of the TDA1047 produces a small current through the S-meter which can be nulled out by adjustment of the 4700-ohm ZERO ADJUST potentiometer. The output at pin 5 of the TDA1047 is a frequency-dependent dc voltage which can be connected to a carrier meter and/or an AFC circuit for the Gunnplexer (**fig. 5**). The Fairchild SGS TAA611B12 (or Texas Instruments 76001) serves as an audio power amplifier.

The frequency stability of the Gunnplexer is important for successful two-way communication; the manufacturer specifies a drift of −350 kHz per °C maximum. When the Gunnplexer is first turned on, the oscillator will drift a few MHz as the Gunn diode warms up, so the 220-kHz i-f bandwidth requires continuous tuning of the oscillator. The Gunnplexer also continues to drift slightly after the initial warm-up period. A simple solution to this problem is to compensate for the drift of the free-running oscillator by changing the operating frequency of the station at the other end of the link.

The AFC circuit shown in **fig. 5** uses the frequency-dependent voltage available from the i-f post-amplifier, as discussed previously. During two-way communications only one operator has his AFC circuit switched on; the Gunnplexer at the other end of the link is allowed to run free. A three-position switch is used because the frequency change might be up or down (center position is AFC OFF). The coupling between the AFC circuit and the Gunnplexer determines the system's holding range.

performance

The successful operation of various 10-GHz amateur stations in the Rhein-Main area, operating with the equipment described here, has proved the system's feasibility and reliability. The use of 17-dB horn antennas at both ends of the link allows communications up to 60 km (35 miles) or more. The 3-dB beamwidth of the horn antenna is approximately 30 degrees, so antenna alignment is not particularly critical.

Some stations are using home-built 23 dB horn antennas or 2 meter (6 foot) parabolic reflectors, so there have been many 10-GHz contacts in the range

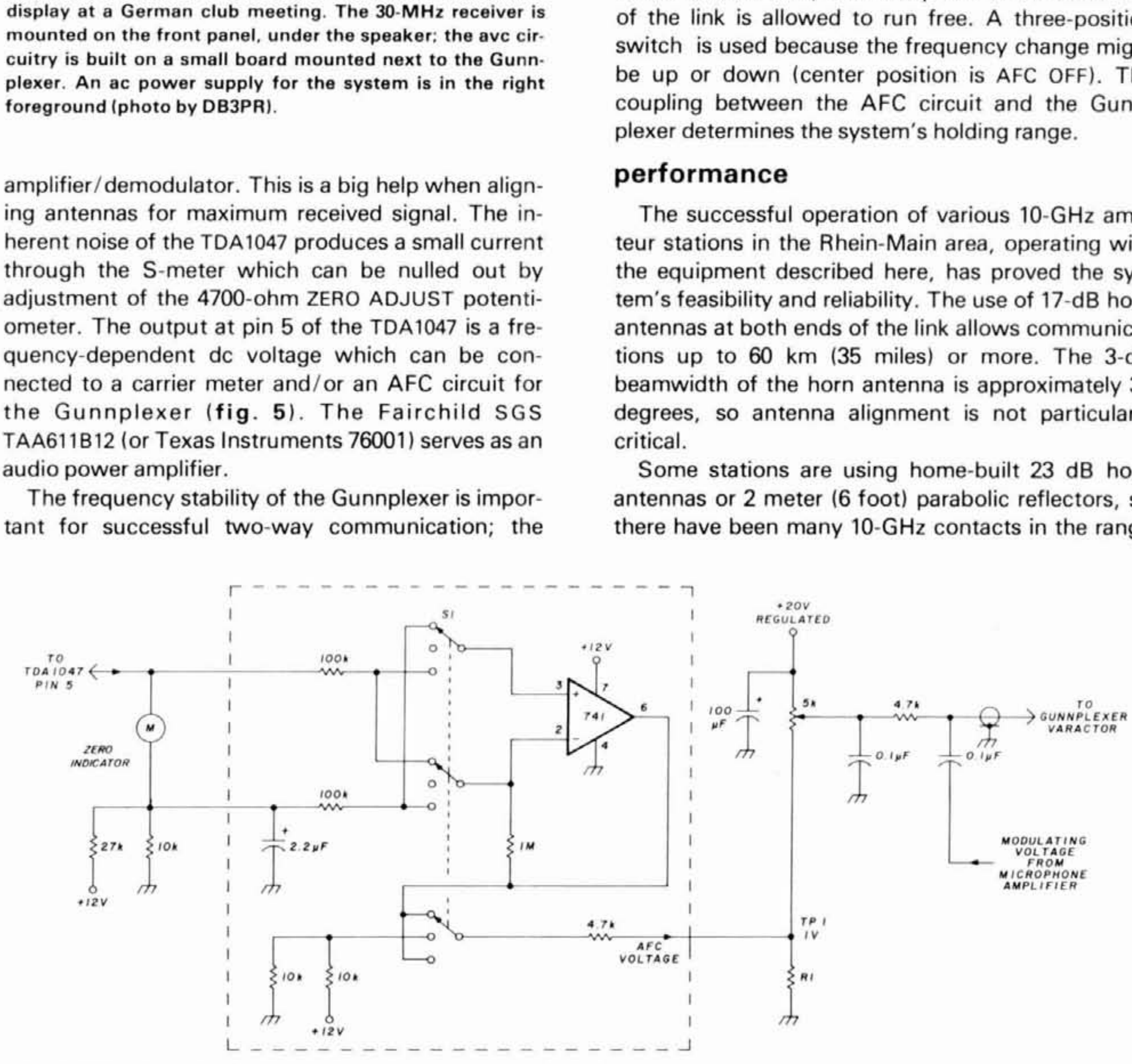
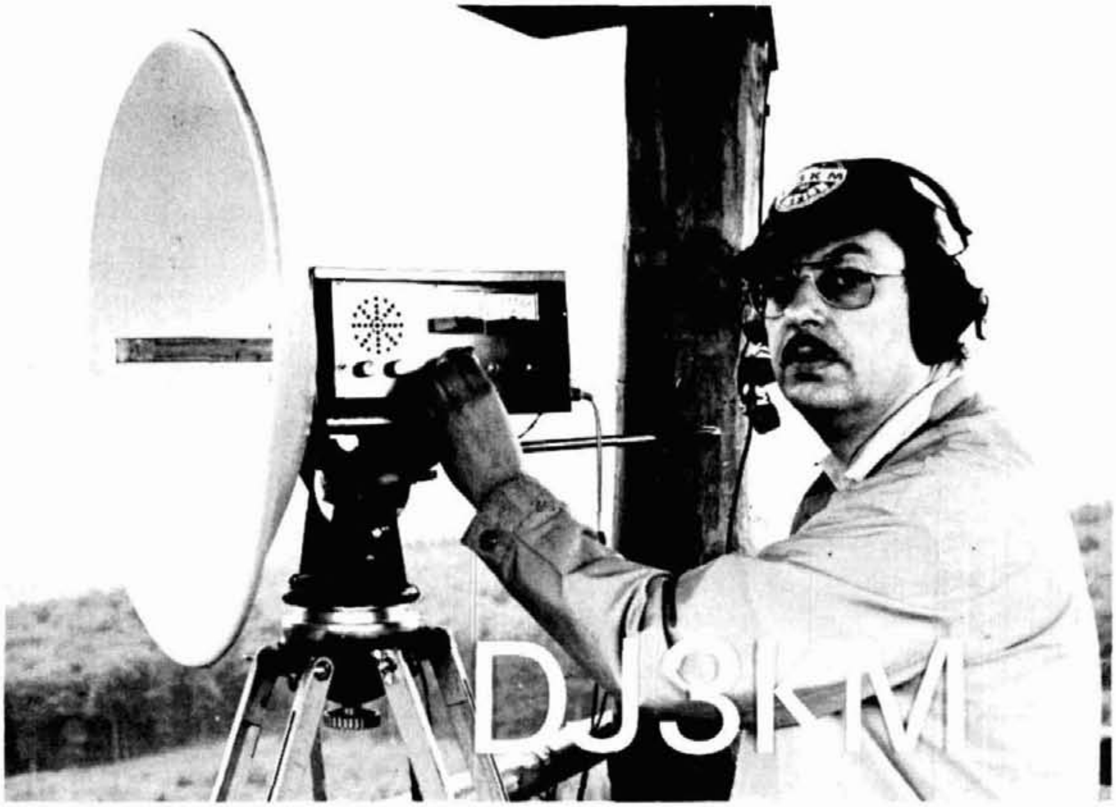


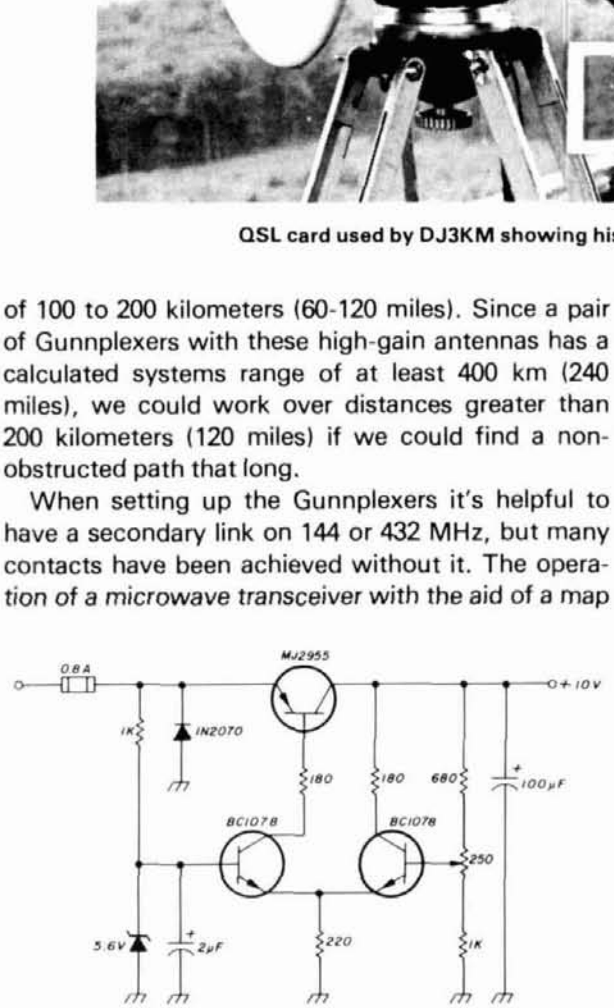
fig. 5. AFC voltage for the 10-GHz Gunnplexer transceiver is derived from the frequency-dependent voltage available from the 30-MHz receiver (fig. 4). The value of resistor R1 (approximately 330 ohms) must be determined experimentally so that 1 volt is measured at TP1.



QSL card used by DJ3KM showing his 10-GHz Gunnplexer and 30-MHz i-f receiver.

of 100 to 200 kilometers (60-120 miles). Since a pair of Gunnplexers with these high-gain antennas has a calculated systems range of at least 400 km (240 miles), we could work over distances greater than 200 kilometers (120 miles) if we could find a non-obstructed path that long.

When setting up the Gunnplexers it's helpful to have a secondary link on 144 or 432 MHz, but many contacts have been achieved without it. The operation of a microwave transceiver with the aid of a map and compass is a new challenge and hobby for many amateurs in Germany.



A +10 volt regulated power supply recommended for use with the 10 GHz Gunnplexer transceiver. The BC107B transistors may be replaced by any small-signal NPN silicon transistors such as the 2N4124. The MJ2955 may be replaced by a 2N3789 or similar 10 amp PNP device.

Activity on 10 GHz in Europe has now reached the point that a 10-GHz bandplan has been approved by amateur groups in Germany, Holland, and Switzerland. In addition to providing space for communications between individual amateurs, the bandplan accommodates beacons, repeaters, and narrowband modes (CW, RTTY, SSTV, and single sideband).

Trial runs with higher gain antennas, narrower i-f bandwidths, and phase-locked loop circuitry for frequency stability are presently going on (reference 3, which describes a phase-locked Gunnplexer system devised by WA6EXV, is available from Microwave Associates).

I would especially like to thank DJ6RW, DJ3KM, DK2DRX, DJ8QL, and DJ8CY for their help in the construction and planning of this equipment.

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ham radio

More Details? CHECK—OFF Page 126

frequency-lock loop

Oscillator stability can be improved by applying this simple but effective frequency-lock loop

One of the main considerations in the design of radio communications systems is frequency stability. The objectives in the amateur radio service, however, are often quite different from those of other hf services. Amateurs have band allocations, while most other users have spot frequencies to work on, and consequently the vfo is usually our preferred primary frequency source. There are three basic frequency generation techniques in common use at the present time. The vfo is the oldest, offering simplicity and the very real asset of continuous tuning, but it is difficult to achieve high stability, especially in the long term. The crystal-controlled oscillator is also simple and very stable, but offers little flexibility, although such variations as the vxo and the "Rock-Mixer" have offered some help in this direction. Finally, there is the synthesizer, based on the phase-locked loop. At the expense of some complexity, this method offers excellent stability and can be very flexible. However, it is inherently a noncontinuously-tuned device, and, therefore, not as well suited to amateur applications — especially on the hf bands.

The vfo, in all respects except stability, offers what we need. It seems a pity to throw away all the results of the continuing development which have made the vfo as good a piece of equipment as it is, and start all over again with the synthesizer. On the other hand, the approach I have taken with the frequency-lock loop (FLL) takes advantage of the positive points of the vfo and adds to it the stability of the crystal oscillator. Moreover, you can readily add an FLL as an outboard unit to an existing vfo without major modification to your equipment.

basic principles

If you have a good frequency counter with a readout down to 1 Hz, you can, by manual tuning adjustments made suitably often, keep the vfo on the required frequency indefinitely. The stability in the medium to long term is that of the counter's clock. The function of the FLL is to automate this operation.

The frequency-lock loop consists of a simplified counter with a crystal derived clock, an error detector and latch circuit, a filter section, and a controlled reactance to compensate for drift in the vfo tank circuit. The error detector may be compared with the operator's recognition of a significant change in frequency, the filter his decision on the magnitude of the correction, and the controlled reactance the action of his hand on the vfo tuning knob.

counter

The purpose of the counter in the FLL system is not to display frequency, but to control it. And, as there is no reason to operate in the decimal or BCD modes, the simple binary counter is used. Comparing the FLL with the manual control, it should be obvious that there is no need to consider the most significant digits of the count. It is hoped that the vfo will not drift so much that the tens and hundreds of kHz would ever change, and surely not the MHz! So, for compensation of drift instabilities, only a small portion of a counter is required, and that can be in binary form.

The gate period is also of fundamental importance.

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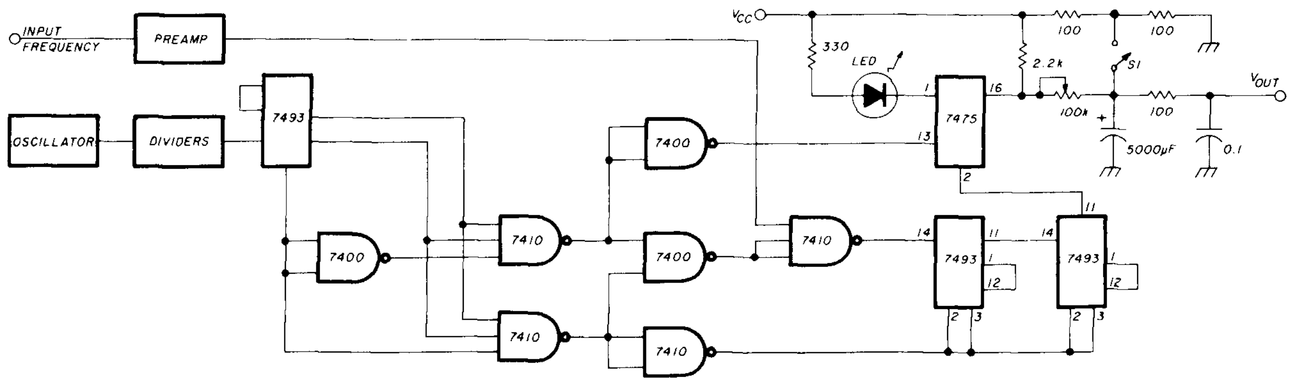


fig. 1. Partial schematic diagram of the basic frequency lock loop circuit. At this point, interpolation within the 256 cycle groups has not been taken into account.

I originally decided on an updating frequency, based on my feelings for drift rate, of once every 3 seconds, (clock 4.2 Hz), arguing that no significant drift would occur in a gate period of 2.8 seconds. Although this is true, I have changed to a higher clocking frequency of about 420 Hz and a gate of 28 mS. The longer period works fine, but the device takes so long to decide what to do next that the user rapidly loses patience with it.

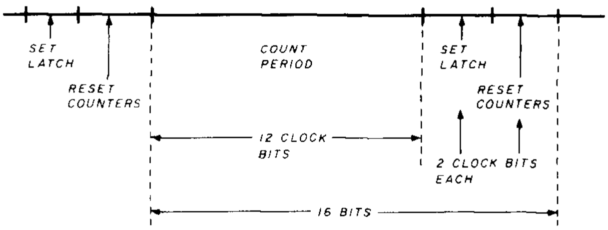


fig. 2. Timing cycle of the basic FLL system.

The counter gate logic is a modification of that presented by MacLeish.[1] The crystal oscillator and dividers can be any arrangement that supplies the correct clock frequency, provided that it has the requisite stability. The counter preamplifier is also a standard circuit for sampling the output of the controlled oscillator.[2]

error detector and latch

At the end of each count period the counter will be in a state which is dependent on the frequency of the controlled oscillator. If the frequency does not vary, neither will the counter's state at that instant. I initially felt that I would need to devise a circuit which would provide an output indicating whether the controlled oscillator was too high or too low in frequency. The obvious way to do this was by the use of a binary logic comparator such as the 7485. However, this would entail the use of switched inputs to cover all the 256 possible states of the counter. Of course, one point of the 256 is available without any comparator at all: when the final stage of the 8-bit counter makes a transition, either 1 to 0 or 0 to 1. This means that during the period the gate was open some multiple of 128 cycles of the input frequency has been counted (256 cycles if you are only looking at the 1 to 0 transition). Therefore, without any further circuitry, the basic FLL shown in **fig. 1** would indicate whenever the input frequency would satisfy these conditions. Assuming that we consider only 1 to 0 transitions, two successive frequency groups are related by:

$$f_n - f_{n-1} = \frac{k}{12} \cdot f_t \qquad \textbf{(1)}$$

where

k = counter total

f_t = clock frequency in Hz

To complete the error detector, I used a latch to hold the output from one count to the next. The output of the latch is a TTL signal; one state indicates that the input frequency is too high and the other state indicates that the input frequency is too low.

filter

If the latch output were applied directly to the controlled reactance, the output frequency of the vfo would constantly be pulled one way and then the

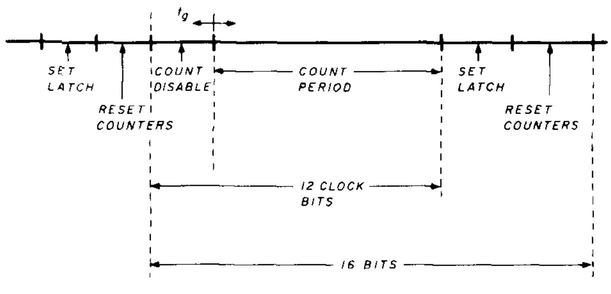


fig. 3. Timing cycle of the frequency lock loop system with interpolation. *The 74121 is used to shorten the count period,* permitting resolution within a 256 cycle group.

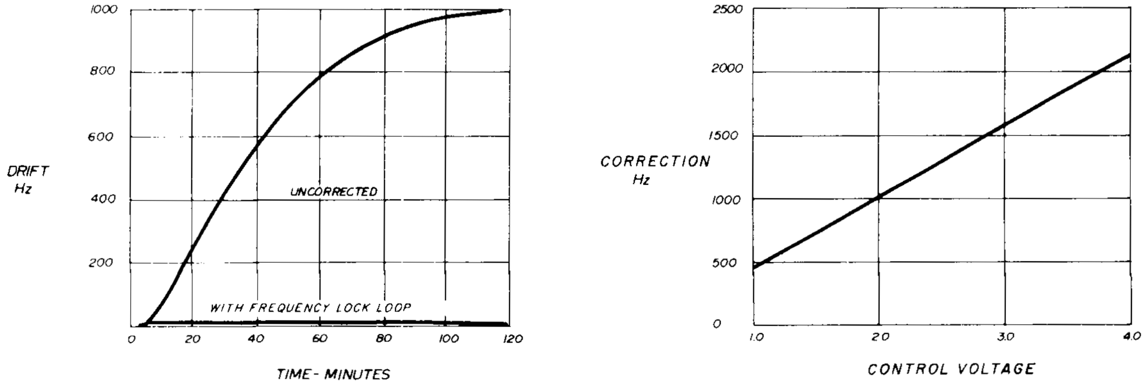


fig. 5. Oscillator drift with, and without, the frequency lock loop system. The range of the correction voltage is shown at the right.

other. However, the mean frequency would be correct. Intuitively, it seems that some smoothing is required. The FLL is very similar to a "bang-bang" servo, and can be readily stabilized by a first order filter or integrator composed of a single RC stage. The optimum filter is probably worth some investigation; nonlinear circuitry may also offer some advantages (a possible approach is described in reference 5).

The filter time constant t_f should be long enough to reduce the fm on the vfo to an acceptable amount, and yet not so long as to make the balancing time excessive. My experiments in this area seem to indicate that somewhere in the region of 50 to 100 seconds is a good starting point.

voltage-controlled reactance

The obvious choice for the controlled tuning reactance is a voltage-variable capacitor diode (varactor

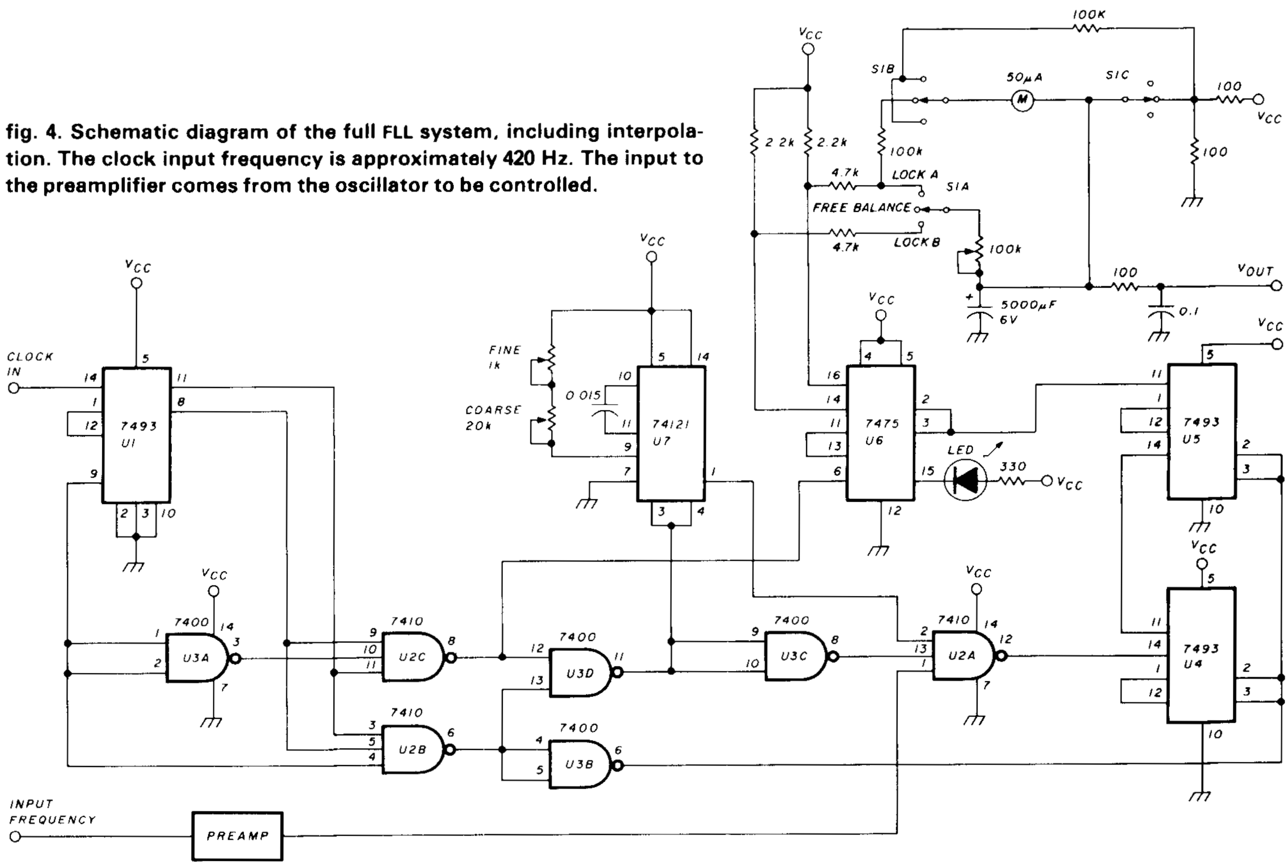


fig. 4. Schematic diagram of the full FLL system, including interpolation. The clock input frequency is approximately 420 Hz. The input to the preamplifier comes from the oscillator to be controlled.

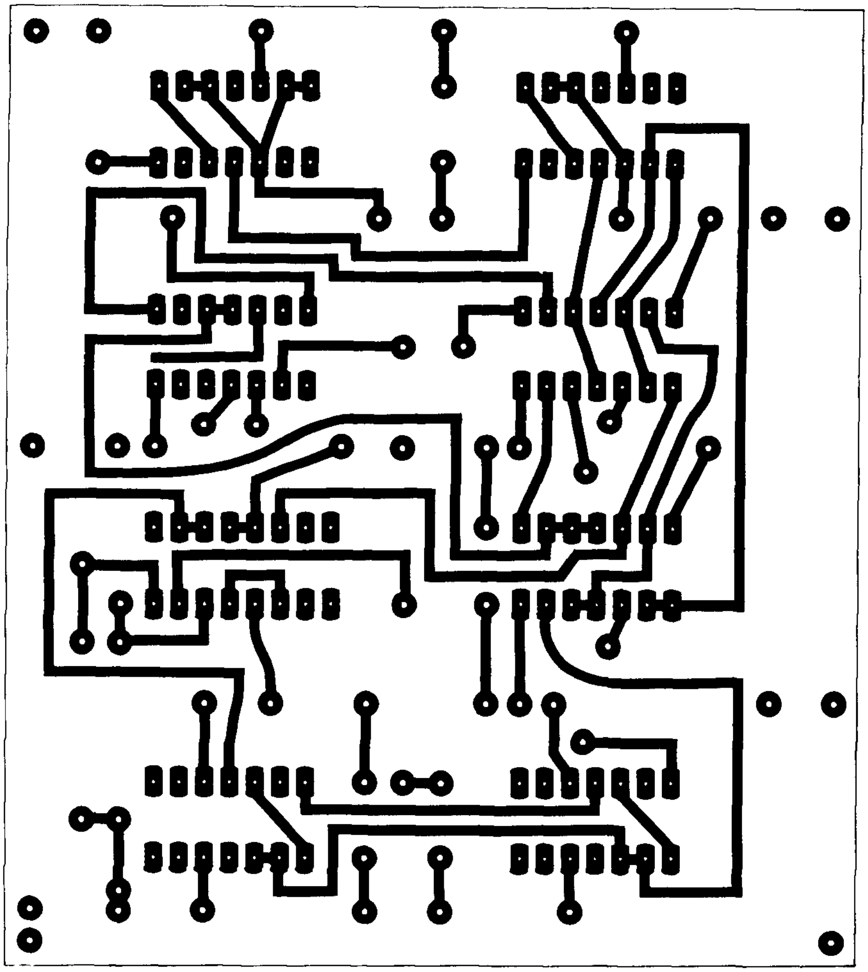


fig. 6. Circuit board layout for the frequency lock loop. Shown above is the back side of the board, with most of the interconnecting wiring; drawing on next page shows the top side of the board and the parts placement diagram. Although not included in fig. 5, this board contains an additional 7490 which is one of the input dividers from the oscillator. Also not shown in fig. 5 are the numerous 0.1-μF bypass capacitors included on the board.

or varicap). Its application is dependent on the design of the vfo which is to be stabilized. The filter output has a useful range of about + 1.5 to 3.5 V dc, although it would be a simple matter to include an op amp if a greater swing were required. The varicap should be connected to the oscillator tank so that it produces, with this voltage range, a frequency variation greater than the drift which is to be corrected.

In my Hammarlund HQ215 receiver I have been able to stabilize the high-frequency oscillator by coupling into a diode frequency shifter, which is provided for resetting the calibration when changing modes from USB to CW to LSB. Many transceivers have RIT circuits which provide similar access to the oscillator tank, while most transmitters and vfos can easily be modified as if you were providing for FSK operation.

interpolation

The basic FLL of **fig. 1** will stabilize a vfo at discrete fixed frequencies, based on a fixed count period determined by the counter clock. The first method of interpolation I considered was that of varying the clock-oscillator frequency, using a vxo as the clock oscillator. With this arrangement I found that

$$\Delta f_a / f_a = \Delta f_x / f_x \qquad (2)$$

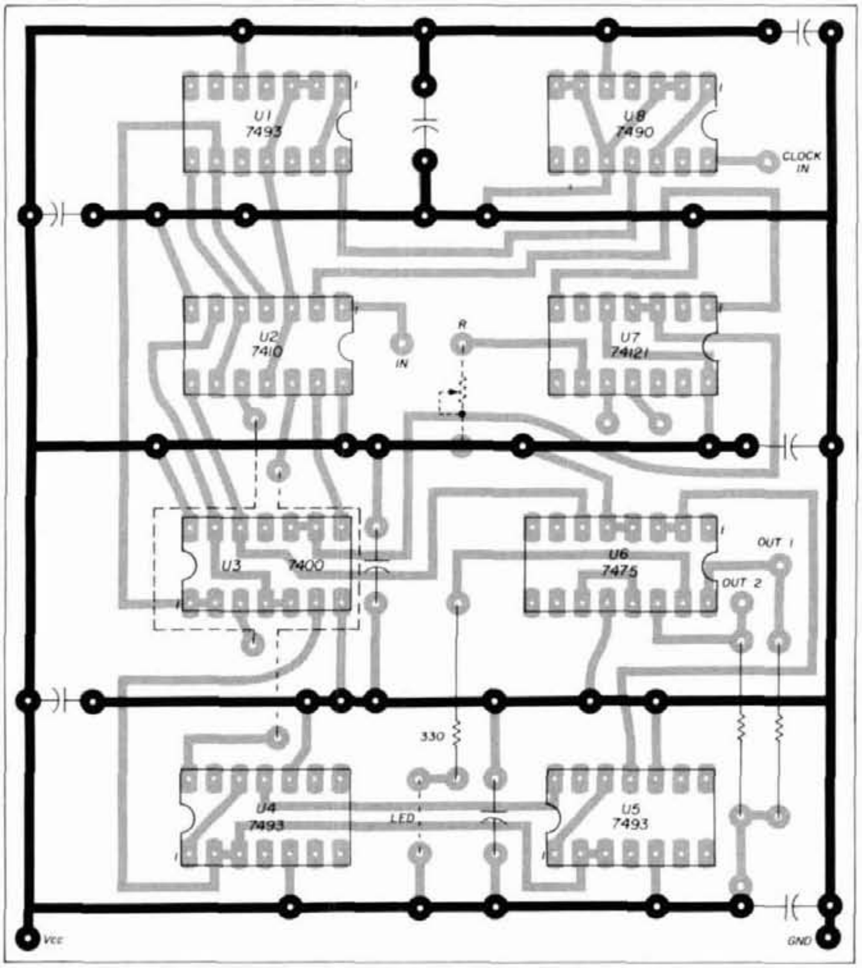
where

f_a is the basic clock oscillator frequency

Δf_a is the change produced by pulling the vxo

Δf_x is the resulting change

f_x is the controlled frequency



This places another constraint on the design, in that Δf_x must be at least as large as $f_n - f_{n-1}$, the difference between successive discrete stabilizing frequencies. But Δf_a is limited by the design of the VXO. Because of this factor, and also the decreased stability of a VXO compared with a regular crystal oscillator, this method was set aside for future consideration in favor of an alternative which permitted the use of a fixed-clock frequency.

The basic timing cycle is shown in **fig. 2**. It should be obvious that if the total counting period could be varied, by at least the time required to count one group of 256 cycles, then the problem of interpolation would be solved. A non-retriggerable one-shot multivibrator is used to create a noncounting period.

The new timing diagram incorporating the interpolating one-shot is shown in **fig. 3**; the schematic diagram shown in **fig. 4**.

operation

The lock switch, S1, is initially set to FREE. In this position the oscillator will be at its nominal calibrated frequency, because R1 and R2 have forced the tuning voltage to its center value. The LED indicator will show the latch's output state. As the oscillator is tuned across its operating range, the LED will cycle on and off every time the frequency changes by $f_n - f_{n-1}$.

If we now choose an operating frequency, the interpolation control is adjusted until the LED flickers, showing that the FLL is ready to lock. The lock point may be either at a 1 to 0 or a 0 to 1 transition as the freqency increases. At this point S1 is moved to either LOCK A or LOCK B. You will know if you've selected the wrong one because the oscillator will rapidly drive off frequency. Initially it is useful to establish a rule such as: clockwise rotation of pot, lights the LED, S1 to LOCK A. After this is established, when you select S1, you're on frequency to stay. Minor frequency adjustments can be made with the potentiometer.

A steady flashing of the LED is a good indication of continuing operation. Meter M1 is valuable in the lock mode to show how far you have drifted and how much corrective capacity you have left. While in the FREE position, it can be used to show which lock position to use and also which way to move the interpolation pot.

performance

In this system almost all of the stability is derived from the crystal clock, with the remainder determined by the RC product in the interpolator. Using the constants discussed, on 80 meters, this amounts to one group out of about 400. In other words, during the total gate period, about 400 groups of 256 cycles are passed, and therefore, only one four-hundredth of the period is dependent on the one-shot's stability. If this is as good as 0.1 per cent, the overall stability is close to one part in 400 000. There is, however, an interesting series of trade-offs between the various constants and values selected. A short-gate period makes the job of the filter easier and reduces the fm effect caused by ripple on the control voltage. A long-gate period, on the other hand, makes the unit difficult to use, but reduces the dependence of the overall stability on the one-shot. Having decided on the gate period, the frequency difference $f_n - f_{n-1}$ is a function of the total count k. If $f_n - f_{n-1}$ is too small, jumping from one stable point to another could presumably occur.

There are a number of points which can be further refined if greater stability were required, but I have found, for instance, that the present design has made it possible to operate unattended on 3600 kHz RTTY autostart, where a stability of ± 10 Hz is desired. My actual achieved stability, as shown in **fig. 5**, is closer to ± 5 Hz, which seems to indicate little drift in the one-shot.

conclusion

The frequency-lock loop provides a simple and effective way of improving the stability of a vfo, effectively competing with a crystal oscillator. Equipment modifications are minimal and can be largely outboard. The components of the FLL itself are all TTL, readily available and inexpensive, while the control system is easy to use and has no tricky components or adjustments. Construction follows normal TTL practice and the simple double-sided layout shown in **fig. 6** is suggested for the main board.

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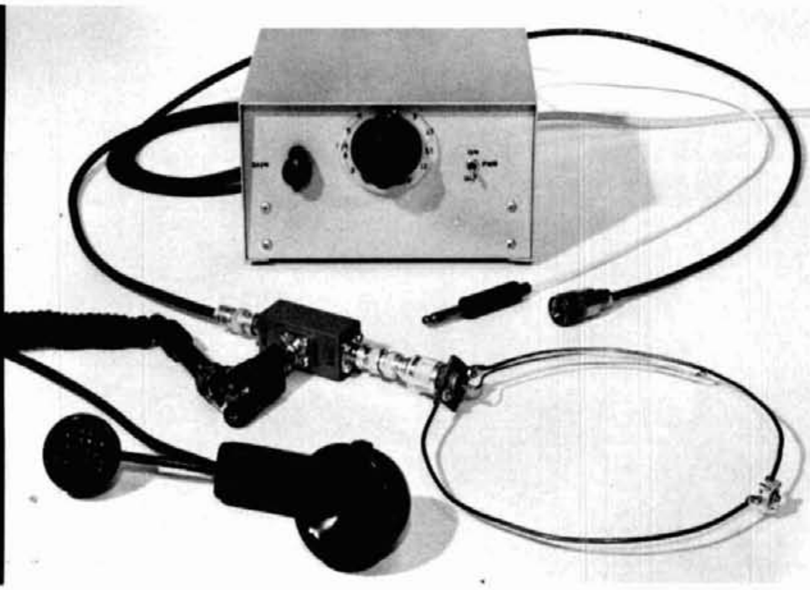

TVI locator

Locating and correcting the source of TVI is perhaps one of the most difficult tasks facing a radio amateur, one which must be performed methodically if satsifactory results are to be obtained. Much has been learned and written about transmitter harmonic radiation and TV receiver overload, but often very little is said about another prevalent and frustrating source of TV trouble, nonlinear rectification TVI.

Rectification TVI is caused by poor or intermittent contact between two conductors in the radiation field of a transmitting antenna. No amount of filtering or shielding at either the transmitter or TV set will correct the problem, since the interference is generated in the TV spectrum as direct harmonics of the transmitter's fundamental frequency.

In January, 1953, a fine article by Mack Seybold, W2RYI, was published in QST,[1] but I have seen nothing of a concrete nature on this particular problem since that time.

how do I know I have it

Rectification TVI can be suspected when suddenly there is TVI on one or more channels where there was none before, and no changes have been made in transmitter operation. Any metallic discontinuity can cause rectification TVI. In 1947, when I was living in a small town and in the days before the blessings of TV, my next-door neighbor said he heard voices coming from his bathtub drain. Another neighbor heard voices coming from her electric kitchen range. Both voices were caused by detection of my 75-meter a-m kilowatt rig. These two phenomena, no doubt, were caused by rectification.

The strength of the TVI will depend on the efficiency of the rectifier, the length of the "antenna" connected to the nonlinearity, the distance from the transmitting antenna, and the transmitter output power. Two signals on widely separated frequencies can also combine to produce a signal at a third frequency — the faithful $2A \pm B$, or intermodulation products. For example, if two hams live near each other, and one is on 21 MHz and the other on 28 MHz, interference can be caused on channel 4 ($2x21+28=70$ *MHz*) or channel 5 ($2x28+21=77$ *MHz*), or both, if a nonlinear discontinuity exists in the area. These two signals, of course, will exist only when both stations are transmitting. Also, each signal alone can cause TVI on channel 2 ($28x2$), channel 3 ($21x3$), and channel 6 ($28x3$ and $21x4$).

Visible TVI can be caused by an interfering signal as weak as 40 dB below the video carrier, depending on the frequency of the interference. A 1000 μV video signal, which is an adequate signal, can be interfered with by a 10 μV harmonic. If the amateur transmitter is running one-kW input, this does not leave much margin for harmonic generation.

All 14-MHz harmonics through the sixth can cause trouble, but the greatest problem is caused by the odd harmonics, the third and fifth. **Table 1** shows the harmonic relationships of the 14, 21, and 28 MHz amateur bands with respect to the TV channels. The worst interference is caused at or near the video carrier, 1.25 MHz above the lower TV channel edge. With all stations using color, however, a particularly vicious interference is caused by a harmonic falling on or near the color subcarrier frequency, 4.8 MHz above the lower TV channel edge.

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This effect was noted at W6BD on channel 4 when operating near 14.2 MHz. The interference appeared as wide diagonal color (rainbow type) bars on the screen. The fifth harmonic of the fundamental fell within 200 kHz of the color subcarrier at 70.8 MHz. Operation in the CW portion below 14.1 MHz caused no interference. Substitution measurements with a calibrated signal generator showed that color bars were caused by an interfering signal at 71.0 MHz with a signal strength of less than 300 μV. The desired channel 4 signal was 1500 μV. The cause was eventually traced to rectification TVI and was located by the methods presented here.

the fix for the hex

The harmonic chaser used in this hex-pedition (an expedition to find the hex) is simple to construct, easy to use, and will rapidly locate the source of the harmonic radiation. It is also, by today's standards at least, inexpensive. In this instance, the whole system was constructed and tested and the TVI source found in one weekend, so the work involved in the project is not great.

table 1. Amateur-band harmonic relationships to low-frequency TV channels. All frequencies are in MHz.

fundamental 28	21	14	harmonic frequency	TV frequency band	TV channel number
harmonics					
2		4	56	54 - 60	2
	3		63	60 - 66	3
		5	70	66 - 72	4
				76 - 82	5
3	4	6	84	82 - 88	6

Since the harmonic strength will be a relative measurement, a narrow-band receiver, tuned to the harmonic frequency, will be used. The easiest approach is to use a TV tuner whose i-f output is in an amateur band. This allows the selective station receiver to become the i-f amplifier and detector.

There are generally two types of tuners used for replacement purposes, the turret type and the wafer type. Due to the coil arrangement of the wafer-type tuner, it is unsuited for this purpose because the tuner's oscillator frequency must be changed. The most easily modified is the turret type, because the coils

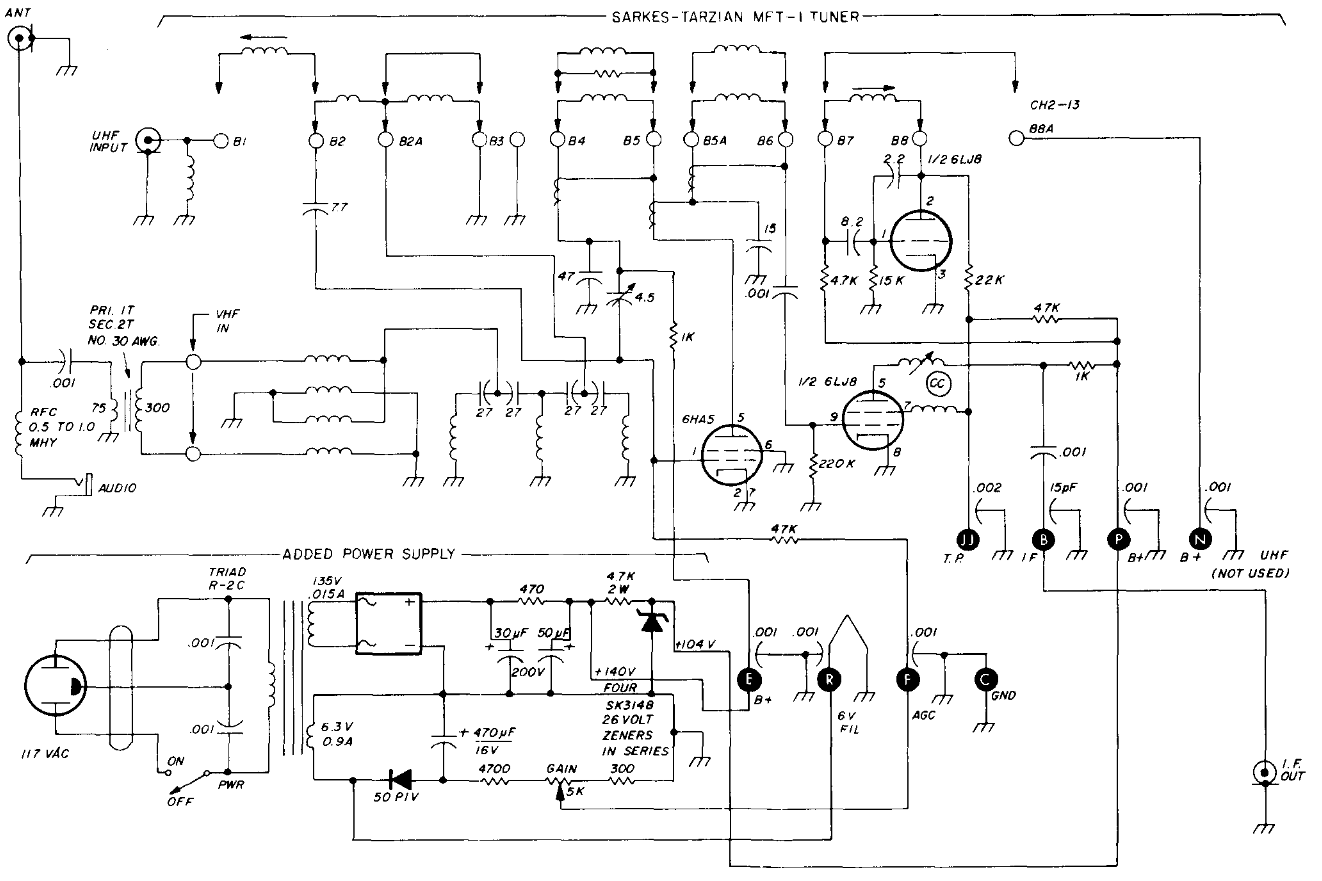


fig. 1. Schematic diagram of the Sarkes-Tarzian tuner and power supply. The coil marked CC is tuned for maximum signal into the receiver. You should not use more than about 60 cm (2 feet) of cable between the tuner and the receiver, otherwise the tuner may not cover the desired output frequency range.

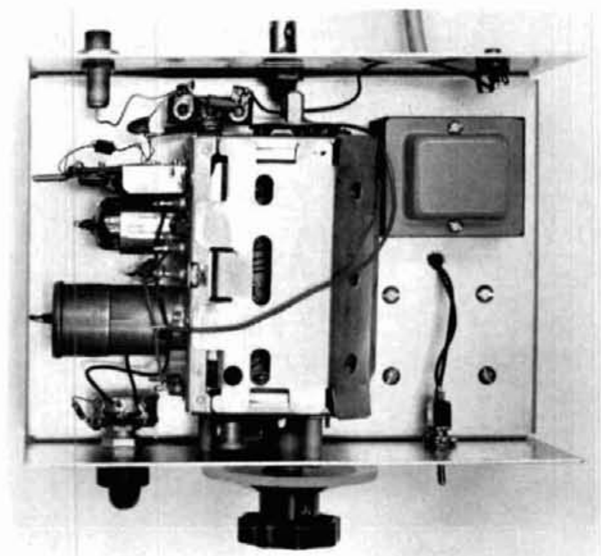
for each channel are mounted on an easily removable bar. Present-day tuners have an i-f of 41.25 to 47.25 MHz, out of the range of most ham receivers. The widest high-frequency amateur band is 28 to 29.7 MHz. Therefore, the oscillator frequency needs to be lowered only about 10 to 12 MHz to produce an i-f output at 29.0 MHz.

The tuner used is a replacement type, Sarkes-Tarzian MFT-1 preset replacement tuner (see **fig. 1**). It is housed, with a small power supply, in an LMB 12.7 x 11.4 x 19.1 cm (5 x 4-1/2 x 7-1/2 inch) W-2F chassis cabinet. Except for the tuner and cabinet, which cost about $27, all parts came from the junk box. Purchasing everything, and with a little horse trading and typical ham ingenuity, the entire cost should not exceed $40.

construction

The original cut-and-try coil modification was performed using a frequency counter. A counter is not absolutely necessary, but if one is available, the job is much easier. If not, a reasonably accurate grid-dip oscillator (GDO) can help set the tuner's oscillator to the required frequencies. The oscillator was tuned to the high side of the desired signal because it did not want to oscillate on the low side. Therefore, as shown in **table 2**, the 10-meter receiver tunes backwards.

The only coil to be rewound is in the oscillator, the coil with the fine-tuning screw slug. Remove the snap-off shield from the tuner chassis. The channels to be modified are 2 through 6, since 7 and above are



Interior view of the tuner section. Loop-antenna input connector is at the left rear, i-f output jack to the receiver in the center, and audio from the receiver is at the extreme right. The 4:1 balun, to match the 75-ohm line to the 300-ohm input, can be seen just below the type-F connector.

not normally subject to rectification TVI. Channel 5 doesn't have to be modified, since no discrete amateur-band harmonic normally falls in this channel. Citizens band harmonics, however, do fall in channel 5.

Rotate the shaft until the bar with the greatest number of coil turns (channels 2 through 6), starting with the bar adjacent to the uhf strip, can be pulled out with the long-nose pliers. The uhf strip has no oscillator coil. The bars are easily removable, but use caution, as they can be broken. Pull at the pressure-finger point, the end with the tuning screw.

Remove all turns from the oscillator coil and clean the soldered portion of the contacts. Use care not to get solder on the switch contact portion of the terminals. Rewind the coils as shown in **table 2**; number 28 (0.32mm) AWG or number 30 (0.25mm) AWG enameled wire can be used. Wind on the number of turns indicated for each channel, observing the same winding direction as used on the other coils on the bar. Wind the turns close-wound, starting at the slug end. If necessary, the turns can be spaced later for the proper frequency range. Unscrew the fine-tuning screw about five turns out from full in. This will provide adjustment range later for the oscillator. Screwing the slug *into* the coil *raises* the oscillator frequency, and therefore raises the intermediate frequency to which the receiver is tuned. After each coil is rewound, return the bar to its original position in the turret to prevent mixing their positions.

Install and wire the power supply, jacks, and splitting filter as shown in **fig. 1**. Jacks and power supply may be whatever you have on hand in the junk box. Plate voltage for the tuner may be anything between 110 and 140 volts dc. The bias voltage is obtained from a rectifier on the 6-volt ac filament winding. The values shown for the resistors give a minimum of −0.8 volt and a maximum of about −4 volts. Normal operation is at full negative, but, if desired, the bias may be permanently set at −3 volts by selection of appropriate resistor values.

Install the tuner in the cabinet, mounting it with screws and spacers to the panel. Three of the front holes (near the shaft) will conveniently accept a 6-32 (M3.5) tap or a number 6 sheet-metal screw. For ease of fine-tuning adjustment, a piece of lucite (*Plexiglas*) — cut to 5.7 cm (2-1/4 inches) in diameter by a circle cutter — forms a good control wheel, similar to the fine-tuning control on a TV set. The center hole is sized for a force fit on the fine-tuning shaft, which is 9.5 mm (3/8 inch) in diameter. Mark the plastic shaft and then cut it to length with a hacksaw, after which the fine-tuning wheel may be forced onto the shaft.

Mark the length required on the selector shaft, cut it with a hacksaw, and smooth with a file. Rotate the

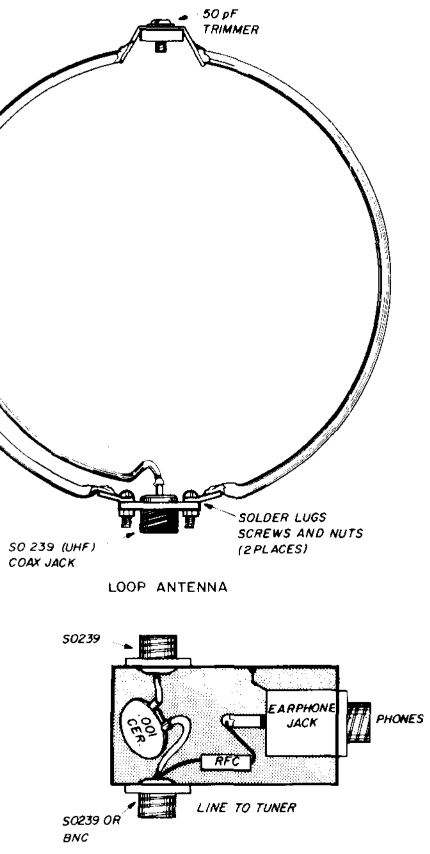


fig. 2. Diagram of the loop antenna and splitting filter. The filter is constructed in a small box, such as an LMB-M-00. The capacitor at the top of the loop is a 50-pF compression trimmer and is used to tune the loop to the desired frequency.

shaft with pliers so the uhf strip is in its operating position, then mount a skirt-type knob with the indicator mark toward the bottom of the panel. Channel 2 will be at the first position to the left of bottom as the turret knob is rotated clockwise.

loop antenna

The loop is constructed of two 25-cm (10-inch) lengths of number 10 (2.6 mm) AWG wire formed into a loop about 18.5 cm (7-1/4 inches) in diameter (see **fig. 2**). The base of the loop is fastened to the shell of an SO239 uhf jack, with screws and nuts holding two soldering lugs onto which the loop wires are soldered.

A 50-pF trimmer is soldered to the wires at the top of the loop. A piece of number 12 (2 mm) AWG or number 14 (1.6 mm) AWG copper wire is soldered to the inner terminal of the SO239 jack, formed to the contour of the loop with 6- to 9-mm (1/4-to-3/8-inch) separation, and soldered to the loop 13 cm (5 inches) up its circumference.

Using appropriate connectors and a very small metal box, the splitting filter is constructed for the earphone or telephone connection at the base of the loop. When connecting the filter to the antenna, observe the connections shown in the figure. If connected backwards, the loop will work, but no sound will be heard in the phones.

tuning

Connect the tuner and station receiver together as shown in **fig. 3**. Temporarily connect the harmonic-producing network (**fig. 4**) between the tuner and transmitter output. Place the tuner on channel 2; tune the receiver to 29 MHz and the transmitter to 28.000 MHz or 14.000 MHz. Only very low output is necessary, just enough to make the diode conduct, producing harmonics. Turn the transmitter on, and also the receiver bfo. *Very slowly*, rotate the fine-tuning control until the transmitter harmonic at 56 MHz is heard. Verify this frequency by using the GDO as a signal generator. If no signal is heard, tune the receiver between 28 and 30 MHz and adjust the fine-tuning control until the 56 MHz harmonic is received. Do not confuse the desired signal with the fundamental or second harmonic of the transmitter output, bypassed around the tuner. Then jockey the receiver tuning and fine-tuning control on the tuner until the second harmonic of 28 MHz or the fourth harmonic of 14 MHz (56 MHz) is at 29 MHz on the receiver. Look up the signal frequencies for the various TV channel video and sound carriers in **table 2**. If channel 2 exists in your area, it can easily be heard when an antenna is connected to the tuner input and the

table 2. LO coil winding and i-f frequency output data for TV tuner modification. All frequencies are in MHz.

channel	LO coil number of turns	LO frequency	TV video / receiver i-f	TV sound / receiver i-f	receiver dial frequency 31 30 29 28 27 26 25
2	16	85	55.25 / 29.75	59.75 / 25.25	54 55 56 57 58 59 60
3	14	92	61.25 / 30.75	65.75 / 26.25	61 62 63 64 65 66 67
4	14	99	67.25 / 31.75	71.75 / 27.75	68 69 70 71 72 73 74
6	11	113	83.25 / 29.75	87.75 / 25.25	82 83 84 85 86 87 88

receiver is tuned to the indicated i-f frequency. In my test set-up, a 3 μV signal on any of the converted TV channels could easily be heard in the receiver.

Repeat the tuning procedure for the other channels and amateur bands according to the table. Note that the video or sound carrier can be used as check points if they're within the tuning range of the station receiver. I use my old Hammarlund HQ129X. The video carrier is a strong signal with 15.75 kHz sidebands extending several hundred kHz each side. The sound carrier has distorted modulation, since it is fm.

The loop is connected to the tuner via a convenient length of RG-58 or RG-59 cable equipped with suitable connectors. The most inexpensive connectors are F-type, used for TV cable connections. In my case, in order to reach the source of the rectification, 60 meters (200 feet) of cable was required. If you use F-type connectors, note that they are designed for coax with a solid center conductor.

The loop antenna operates as a radio direction finder to locate the source of signal rectification causing generation of harmonics. In order to hear the effect of loop rotation on the signal, the audio output of the receiver is sent via the coax cable to headphones or a telephone carried by the loop-antenna operator. While slowly rotating the loop about its vertical axis, a distinct null, about 2 or 3 degrees wide, is easily heard.

Although a loop is normally bidirectional, in this case, due to the tapped feed point, it exhibits about 10 dB of front-to-back ratio when properly tuned. With the operator looking through the loop, he is facing the signal when the deepest null is heard with the feed tap on the *left* side of the loop. Rotating the loop about its horizontal axis will indicate, by a deeper null, the angle of elevation of the incoming signal. For maximum directivity, the trimmer capacitor must be tunned for maximum signal at the frequency of interest.

Loop operation can be verified by tuning it and the

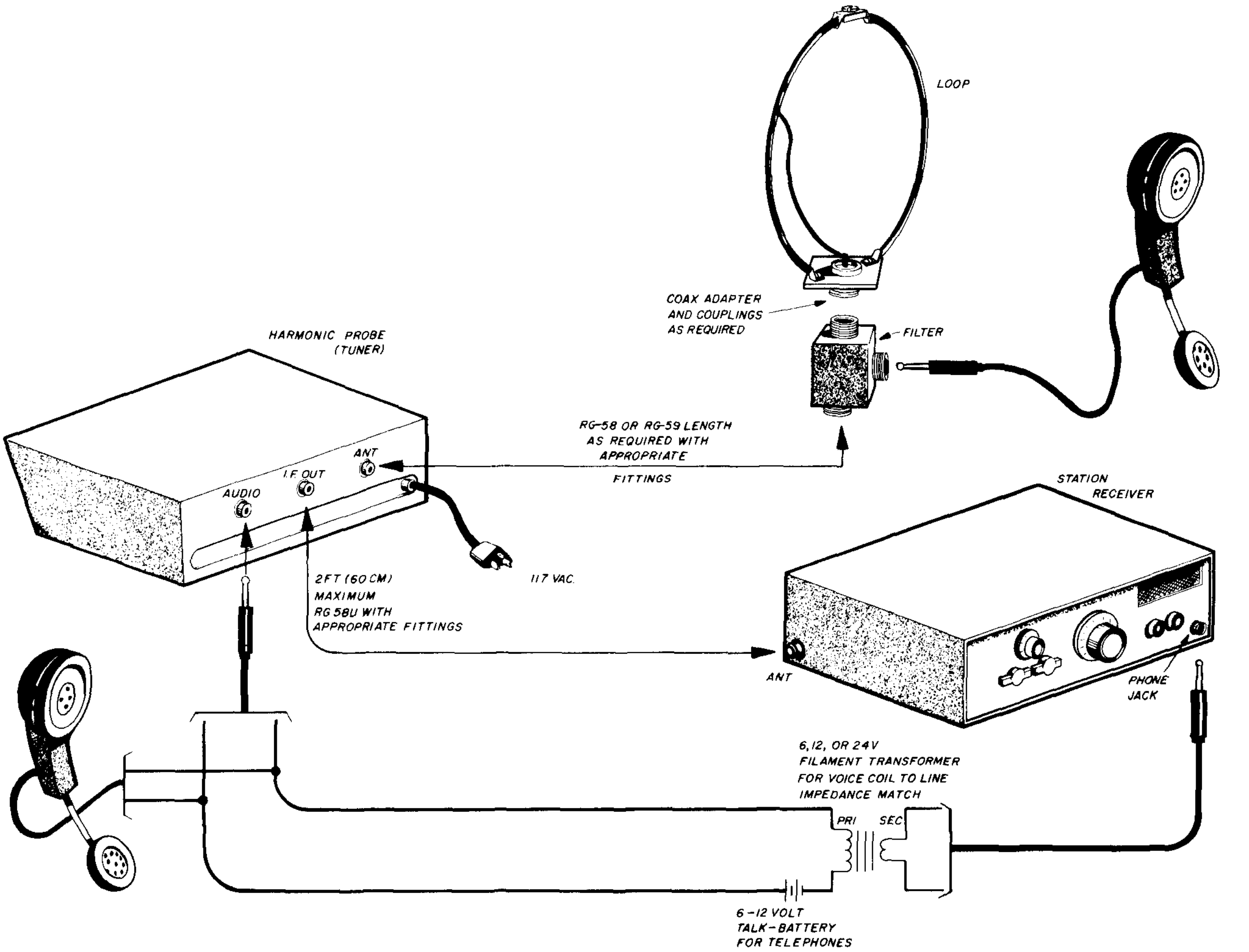


fig. 3. Interconnection diagram of the loop, tuner, and receiver. The earphone and microphone of each handset are connected in series. The battery is not required if the earphones alone are used.

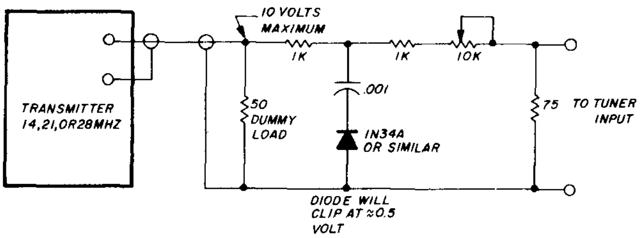


fig. 4. Schematic diagram of the harmonic-producing network. This circuit is used to produce harmonics to calibrate the tuner and receiver. A maximum of 2 watts should be applied.

receiver to a TV station and observing the effect of rotation. This test may be invalid if many echoes exist from pipes, ducts, or other large metal surfaces. This same effect must be considered when looking for TVI.

finding the hex

Set up the equipment as shown in the block diagram, **fig. 3**. Tune the TV set to the channel having interference. Turn on the transmitter and verify that it is causing interference, then turn the tuner to the same channel. Use only sufficient transmitter power to cause TVI. Tune the receiver to 29 MHz and find the harmonic. Note that **table 2** is based on the lower edge of the 14-, 21-, and 28-MHz bands. Also note that the receiver, used as an i-f amplifier, tunes backwards. For example, if 21 MHz interferes with channel 3, the third harmonic is at 63 MHz and is tuned on the receiver at 29 MHz. If the transmitter is tuned to 21.3 MHz, the third harmonic is at 63.9 MHz and will fall at an i-f frequency of 28.1 MHz on the receiver dial.

Set the receiver controls for CW operation, and tune the harmonic so that its detected audio frequency is about 1 kHz. It will be necessary to retune the receiver from time to time since the oscillator will drift slightly. Therefore, an operator should be at the receiver for periodic tuning, and to key the transmitter on request. If two telephone handsets or operator's headsets are available, constant communication between the antenna and receiver operators is possible.

Go outside the house and take a preliminary bearing on the interference source. Note the direction (a rough sketch or map may be helpful). Go to a second location and take a second bearing. In all but the most elusive cases of interference, two or three bearings will suffice. Rotating the loop axis vertically, rather than horizontally, will indicate the elevation of the source above ground level.

Under certain conditions, it may be advantageous to turn off the receiver agc and have the receiver operator control the signal level with the receiver's rf gain control. When nearing the interference source, or when using the probe as a "sniffer" for harmonics radiating from equipment, a coax plug fitted with a few centimeters of stiff wire will serve as a probe antenna.

Due to the attenuated response of the loop antenna at the normal amateur frequencies, a highpass filter of the TV type was not found necessary. If one is used, it must be located after the splitting filter in the tuner, or the telephone extension will not work.

where to look

Many things can cause a rectification-harmonic problem. Some of these are rain gutters, downspouts, roof flashing (the metal under shingles), corroded TV antennas, rusty TV masts, poor (unsoldered) splices in TV feedlines (or in the station antenna system both transmitting and receiving), poor electrical conduit joints and other metal junctions of this nature, all transistorized equipment, intercoms, pipes, telephones, concrete reinforcing bars — the list is almost endless. Any two touching pieces of metal more than a few centimeters long in the field of the transmitting antenna are suspect. The obvious solution to the problem is to permanently bond the two pieces, or, if no electrical continuity is necessary, to permanently insulate them.

Three cases have been found and corrected at my location, galvanized-tin roof flashing and corroded TV antennas on two adjacent houses being the cause. In the latter case, good relations have always been maintained with the neighbors, so no problem existed in correcting the situation. In fact, one case resulted in a very nice Christmas gift as an expression of gratitude. The tin flashing problem was fixed by permanently connecting the two pieces with sheet metal screws and anti-corrosive grease, permanent separation being impractical. The corroded TV antennas were scraped clean at the connection points and then painted with an anti-corrosive grease.

About eight years ago, long before this equipment was built, I found a source of rectification in my own TV antenna so severe that a 75-watt transmitter on 3.5 MHz feeding a dummy load caused TVI. A friend and I found the cause, wholly by accident, after a prolonged search. With the equipment described here, it would have been found in minutes. Now that you have the tools, good hunting, and may all your hexes be easy ones.

reference

1. Mack Seybold, "Harmonic Radiation from External Nonlinear Systems," *QST*, January, 1953, page 11.

ham radio

a dream realized: the ultimate antenna array

A 7-element quad on 40 meters? You'd better believe it! Here's an account of how one DXer solved the problem of big antennas

Most of us at one time or another have fantasized about having the ultimate array: the antenna to make you king of the band; the supergain bone crusher. Usually these dreams are dashed away by the reality of circumstances, but sometimes someone will succeed in getting one of these monsters up. Although, generally, this supreme achievement will go unnoticed by most, the rewards of the labor are still collected in abundance by the ambitious amateur who undertakes the challenge and succeeds.

The following account isn't meant to be a construction project but is presented with the hope that some of the ideas will convince others that, first, you don't need a lot of money to build a large array; and, second, some dreams can come true with a little applied ingenuity.

how it all began

Having been one of those few fortunates who've had the pleasure of operating at a large multi-multi station during DX contests, I've become appreciative of the merits of high-gain antennas. One day in early 1973 I was discussing various antennas with Jerry, WA7KYZ, when the subject of 40-meter arrays came up. Since 40 meters is generally considered to be the transition between wire dipoles and rotatable beams, we decided to experiment with some high-gain fixed-wire antennas on that band. Fortunately, we had a sizable piece of land on which to work. This property was dotted with 46-meter (150-foot)-high Douglas fir trees.

initial attempts

The first antenna we tried was a full-size four-section 8JK beam. On paper it looked really simple, but it turned out to be a real monster. We had to resort to using 2.6 mm (no. 10) copper-plated steel wire for the elements and 17-foot-long 1x6s (5 meters x 25 x

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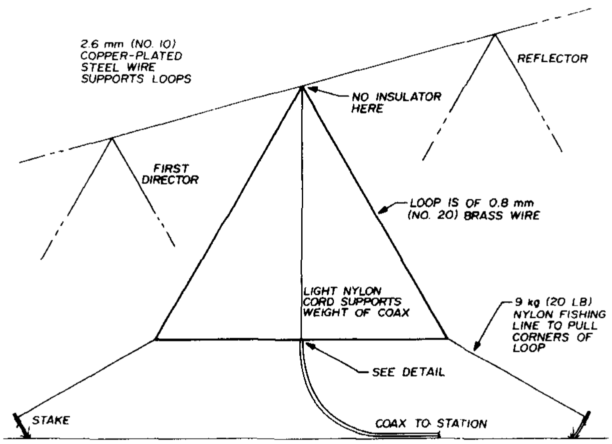
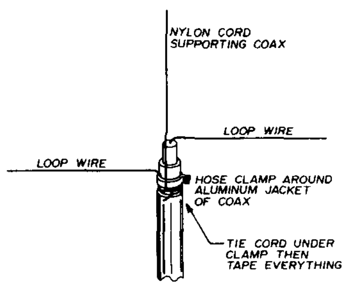
152 mm) for the spreaders. We finally got the thing up in the air by pulling up the ends with a pickup truck.

The antenna worked reasonably well. It seemed to have a low angle of radiation, as it was supposed to, and it definitely had gain. But it performed well in only two directions. It had a very narrow beamwidth. Additionally, we had a problem that we hadn't contemplated: we had to keep untangling the open-wire feedlines. Also, we had to use a transmatch, which made things even more cumbersome. The antenna eventually came down when an ambitious ten-year-old neighbor untied one of the support ropes at the base of the tree. We had mixed feelings about the array's demise.

the grand experiment

We fiddle-fumbled around for some time before we came up with the ultimate solution, the utopian array. It was to be a multi-element delta-loop quad. We decided to go with seven elements aimed at Europe. Every amateur in Washington state who works DX knows that the European path is the toughest nut to crack, because we have to battle the northern auroral zone. The east-coast guys have the same problem working into Japan. So we had to have a lot of gain; however, we didn't want to narrow the pattern of the array too much. We could have put three times as many elements on the thing,





DETAIL OF FEED POINT

fig. 1. Details of the driven element for the 7-element, 40-meter delta-loop quad antenna. High Douglas fir trees provided the supports. Handbook data were used for loop dimensions and element spacing, which was 0.2 wavelength. The vswr was measured at 1.5.

since the supporting wire was 137 meters (450 feet) long! We couldn't use the 2.6-mm (no. 10) wire for all the elements and support because it would have made the antenna much too heavy, so we used 0.8-mm (no. 20) brass wire for the elements. Sounds

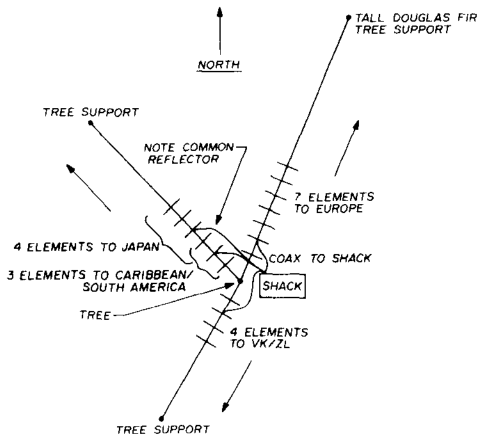


fig. 2. The ultimate antenna farm, which includes three switchable monster arrays covering Oceania, Europe, and South America, including the long path to the Orient.

flimsy, all right, but it works fine for a temporary effort. We really lucked out on the element wire. I picked up 1220 meters (4000 feet) of it at a surplus place for $4.00. We used 9 kg (20-lb) nylon fishing line to pull out the corners of the loops. Jerry picked up some 75-ohm coax remnants from the local cable television company, so we used some of this for the feedline.

up she goes

Now, back to the support wire. Our two support trees were 137 meters (450 feet) apart. We couldn't afford polypropylene or similar rope, so we decided to use some of the 2.6-mm (no. 10) wire left over from the 8JK project. We used no insulators to separate the loops from the support wire as they were unnecessary. As soon as the array was secured, we checked the swr to find that it was only about 1.5:1. We used 0.2-wavelength spacing between elements and the customary formula for loop dimensions. We kept all directors the same size. We found that the array would sway freely but not excessively with the breeze.

I wanted to photograph our antenna for posterity, but this proved impossible. All that was visible in the photos was a 137-meter-long (450 feet) wire, two trees, and a piece of coax reaching up into the air and seemingly terminating into nothing. There are definite possibilities here for those who need to display as little antenna as possible.

It took Jerry, my brother, John (K7TU, ex-WA7OTT), and me about a day and a half to build the antenna from scratch. As we secured each element, we pulled up the support wire a bit. We used a small butane torch to solder the loops to the supporting wire. To support the coax so it wouldn't pull the loop out of shape, we ran a nylon cord down from the supporting wire to the feed point (**fig. 1**).

performance

I only use published gain figures as a ballpark method for deciding what kinds of array to consider, and I never tried to measure the gain of this antenna with respect to another antenna because of the many variables involved. My method of evaluation is to just get on the air and see how well the array works by communicating.

With the antenna connected to the rig, we tuned through the CW band and came across several UA1s and UA3s. (Remember — this was on the 40-meter band.) Their signals were so weak the S-meter didn't move, but all were solid copy. The only other signals on the band were some rag-chewing W6s. It doesn't sound too impressive until I mention that this first check was carried out at 12 o'clock noon.

A couple hours later we were able to work into Europe with consistent S4-S6 signals using only a barefoot T4X exciter. Later on that evening we were getting consistent 599 reports from all over Europe. The Europeans we worked were all solid copy. Our antenna was turning out to be a great performer.

further experiments

When we found out how well our antenna was performing, we decided to erect three more of similar type. We had enough material to erect three elements centered on the Caribbean/South America region, four elements on Japan, and four elements on the VK/ZL/Europe long path (**fig. 2**). By now we knew how to go about constructing the antennas, and the three new ones only took another day to erect. Upon trying them out we found that all three new antennas performed very well also.

sidelights

At this point a small anecdote relative to our antennas is appropriate. Soon after we got the four arrays up I was stringing JAs at about 9 o'clock in the evening when Gordy, W7SFA (now W7FU), broke in. He wanted to know how well I was hearing Japan. I told him that signals were moderate. This revelation must have surprised him, because he asked me what kind of antenna I had. I told him I was using a 4-element quad and that it was working quite well. Upon being asked by him if I could rotate my quad, I replied that I could and told him to stand by. At that point I paused and flipped the antenna switch over to the European 7-element job, which just happened to be pointing directly at him. I hit the key again and asked him how it sounded. I won't repeat his reply here. And, quite frankly, his signals came up so much with the switch of antennas that their strength almost blasted me right out of my chair. Whew!

As flimsy as the antennas appeared, they proved to be very durable. They remained erect through several storms and during both weekends of the CQ WW DX Contest. In fact they were still in the air when the location had to be vacated a couple of months later.

Although we couldn't use the antennas on a permanent basis, they were still well worth the effort. I'll never forget how much fun it was to tell the Europeans on 40 meters; "The antenna here is a 7-element quad."

ham radio

"Since you're afraid of heights I was sort of hoping for a brother to help with my antenna."

Pictured with optional HD-1984 Micoder II™

More Details? CHECK—OFF Page 126

higher frequency resolution

for an hf synthesizer

A unique method for obtaining 10-Hz increments from an hf synthesizer using a dual vco system

The advent of low cost phase-locked-loop frequency synthesizers has had considerable impact on vhf amateur radio equipment. Unfortunately, the frequency synthesizer is most adaptable to channelized systems, consisting of a finite number of discrete operating frequencies. Typical high-frequency amateur activity consists of tuning an analog-oscillator controlled radio to a clear frequency and making a call. To answer such a call, with single-sideband equipment, you must tune to within 50 Hz of the originating station's frequency for near natural voice reproduction. This means that a practical, synthesized, hf ssb transceiver must be capable of continuously tuning in 100 Hz steps, and requires an internal, loop-reference frequency of 100 Hz in a conventional configuration. The loop filter cut-off frequency required to effectively eliminate reference frequency sidebands from the synthesizer's output increases the loop lock-up time to several seconds after each frequency change. The ideal amateur CW receiver, equipped with narrowband i-f or audio filters, must be continuously tunable in 10-Hz steps, and this would have ten times longer lock-up time between frequency changes.

This article briefly describes a less common approach to an hf synthesizer which offers 10-Hz frequency steps from a 10000 Hz reference, and therefore offers 1000 times faster recovery after frequency excursions. In addition, less rugged mechanical construction of system oscillators is possible because of loop correction of low-frequency fm due to vibration.

Fig. 1 is a functional block diagram of a conventional PLL frequency synthesizer. The phase detector supplies correction pulses to the vco, through a low-pass filter, at a frequency equal to the reference frequency, until the vco is locked at a frequency equal to N times the reference frequency. A lower reference frequency requires a lower filter cutoff for a given attenuation of the ac component of the reference frequency. The filter is part of the closed loop and its response determines the maximum rate of vco frequency correction.

Fig. 2 is a functional block diagram of a two-part synthesizer, offering 10-Hz steps with the advantages of a 10 kHz reference frequency. Note the use of two reference frequencies, 10.000 kHz and 9.990 kHz. The output frequency is actually the difference frequency between two phase-locked oscillators. To change the output frequency by 10 Hz, we move the first oscillator 10.00 kHz; next, we move oscillator number two 9.99 kHz in the same direction. The difference between the oscillators' frequencies has only changed 10 Hz.

In the following example, I have made provisions for high-side LO injection in a super-heterodyne application, employing a 9.0 MHz i-f system. Also, sample calculations are shown for bfo/carrier frequencies of 8998.5 kHz for lower sideband and 9001.5 kHz for upper sideband (remember the sideband inversion with high-side local oscillator injection). The actual operating carrier frequency is programmed in BCD into the circuit's adders. Functionally, the circuit is divided into two major sections. Section two covers a range of approximately 50 to 60 MHz, with section one covering approximately 59 to 99 MHz.

To run section two at approximately 50 MHz, a divide ratio (programmed vco 2 offset) of 5005 is *initially* chosen for divider 2. To the resulting frequency

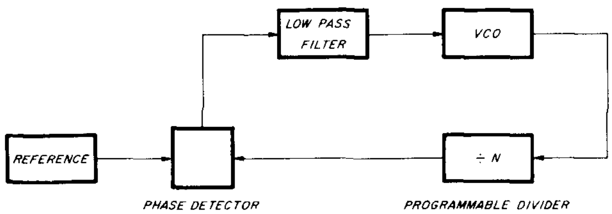


fig. 1. Block diagram of a conventional PLL synthesizer.

By William E. Coleman, N4ES, E-Systems/ECI Division, Box 12248, MS 11, St. Petersburg, Florida 33733

(49999.95 kHz) is added the bfo frequencies of 8998.5 kHz and 9001.5 kHz, producing the initial vco 1 frequency. This procedure allows us to calculate the final required programmed offsets for dividers 1 and 2 (**fig. 3**).

Therefore, for a programmed operating frequency of 00000.00 kHz, divider 1 must divide by 6744 for lower sideband, and 6045 for upper sideband as shown in **fig. 1**. Vco 1 will then operate at 67440 kHz for LSB and 60450 kHz for USB (**fig. 4**).

And, for a programmed operating frequency of 00000.00 kHz, divider 2 will divide by 5850 for LSB and 5150 for USB. Vco 2 will operate at 58441.5 kHz for LSB, and 51448.5 kHz for USB (**fig. 5**).

With a sample operating frequency of 14307.96 kHz USB programmed into the synthesizer's data input, divider 1 would divide by 8271. Vco 1 would operate at 82710 kHz (**fig. 6A**). Divider 2 would divide by 5946, and vco 2 would operate at 59400.54 kHz (**figs. 6B** and **6C**).

The i-f offset is implemented by separating the divide cycle of each programmable divide chain into

ESTABLISHING VCO STARTING FREQUENCIES AND I-F OFFSET.

5005	49,999.95 kHz	49,999.95 kHz
x 9.99 kHz	+ 8,998.50 kHz	+ 9,001.50 kHz
49,999.95 kHz	58,998.45 kHz	59,001.45 kHz
VCO 2 INITIALLY SELECTED FREQUENCY	INITIAL VCO 1 LSB FREQUENCY	INITIAL VCO 1 USB FREQUENCY

fig. 3. The initial frequency for vco 2 is determined by assuming there is no programmed input frequency (00,000.00 kHz). For the vco to be at its proper lower frequency limit, the divider would have to have an initial divide factor of 5005, producing a 49999.95 kHz output. Vco number 1 will also start with the same frequency, except with the added offset required for either LSB or USB.

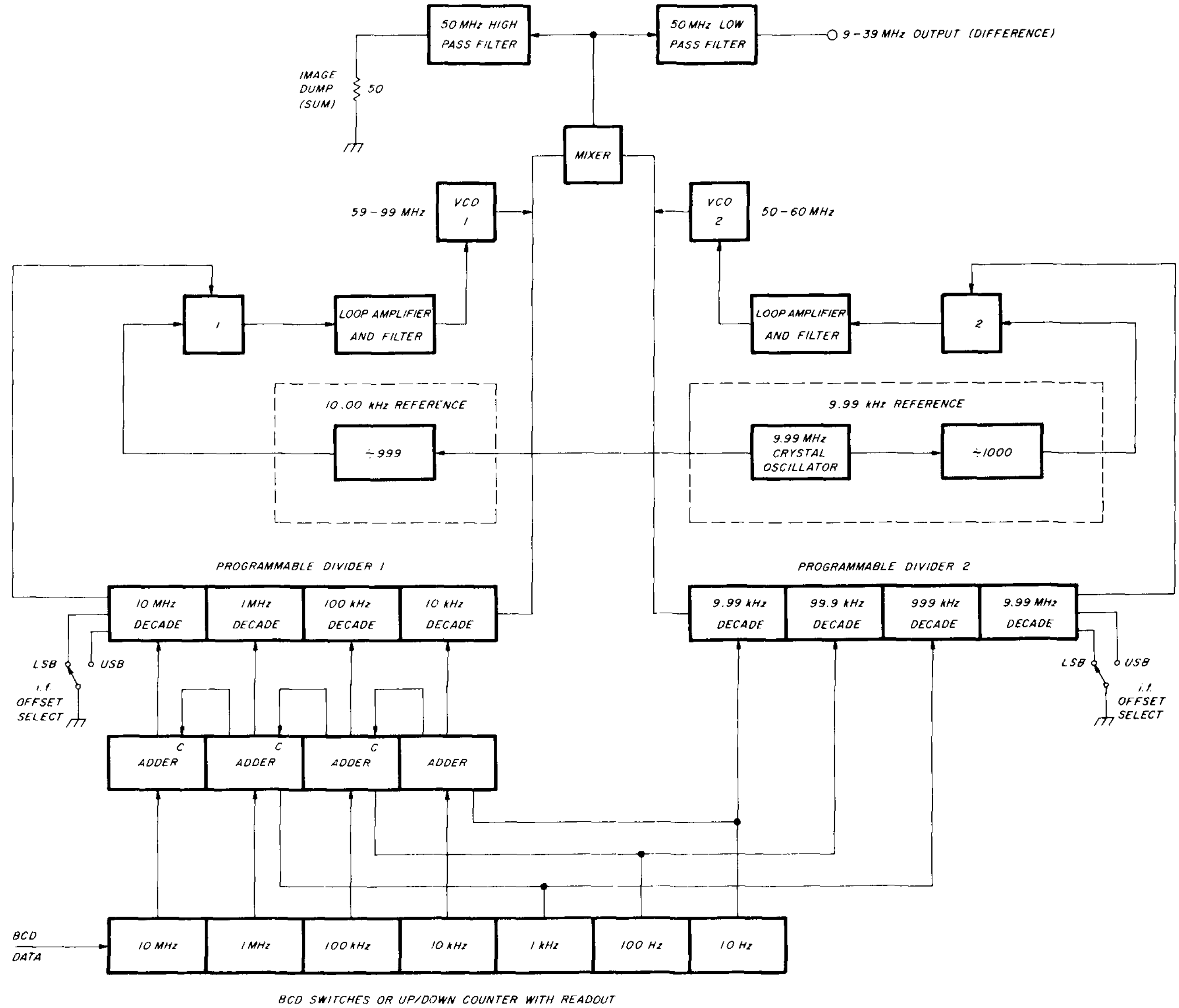


fig. 2. Functional block diagram of a high frequency synthesizer capable of 10-Hz steps, with a 10-kHz reference.

A CALCULATING DIVIDER I LSB PRESET

58,998.45kHz
5899
+845
6744

6744
x10kHz
67,440kHz

VCO I PROGRAMMED OFFSET FREQUENCY FOR LSB

B CALCULATING DIVIDER I USB PRESET

59,001.45kHz
5900
+145
6045

6045
x10kHz
60,450kHz

VCO I PROGRAMMED OFFSET FREQUENCY FOR USB

fig. 4. As seen in fig. 2, the data from the three most significant digits is added to the data from the fourth through the sixth significant digits. This number is then the final number which is used to control the programmable divider number one. (B) shows the same divider calculation, except for USB instead of LSB. The divider then controls vco 1 in 10 kHz steps.

two subcycles. During the first subcycle, the chain is loaded from and divides by the number programmed in a diode ROM (i-f offset data for the sideband in use). For the second subcycle, the chain is loaded with and divides by the data presented to the BCD frequency-select input lines. After both subcycles are completed, one pulse is sent to the phase comparator, and the entire cycle repeats. This approach may also be applied to single-divider PLL systems.

The reference frequencies are derived by dividing a 9.99-MHz crystal oscillator's output by 1000 and 999 to obtain outputs at 9.99 kHz and 10.00 kHz, respectively. An oven is recommended if the synthesizer's 10-Hz resolution is to be used to full advantage.

Vco 1 and vco 2 are combined in a mixer, which supplies the difference-frequency output through a 50-MHz lowpass filter. The mixer is image terminated through a highpass filter to reduce any unwanted intermodulation products which would result from an impedance mismatch at the vco sum frequencies.

A DIVIDER 2 LSB PRESET

58,998.45kHz
5005
+845
5850

5850
x9.99kHz
58,441.50kHz

VCO 2 PROGRAMMED OFFSET FREQUENCY FOR LSB

B DIVIDER 2 USB PRESET

59,001.45kHz
5005
+145
5150

5150
x9.99kHz
51,448.50kHz

VCO 2 PROGRAMMED OFFSET FREQUENCY FOR USB

C OFFSET CHECK

67,440.0 kHz
−58,441.5 kHz
8,998.5 kHz (LSB)

60,450.0 kHz
−51,448.5 kHz
9,001.5 kHz (USB)

fig. 5. For vco 2, the same initial frequency, as determined in fig. 3, is preset into the counters, plus the three most significant digits from the data switches. The final divider number, times 9.99 kHz, produces the required vco frequency, except now in 9.99 kHz steps. As a check, subtracting the value of the two vco frequencies will equal the sideband offset value (C).

Both filters must employ T-input sections so they appear invisible to the mixer in their cutoff regions.

Because the high-reference frequencies used in this synthesizer allow loop correction of vco microphonics below about 1 kHz, this circuit is ideal for mobile applications where vibration would otherwise require the use of extremely rugged oscillator enclosures.

This approach may be expanded to yield 1 Hz steps, or to utilize a 100 kHz reference, but either change would require a ten times greater frequency

A EXAMPLE OPERATING FREQUENCY (DIVIDER 1)

14,307.96kHz (USB)
1430
+796
+6045 (OFFSET COUNT)
8271

8271
x10kHz
82,710kHz (VCO 1)

B EXAMPLE OPERATING FREQUENCY (DIVIDER 2)

14,307.96kHz
5150 (OFFSET COUNT)
+796
5946

5946
x9.99kHz
59,400.54kHz (VCO 2)

C EXAMPLE OPERATING FREQUENCY CHECK

82,710.00kHz (VCO 1)
−59,400.54kHz (VCO 2)
− 9,001.50kHz (USB BFO)
14,307.96kHz (OPERATING FREQUENCY)

fig. 6. With a sample operating frequency of 14,307.96 kHz (USB), the programmable divider, for vco 1, would have a value of 8271. The offset is that calculated in fig. 4B. This final value determines the frequency of vco 1. The programmable divider for vco 2 uses the input from the data switches plus the offset from fig. 5B to determine the vco's frequency. Since this synthesizer is actually a local oscillator in a transmitter or receiver, its output will differ from the actual transmitted (or receiver) frequency by the value of the i-f frequency. Therefore, the difference between vco 1 and vco 2 will equal the operating frequency plus the i-f offset. Or, subtracting both the i-f offset and vco 2's frequency from vco 1, will give the actual operating frequency (C).

range of vco 2, and that much additional range added to the upper frequency limit of vco 1.

A recommended frequency programming scheme would incorporate thumbwheel switches to set the MHz range, with smaller frequency divisions being continuously tunable by an optically coupled, tuning-knob-controlled, up-down counter with readout. The high speed of this synthesizer makes it an ideal candidate for use in an automated, microprocessor controlled station, in which case tuning could be implemented with the computer's ASCII keyboard, or even remote controlled via a modem. Wouldn't it be nice to have a remote 20-meter transceiver atop a 150-meter (500-foot) building?

I would like to thank Fred Studenberg, W4CK, and Chuck Jackson for their technical advice and constructive criticism of this article.

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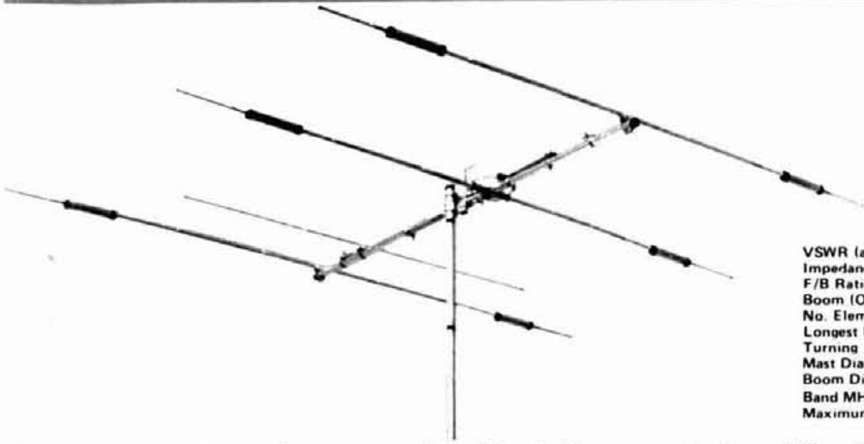

Wilson

SY-2

SPECIFICATIONS

VSWR (at Resonance)	1.5:1	Gain (dB)	8.5
Impedance	50 Ohms	Surface Area (Sq. Ft.)	6.15
F/B Ratio (dB)	20-25	Wind Loading at 80 mph	153
Boom (O.D. x Length)	2" x 18'6"	Assembled Weight (Lbs. - Approx.)	47
No. Elements	4	Shipping Weight (Lbs. Approx.)	50
Longest Element (Ft.)	26'7"	Matching Method	Beta
Turning Radius (Ft.)	16'4"	Only One Feed Line Required	
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Boom Diameter	2" O.D.		
Band MHz	14-21-28		
Maximum Power Input	4 Kw		

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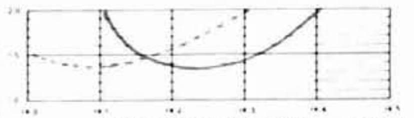
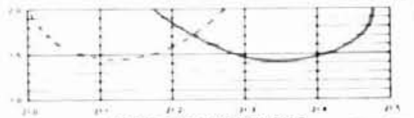
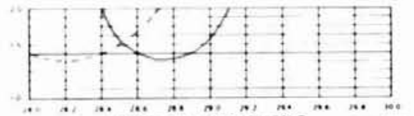


20 METERS - MODEL SY-2

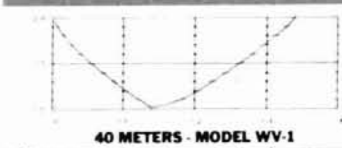


15 METERS - MODEL SY-2

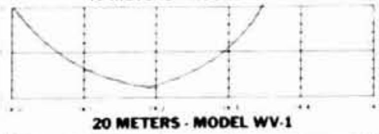


10 METERS - MODEL SY-2

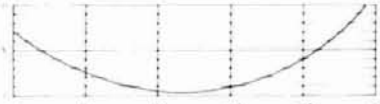
40 THRU 10 METERS VERTICAL TRAP



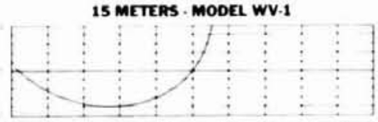
40 METERS - MODEL WV-1



20 METERS - MODEL WV-1



15 METERS - MODEL WV-1



10 METERS - MODEL WV-1

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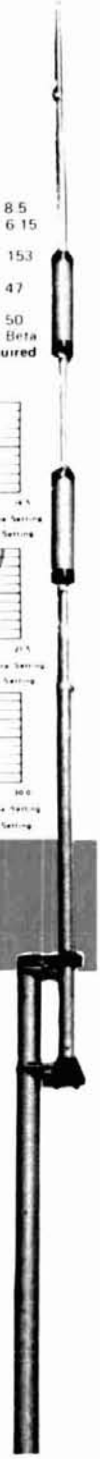
SPECIFICATIONS

Input Impedance: 50 ohms • Powerhandling capability: Legal Limit • Two High-Q Traps with large diameter coils • Low Angle Radiation Omnidirectional performance • Taper Swaged Aluminum Tubing • Automatic Bandswitching • Mast Bracket furnished • SWR: 1.1:1 on all Bands • 1½" O.D. heavy wall aluminum tubing • Does not require guying • Overall length: 19' 8".



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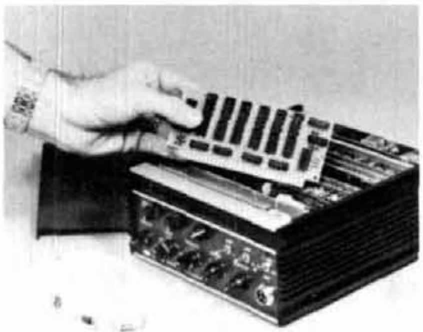
The Extra Diode-Programmed Channels



You can diode-program up to four fixed channels, with their offsets, for each band. This feature allows super-quick selection of favorite channels. The five-kHz synthesizer operates independently of these programmed channels. And best of all, soldering is not necessary for programming. The program board has special sockets mounted on it for direct insertion of diodes. We even provide the diodes.

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Bob Stein, W6NBI

automatic noise-figure measurements — fact and fancy

One of the major attractions at the regional vhf/uhf conferences is the noise figure measurement session. Everyone with a new converter or preamp, and especially anyone who does not possess or have access to calibrated noise-figure measuring equipment, anxiously awaits the measurement results. The session becomes a contest of sorts, in which you find out how your latest endeavor or purchase compares with the best of show.

Invariably these measurements are made using automatic noise-figure equipment because of the simplicity and speed with which measurements may be accomplished. Given any one test setup, the comparisons among the various units under test may be valid, in that the relative noise figures for each unit can be determined, as can the difference in noise figure between any of the units. But what about a preamp whose measured noise figure was 1.5 dB at the West Coast Conference and another which yielded 1.7 dB at the East Coast Conference? Is this a valid comparison, or going one step further, is either measurement really accurate? The discussion which follows will, I hope, provide these answers.

In addition, this article becomes another in the series devoted to the use and application of available surplus test equipment. Automatic noise-figure meters, such as the Hewlett-Packard models 340A, 340B, and 342A, and the AILTECH* types 74A and 75, are typical of those in general use. Noise sources which are usable from 10 MHz to 5 GHz, and which may be used with one or more of these instruments, are the Hewlett-Packard models 343A, 345B, and 349A, and the AIL types 7006, 7010, 7011, and 7012. **Tables 1** and **2** list the pertinent specifications for the noise-figure meters and noise sources, respectively.

With the exception of the AIL 75, which is probably too new to show up on the surplus market, all of these noise-figure meters and noise sources are available from time to time. Oftentimes a solid-state noise source also becomes available. If it is one of the AIL series 76, it is compatible with the AIL 75 noise-figure meter; if it is manufactured by another company, it may be adaptable to one of the aforementioned noise-figure meters, but detailed information must be obtained from the manufacturer. However, because of their relative scarcity and the fact that they may not be truly compatible with most of the available noise-figure meters, no coverage can be provided in this article for any solid-state noise source.

As noted in **table 1**, many of the Hewlett-Packard instruments have been special versions which accept one or more input frequencies different from those in the standard models. This should present no problem to the potential user, even if none of the instrument input frequencies corresponds to the output frequency from his converter. Either the converter output can be heterodyned to the noise-figure meter input frequency, as explained later, or the noise-figure meter can be modified. This modification involves nothing more than retuning or replacing coils in the instrument's tuned amplifier, and is described in the appendix.

noise-figure equations

Before we can analyze the operation of automatic

The Hewlett-Packard model 340B Noise Figure Meter can be used with either a gas-discharge noise source or a temperature-limited diode source. Models 340A and 342A are similar in appearance (*courtesy Hewlett-Packard Company*).

*AILTECH, a Cutler-Hammer Company, was formerly Airborne Instruments Laboratory. Throughout this article, AIL will be used to identify equipment manufactured under either name.

noise-figure meters, it is necessary to understand the mathematical definition of noise figure insofar as it applies to the noise-figure meter. I will skip the basic mathematical derivation, since this has been covered extensively in references 1 through 5. Instead, I will start with a mathematical definition of noise figure and proceed to derive the relationships which permit the automatic noise-figure meter to function.

To eliminate any confusion between noise figure expressed as a numerical ratio and the logarithmic equivalent expressed in dB, I will limit the use of the term *noise figure* (NF) to the logarithmic version and call the numerical ratio *noise factor* (F).

The noise factor of a receiver is defined as the input signal-to-noise power ratio divided by the output signal-to-noise power ratio, and is expressed as

$$F = \frac{S_i/N_i}{S_o/N_o} \tag{1}$$

where S_i is the input signal power, N_i is the noise power at the input, S_o is the output signal power, and N_o is the output noise power.

If a broadband noise source is used at the receiver input

$$S_i/N_i = EN = \frac{T_2 - T_o}{T_o} \tag{2}$$

where

EN = excess noise power (generally expressed in dB, but the equivalent numeric ratio in this case)

T_2 = equivalent absolute temperature of noise source when on, in °K

T_o = °K

If we designate the output power from the receiver when the noise source is off as N_1, and the receiver output power when the noise source is on as N_2, the output signal power, S_o, can be expressed as

$$S_o = N_2 - N_1 \tag{3}$$

and since

$$N_o = N_1 \tag{4}$$

$$S_o/N_o = \frac{N_2 - N_1}{N_1} = \frac{N_2}{N_1} - 1 \tag{5}$$

Rewriting **eq. 1** by substituting **eqs. 2** and **5**, we get

$$F = \frac{\dfrac{T_2 - T_o}{T_o}}{\dfrac{N_2}{N_1} - 1} \tag{6}$$

Converting **eq. 6** to the equivalent noise figure, where $NF = 10 \log F$,

$$NF = \left[10 \log \frac{T_2 - T_o}{T_o}\right] - \left[10 \log \left(\frac{N_2}{N_1} - 1\right)\right] \tag{7}$$

Since the first term in **eq. 7** is the logarithmic equivalent of **eq. 2**, it is equal to the excess noise ratio (ENR), in dB, of the noise source. Therefore **eq. 7** can be rewritten

$$NF = ENR - 10 \log \left(\frac{N_2}{N_1} - 1\right) \tag{8}$$

The ratio N_2/N_1 is often designated the Y-factor, so that an equivalent expression for **eq. 8** is

$$NF = ENR - 10 \log (Y - 1) \tag{9}$$

Thus we have arrived at an expression for noise figure in which the only variable is Y when a noise

table 1. Automatic noise-figure meter specifications.

model	NF ranges and accuracy		input frequencies (MHz)	bandwidth (MHz)	sensitivity (dBm)	agc range (dB)
Hewlett-Packard 340A, B	0-15 dB:	±0.5 dB	*30, 60	1 (min.)	−60	50
	3-30 dB:	±0.5 dB from 10-25 dB				
		±1.0 dB from 3-10 dB				
		±1.0 dB from 25-30 dB				
Hewlett-Packard 342A	Same as 340A, B		*30, 60, 75, 105, 200	1 (min.)	−60	50
AIL 74A	0-25 dB:	±0.5 dB	**One of the following:			65
	23-36 dB:	±1.0 dB	10, tunable 20-60	2	−67	
			30	6	−73	
			30, tunable 40-180	2	−67	
			60	6	−67	
AIL 75	0-15 dB:	±0.15 dB from 0-3 dB	30 (other options available)	5 (min.)	−73	65
		±0.25 dB from 3-6 dB				
	3-18 dB:	±0.15 dB from 3-6 dB				
		±0.25 dB from 6-9 dB				
	6-21 dB:	±0.15 dB from 6-9 dB				
		±0.25 dB from 9-12 dB				
	12-27 dB:	±0.5 dB from 12-18 dB				
	18-33 dB:	±1.0 dB				

*Standard input frequencies are listed; many special models were manufactured with one or more different input frequencies.

**Depends on i-f amplifier installed in noise-figure meter.

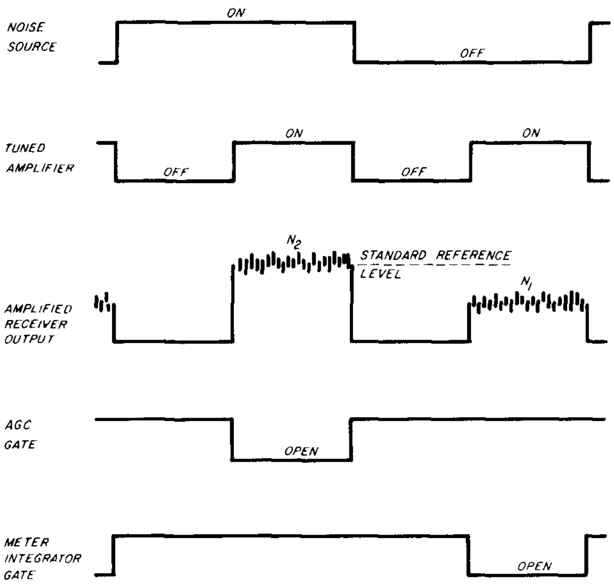


fig. 2. Operational effect of the switching circuit in the automatic noise-figure meter.

source of known ENR is used. Furthermore, since Y is the ratio of N_2/N_1, we need only measure this ratio, without regard to absolute power levels, in order to obtain the receiver noise figure.

automatic noise-figure meters

Now that we have a simplified noise-figure equation, let us investigate the actual method by which noise figure is measured automatically. **Fig. 1** shows a simplified block diagram of a typical Hewlett-Packard noise-figure meter. The external noise source and receiver under test are included in the diagram so as to close the loop.

The noise source, powered by the noise-figure meter, is connected to the antenna input of the receiver under test, and the i-f output from the receiver is connected to the input of the noise-figure meter. A switching circuit in the noise-figure meter gates the tuned amplifier, meter integrator, agc, and noise source (via its power supply) on and off at a low audio-frequency rate. As shown in **fig. 2**, the noise source is gated on and approximately one-quarter cycle thereafter the tuned amplifier is gated on and the agc gate is opened. During this "on" time the receiver output, N_2, consists of the amplified power from the noise source plus the amplified receiver noise. This is used to establish a standard reference level through agc action.

After the noise source is gated off, the amplifier is again gated on, as is the meter integrator. During this time the receiver output, N_1, consists only of the amplified receiver and input termination noise, which is detected and integrated, and applied to the meter. Since the noise-source ENR is known, and N_2 is always amplified to a standard reference level, the only variable in **eq. 8** is the metered value of N_1. The meter can therefore be calibrated to display noise figure directly, as a function of N_1.

The tuned amplifier is gated on for only one-half of the noise-source on and off periods in order to be certain that the output from the noise source has reached its maximum level or has fallen to its quiescent level.

The AIL noise-figure meters function in a similar manner, although there are differences in the actual circuits used to achieve the resulting indication.

noise sources

Although both coaxial and waveguide noise sources are available for use with automatic noise-figure meters, this discussion will be limited to the coaxial types, since waveguides presently have limited amateur use.

The Hewlett-Packard model 343A VHF Noise Source provides a wideband noise spectrum from 10 to 600 MHz and has a source impedance of 50 ohms. It generates an excess noise ratio of 5.2 to 6.6 dB, depending on the measurement frequency, at its specified current of 3.31 mA; refer to **table 2**. The noise source employs a special temperature-limited

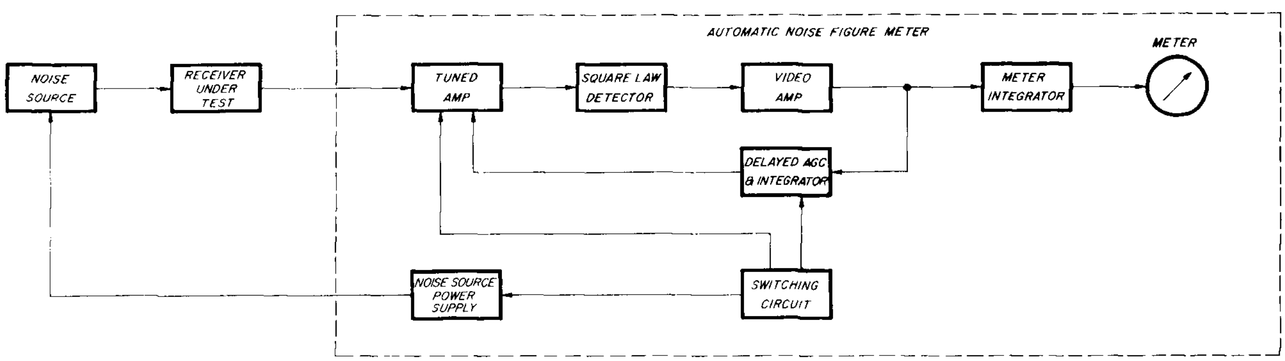


fig. 1. Simplified block diagram of the Hewlett-Packard model 340A or 340B Noise Figure Meter.

vacuum-tube diode (similar to the Sylvania 5722) whose plate and filament voltages are supplied by the Hewlett-Packard 340A, 340B, or 342A noise-figure meter. The noise output of a saturated temperature-limited diode is a function of plate current, which is set to an established value by means of a control on the noise-figure meter.

The Hewlett-Packard model 345B IF Noise Source produces an excess noise ratio of 5.2 dB from any one of four switch-selected source impedances: 50, 100, 200, or 400 ohms. Since tuned circuits within the noise source limit its spectrum to either 30 or 60 MHz, also switch-selected, it has limited amateur application and can be dismissed without further discussion.

Also usable with any of the Hewlett-Packard noise-figure meters are several 5722 noise generators whose construction has been described in references 6 through 8. It should be noted that most, if not all, of these homebrew noise sources suffer from impedance mismatch problems when used above 400 MHz. However, it is possible to build a noise source which compares favorably with the Hewlett-Packard 343A to at least 450 MHz; its construction will be described in a future article.

For receiver frequencies above 450 MHz, a noise source using a gas-discharge tube is generally used. Coaxial noise sources of this type may also be used at frequencies as low as 200 MHz. The Hewlett-Packard model 349A UHF Noise Source and the AIL Type 7010, 7011, and 7012 Coaxial Noise Generators all employ an argon-filled gas-discharge tube coaxially mounted in a helical transmission line. These noise

The Hewlett-Packard model 343A VHF Noise Source utilizes a temperature-limited diode, and can be used from 10 to 600 MHz (*courtesy Hewlett-Packard Company*).

sources produce excess noise ratios of 15.2 to 15.7 dB over their specified frequency ranges, as shown in **table 2**.

A simplified diagram of a coaxial gas-discharge tube noise generator is shown in **fig. 3**. The tube is alternately turned on and off by the switched power supply in the noise-figure meter. When a high-voltage pulse is applied between the anode and cathode of the tube, the argon gas ionizes and noise is generated. The noise is coupled into the helix and appears at the two coaxial connectors. One connector is used

table 2. Coaxial noise-source specifications.

model	frequency range (MHz)	excess noise ratio (dB)	operating current (mA)	output vswr
Hewlett-Packard 343A	10-600	5.2 ± 0.2 from 10-30 MHz 5.5 ± 0.25 at 100 MHz 5.8 ± 0.3 at 200 MHz 6.05 ± 0.3 at 300 MHz 6.3 ± 0.3 at 400 MHz 6.5 ± 0.5 at 500 MHz 6.6 ± 0.5 at 600 MHz	3.31	10-400 MHz: 1.2 max. 400-600 MHz: 1.3 max.
Hewlett-Packard 345B	30 or 60, switch selected	5.2	0.41 to 3.31	50, 100, 200 or 400 ohm (± 4%) source impedance, switch selected
Hewlett-Packard 349A	400-4000 (usable to 200)	14.6 ± 0.6 at 220 MHz 15.6 ± 0.6 from 400-1000 MHz 15.7 ± 0.5 from 1-4 GHz	150	200-2600 MHz: 1.35 max. fired 1.5 max. unfired 2.6-3.0 GHz: 1.5 max. fired 1.5 max. unfired 3.0-4.0 GHz: 2.0 max. fired 3.0 max. unfired
AIL 7006	10-250	15.2 ± 0.5	33.1	1.2 max.
AIL 7010, 7011	200-2600	15.2 ± 0.3	175	1.15 (nominal) fired 1.3 (nominal) unfired
AIL 7012	2-5 GHz	15.5 ± 0.2	175	1.5 (nominal) fired 2.0 (nominal) unfired

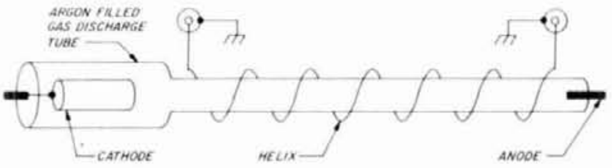


fig. 3. Simplified diagram of a gas-discharge tube noise source. One connector is used for the noise output; the other must be terminated by a precision 50-ohm load.

for the noise output, while the other must be terminated by a precision 50-ohm load.

connecting the noise source to the noise-figure meter

Obviously each manufacturer supplies noise sources which are compatible with his own noise-figure meters. There is nothing, however, other than the problem of physically interconnecting the source and noise-figure meter, which precludes using one manufacturer's gas-discharge source with another's noise-figure meter.

The same interchangeability is not true for diode noise sources. The AIL type 7006 noise diode can be used only with the AIL 74A noise-figure meter, and the Hewlett-Packard diode noise sources can only be used with the Hewlett-Packard noise-figure meters. But, as previously mentioned, there are several 5722 noise generators which can also be used with the Hewlett-Packard noise-figure meters.

All of the Hewlett-Packard noise-figure meters discussed in this article originally included an interconnecting cable for that manufacturer's gas-discharge noise sources. Unfortunately, the cable is invariably missing when the instrument reaches your local surplus emporium. On the other hand, the interconnections are rather simple, so that with the information which follows, you should be able to solve all of your interface problems.

To connect the Hewlett-Packard 349A coaxial (or any of the Hewlett-Packard 347-series waveguide) gas-discharge noise source to any Hewlett-Packard noise-figure meter, a 6-foot (1.8-meter) type 340-16A cable was originally furnished. You can buy a replacement directly from Hewlett-Packard, but the price was $100 the last time I checked. A good alternative is to make your own cable, as shown in **fig. 4**.

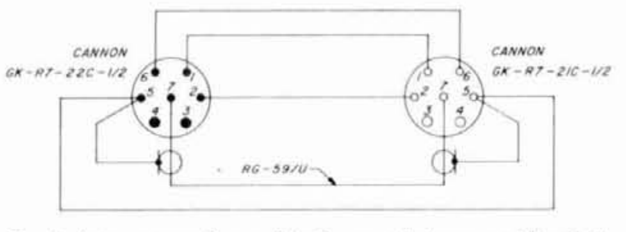


fig. 4. Interconnecting cable for use between a Hewlett-Packard 349A or 347-series noise source and a Hewlett-Packard 340A, 340B, or 342A noise-figure meter. The cable length should be limited to about 2 meters (6 feet).

If you want to connect a Hewlett-Packard gas-discharge source to either the AIL 74A or 75 noise-figure meter, it will be necessary to modify the captive cables on the AIL instrument, as follows.*

1. Cut the high- and low-voltage cables at a point at least 20 inches (51 cm) back from the connector ends.

The AILTECH type 75 Precision Automatic Noise Figure Indicator is the latest and most versatile instrument of its kind on the market. It can be supplied for use with both gas-discharge and solid-state noise sources, or for use with the latter type only (*courtesy AILTECH*).

2. Wire the cables from the noise-figure meter as shown in **fig. 5A**.

3. Wire the cable ends with the connectors attached as shown in **fig. 5B**.

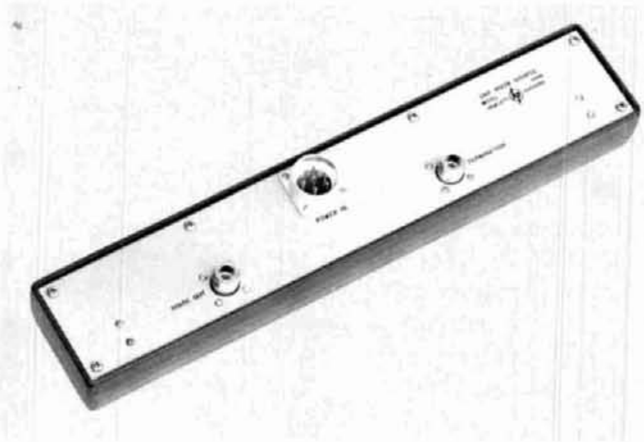
The instrument cables, now terminated in a single multipin connector, will plug into the connector on the Hewlett-Packard noise source. An AIL noise source can still be used by connecting the multipin connector on the instrument cables to the mating connector on the now separate cable assembly shown in **fig. 5B**, thereby restoring the original configuration.

Fig. 6 shows the cabling needed to connect an AIL 7010, 7011, or 7012 noise source to any of the Hewlett-Packard noise-figure meters. The high-voltage connector required to mate with the anode connector on the AIL 7010 or 7012 is not available except as a part of the AIL 7003 cable set. Therefore it must be fabricated by using brass tubing of the appropriate size and suitable high-voltage insulating material

*Taken from AIL Application Engineering Bulletin 70-15, dated August, 1961.

(teflon, polystyrene, etc.) between the inner high-voltage and outer ground conductors. WARNING: the anode lead and connector must be insulated for up to 5 kV; USE EXTREME CARE.

The Hewlett-Packard 343A and 345B noise sources each have a captive cable and connector to mate with the Hewlett-Packard 340B and 342A noise-figure meters. If you intend to use any of the previously referenced 5722 noise generators, the appropriate connector wiring is shown in **fig. 7**. The 5722 filament draws between 1.5 and 2 amperes, so



The Hewlett-Packard model 349A UHF Noise Source is a gas-discharge type using an argon-filled tube. Its usable range is 200 MHz to 4 GHz (*courtesy Hewlett-Packard Company*).

be sure to use wire that is large enough to minimize the voltage drop between the tube and the noise-figure meter.

Connecting any of the commercial or homebuilt diode noise sources to the Hewlett-Packard 340A noise-figure meter requires somewhat more discussion. The *diode* panel connector on the 340A was originally a 3-pin connector, rather than the 5-pin Cannon WK-5-31S connector used on the later 340B and 342A models. (It was intended to mate with the long obsolete 345A noise source.) However, Hewlett-Packard Service Note 340A-1A* described how to replace the old 3-pin connector with the later 5-pin connector, and virtually everyone who had a 340A made the change. In fact, I have never seen an instrument with the old connector still in place.

If a new connector has been installed and you are going to use a homebuilt 5722-type noise source, the wiring information in **fig. 7** applies. If the old connector is still on the instrument, you will have to be lucky enough to find a mating connector or else change

*Available from Hewlett-Packard Company, 1820 Embarcadero Road, Palo Alto, California 94303.

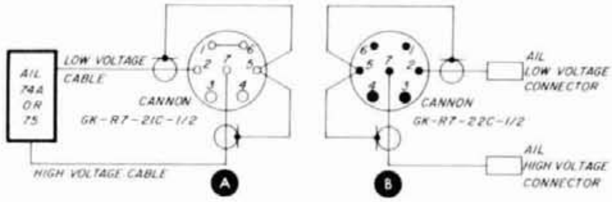


fig. 5. Modification of the AIL 74A or 75 noise-source cables which will permit use of Hewlett-Packard 349A or 347-series noise sources. (After AIL Application Bulletin 70-15, August 1961).

the connector on the instrument. The filament connections on the old 3-pin connector are pins 1 and 2; pin 3 connects to ground.

The Hewlett-Packard 343A noise source can only be used with the 340A if the 5-pin connector has been installed. Before trying to use it, however, check the internal wiring to the connector to be sure that there is a connection to pin 4. If there is no wire on pin 4, run one from that pin to the black center-tap lead of transformer T101. (The transformer may be identified by tracing the leads from pins 1 and 2 of the connector, which are wired to the green and yellow leads, respectively, of T101.)

measurement techniques

We can now discuss the procedures and techniques of measuring noise figure with an automatic noise-figure meter. Because the actual operating procedures vary, depending on the instrument being used, no attempt will be made to describe the detailed operational steps. These appear in the instruction manual for the specific instrument, available from the manufacturer at nominal cost. In general, operation of the noise-figure meter consists of the following steps:

1. Connecting the receiver under test as shown in **fig. 8**. For the purposes of this discussion, the term "receiver" means any receiver or portion thereof (such as a converter, mixer, etc.) which provides an output signal at the input frequency of the noise-figure meter.

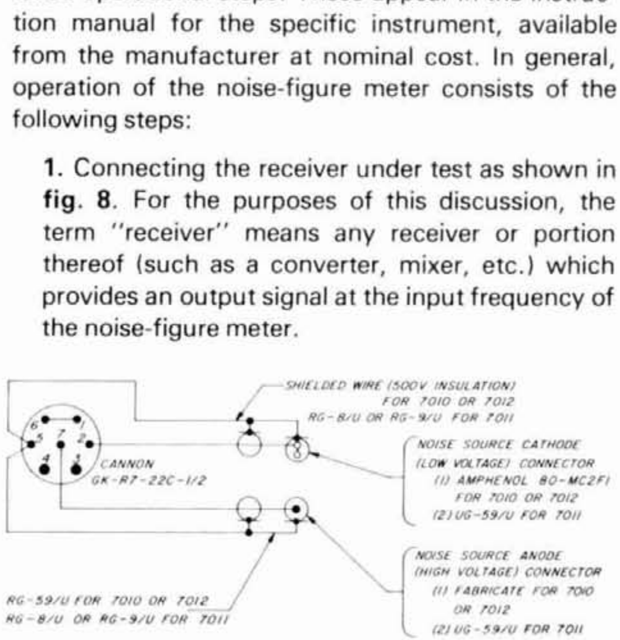


fig. 6. Interconnecting cable for use between an AIL 7010, 7011, or 7012 noise source and a Hewlett-Packard 340A, 340B, or 342A noise-figure meter.

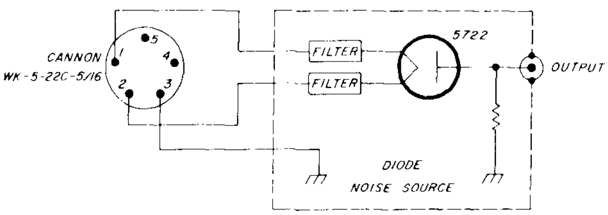


fig. 7. Wiring a homebuilt 5722-tube noise source to permit its use with a Hewlett-Packard 340B or 342A noise-figure meter. See the text for additional information applicable to the Hewlett-Packard 340A.

2. Energizing the noise-figure meter and establishing the fixed agc reference level.

3. Setting the noise-source operating current.

4. Calibrating the noise-figure meter to the noise-source *ENR*. (This step is not applicable to Hewlett-Packard noise-figure meters.)

5. Reading the receiver noise figure on the meter, and correcting for noise-source characteristics and/or loss-pad attenuation.

Although this generalized procedure sounds almost too simple to be true, it is just about as easy in practice. Any adjustments on the receiver can be made while it is under test by merely tuning for the best noise figure. Compare that to measuring noise figure by the manual twice-power method!

Let us now examine **fig. 8** block by block. Most important, there should be a direct connection between the noise-source output connector and the loss pad, and between the pad and the receiver. This means *no cables*, and a minimum of adapters.

The use of a loss pad between the noise source and the receiver is an absolute necessity when using a gas-discharge source, and is highly recommended for diode noise sources. One of the disadvantages of gas-discharge noise sources is that they require a high-voltage ionizing pulse, typically several kilovolts. Because of capacitive coupling between the tube and the helix, this pulse appears as a spike in the noise output. Although the pulse is attenuated, the amplitude of the spike may still be several volts, which may be enough to destroy your expensive low-noise transistor. Therefore, a 6- to 10-dB pad must always be used with a solid-state receiver to attenuate the spike. Even with a 10-dB pad, there may be sufficient spike voltage to destroy certain GaAs fets. A solid-state noise source should be used to check devices of this type.

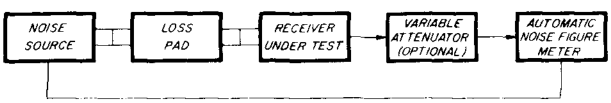


fig. 8. Measuring noise figure with the automatic noise-figure meter. The use of the loss pad and variable attenuator are discussed in the text.

The use of a loss pad with a diode noise source is not absolutely essential, but can minimize several problems. First of all, most receivers (remember the general use of this term) do not present a 50-ohm input when optimized for a noise match. Because the rated *ENR* of a noise source is based on a 50-ohm load, there will be an indeterminate mismatch loss if the receiver vswr is greater than 1.0:1. A 3- to 6-dB pad will not eliminate the mismatch loss, but may reduce it somewhat.

A second reason for using a loss pad is to ensure a 50-ohm source impedance for the receiver, since the vswr of the noise source also is not a perfect 1.0:1.

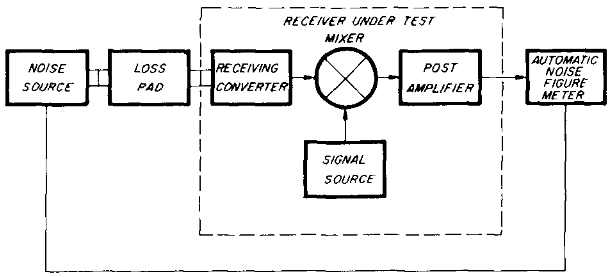


fig. 9. Using an external mixer and signal source to convert the receiver output frequency to that of the noise-figure meter input. The "receiver under test" corresponds to the equivalent block in fig. 8.

Any tendency of the receiver to "take off" when looking into an impedance of other than 50 ohms will be reduced by use of a pad.

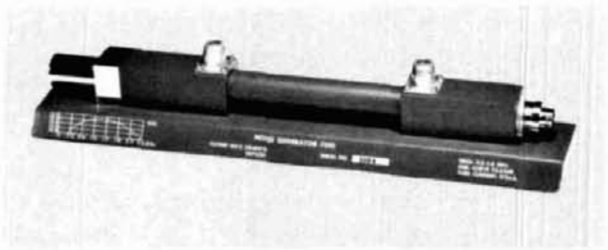
Both of these reasons apply equally to gas-discharge noise sources, but are automatically realized by the absolute necessity of using a loss pad to protect the receiver. In either case, the attenuation of the pad must be known to a fair degree of accuracy; *remember that the loss, in dB, must be subtracted* from the reading obtained on the noise-figure meter, since any loss ahead of a receiver adds algebraically to the receiver noise figure.

In addition to providing an output at a frequency which is compatible with the noise-figure meter, the receiver must also provide enough gain to amplify the noise input to a level which exceeds the sensitivity of the noise-figure meter. However, the difference in the receiver output levels with the noise source on and off must not exceed the agc range of the instrument and overload it. This means that the output from the receiver, when the noise source is off, should be only slightly above the sensitivity level of the noise-figure meter. This can be determined by the use of the variable attenuator shown in **fig. 8**. The amount of attenuation which is introduced should be 6 to 10 dB less than the value which causes the receiver output to fall below the threshold required to establish the reference level.

Conversely, if the receiver has insufficient gain, it will not be possible to establish a signal reference level in the noise-figure meter. In that case, a post-amplifier must be substituted for the variable attenuator to provide sufficient overall gain.

receiver configuration

Thus far we have imposed two conditions which the receiver must satisfy — its gain must be compatible with the sensitivity requirement and agc range of the noise-figure meter, and its output frequency must match that of the noise-figure meter input. We



The AILTECH type 7010 Noise Generator covers the range from 200 MHz to 2.6 GHz. The similar appearing type 7012 is used between 2 and 5 GHz. Both noise sources utilize gas-discharge tubes (*courtesy AILTECH*).

have already discussed the first of these, and can proceed to the second.

The typical vhf or uhf receiving converter provides an output which is applied to a communications receiver used as a tunable i-f amplifier, detector, and audio amplifier. This output can fall anywhere in the entire hf, vhf, or even uhf spectrum. On the other hand, the input to the noise-figure meter must be at a specific frequency which may not correspond to the output from the converter. The combination of a 30-MHz amplifier in most of the noise-figure meters and most receiving converters with a nominal 28-MHz output has sufficient bandwidth to permit meaningful measurements.

For other converter output frequencies which do not correspond to the noise-figure meter input, an external mixer and signal source can be used to convert the output frequency of the receiving converter to the input frequency of the noise-figure meter. **Fig. 9** shows the connections for such a frequency conversion. Any type of mixer can be used, although a

*Available from Mini-Circuits Laboratory, Merrimac Industries, Anzac Electronics, Hewlett-Packard, Cimmarron, and others.

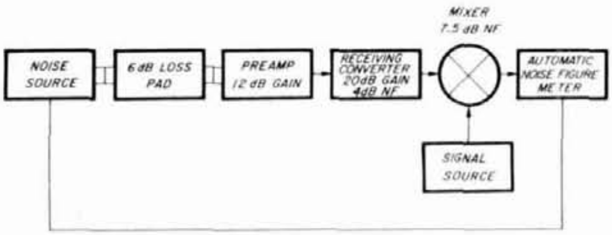


fig. 10. Test setup to determine receiving system and preamplifier noise figures, using a receiving converter following the preamplifier.

packaged double-balanced mixer with coaxial connectors will prove to be the most convenient and versatile. These are available commercially;* a less expensive mixer can be packaged as described by Paul Shuch.[10]

The signal source functions as a local oscillator for the mixer, and may be anything which generates a relatively stable unmodulated output, such as a signal generator or vfo. The sum of the converter and signal-source frequencies, or the difference between them, must result in the input frequency required by the noise-figure meter. It makes no difference whether the sum or difference frequency is used; however, the signal source must not be set to a frequency which is close to or is a subharmonic of the noise-figure input frequency.

For example, if the receiving converter output is 14 MHz and the noise-figure meter input is 30 MHz, a signal-source frequency of either 16 or 44 MHz would provide the proper output frequency from the mixer. In this case, the 16-MHz choice should be avoided because its second harmonic at 32 MHz may appear at the mixer output and fall within the passband of the noise-figure meter. This, of course, will render any measurements meaningless, since the noise-figure meter cannot distinguish between the receiver signal and the spurious mixer output.

If a signal generator is used as the signal source, it can function indirectly as the variable attenuator shown in **fig. 8**. Varying the signal-generator output will vary the conversion loss of the mixer and permit

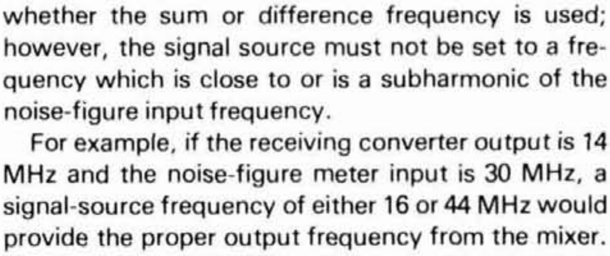


fig. 11. Test setup to determine receiving system and preamplifier noise figures, using a mixer following the preamplifier. In this case, a poor post-amplifier contributes significantly to the overall noise figure.

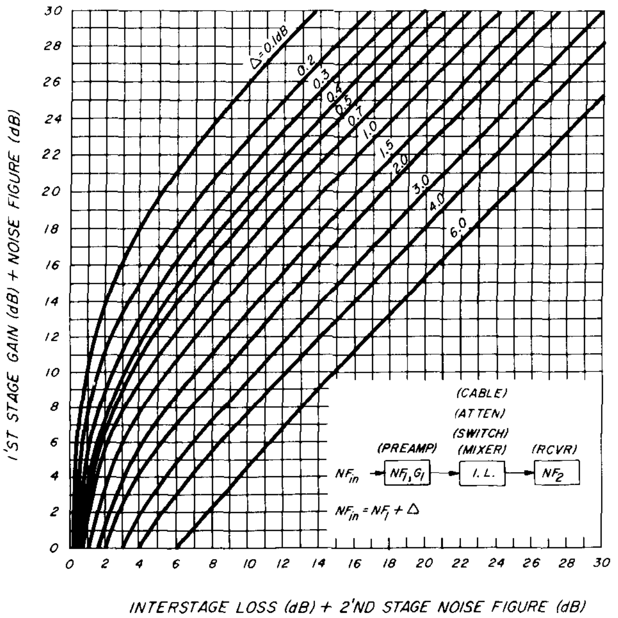


fig. 12. The system noise figure (NF_{IN}) can be found from these curves when the first- and second-stage noise figures, first-stage gain, and interstage losses are known (*courtesy Daico Industries, Inc.*).

control of the mixer output level. A post-amplifier has been shown in **fig. 9** because the receiving converter gain, less the mixer conversion loss, will generally be insufficient to provide the necessary signal level into the noise-figure meter. This post-amplifier can be any type, such as a surplus i-f strip or a broadband amplifier, which will amplify the desired mixer output frequency. The mixer image frequency will be rejected by the tuned amplifier in the noise-figure meter.

The configuration shown in **fig. 9** will result in valid noise figures only if the gain of the receiving converter is 20 dB or more. If the converter gain is less than 20 dB, the indicated noise figure will be worse than the actual noise figure because of the noise contribution of the external mixer. The actual noise figure must then be calculated, as explained later.

preamplifiers

In order to measure the noise figure of a preamplifier, the test setup of either **fig. 8** or **fig. 9** is used, with the preamp inserted between the loss pad and the receiver. To prevent any possible instability of either the preamp or the converter, in the event that either is not unconditionally stable, it is wise to use an additional loss pad between the preamp and the converter, directly at the converter input. This pad should provide about 3 dB loss; the exact value is not critical nor need it be known accurately. Its effect will be incorporated into the measured noise figure of the receiver (without the preamp), since this measurement is necessary to *calculate* the true noise figure of the preamp, as explained in the following section. If only an overall system noise figure is of interest, then the second loss pad should not be used.

A major consideration in the measurement of preamp noise figure is that of image response and the effect of filters on that response. It is mentioned here as a preliminary precaution only, and will be covered in detail under the heading *image response error*.

cascaded stages

The overall noise figure of any receiver depends primarily on the noise figure of the first stage. However, the noise generated by succeeding stages will contribute to the overall noise figure and, if the gain of the first stage is not over 20 dB or so, have a significant effect. Since low-noise preamps seldom have gains in excess of 15 dB, taking the noise contribution of the following stages into account is of major importance in determining the preamp noise figure.

The general equation for the noise *factor* of networks in cascade is

$$F_s = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \ldots \qquad \textbf{(10)}$$

where

F_s = system noise figure

F_1, F_2, F_3 = noise factor of first, second, third stages

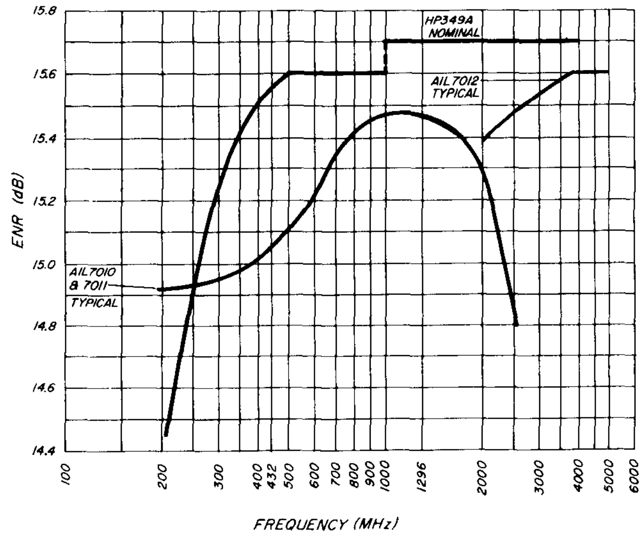


fig. 13. Excess noise ratios for Hewlett-Packard and AIL coaxial noise sources which utilize gas-discharge tubes. The curve for the Hewlett-Packard 349A is subject to the *ENR* tolerances listed in table 2; those for the AIL noise sources are typical and take into account the gas-tube-variations and hot-cold insertion losses.

G_1, G_2 = power-gain ratio of first, second stages

The system noise *figure*, NF_s, is derived from the expression

$$NF_s = 10 \log F_s \qquad \textbf{(11)}$$

It can be seen from **eq. 10** that the numerical value of the second and succeeding terms is a function of the first-stage gain; the higher the gain, the lower will be the values of those terms. If all stages are active amplifiers, only the second-stage noise will be of importance, and only the first two terms of **eq. 10** need be used in the calculation. However, if any of the early stages in the receiver has a gain of 1 or less (*e.g.*, mixers and loss pads), three or even four terms of the equation may have to be taken into account.

As an example, refer to the test setup shown in **fig. 10**. Assume that the preamp gain (A_1) and the converter gain (A_2) have been measured at 12 dB and 20 dB respectively; the measured converter noise figure (NF_2) is 4 dB; and the measured mixer noise figure (NF_3) is 7.5 dB. The system noise figure indicated on the noise-figure meter is 8.65 dB. What is the preamp noise figure (NF_1)?

First, we must subtract 6 dB from the noise-figure meter reading, since that is the increase in noise figure caused by the 6-dB pad. Therefore the actual system noise figure (NF_s) is 2.65 dB. Second, we must convert the noise figures and gains (in dB) to noise factors and numerical gain ratios, as follows:

$$F_s = \text{antilog} \frac{NF_s}{10} = \text{antilog} \frac{2.65}{10} = 1.841$$

$$F_2 = \text{antilog} \frac{NF_2}{10} = \text{antilog} \frac{4}{10} = 2.512$$

$$F_3 = \text{antilog} \frac{NF_3}{10} = \text{antilog} \frac{7.5}{10} = 5.623$$

$$G_1 = \text{antilog} \frac{A_1}{10} = \text{antilog} \frac{12}{10} = 15.849$$

$$G_2 = \text{antilog} \frac{A_2}{10} = \text{antilog} \frac{20}{10} = 100$$

By rearranging **eqs. 10** and **11**, and substituting the above values,

$$NF_1 = 10 \log \left(F_s - \frac{F_2 - 1}{G_1} - \frac{F_3 - 1}{G_1 G_2} \right)$$

$$= 10 \log \left(1.841 - \frac{2.512 - 1}{15.849} - \frac{5.623 - 1}{15.849 \times 100} \right)$$

$$= 10 \log (1.841 - .095 - .003)$$

$$= 10 \log 1.743 = 2.41 \text{ dB} \qquad \textbf{(12)}$$

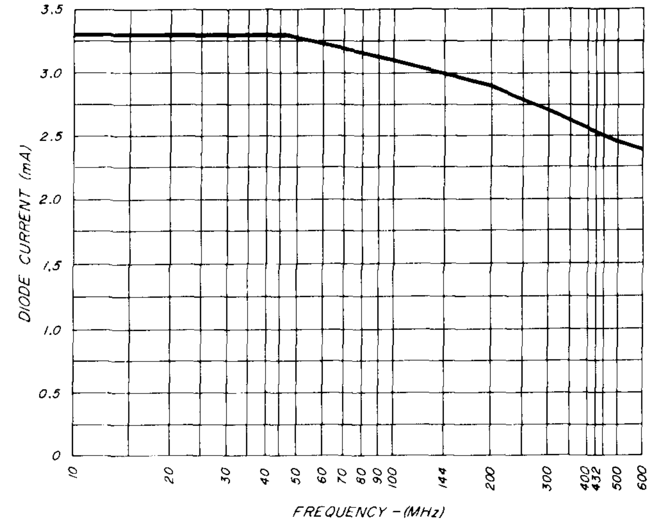


fig. 14. Diode current required by the Hewlett-Packard 343A VHF Noise Source to maintain a nominally constant 5.2-dB excess noise ratio (*curve by J. R. Reisert, W1JR*).

It can be seen from inspection of the above example that the third term is insignificant and can be ignored. However, suppose that the configuration shown in **fig. 11** is being used to check out the same preamp, using the same mixer and a post-amplifier with a measured noise figure of 10 dB. Now the mixer is the second stage, so that $F_2 = 5.623$. Since, in a stage having a gain of less than 1, the noise figure is equal to the loss, the converse must be true. Therefore, the mixer loss ratio is also 5.623, making the gain (G_2) the reciprocal of 5.623, or 0.178. The post-amp noise figure of 10 dB results in F_3 being equal to 10 (the antilog of 10 divided by 10). In this case, the receiver noise figure reading on the noise-figure meter is 13.2 dB. Subtracting 6 dB for the loss pad, we obtain an actual noise figure (NF_s) of 7.2 dB, or a noise factor (F_s) of 5.248.

Again substituting the measured noise factors and gain ratios in **eq. 12**, we arrive at the following:

$$NF_1 = 10 \log \left(5.248 - \frac{5.623 - 1}{15.849} - \frac{10 - 1}{15.849 \times .178} \right)$$

$$= 10 \log (5.248 - .292 - 3.190)$$

$$= 10 \log 1.766 = 2.47 \text{ dB}$$

This is approximately the same noise figure as was calculated in the previous example, taking into account rounded-off numbers. Note that in this case the third term of the equation contributes significantly to the overall system noise figure, which leads to the conclusion that a low-noise post-amplifier should always follow a mixer when there is only one stage of amplification ahead of the mixer. If the post-amplifier noise figure were reduced to 1.0 dB, the system

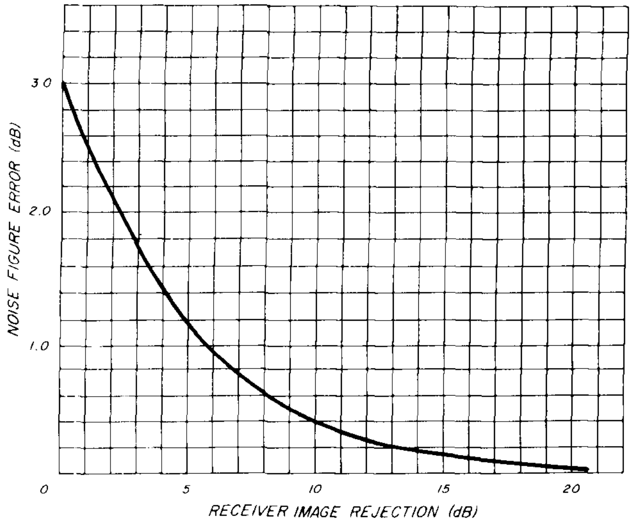


fig. 15. Noise-figure error as a function of receiver image rejection.

noise figure would improve from 7.2 to 3.3 dB. To paraphrase many textbooks, the calculation of this improvement is left as an exercise to the reader.

An interesting graphical representation of the relationships expressed in **eq. 12** is shown in **fig. 12**. If the various stage noise figures, gains, and losses are known in dB, the difference between the system and first-stage noise figures can be read as Δ, directly from the curves, which is added to the known first-stage noise figure to obtain the system noise figure.

For instance, let's use the same preamp and mixer, and the 1-dB post-amplifier from the preceding example. The first-stage gain plus noise figure is 14.4 dB, and the interstage (mixer) loss plus second-stage (post-amplifier) gain is 8.5 dB. The curves of **fig. 12** show that Δ is 0.9 dB at the intersection of these two values. Thus, the system noise figure is equal to the preamp noise figure plus 0.9 dB, or 3.3 dB.

noise-source ENR corrections

In our discussion of the noise-figure equations which govern the operation of automatic noise-figure meters, we established that the only variable in **eq. 8** was the ratio N_2/N_1, and that the *ENR* term in that equation was a fixed value determined by the noise source. It follows, therefore, that the noise-figure meter calibration must be based on a known or predetermined *ENR*.

In the case of the AIL noise-figure meters, the operating procedures entail calibrating the instrument to the *ENR* of the noise source. For the AIL 7006 diode noise source used with the AIL 74A noise-figure meter, the *ENR* is 15.2±0.5 dB when the diode current is set to 33.1 mA. If a gas-discharge noise source is to be used with either the AIL 74A or 75 noise-figure meter, the instrument is calibrated for the *ENR* of the source at the frequency of measurement. **Fig. 13** shows typical values for the AIL noise sources and the nominal *ENR* for the Hewlett-Packard 349A for frequencies between 200 and 5000 MHz.

The meter scales of the Hewlett-Packard 340A, 340B, and 342A noise-figure meters are based on a fixed *ENR* of 5.2 dB from a diode noise source and a fixed *ENR* of 15.2 dB from a gas-discharge noise source. There is no adjustment for other values of *ENR*; if the noise-source *ENR* is different from the value upon which the calibration is based, a correction factor must be applied to the noise-figure reading. If the *ENR* exceeds the noise-figure meter calibration design value, the "excess" *ENR* must be added to the noise-figure readings. If the ENR is less than the calibration design value, the difference be-

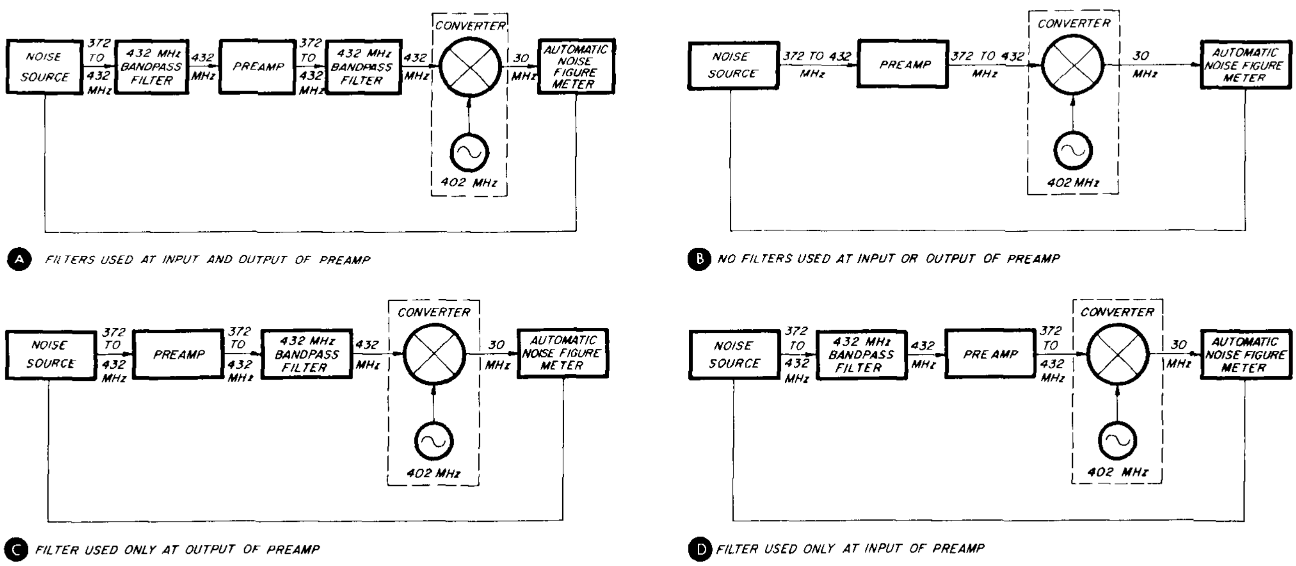


fig. 16. Simplified test setups for noise-figure measurements, using an untuned pre-amp and bandpass filters. The positions of the filters in each test setup are different. *All configurations, except that at D, yield valid system noise figures.*

tween the two values must be subtracted from the noise-figure readings.

An examination of **table 2** reveals that the only noise sources which match either of the Hewlett-Packard design values are the Hewlett-Packard 343A, only when used below 30 MHz, and the Hewlett-Packard 345B, which has little amateur application. This means that whenever the 343A is used above 30 MHz, the indicated noise figure must be increased by the difference between 5.2 dB and the noise-source *ENR* at the frequency of use. If the measurements were being made at 400 MHz, for instance, the indicated noise figure would be too low, requiring a corrective addition of 1.1 dB to the meter reading.

Fortunately, in the case of the 343A, there is a simpler method which allows use of the noise-figure meter readings without correction. This involves reducing the diode current from its specified 3.31-mA value to one which maintains a nominally constant 5.2-dB *ENR*. **Fig. 14** is a plot of the diode current versus frequency, which provides this compensation.

Varying the current in a gas-discharge noise source has little effect on its *ENR*, typically only 0.005 dB/mA. Therefore, the Hewlett-Packard noise-figure meter readings must be corrected if the noise-source *ENR* is not 15.2 dB at the frequency of measurement. See **fig. 13** to determine the difference between the *ENR* and 15.2 dB; remember that the difference is added to the noise-figure readings if the *ENR* exceeds 15.2 dB, and is subtracted if the *ENR* is less than 15.2 dB.

If measurements are being made with a Hewlett-Packard noise-figure meter at one or only a few frequencies, as is the usual case for amateur receivers, the need for making corrections to the noise-figure readings can be eliminated by the use of a selected loss pad. The graduations on the two scales of the Hewlett-Packard instrument meters correspond, differing by exactly 10 dB. Therefore, if the noise-source *ENR* were exactly 15.2 dB, and a precision 10-dB pad were used between it and the receiver under test, the noise figure could be read directly on the meter *diode* scale, which is based on an *ENR* of 5.2 dB. Since the noise-source *ENR* is not 15.2 dB, a pad must be selected so that its loss is algebraically equal to the difference between 5.2 dB and the *ENR* shown in **fig. 13**. Thus for the 349A noise source, the use of a 10.35-dB pad at 432 MHz, or a 9.5-dB pad at 220 MHz, will allow direct readout of noise figure on the *diode* scale of the noise-figure meter.

image-response error

Noise figure, as we have been using the term, is more correctly designated as the single-sideband noise figure. This has nothing to do with ssb as a method of modulation; it refers to the fact that any superheterodyne receiver has both a signal and an image sideband (channel), and that we are interested in measuring the noise figure in only a single (the signal) sideband.

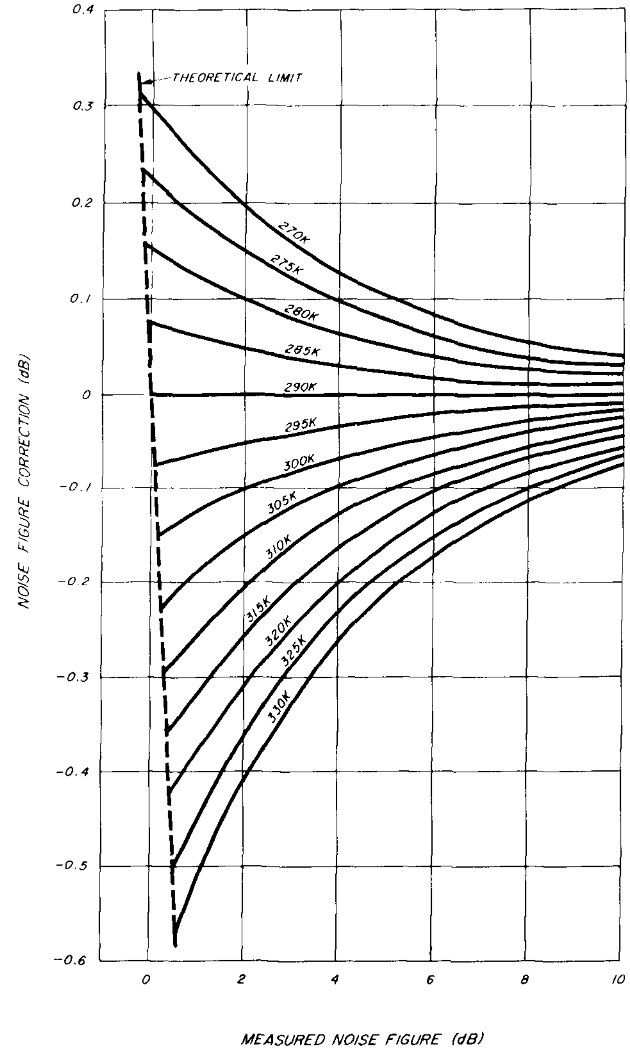


fig. 17. Noise-figure corrections, as a function of termination temperature, for a typical gas-discharge noise source (*courtesy AIL TECH*).

The image response of a system consisting of wideband amplifiers followed by a heterodyne receiver (converter) can be an important factor when measuring noise figure. The image-channel signal adds to the signal-channel signal and results in a measured noise figure which is lower than the true noise figure. The noise-figure error is a function of the receiver gain at the signal and image frequencies, as expressed by the following equation:

$$Error_{NF}\,(dB) = 10 \log \left(1 + \frac{G_i}{G_s}\right) \qquad \textbf{(13)}$$

where G_i is the image-channel gain ratio and G_s is the signal-channel gain ratio. It can be seen that, for

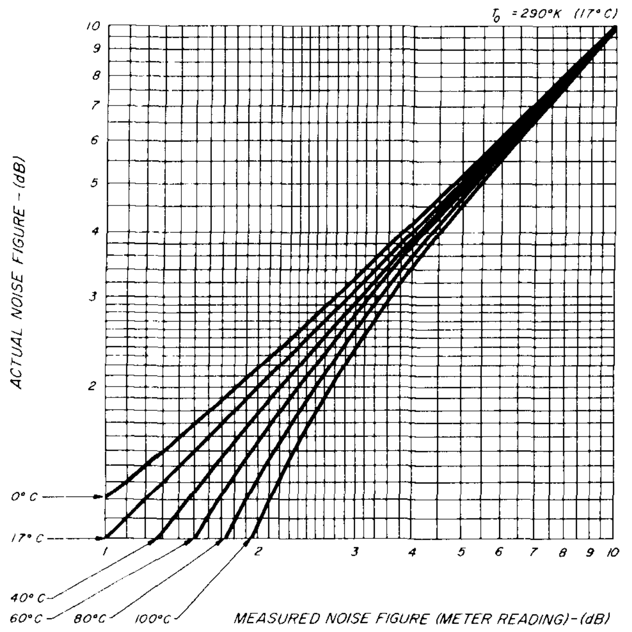


fig. 18. Temperature corrections for the Hewlett-Packard model 343A VHF Noise Source (*courtesy Hewlett-Packard Company*).

equal signal- and image-channel gains, the error will be equal to 10 log 2, or 3 dB.

Fig. 15 is a graphical representation of **eq. 13**, and shows the amount by which the measured noise figure must be increased. It is apparent that the noise-figure error is negligible if the receiver image rejection is greater than 20 dB. However, the corrections, especially when measuring low noise figures, can be significant at image rejections under 20 dB.

Which brings us back to the measurement of low-noise preamp noise figure. The prevailing concept in the design of low-noise amplifiers is to have untuned input and output circuits, and to rely on a separate high-Q filter ahead of the preamp to discriminate against unwanted signals. This is a valid design concept, but may lead to serious errors in the measurement of noise figure, especially at the aforementioned vhf/uhf conferences.

Fig. 16 illustrates, in simplified form, the four possible configurations of measuring preamp noise figure, using a receiving converter and a noise-figure meter with a 30-MHz input. In the examples shown, measurements are to be made at 432 MHz, and both the noise source and the preamp are assumed to be flat from 372 to 432 MHz. The bandpass filters can be of any type — tuned circuits, cavities, stub tuners, etc. — and may actually be part of the input or output circuits of any of the individual blocks. However, the absence of a filter indicates that it does not exist, either separately or as a part of any circuit; thus, in **fig. 16B**, the preamp has no filter in either its input or output circuit, and the converter has no filter at its input. The converter output circuit has no effect on this discussion, and is assumed to be tuned to 30 MHz.

In **fig. 16A**, bandpass filters at the input and output of the preamp limit the overall system response to 432 MHz. This is the normal communications configuration, and yields valid noise-figure measurements. In **fig. 16B**, both filters have been eliminated, so that the preamp accepts noise inputs from 372 to 432 MHz and, in addition, contributes its internal noise over the same frequency range. Since the converter produces a 30-MHz output from the noise power at both 372 and 432 MHz equal to $2N_2/2N_1$, the ratio remains the same as from one channel only, resulting in a valid noise figure.

Fig. 16C shows a test configuration in which a filter is used only between the preamp and the converter. It can be seen from the frequencies indicated on that diagram that only the 432-MHz noise signal reaches the converter, so that it too is a valid method of measuring noise figure. (It is equivalent to using an untuned preamp with a normal, tuned-input converter.)

In **fig. 16D**, the filter position has been changed from the output to the input of the preamp. Notice that in this arrangement the noise input to the preamp is limited to 432 MHz. However, this amplified noise plus the internal noise generated by the preamp at *both* 372 and 432 MHz are converted to the 30-MHz input of the noise-figure meter. Therefore, the noise-figure reading will be erroneous. The conclusions to be drawn from this discussion are that meaningful noise figures will be obtained if no filters are used, or if a filter is used following the preamp, but in no case should a filter be used ahead of the preamp without an equivalent filter at the output.

temperature error

In the derivation of the noise-figure equations, T_0 is equal, by definition, to 290°K and represents the noise temperature of the noise source when de-energized. It is therefore apparent that if the noise source is at a temperature other than 290°K (17°C or 62.6°F), an error will be introduced. Although such errors are of relatively small magnitude, especially over a limited ambient temperature range, it may be necessary to take them into account when measuring very low noise figures. **Fig. 17** shows the noise-figure correction, as a function of measured noise figure and temperature, for a typical gas-discharge noise source. It can be seen that if a noise-figure measurement of 2.0 dB were made in a room where the temperature was 80°F (approximately 27°C or 300°K), a correction of −0.1 dB should be made, making the corrected noise figure 1.9 dB. Extended use of a gas-discharge noise source also raises the cold temperature, so that the source should be allowed to cool down to room ambient when accurate measurements are required.

The temperature-correction curves for the Hewlett-Packard 343A diode noise source appear in **fig. 18**. Since the diode heat will cause the termination temperature inside the noise-source housing to be somewhat higher than the ambient, this factor should be taken into account when establishing a corrected noise figure.

Noise power obeys all power-transfer laws, but because noise is random in phase, mismatches cause ambiguous errors rather than known power losses. Because an automatic noise-figure meter measures the ratio N_2/N_1, a mismatch affecting both of these powers has no effect on accuracy, since the ratio remains unchanged.

The major consideration in matching involves the excess noise power available from the noise source. The ENR of any of the noise sources discussed in this article, excluding the Hewlett-Packard 345B, is based on developing the noise power in a 50-ohm resistive load. If the load is not 50 ohms, the ENR will be indeterminate.

The mismatch error must be calculated for each

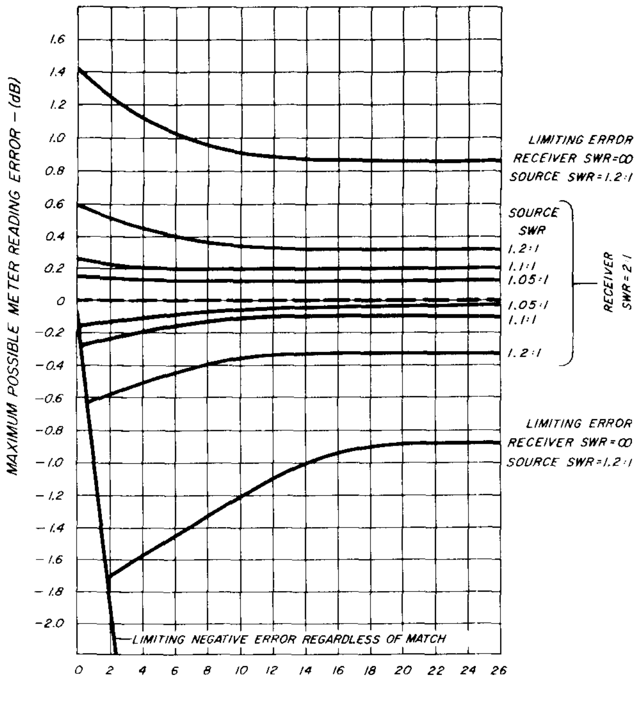


fig. 19. Typical errors for several possible conditions of mismatch between the noise source and receiver (*courtesy Hewlett-Packard Company*).

system by considering that noise power follows the power-transfer laws. A typical plot of error limits for a receiver swr of 2:1 is shown in **fig. 19**; the actual error can fall anywhere between the limits indicated.

transmission-line (insertion loss) error

This error is a function of the coupling of the gas-discharge tube to the helical transmission line (see **fig. 3**) and the attenuation of the transmission line, and always reduces the noise-source ENR. In **fig. 13**, this error has been taken into account in determining the excess noise ratios of the AIL noise sources. It has not been considered in the ENR curve for the Hewlett-Packard 349A, but according to the published data, the error is less than 0.25 dB. This is well within the ENR tolerances specified in **table 2**.

cumulative errors

If all errors are in decibels, they accumulate additively. Therefore, the total possible measurement error will be the sum of the following:

1. Noise-figure meter accuracy

2. Noise-source accuracy, corrected for frequency

3. Receiver image-response error

4. Temperature error

5. Mismatch error

6. Transmission-line (insertion-loss) error, if a gas-discharge noise source is used.

This is an imposing list, and could total well over 1.5 dB if all errors were of the same algebraic sign. However, many of these errors will cancel because of opposite signs, and generally the accuracy of the test equipment is far better than the limits of its specifications. Nevertheless, these possibilities of error are very real and cannot be ignored except for *comparative* measurements using the same equipment at one particular time. And even then, the mismatch errors between the noise source and the different receivers under test still exist.

summary

We have seen how automatic noise-figure measurements are accomplished, and have discussed their limitations and areas of inaccuracy. We can therefore answer the questions posed at the beginning of this article. A difference of 0.2 dB, or even 0.5 dB, in the noise figures of two different preamps measured at two different times on two different test setups is meaningless. Furthermore, the accuracies of such measurements, especially outside of a laboratory environment, are subject to rigorous examination. This is not a criticism of those amateurs who spend many hours at vhf/uhf conferences performing the tests; they know the limitations of their methods and equipment. Rather it is meant to warn those who accept noise figures as gospel that such is not the case.

The same warning applies equally to the "typical noise figure" specifications on some transistor data sheets. Unless an accurately calibrated hot-cold noise source is used to determine the noise figure of the device (and I personally know of cases where this was not done), the published figures may be no more accurate than you or I could obtain with surplus equipment — *caveat emptor.*

The automatic noise-figure meter can also be used to measure noise figure by the twice-power or *Y*-factor methods. However, since this article was intended to cover only the automatic mode of measurement, no attempt has been made to discuss manual operation. Gain measurements may also be made, in a clever application described by Paul Shuch.[11]

I sincerely hope that this article has taken some of the mystery out of automatic noise-figure measurements. More important, I hope that it will dispel any idea that you know your receiver or preamp noise figure to within a tenth of a dB.

appendix

To change the input frequency of a Hewlett-Packard noise-figure meter, only the frequency-determining circuits in the instrument's *tuned amplifier need* be changed to the desired frequency. If the new frequency is relatively close to one already established in the instrument, it may be possible to make the change merely by retuning the variable inductors in the tuned circuits. Otherwise, the coils will have to be modified or replaced.

The Hewlett-Packard models 340A and 340B employ a four-stage tuned amplifier. The front-panel *input* frequency switch selects one of two coils in each stage of the amplifier. In the standard models, these coils and their inductance ranges are as follows:

input frequency (MHz)	model 340A	model 340B	inductance (μH)
30	L1, L3, L5, L7	L6, L8, L10, L12	1.2 - 1.75
60	L2, L4, L6, L8	L5, L7, L9, L11	0.27 - 0.41

Regardless of whether the standard model, having the above input frequencies, or a special model having different input frequencies, is involved, the coil designations will be the same.

The coils resonate with approximately 20 pF. If the existing coils have sufficient inductance range to permit retuning, the procedure is simple. Set the METER FUNCTION switch to NOISE FIGURE and turn the *INF CALIBRATION potentiometer fully clockwise.* Then, using a signal generator, feed an unmodulated signal at the new frequency into the input of the noise-figure meter. Keep the signal level low enough so that the meter is never at full scale, and adjust the appropriate coils for maximum meter reading. If the meter reaches full scale, reduce the input signal before continuing the adjustments.

If new coils are required for the desired input frequency, select four adjustable coils whose mid-range inductance will resonate with 20 pF at the new frequency. Coils in the Miller 4300 series or Cambion 556-3338 series will replace those in the instrument without any mechanical modifications. After replacing the existing coils in the noise-figure meter with the new ones, retune the amplifier as described above. If the new frequency is 30 MHz or lower, a 3300-ohm composition resistor can be connected across each coil to broaden the amplifier response.

The Hewlett-Packard model 342A has provisions for five input frequencies. Instead of switched coils throughout the tuned amplifier, a fixed-tuned 30-MHz i-f amplifier is used in conjunction with a mixer and local oscillator circuit, which heterodynes four of the five input frequencies to 30 MHz. The fifth input frequency is 30 MHz, which is fed through the mixer with the oscillator disabled.

In the standard model 342A, the following coils and frequencies are used in the mixer-oscillator circuit:

input frequency (MHz)	mixer coil	oscillator coil	oscillator frequency (MHz)
30	—	(100-ohm resistor)	—
60	L10 (0.32 – 0.55μH)	L14 (0.156 – 0.228μH)	90
70	L9 (0.32 – 0.465μH)	L13 (0.156 – 0.228μH)	100
105	L8 (0.156 – 0.228μH)	L12 (0.32 – 0.465μH)	75
200	L7 (0.0392 – 0.0412μH)	L11 (0.057 – 0.063μH)	170

Special versions of the 342A will have one or more input frequencies which differ from those listed above. Therefore the coil inductances may also be different, but the designations will be the same.

To change any of the input frequencies except the 30-MHz input, either retune the coils associated with the *input* switch position to be changed, or use new adjustable coils whose mid-range inductance will resonate with 14 pF at the required frequencies. The mixer coil obviously must be tuned to the input frequency. The oscillator coil must be tuned to a frequency which is 30 MHz above or below the input frequency; be sure that the oscillator frequency and its harmonics are well removed from the 30-MHz intermediate frequency.

Set the local oscillator on frequency by means of a frequency counter or a dip oscillator. Then adjust the oscillator and mixer coils (but not the coils in the i-f stages) as previously described for the model 340A or 340B, using a signal generator at the new input frequency.

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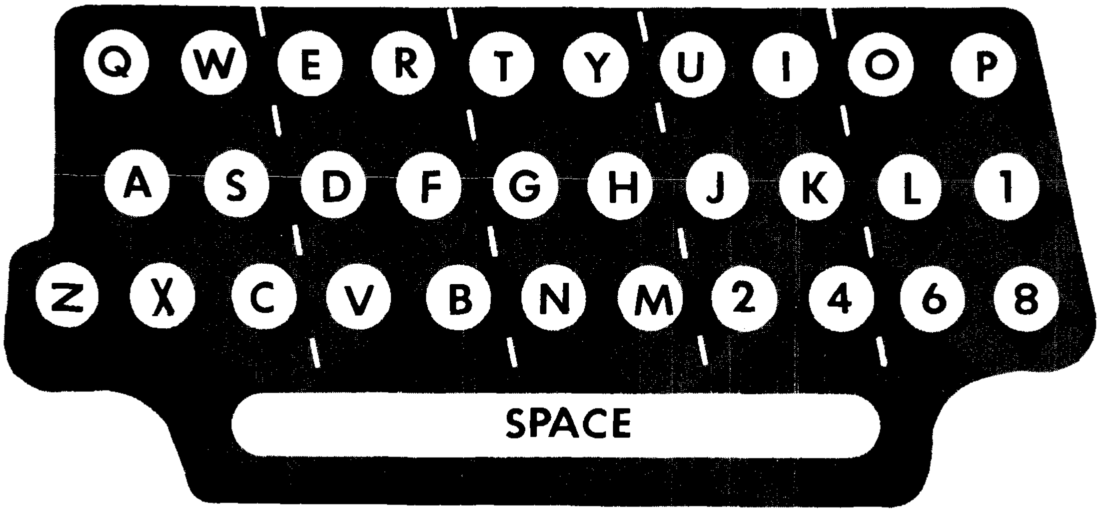

electronic teleprinter keyboard

This novel electronic keyboard uses toroids and a pulse generator to create the correct mark/space coding

This project grew out of a desire to design an electronic Teletype keyboard which would permit handicapped people to communicate with others. I took an initial design suggested by Ed Brown, WØEPV, determined that it was feasible, and developed the circuit shown in this article. The keyboard itself would generally have to be custom designed for each particular individual; for amateur use any surplus keyboard with a simple, closing-type contact will be sufficient.

circuit description

The heart of the circuit is a set of eight shift registers, composed of four 7474 ICs (see **fig. 1**). During static conditions, the $\overline{Q}$ outputs of the shift registers are all high, forcing the 7430 NAND gate low. This low disables the clock, while also enabling the pulse generator. When a particular key is actuated (key line taken low), the pulse generator is discharged through the respective cores. For example, if the Y line went low, the pulse generator would be discharged through cores T1, T3, T5, T6 and T7. The pulse from each core sets its respective shift register, causing the $\overline{Q}$ output to go low. Now that one of the inputs of the 7430 has been driven low, its output will change states, both enabling the clock and disabling the pulse generator.

Prior to the change in the 7430, the magnet driver was held in a mark condition by the action of U2.

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With both inputs to U2A now low, U2 pin 8 will go high, forcing the magnet driver into the space condition. Since the clock has now been enabled, it will put out a pulse after 21 ms, moving the contents of the shift register down one increment. Each low state, on the Q_0 line, will create a *mark*, while a high forms a *space*.

With the clock free running, as long as there is a low into U1, the shift register will receive pulses and move the data one increment for each clock pulse. After 8 shift operations, the registers will be clear and their high outputs will cause U1 to change states again, completing the character.

construction

Building this electronic keyboard is extremely straight-forward with the use of TTL circuitry.* Before operation, R5 should be adjusted with U1 pin 8 high, to provide 1.6 volts on pin 6 of the NE555. If

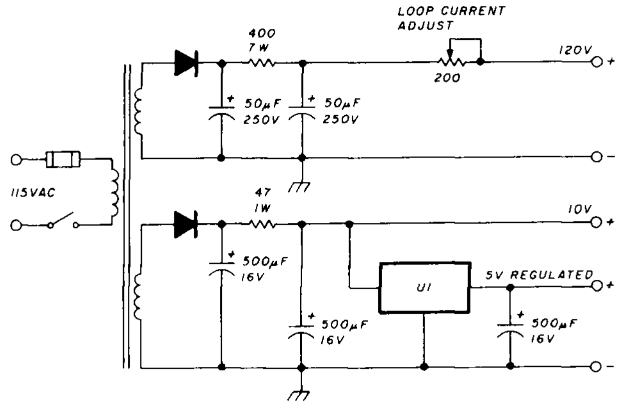

fig. 2. This power supply will provide voltages for both the keyboard plus the Teletype loop. The transformer is a Stancor 8626.

the keyboard is to be used at 60 words per minute, R1 should be adjusted so the 555 oscillates at 45 Hz; for 75 words per minute, use 61 Hz.

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*A copy of the circuit board layout and parts placement diagram is available by sending a self-addressed, stamped envelope to *ham radio*, Greenville, New Hampshire 03048.

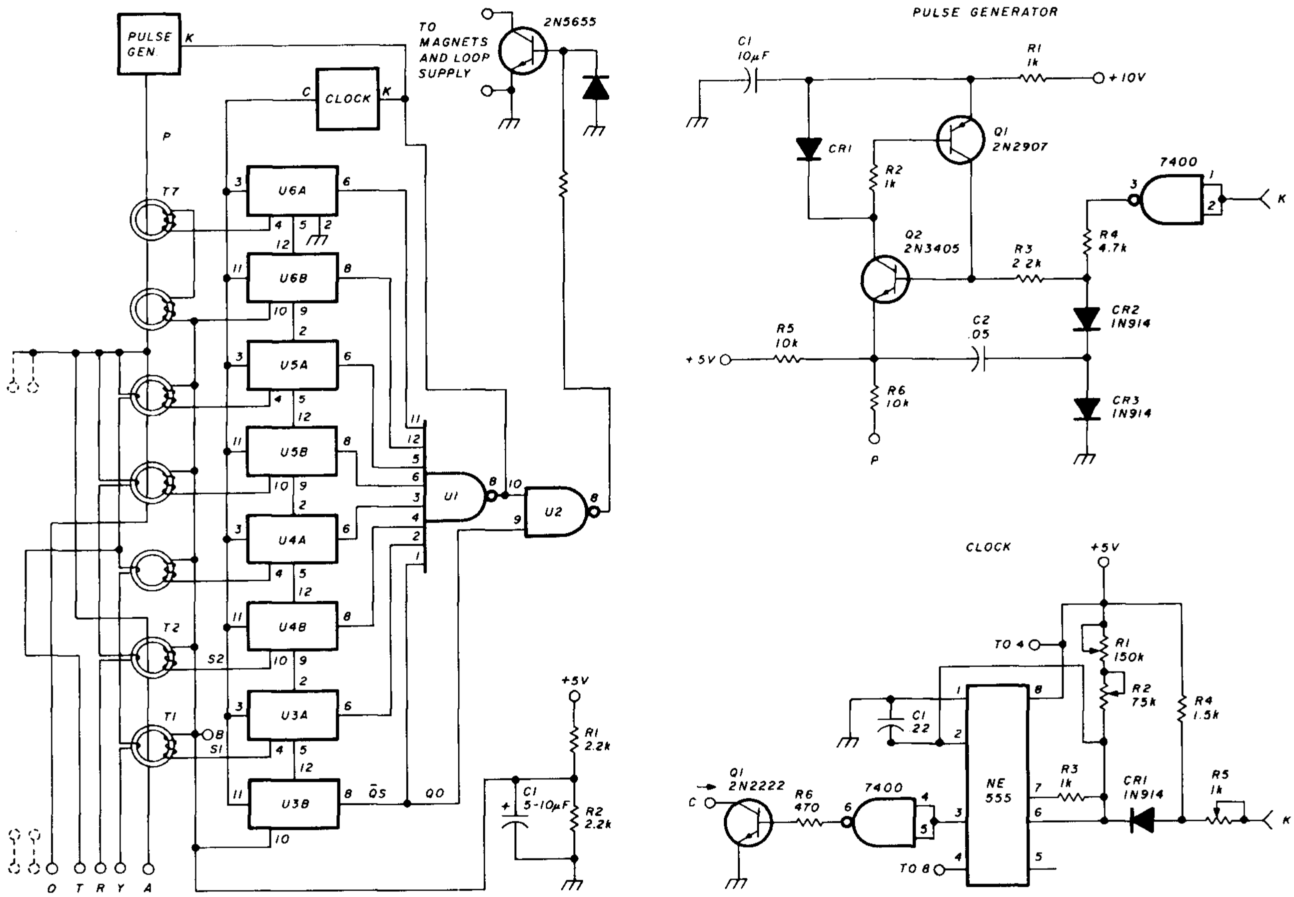


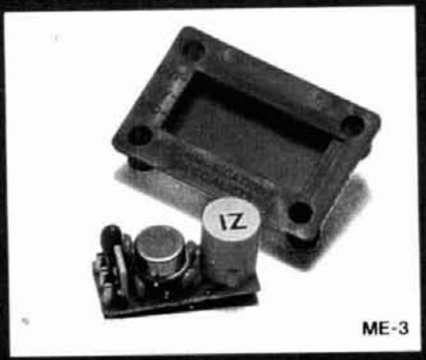
fig. 1. Schematic diagram of the electronic keyboard. Each toroid is an Indiana General CF-102, 0-6, wound with a 10-turn primary. The wires from the pulse generator are fed through the appropriate core to form the mark periods for each character.

TS-1

TS-1JR

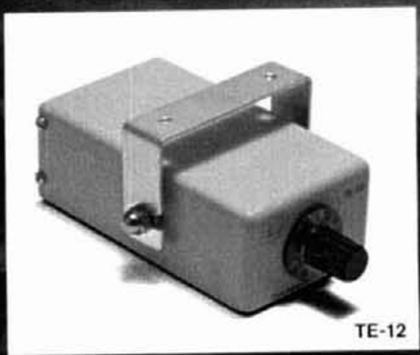
PE-2

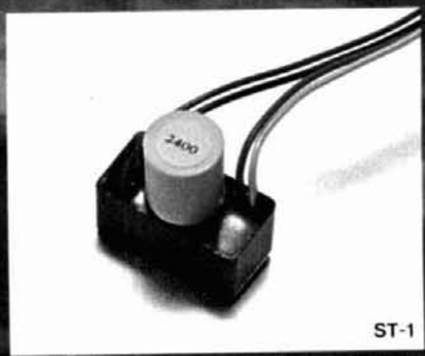
SD-1



ME-3

TE-8


TE-12



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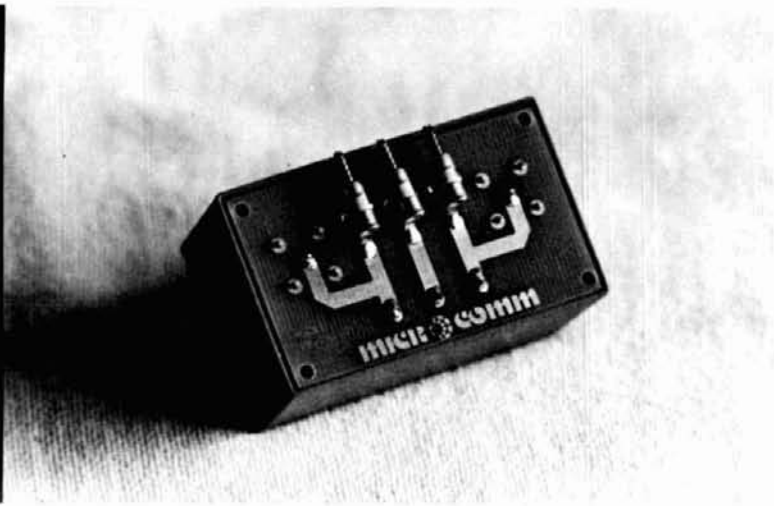


improved grounding for the 1296-MHz microstrip filter

Construction techniques for improving the performance of the three-pole 1296-MHz bandpass microstripline filter

The 1296-MHz microstripline bandpass filter I discussed in a previous article has allowed dozens of uhf experimenters to "clean up their act" on the 23-cm band.[1] As shown in **fig. 1**, the filter consisted of three top-coupled parallel-resonant circuits with grounded microstripline inductors. The filter is easy to assemble and tune, but several amateurs who have built it experienced difficulties caused by erratic stripline grounding. The new design presented here eliminates those difficulties and provides lower insertion loss and steeper skirts that will not tend to degrade as the filter is used.

The grounding of the microstriplines in the original design was accomplished by wrapping a thin brass or copper strap around the edge of the PC board, soldering it to the stripline on one side of the board and the groundplane on the other. Although this method of grounding worked well in the prototypes, the stripline inductance is a function of the placement of the grounding strap. Furthermore, the strap's placement on the edge of the board makes it extremely susceptible to physical damage, especially when installing or removing the filter board from its box. A third difficulty with wraparound grounding is that it forces the end of the microstripline inductor to extend to the edge of the board, where stray coupling can cause the tuning of the filter to change when the unit is placed inside an enclosure.

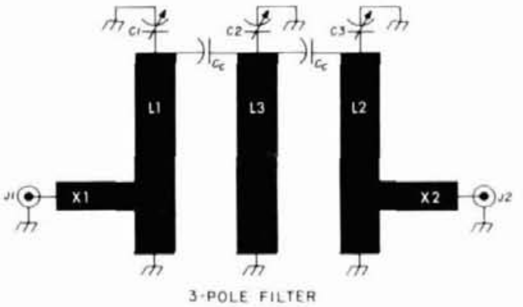
All of these difficulties can be easily eliminated by placing the grounded end of the microstripline inductors somewhat away from the edge of the board and drilling through the board for the installation of a grounding wire or post. With the ground connection running through (rather than around) the board, its mechanical integrity is assured, and the groundstrap inductance is more nearly constant from one filter to the next, especially if the diameter of the grounding wire or post is specified.

By H. Paul Shuch, N6TX, Microcomm, 14908 Sandy Lane, San Jose, California 95124

Although a short length of number 18 (1.0 mm) tinned copper wire makes an acceptable through-board ground connection, maximum grounding effectiveness and mechanical integrity, I have found, can be achieved by installing small electronic eyelets through the board, setting them with a press, and soldering both sides. The eyelets I use are made of thin brass, measuring 0.47 inch (1.2 mm) diameter by 0.093 inch (2.5 mm) long. They look something like tiny rivets. The eyelets are available from a number of vendors* and can be easily set using a center-punch (or sharp nail) and hammer.

grounding the trimmer capacitors

Another area of difficulty encountered by several readers is the grounding of the piston trimmer capacitors. The capacitors I originally used were designed for chassis mounting, so it was necessary to modify



C1 - C3	1.5-pF ceramic piston trimmer (Triko 202-08M or equivalent)
C_c	Stray coupling capacitance between stator ends of trimmer capacitors
J1, J2	SMA or equivalent microstripline launchers (E.F. Johnson 142-0298-001 or similar)
L1, L2, L3	Microstripline inductor, 0.5" (13 mm) long, 0.1" (2.5 mm) wide, spaced 0.3" (7.5 mm) center to center. Bottom ends strapped to ground plane with thin copper strap
X1, X2	50-ohm microstripline, 0.1" (2.5 mm) wide, any length. Centerline tapped to L1 and L2 0.2" (5 mm) from grounded end

fig. 1. Three-pole microstripline bandpass filter, which will tune the range from 1100 to 1500 MHz. Full-size printed-circuit layout for this filter is shown in fig. 2.

them for circuit-board use by adding a bus-wire loop around the terminal nearest the adjusting screw (see **fig. 4** of reference 1). It would have been better to use a trimmer specifically designed for PC use, with legs installed for grounding the rotor end through the circuit board. One such capacitor is the R-Triko 202-

*One acceptable eyelet is part number F-4793-B, available from International Eyelets, Inc., 528 Santa Barbara Street, Santa Barbara, CA 93101.

fig. 2. Full-size printed-circuit layout for the three-pole 1296-MHz bandpass filter. Etched on double-clad 1/16" (1.5 mm) fiberglass-epoxy circuit board; the unetched side serves as a ground plane.

08M, a German ceramic piston trimmer available in the required 1-to-5-pF range.* I find filters using this capacitor easier to tune up, although I caution the builder against repeated adjustments because the tuning mechanism loses spring tension and becomes erratic after a couple dozen adjustments. The best procedure is to set the filter on frequency *once*, and then place a dot of nail polish, epoxy paint, or *Loctite* on the tuning screw as a reminder to leave it alone!

assembling the modified filter

Fig. 2 is a full-size printed circuit layout for the 3-pole bandpass filter, modified for through-board grounding. The board should be etched from double-clad 1/16-inch (1.5-mm) fiberglass-epoxy printed-circuit stock, with one side left unetched to serve as a ground plane. The board should be drilled in the same manner as the template in **fig. 3** and the three eyelets installed at the bottom end of the microstriplines.‡ Don't forget to remove a bit of ground plane

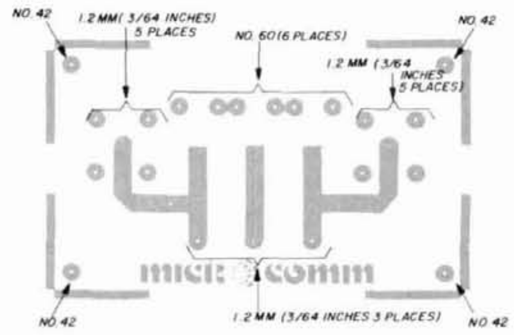


fig. 3. Full-size drilling template for the bandpass filter board.

*These capacitors are available in the United States through Stettner-Trush, Inc., 67 Albany Street, Cazenovia, NY 13035.

‡Completely etched, drilled, and plated printed circuit boards, with the three eyelets installed, are available for $4.50 postpaid within the U.S. and Canada, $5.00 elsewhere, from Microcomm, 14908 Sandy Lane, San Jose, CA 95124. Completely assembled, tuned, and tested filters are also available. Send a stamped, self-addressed envelope for details.

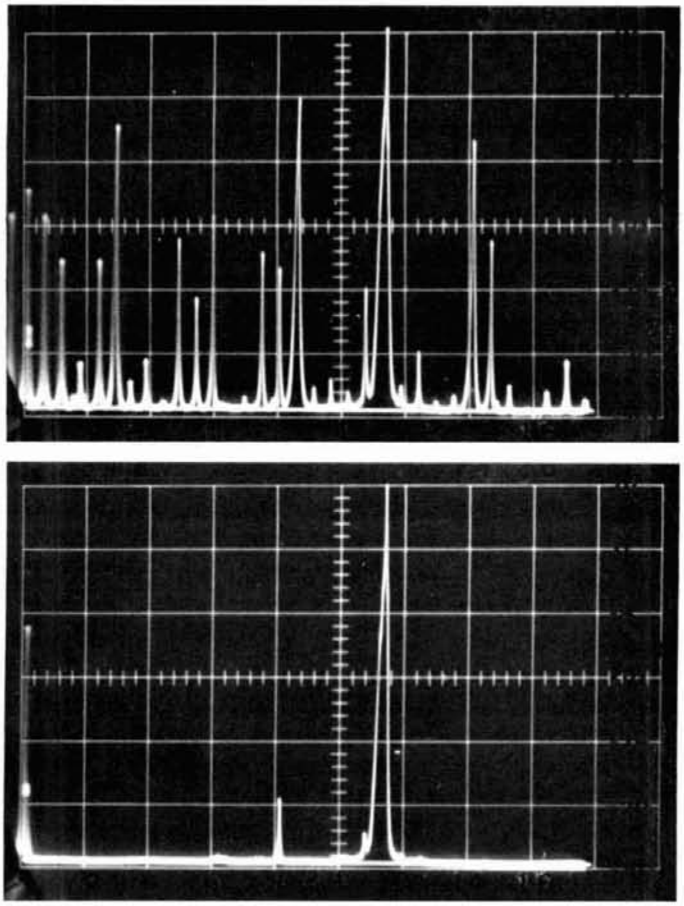


fig. 4. Effect of the bandpass filter on a 1296-MHz local oscillator chain. Spectrum display at top shows the various spurious outputs of a poorly designed LO. Spectrum at bottom is the result of passing the LO signal through a three-pole bandpass filter of fig. 1. The worst remaining spurious component is suppressed 25 dB. (Both displays: dc - 1.8 GHz sweep; horizontal scale, 200 MHz/division; vertical scale, 5 dB/division.)

metallization from around the center-pin holes for the input and output coaxial connectors so the signal isn't grounded out. A 1/8-inch (3-mm) twist drill, used as a deburring tool, works well for this operation.

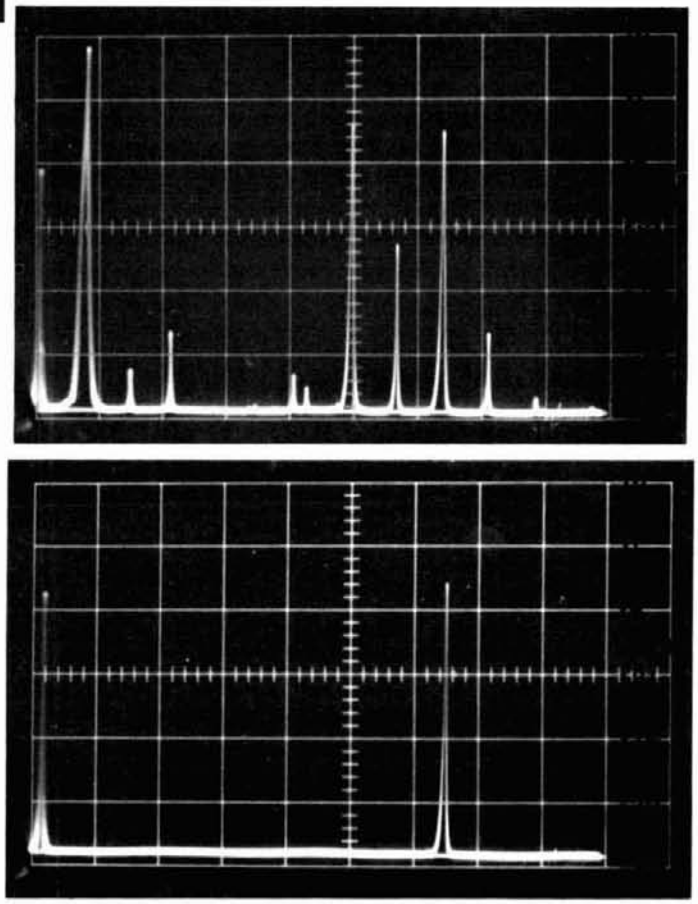
Connectors J1 and J2 are installed next, soldering the center pin to the input and output microstriplines, and running a bead of solder around the connector body on the ground-plane side of the board. The trimmer capacitors are installed last. If you use the recommended Triko trimmer, be sure to bend the two mounting legs nearest the adjusting screw down against the ground plane before soldering. The photograph of the completed filter will assist you in assembly.

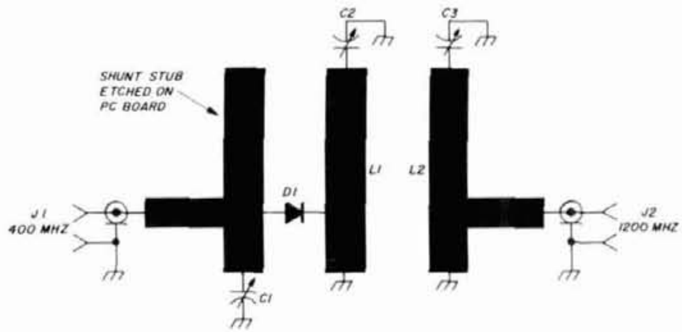
filter performance

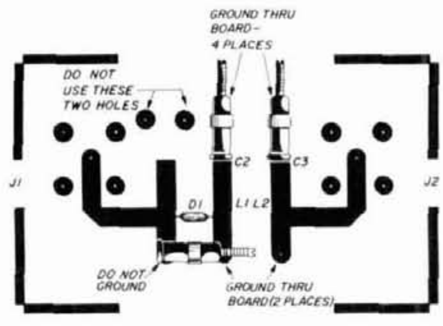
Reference 1 included a swept response curve for the original bandpass filter, as measured on a network analyzer. The response curve for the modified filter design shows slightly reduced insertion loss (on the order of 0.5 dB) and slightly steeper skirts. Perhaps the most realistic indication of filter performance is not its swept response, but the filter's behavior in an actual system. **Fig. 4** shows the effect of installing the bandpass filter behind an extremely spurious local oscillator chain. Note that the numerous spurious components are all significantly suppressed, with the worst remaining spur reduced from −5 dB to about −25 dB, relative to the desired output.

Fig. 5 shows the results when the filter is used to clean up the output of a previously published transmit balanced mixer.[2] Notice that the i-f feedthrough signal and its harmonics, the LO feedthrough, the

fig. 5. Effect of the three-pole bandpass filter on the output of a 1296-MHz transmit mixer. Spectrum display at top shows the output from a singly balanced diode mixer; visible spurious components include the desired signal and image, some LO feedthrough, a very strong component of the i-f injection, and its second and third harmonics, and transmit intermods (resulting from these harmonics mixing with the LO signal). With the three-pole bandpass filter installed in the system, the spectrum (bottom photo) shows that all spurious outputs have been attenuated by more than 25 dB. (Both displays: dc - 1.8 GHz sweep; horizontal scale, 200 MHz/division; vertical scale, 5 dB/division.)







C1	1-9 pF piston trimmer (Triko 203-09M or equivalent)
C2, C3	1-5 pF pistion trimmer (Triko 201-01M or equivalent)
CR1	Step recovery diode (H-P 5082-0180)
J1, J2	SMA coaxial connector (E.F. Johnson 142-0298-001 or similar)
L1, L2	Microstripline inductors (see **fig. 2**)

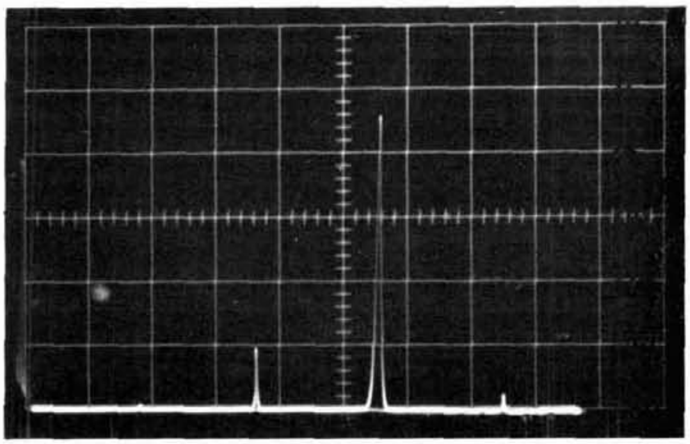
fig. 6. Circuit and construction details for a local-oscillator multiplier which provides 0.5 mW at 1200 MHz from a 5-mW 400-MHz drive signal. This circuit uses the same printed-circuit layout as the bandpass filter (see fig. 2). Output spectrum of this circuit is shown in fig. 7.

image signal, and the intermodulation products are all suppressed below the dynamic range of the spectrum analyzer.

local-oscillator multiplier

In a previous article I described a diode multiplier for developing local-oscillator injection for a 1296-MHz converter.[3] As this multiplier used a microstripline output filter, it seemed reasonable to assemble a similar multiplier on the bandpass filter PC board, thus allowing one PC artwork to do the job of two. The circuit, which makes a rather nice low-level tripler, is shown in **fig. 6**. Note that the microstripline previously associated with the first filter pole is now used to support the multiplier diode and its input matching circuit. Do *not* install a grounding eyelet on this first stripline if you are building the multiplier! The other two filtering poles help reject the many other harmonic components generated by the step-recovery diode, as shown in the spectrum analyzer display of **fig. 7**. When driven by the 5-to-10 mW signal from my uhf LO chain, this multiplier provides about 0.5 mW of third-harmonic output. This power level can be easily buffered in a 1296-MHz preamp,[4] applied to a 3-pole filter for additional spurious rejection, and used to drive the LO port of a transmit or receive balanced mixer.

fig. 7. Output spectrum of the 400-MHz to 1200-MHz LO multiplier. Note that the tripler circuit provides some degree of filtering of the 400-, 800-, and 1600-MHz components from the step recovery diode.



I should point out that the circuit of **fig. 6** provides no dc return for the anode side of the multiplier diode. A dc return is necessary for the diode to properly develop self-bias; in my system this dc path is provided at the output of the uhf LO. If the driving stage does not offer dc continuity to ground, it will be necessary to install a dc return circuit on the multiplier board. This can be most readily accomplished by adding a small (0.33-μH) rf choke to ground at the location normally occupied by the first trimmer capacitor when this board is used as a filter.

summary

The printed-circuit layout can be used to fabricate high-quality bandpass filters and diode multipliers for the amateur 23-cm band. The designs are based upon previous articles, but the addition of through-board eyelet grounding significantly improves performance and reliability. Further details on construction, tune-up and testing, and system application are discussed in reference 1.

references

1. H. Paul Shuch, WA6UAM, "Microstripline Bandpass Filters for 1296 MHz," *ham radio*, December, 1975, page 46.
2. H. Paul Shuch, WA6UAM, "Rat-race Balanced Mixer for 1296 MHz," *ham radio*, July, 1977, page 33.
3. H. Paul Shuch, WA6UAM, "Easy-to-build SSB Transceiver for 1296 MHz," *ham radio*, September, 1974, page 8.
4. H. Paul Shuch, WA6UAM, "Low-cost 1296-MHz Preamplifier," *ham radio*, October, 1975, page 42.

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for vhf fm

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about those signal reports
on two meters?
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pays off in
increased versatility

Adding an inexpensive oscilloscope to your fm transceiver will make your base station much more versatile. You'll have a signal monitor capable of measuring (+ 0 –) carrier frequency, peak-deviation modulation, per cent noise quieting, and *Touch-Tone* signal levels. You'll be able to tweak transmit crystals in other rigs (great for netting CD-MARS members on frequency) and much more. Now blow the dust off your old scope and put it to good use — or give the test scope a dual function, as I did.

fm signal reports

How often have you heard, "You're 40 per cent quieting but Q5 copy," and wondered how the operator on the other end arrived at the 40 per cent figure? He must have been good at guessing, had a super trained ear, or maybe trying to be friendly.

When I became interested in two-meter fm I was very much confused with per cent quieting signal reports (especially if I had to give one). The transceiver I used was an ICOM IC20 and it did have a relative strength S-meter. While working simplex, whatever the meter indicated would be the report I gave. However, working through repeaters presented a whole new ball game. Unlike simplex, repeaters may come slamming into your location, but the signal on the input side may be quite weak. Under such circumstances the S-meter reading is invalid for a report, but a monitor scope would immediately show the per cent noise quieting into the machine. One day while working on a circuit and using my old EICO model 460 scope, I saw the light for a per cent quieting indicator.

operation

After examining the IC20 schematic for a good signal pickoff point, I decided the best place would be at the output of the discriminator stage (at TP3) and ahead of the audio control circuit (see **fig. 1**).

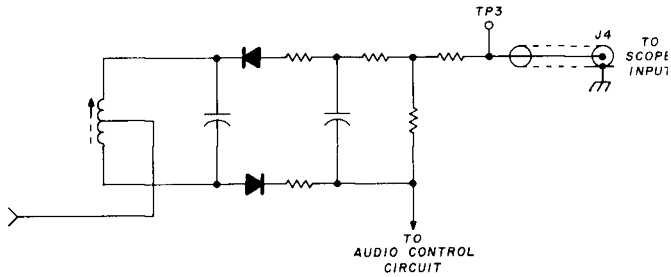


fig. 1. Pickoff point in a typical amateur 2-meter transceiver for connecting a monitor scope. In this case it's at TP3 in the popular ICOM model IC20. The pickoff point should be made at the receiver discriminator output, but ahead of the audio control circuit.

Several advantages would be obtained by doing this: 1) I'd see the noise figure as it appeared, unaffected by audio and squelch-control settings; 2) I'd see peak deviation (modulation); 3) by connecting directly from the discriminator output to my scope's dc vertical input I'd be able to measure the dc voltage produced by the received-signal carrier. Most fm transceivers (or receivers) have a test point at the location mentioned for alignment purposes. Your manual or schematic should indicate if this point is available.

connection

Modification and wiring of the transceiver was simple (**fig. 1**). Connection to the outside world was made using a small-diameter, single-conductor, shielded cable from the discriminator circuit to a

By Ed Spadoni, W1RHN, 91 Tower Street, Dedham, Massachusetts 02026

rear-panel-mounted phono connector (Radio Shack No. 274-346) designated J4 in **fig. 1**. The shield was wired to J4 ground lug only. Next my scope was connected through a suitable length of shielded cable, with a male phono plug on the end, to mate with J4.

calibration

Scope control settings will vary depending on the types of scope used. My EICO 460 control settings were as follows: Vertical attenuator in the DC-X1 position, horizontal sweep at 100 Hz, and sync on INTERNAL. With the transceiver tuned to an inactive channel, adjust the vertical gain for 51 mm (2 in.) p-p noise level (**fig. 2**). The noise as seen on the scope indicates the total passband of the rig's receiving section. My IC20 has a passband of better than 16 kHz, which allows me to see signals ±8 kHz from the passband center with reasonable accuracy. At present I can read 1 kHz = 2.5-mm or 0.1-in. division on the scope with good linearity to ±8 kHz.

It's essential to have your receiver properly aligned and your receiving crystals adjusted to the passband center. If you're synthesized, be sure the receive oscillator is also properly adjusted. I've found that a very convenient frequency reference source is a repeater output signal. By tuning in several machines you can see if things are properly adjusted by noting if the repeater signals are located in the passband center. If not, a little trimming must be done.

Working someone with a synthesized or vfo rig can prove very helpful in determining the linear portion of your receiver and its frequency limits. After determining the useful reading range of your transceiver-scope combination, you should be able to read signals to ±1 kHz of your receiver passband center.

using your scope

Here are some samples of the more important waveforms observed while monitoring both simplex and repeater signals.

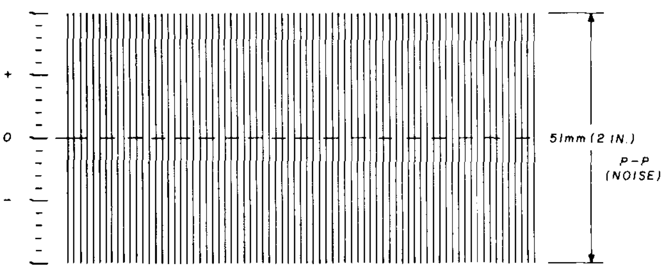
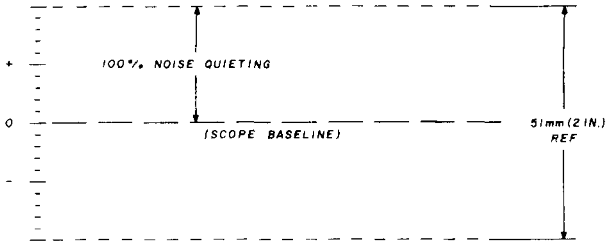
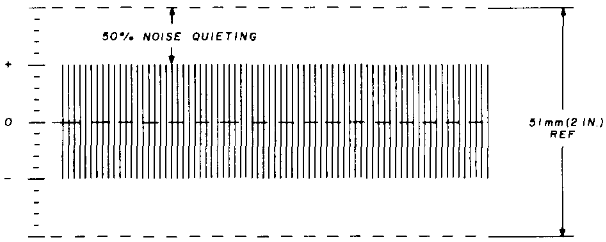


fig. 2. Scope presentation for calibration. Peak-to-peak noise should occupy the entire scope face, which represents the total passband of the receiver on noise.

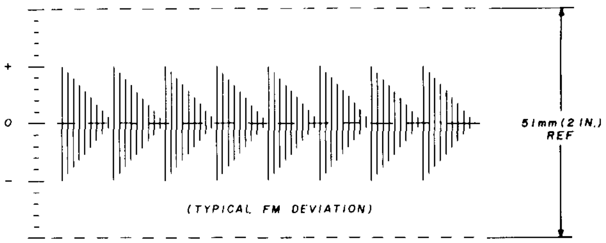
1. 100 per cent noise quieting signal, either simplex or repeater, with a pause in modulation:



2. 50 per cent noise quieting signal, either simplex or repeater, with a pause in modulation:

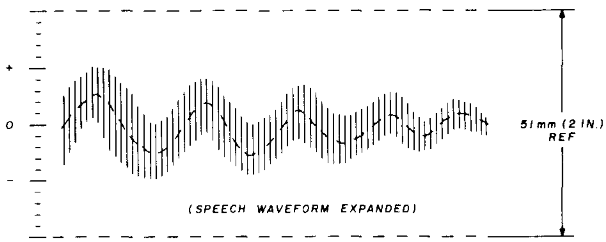


3. Normal *signal showing deviation* (modulation). Most transceivers and repeaters have their deviation set for a nominal peak of 5 kHz:

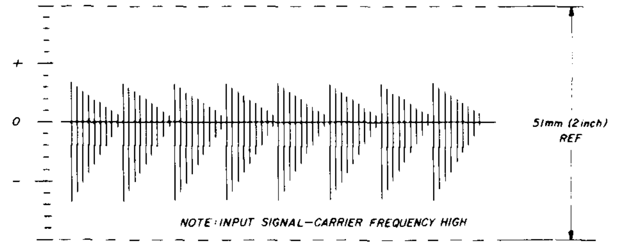


EACH 2.5mm (0.1 IN.) ON VERTICAL SCALE EQUALS 1kHz

4. 100 per cent quieting repeater signal received at your location with a weak and noisy input signal. Horizontal sweep adjusted for expanded one or two speech waveforms:

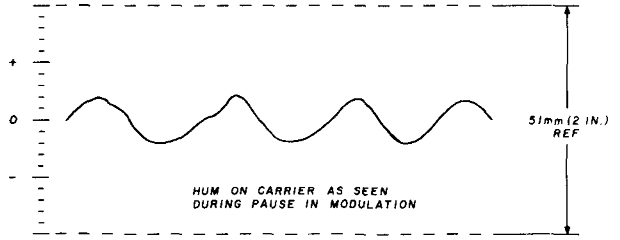


5. Repeaters normally produce equal swings of deviation, in both up and down directions, with most input signals. If a new station comes into the machine and produces the pattern shown below, this means that the new signal's carrier frequency is off and higher than the repeater passband center. The opposite would be true with a low-frequency carrier signal into the machine:

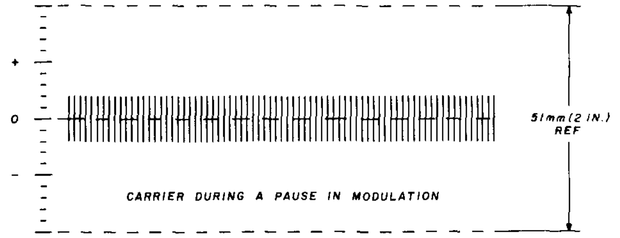


6. Hum accompanying signal. Frequency and ratio of hum to modulation can be determined. Hum frequency is referenced to 60 Hz.

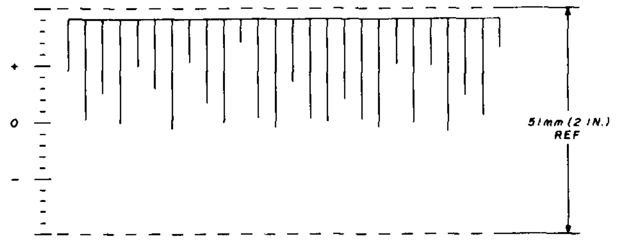
$$Per\ cent\ of\ hum = \frac{hum\ p\text{-}p}{deviation\ p\text{-}p} \times 100:$$



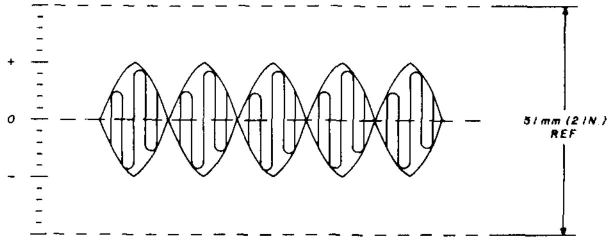
7. Power supply whine accompanying the received-signal carrier has a constant amplitude and frequency. Mobile alternator whine is similar, except the amplitude and frequency will change as the vehicle is accelerated or decelerated. Whine appears as a high-frequency modulated carrier with or without voice modulation:



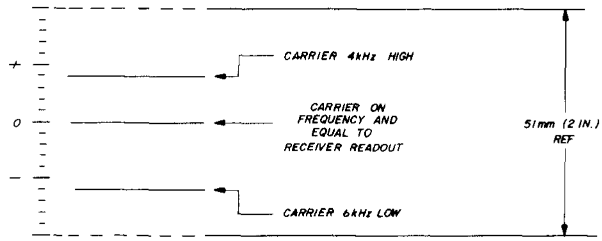
8. Upper-channel interference from a strong simplex or repeater station. Many hams have experienced this condition and termed it (in error) intermodulation. Lower-channel interference is similar, except that the baseline would appear on the lower side of the passband with audio transients shooting upward:



9. Checking and adjusting *Touch-Tone* signals. Preferably, use a simplex channel and have the operator close-talk into the microphone at a normal voice level. (Note the peak deviation.) Next, have the operator switch in the TTP, push buttons 1 and 2 or 1 and 4, and observe the peak amplitude. Peak deviation and amplitude should be the same for both; if not, adjust TTP output level. Then have the operator push all buttons to see if all levels are the same. When a single button is pressed a dual frequency is generated and is a normal function for a TTP, as shown below. Each button produces its own set of different frequencies:



10. Frequency measuring. Using a scope with your transceiver gives you a limited-range frequency meter, allowing you to read up to ±8 kHz per channel on 2 meters. The range is restricted only by the passband capability of your transceiver.

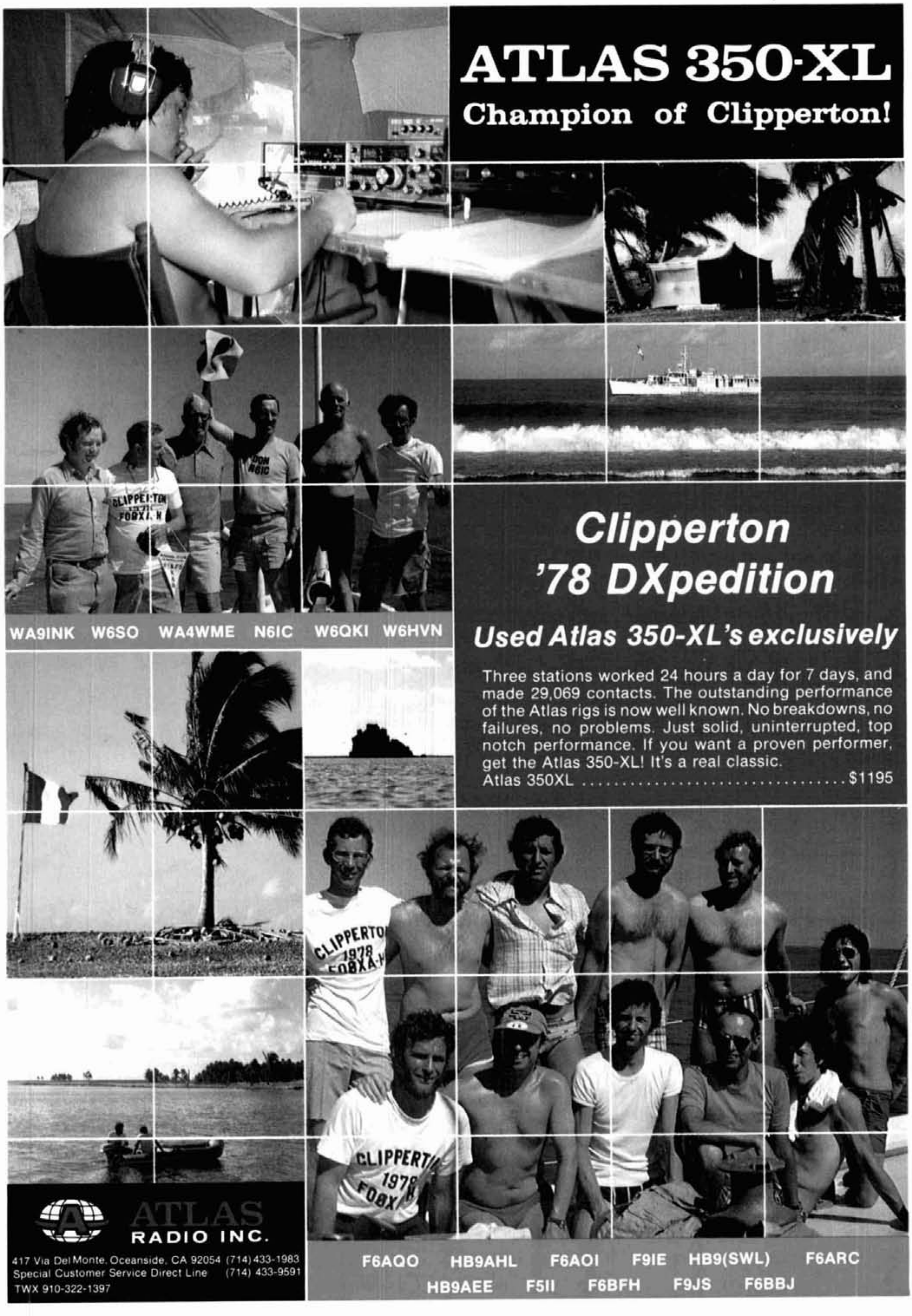


final comments

You can leave the scope in the circuit without affecting transceiver performance. If you have separate receive-transmit capability, the scope can also be used to monitor your own transmitted signal. The waveforms illustrated are those most often encountered and are therefore the most important.

Scopes aren't difficult to come by. Try surplus houses, auctions, or build one from a kit. A monitor scope beats the cost of frequency counters and you see much more. Making this simple modification to your radio and adding a scope will allow you to keep watch over other rigs (your hand-held; repeater output), especially the transmitted signals. The combination becomes unbeatable when used with synthesized transceivers or those with ± 5-kHz offset or with transceivers having a VFO and 1-kHz readout.

ham radio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single-tone decoder

for vhf fm

Design and construction of a false-free device using a single tone to alert you on two-meter fm

A single-tone decoder is adequate for many applications on vhf fm, but very little practical information on these devices has been published. Several years ago K2OAW described the use of a 741 op amp as a carrier-operated relay (COR) and tone decoder,[1] but I didn't know what a COR was at that time. So I read the part about the tone decoder, and within 15 minutes I was at the junk box struggling to put a reasonable fascimile together to see whether or not all that was claimed for this circuit was true. The claims were that the decoder would not trigger on noise, speech, or even singing but would activate immediately in response to the chosen tone. Beyond that, the decoder bandwidth was not supposed to get any broader as the input amplitude increased. Also, the decoder was not supposed to trigger on the selected tone if that tone were accompanied by any other tone or noise.

This article describes a single-tone decoder with hints on how to set it up. It has the advantage of being free from falsing while coming on quickly enough to stop a scanner on the frequency where the tone was transmitted. An appropriate encoder, small enough to fit in most hand-held transceivers, is also described.

In those days I had two CB hand-held transceivers with built-in tone encoders for mutual noise making on 11 meters. I wanted to use the decoder (if it worked) with these units. Fortunately I had all I needed on hand to make the circuit on a perf board. When I was finished, lo and behold, it worked! It was so selective that it wouldn't false, even on channel 11 with the band open; when my tone came through, the decoder came right on.

I put it all together in a box with a speaker and some jacks and used it that way for several years until I got on 2-meter fm. I then discovered some problems and shortcomings that needed solutions. Over the years I came up with a modified circuit that filled my needs and has been working well ever since. Before going any further, let me explain why I used a single-tone decoder rather than *Touch Tones*, sequential tones, or some other type of selective decoding device. It's not really the decoder but the *encoder* that makes the difference. A stable, single-tone encoder can be easily and inexpensively built to fit into a hand-held transceiver, and that's exactly what I did.

operation

The radio is on at all times and tuned to a repeater frequency, but a relay directs the audio to a 10-ohm, 2-watt resistor and the decoder input. When the desired tone is received the audio is directed through a 7-second timer to both a local and an extension speaker. (The extension speaker, in my case, is located in the kitchen.) After seven seconds the unit resets, and the audio is removed from the speakers. My wife (the technician in the house) then goes to the shack and operates a toggle switch that defeats the decoder, disconnects the extension speaker, and supplies the audio at a conversational level to the

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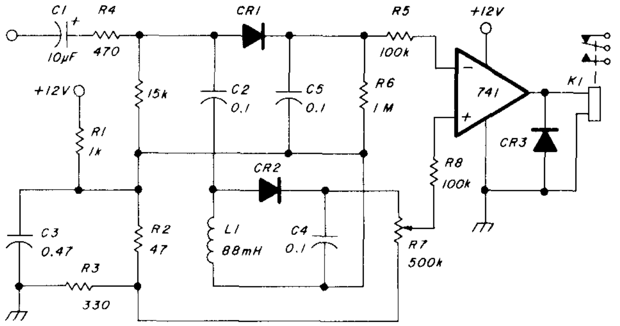

fig. 1. Original circuit of the single-tone decoder, which forms the basis of the modified system. (From *73*, July, 1972.)

local speaker. After two-way communications are completed, the same switch returns the unit to normal operations. Nothing need be disconnected from the rig at any time.

The original circuit is reproduced here (**fig. 1**) to demonstrate its operation. I'll dispense with a detailed description of how the decoder works. Briefly, the incoming signal is separated into two components — the desired component and all others. The two voltages so derived are rectified and fed respectively to the positive and negative inputs of the 741 op amp. The voltage at the positive input must exceed that at the negative input for the 741 to turn on. The bandwidth is set by R7, which determines the op amp bias. (A complete description of the circuit can be found in the original article.)[1]

modified decoder

Fig. 2 shows the modified circuit. C1, the frequency-determining capacitor, is replaced by seven capacitors and a seven-pole, single-throw switch on a 14-pin DIP. (This is only a convenience to allow easy frequency change.)

choosing capacitors

Be sure to use only NPO capacitors for C1; that is, capacitors whose values do not change with temperature, otherwise you may find, as I did, that on warm or cool days the decoder will not respond to your tone. A drift of only a few hertz can prevent the decoder from working. If you're not sure of your capacitors but have access to a capacitance bridge, connect the chosen capacitor across the bridge, take a reading, and then cool the capacitor with freeze mist and take a second reading. If the change is more than slight (say about 10 per cent), don't use it. You'll find that most disk ceramics will change value by as much as 50 per cent under these conditions. Mylar or tantalum capacitors are usually good.

My unit is set up to decode frequencies between 300-600 Hz using a 150-µH toroid; an 88-µH toroid, as originally described, is fine. Experiment with values of C1 to see where you are and work up or down from there. If you have a low-band rig, connect the audio output to the decoder and use the crystal calibrator to generate a test signal. Of course, an audio signal generator may be used, but remember that the amplitude must be similar to that of an audio power amplifier since these are the conditions under which the decoder was designed to work.

adjustment and tests

If the decoder doesn't operate at first, test the frequency determining components by placing a dc voltmeter across the 741 positive and negative inputs. Sweep an audio-frequency generator over as

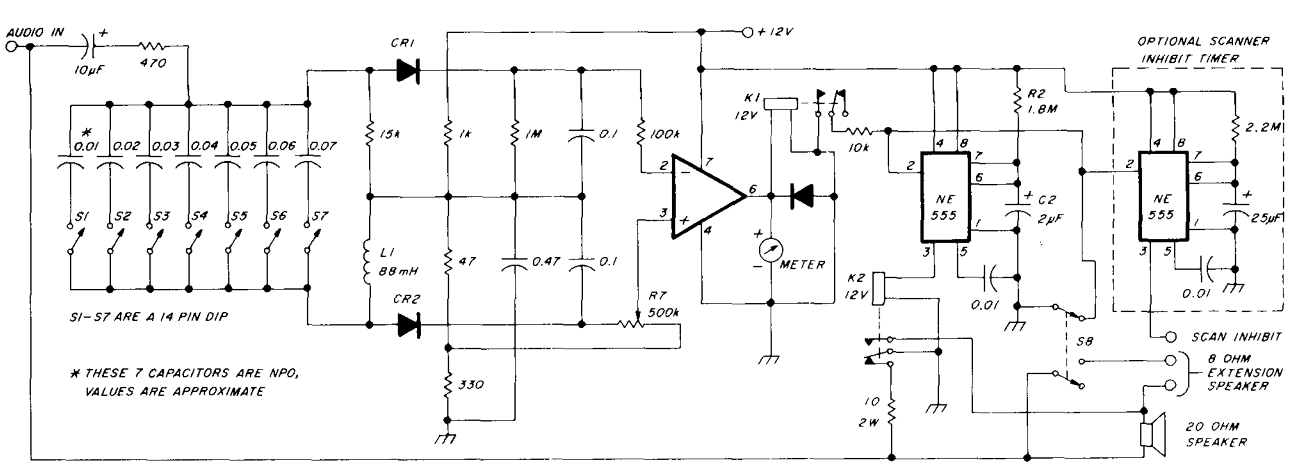

fig. 2. Modified decoder featuring easy frequency change using 7 NPO capacitors and a 7-pole, single-throw switch on a 14-pin dual in-line package. Unit decodes frequencies from 300-600 Hz. The universal 741 op amp does the work; bandwidth is set by resistor R7.

wide a band as possible. The voltage will peak at one frequency and remain negative at all others. Play around with the bandwidth while you are doing this.

The 555 timer is set to keep the speakers on for about seven seconds, but you can substitute a pot for R2 to give different lengths of time.

The meter across K1 is used to adjust the encoder to the decoder frequency. The meter will read highest at the decoder's most sensitive frequency. The meter is also useful for quick checks and adjustments. Almost any sensitive meter can be used with the appropriate series resistor to keep it in range. I used a tape recorder VU meter.

encoder

I tried several circuits as an encoder, but by far the best is the "Twin-T Oscillator" taken from the *Radio Amateur's VHF Manual*. While the output amplitude is low and must be fed into the transmitter mike input, the frequency is completely independent of the supply voltage over its operating range. When NPO capacitors are used, a very stable source of oscillation results, which is mandatory if the encoder-decorder pair are to work reliably. It's best to set up the encoder with an oscilloscope to try to achieve a near-perfect sine wave. Other waveforms contain harmonics, which will tend to desensitize the decoder. Keep this in mind when you operate through a repeater. The repeater's audio shaping, or your own overdeviation, may cause tone distortion.

suggested improvements

This unit has worked well for several years, but, for still further usefulness, the following may be done. A scanning board can be added to the receiver and connected so that the decoder, when coming on, will inhibit the scanner and lock the receiver onto the tone frequency. This may be accomplished by a second 555 timer set to lock on for about one minute. The manual defeat switch would also inhibit the scanner. This setup will allow you to use whichever repeater or simplex frequency is most convenient at the time, especially if your favorite repeater happens to be down just when you want to make the call. The decoder can be used in this way because it triggers almost instantly on the appropriate tone. Other single-tone decoders using the 567 chip require a prolonged tone to achieve freedom from falsing. A scanner would pass by too fast to decode the tone in this case. Other modifications will come to mind I'm sure. I hope you find this project useful and fun.

reference

1. Peter Stark, K2OAW, "741 Op Amp COR and Tone Decoder Circuits," *73*, July, 1972, page 83.

ham radio

When the FCC acted

we reported:


hr REPORT

Amateur Radio's WEEKLY NEWSLETTER

prepared by the editors of Ham Radio Magazine

Number 201

May 12, 1978

EX-NOVICES WHOSE LICENSES expired less than a year ago will be eligible to apply for reinstatement just like any other Amateur licensees under the FCC's recent rules change making Novice licenses good for five years and renewable (HRR 195). This means any former Novice whose license expired after May 15, 1977, can submit a Form 610 on or after this May 15, but within one year of his original expiration date, when the new provisions become effective, and regain his license for a full five years — without retaking an exam.

Present Novice License holders must realize the new five year Novice license terms are not retroactive — their licenses still expire in two years on the expiration date they bear and must be renewed with Form 610 — available from Ham Radio for an SASE.

THE RUSSIAN "RS" AMATEUR satellites are now reported due to be launched before the end of this year and are to be inserted into "high altitude" orbits.

Control station for various AMSAT nets, is shut
Spaceflight Center facilities are being refur-

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electronic bias switching
for the Henry 2K4 and 3KA linear amplifiers

Easy modifications
you can make
to these popular linears
to increase efficiency
in CW and ssb modes

Two excellent articles have appeared in the amateur literature dealing with electronic bias switching (EBS) for high-power linear amplifiers.[1,2] Why electronic bias switching? It's a great saver of tube life. It reduces tube dissipation, ambient noise, and your power bill. EBS, in general, is a way to make your amplifier operate more efficiently in whatever mode you choose, ssb or CW.

The EBS method described here may be used by those amateurs interested in CW only operation or by those using ssb with or without signal processing. Using the basic circuits described in references 1 and 2, a very efficient EBS circuit can be built into the popular Henry 2K4 or 3KA linear amplifier. The circuit can be adapted to your home-brew linear with a little ingenuity.

Henry rf decks

First of all, for those not knowing it, the rf decks in the 2K4 and the 3KA amplifiers are almost identical. The only difference is the use of wider-spaced loading variable capacitors in the 3KA (two 350 pF instead of two 500 pF, plus three additional 100-pF, 5-kV doorknob fixed capacitors). A 2K4 rf deck can easily be modified to a 3KA rf deck by simply changing these components. Of course, the 3KA uses higher plate voltage (3.6 instead of 2.8 kV). A 2K4 can be driven to 2 kW PEP with 100 watts rf, while the 3KA needs at least 150 watts of rf drive to run at its full rated output.

The EBS circuit will not be dealt with in detail. The referenced articles discuss the principles of operation of the circuit. The circuit components can be mounted on the aluminum panel covering the compartment that houses the swr bridge, zener diode, etc.

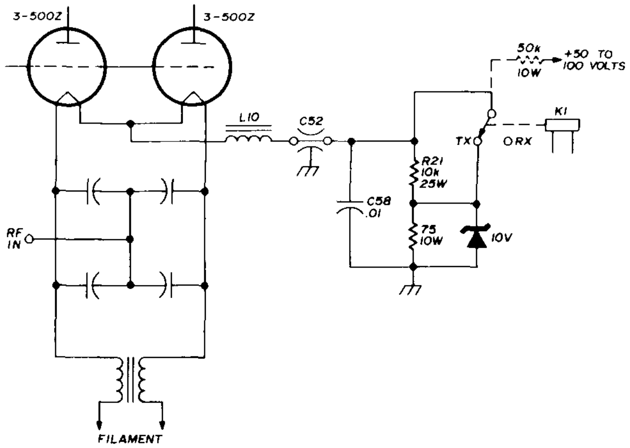

fig. 1. The bias and transmit-receive switching circuits in the Henry 2K4/3KA linear amplifiers. Dashed line (upper right) shows a 50k resistor added to the circuit through a +50-100-volt power supply to effect complete amplifier cutoff during receive mode.

Fig. 1 shows the original bias plus transmit/receive switching circuit as used in the 2K4 and 3KA amplifiers. During receive, R21 is switched into the cathode circuit, whereby the tube is biased to a point very near cutoff. Simply adding a 50-k resistor (**fig. 1**) and connecting it to a +100-volt supply (50-150 V) will improve the circuit; the tube will then be *completely* cut off during reception (+100 volts on the cathode).

By Michael James, W1CBY

improved bias circuit

Fig. 2 shows the EBS circuit as developed especially for the 2K4 and 3KA linears. R1 through R4 are well over-dimensioned resistors (in wattage), where a parallel combination is used for added safety (if one resistor opens, the system will still function on the remaining resistor). These resistors can be mounted on the bottom side of the cover plate. The Darlington transistor and the thyristor can be bolted to the plate using mica washers. All other components should be wired point-to-point on wiring strips. The rf choke (2.5 mH) in the integrator circuit between the Darlington transistor collector and base was necessary to prevent rf from getting into the base circuit and being rectified. This was the case with one particular unit in which the circuit functioned even without rf applied to the diode rectifier from the exciter input. Installing the rf choke cured the problem.

operation on cw

If you're a CW-only man, the time constants on the make and break side of the switch can be made much shorter. Change the 0.47-μF capacitor to 0.047-μF and the 20-nF to 2 nF. This will turn the amplifier on and off much faster and still further reduce tube dissipation between dots and dashes. Closing S1 allows you to run the amplifier in its original condition; that is, without the EBS circuit. It also allows you to check tube idling current.

operation on ssb

Using signal processing. One general disadvantage of running a great amount of clipping (10-20 dB) is the objectionable background noise that may occur between words, especially if you have some noisy fans or if room acoustics are not the best.

First it's essential that, when using speech processing, you speak very closely to the microphone (lips almost touching). When doing so the amount of clipping permissible with a processor such as the Magnum Six, Comdel, Vomax, DX engineering, or Datong, in a noisy shack, is determined by the acceptable signal-to-background noise ratio. An acceptable ratio is *−25 dB*. This means that, if your average power output with the processor, on a steady, stretched-out "Aaaa," is 1 kW (on your output meter), the background noise should be no more than 3.2 watts on the same output meter (that is, 25 dB down from 1000 watts). Adjustment procedure:

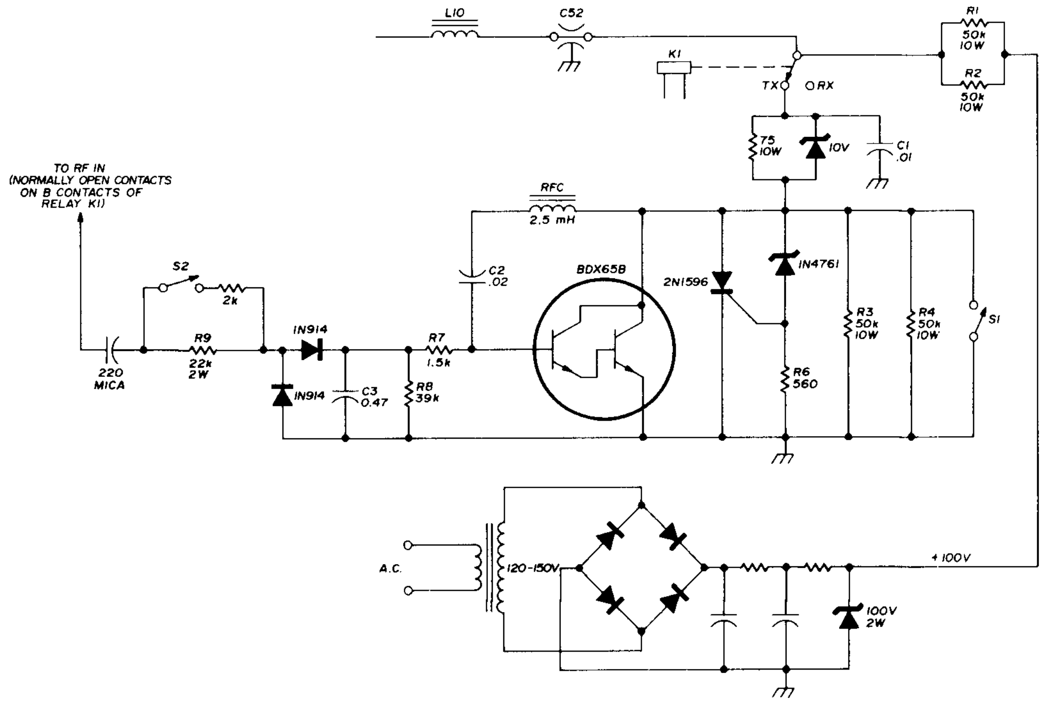

fig. 2. The electronic bias system circuit that can be added to the Henry 2K4/3KA linear amplifiers — an easy way to improve operation on CW or on ssb modes with or without signal processing.

1. Switch off the EBS circuit by closing S1.

2. Tune up the amplifier in the normal way.

3. Adjust the clipping level in the prescribed way, but certainly no further than to the point where the background noise, as indicated on your

wattmeter, is at least 25 dB down from your steady "Aaa. . ." (3.2 watts versus 1000 watts).

4. Open S1, without changing any setting to your transmitter or processor. If the background noise (at −25 dB or better) trips the EBS circuit (meaning that if you see the background on the scope or output meter, or if your plate meter does not drop to zero) then the EBS-circuit input sensitivity is too high. Increase the value of the 22k resistor until you find a value where the background noise *just* does not trip the EBS circuit. This value should be such that a drive of a little higher than −25 dB (say 5 watts or −23 dB in our example) turns on the EBS circuit.

If, when first switching on the EBS circuit, your −25-dB background noise does not trip the EBS circuit, *reduce* the value of R9 (22k), and determine the value where a −25-dB signal will not trip the EBS circuit, while a −23 dB signal does.

Once you've determined the correct value of R9, you've not only installed a good working power saver but have achieved *total elimination of all bothersome background noise,* while running 15 or 20 dB of processing in a noisy environment. Nobody (especially the locals) will hear the blowers and accuse you of running excessive power!

Ssb using no signal processing. Using the EBS circuit with a value of R9 as determined above but driven by a nonprocessed ssb drive signal will result in too-low sensitivity of the input circuit. This will cause the circuit to switch on syllables. The result will be a distorted signal (similar to a vox dropping in and out while you talk because of too-short vox delay).

To work properly, the value of R9 must be decreased until switching does not occur between syllables. The best way to find out is to listen to your own signal using headphones and adjust R9 until the breaking up on syllables disappears. A value of 1.5 - 3.3k seems to be a good starting value.

If you want the EBS circuit to be fully flexible for both ssb modes (processed and nonprocessed ssb drive signals), a small switch (S2) or relay can be installed, which switches a second resistor in parallel with R9 to reduce its value when operating with a nonprocessed drive signal.

references

1. Marv Gonsior, W6VFR, "Electronic Bias Switching for Linear Amplifiers," *ham radio*, March, 1975, page 50.
2. J. A. Bryant, W4UX, "Electronic Bias Switching for RF Power Amplifiers," *QST*, May, 1974, page 36.

bibliography

1. John A. Devoldere, ON4UN, "Improved Performance from the Drake R4-B and T4XB," *CQ*, March, 1976.

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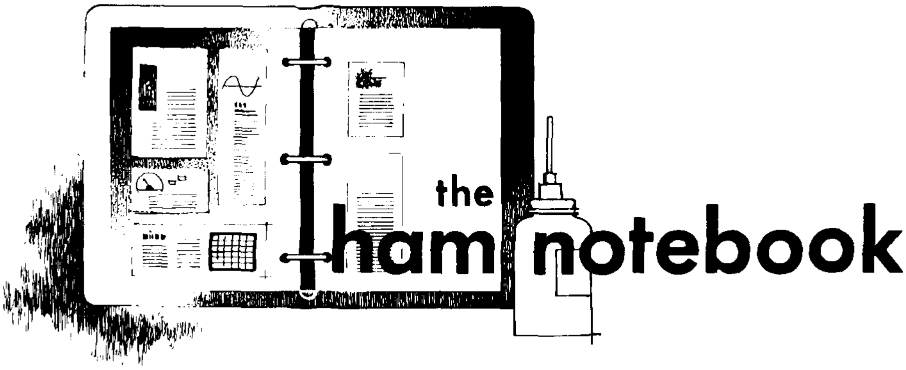


rejuvenating transmitting tubes with thoriated-tungsten filaments

Many amateur high-powered linear amplifiers are designed around the popular Eimac family of tubes, such as the 4-250A, 4-1000A, and the 3-500Z. All these tubes use thoriated-tungsten filaments. All other things being equal, the life of these tubes depends on the filament, which should be treated with care if you expect your tubes to last.

Filament emission is a complex process. As the chemical composition of the filament changes, the electron emission changes. As soon as the tube is turned on, it starts to lose electron emission, which finally drops below a value determined to be the "end-of-life" point. This process generally takes several thousand hours.

Once the end-of-life point is reached, the filament's chemical composition is so changed that nothing can be done by the user to restore the filament emission. The tube is then said to be "decarburized." The ditungsten carbide on the filament surface has thus evaporated or has combined with residual gas, and the carbide surface layer on the filament is gone.

Theoretically, it's estimated that a four per cent increase in filament voltage will result in a 20K increase in temperature, a 20 per cent increase in peak emission, and a 50 per cent decrease in life because of filament carbon loss. This, of course, also works the other way. For a small decrease in temperature and peak emission, life of the filament carbide layer, and hence the tube, can be increased substantially.

For the Eimac 4-1000A and other tubes of this filament voltage, broadcast stations run the tube at 7.2 volts instead of 7.5 volts. The reason is extended life. The 3-500Z filament should be run at 4.8 volts instead of 5.0 volts, and so on. The filament voltage should be checked with a 1 per cent meter to achieve these values.

If the tube filament is contaminated, or if electron emission is otherwise inhibited (perhaps a grid has been overheated and has liberated gas, or filament chemistry has been upset by running the filament at a *very low* voltage), the tube can be rejuvenated by increasing the filament voltage by about 15 per cent and running it for a time at this overvoltage (filament power only; no other voltages on the tube elements). This filament overvoltage action will cause emission material in the filament to "boil" out from the filament interior and form a new emissive surface.

The "cooking" time depends on the filament condition — the time may be only a few minutes or it may be longer. The only way to tell is to test the tube at intervals for emission. If the tube has been cooked properly, and the filament is in the right condition chemically to begin with, normal electron emission will be restored.

If you have a power tetrode or triode tube that has lost filament-emission (evidenced by decreased power output), it's certainly worth a try to get the tube back to near-new condition. Make sure that you meter the "cooking" circuit properly and that adequate cooling for the tube envelope and filament connectors is allowed.

These large tetrodes are expensive to replace, and you haven't anything to lose by cooking the filament of one that's lost emission. However, don't expect miracles. If your linear has used tubes, you probably don't know the history of the tube's operation and the cause of filament emission loss. If's worth a try, though, and you may be pleasantly surprised.

Alf Wilson, W6NIF

audio rolloff

Many people find that their external *Touch-Tone** encoder will not access some systems. Many times, this is not the fault of the radio or the encoder, but actually the interface between the two units. What often occurs is that the signal from the encoder is connected into the audio input. Most radios incorporate a small-value capacitor (0.001 to 0.0033 μF is typical) between the microphone input and the first audio IC. This capacitor rolls off the low frequencies from the *Touch-Tone* encoder, yet passes the high frequencies relatively unattenuated.

One possible solution to this problem is to change the value of the input capacitor to 0.1 μF. If this is not practical, another remedy would be to directly inject the signal from the encoder into the input of the first audio IC. In this case, connect a 0.01 μF capacitor between the encoder and the IC. The capacitor should be mounted as close to the circuit board as possible to preclude any problems with rf getting into the audio stage.

Joe Olivera

**Touch-Tone* is a registered trademark of the American Telephone and Telegraph Company.

tester for 6146 tubes

Since many popular exciters and transceivers use 6146 tubes, and since it is not easy to find a tube tester to accommodate this tube, there is a need for a simple tester to evaluate the condition of 6146 transmitting tubes. This is particularly important when speech processors are used — they tend to raise the average power input, thus shortening tube life. The circuit shown in **fig. 1** uses junk box parts, but will provide a very acceptable 6146 tube tester.

In this tester an ac bias for the grid is provided from the filament winding. It must be polarized. It must be polarized properly, *i.e.*, the grid must be going positive as the plate is going positive. To check this, reverse the filament connections. Choose the one which yields the greatest plate current. The tester is then ready for use.

A good tube will draw 115 mA or more as indicated on the meter. Note that this meter indication is the average of half-wave rectified current. Tubes providing 90 mA or less should be discarded or, at most, kept for emergency spares. The tester is also useful for balancing pairs of tubes.

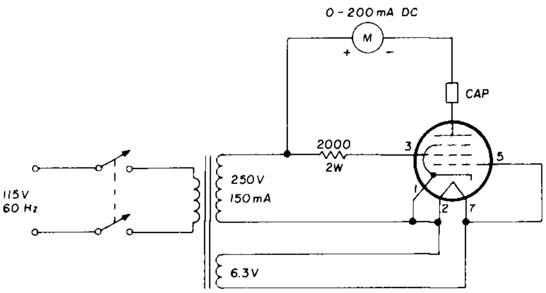


fig. 1. Simple tester for 6146 transmitting tubes is easily built from junk-box parts.

Gary Liegel, W6KNE

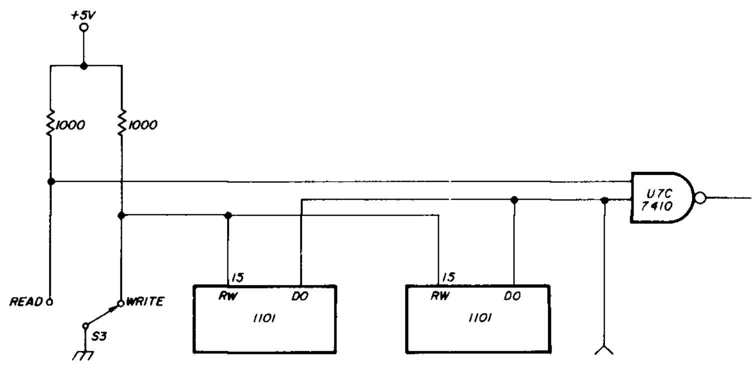
---

programmable accessory for electronic keyers

Since completing the programmable accessory for electronic keyers, August, 1975, *ham radio*, I've struggled to get it operational with my WB4VVF keyer,[1] achieving only intermittent success. The problem has always centered around the memory address and the READ/WRITE control line.

As I've discovered, the READ/WRITE line of the memories does not have to be synchronously pulsed with the address locations, merely taking the R/W line to +5 volts during the READ is sufficient. Therefore, since it turned out that the clock pulse from Q2's collector will directly drive U9A, both U8 and U11A are no longer required. The READ/WRITE switching is still done with S3 as seen in **fig. 2**.

Another problem was that the output pulse from U11B was fast enough to feedthrough the first binary counter in U12 and trigger the second binary counter simultaneously. This prevented full address of the memories. Bypassing pin 4 of U11B with a 1000 pF capacitor cured the problem.



Since programmable memory ao dress was not required, 7493s were substituted for 74193s. Additionally, sockets must be changed from 16 pin to 14 pin. The 7493 is somewhat cheaper and more available from suppliers.

1. James Garrett, WB4VVF, "The WB4VVF Accu-Keyer," *QST*, August, 1973, page 19.

John M. Korns, K9WGN/WØUSL

simple frequency counter

The frequency counter described by K4JIU in February, 1978, *ham radio*, page 30, has proven to be a simple, but useful, design. Unfortunately, after building the counter on the board supplied by Mr. Bordelon, the counter wouldn't operate above about 30 MHz on the 50-MHz range, or above 300 MHz on the 500-MHz range. Discussions with the author indicated that the problem probably revolved around the waveform presented to the 7208. The Intersil data sheet stated that the optimum input waveform should have a 50 per cent duty cycle. This is the case in the 5-MHz range. But, when using the 74196 prescaler, the Q_D output has an 80 per cent duty cycle.

One possible cure is to use the Q_C output from the 74196 to drive the counter. This will give a duty cycle of 60 per cent. This change also requires that the nonscaled 5-MHz input be loaded through Data Input C instead of Data Input D. The change is accomplished by cutting the foil runs at pins 12 and 13 of U3 and using pieces of insulated wire to connect the foils to pins 2 and 3 respectively. After the change, there will be no connections to pins 12 or 13.

Carroll Hamlet, W2QBR

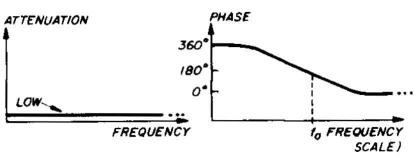
comments

phasing networks

Dear HR:

In regard to VK2ZTB's article summarizing ssb phase shift networks in the January, 1978, issue, several comments are in order. First, a review of the many existing broadband audio phase-shift networks is fine, but the underlying theory *common* to each should also be presented.

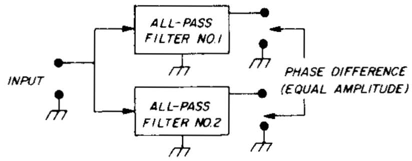
In general, the type of networks employed are called all-pass filters (the attenuation is constant, and the phase changes montoroically with respect to frequency, over the entire frequency band of interest). All-pass filter characteristics:



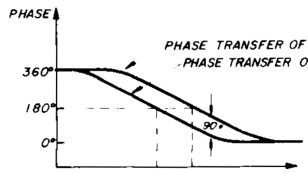
$$\frac{V_{output}}{V_{input}} = \frac{-\omega^2 - j\,\dfrac{\omega_o}{Q}\,\omega + \omega_o^2}{-\omega^2 + j\,\dfrac{\omega_o}{Q}\,\omega + \omega_o^2}$$

where $\omega = 2\pi f$ and ω_o and Q are constants.

If two all-pass filters are constructed with the proper Q and ω_o (for each), an audio phase shifter for ssb generation results. This is done as follows:

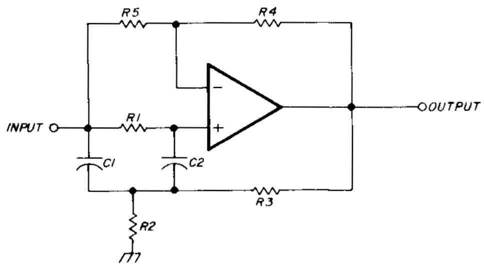


The Q of both filters is chosen to be 0.2252. ω_o of all-pass filter 1 is 2π (428 Hz); ω_o of all-pass filter 2 is 2π (2104 Hz).



Note that even though the phase shift of each filter changes with frequency, the phase *difference* between the two outputs is 90 degrees over a wide band of frequencies.

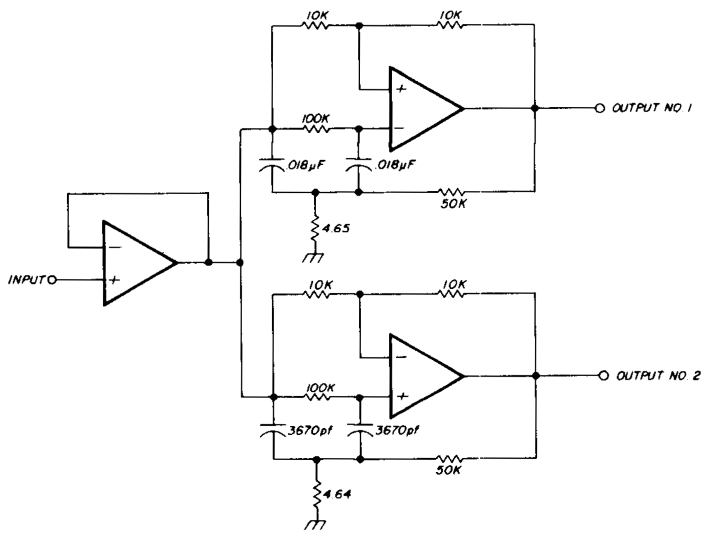
No active filter examples were included in the article (VK2ZTB's **fig. 11** uses op amps, but there are no RC networks in the feedback path). Why not use the more state-of-the-art active filter approach? One realization of this type of circuit uses two Steffen all-pass filters.



The general transfer function for the Steffen circuit is:

$$\frac{V_{out}}{V_{in}} = \frac{-\omega^2 - j\omega\left[\dfrac{R_4}{R_5}\left(\dfrac{1}{R_2}+\dfrac{1}{R_3}\right)\dfrac{1}{C_1} - \dfrac{1}{R_1C_1} - \dfrac{1}{R_1C_2}\right] + \dfrac{1}{R_1C_1C_2}\left(\dfrac{1}{R_2}+\dfrac{1}{R_3}\right)}{-\omega^2 + j\omega\left[\dfrac{1}{R_1C_2} + \dfrac{1}{R_1C_1} + \left(\dfrac{1}{R_2}+\dfrac{1}{R_3}\right)\dfrac{1}{C_1} - \dfrac{1}{R_3C_1}\left(1+\dfrac{R_4}{R_5}\right)\right] + \dfrac{1}{R_1C_1C_2}\left(\dfrac{1}{R_2}+\dfrac{1}{R_3}\right)}$$

The resulting audio phase shift network for ssb generation (300 to 3000 Hz) is as follows:



Tom Apel, WB9YEM
Madison, Wisconsin

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NEW products

For literature on any of the new products, use our *Check-Off* service on page 126.

EMI Power Purifier Pack

Now you can obtain a three-in-one package that will eliminate over 90 per cent of your mobile electrical-noise problems. Called the *Power Purifier Pack*, the kit from Marine Technology includes a power-line filter for use between the battery and your transceiver or other equipment; an alternator filter to reduce or eliminate alternator whine; and an ignition filter to clean up noise from that source.

The EMI-ACE, while not offered as part of the kit, can be obtained separately for use with fuel pumps, windshield wiper motors, cooling or heating blowers, and the like. The ACE may not be necessary in all cases.

For more information on the EMI *Power Purifier Pack* and other Marine Technology products, write to Marine Technology, 2780 Temple Avenue, Long Beach, California 90806; or use *ad check* on page

new Heath wattmeter

Heath Company, the world's largest manufacturer of electronic kits, has released a new wide-band Bidirectional Wattmeter. Called the IM-4190 (or SM-4190 in an assembled version), it is a self-contained unit that measures transmitted radio power up to 300 watts and reflected power up to 30 watts. It covers the 100-MHz to 1-GHz spectrum, and is an ideal tool for two-way radio service and repair, or for the amateur-radio enthusiast.

The IM-4190 is capable of withstanding full power overloads on its lower scales without damage to the meter movement. A single 9-volt battery powers the IM-4190, so it may be used while portable. N-type coaxial connectors are used for low insertion loss. Adaptors are included for use with UHF-type connectors.

The IM-4190 kit retails for $114.95 and the SM-4190 assembled version $195.00 (mail order from Benton Harbor). For more information on the IM/SM-4190, write Heath Company, Department 350-630, Benton Harbor, Michigan 49022.

VIZ wattmeters

The Test Instruments Group of VIZ Manufacturing Company has introduced two new easy-to-use wattmeters that are ideal for testing vhf, fm, and even uhf transmitters as well as popular high-frequency and CB units.

The WV-551A dummy-load rf wattmeter has a broad frequency range — from 1.9 to 512 MHz. Its power range is 0.5 to 15 watts with full-scale accuracy better than 5 per cent. Input impedance is 50 ohms, and vswr is less than 1.15:1 at 500 MHz. It is simple to use: the transmitter output line is connected directly to the unit and readings are taken from the scale on a taut-band meter. The user price for the WV-551A is $60.

The WV-552A in-line rf wattmeter is a dual unit used to measure both forward and reflected power — especially useful in matching and adjusting antennas, or for tuning transmitters for maximum output. Readings are taken from the two easy-to-read meters.

Measurements with the WV-552A are possible over three selectable frequency ranges: 20-40 MHz, 40-100 MHz, and 100-230 MHz. The meter's power ranges are 0-20 watts and 5-100 watts (forward), and 0-5 watts and 1-20 watts (reflected); full-scale accuracy is better than 5 per cent. The vswr is less than 1.15:1 over the entire frequency range, and input impedance is 50 ohms.

Both wattmeters are supplied with type M connectors; M-to-N and M-to-BNC adapters are available.

The user-price is $150. For further information and data sheets, contact Bob Liska, VIZ Test Instruments Group, VIZ Manufacturing Company, 335 East Price Street, Philadelphia, Pennsylvania 19144; telephone (215) 844-2626.

Palomar Electronics hand-held transceiver

The new Palomar Mini-I VHF-FM transceiver is about the same height as a dollar bill — yet it's a giant in performance. The transmitter output is one watt, with a total of 18 channels available in the 144-148-MHz band. The channels are obtained by using up-down split, down-up split, or simplex, all with only six crystals.

With the Auto-Patch option, the Palomar Mini-I can access a repeater and communicate through the telephone system as well.

Dimensions of the Palomar Mini-I are 152 mm high by 67 mm wide by 46 mm deep. Its compact size makes it exceptionally convenient as a means of portable communications.

More Details? CHECK—OFF Page 126

For more information about the Palomar Mini-I VHF transceiver, write to Palomar Electronics, 655 Opper Street, Escondido, California 92025.

Hamtronics converters

Hamtronics, Inc., announces a new series of low-cost vhf and uhf converters for use in receiving Oscar and other exciting signals on your present high-frequency receiver. At prices of $34.95 for the kit (or $54.95 wired and tested), they're quite a bargain for the enjoyment you'll get from listening to the ever-increasing activity on these bands.

The converters are small in size: only 7 x 11 x 2.5 cm (2-3/4 x 4-1/2 x 1 in). They can be constructed and tested in only a few hours. Built-in test points make alignment simple. The converters feature new high-*Q* coils, compartmental shielding, and ferrite-bead decoupling.

Any 2-MHz segment in the vhf and uhf range can be covered, using the 10-meter band on your existing receiver. Standard models are listed below, and other rf and i-f ranges are available on special order at the same price. An attractive extruded aluminum case kit is available as an option for $12.95 additional.

standard converters for 28-30 MHz i-f

model	input range
C50	50-52 MHz
C144	144-146 MHz
C145	145-147 MHz
C146	146-148 MHz
C110	Any 2 MHz of aircraft band
C220	Any 2 MHz of 220-MHz band
C432-2	432-434 MHz
C432-5	435-437 MHz
C432-7	427.25 (61.25 MHz i-f)
C432-9	439.25 (61.25 MHz i-f)

To order, or to request a free 40-page catalog on vhf and uhf transmitters, receivers, preamps, and accessories, call 716-663-9254; or write Hamtronics, Inc., 182F Belmont Rd., Rochester, New York 14612.

artwork transfer film for PC boards

Printed Circuit Products Company, of Helena, Montana, has produced a film that can be used to pick up artwork from printed pages and used for etching sensitized board. Called **PCP Type-A**, the film is easy to use. A protective backing is peeled off, then the clear film is pressed in place over the desired artwork. A blunt instrument is used to burnish the film into firm contact with the paper, and to remove all air bubbles. The combination is soaked in water until the paper softens and can be removed by rubbing, leaving the "print" on the film.

After the film has dried, the artwork is ready for use. Simply apply it over the surface of any sensitized pc board material in the normal manner, and expose, develop, and etch your own printed circuits.

The Type-A film eliminates the many photographic processes that usually accompany transferring artwork from the printed page to a form useful in etching boards. Note, however, that the artwork does not change form in the process — it remains either negative or positive, just as it is printed.

PCP Type-A film can also be used to create custom decals for your equipment, relabel meter faces, dials, or panels. For more information and prices, write to Printed Circuit Products Company, P.O. Box 4034, Helena, Montana 59601.

Touch-Call encoder

Standard Communications has announced the availability of their new TT-1A Touch-Call encoder which can be mounted on the front of SCC Model C146A, C730L, and C830L hand-held transceivers. The unit uses the dual-tone multiple frequency (DTMF) system to enable the user to place remote telephone calls, obtain access to repeater systems, activate decoders in other transceivers, or to

More Details? CHECK—OFF Page 126

perform other remotely controlled operations.

The tones generated are compatible with both the Bell and RCC radiotelephone requirements. The unit is solid state and generates two simultaneous audio tones between 600 and 1700 Hz. The digitally synthesized frequencies generated are nonharmonic and provide high immunity to falsing. The TT-1A requires 7.5 to 15 Vdc for operation, which is obtained from the battery pack in the hand-helds. These encoders may be used with the commercial versions of SCC's hand-helds, which cover 450 to 512 MHz or 148 to 174 MHz and the amateur radio 144 to 148 MHz model. See your Standard dealer or write Standard Communications Corporation, P.O. Box 92151, Los Angeles, California 90009.

Multicore Solder products

Multicore Solders, a leading worldwide supplier to aerospace, electronic, and industrial manufacturers has introduced a line of selected, professional-quality solders and soldering accessories specifically packaged for the technician, service man, home owner, hobbiest, and do-it-yourselfer. Included in the product line are multiple-core wire solders in a variety of alloys and/or flux formulations, solid wire solder, solder creams, an emergency solder, flux pastes, and a line of desoldering wick.

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Among the different solder alloys offered are those for electronic, general-purpose electrical, and a number of nonelectrical applications including sheet-metal work, plumbing, aluminum, and even a solder specifically formulated for stainless steel and silver jewelry.

The packaging for each of the products has been carefully designed to provide the user with a functional and practical choice, depending on the quantity he plans to use as well as storage requirements. All packaging is printed with complete application and instructional data, and is color coded according to alloy for quick identification. Complete information on all these products is available from Multicore Solders, Westbury, New York 11590.

Whitehouse parts catalog

A new catalog is available from G. R. Whitehouse & Co. of Amherst, New Hampshire. It lists many of the parts for amateur projects which have been described in *ham radio*, *Ham Radio Horizons*, and other amateur literature.

A scan through the pages reveals such items as a kit of parts for noise bridges, transmatches, and computing swr indicators. There are several pages of individual component listings, such as toroid coils, ferrite beads and rods, and an assortment of cores for the experimenter.

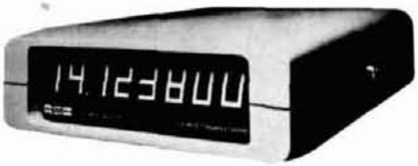
A number of Barker & Williamson items are carried by Whitehouse, including coaxial switches, air-wound coils, multi-band plate circuits for high-power final amplifiers, and attenuators and filters.

The catalog shows a good selection of variable capacitors, including those made by E. F. Johnson, James Millen, and some Cardwell and Hammarlund types. Another section displays Jackson Brothers dials and drives, James Millen knobs and shaft couplers, and aluminum cases.

There is also a large section listing the J. W. Miller inductors and the Cushcraft line of antennas and accessories.

To obtain your copy of this free catalog, write to G. R. Whitehouse & Co., 16 Newbury Drive, Amherst, New Hampshire 03031.

MAX-100 frequency counter



A new state-of-the-art LSI counting technology has enabled Continental Specialties Corporation to offer a competent frequency counter at a very good price. The counter, called MAX-100, delivers an accurate 8-digit display of frequencies from 20 Hz to 100 MHz. The crystal-controlled timebase features 3 ppm (parts per million) accuracy, and the counter updates the display every second.

The counter input includes a preamplifier which allows it to work with as little as 30 mV of signal. Diodes protect the input up to 200 Volts. Although it is a low-profile unit, the MAX-100 features large, bright, 15-mm (0.6-in.) digits. No range switch is necessary, because the least significant digit always represents 1 Hz. Leading zeroes are blanked, and over-range signals cause the most significant digit to flash.

The MAX-100 can be operated on internal alkaline or nickel-cadmium cells; or from automotive or 115-Vac power by using a battery charger or eliminator. All 8 digits flash to indicate a low battery condition, which permits extended battery life.

The input impedance of the counter is 1 megohm, shunted by 56 pF. Sine-wave sensitivity is rated at 30 mV RMS from 10 Hz to 50 MHz, 100 mV RMS to 80 MHz, and 300 mV RMS above. A number of accessories are available, including a battery charger/eliminator, tap-offs, a whip antenna, and a carrying case.

The MAX-100 is accurate enough for most professional field service applications; with a suggested price of $134.95, it's economical enough for personal or educational use. For further information contact Continental Specialties Corporation, 44 Kendall Street, New Haven, Connecticut 06509.

ICOM programmable vhf marine radio

ICOM has announced a new addition to its Marine VHF radio line by introducing the ICOM M25D — similar in appearance and features to ICOM's popular 25-channel M25. A key advantage of the ICOM M25D is its 25-channel diode-programmable system. The diode matrix in the M25D can be "programmed and reprogrammed" to any 25 of the commercial, pleasure, or international Marine VHF channels, thus eliminating the need to buy expensive crystals when additional channels are required.

ICOM enjoys an industry-wide reputation for producing one of the most thoroughly sealed and weather-protected Marine VHF units on the market. Like the M25, the M25D features a unique single-piece, molded-aluminum-base construction, incorporating a series of O-ring seals and gaskets around the switches and case covers to provide the maximum protection of the internal electrical components. The speaker is protected from rain and moisture by a tough, water-resistant membrane. The transceiver also features safety memory to channel 16, automatic start on 16, pushbutton selection for both weather and channel 16, a locking mounting system, a 5-watt audio system, an automatic nighttime dimmer system, and a provision for external speakers.

The ICOM M25D, like the M25, is FCC certified under both Parts 81

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and 83, as well as Canadian DOC certified for pleasure vessels and compulsorily equipped commercial vessels. Learn more about the ICOM M25D by writing for a free brochure to: Icom-East, Suite 307, 3331 Towerwood, Dallas, Texas 75234; or in the western U.S., Icom-West, Inc., 13256 Northrup Way, Suite 3, Bellevue, Washington 98005.

CW speaker system

Skytec is offering a loudspeaker unit designed expressly for CW. Employing a unique, acoustic-chamber resonator, the Skytec CW-1 combines good single-frequency selectivity with a nice tone shaping characteristic.

By filtering right at the audio output, the unit suppresses hum, hiss, ringing, and miscellaneous noises left in the audio by most communications receivers. The CW-1 adds a remarkable degree of selectivity to any CW receiver, and it gives the best of receivers the most pleasant, "just right" bandpass for long contacts, net operating, and band scanning.

Priced at $19.95, the 8.9 x 16.55 cm (3-1/2 x 6-1/2 inch), 0.9 kg (2 pound) unit is shipped with a connecting cable. A front switch provides for bypassing the audio to the regular station speaker for other than CW reception. Skytec's ordering address is Box 535, Talmage, California 95481, or for more information contact Jim Bowles, W6DLQ, at 707-462-6882.

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uhf mobile antennas

A line of 5-dB gain uhf mobile antennas covering the 3/4 meter (420 MHz) frequency range and featuring simplified field tuning requirements has been introduced by Antenna Incorporated of Cleveland, Ohio.

Most 420 MHz antennas require the whip to be cut from the top and bottom for exact tuning. The Antenna Incorporated antennas feature a top sleeve which slides to adjust the upper portion of the whip, so only the bottom portion of the antenna needs to be cut for tuning.

These uhf antennas feature plated stainless-steel whips to make the antenna more conductive for reduced power loss, stainless-steel shock springs, and 17 feet (5 meters) of coaxial cable. They are available in 100- and 150-watt versions; the 150-watt models are supplied with Antenna Incorporated's high-power cable which has electrical characteristics similar to RG-8/U but in a size similar to RG-59/U.

These antennas are available in a variety of mounting configurations, including hole mount, trunk-lip mount, cowl mount, and a mount which adapts to existing Motorola mounts. The 100-watt versions also are available with a spring-clip gutter mount.

"The simplified tuning process means there is less chance for error

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when the antenna is field-cut to exact frequencies," sales manager Friedberg said. "Add to this the variety of mounting configurations we offer, and these antennas are the fastest and simplest antennas to install."

Further information on the new antennas, and the complete line of Antenna Incorporated communications antennas and accessories, is available from Antenna Incorporated, 26301 Richmond Road, Cleveland, Ohio 44146.

MFJ rf noise bridge

MFJ Enterprises has a new rf noise bridge, model MFJ-202, which allows quick adjustment, for maximum performance, of any antenna, whether a single or multiband dipole, inverted vee, beam, vertical mobile whip, or random-wire system. It indicates resonant frequency, radiation resistance, and reactance of these antennas, and also whether to shorten or lengthen the antenna for minimum swr over any portion of a band.

The MFJ rf noise bridge has a resistance range of 250 ohms and a wide capacitance range of ± 150 pF for reactance measurements. Included is a unique range-extender that shunts large unknown impedances down to within the measuring range of the noise bridge. In addition to measuring antenna characteristics, the noise bridge can be used to tune transmatches, adjust tuned circuits, and measure inductance and the rf impedance of amplifiers, baluns, transformers, and other rf circuits. It can also be used to determine electrical length, velocity factor, and impedance of coax cable. With a transmatch and dummy load, it can synthesize rf impedances for test purposes.

MFJ provides a 30-day money back trial period and a one year unconditional warranty.

The MFJ-202 RF Noise Bridge is available from MFJ Enterprises for $49.95 plus $2.00 shipping and handling. To order call toll free 800-647-8660 or mail order to MFJ Enterprises, P.O. Box 494, Mississippi State, Mississippi 39762.

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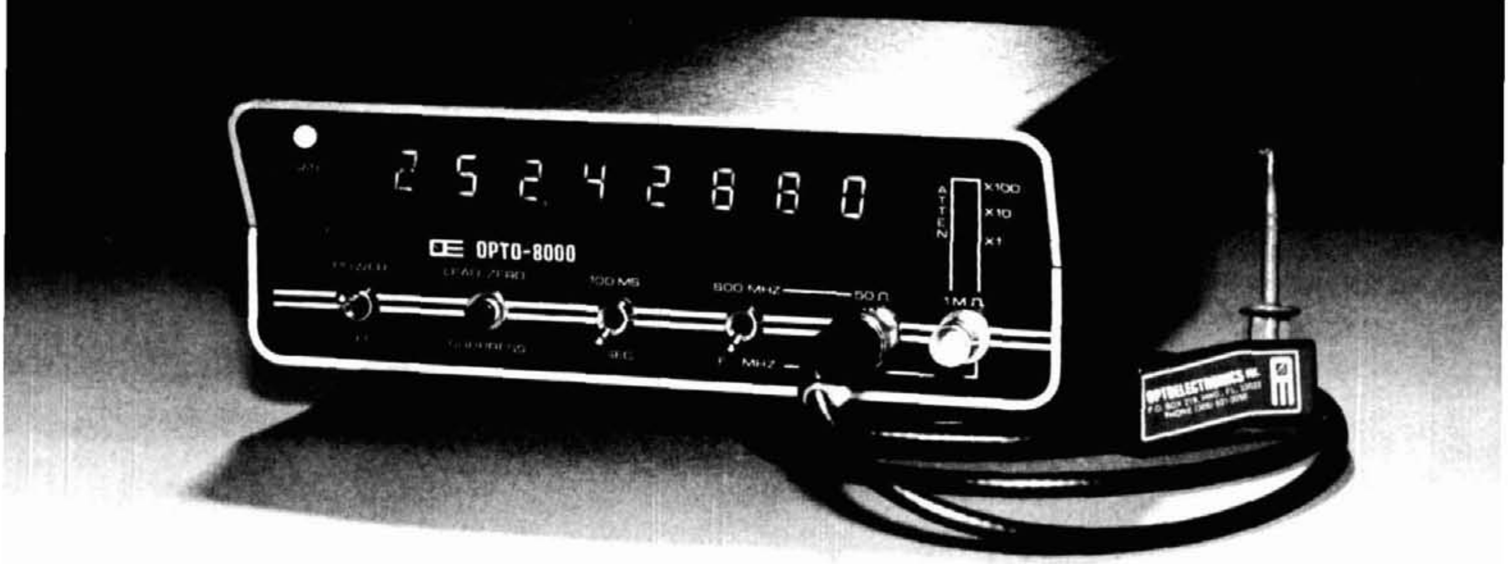
More Details? CHECK—OFF Page 126

600 MHZ. FREQUENCY COUNTER
±0.1 PPM TCXO

OPTO-8000.1



This new instrument has taken a giant step in front of the multitude of counters now available. The Opto-8000.1 boasts a combination of features and specifications not found in units costing several times its price. Accuracy of ±0.1 PPM or better — *Guaranteed* — with a factory-adjusted, sealed TCXO (Temperature Compensated Xtal Oscillator). **Even kits require no adjustment for guaranteed accuracy!** Built-in, selectable-step attenuator, rugged and attractive, black anodized aluminum case (.090" thick aluminum) with tilt bail. 50 Ohm and 1 Megohm inputs, both with amplifier circuits for super sensitivity and both diode/overload protected. Front panel includes "Lead Zero Blanking Control" and a gate period indicator LED. AC and DC power cords with plugs included.

SPECIFICATIONS:
Time Base—TCXO ±0.1 PPM GUARANTEED!
Frequency Range—10 Hz to 600 MHz
Resolution—1 Hz to 60 MHz; 10 Hz to 600 MHz
Decimal Point—Automatic
All IC's socketed (kits and factory-wired)
Display—8 digit LED
Gate Times—1 second and 1/10 second
Selectable Input Attenuation—X1, X10, X100
Input Connectors Type —BNC
Approximate Size—3"h x 7½"w x 6½"d
Approximate Weight—2½ pounds
Cabinet—black anodized aluminum (.090" thickness)
Input Power—9-15 VDC, 115 VAC 50/60 Hz
or internal batteries

OPTO-8000.1 Factory Wired	**$299.95**
OPTO-8000.1K Kit	**$249.95**

ACCESSORIES:
Battery-Pack Option—Internal Ni-Cad Batteries and charging unit **$19.95**

Probes:
- P-100—DC Probe, may also be used with scope **$13.95**
- P-101—LO-Pass Probe, very useful at audio frequencies **$16.95**
- P-102—High Impedence Probe, ideal general purpose usage **$16.95**

VHF RF Pick-Up Antenna-Rubber Duck w/BNC #Duck-4H **$12.50**
Right Angle BNC adapter #RA-BNC **$ 2.95**

FC-50 — Opto-8000 Conversion Kits:
Owners of FC-50 counters with #PSL-650 Prescaler can use this kit to convert their units to the Opto-8000 style case, including most of the features.

FC-50 — Opto-8000	**Kit $59.95**
*FC-50 — Opto-8000F	**Factory Update $99.95**
FC-50 — Opto-8000.1 (w/TCXO)	**Kit $109.95**
*FC-50 — Opto-8000.1F	**Factory Update $149.95**

*Units returned for factory update must be completely assembled and operational

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flea market

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ELECTRONIC BARGAINS, CLOSEOUTS, SURPLUS! Parts, equipment, stereo, industrial, educational. Amazing values! Fascinating items unavailable in stores or catalogs anywhere. Unusual FREE catalog. ETCO-012, Box 762, Plattsburgh, N.Y. 12901. SURPLUS WANTED.

CUSTOM printed and photo QSL's, very economical; free samples. Stamp appreciated. Stu, K2RPZ, Box 412, Rocky Point, NY 11778. (516) 744-6260.

TELETYPE EQUIPMENT for beginners and experienced operators. RTTY machines, parts, supplies. Beginner's special: Model 15 Printer and demodulator $139.00. Dozen black ribbons $6.50; case 40 rolls 11/16 perf. tape $17.50 FOB. Atlantic Surplus Sales, 3730 Nautilus Ave., Brooklyn, N. Y. 11224. Tel: (212) 372-0349.

THE "CADILLAC" of QSL's! Samples: $1.00 (Refundable) — W5YI, Box #1171-D; Garland, Texas 75040.

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EXCLUSIVELY HAM TELETYPE 24th year, RTTY Journal, articles, news, DX, VHF, classified ads. Sample 35¢. $3.50 per year. 1155 Arden Drive, Encinitas, Calif. 92024.

MANUALS for most ham gear made 1937/1970. Send only 25¢ coin for list of manuals, postpaid. HI, Inc., Box H864, Council Bluffs, Iowa 51501.

QSL FORWARDING SERVICE — 30 cards per dollar. Write: QSL Express, 30 Lockwood Lane, West Chester, PA. 19380.

HAM RADIO HORIZONS, a super new magazine for the Beginner, the Novice and anyone interested in Amateur Radio . . . What it's all about, How to get started, The fun of ham radio. It's all here and just $10.00 per year. HURRY! HURRY! Ham Radio HOIRZONS, Greenville, NH 03048.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 93862.

HAPPY BIRTHDAY! Now ten years fighting TVI. The RSO low pass filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada MIS 3B4.

DRAKE B LINE: T4XB, R4B, MS-4, AC-4 PS; Mint, with manuals. Sell as complete station only, $750 firm. Prefer you examine and pick up, but will ship your cost. Jim Gray, W1XU, P.O. Box 186, Peterborough, N.H. 03458, or 603-924-6759 evenings.

WANTED: Davco DR-30 receiver, working or not. Please state price and condition in first letter. Also interested in accessory power supply/speaker unit for the DR-30. Jim Fisk, W1HR, 25 Main Street, Greenville, N.H. 03048.

WANTED: HF Transmitter, Drake preferred. Paul, WA3JXX, 3535 California Ave., Pgh., PA 15212.

HQ-140XA MINT 100KC Cal $100. HT-32A New Tubes $150. DenTron 80-10AT Tuner $45. Half Done Accu-Memory $15. Power Tubes 4-400, 4CX 250, 4X150, 2C39, Etc. 455 Kc Panoramic display $40. B&K 2050 rf sig gen new $50. Motor Driven Roller Inductor $20. Stephen Johnson, N2FT, 2011 Ferry Ave., Apt. I-2, Camden, NJ 08104. (609)962-8418.

ATRONICS Code Reader, Model CR101, mint condition. First certified check or M.O. $140 takes it. WD8MRC, 3960 N.M. — 30, Gladwin, Michigan 48624.

CERTIFICATE for proven two-way radio contacts with Amateurs in all ten USA call areas. Award suitable to frame and proven achievements added on request. SASE brings TAD data sheet from W6LS, 2814 Empire, Burbank, CA 91504.

CANADIANS: 1,000,000 surplus electronic parts. Hundreds of fantastic bargains! Good deals on Yaesu & Icom. Free catalog. ETCO-HR, 183G Hymus Blvd., Pointe Claire, Quebec H9R 1E9.

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THE NEW RTTY Beginners Handbook now available, Box RY, Cardiff, CA 92024 $4.50 postpaid.

HP-434A calorimeter, complete with cabinet, book. Inoperative $130. Alden RJ4 19" weather-FAX machine, complete; cheaper than replacement parts, $85. 30-300 MHz commercial antenna preamp (3 bands remotely switched) transistor with separate power supplies for each amplifier $80. SELLERS, 4002 Columbus, Norfolk, VA 23504.

BUY-SELL-TRADE. Send $1.00 for catalog. Give name, address and call letters. Complete stock of major brands new and reconditioned equipment. Call for best deals. We buy Collins, Drake, Swan, etc. SSB & FM. Associated Radio, 8012 Conser, Overland Park, KS 66204. 913-381-5900.

TELONIC Slim Lowpass filter, 0.4 dB at 450 MHz; $11 2/$20 prepaid. Accurate 29.9 dB coupling signal sampler at 432 MHz, use two for FWD/REF power. Like micromatch 313N, 300-2000 MHz. $15 each prepaid with data sheets. SELLERS, 4002 Columbus, Norfolk, VA 23504.

VFO WANTED. Prefer 5.0 to 5.5 mc. Stable, attractive, repairable. Yost, 70 Mt. Pleasant, Stratford, CT 06497.

More Details? CHECK—OFF Page 126

flea market

ELECTRONIC EQUIPMENT HOTLINE is a new classified advertising newsletter for buying and selling professional, industrial, and surplus electronic equipment. Subscriptions $6/year, ads 50¢/word. Prepublication offer: $1 off subscriptions and 20% off all ads postmarked by October 1, 1978. Electronic Equipment Hotline, P.O. Box 4768, Panorama City, CA 91402.

LORAN-C RF front-end & Preamp boards. See '73, May 1978, SASE: R. W. Burhans, 161 Grosvenor St., Athens, OH 45701.

WANTED: Hallicrafter SX115 and Heath CW/SSB filters. Andre, VE2BBT, 456 Route 138, St. Augustin, Quebec, Canada G0A 3E0.

PORTA PAK the accessory that makes your mobile really portable. $67.50 and $88.00. Dealer inquires invited. P.O. Box 67, Somers, Wisc. 53171.

RTTY — NS-1A PLL demodulator W/T $24.95 ppd. Price advance effective Sept. 1st. SASE for info. Nat Stinnette Electronics, Tavares, FL 32778.

HAM RADIO HORIZONS, a super new magazine for the Beginner, the Novice and anyone interested in Amateur Radio . . . What it's all about, How to get started, The fun of ham radio. It's all here and just $10.00 per year. HURRY! HURRY! Ham Radio HOIRZONS, Greenville, NH 03048.

FREE CATALOG of new merchandise. Resistors, capacitors, IC's, semiconductors, and more. Send to: Key Electronics, Box 3506H, Schenectady, New York 12303.

WANTED: Measurements 59 grid dipper. Also interested in HF and UHF tuning heads. Jim Fisk, W1HR, Ham Radio, Greenville, NH 03048.

B&K TEST EQUIPMENT. Free catalog. Free shipping. Dinosaur discounts. Spacetron-CH, 948 Prospect, Elmhurst, IL 60126.

MOTOROLA HT220, HT200, and Pageboy service and modifications performed at reasonable rates. WA4FRV (804) 320-4439, evenings.

AUTHORIZED DEALER for DenTron, KLM, Larsen, Bearcat, etc., Big Catalog 201-962-4695 Narwid Electronics, 61 Bellot Road, Ringwood, N.J. 07456.

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

TELETYPEWRITER PARTS WANTED: for all machines manufactured by: Klienschmidt Corp., Teletype Corp. and Mite. Any quantity, top prices paid send list for my quote. Phil Rickson, W4LNW, Rt. 6, Box 1103G2, Brooksville, Fl. 33512.

VERY in-ter-est-ing! Next 3 issues $1. "The Ham Trader", Sycamore, IL 60178.

QSL CARDS 500/$10. 400 illustrations, sample. Bowman Printing, Dept. HR, 743 Harvard, St. Louis, MO 63130.

HOMEBREWERS: Stamp brings component list. CPO Surplus, Box 189, Braintree, Mass. 02184.

WE MAY NOT HAVE a toll-free number, but we'll save you more $$$ in the long run! This month's special: CDE Ham-III Heavy-Duty rotor for only $114.95, prepaid anywhere in the Continental United States! We are also factory-authorized dealers for Yaesu, Drake, Kenwood, Ten-Tec, ICOM, DenTron, and many more. For the best deal around on the HF or VHF gear of your choice, write or call us today for our low quote. Try our personal, friendly Hoosier service and become one of our many happy and satisfied customers. HOOSIER ELECTRONICS, P.O. Box 2001, Terre Haute, Indiana 47802. (812) 238-1456.

WANTED — Millen i-f's 455 kc and 1600 kc — #61455 #61160 several needed. Also schematic for Misers Dream Rec. Owen Laughlin, 1310 Pinecrest Dr., Ferndale, MI 48220.

AUTHORIZED DISTRIBUTOR F9FT Antennas, Microwave Modules, RIW Products' new tandem reflector, 19 element, 432 MHz Yagi — Radio Clinic — N2MB (formerly WA2BIT) 212-327-4952.

ANTENNA: All ham bands (80 thru 10) $25 postpaid U.S.A. (CA residents add $1.50 sales tax) Rudy Plak, P.O. Box 966, San Marcos, CA 92069.

SCANADAPTER — scan up to 10 channels of any receiver/transceiver, variable scan rate, manual advance, and 7 segment readout. Only $29.95 wired. Pulse generators, high gain instrument amps, more. Free literature. Tek Devices, Box 19154, Honolulu, HI 96817.

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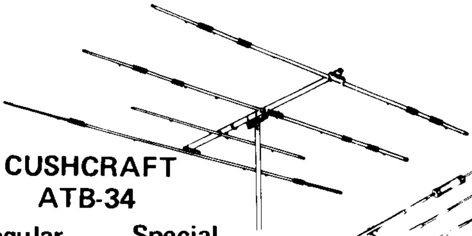
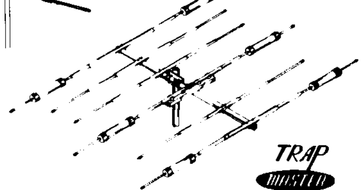


CUSHCRAFT ATB-34



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TH6-DXX	Super Thunderbird	$249.95	$209.95
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TH3-Jr.	3 ele. 10, 15, 20 Mtr. beam	144.50	129.95
18 HT	Hy-Tower 10-80 Mtr. Vertical	279.95	239.95
14AVQ/WB	10-40 Mtr. Trap Vertical	67.00	57.00
18AVT/WB	10-80 Mtr. Trap Vertical	97.00	84.95
203	3 ele. 2 Mtr. beam	12.95	
205	5 ele. 2 Mtr. beam	16.95	
208	8 ele. 2 Mtr. beam	19.95	
214	14 ele. 2 Mtr. beam	26.95	
MOSLEY			
Classic 33	3 ele. 10, 15, 20 Mtr. beam	232.50	189.95
Classic 36	6 ele. 10, 15, 20 Mtr. beam	310.65	249.95
TA-33	3 ele. 10, 15, 20 Mtr. beam	206.50	169.95
TA-36	6 ele. 10, 15, 20 Mtr. beam	335.25	279.95
TA-33 Jr.	3 ele. 10, 15, 20 Mtr. beam	151.85	129.95
TA-40KR	40 Mtr. add on	92.25	74.95
CUSHCRAFT			
ATB-34	4 ele. 10, 15, 20 Mtr. beam	259.95	209.95
ARX-2	2 Mtr. Ringo Ranger	36.95	32.95
A147-20T	2 Mtr. Twist	59.95	52.95
A144-10T	10 ele. Twist 2 Mtr.	39.95	32.95
A144-20T	20 ele. Twist 2 Mtr.	59.95	52.95
HUSTLER			
4BTV	10-40 Mtr. Trap Vertical	99.95	82.95
RM-75	75 Meter Resonator	15.50	13.50
RM-75s	75 Meter Super Resonator	30.00	26.50
G6-144-A	6 db. 2 Mtr. Base Colinear	67.55	57.95
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System One	5 ele. 10, 15, 20 Mtr. beam	274.95	239.95
System Two	4 ele. 10, 15, 20 Mtr. beam	219.95	189.95

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Ham III	$125.00
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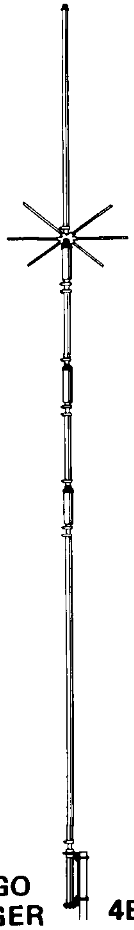

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More Details? CHECK—OFF Page 126

flea market

RECEIVE PARTS LISTS regularly for $4/yr. Surplus Parts, P.O. Box 7057, Norfolk, VA 23509.

WANT UP-TO-DATE INFORMATION? Radio-Hobbyist Newsletter issued every 2 weeks. Only $5.00 year. W5YI, Box 1171-D, Garland, Texas 75040.

EZ deals are the best! Try me and see for Yaesu, Drake, KLM, Swan, Cushcraft, DenTron, VHF Eng, ICOM, CDE, Hustler, Wilson and more. Call, see or write WØEZ, Bob Smith Electronics, RFD 3, Hwy 169 & 7, Fort Dodge, IA 50501. (515) 576-3886.

TRAVEL-PAK QSL KIT — Send call and 25¢; receive your call sample kit in return. Samco, Box 203, Wynantskill, NY 12198.

THE MEASUREMENT SHOP has used/reconditioned test equipment at sensible prices; catalog. 2 West 22nd St., Baltimore, MD 21218.

RADIO MUSEUM NOW OPEN. Free admission, 15,000 pieces of equipment from 1850 telegraph instruments to amateur and commercial transmitters of the 1920s. Amateur station W2AN. Write for information: Antique Wireless Assn., Main St., Holcomb, NY 14469.

AMATEUR MICROPROCESSOR EXPERIMENTERS: 10 MHz ± 20 ppm Coldweld crystals. 1 ppm/yr. 32 pF. C_0 6 pF. $4.25 ea. postpaid. Savoy Electronics, Inc., P.O. Box 5727, Ft. Lauderdale, FL 33310. 305-563-1333.

Coming Events

ALASKA: ARRL Convention, Anchorage. August 26, 27. Write: ARRL Alaska Convention 78, Anchorage ARC, PO Box 1987, Anchorage, AK 99510.

WIMU (Wyoming, Idaho, Montana, Utah) The 46th Annual WIMU Hamfest is scheduled for August 4, 5, and 6, 1978 at Mack's Inn, Idaho; 25 miles South of West Yellowstone, Montana. Talk-in 146.34/94 and 3935. Advance registration: $6.00 for adults and $2.00 for children, before July 25th, 1978. Late/regular registration: $7.00 and $2.50. SPECIAL PRIZE DRAWING FOR PRE-REGISTRATION. Please send pre-registration to: WIMU Hamfest, 3645 Vaughn Street, Idaho Falls, Idaho 83401. Phone (208) 522-9568.

ILLINOIS: Fox River Radio League Hamfest Sunday, August 27, 1978 Kane County Fairgrounds Exhibition Hall, St. Charles. 8:00 AM - 5:00 PM. Commercial exhibits & sales, used equipment market, raffle drawing; 1st prize: Kenwood TS-520 S Transceiver; 2nd prize: Midland 13-500 Transceiver. Door prizes. Motorhome camping. Admission — Raffle Tickets: $1.50 advance; $2.00 gate. For information & Tickets Contact: Don Berridge WB9PAC — 2303 Deerfield Way, Geneva, IL 60134. Telephone: (312) 232-0093. Talk-in frequency — 146.94 Simplex (7:00 AM to 3:00 PM).

NEW JERSEY — The 550 Amateur Radio Club annual flea market Saturday, August 26, 1978 9:00 AM to 5:00 PM American Legion Hall, Oak Street, Oakland, NJ. Admission $1.00, tables $3.00, tailgate $2.00. Talk-in WR2AHD 147.49/146.49 or simplex 146.52. Dealers invited. Refreshments. For information or table reservations, write 550 ARC, P.O. Box 364, Oakland, NJ 07436, attention Mark Kirschner — WA2HLE (201) 337-3259.

IOWA: 75 Meter Net's annual Potluck picnic and hamfest Sunday, August 20, Riverside Park, Marshalltown. Awards and prizes. Lovelle Pedersen, WBØJFF Sec.

INDIANA: The Delaware Amateur Radio Assocation hamfest 8:00 AM until 5:00 PM., Saturday, August 12, Springwater Park, east of Muncie on Country Club Road. Hourly prize drawings from 10:00 AM until 4:00 PM, grand prize drawing at 4:00 PM. Flea market/no charge. Talk-in on 146.25-.85 or 146.52 simplex. Tickets $1.50 advance, $2.00 gate. Send check and SASE to: P.O. Box 3021, Muncie, IN 47302.

SPECIAL EVENT: Miss America Pageant, Atlantic City, N.J. Station K2BR. Dates: Sept. 1 to 10, 1978; Approx. frequencies: CW: 3555, 7055, 14055, 21055; Phone: 3935, 7235, 14280, 21380; Novice: 3730, 7130, 21130. QSL to K2BR. Operation from Atlantic City Convention Hall. Traffic to and from Contestants will be welcome. This station is sponsored by the Southern Counties Amateur Radio Association.

MICHIGAN: Hamfest! Aug. 6, Saline Fairgrounds — table and trunk sales, food, prizes. Talk-in 146.37/97 and 146.52. General info, advance tickets, table reservations — write Arrow, Box 1572, Ann Arbor, MI 48106.

More Details? CHECK—OFF Page 126

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flea market

BYTE, Drink and be merry at the Tidewater Hamfest, Flea Market and Computer Show, Norfolk, Virginia. September 23-24. Over 60,000 sq. ft. of exhibit and flea market space. All indoors. All air-conditioned. Write TRCI, P.O. Box 9371, Norfolk, Virginia 23505.

FOX RIVER RADIO LEAGUE HAMFEST New Location: Indoors — Kane Co. Fairgrounds, St. Charles, IL. — Sunday, August 27th. Tickets: $2.00 at gate — $1.50 advance. Contact: Don Berridge WB9PAC, 2303 Deerfield Way — Geneva, IL 60134.

MANSFIELD, PA. — The Tioga County PA ARC Hamfest will be held Saturday, August 26th starting at 9:00 AM at the Tioga Co. Fair Grounds on Rt. 6 between Wellsboro and Mansfield, PA. The $2 admission is good for all special programs and the XYL and children are free. In addtition to the usual Flea Market and displays a bingo table and other items of interest will be available for the ladies and the PA Grand Canyon is within a short distance. Talk-in on 19/79, 52 Sim. and CB 5. For more information write to Denny Vorhees, WA3FWQ, RD #2 - Box 117A, Millerton, PA 16936.

TEXAS: Panhandle ARC's 4th Annual Golden Spread Amateur Radio Convention at Holiday Inn West, Amarillo. August 11, 12 and 13. Technical programs. Ladies programs. Free Bingo Saturday evening. Flea Market. Door prizes. Preregistration $4.00. Door — $6.00. For information: Golden Spread ARC, P.O. Box 10221, Amarillo, TX 79106.

CONN. WELI ARC 2nd Annual Flea Market & Auction Sunday, August 20 (rain date August 27) 10:00 AM - 4:00 PM Radio Towers Park, Benham St., Hamden, CT. Admission 50¢ Sellers $5.00 ea. Info — Mike, WA1PXM (203) 943-1063 or Dave WA1ZWB (203) 467-3258.

NORTH ALABAMA HAMFEST. Sunday, August 20, 1978 at The Mall in Huntsville, AL. Prizes, large flea market, ARRL forum, MARS meetings, ladies' activities. Hamfest supper on Saturday night. For more information: N.A.H.A., P.O. Box 423, Huntsville, AL 35804.

MISSOURI: Annual Zero-Beaters ARC Hamfest Sunday, August 6, Washington City Park. Traders-row, displays, exhibitors, no extra charge. Refreshments. Ladies' activities. Prizes. For info write: WAØFYA, Dutzow, MO 63342.

INDIANA: LaPorte County Summer Hamfest, Sunday, August 27, LaPorte County Fairgrounds, LaPorte. Dealers 6:00 AM. Public 8:00 AM. 50 miles southeast of Chicago on Indiana #2. Talk-in on .01/.61, .37/.97 and .52 simplex. Donation $2.00 at gate. For information: LPARC, P.O. Box 30, LaPorte, IN 46350.

PENNSYLVANIA: The Beaver Valley Amateur Radio Association's first annual hamfest Saturday, August 19, 9 AM to 5 PM at Brady's Run Park, 5 miles north of Rochester, PA on Route 51. Tickets: advance $3.00 or 3/$8.00. $4.00 or 3/$10.00 gate. Seller's fee $1.00 your table. Flea market. Camping space, swimming, boating, fishing at park. Refreshments. Prizes: (1st) Kenwood TS-520S, (2nd) Midland 13-500 2 Meter FM Xcvr, (3rd) Den-Tron Super Tuner. Talk-in on 25/85, check-in on 52/52. For more info write Wayne R. Sphar WA3ZMS, Sec'y BVARA, 1200 Atlantic Ave., Monaca, PA 15061.

MISSOURI: SCARC Hamfest, August 27, Wentzville Community Club. Many prizes, refreshments, free bingo. Admission $1.00 per car. Talk-in on 34-94 & 07-67. For information: SCARC, P.O. Box 1429, St. Charles, MO 63301.

PENNSYLVANIA: South Hills Brass Pounders and Modulators 41st Hamfest, August 6, noon to dusk, St. Clair Beach, Upper St. Clair Township on Route 19 South. Swap and Shop, picnicking and swimming. Mobile check-in on 29.0 MHz and 146.52 simplex. $1.50 advance, $2.00 door. For information: Bruce Banister, 5954 Leprechaun Dr., Bethel Park, PA 15102.

ELMIRA, NEW YORK HAMFEST — September 30th from 9-5. Door prizes, grand prize, Free Flea Market, tech talks, and more! Contact WA2-FJM, John Breese, 340 West Avenue, Horseheads, New York 14845 for tickets and info.

OHIO: 21st Annual Warren ARA Hamfest, Sunday, August 20, Trumbull KSU Campus, Ohio Rt. 45 at Warren outerbelt. 2 meter check-in. Dawn to dusk. Flea Market. Parks, lakes & family camping nearby.

ARKANSAS: Little Rock Ham-A-Rama, August 5-6, Arkansas State Fair Grounds, Little Rock. Air conditioned building. Flea market. Hourly door prizes, grand prize for $1.00 registration. RV hookups. Talk-in on 146.52, 146.34/94 and 3995. For info call (501) 753-3450 or write CAREN, c/o Don Gephardt, WB5TSH, P.O. Box 2844, Little Rock, AR 72203.

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More Details? CHECK—OFF Page 126

flea market

NEW YORK: Mt. Beacon ARC 5th Annual Hamfest, Saturday, August 19th, 9AM to 5PM at Stewart Field, Newburgh. Talk-in 37/97 and 52. Admission, $1; sellers, $2; under 12 free. Additional information: Ron Perry, WA2CGA, RD 1, Glen Ave., Fishkill, N.Y. 12524.

VIRGINIA: 2nd Annual Bristol ARC Hamfest, August 19 and 20, New Washington County Fair Grounds, Route 11, Abingdon. Admission $1.00, flea market $2.00 extra. Talk-in 01-61 and 07-67. For info send SASE to WD4ECF Lowry Rouse, 77 Bordwine Rd., Bristol, VA 24201. (703) 669-3086.

OHIO: 42nd Annual Cincinnati Hamfest — Sunday, September 17, 1978 at Stricker's Grove on State Route 128, one mile west of Ross (Venice) Ohio. Exhibits, Prizes, Good Food, Refreshments, Flea Market (radio related products only) Music, Good Fellowship, Hidden Transmitter Hunt and Sensational Air Show. No increase in cost, same as last year — $7.50 in advance. For further information: Lillian Abbott, K8CKI, 1424 Main Street, Cincinnati, Ohio 45210.

MINNESOTA: St. Cloud Radio Club Hamfest, Sunday, August 13, Sauk Rapids Municipal Park. Free camping and overnight parking at Lions Park, 1 mile from municipal park. Check in — 10:00 AM. Door prizes. Talk-in on 34/94 and 3925. For further info — Bill Zins, WA0OTO, Rt. #4, St. Cloud, MN 56301. (612) 253-3428.

PENNSYLVANIA: 23rd Annual York County Hamfest, September 3 U.S. 30 Dragway at Thomasville Airport, 10 miles west of York. 8:00 AM to 4:30 PM. Registration $3.00. XYLS and children free. Tailgate $1.00 per space extra. Talk-in 146.37-.97, 146.52-.52, 147.93-.33. Fly-ins to site. Self-contained campers. Display tables under roof by advance registration. Cafeteria. Contact Leroy Frey, K3POR, 170 S. Albemarle St., York, PA 17403. (717) 854-1203.

INDIANA: Tippecanoe ARA Hamfest, Sunday, August 20, Tippecanoe County Fairgrounds, Lafayette, 18th Street at Teal Road (Indiana Highway 25). Flea market setups after 6:00 PM Saturday, August 19. Camping on grounds, limited electricity, Friday through Sunday night. Major pre-registration and attendance prizes. Tickets $2.00 — mail or gate. Talk-in 146.13-73 repeater and 146.94 simplex. SASE to Bill Bayley, WA9ZDI, 1021 Beck Lane, Lafayette, IN 47905 before August 10.

INDIANA: Tioga Amateur Radio Society's Ham Radio Cruise Day, Sunday, August 27. Lake Freeman, Monticello. Decks open at 1:00 PM. 2 Cruises — 2:00 PM and 4:00 PM. Marine Mobile. Special certificates and QSL's. Advance tickets $2.00 — at dock $2.50. SASE Byron Robbins, WD9EXI, Sec'y, 571 South Bluff St., Monticello, IN 47960.

KENTUCKY: The Lexington Bluegrass Amateur Radio Club Annual Hamfest Aug. 13th starting 8:00 AM, at the National Guard Armory near Bluegrass Field. Talk-in on .16/.76. Large indoor exhibit area, paved outdoor fleamarket. Major prizes, forums, refreshments, free parking. Advance tickets $2.50, $3.00 at door. Fleamarket space $1.00 extra. For information: Paul Heflin, WA4PAB, 434 Potomac Dr., Lexington, KY 40503. Phone: (606) 278-0646.

WEST VIRGINIA: Jackson County ARC's 2nd Annual Hamfest, West Virginia FFA-FHA Conference Center, Ripley, Sunday, August 13. Just off interstate 77 at Ripley. For information: Robert D. Morris, WA8CTO, JCARC, 628 Church St. South, Ripley, West Virginia 25271.

NEW JERSEY: South Jersey Radio Assn Hamfest is Sept. 10, 1978 rain or shine at Ellisburg Shopping Center, Cherry Hill N.J. at intersection of routes 41 and 70. Family registration $2.00 Tailgating $3.00. Flea market, auction, & activities. Many prizes. Talk-in 52. Contact K2KA, Box 2736, Cherry Hill, N.J. 08002. Tel: (609) 429-6032 for info.

HAMFESTERS 44TH ANNUAL PICNIC AND HAMFEST, Sunday, August 13, 1978 at Santa Fe Park, 91st and Wolf Road, Willow Springs, Illinois, Southwest suburb of Chicago. Exhibits for OM's and XYL's, FAMOUS SWAPPERS ROW. Tickets at gate $2.00, Advance $1.50. For Hamfest info or Advance Tickets (send check or money order — SASE appreciated) to Bob Hayes W9KXW, 18931 Cedar Ave., Country Club Hills, IL 60477.

ILLINOIS: The Sangamon Valley Radio Club of Springfield, Third Annual Hamfest Sunday, September 24th, Sangamon County Fairgrounds in New Berlin, 16 miles west of Springfield. Hear Hugh Vandegrift WA4WME talk on the Clipperton DX-pedition! Various exhibits, kids activities and food. Camping. First Prize — Bearcat 210; Tickets: $1.50 advance, $2.00 at gate. Information — Al K9QFR; Tickets — Carole WB9QWR, write C/O 1025 S. Sixth, Springfield, Illinois 62703.

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SN7408N	20	SN7483N	59	SN74170N	1.59
SN7409N	20	SN7485N	79	SN74172N	6.00
SN7410N	18	SN7486N	35	SN74173N	1.25
SN7411N	25	SN7489N	1.75	SN74174N	89
SN7412N	25	SN7490N	45	SN74175N	79
SN7413N	40	SN7491N	50	SN74176N	79
SN7414N	70	SN7492N	43	SN74177N	79
SN7416N	25	SN7493N	43	SN74179N	1.95
SN7417N	25	SN7494N	65	SN74180N	79
SN7420N	20	SN7495N	65	SN74181N	1.95
SN7421N	29	SN7496N	65	SN74182N	79
SN7422N	39	SN7497N	3.00	SN74184N	1.95
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SN7425N	29	SN74107N	35	SN74186N	9.95
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SN7427N	25	SN74116N	1.95	SN74190N	1.25
SN7429N	39	SN74121N	35	SN74191N	1.25
SN7430N	20	SN74122N	39	SN74192N	79
SN7432N	25	SN74123N	49	SN74193N	79
SN7437N	25	SN74125N	49	SN74194N	89
SN7438N	25	SN74126N	49	SN74195N	69
SN7439N	25	SN74132N	75	SN74196N	89
SN7440N	20	SN74136N	75	SN74197N	89
SN7441N	89	SN74141N	79	SN74198N	1.49
SN7442N	49	SN74142N	2.95	SN74199N	1.49
SN7443N	75	SN74143N	2.95	SN74200N	5.59
SN7444N	75	SN74144N	2.95	SN74251N	1.79
SN7445N	75	SN74145N	79	SN74279N	79
SN7446N	69	SN74147N	1.95	SN74283N	2.25
SN7447N	59	SN74148N	1.29	SN74284N	3.95
SN7448N	79	SN74150N	89	SN74285N	3.95
SN7450N	20	SN74151N	59	SN74365N	69
SN7451N	20	SN74153N	59	SN74366N	69
SN7453N	20	SN74154N	99	SN74367N	69
SN7454N	20	SN74155N	79	SN74368N	69
SN7459A	25	SN74156N	79	SN74390N	1.95
SN7460N	20	SN74157N	65	SN74393N	1.95
SN7470N	29				

C/MOS

CD4000	23	CD4028	89	CD4070	55
CD4001	23	CD4029	1.19	CD4071	23
CD4002	23	CD4030	49	CD4072	49
CD4006	1.19	CD4035	99	CD4076	1.39
CD4007	25	CD4040	1.19	CD4081	23
CD4009	49	CD4041	1.25	CD4082	23
CD4010	49	CD4042	99	CD4093	99
CD4011	23	CD4043	89	CD4098	2.49
CD4012	25	CD4044	89	MC14409	14.95
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CD4017	1.19	CD4050	49	MC14506	75
CD4018	99	CD4051	1.19	MC14507	99
CD4019	49	CD4053	1.19	MC14562	14.50
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CD4022	1.19	CD4060	1.49	CD4510	1.39
CD4023	23	CD4066	79	CD4511	1.29
CD4024	79	CD4068	39	CD4515	2.95
CD4025	23	CD4069	45	CD4518	1.29
CD4026	2.25			CD4520	1.29
CD4027	69			CD4566	2.25

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74C00	39	74C89	6.49	74C163	3.00
74C02	55	74C90	3.00	74C164	3.25
74C04	75	74C93	2.00	74C173	2.60
74C08	75	74C95	2.00	74C192	3.49
74C10	65	74C107	1.25	74C193	2.75
74C14	3.00	74C151	2.90	74C195	2.75
74C20	65	74C154	3.00	74C922	9.95
74C30	65	74C157	2.15	74C923	8.95
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74C73	1.50			80C95	1.50
74C74	1.15			80C97	1.50

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LM301CN	35	LM340T-18	1.25	LM741CN	35
LM302H	75	LM340T-24	1.25	LM741-14N	39
LM304H	1.00	LM350N	1.00	LM747H	79
LM305H	60	LM351CN	65	LM747N	79
LM307CN/H	35	LM370N	1.15	LM748H	39
LM308H	1.00	LM373N	3.25	LM748N	39
LM308CN	1.00	LM377N	4.00	LM1303N	90
LM309H	1.10	LM380N	1.25	LM1304N	1.19
LM309K	1.25	LM380CN	99	LM1305N	1.40
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LM320K-12	1.35	NE550N	1.30	LM1556V	1.75
LM320K-15	1.35	NE555V	39	MC1741SCP	3.00
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LM320K-24	1.35	NE560B	5.00	LM3053	1.50
LM320T-5	1.25	NE561B	5.00	LM3065N	69
LM320T-5.2	1.25	NE562B	5.00	LM3900N(3401)	49
LM320T-8	1.25	NE565H	1.75	LM3905N	89
LM320T-12	1.25	NE565N	1.25	LM3909	1.25
LM320T-15	1.25	NE566CN	1.75	MC5558V	1.00
LM320T-18	1.25	NE567H	1.25	LM7525N	90
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LM339N	99	LM709H	29	75451CN	39
LM340K-5	1.35	LM709N	29	75452CN	39
LM340K-6	1.35	LM710N	79	75453CN	39
LM340K-8	1.35	LM711N	39	75454CN	39
LM340K-12	1.35	LM723H	55	75491CN	79
LM340K-15	1.35	LM723N	55	75492CN	89
LM340K-18	1.35			75494CN	89
LM340K-24	1.35			RC4151	5.95
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LM340T-6	1.25			RC4195	4.49

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74LS00	23	74LS51	23	74LS139	69
74LS01	23	74LS54	23	74LS151	69
74LS02	23	74LS55	23	74LS155	69
74LS03	23	74LS73	35	74LS157	69
74LS04	29	74LS74	35	74LS160	89
74LS05	29	74LS75	49	74LS161	89
74LS08	33	74LS76	35	74LS162	89
74LS09	29	74LS83	75	74LS163	89
74LS10	23	74LS85	99	74LS164	89
74LS13	49	74LS86	35	74LS175	79
74LS14	99	74LS90	49	74LS181	2.49
74LS15	29	74LS92	59	74LS190	89
74LS20	23	74LS93	59	74LS191	89
74LS21	29	74LS95	79	74LS192	89
74LS22	29	74LS96	89	74LS193	89
74LS26	29	74LS107	35	74LS194	89
74LS27	29	74LS109	35	74LS195	89
74LS28	29	74LS112	35	74LS253	79
74LS30	23	74LS123	99	74LS257	69
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MAN 3	Common Cathode-red	125	.75	MAN 6730	Common Anode-red ±1	560	99
MAN 4	Common Cathode-red	187	1.95	MAN 6740	Common Cathode-red D.D	560	99
MAN 52	Common Anode-green	300	1.25	MAN 6750	Common Cathode-red ±1	560	99
MAN 71	Common Anode-red	300	1.25	MAN 6760	Common Anode-red	560	99
MAN 72	Common Anode-red	300	99	MAN 6780	Common Cathode-red	560	99
MAN 74	Common Cathode-red	300	1.25	DL701	Common Anode-red ±1	300	1.25
MAN 81	Common Anode-yellow	300	99	DL702	Common Cathode-red	300	99
MAN 82	Common Anode-yellow	300	99	DL704	Common Cathode-red	300	99
MAN 84	Common Cathode-yellow	300	99	DL707	Common Anode-red	300	99
MAN 3620	Common Anode-orange	300	99	DL741	Common Anode-red	600	1.25
MAN 3630	Common Anode-orange ±1	300	99	DL746	Common Anode-red ±1	630	1.49
MAN 3640	Common Cathode-orange	300	99	DL747	Common Anode-red	600	1.49
MAN 4610	Common Anode-orange	300	99	DL749	Common Cathode-red ±1	630	1.49
MAN 4640	Common Cathode-orange	400	99	DL750	Common Cathode-red	600	1.49
MAN 4710	Common Anode-red ±1	400	99	DL338	Common Cathode-red	110	35
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MAN 4740	Common Cathode-red	400	99	FND359	Common Anode	350	75
MAN 4810	Common Anode-yellow	400	99	FND503	Common Cathode (FND500)	500	99
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MAN 6630	Common Anode-orange	560	99	5082-7300	4 x 7 Sgl. Digit-RHDP	600	19.95
MAN 6640	Common Cathode-orange D.D	560	99	5082-7302	4 x 7 Sgl. Digit-LHDP	600	19.95
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CA3059	3.25	CA3140	1.25
CA3060	3.25	CA3160	1.25
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14 pin SG	.35	.32	.29	28 pin SG	1.10	1.00	.90
16 pin SG	.38	.35	.32	36 pin SG	1.75	1.40	1.26
18 pin SG	.52	.47	.43	40 pin SG	1.75	1.59	1.45

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ASST. 3	5 ea	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	1/4 WATT 5%	50 PCS
ASST. 4	5 ea	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	1/4 WATT 5%	50 PCS
ASST. 5	5 ea	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	1/4 WATT 5%	50 PCS
ASST. 6	5 ea	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	1/4 WATT 5%	50 PCS
ASST. 7	5 ea	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	1/4 WATT 5%	50 PCS

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XR556	.99	XR2209	1.75	XR4194	1.45
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XR567CT	1.25	XR2212	4.35	XR4212	2.05
XR1310P	1.30	XR2240	3.45	XR4558	.75
XR1468CN	3.85	XR2264	4.25	XR4739	1.15
XR1488	1.39			XR4741	1.47

ZENERS — DIODES — RECTIFIERS

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1N751A	5.1	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	4/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	28	1N4734	5.6	1w	28
1N5234	6.2	500m	28	1N4735	6.2	1w	28
1N5235	6.8	500m	28	1N4736	6.8	1w	28
1N5236	7.5	500m	28	1N4738	8.2	1w	28
1N456	25	40m	6/1.00	1N4742	12	1w	28
1N458	150	7m	6/1.00	1N4744	15	1w	28
1N485A	180	10m	5/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.70
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

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MPSA06	5/1.00	2N3392	5/1.00	2N3906	4/1.00
TIS97	6/1.00	2N3398	5/1.00	2N4013	3/1.00
TIS98	6/1.00	PN3567	3/1.00	2N4123	6/1.00
1IS133	5/1.00	PN3568	4/1.00	PN4249	4/1.00
TIS135	5/1.00	PN3569	4/1.00	PN4250	4/1.00
40409	1.75	MPS3638A	5/1.00	2N4400	4/1.00
40410	1.75	MPS3702	5/1.00	2N4401	4/1.00
40673	1.75	2N3704	5/1.00	2N4402	4/1.00
2N918	4/1.00	MPS3704	5/1.00	2N4403	4/1.00
2N2219A	3/1.00	2N3705	5/1.00	2N4409	5/1.00
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2N2222A	5/1.00	2N3706	5/1.00	2N5087	4/1.00
2N2369	5/1.00	MPS3706	5/1.00	2N5088	4/1.00
2N2369A	4/1.00	2N3707	5/1.00	2N5089	4/1.00
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2N2484	4/1.00	2N3724A	.65	PN5134	5/1.00
2N2906	4/1.00	2N3725A	1.00	PN5138	5/1.00
2N2907	5/1.00	2N3772	2.25	2N5139	5/1.00
2N2925	5/1.00	2N3823	1.00	2N5210	5/1.00
MJE2955	1.25	2N3903	4/1.00	2N5449	3/1.00
2N3053	2/1.00			2N5951	3/1.00

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

100 VOLT MYLAR FILM CAPACITORS

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

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

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

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/15V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

More Details? CHECK—OFF Page 126

flea market

FLORIDA: Five Flags ARA's Annual Ham-A-Rama, September 3, University of West Florida field house, Pensacola. Write: FFARA, P.O. Box 17343, Pensacola, FL 32522.

OHIO: Union County ARC Hamfest, Sunday, August 27, Plain City Fairgrounds, Plain City. Tickets: $1.50 advance, $2.00 at door. Refreshments, free flea market, free overnight camping Saturday, inside tables for dealers. Talk-in on 146.52. For info: Gene Kirby, W8BJN, Sec'y, 13613 U.S. 36, Marysville, OH 43040. SASE please.

MINNESOTA: Central States VHF Contest, August 17, 18, 19 and 20, 1978 at the Midway Motor Lodge, Rochester, Minnesota. Antenna gain measurements, speakers, entertainment, banquet, and prizes, plus much more that *you cannot afford to miss*! Send registration immediately to: Terry Van Benschoten, WØVB, 2326 NW 11th Avenue, Rochester, Minnesota 55901. For motel reservations call (507) 289-8866; for information, call Ed, (507) 288-3584 (home) or (507) 286-3090 (work); and Terry (507) 289-1496 (home) or (507) 286-5568 (work). Central States VHF NET Sunday night 8:30 Central time on 3818 kHz. Rochester repeater on 146.82/22.

FLORIDA: Jacksonville Hamfest, August 5th and 6th at the Jacksonville Beach Municipal Auditorium. Doors open 8:00 AM Advanced registration $2.50, tables $5.00. Ladies and children with registered amateur admitted free. Activities include commercial exhibits, ARRL forum, QCWA meeting, DX forum, antenna forum, microcomputer seminar and much more that *you must see to believe*! For more information, write: Jacksonville Hamfest Association, 911 Rio St. Johns Dr., Jacksonville, Florida 32211. Telephone (904) 744-9501.

ILLINOIS: Sixteenth Annual QSO Party, sponsored by RAMS; 1800Z August 5th to 2300Z August 6th, 1978 with a rest period from 0600 to 1200Z August 6th. Frequencies: CW — about 60 kHz from low end of each band; Phone — about 3975, 7275, 14275, 21375 and 28675. Novice: about 25 kHz from low end of each Novice band, especially on half hour. Write: RAMS — K9CJU, 3620 N. Oleander Ave., Chicago, Illinois 60634.

CALIFORNIANS: Microcomputer Net on WR6ACV (146.28/88) Mt. Oso, Sunday nights at 9:00. Listen for N6HF. Beginners welcome.

OHIO: Cleveland Hamfest; come for the fun on September 9th from 8:00 AM to 6:00 PM at County Fairgrounds, Berea, Ohio. Talk-in on 146.52 simplex. $2 admission. Write to: Cleveland Hamfest Association, P.O. Box 27211, Cleveland, OH 44127.

LANSING, MI CMARC Swap-Shop. Oct. 1, 1978. Grand Ledge High School. Prizes — Food — Tables. CMARC Box 10073, Lansing, MI 48901.

MISSOURI: The Saint Charles Amateur Radio Club's Third Annual SCARC HAMFEST, August 27th, Wentzville Community Club, Wentzville, on Interstate 70, 25 miles West of Saint Louis. Talk-in on 34/94 and 07/67. Refreshments, kids games, FREE bingo, Prizes. Admission: $1.00 per carload. For information contact: SCARC, P.O. Box 1429, Saint Charles, Missouri 63301.

ILLINOIS: Rockford ARA Hamfest and ARRL State Convention, September 10, 1978, Winnebago County Fairgrounds, Pecatonica, 10 miles west of Rockford on U.S. 20. Large inside and outside display areas; inside tables available $3. Snack bar/free camping (electrical hookup $4). Prizes, microcomputer seminar, ARRL technical discussion, OSCAR presentation, contest talk, Midwest Country Cousins meeting, many others. Come one, come all for FUN. Talk-in on 146.01/61 and 146.52 simplex. Tickets $1.50 advance, $2 at door. SASE to Rockford County Amateur Radio Association, P.O. Box 1744, Rockford, Illinois 61110.

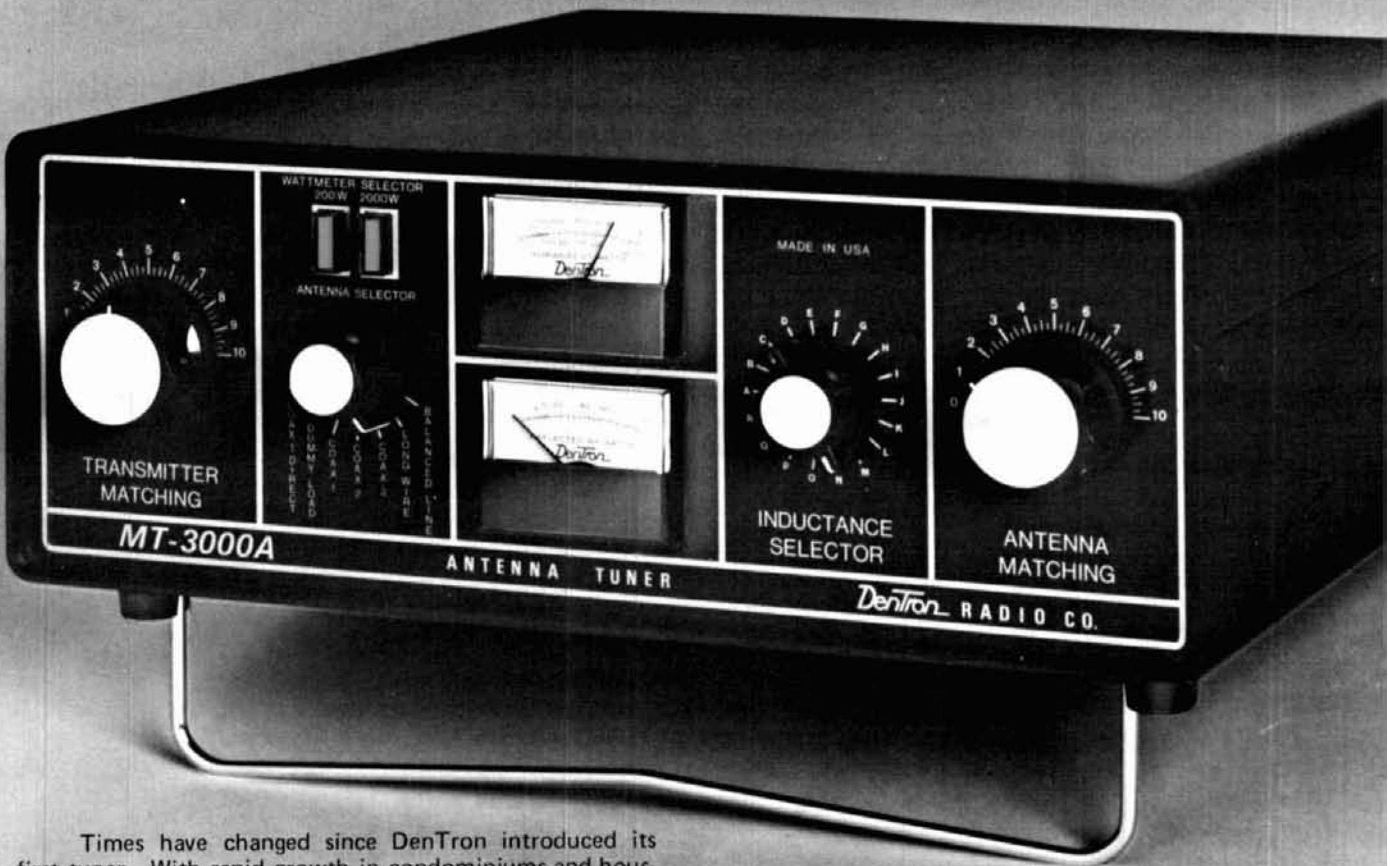
Stolen Equipment

STOLEN FROM AIRLINE BAGGAGE, probably either in Minneapolis/St. Paul or San Francisco, Wilson WE-800 s/n 12521811 with 10 white "no brand" Ni-Cad batteries inside, flex antenna with UHF ell connector and UHF to BNC connector. Also homebuilt battery charger with 723 IC. Mitt Nodacker, WA7TFE, Box 2632, Pocatello, ID 83201.

STOLEN EQUIPMENT: 1. KLM 160 watt amplifier, no I.D. 2. Black Heath 2036 with Micoder and several obvious modifications: hi-low power selector on squelch knob, variable power on internal potentiometer, RCA plug replaced with SO-239, Social Security No. 350-30-1717 etched in foil on transmitter board. Darrel Dorsett, K9JKZ, Kankakee Area Career Center, Rt. 2, Road 100-W, Bourbonnais, IL 60914.

More Details? CHECK—OFF Page 126

Look closely at the new MT-3000A. You've never seen anything like it.



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XF903	8999.0 kHz	BFO	$4.15
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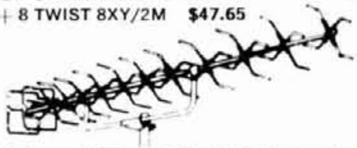

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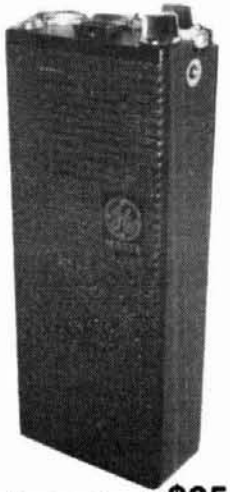

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More Details? CHECK—OFF Page 126

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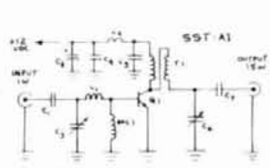

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SEPTEMBER 22—23—24

TOWN & COUNTRY CONVENTION CENTER

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ALL-MODE VHF amplifiers

FOR BASE STATION & REPEATER USE

MODEL	INPUT	OUTPUT	PRICE
V70	10-20W	70-90W	$298
V71	1-3W	70-90W	$329
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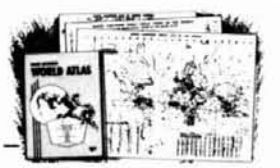

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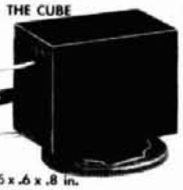

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August, 1978

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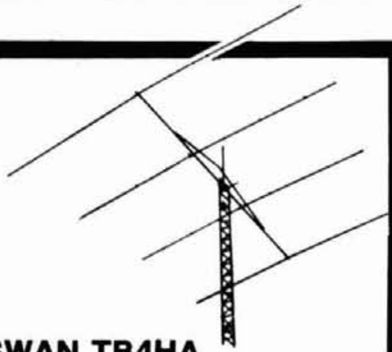

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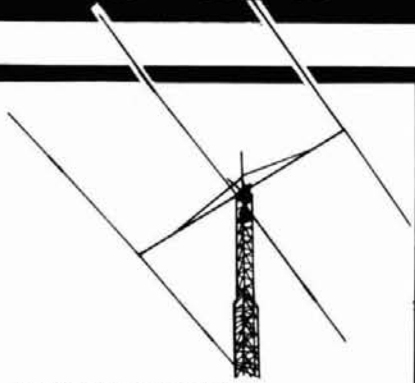

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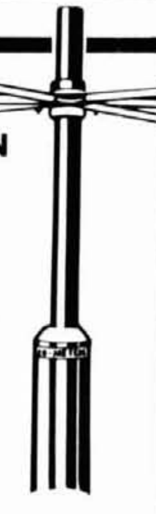

1040V GOLDEN SWAN vertical antenna

The heavy duty omni-directional 1040V features High-Q adjustable traps precision set for max. radiation efficiency on each band with low VSWR. Designed for 52 ohm coaxial • Base mounting hardware included • 10-40 meter operation (75 meter 75 MK resonator optional 39.95).

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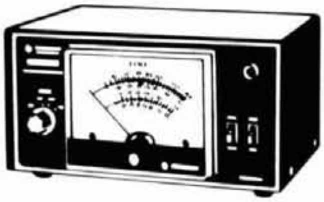

SWAN WM-3000
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Read forward or reflected power with maximum accuracy from 3.5 to 30 MHz • RMS readings available with the flick of a switch • Four scales from 9 to 2000 watts. Requires 117V AC power source.

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SWAN WMM200 SWR and power meter

Designed for mobile operation and illuminated for night operation • Directional coupler measuring method • Impedance 50 ohms • Power range: 0-20 watts and 200 watts in the second range • VSWR 1:1 - 3:1.

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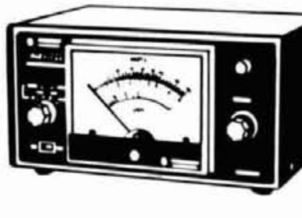

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PLUG IN MODULE

NEW ON 2 FROM YAESU

A compact versatile transceiver for the dedicated two-meter DXer, the built-in memory and twenty-five watt output puts the FT-225RD far ahead. See it at your dealers today, or write for our 1978 full line catalog.

SPECIFICATIONS:

General

Frequency Range: 144-145 MHz, 145-146 MHz, 146-147 MHz, 147-148 MHz
Frequency Readout: Digital readout to 100 Hz, analog display resolution better than 1 KHz.
Modes of Operation: LSB, USB, CW, AM, FM
Frequency Stability: Within 100 Hz during any 30 minute period after warmup. Not more than 20 Hz with 10% line voltage variation.
Intermediate Frequencies: 1st IF=10.7 MHz; 2nd IF=455 KHz.
Antenna Impedance: 50 ohms unbalanced
Repeater Split: 600 KHz installed, any split up to 1 MHz with optional crystal.
Power Requirements: AC 100/110/117/200/234 Volts
DC 13.8 Volts, negative ground
Power Consumption: AC Receive 30 VA
Transmit 160 VA at full output
DC Receive 1.2 Amps Transmit 6.5 Amps
Size: 280mm (W) × 125mm (H) × 315mm (D)
Weight: Approximately 9 kg

Receiver

Sensitivity: SSB/CW 0.3 uV for 10dB S/N
FM 0.35 uV for 20dB QS
AM 1.0 uV for 10dB S/N
Selectivity: SSB/CW/AM 2.3 KHz at 6dB down
4.1 KHz at 60dB down
FM 12 KHz at 6dB down 28 KHz at 60dB down
Image Response: Better than —60dB
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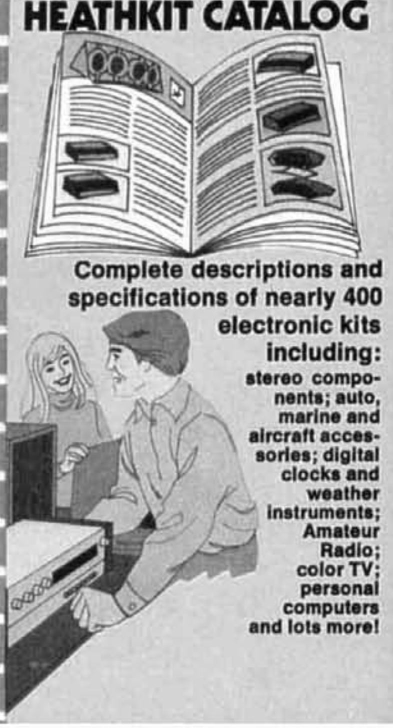

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