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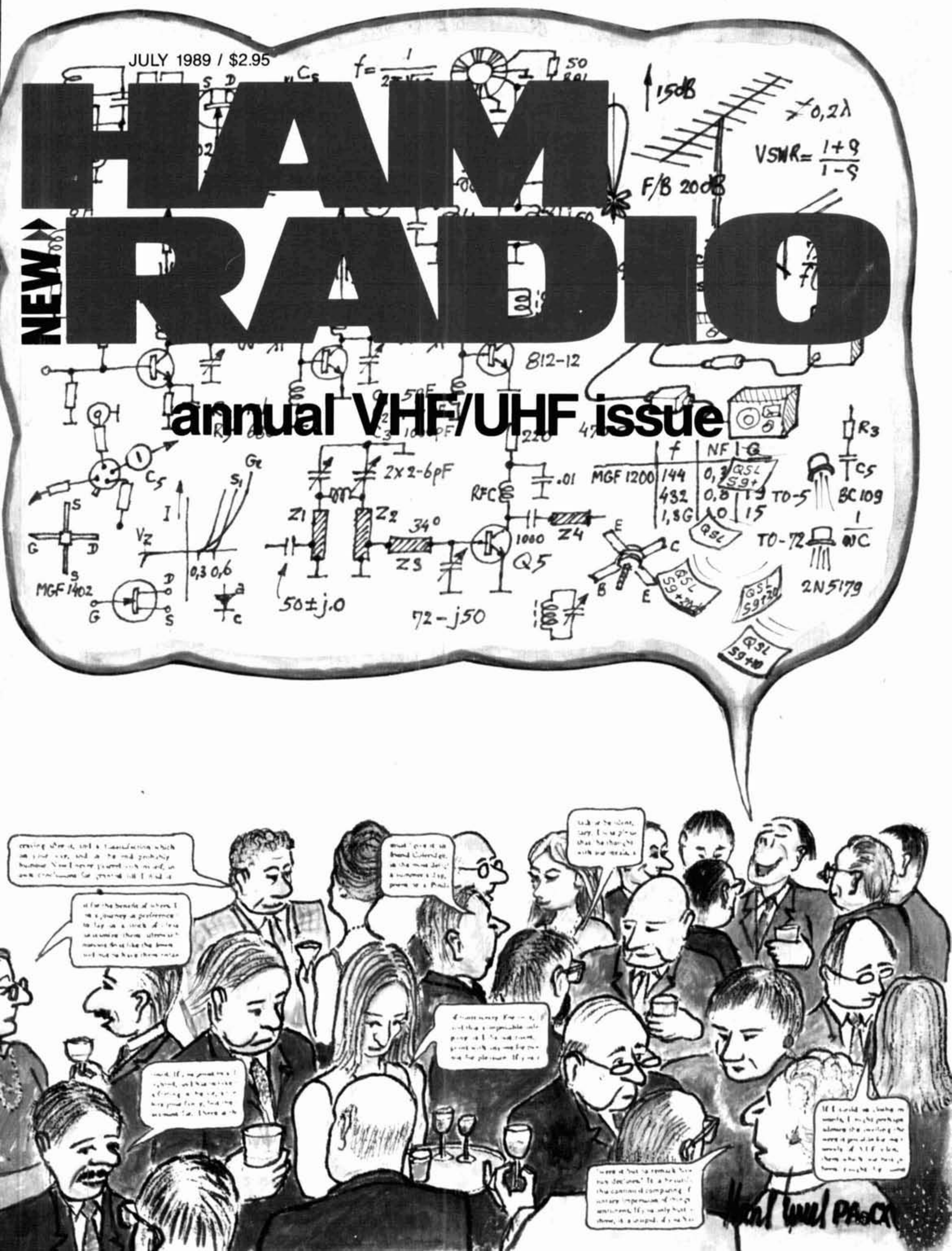
# NEW HAM RADIO

## annual VHF/UHF issue

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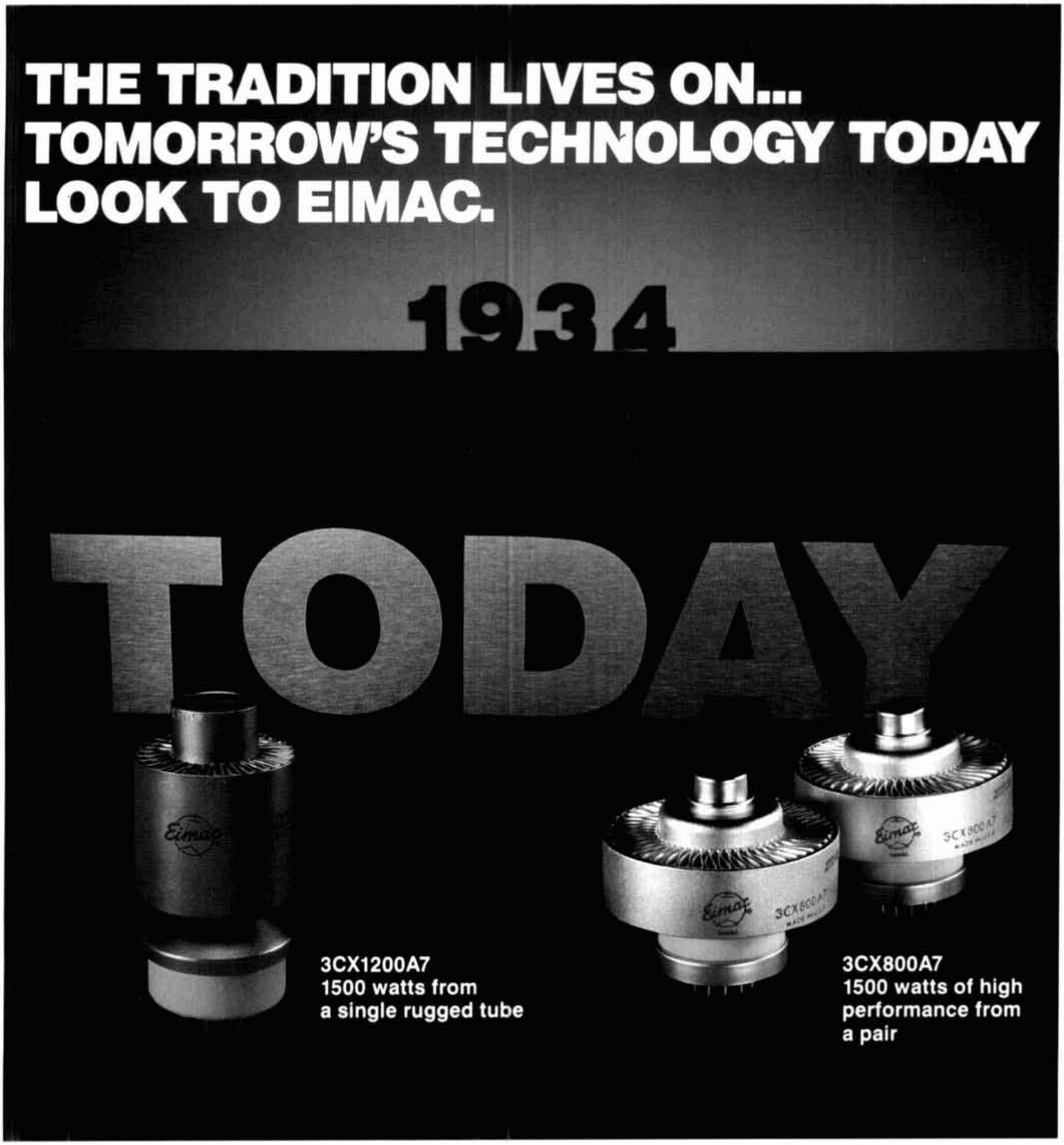


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# HAM RADIO

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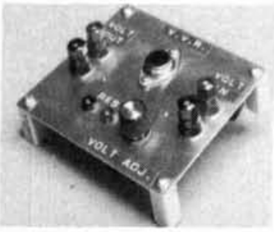


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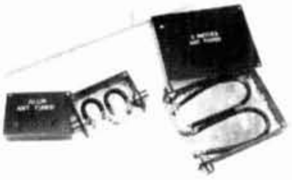

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**Cover Photo:** Hans Evers, PAØCX

## FEATURES



## DEPARTMENTS




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# Backscatter

## The more things change, the more they remain the same

Sometimes, I get the feeling that Amateur Radio is going to explode into open warfare. No, I'm not talking about IARU societies fighting each other. But in certain aspects of the service, lawsuits, accusations, and innuendo seem to be the order of the day. Whatever happened to talking, reason, and the subtle art of negotiation?

Two repeater wars are brewing — one between a repeater group in Los Angeles, California and a group in Mexico. The other is between repeater groups in Illinois and Indiana. While I don't know if the group in the Southwest tried to arbitrate a solution to their problem, I am sorry to see that they chose the route of litigation in an attempt to solve it. According to *Westlink*, both repeaters have been coordinated by their local authorities onto the same frequency pair. I wonder if there was any communications between the two coordinating groups before the frequency assignment. I'd like to think there was. If not, we have slipped one step closer to spectrum anarchy. In the Midwest, a similar situation exists. With luck a solution can be negotiated between the coordinators and repeater owners so that they don't have to resort to litigation.

**A glimmer of hope**

But despite all the repeater troubles, there is a movement afoot which could help us cast off the chains of the past and move forward to a revitalized interest in Amateur Radio. I'm referring to the on-going discussions about no-code. (I would much rather call the new license class code-free or beginner's class, as I'm afraid no-code presents a negative image to some within the hobby.) *CQ*'s recent survey of their readership showed a 60-40% split in favor of a code-free beginner's license. As I reported last month, our informal sampling resulted in an even split. The ARRL's study committee has even suggested a code-less license to the ARRL Board of Directors with some very intiguing privileges. And even though some clubs and groups are vehemently against the idea, many others embrace it with open arms.

Marty, NB1H, and I gave a presentation to the Granite State Amateur Radio Club on the code-free license this past May. Most of the group looked on the idea favorably. Several, however, did not. Among other things, their biggest concern was control — would this new class of license open the floodgates to bad habits and other potential problems. On the drive home, I thought about their objections; I find that I do not agree with them. The code-free license is more than an attempt to reach out to those who simply do not want to learn the code. It is a effort to bring licensing into the 1980s with a ticket designed for a communicator. These hams will not be any less than those now currently licensed. It will be incumbent on us to get them to upgrade and gain more privileges. What will be the eventual outcome of the proposal? No one knows and it will be months before we have any idea.

So, the more things change, the more they remain the same! I sure hope we can find a way to mediate our differences and, at the same time, accentuate the positive things that are happening in our hobby. What we do not need is more litigation between Amateurs. In this era of government deregulation, the FCC simply is not going to be the "all powerful, omnipotent Oz" it used to be. Funds and personnel have been cut in the FCC offices to the bare bones. One communications lawyer commented to me that FCC regulation and operation were being done through "mirrors and tricks" — illusion in fact! We simply cannot depend upon the FCC to solve our problems. It is up to us to solve them for ourselves.

Can we do it? Can we police and maintain order in the Amateur service? I don't know, but I hope so. As long as the trend is toward asking the courts to solve our problems, we cannot. If we go back to arbitration amongst ourselves and depend on each other to deal in good faith, maybe it is possible. We'll see.

**Craig Clark, N1ACH**

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# Comments

## Need for new challenges

**Dear HR**

Many of the ham magazines have recently featured letters or editorials which bemoan the slow or even negative growth in our numbers. Some press for some sort of "no-code" license as a panacea, guaranteed to reverse all of the undesirable trends and to rejuvenate the hobby.

What sort of growth would satisfy a manufacturer of ham gear or a publisher of Amateur Radio magazines? At the beginning of World War II, the ham population totalled about 50,000. The latest total I have heard is around 250,000. This five-times increase, which occurred during a period of time when our total population approximately doubled, seems a remarkable growth to me.

I am surprised however, that we retain as many in the hobby as we do. I have many memories of young children leaving sophisticated toys in the closet while spending long hours with crude, self-made ones. Could this same psycological mechanism be at work among hams who have tired of their complex toys? Where is the challenge in a hobby if the required license can be obtained by memorizing a few pages of data — and when sophisticated gear, beyond the understanding of most operators, is cheaply available? I can easily see why the excitement and the near magic I felt when I first became a ham does not exist for a big segment of our present group.

No one tried to encourage me in the mid-30s when I developed an interest in Amateur Radio and decided to get my license. I studied hard to understand the theory and copied code for long hours to get my speed up to 15 wpm or so. Then, I had to build homebrew gear as I could not afford commercial equipment. Every step along the way to getting on the air presented a challenge to a young teenager. I suspect it was the challenge that initiated and sustained my resolve.

What are the current challenges, technical or otherwise, that would entice newcomers to our hobby? Just acquiring the legal right to communicate with ham gear is not enough. Most publishers and even the ARRL appear to promote more and more sophistication in our equipment, but then sponsor increasingly simple activities in which to use it. Just learning a new computer program so that you can use your PC on packet requires little or no technical skill and is not much of a challenge. Occasionally, I read or hear a derogatory remark about the simplicity of the homebrew gear so strong in the memories of those who were hams prior to WW2. I have but one response: The gear we built was near state-of-the-art for the times. How much homebrew gear is around today that you could consider state-of-the-art?

The early enchantment with the mysteries and complexities of the hobby does appear to be slipping away and cannot be restored by producing a mass of appliance operators. If up-to-date technical challenges cannot be initiated, I am afraid that our hobby will slowly be downgraded to a CB-type of activity, we'll hear more and more stations "backing-out" of QSOs, and blown fuses will soon become major problems.

**Paul Swearingen, W9PJF,**
**Benton, Illinois 62812**

## Here we go again!

**Dear HR**

Well, the long suffering public (especially the Amateur Radio community) has been had again. The Feds have laid another bundle of fallacious logic on our heads and again expect us to bow down and take it.

The incising of the 220-222 MHz portion of the electromagnetic spectrum was again performed "in the public interest." Somehow I am sharply reminded of a child receiving a beating "for his own good." Oh, yeah? Really? Is THAT logical? "For his own good" indeed! Have you ever heard of anyone running up and asking for a beating "for his own good?"

Another one that goes right along with this is, "This is going to hurt me more than it will you." Oh, yeah? Then let ME do it to YOU — then it won't hurt you so much. I might admire a little more honesty in all of this. "I am going to beat you as a punishment for" or "I am going to beat you because I am bigger and stronger and have more power than you." At least you would know just where you stood in the grand schematic of things.

If we are going to play the numbers game with the FCC chief engineer (and treat ALL frequencies alike) and the land mobile service needs 2 MHz, then why not give them 2 MHz up at 24,000 MHz? That would amount to the same 2 percent that he claims is all that we are losing.

What is the fierce pressure to force a breakthrough in land mobile communications? Will those brown UPS trucks get the goods to your door appreciably faster? It would be most interesting to find out whose brother-in-law has a warehouse FULL of this new, breakthrough 220 mobile equipment — already. Or to unearth which country is ready to load ships full of this new, breakthrough stuff.

Remember that business (and politics) function just like the King — who always announces that he CAN TOO put Humpty Dumpty back together again. ALL HE NEEDS IS MORE HORSES AND MORE MEN!

**Joseph A. Weite, KH6GDR,**
**Makakilo, Hawaii 96706**

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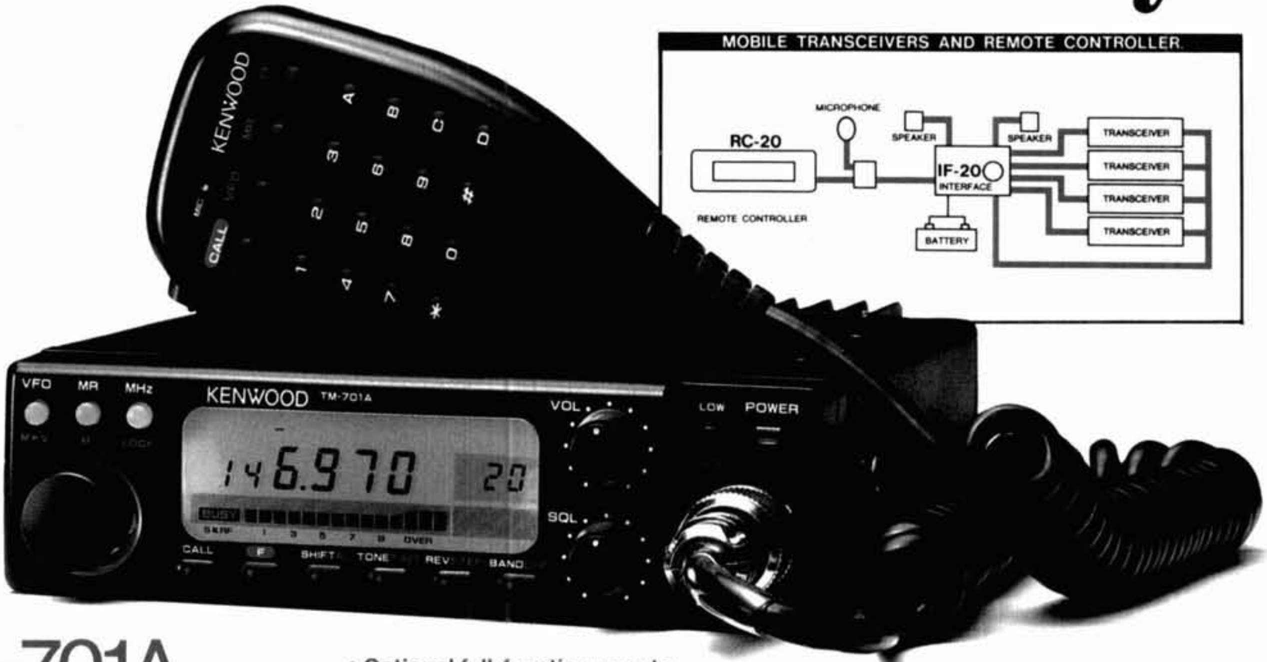


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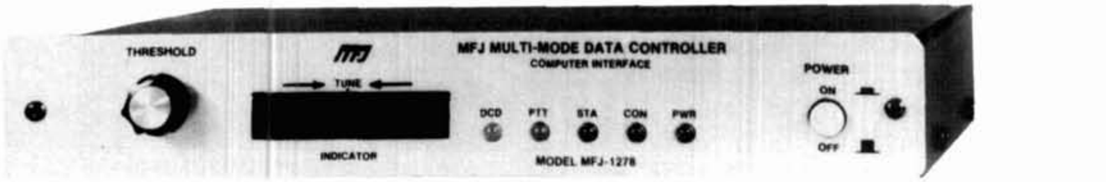


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# A 435-MHz LOW-NOISE GaAsFET PREAMPLIFIER

## Upgrade your 435-MHz receiving system for OSCAR and terrestrial weak signal reception

*Paul Gregory, WA2FTK, 136 Covered Wagon Trail, W. Henrietta, New York 14586 with Vic Gauvin, K1JUL, 27 Van Cortland Drive, Pittsford, New York 14534*

Articles on VHF/UHF GaAsFET preamplifier construction aren't unusual. But many feel that these preamps are too difficult to build, that they are too unstable, or that parts are too hard to get. I hope my project will help to allay some of these fears.

### Why a preamplifier?

Why add a preamplifier to your receiving system in the first place? Under extremely weak signal conditions (like those from a satellite), your receiving system needs all the help it can get. Things like feedline loss between the antenna and the receiver degrade the signal strength seen at the receiver's front end. In addition, the receiver may not be sensitive enough to hear the weak satellite signals. To overcome these problems you can add a low-noise preamplifier, like a GaAsFET, to the receiving system to improve overall receiving system performance.

Let's look at the satellite downlink receiving system at my station. I have 65 feet of 9086 coax (similar to 9913) between the antenna and a 435-MHz receiver. The cable loss is approximately 3.1 dB per 100 feet, which is 2 dB for 65 feet at 435 MHz. The receiver's RF amplifier has 10 dB of gain with a noise figure of 5 dB — not a very sensitive system. With a typical satellite signal level at the antenna terminals, the receiving system performance can be illustrated by the signal-to-noise (S/N) ratio at the receiver input to the mixer. This is shown in **Figure 1** (see appendix A at the end of the article for assumptions and computations). As is the case with any system, the losses and noise contributed by the system components degrade the S/N ratio at each step in the signal path. Because of the low signal levels in this case, the contribution is significant and greatly degrades the signal by the time it reaches the receiver mixer. There's 4 dB of S/N reduction due to the coax and 7 dB at the receiver — a net S/N ratio of 6 dB. It's necessary to increase the working signal to levels much higher than the noise, so that the noise has less effect.

### Where to add a preamp?

The addition of a preamplifier at the receiver input is a common solution to this problem. **Figure 2** shows what happens when you add the 20-dB low-noise amplifier discussed later in this article. The 4-dB S/N degradation resulting from the coax is still present, and you have an additional degradation of 1 dB due to the preamp itself. However, the noise contribution caused by the receiver has been reduced to approximately 0.1 dB, as compared with the 7 dB of the previous system. This is a 6-dB net improvement in S/N for a final ratio of 12 dB. For a greater improvement, increase the working signal level at the coax to the point where the coax noise is insignificant with respect to the signal level — just as you did with the receiver noise.

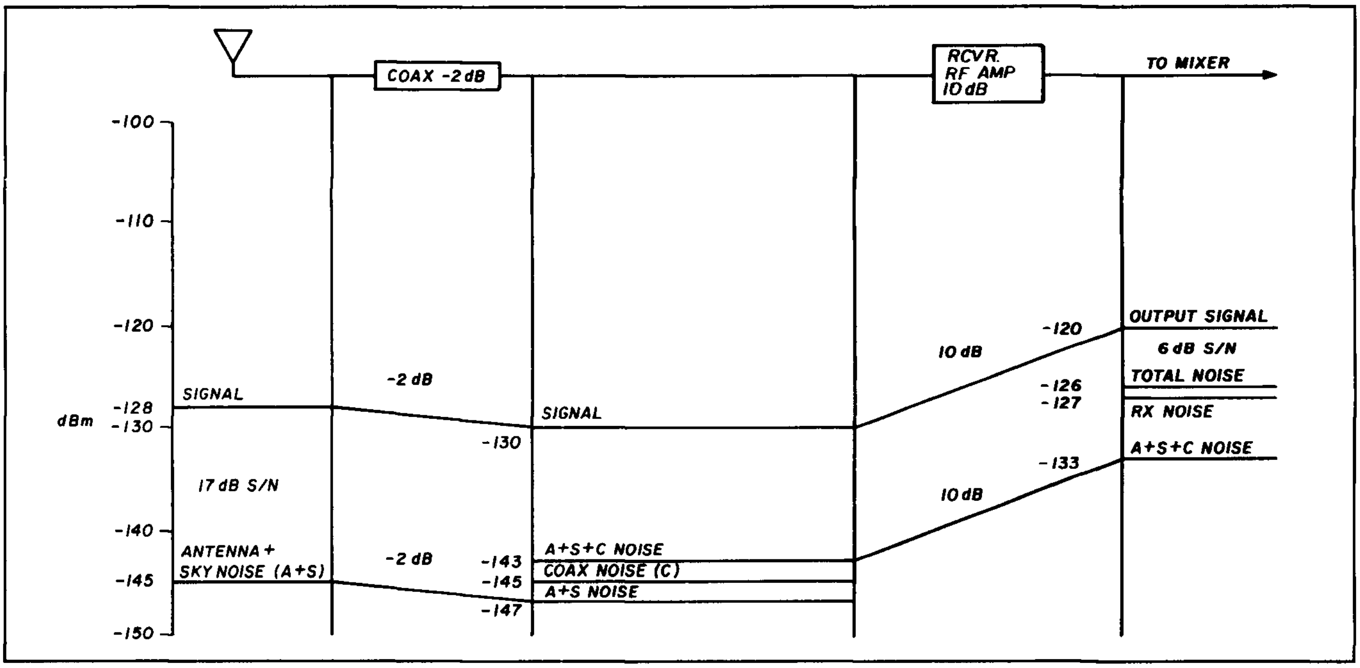
To do this, you must amplify the input signal at the antenna before it reaches the coax. The results of this configuration are illustrated in **Figure 3**. As you can see, the preamp S/N degradation is now roughly 0.6 dB and the coax contribution changes from 4 dB to 0.1 dB! The receiver contribution is still insignificant at 0.3 dB and the net S/N is now 16 dB, nearly as good as it is at the antenna.

As these examples show, *it's not how much gain your* amplifiers have (the final signal level in **Figures 2** and **3** is the same), but where in the circuit the gain occurs that determines your ability to increase the signal above the noise to a point where you can reduce its effect significantly.

### The preamp

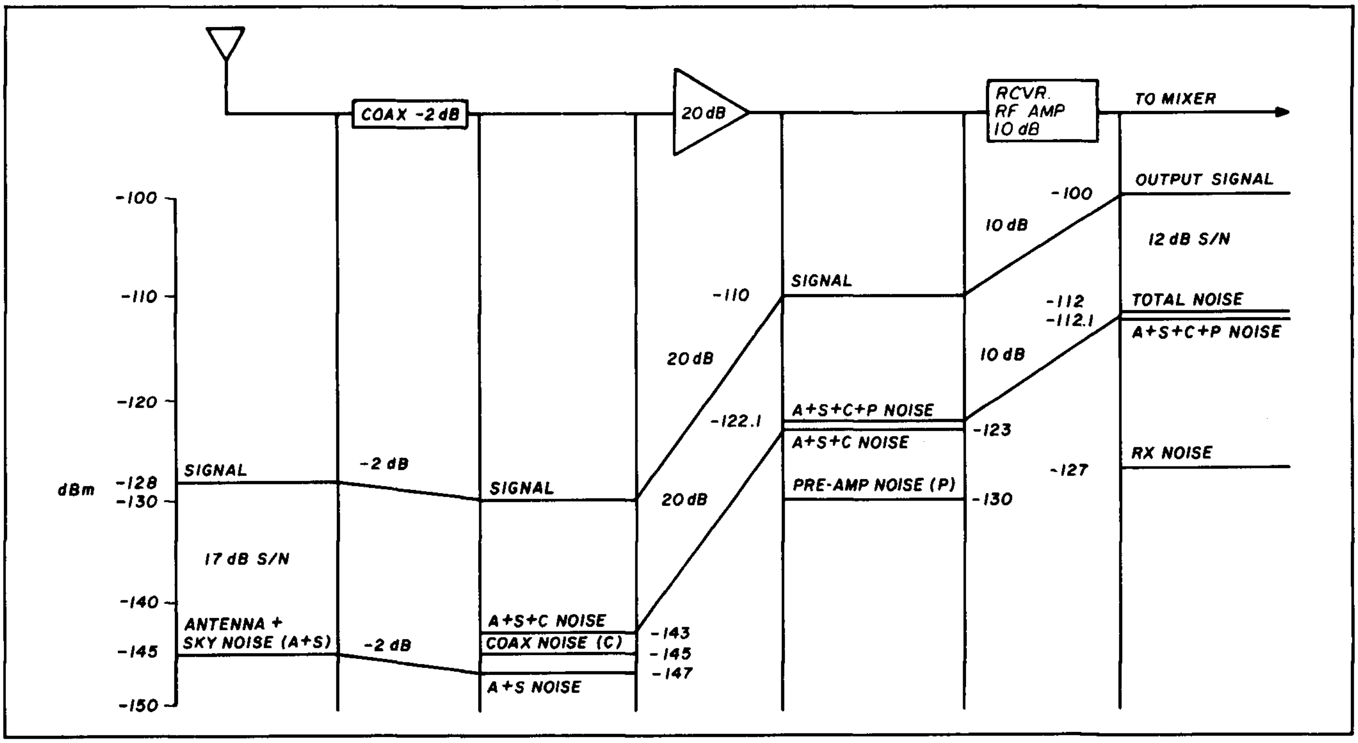
The GaAsFET preamplifier circuit I've described here is similar to one in *The ARRL Handbook*[1]. I made minor changes to improve stability and allow operation at 28 volts DC because of my relay requirements. It offers excellent

FIGURE 1




**S/N calculations — no preamplifier.**

FIGURE 2



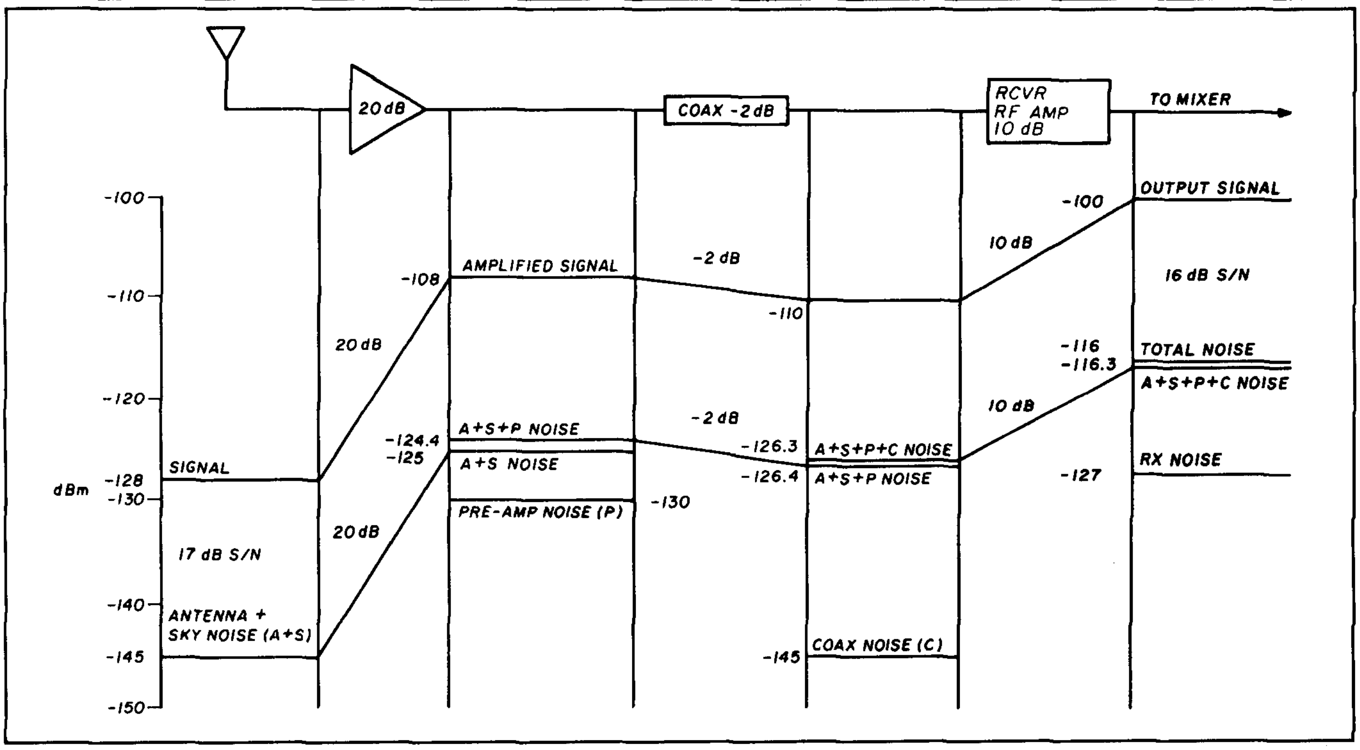

**S/N calculations — preamplifier at receiver input.**

performance and gain, and can be used for both satellite and terrestrial communications.

## Circuit details

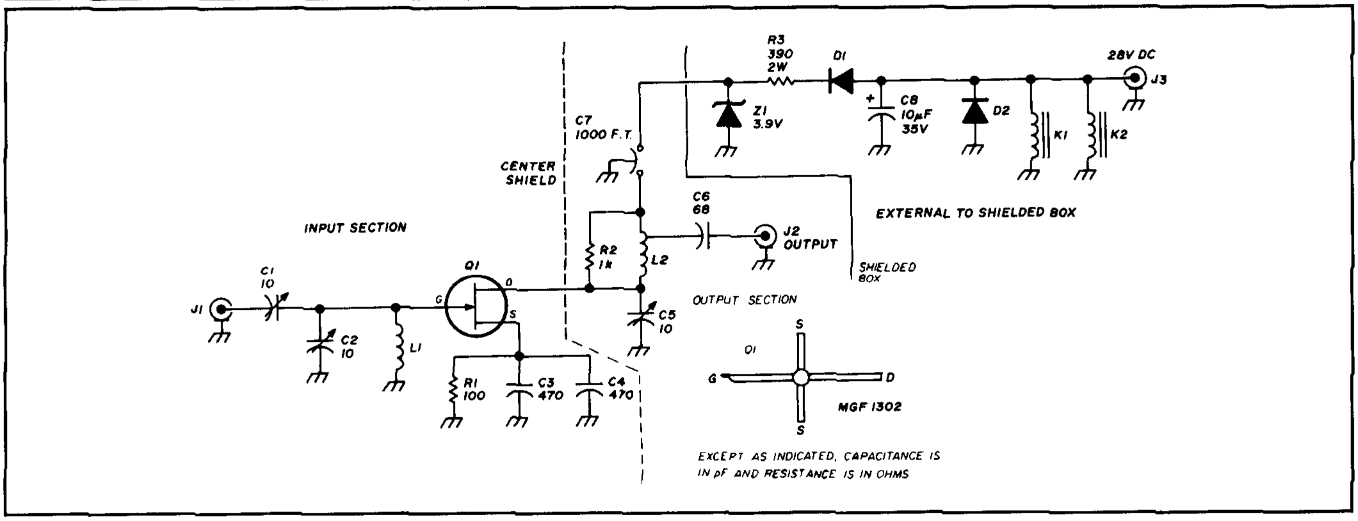
The basic circuit is shown in **Figure 4**. The GaAsFET transistor is a Mitsubishi MGF 1302, which provides approximately 18 to 20 dB of gain in this circuit. The input is tuned by C1, C2, and L1; the output is tuned by C5 and L2. You can use miniature ceramic trimmer capacitors for the variable capacitors; however, I recommend piston-type capa-

FIGURE 3




**S/N calculations — preamplifier at antenna.**

FIGURE 4




**Schematic diagram. Except as indicated, values of capacitors are in pF. Resistances are in ohms.**

citors. The source bypass capacitors, C3 and C4, are leadless trapezoidal capacitors. Note that there are two source leads on the GaAsFET transistor, and that each lead is connected to a trapezoidal bypass capacitor. The output coupling capacitor, C6, is a silver mica.

The relays I used require 28 volts DC, so the preamplifier circuit is designed to work at that voltage. If you use 12-volt relays instead, change R3 from 390 ohms to 150 ohms, 2 watts.

When DC voltage is not applied to the amplifier circuits, the preamp is in transmit mode, bypassing the amplifier (see **Figure 5**) and protecting the GaAsFET from static charges when not in use.

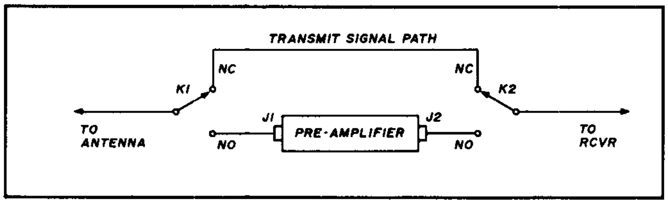
## Construction details

I built the complete amplifier circuit on a piece of double-sided pc board 3-3/4" × 1-5/8". The remaining sides are double-sided pc board soldered together. The long sides

## PARTS LIST

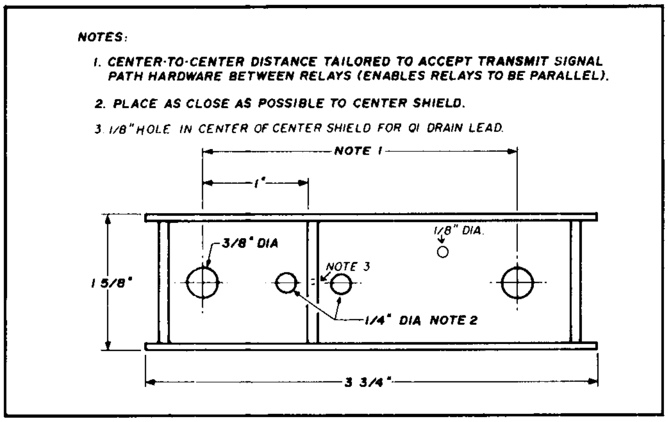
| | |
|---|---|
| C1,C2,C5 | 0.8 to 10-pF piston trimmer, Johanson or Trimtronics |
| C3,C4 | 470-pF leadless trapezoidal |
| C6 | 68-pF silver mica |
| C7 | 1000-pF solder-in feedthrough |
| C8 | 10-μF, 35-volts DC electrolytic |
| D1,D2 | 1N4004 |
| J1,J2 | BNC chassis mount |
| J3 | F connector, Radio Shack 278-212 |
| K1,K2 | Relay, Amphenol 300-11361 (shorting type) |
| L1 | 2.5 turns 3/16-inch inside diameter, 1/4 inch long, 22 AWG |
| L2 | 2 turns 3/16-inch inside diameter, 22 AWG, tapped 1/2 turn from C7 end, turns spaced 2 wire diameters |
| Q1 | Mitsubishi MGF 1302 |
| R1 | 100-ohm, 1/4-watt metal film |
| R2 | 1-k, 1/4-watt metal film |
| R3 | 390-ohm, 2-watt carbon composition |
| Z1 | 1N4730, 3.9 volts, 1 watt |
| | Enclosure approximately 4 x 5 x 6 inches |

## FIGURE 5




**Normally closed position of antenna switching relays is used to bypass the preamplifier for protection from atmospheric static charges. A shorting-type relay is used to short the open contacts to ground during transmit, therefore providing further protection from RF leakage.**

## FIGURE 6




**Shielded box dimensions. Note 1: Center-to-center distance tailored to accept transmit signal path hardware between relays (enables relays to be parallel). Note 2: Place as close as possible to center shield.**

are 3-3/4" × 1", and the two end pieces are sized to fit. Refer to Figure 6 for dimensions and hole locations. Make sure the solder joining the sides is continuous along the board edges, both inside and outside the enclosure. (Tack solder all the sides first to be sure everything fits properly.)

Before you install the center shield, drill a 1/8" hole in its center and solder one 470-pF trapezoidal capacitor (C3 and C4) to each side of the hole.

**Figure 7** shows a suggested component layout diagram. Install J1, C2, C5, C7, and J2, as well as C3 and C4 on the center shield, first; they're used as mounting points for other components. You may wind L1 and L2 on a 3/16" drill bit. The direction of the turns isn't important, but you should wind the input and output inductors in opposite directions. This will help to minimize coupling. Make your lead lengths as short as possible. I did this for L2 and R2 by placing the resistor inside the coil and soldering to a common point.

To protect the GaAsFET, I suggest that you install it last (along with R1). Place the drain of the GaAsFET (the longest lead) through the hole in the center shield and solder each source lead to the trapezoids (see **Figure 7**). Use care when handling the GaAsFET: discharge yourself by touching a grounded metal object before handling the transistor. It is static sensitive and may be damaged if you don't. Also, when soldering the leads, be sure not to use excessive heat. Be sure the drain lead is centered in the hole after you've soldered the two source leads.

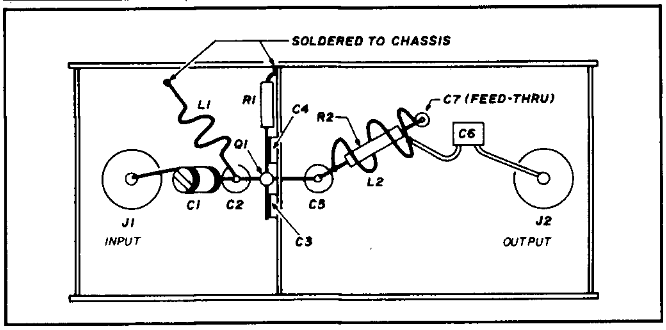
Note that Z1, D1, D2, R3, and C8 are located outside the shielded box. D2 and C8, as well as K1 and K2, are connected at J3, the DC input connector at the enclosure that houses the entire assembly. D1 and R3 are in series to feedthrough capacitor C7 at the shielded box. Z1 is connected to C7 and grounded right to the outside of the box.

The shielded box is designed to connect to the coaxial relays (see **Photo A**). Each relay contains two bulkhead-mount N connectors, with O rings on one side for weatherproof mounting and a BNC male connector on the other side. The preamplifier connects directly to these BNCs and is supported by the relays. Attaching the relays to a weathertight chassis provides a convenient method of installation; everything is held in place by the mounting hardware (**Photo B**).

The transmit signal path connection between the relays is made up of two 90° elbow N connectors and the double-male N.

The final assembly (before weatherproofing) is illustrated in **Photo C**. I used an F connector for the DC input (J3) because I needed shielded cable (like RG-59) to protect the preamp from atmospheric static while not in use. The enclosure should also be grounded to the antenna tower.

## FIGURE 7




**Suggested component layout. All leads must be as short as possible (use C6 to make up the distance required to J2 because of relay spacing).**

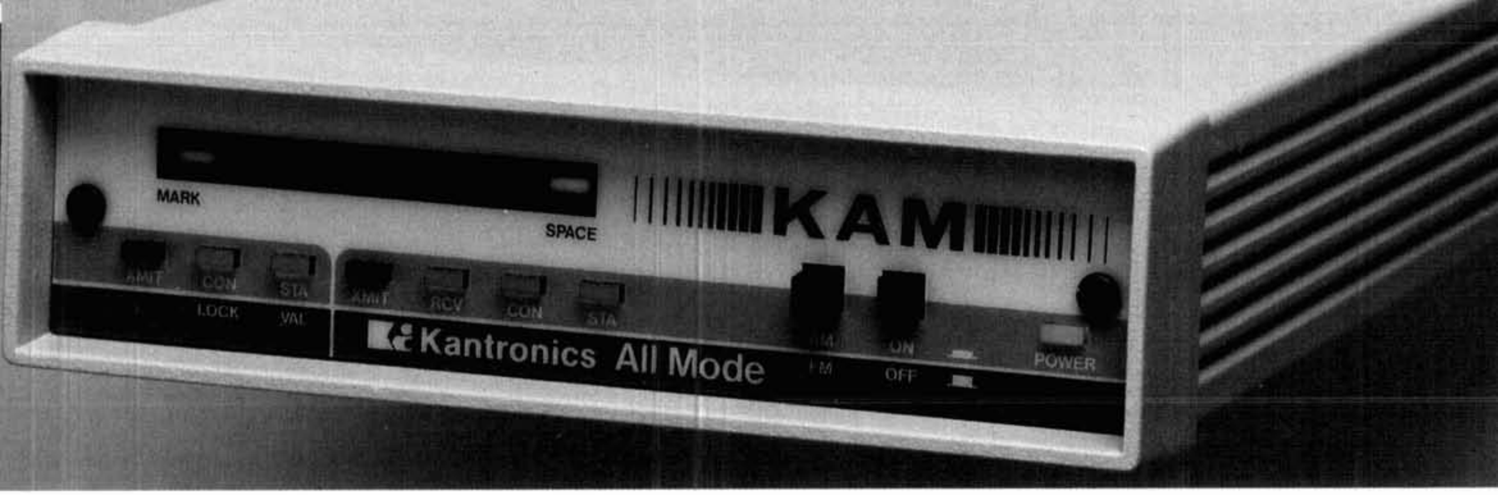



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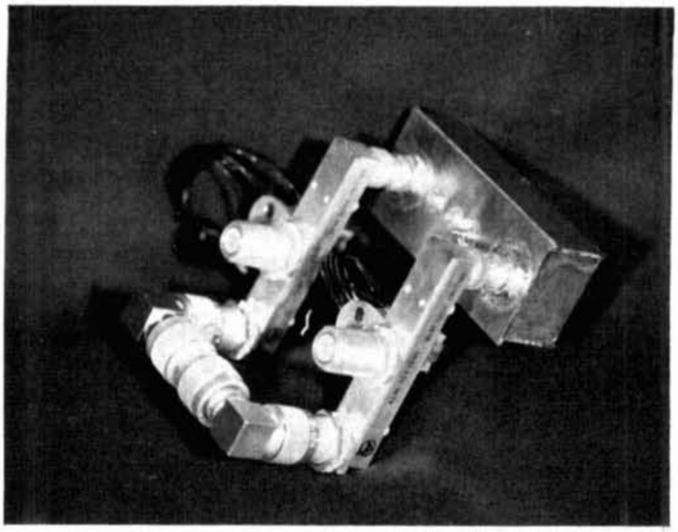
PHOTO A



**The shielded assembly connects directly to the transmit/receive relays. The photo illustrates the hardware used for the transmit signal path (used whenever preamplifier is not in operation).**

## Tuneup

You can do the initial amplifier tuneup before you connect it to the relays and install it in the receive line. Be sure that the transmitter cannot be keyed. Tune in a known signal strong enough to just move the S-meter and adjust C2 and C5 for maximum S-meter reading; then tune C1 for best signal-to-noise ratio. Retune C1 and C2 for best signal-to-noise and maximum gain as necessary. Disconnect the antenna; the background noise should be greatly reduced.

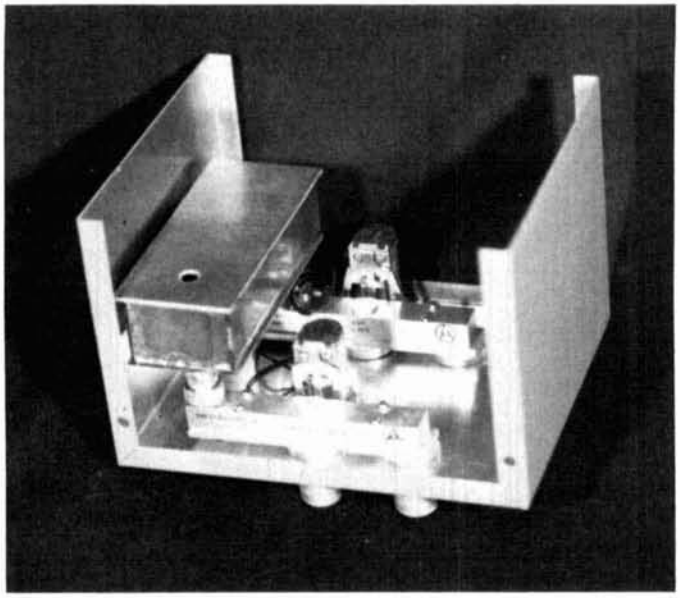
Tune around the band to determine if there are any "birdies" caused by the amplifier. If there are, adjust C5 until they disappear. *Do not touch C1 and C2.* (Since I added R2, I've encountered no difficulties in this configuration. If you do have problems, refer to the December 1987 *Ham Radio* "VHF/UHF World" column by Joe Reisert, W1JR.) Reconnect the antenna and you'll find that the background noise reappears. Readjusting C5 will slightly detune the output stage; however, sufficient gain in the circuit means that gain reduction will be insignificant.

## Parts information

Components C1-C5, C7, and Q1 are available from:
Microwave Components of Michigan
11216 Cape Cod
Taylor, Michigan 48180

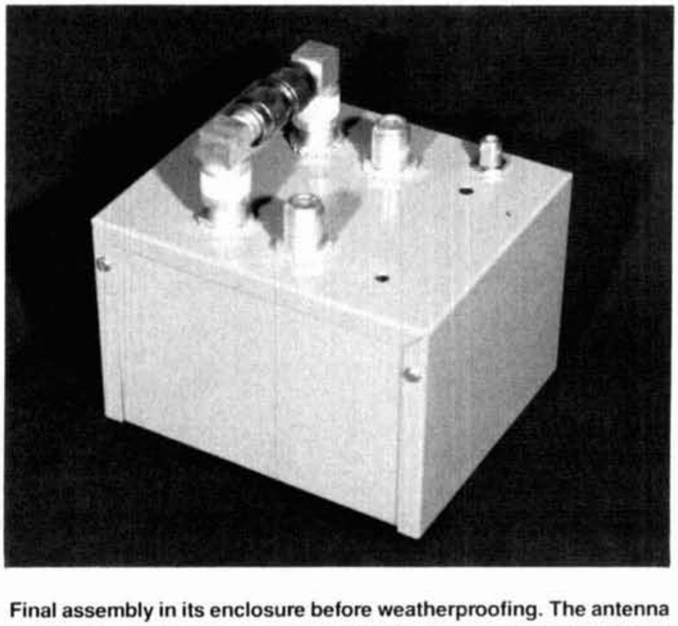
I purchased the relays at a hamfest. They are manufactured by Amphenol, and provide the minimum number of external adapters to connect to the preamplifier without requiring a custom relay. You can use any high quality coaxial relay provided it can handle the power requirements of the transmitter, provides enough isolation during transmit to protect the preamplifier, and is rated to at least 500 MHz. Relay substitution may require additional adapters to interface to the preamplifier and external coax to the antenna and the station.

PHOTO B



**The entire assembly mounted in its enclosure. The hole in the shielded box is an optional access hole for adjustment of C1. The "power-related" components attach to J3 at the enclosure (hidden under the shielded box), keeping them out of the RF section of the circuit.**

PHOTO C



**Final assembly in its enclosure before weatherproofing. The antenna and feedline to the receiver connect at the N connectors. The F connector is the input for the shielded power cable.**

## Conclusion

Adding this amplifier to your station will give you a state-of-the-art receiving system for modes J and L operation, as well as significantly improved terrestrial operation. You'll really be able to hear those weak signals and enjoy satellite/UHF DXing.


REFERENCE

1. "GaAsFET Preamplifiers for 144 and 220 MHz," *The ARRL Handbook for the Radio Amateur*, ARRL, 1986 and later editions.

## Appendix A

## Computations and assumptions

The values used in the signal-to-noise ratio diagrams are based on typical signal levels in "average" station setups. Values are given in dBm since most people can relate to these by way of other experience. All values in the illustrations have been rounded, and some "adjusted" by no more than a few tenths to simplify the diagrams. The following is the basis for several of the values used.

## Input signal level (−128 dBm)

This value of −128 dBm results when you have a satellite roughly 22,000 miles (35,406 km) away operating at 435 MHz on mode J or JL, with an EIRP output of 2.5 watts (due to uplink station limitations and/or the amount of activity on the satellite). The receiving antenna has a gain of 14 dBi and you're using SSB filters (2.1 kHz) in your receiver. The power ($P_{ant}$) at your antenna terminals is determined by the strength of the signal, its path loss to the antenna, and your antenna gain:

$P_{ant}$ = EIRP (dBm) − path loss ($P_{loss}$) + ant gain

An EIRP of 2.5 watts equals 34 dBm. The path loss is computed by:

$$P_{loss}\ (dB) = 10 \text{ Log } [(4\pi \times \text{distance meters})/\text{wavelength meters}]^2$$
$$= 10 \text{ Log}[(4\pi \times 35{,}406{,}000)/0.68]^2$$
$$= 176.2 \text{ dB}$$

Therefore:

$$P_{ant} = 34 - 176.2 + 14$$
$$= -128.2 \text{ dBm at the antenna terminals}$$

## Antenna and sky noise (−145 dBm)

To compute the noise received from the atmosphere (sky) and generated in the antenna, you must consider the atmospheric and antenna "noise temperature"[1] (the temperature at which the noise from a reference resistor noise standard is comparable to the noise in the atmosphere), and the receiver bandwidth (the noise that the bandwidth of the receiver will let through). Use the following formula:

$Noise_{(A+S)}$ (W) = k × sky/ant noise temp (Kelvin) × bandwidth (Hz)

where *k* = Boltzmann's constant = $1.38 \times 10^{-23}$ joules/Kelvin

*noise temp* = 100 Kelvin[1] (typical)

*bandwidth* = 2100 Hz

Therefore:

$$N_{(A+S)} = (1.38 \times 10^{-23}) \times 100 \times 2100$$
$$= 2.9^{-18} \text{ watts}$$
$$= -145.4 \text{ dBm}$$

## Component noise

The noise generated within each of the components is determined by the following general formula:

$N_{pwr}$ (W) = GktB

where G = gain of component

*k* = Boltzmann's constant ($1.38 \times 10^{-23}$J/K)

*t* = noise temperature of component (Kelvin)

*B* = bandwidth of system (2100 Hz)

The formula stated in dBm is:

$$N_{pwr}\ dBm = G\ (dB) + 10 \text{ Log } \frac{ktB}{0.001} \quad (1)$$

The only item you don't know for each component is its noise temperature. However, you do know the noise figure (NF), so temperature may be derived as follows:

$$T_{comp} = 290\ [\text{antilog } (NF/10) - 1] \quad (2)$$

Use formulas (1) and (2) in each of the following derivations.

## Coax noise

The coax provides a 2-dB loss in the system; therefore, its noise figure (as a passive component) is also equal to that amount.

$$T_{coax} = 290\ [\text{antilog } (2/10) - 1]$$
$$= 169.6 \text{ Kelvin}$$

$$N_{pwr} = -2 + 10 \text{ Log } \frac{k \times 169.6 \times 2100}{0.001} \quad (3)$$
$$= -145.1 \text{ dBm}$$

## Preamp noise

The preamp noise figure is 0.5 and its gain is 20 dB.

$$T_{preamp} = 290\ [\text{antilog } (0.5/10) - 1]$$
$$= 35.4 \text{ Kelvin}$$
$$N_{pwr} = 20 + 10 \text{ Log } \frac{k \times 35.4 \times 2100}{0.001}$$
$$= -130 \text{ dBm}$$

## Receiver noise

The receiver noise figure is 5.0. Its gain is 10 dB.

$$T_{rx} = 290\ [\text{antilog } (5/10) - 1]$$
$$= 627.1 \text{ Kelvin}$$

$$N_{pwr} = 10 + 10 \text{ Log } \frac{k \times 627.1 \times 2100}{0.001}$$
$$= -127.4 \text{ dBm}$$

## How to "add" power expressed in dBm

The adding of different dBm power levels to arrive at noise totals is not necessarily an intuitive task, so I'll discuss it here. Power in dBm is a log function with respect to a standard reference value (1 mW), and values can't be added directly. Instead, they must be converted back to power (in watts, or milliwatts in our example), added, and the total reconverted to dBm. As an example, add the coax noise (C) and the combined antenna plus sky noise (A+S) levels of **Figures 1** and **2**. These values are −145 and −147 dBm, respectively.

The formula for converting power to dBm is:

dBm = 10 Log (power in mW)

The inverse of this is the formula for converting dBm to power:

$P_{mW}$ = antilog (value in dBm/10)

Taking the values:

$$\text{antilog } (145/10) = 3.16 \times 10^{-15} \text{ mW}$$
$$\text{antilog } (147/10) = 2.00 \times 10^{-15} \text{ mW}$$
$$\text{Total power} = 5.16 \times 10^{-15} \text{ mW}$$

Converting back to dBm:

$$P_{dBm} = 10 \text{ Log } (P_{mW})$$
$$= 10 \text{ Log } (5.16 \times 10^{-15})$$
$$= -143 \text{ dBm}$$

REFERENCE

1. *The Satellite Experimenter's Handbook*, ARRL.

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# VARIABLE VOLTAGE REGULATOR

By Howard Weinstein, K3HW, 15 Lakeside Drive, Marlton, New Jersey 08053

The variable voltage regulator (VVR) is a versatile and indispensable device for use on the workbench or in the shack. It lets you adjust the output voltage of a fixed DC power supply between 1.2 and 37 volts DC, and will supply output current in excess of 1.5 A. The circuit incorporates an LM117K three-terminal adjustable output, positive voltage regulator in a TO-3 can. Thermal overload protection and short-circuit current-limiting constant with temperature are included in the package. This device is *almost* blow-out proof!

## Circuit description

The LM117K is a three-terminal floating regulator. During operation, the LM117K develops and maintains a nominal 1.25-volt reference ($V_{ref}$) between its output and adjustment terminals. This reference voltage is converted to a programming current ($I_{prog}$) by R1 (refer to **Figure 1**), and this constant current flows through R2 to ground. The regulated output voltage is determined by:

$$V_{out} = V_{ref}(1+R2/R1) + I_{adj}\,R2$$

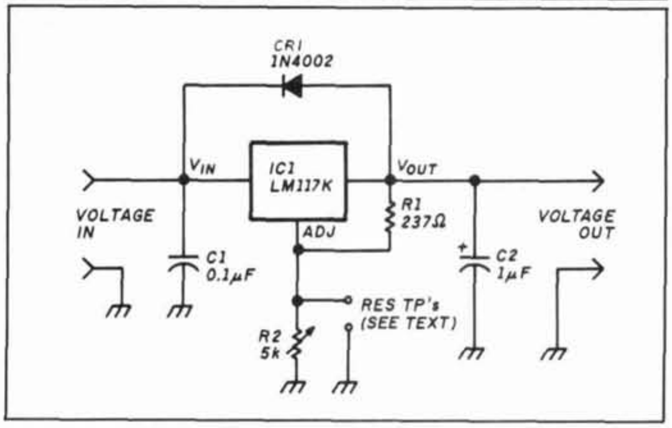
Capacitor C1 reduces sensitivity to input line impedance. Capacitor C2 reduces excessive ringing. Diode CR1 prevents C2 from discharging through the IC during an output short.

## Construction notes

Any available enclosure will suffice for building the VVR. For my project, I installed the parts on a piece of aluminum scrap and attached ceramic standoffs (refer to **Photo A** and **Figure 2**). The circuit can be used in your own power supply, or even in a piece of equipment that requires tight regulation. Be creative!

When installing programming resistor R1, locate it as close to the regulator as possible to minimize line drops

**FIGURE 1**

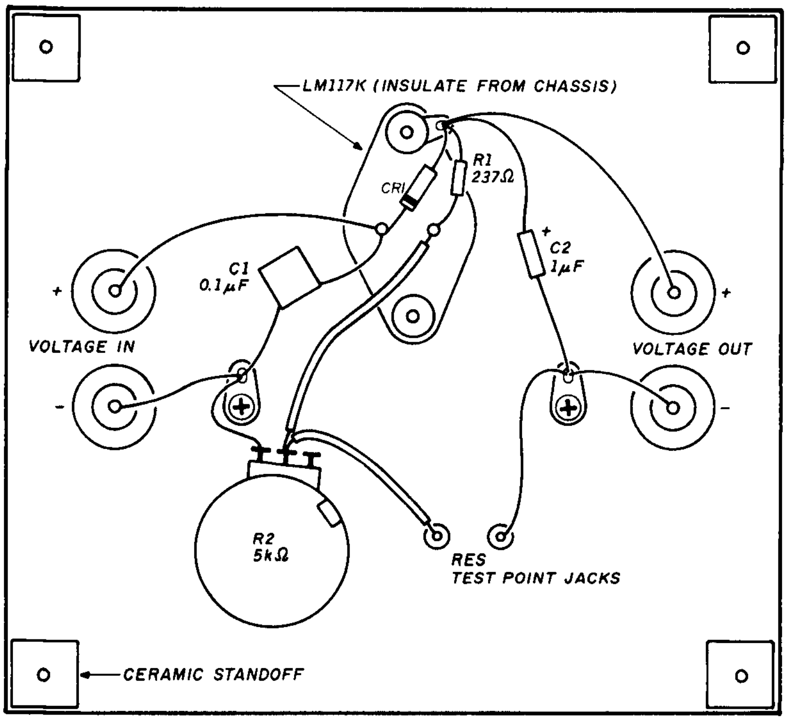



**Circuit diagram—VVR.**

**PHOTO A**

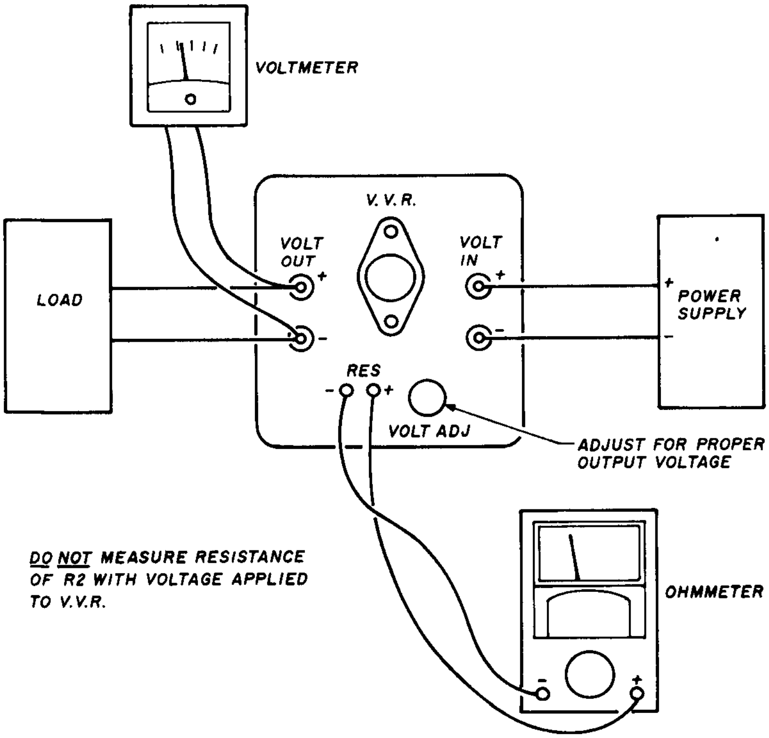

**Top view of VVR showing ceramic standoffs.**

FIGURE 2




**Bottom view—VVR.**

FIGURE 3

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| *CR1* | *1N4002 or equivalent* |
| *R1* | *237 ohm, 0.25 watt* |
| *R2* | *5000-ohm potentiometer, linear taper* |
| *C1* | *0.1-μF disc* |
| *C2* | *1.0-μF tantalum electrolytic, 100 volts* |
| *IC1* | *LM117K* |

MISCELLANEOUS
*Enclosure, mounting plate, standoffs*
*Five-way binding posts (4)*
*Female test jacks (2)*
*TO-3 insulator kit*

which may appear in series with the reference. The ground end of R2 can be returned near the load ground to provide remote ground sensing and improve load regulation. The test point jacks labeled "RES" are provided so you can measure the resistance of R2 when determining the value for a *fixed* resistor. This is necessary when designing regulator circuits for single fixed-voltage regulators.

**Caution: Do not measure resistance at the "RES" test point jacks with voltage applied to the VVR! You will damage your ohmmeter!**

Remember that $V_{out}$ on the LM117K is the transistor case. Therefore, it must be carefully mounted and properly insulated from chassis ground.

## Applications

As I mentioned earlier, the uses and applications for this simple, easy-to-build project are limitless. I have used it at my place of employment for designing fixed-voltage regulators. I use it on my workbench at home with an old military surplus 24-volts DC power supply to provide 12 and 5 volts DC for various projects. I have included the circuit in all of my portable QRP gear, and have built an outboard regulator which I use in the mobile to protect an IC-37A from surge damage. Refer to **Figure 3** for a typical test-bench setup.

## Parts availability

All of the components used in the VVR are readily available through Radio Shack retail outlets and most mail-order houses. I have assembled a VVR parts kit consisting of IC1, TO-3 insulator and mounting kit, C1, C2, CR1, R1, and R2 with instructions, diagrams, and schematic for $13.00 plus $2.00 shipping. Send a check or money order for immediate delivery. hr

**Invitation to Authors**

*ham radio* welcomes manuscripts from readers. If you have an idea for an article you'd like to have considered for publication, send for a free copy of the *ham radio* Author's Guide. Address your request to *ham radio*, Greenville, New Hampshire 03048 (SASE appreciated).

# COMMON-POINT GROUNDING: LIGHTNING PROTECTION FOR REPEATERS

## Practical tips to minimize damage at your repeater site

*Peter J. Bertini, K1ZJH, 20 Patsun Road, Somers, Connecticut 06071*

Many of us don't worry about lightning until after it's done some damage. It's almost impossible to protect your equipment fully against a direct hit, but you can still take steps to avoid most lightning damage.

### What is lightning?

Lightning can be compared to RF energy. This analogy may not be entirely accurate, but both share similar characteristics. Series impedance will hinder lightning's path, just as it does RF. A recent article on lightning and commercial radio sites mentioned that a typical lightning strike could produce a 1000-volt differential between the top and bottom of a 6-foot communications rack! Resistance has little to do with it; it's the result of the 1-$\mu$H inductance of an average rack frame. Every $\mu$H of inductance offers enough impedance (to lightning) to cause a 1000-volt drop. A lightning bolt can carry currents in excess of 60,000 A and hundreds of millions of volts.

### Transverse and common mode

Transverse and common-mode voltages are two forms of foreign voltages that affect single-pair lines. The pair of wires in question could be the AC power line, the autopatch phone line, or antenna feedline.

Transverse-mode voltage appears across the line. Spikes, transients, or other glitches imposed on AC line voltage fall into this category. Many hams use coaxial arresters on HF dipole antennas for transverse protection.

A common-mode voltage is one that is in phase (zero potential) across the wire pair; it's measured from one or both wires to a third point. For example, imagine that lightning strikes the power lines outside your house on both sides of the line, simultaneously. Theoretically it's possible that the line voltage would remain unaffected, while everything that's plugged into it is suddenly millions of volts above earth ground!

Of course this doesn't happen in real life. Both transverse and common-mode voltages will appear on antenna feedlines, power, or phone lines when hit by lightning. Our friendly HF'er, with his dipole and coaxial arrester, probably has a good earth ground tied into his station. He's using forms of both common and transverse-mode protection, though he may not know it. (Sometimes common mode is referred to as longitudinal mode; transverse mode may also be called differential mode.)

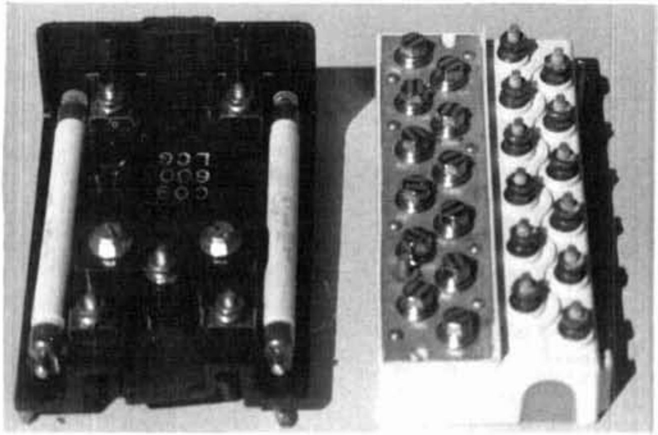
### Protective devices

**Photo A** shows AC surge suppressors often used by commercial and Amateur installations for AC power line protection. These are professional units, not to be confused with the low-cost variety sold in many stores. They contain gas discharge devices, MOVs, and fuses for transverse and common-mode protection. Telephone installers use something like the Cook Electric suppressor shown in **Photo B**.

**PHOTO A**


**Typical AC line protection device.**

PHOTO B



**Cook Electric model 600 phone line protection device uses high-voltage fuses and gas discharge cartridges for phone line protection. Also shown is multiple phone line protection block with replaceable gas discharge cartridges.**

These units use high-voltage fuses and gas discharge devices to protect the customer's equipment.

A typical repeater station will have a good-quality surge suppressor installed at the AC outlet. There's also a phone company arrester at the service drop for the autopatch line. The repeater cabinet is well grounded, as well as the antenna tower. Everything's been done "by-the-book," but when lightning strikes two weeks later, the repeater suffers major damage! What went wrong?

## Lightning looks for the shortest path

Here's what might happen when lightning strikes. Suppose telephone installers run 60 feet of ground wire between protection blocks and the nearest ground. Where's a lightning strike going to go after hitting the phone line? When it reaches the protection block, the lightning seeks the shortest path to ground. The phone company's ground gives some protection, but the rest heads for the well-grounded repeater! Maybe 5 percent of the charge makes it to the repeater, perhaps only a few thousand volts. It travels through the autopatch (poof!) and finally to ground.

Let's say there's a commercial base in the same building. His radio takes the hit, not yours. He has grounds and AC protection just like yours. He's also at the end of the AC leg feeding your repeater. Most of the strike is shunted to his base station grounds. What wasn't dissipated heads back towards the service entrance ground. The current races by your outlet, the suppressor fires, and the lightning finds the shortest path — through your repeater power supply into that good earth ground you thoughtfully provided. When the gas arresters fired, all three AC leads — white, black, and ground — became one common ground path.

What about a lightning strike on the repeater antenna? There's a good ground at the tower base, and much of the current is dissipated there. The antenna hard line is bonded to the tower about two-thirds of the way down before leaving for the building. Several feet of ground wire connect the tower base to the ground rods. The tower has inductance, it acts like a voltage divider when the lightning strikes — and the coax is at the tap-off point! The coax offers some resistance to the lightning. Inside the building the equipment ground will dissipate most, but not all, of what's left. The rest finds a path back through the phone and power lines — after passing through your repeater.

## Never provide the ground path

As these hypothetical cases illustrate, it's often easy to unwittingly give lightning a path through equipment you had intended to protect. Even the best ground offers limited protection; zero-inductance wire just hasn't been invented yet! Transverse protection is easy, but common-mode protectors need a low-impedance ground to work best. With a high-impedance ground, a transverse voltage can impinge upon the AC power lines' hot, neutral, and ground wires, becoming a common-mode hazard. That's why wall socket-mounted AC suppressors are often ineffective. The ground lead is too far removed from a real earth ground to deal with fast rise time transients.

We've done a lot of lightning protection work at our Soapstone Mountain repeater site in northern Connecticut. Two of our club repeaters share this site, where we have at least one lightning-induced outage every summer.

First, we ran the antenna hard-line cables down to the tower base and bonded them to the tower's grounding system. We sealed everything with 3M's Scotch-Kote™ to protect the aluminum coax from galvanic action. All our antennas' elements are at DC ground potential. Running the coax down the inside of the tower, instead of on an outside leg, might offer some additional protection. Because lightning acts like RF, the skin effect would minimize currents on cables inside the tower.

It's okay to have one ground rod at the tower base. But it's even better to drive additional ground rods several feet out from each tower leg, increasing the size of the ground field. Use heavy copper straps to bond the ground rods and tower legs together. Ground wires must be short; avoid sharp bends. Some Amateurs believe that grounds aren't needed if a tower is set in concrete. Don't fall for this old wives' tale!

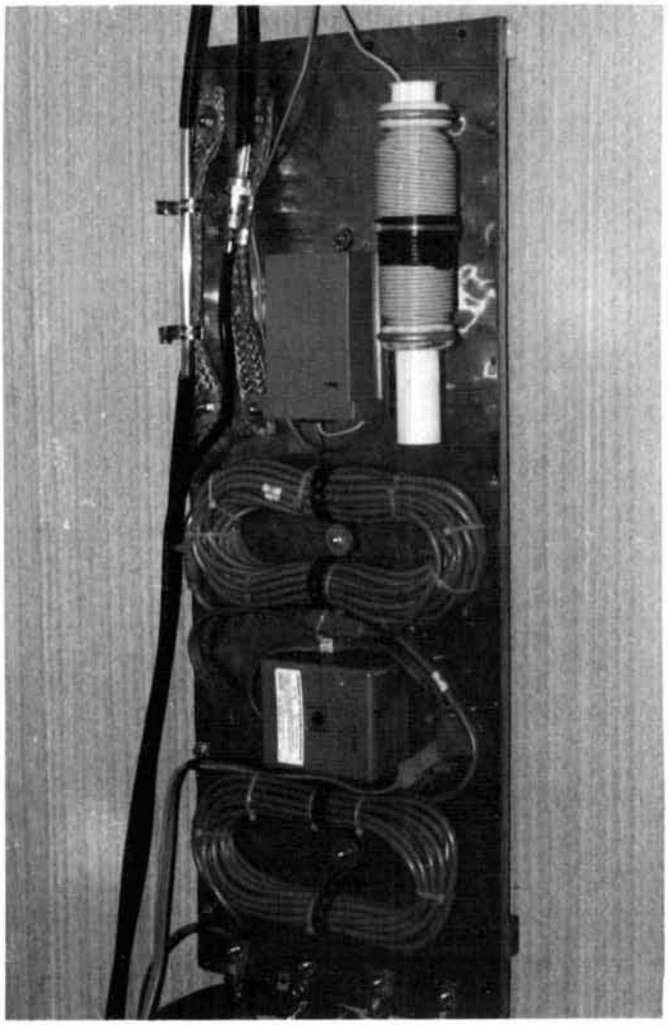
Chemical ground rods work best. They are expensive — about $150 apiece. These rods are hollow pipes filled with a special chemical. Small holes along the pipe allow a small amount of chemical to leach into the soil, improving the ground conductivity.

Use the longest ground rods possible. Stay away from the kind sold at TV shops; they are too short to be of much use. Electrical supply dealers carry the larger sizes. Some mountaintop locations are rocky enough to prevent you from driving a ground rod. If you must, bury the rods horizontally in trenches laid out in "wheel spoke" fashion around the tower. *Never* add rock salt around the ground rods. The short-term benefits will soon be outweighed by the salt's corrosive action.

## Multiple ground paths eliminated

**Establishing the common-point ground:** Our first step in establishing a common-point ground system was to remove all the earth grounding from the repeater racks. We mounted a 2 × 3-foot piece of plywood covered with copper roofing flashing on the wall near the ground wire entrance, and attached the ground wire to this surface (see Photo C). The better the earth ground, the better the common-point ground will work. Lightning arresters for the coax, phone line,

**PHOTO C**



**Common-point grounding system installed at the Soapstone, Connecticut repeater site.**

and AC power feed are all mounted on the copper flashing; their ground connections are fastened directly to this surface. This common grounding surface eliminates ground loops through the repeater equipment, and lets the suppressors deal with common-mode transients properly.

**AC power line decoupling:** The common-point ground is only the first step in isolating the repeater from lightning discharge ground loops. A heavy-duty 100-foot extension cord connects the repeater equipment to the AC line arrester at the common-point ground. The extension cord is wound into a large coil, forming a trifilar choke. The choke's bulk impedance yields a poor return path for lightning through the repeater. A short extension cord is used betwen the AC arrester and the wall socket. A surge supressor is used at the wall socket with another at the repeater rack for cascaded protection.

**Phone line decoupling:** Treat the phone line the same way as you would the AC power. We scramble wound a large choke on a 2-inch PVC pipe form using 100 feet of in-house telephone wire, and connected it between the arrester

(mounted on the common ground point) and the repeater. We used the Cook electric model 600 arrester here.

**Coax cable decoupling:** Fifty feet of low-loss Belden 9913 coax wound into a coil serve as the antenna choke. Use this between the repeater and the coaxial arrester on the common-point ground.

We placed the arresters mounted on the repeater rack close together to limit induced currents through the rack frame. This is a duplication of the common-point ground, except that no earth ground is attached at the repeater cabinet. If the rack is sitting on a concrete floor, filed or not, it should be raised on wooden two-by-fours to lower capacitive ground coupling.

## Loose ends

Try to keep everything in one rack; two racks invite multiple ground paths. All racks must be firmly bonded together. Rack interconnections can be protected with chokes or transorbs. The relays can be driven by open-collector outputs before the signal lines leave the rack. Audio transformers in series with audio signal leads going between cabinets will give common-mode isolation and stop ground loops between racks.

Our lightning problems were caused by ground loops between the racks housing our two repeaters. The two controllers were tied together to allow cross control between the two systems. A good lightning hit usually knocked out a few driver chips and both processors. While it might take only about an hour to effect repairs, the processor chips with their piggybacked programmed EPROMs would cost us $150 each!

Finding good protective equipment may be a problem. PolyPhaser Corporation* carries a wide line of lightning protection devices similar to the ones shown and mentioned here. They also offer a 10-percent Amateur discount, and give Amateurs dealer rates on orders over $240. hr

*PolyPhaser Corporation, 1425 Industrial Way, P.O. Box 1237, Gardnerville, Nevada 89410-1237.

**ASTRON CORPORATION**

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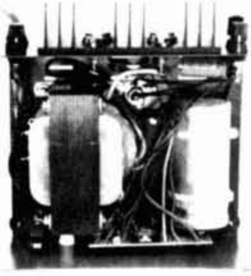
Irvine, CA 92718
(714) 458-7277



INSIDE VIEW — RS-12A

# ASTRON POWER SUPPLIES

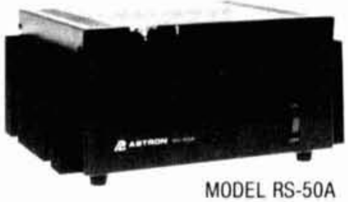
**• HEAVY DUTY • HIGH QUALITY • RUGGED • RELIABLE •**

## SPECIAL FEATURES

- SOLID STATE ELECTRONICALLY REGULATED
- FOLD-BACK CURRENT LIMITING Protects Power Supply from excessive current & continuous shorted output
- CROWBAR OVER VOLTAGE PROTECTION on all Models **except RS-3A, RS-4A, RS-5A.**
- MAINTAIN REGULATION & LOW RIPPLE at low line input Voltage
- HEAVY DUTY HEAT SINK • CHASSIS MOUNT FUSE
- THREE CONDUCTOR POWER CORD
- ONE YEAR WARRANTY • MADE IN U.S.A.

## PERFORMANCE SPECIFICATIONS

- INPUT VOLTAGE: 105-125 VAC
- OUTPUT VOLTAGE: 13.8 VDC ± 0.05 volts (Internally Adjustable: 11-15 VDC)
- RIPPLE Less than 5mv peak to peak (full load & low line)
- **Also available with 220 VAC input voltage**

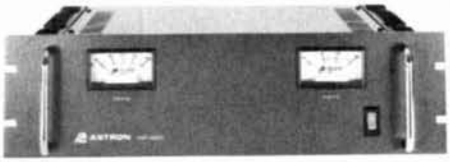


MODEL RS-50A

MODEL RS-50M

MODEL VS-50M

## RM SERIES



MODEL RM-35M

## 19″ × 5¼ RACK MOUNT POWER SUPPLIES

| MODEL | Continuous Duty (Amps) | ICS* (Amps) | Size (IN) H × W × D | Shipping Wt. (lbs.) |
|---|---|---|---|---|
| RM-12A | 9 | 12 | 5¼ × 19 × 8¼ | 16 |
| RM-35A | 25 | 35 | 5¼ × 19 × 12½ | 38 |
| RM-50A | 37 | 50 | 5¼ × 19 × 12½ | 50 |
| • Separate Volt and Amp Meters | | | | |
| RM-12M | 9 | 12 | 5¼ × 19 × 8¼ | 16 |
| RM-35M | 25 | 35 | 5¼ × 19 × 12½ | 38 |
| RM-50M | 37 | 50 | 5¼ × 19 × 12½ | 50 |

## RS-A SERIES

MODEL RS-7A

| MODEL | Continuous Duty (Amps) | ICS* (Amps) | Size (IN) H × W × D | Shipping Wt. (lbs.) |
|---|---|---|---|---|
| RS-3A | 2.5 | 3 | 3 × 4¾ × 5¾ | 4 |
| RS-4A | 3 | 4 | 3¾ × 6½ × 9 | 5 |
| RS-5A | 4 | 5 | 3½ × 6⅛ × 7¼ | 7 |
| RS-7A | 5 | 7 | 3¾ × 6½ × 9 | 9 |
| RS-7B | 5 | 7 | 4 × 7½ × 10¾ | 10 |
| RS-10A | 7.5 | 10 | 4 × 7½ × 10¾ | 11 |
| RS-12A | 9 | 12 | 4½ × 8 × 9 | 13 |
| RS-12B | 9 | 12 | 4 × 7½ × 10¾ | 13 |
| RS-20A | 16 | 20 | 5 × 9 × 10½ | 18 |
| RS-35A | 25 | 35 | 5 × 11 × 11 | 27 |
| RS-50A | 37 | 50 | 6 × 13¾ × 11 | 46 |

## RS-M SERIES

MODEL RS-35M

| MODEL | Continuous Duty (Amps) | ICS* (Amps) | Size (IN) H × W × D | Shipping Wt. (lbs.) |
|---|---|---|---|---|
| • Switchable volt and Amp meter | | | | |
| RS-12M | 9 | 12 | 4½ × 8 × 9 | 13 |
| • Separate volt and Amp meters | | | | |
| RS-20M | 16 | 20 | 5 × 9 × 10½ | 18 |
| RS-35M | 25 | 35 | 5 × 11 × 11 | 27 |
| RS-50M | 37 | 50 | 6 × 13¾ × 11 | 46 |

## VS-M AND VRM-M SERIES

MODEL VS-35M

- Separate Volt and Amp Meters • Output Voltage adjustable from 2-15 volts • Current limit adjustable from 1.5 amps to Full Load

| MODEL | Continuous Duty (Amps) @13.8VDC | @10VDC | @5VDC | ICS* (Amps) @13.8V | Size (IN) H × W × D | Shipping Wt. (lbs.) |
|---|---|---|---|---|---|---|
| VS-12M | 9 | 5 | 2 | 12 | 4½ × 8 × 9 | 13 |
| VS-20M | 16 | 9 | 4 | 20 | 5 × 9 × 10½ | 20 |
| VS-35M | 25 | 15 | 7 | 35 | 5 × 11 × 11 | 29 |
| VS-50M | 37 | 22 | 10 | 50 | 6 × 13¾ × 11 | 46 |
| • Variable rack mount power supplies | | | | | | |
| VRM-35M | 25 | 15 | 7 | 35 | 5¼ × 19 × 12½ | 38 |
| VRM-50M | 37 | 22 | 10 | 50 | 5¼ × 19 × 12½ | 50 |

## RS-S SERIES

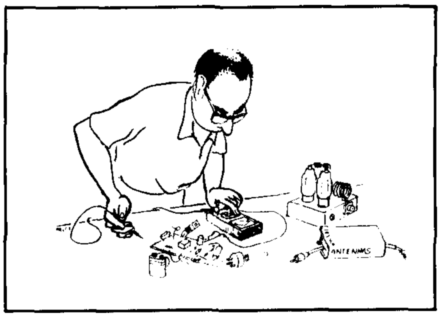
MODEL RS-12S

- Built in speaker

| MODEL | Continuous Duty (Amps) | ICS* Amps | Size (IN) H × W × D | Shipping Wt. (lbs.) |
|---|---|---|---|---|
| RS-7S | 5 | 7 | 4 × 7½ × 10¾ | 10 |
| RS-10S | 7.5 | 10 | 4 × 7½ × 10¾ | 12 |
| RS-12S | 9 | 12 | 4½ × 8 × 9 | 13 |
| RS-20S | 16 | 20 | 5 × 9 × 10½ | 18 |

*ICS — Intermittent Communication Service (50% Duty Cycle 5min. on 5 min. off)

# Ham Radio Techniques



*Bill Orr, W6SAI*

## Have you met SID?

Nice to have 10 meters active again! The "Bad Old Days" of 1984 to '87, when DX deserted 28 MHz, have faded into the recesses of my mind. Now the band is jumping, except for a few hours now and then when it seems as if somebody has cut the coax to my antenna. I wonder where the signals have gone. Are they gone for good? No! In a few hours the band comes slowly back to life. I have met SID before! I remember him from 20 meters, and here he is once again!

SID (sudden ionospheric disturbance) is a period of time when HF communications are blacked out during daylight hours by abnormally high signal absorption in the D-layer region of the ionosphere. This condition of high absorption may last anywhere from a few minutes to several hours.

The absorption is caused by a solar flare. The flares seem to follow the same 11-year cycle as the sunspots. This means there are more flares and SIDs during a period of high sunspot activity than during a period of low activity. There were only five SIDs during 1944, a year of minimum solar activity. During 1947, a year of maximum solar activity, there were 121 SIDs. It looks as if this figure will be exceeded in 1989.

**Figure 1** shows examples of a SID. This recording was taken by Steve Barnes, KH6SB, of the National Oceanographic and Atmospheric Administration (NOAA) at their Ionospheric Station in Maui, Hawaii. It's a record of the strength of the 5-MHz signal of WWV in Colorado on November 13, 1988, as read on the Y-axis. The X-axis represents time and reads from right to left, starting at 2030 UTC. The energy from a solar flare which took about 8.3 minutes to reach the earth occurred at about 2100 UTC. The ultraviolet energy in the flare bombarded the D-layer of the ionosphere, heating it and increasing radio wave absorption. The immediate result was a shortwave fadeout.

### The 2300 UTC SID

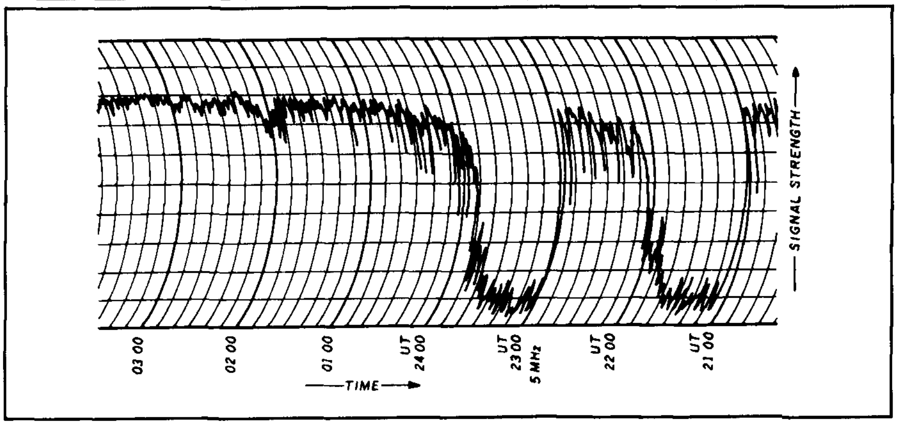
The 2100 UTC fadeout lasted for about an hour and was followed by a second SID, which caused another fadeout starting at 2300 UTC. This fadeout was slightly shorter in duration than the first one. In each case, the onset of the fadeout was quite rapid and the recovery was somewhat slower. Each time, the received signal dropped into the noise level.

Simultaneous recordings of WWV on 5, 10, 15, and 20 MHz reveal that the fadeout is less severe and shorter in duration as the frequency rises. Thus, the fadeout is more pronounced on the 80 and 40-meter bands, somewhat less severe on 20 meters, and minimal on 15 meters. In many cases, 15 and 10 meters are only slightly affected. A more severe SID can cause 15 and 10 meters to drop out, in addition to the lower bands.

### A SID early-warning receiver

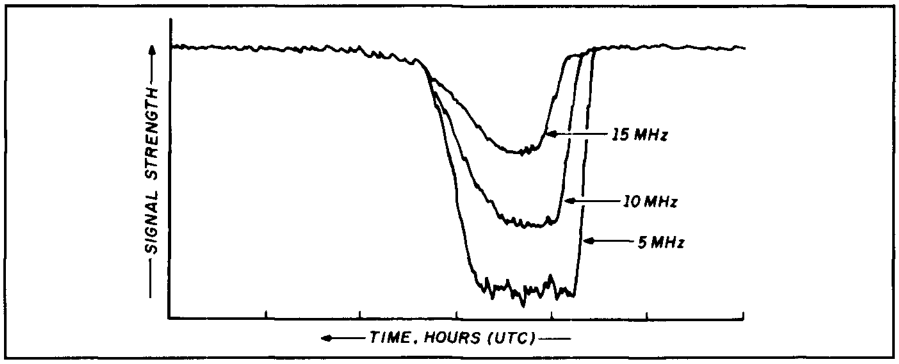
Steve has a quick and easy SID-alert scheme. He suggests you monitor WWV on several frequencies. Radio Shack weather receiver model 12-148 covers 5, 10, and 15 MHz at the touch of a key. Steve added a short antenna to the receiver and set it on 5 MHz. He lets it run at low volume in his ham shack. If 5 MHz drops out, he hits the

FIGURE 1




**Recording of signal strength of WWV (5 MHz) taken at Maui, Hawaii, November 13, 1988. About 2100 UTC signal strength drops abruptly, signifying start of SID. Ionospheric effect remains for about an hour, then the signal builds back to normal level. Shortly before 2300 UTC a second SID occurs which lasts approximately 50 minutes.**

FIGURE 2




**SID blanks out the lower frequencies first, and for a longer period of time. Monitoring the 5-MHz signal of WWV provides an early warning of SID. The particular event shown may have little effect at 30 MHz.**

10-MHz key. Poor reception on that frequency indicates a SID may be in progress, so he shifts to 15 MHz. When the latter frequency drops out, Steve notes that 20 and 15 meters are gone — and possibly 10 meters. The SID blacks out the lower frequencies first, and for a longer period of time as compared with the higher frequencies (see **Figure 2**). His little WWV receiver gives him an early warning that the DX bands are about to drop out.

## Overcoming the SID

Shift operation to a higher frequency band to overcome SID effects. If you experience a quick fadeout on 20 meters, try 15 or 10 meters. You might get through even though 20 meters seems dead. If that doesn't work, go even higher in frequency.

## The SID at VHF

In the 50-MHz region, radio signals can be propagated over long distances by ionospheric scatter occurring mainly in the D-layer. During a SID, D-layer ionization increases and 6-meter scatter signals are enhanced — sometimes by as much as 9 dB. Six meter DX may be jumping while the lower bands are useless. So each SID seems to have a silver lining (at least for the 50-MHz operators).

## Polar cap absorption

Polar cap absorption (PCA) takes place in the higher latitudes and may last up to five or six hours. It's usually preceded by a major solar flare which seems to ionize solar protons in the D-layer. The PCA appears one or two hours after the flare and lasts anywhere from a day to nearly two weeks. Since the PCA is associated with a solar flare, it's tied in closely with the sunspot cycle — the higher the sunspot number, the greater the number of PCA events.

The PCA can lower the MUF and boost the lowest usable frequency (LUF) simultaneously, narrowing the usable frequency spectrum. A breakup in the ionospheric layers often accompanies the PCA event, creating "auroral flutter." This flutter is very noticeable on SSB contacts.

DX contacts over the pole (United States to Europe) are difficult to make during a PCA. For example, the path between California and Europe may be closed, but the path from California to North Africa may be open as the Great Circle route of the latter path skirts the edge of the auroral zone.

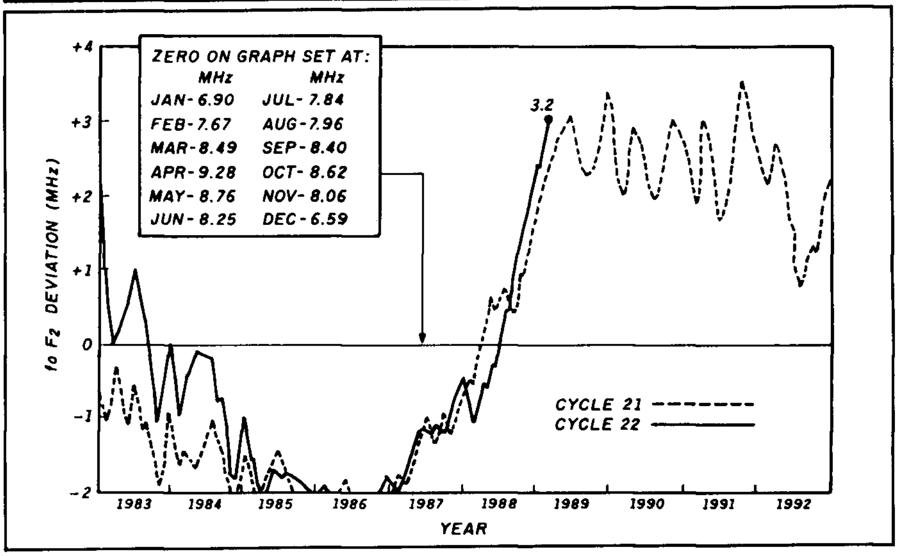
## Beating the odds

As the sunspot cycle rises, SID and PCA events increase. However, it's possible for the serious DXer to "beat the odds" during these happenings. The SID blackout is relatively short in duration and may be avoided if you increase the operating frequency. The PCA creates ionization in the D-layer and absorption is less on the lower frequencies. Going from 21 to 7 MHz may do the job. If all else fails, and the bands are dead, sit down and read a good book!

## Goin' up, lookin' good

How goes sunspot cycle 22 (the present one) as compared with cycle 21? One way to judge cycle progress is to observe ionospheric reflection. Ionospheric stations do this by transmitting a pulsed signal vertically to the ionosphere. The frequency of the signal is swept between 3 and 20 MHz and the reflected return pulse is monitored. The maximum reflected frequency for a vertical incident wave is about one-third the maximum usable frequency (MUF), at Maui. Thus, if the highest reflected frequency of the

FIGURE 3




**Comparison of $F_0F_2$ for sunspot cycles 21 and 22. The two cycles are superimposed on one graph. The X-axis shows years in cycle 22. The Y-axis represents deviation from average monthly value of $F_0F_2$. Zero value on graph is determined from *Table*.**

pulse is 10 MHz, the MUF is about 30 MHz. You can observe the reflected signal on an oscilloscope and record it on a tape.

The average monthly value of the signal reflected from the F-layer has been observed for many years. The easiest way to get a quick fix on F2 reflection is to plot the deviation in MHz from the average monthly value for each month. This has been done for you in **Figure 3**. The zero point on the X-axis changes each month, according to the chart on the graph. For example, the chart shows that in January 1983 the average monthly value of the F2 maximum frequency of reflection ($F_oF_2$) was 6.97. The measured value of $F_oF_2$ during January 1983 deviated from that figure by +2.4 MHz, as read on the Y-axis of the graph. The actual value of $F_oF_2$ for cycle 22 was 6.97 + 2.4, or 9.37 MHz. The MUF was about three times this figure, or 28.11 MHz.

For cycle 21, the deviation from the average monthly value during January was −0.4 MHz. The value of $F_oF_2$ was 6.97 − 0.4, or 6.57 MHz. The MUF was three times this value, or 19.71 MHz.

## Where we stand now

The most recent ionospheric observation plotted was for February 1989. The zero point on the graph for February (from the table in **Figure 3**) is 7.67 MHz. The deviation is +3.12 MHz, giving an incident reading of 10.87 MHz. The MUF accordingly is 32.61 MHz for that month.

Remember that Hawaii is closer to the equator than the mainland and the MUFs are much higher in that part of the world.

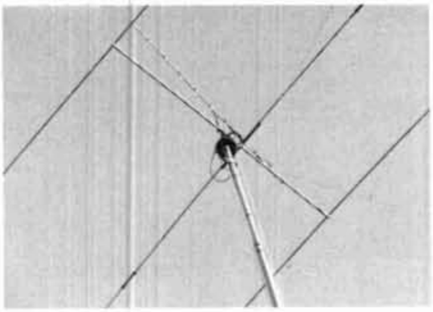
Cycle 22 plots a tantalizing course. As of February 1989 it seems to be running ahead of old cycle 21. You can see that cycle 21 "topped out" at deviations of +3 to +3.7. It never reached a deviation of +4. If by chance a deviation of +4 is noted for April 1990 (where the average monthly value of $F_oF_2$ is 9.28), the incident measurement would be 13.28 MHz, giving a MUF value of 39.8 MHz.

A quick look at the graph shows that chances of the MUF reaching 50 MHz are slim. But F2 skip has been recorded on 50 MHz in the past! The next six months will give a good indication as to where the MUF is heading. Do you want to place your bets now? I'd place my money on the spring or fall of 1989, 1990, and 1991!

## The record cycle of 1958

Cycle 19 is the highest sunspot cycle on record; the deviation reached +4.4 during early 1958 with a smoothed sunspot number of 200. During March of that year a new 50-MHz DX record was established when JA6FR in Japan worked LU9MA, LU3EX, and LU2EW in Argentina. About the same time, K6OBO worked LU8AE and LU9EV. Shortly thereafter, 50-MHz DXers in California filled their log books with JA and LU stations, in addition to other South and Central American stations. By the fall DX season, East Coast stations were working Rhodesia in Africa, South America, and European stations in Sweden, Norway, and Ireland. I'm sure these DX records will be broken during this coming cycle!

**PHOTO A**



**Looking up the 50-foot high tilt-over tower at W4OTS. Tribander, 2-meter beam and rotor are mounted atop a circular metal plate welded to the top of the tower. Tower also supports center-fed inverted-V for 75 meters.**

**PHOTO B**

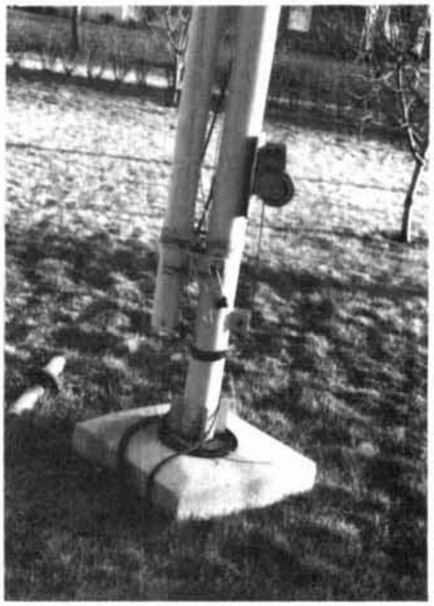
**Base of W4OTS tower. Tower is affixed to ground post sunk in cement. Clevis at top of post permits to tilt over. The mast is locked in position by second clevis near base of the ground post.**

## More on tilt-over towers

My remarks about tilt-over towers in the May column brought some interesting letters. Cal Hoerneman, W4OTS, provided interesting pictures of his freestanding, 50-foot, tilt-over tower (**Photos A, B**, and **C**). At the top of the tower he has a rotor, a TA-33 tri-band beam, and an 11-element, 2-meter array. The tower has been up for eight years with no problems.

The tower is mounted to a finned ground post set in cement. A local welder constructed the tower out of iron pipe. The bottom section is filled with steel bars to act as a counterweight.* The hoist is the type used to lift a boat onto a trailer.

**PHOTO C**



**Closeup of ground post and base of mast. Winch is mounted to side of post. Tower was designed following data provided by Bob Haviland, W4MB.**

*If it's rebar, it's for mechanical strength in concrete, not counterweight!

Cal notes that the basic information for building a tilt-over tower was discussed by Bob Haviland (ex-W3MR, now W4MB) in the September 1974 issue of *Ham Radio* magazine. Sure enough! When I found the article, I immediately recognized its value and asked if it could be rerun in this issue.* The article was 15 years ahead of its time and any Amateur interested in building a tilt-over tower should read it.

Thanks to Ralph Fowler, N6YC; Phil Dejarlais, WØJHS; and Lloyd Hanson, W9YCB, who also provided information on their towers.

## MINIPROP 3.0 propagation program

Sheldon Shallon, W6EL, sent me a "floppy" of his MINIPROP program. It's not based on the older MINIMUF, but on a method developed by the British Broadcasting Corporation (BBC) for predicting MUF. The program extends the predictions to forecast signal levels, take-off angle for the mode, and the percentage probability that the transmission mode exists. It also provides MUF, beam headings for the path, path length, sunrise and sunset times for the path, gray line directions, and more. All of this data is projected for both long and short-path openings.

MINIPROP was used successfully by NOAA to schedule communications with its ozone hole measurement team in the Antarctic.

This program supercedes MINIPROP 2.0. It's designed for use with an IBM PC, XT, AT, PS/2, or true compatible with 320K memory, one floppy (5-1/4 inch) or microfloppy (3-1/2 inch) drive, and PC-DOS or MS-DOS 2.11 (or later version). An 80-column monitor is required. An 8087, 80287, or 80387 math co-processor is strongly recommended, but not required.

Contact W6EL Software, 11058 Queensland Street, Los Angeles, California 90034-3029 for complete information. hr

*Done! Ed.

# DESIGN DATA
# FOR PIPE MASTS

## Design your own antenna mast using steel pipe

*By R. P. Haviland, W4MB, 1035 Green Acres Circle N., Daytona Beach, Florida 32019*

One of the best materials available for building self-supporting antenna masts is steel pipe. It is widely available, uniform in quality, and reasonable in price. A well-designed mast is adequately strong, neat and attractive, and relatively light weight. And, using steel pipe, it's not too difficult to design a fold-over mast which allows all antenna work to be done at ground level. Even maintenance on the mast itself does not require work at any great height.

However, attaining all of these advantages does require some design work. This is particularly important for safety. The purpose of this article is to present a set of design curves which will give a safe and satisfactory design, while using the minimum of material.

### Construction

The general construction of a typical fold-over pipe mast is shown in **Figure 1**. At the top are the antenna and rotator, carried by the smallest size pipe. This is inserted into the upper end of the next size pipe for a short distance, and fastened by through-bolts or welding. The second section is inserted into the next larger, and so on. The bottom section is hinged to a fixed upright pipe, which gives the fold-over feature. It, in turn, nests into a larger section of pipe set into the ground. A yoke is provided to fasten the mast to the upright after erection. **Figure 1** shows a block and tackle for pulling the mast to the vertical position, but a winch fastened to the upright may be used instead.

Most mast designs use the widely available standard weight pipe, each size of which nests neatly into the next larger size, over the range from 1-1/2 to 4 inches. Larger sizes still nest, but there is a gap between the walls. Very high masts, or those with unusually heavy top loads, can be built with extra-strong or double extra-strong pipe, but such designs are not considered here as the data are calculated for standard weight pipe.*

### Design criteria

Because of the change in diameter, beam formulas cannot be applied to a stepped diameter mast as a whole. Instead, each individual pipe section must be analyzed by itself, as a free body, starting at the top. The section load must then be transferred to the next lower section. This is done by converting the lateral load to a couple, acting across the diameter of the section, then multiplying the couple magnitude by the ratio of pipe diameters to get the top load of the next section. Intermediate antennas can be assumed to be concentrated at the junction of sections. The next section is then considered.

The critical or design load on a section may be caused by wind load when the mast is vertical, or by erection load as the mast is being raised. Both loads should be calculated and the design chosen for the worst of the two.

For wind load, two design winds are commonly used. For most of the country, it is assumed that the worst wind to be encountered is 85 mph, a value to be expected once in 50 years or so. For Florida, the Gulf Coast, and locations

---

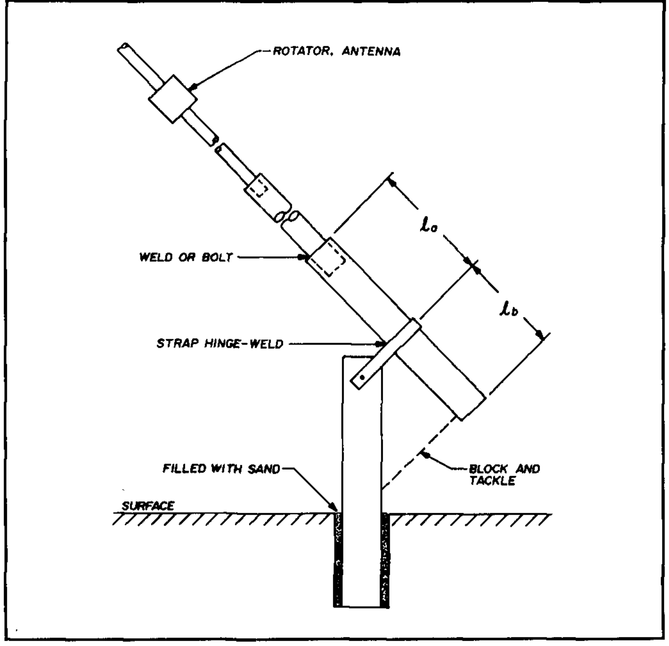
**Standard and extra strong* (ASTM nomenclature) are the two pipe weights commonly encountered. The American Petroleum Institute has a separate designation for well casing, but this is called tubing rather than pipe — although some sizes are identical to pipe sizes. The critical dimensions for standard weight pipe are:

| Size | Outer diameter | Wall thickness |
|---|---|---|
| 4 inch | 4.5 inch | 0.237 inch |
| 3-1/2 inch | 4.0 inch | 0.226 inch |
| 3 inch | 3.5 inch | 0.216 inch |
| 2-1/2 inch | 2.875 inch | 0.203 inch |
| 2 inch | 2.375 inch | 0.154 inch |

The ASTM recommended fiber stress values for *standard* weight pipe is 20,000 psi (bending). The design procedure presented here uses a 10-percent reduction from this stress figure, based on good used pipe.

Note that the extra-strength and double extra-strength sections do not nest because of thicker walls. Such heavier pipe can be used for the topmost section and for the standing or ginpole section. However, the curves apply only to standard weight pipe or tubing of the sizes given in the table. **Editor**

FIGURE 1




**General layout of the fold-over pipe mast (not to scale).**

like Cape Hatteras, a maximum wind of 125 mph is also used. Your county engineer can provide the recommended value for your location (see **reference 1**).

During erection there is some deflection, or bending, of the mast. The greatest load occurs when each section is horizontal; this is the loading which must be designed for.

The wind and erection impose two different types of load on the section. One is the concentrated load at the topmost end of a section due to the forces on the section above. The second is the distributed load acting along the length of the section. As the concentrated load becomes larger there is less strength left for the distributed load, so the section length must become smaller. Accordingly, the problem of design is to determine the allowable section length.

The concentrated load during erection is the weight of the antenna, rotator, and sections above the one being considered. The concentrated wind load includes the sum of all wind loads above the section being considered. The usual load is calculated on the basis of projected area. This is the area covered by the shadow of the object. If the object is not symmetrical, like a Yagi beam, the largest projected area is used. The loading depends on whether the object is flat or round, as follows:

Wind loading in pounds per square foot

| | 85 mph wind | 125 mph wind |
|---|---|---|
| Flat objects | 30.3 | 65.9 |
| Round objects | 18.1 | 39.0 |

The projected area is often given in the instructions for commercially made antennas and rotators. It is easily calculated from the dimensions of the element.[1]

Given this concentrated load on the topmost section, design of the mast itself involves solving section load equations for allowable section length. To simplify this process, the equations have been reduced to a series of graphs — Figures 2 and 3 for load during erection, and **Figures 4 A** and **B** and **5 A** and **B** for wind loads. Use of these curves will be explained through an example.

## Example

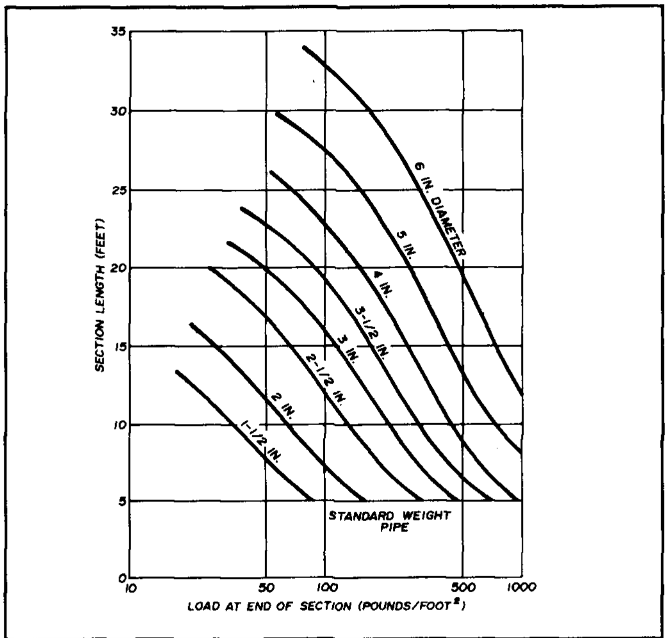
Assume that the design is for an all-tubing 6-meter antenna, having 2 square feet projected area and weighing 15 pounds. A small TV rotator is available, having 1/2 square foot of mostly flat plate area, and weighing 8 pounds. This area is not subjected to unusual winds. Mast height is 40 feet.

The concentrated load on the top section is 15 + 8, or 23 pounds. Entering **Figure 2** at the bottom with this weight and moving upwards, it is seen that the top section could consist of 12 feet of 1-1/2 inch pipe, 16 feet of 2-inch pipe, or 20 feet of 2-1/2 inch pipe. In keeping with the scale of the antenna, suppose the 1-1/2 inch diameter pipe is used.

The concentrated wind loading is due to 2 square feet of antenna and 1/2 square foot of rotator. From the table above, the loading is (2 × 18.1) + (0.5 × 30.3), or 51 pounds per square foot. Reading upward from this load on **Figure 4**, it is seen that the maximum allowable length for 1-1/2 inch pipe is 8 feet. Since this is the critical value, it becomes the length of the topmost section.

Assume that the sections are to be fastened by welding, with 6-inch insertion into the next section. From **Figure 3**, the weight of the 8-1/2 foot total of the top section is 23 pounds. The wind loading on the exposed 8 feet from **Figure 5** is 25 pounds per square foot. Thus, the weight load at the top of the second section is 23 + 23, or 46 pounds and the wind loading is 51 + 25, or 76 pounds per square foot.

FIGURE 2




**Allowable section length at erection for standard weight pipe, fiber stress = 18 kips. (The units of force are pounds, tons, kilograms, etc. In engineering practice the word *kip* is frequently used; it merely means 1000 pounds. Thus 18 kips can also be written 18,000 pounds. Ed.)**

Using **Figure 2** again, the maximum allowable length of the next section with the nesting 2-inch pipe is 11-1/2 feet for erection loads. From **Figure 4**, the allowable length for wind loads is 9 feet, which becomes the section length. Proceeding as before, the loads on the next section are 46 + 35, or 81 pounds during erection, and 76 + 35, or 111 pounds per square foot for wind.

Again, using **Figures 2** and **4**, the allowable length of 2-1/2 inch pipe is 13 feet for erection load, and 12-1/2 feet for wind load. The 12-1/2 feet is the length $\ell_a$ in **Figure 1**. The load on the section $\ell_b$ in **Figure 1** is the same in magnitude, so this part could also be 12-1/2 feet long. However, a stock length for pipe is 21 feet. Assume that this is all that's available. Then the third section will need to end 1 foot above ground to reach the desired 40-foot total height. This is not unreasonable.

If a counterweight is added to the lower part of the third section to just balance the top weight, the erection loads on the fixed upright pipe are essentially zero. Even if no counterweight is used, the balancing effect of the part $\ell_b$ of **Figure 1** reduces the load on the upright to less than the load on section $\ell_a$ of **Figure 1**. Thus, if the upright is no smaller than the lowest mast section, it will have adequate strength for erection.

The wind load on the upright is that of the upper sections plus that on the top 10-1/2 feet of the lower section, plus some amount on the upright. Assume that the upright is fully exposed (a safe assumption). The wind load to the top of the upright is 111 + 55, or 166 pounds per square foot maximum, the exact value depending on the final choice of upright length. From **Figure 4**, the upright can be only 6 feet long if it is 2-1/2 inches in diameter, or 13 feet long if it is 3 inches in diameter. Since 12-1/2 feet is needed as a minimum, this is just about right (half of the 21-foot length of the 2-1/2 inch section, plus 1-foot ground clearance).

Even with the curves, the process is somewhat tedious and it's easy to make mistakes. Most of the tedium and mistakes can be avoided by transferring the relations to a computer program.*

While this design is intended to be used without guys, they can be added for greater safety or increasing the allowable wind load. Usually the wall thickness is sufficient to withstand the compressive forces caused by guy tension, but this should be checked if a guyed design is attempted.

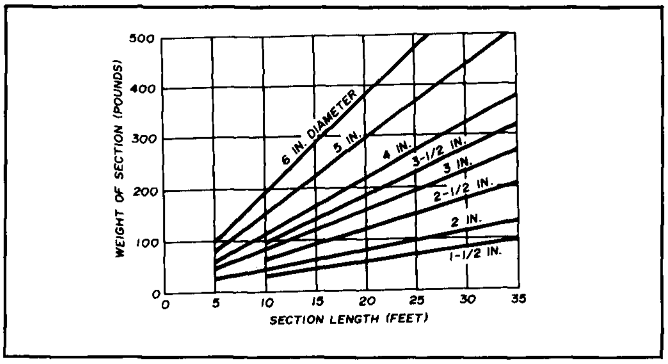
Factors affecting the length of pipe buried in the ground are discussed below. For this example, assume that this is 10 percent of mast height, or 4 feet. Total upright length is thus 13-1/2 + 4, or 17-1/2 feet. The jacket section buried in the ground needs to have 1-inch clearance, so it must be a 4-foot length of 5-inch diameter pipe.

The results of this design example are:

**Top section:** 1-1/2 inch diameter top section, total length 8-1/2 feet, exposed 8 feet.

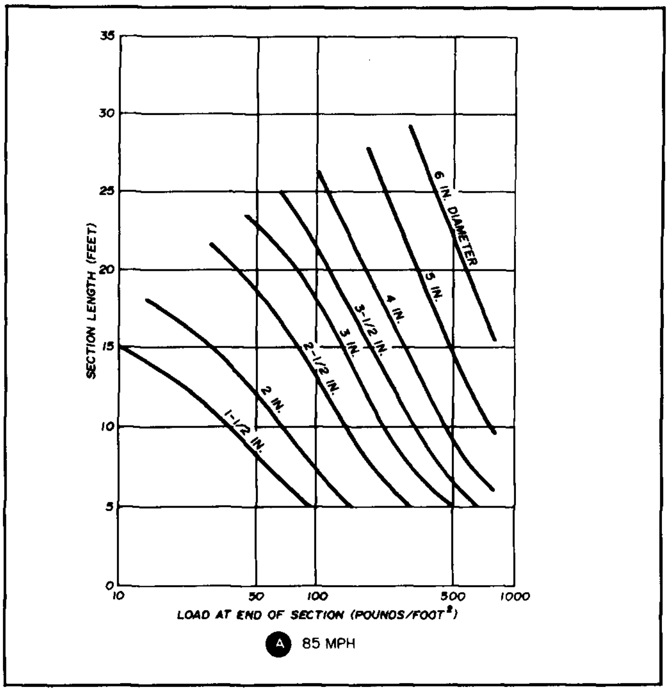
**Second section:** 2-inch diameter second section, total length 9-1/2 feet, exposed 9 feet.

FIGURE 3




**Weight of standard pipe.**

FIGURE 4A




**Maximum allowable section length for standard weight pipe with winds of 85 mph (fiber stress = 18 kips).**

**Lower section:** 2-1/2 inch diameter lower section, total length 21 feet, hinge at 12-1/2 feet, 1-foot ground clearance at bottom.

**Upright:** 3-inch diameter upright, total length 17-1/2 feet, exposed 13-1/2 feet, buried 4 feet.

**Jacket:** 5-inch diameter, total length 4 feet, all buried.

If necessary, this design could be carried higher, using larger pipe sizes.

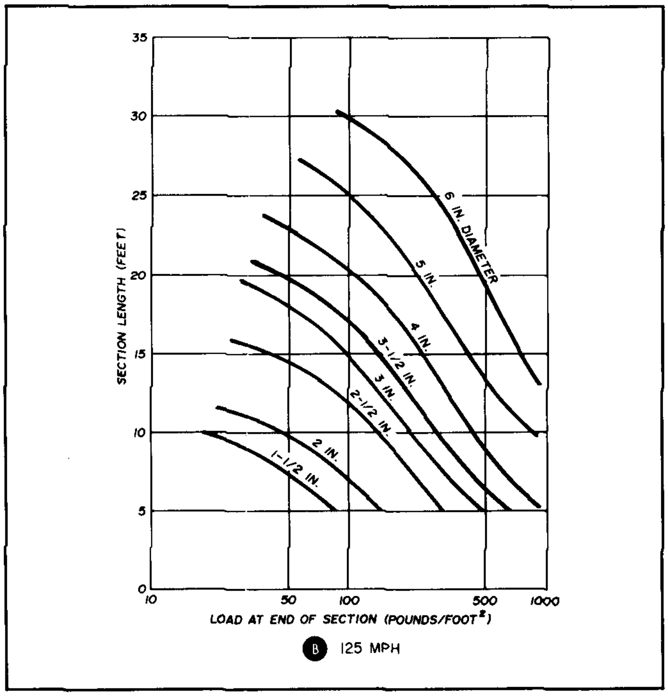
It is often necessary to try several initial assumptions as to length and diameter of the top section. With a little practice, this can be done in a few minutes.

## Construction details

The 6-inch overlap assumed in the example is sufficient for either welding or bolt fastening. Bolts are suggested as they are simpler and allow disassembly.

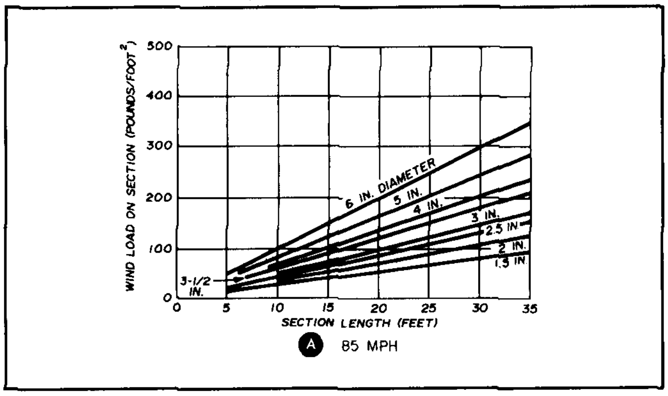
*Such a program is included in the author's "Practical Antenna Design and Analysis" available from MiniLab Books, Daytona Beach, Florida, 32021-1086, or from the HAM RADIO Bookstore. Editor

FIGURE 4B



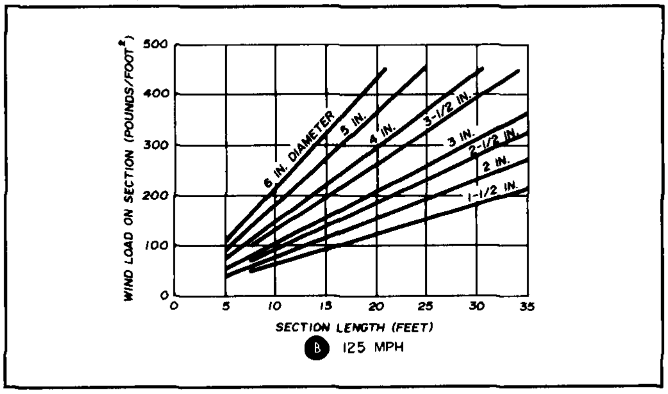

**Maximum allowable section length for standard weight pipe with winds of 125 mph (fiber stress = 18 kips).**

FIGURE 5A




**Wind loading for standard weight pipe, 85 mph winds.**

FIGURE 5B




**Wind loading for standard weight pipe, 125 mph winds.**

Two bolts at right angles passing completely through both pipe sections are recommended. The thread root diameter should be no less than the thickness of the larger section. As a refinement, drill and tap the outer pipe for alignment screws to be placed just above the top bolts and just below the bottom ones. These are a necessity if the pipe sections differ much in size (for example, if a 4-inch pipe is to be nested into a 5-inch one). The space between pipes can be filled with silicon rubber in the final assembly.

The "U" strap hinge shown in **Figure 1** should have a thickness at least as great as the wall thickness of the pipe it supports. For strength in bending, its width can be about 12 times the thickness. The pin hinge diameter should be at least twice the wall thickness for bending strength. (These bending forces are likely to occur in handling and erection, and are difficult to estimate).

A second "U" and pin can be placed at the very bottom of the movable mast part to anchor it to the ginpole section. The pin can be drilled for insertion of a padlock, to prevent sabotage or tampering. A bicycle chain does nearly as well. Another refinement is to wrap both the ginpole and lower pipe section with several turns of barbed wire, about 8 feet above ground level. This helps prevent anyone from climbing the mast.

The suggested assembly routine is to mark each section with the bolt locations and the nesting length. Then lay the pipe on the ground, with blocks or pegs to hold it in place. Use a cord to get the correct alignment. Drill one of the bolt holes, insert the bolt, and then drill for the other one. Without shop facilities, it's nearly impossible to pre-drill these holes and have them line up.

Weight and area aloft can be reduced by turning the entire mast. This complicates the attachment to the ginpole section. However, the bearings needed can be simple sleeve bearings — essentially "U" straps with filler blocks, plus bearing rings attached to the pipe. The vertical load on these bearings can be removed by mounting a heavy-duty rotator under the very bottom of the mast and using a scissors jack to raise the rotator and mast just enough to take the load off the straps. Look at one of the commercial designs for ideas.

Since guys are not needed, the rotating mast type is excellent for stacked beams.

## Foundations

Because of the great variability of soils, it isn't possible to provide a set of all-purpose design curves for foundations. The best way of proceeding is to work with your county engineer, and use the practices developed for your particular area. The local power or telephone company should also be able to supply the necessary data.

For reasonably good soils, like firm loams or clays, a good starting point is to assume that the foundation depth is equal to 10 percent of the height, with the jacket set in concrete of sufficient size to keep the soil load to a safe value. A maximum load of 4000 pounds per square foot is often used, with the design adjusted to give a 100-percent safety factor above the design load. If you haven't done this work

✓ 156

before, the county engineer can show you the steps.

The ginpole pipe section going into the ground must be protected from rust and corrosion on the inside and outside. This is especially important to prevent rusting at the waterline, if free water is present.

Usually, adequate protection can be assured by painting the pipe with a grout of cement and water. Even better protection can be obtained by wrapping the outside with several layers of builder's felt, painted with cold application roofing tar as the felt is wound on.

Pipe sections can be sealed with wooden plugs and a layer of silicon putty. The entire mast and all hardware should be painted as a last step before installation of the antennas. Aluminum Rustoleum™ is suggested, as it is compounded to remain flexible, and is nearly as good for rust prevention as a zinc coating.

## Safety

More and more communities are requiring permits for structures of this type. There may be height restrictions. Know your local laws!

In many areas, one requirement for obtaining a permit is certification by a professional engineer. You can usually save time and cost by doing the preliminary design and analysis yourself; use standard formulas or the curves here. Do the work neatly, in an easy-to-follow form. The engineer will want to at least check the method and critical loads. If he wants to do a complete analysis, you'll be able to use it to argue about the cost of insurance coverage (a generous policy is recommended).

Any antenna mast can become a hazard if good safety practices are not followed. Remember that a quarter- or half-ton of steel 30 to 70 feet in the air is no toy. If you lack experience or don't have the proper facilities, get qualified help. Always remember, *safety is no accident.* hr

REFERENCE


1. John J. Nagel, K4KJ, "How to Calculate Wind Loading on Towers and Antenna Structures," *Ham Radio*, August 1974, page 16.


This article first appeared in the September 1974 issue of *Ham Radio*. Editor

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# NEW PRODUCTS

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The AH-3 can also be used for HF mobile operation. It installs in your trunk and tunes automatically. The optional AH-2b antenna element is available and includes a bumper mount system for holding an 8.2-foot stainless steel antenna element. The AH-3 and AH-2b system allows you 3.5 to 28-MHz mobile operation.

The AH-3 is priced at $489. For additional information contact ICOM America, Inc., 2380 116th Avenue N.E., P.O. Box C-90029, Bellevue, Washington 98009-9029.

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## New features available for the multi-mode data controller

MFJ Enterprises, Inc. originally released the MFJ-1278 (priced at $249.95) with transmit and receive in seven modes: Packet, RTTY, WeFAX, SSTV, CW, ASCII, and Contest Memory Keyer. MFJ announces two new modes: Navtex receiving and AMTOR transmit and receive.

There are also two new features for the MFJ-1278 Packet mode: the new Easy Mail™ Personal Mailbox and a new KISS Interface for TCP/IP compatibility.

New terminal software for the Macintosh computer, the MFJ-1287 Starter Pack with interface cable and Wefax printing to screen, is available for $19.95.

Existing programs for the IBM (MFJ-1284) and Commodore (MFJ-1282 disk/MFJ-1283 tape) are available with cable and instructions for $19.95 each.

For more information contact any MFJ dealer or MFJ Enterprises, Inc., PO Box 494, Mississippi State, Mississippi 39762, or call toll free 800-647-1800.

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## RADIO WORKS' Discovery Catalog

The RADIO WORKS' 1989 discount catalog is a source book of wire antenna systems, components, and accessories.

It includes 56 pages of mobile and base antennas, mounts, antenna wire, insulators, coaxial connectors and cable, surge protectors, coax switches, Dacron® and MilSpec support line.

Pre-built antennas include RADIO WORKS' two new versions of the Carolina Windom®, and a high performance, 3/2 wavelength loop called the BigSig Loop®. Also featured are the new InTreeVert® and the 16-foot MicroDipole®. All RADIO WORKS' antennas are available for the new WARC bands.

The SWL section features new antennas. There are also SWL products and active antennas to preselectors from other manufacturers.

You can select from ten different balun models including the B4-2KX Current-type® and RemoteBalun®.

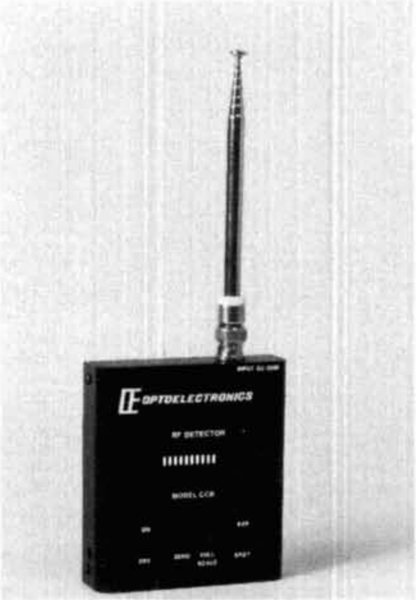
The RADIO WORKS' 1989 catalog costs $2, but is FREE to all *Ham Radio* magazine readers. Include $1 for first-class postage if you want speedy delivery. Contact the RADIO WORKS, Box 6159, Portsmouth, Virginia 23703. Phone: (804)484-0140.

**Circle #304 on Reader Service Card.**

## New CCB handheld RF detector

Optoelectronics, Inc. introduces the new CCB handheld RF detector. Applications include checking the output from small or large transmitters used in radio telemetry, two-way radio, ham radio, garage door openers, RC transmitters, cordless phones, cellular phones, marine radio, aircraft radio, CB, police, fire, or other radio services.

The CCB has a ten-segment LED bar graph readout, two-stage wideband RF amplifier, and a forward biased hot carrier diode for a detector. The detector output is filtered and fed to the log output bar graph driver circuit. Each segment responds to a 3-dB step increase in signal strength. Screwdriver adjustable pots are provided for zero and full-scale adjustment.




The CCB is available for $99.95 from Optoelectronics, Inc., 5821 N.E. 14th Avenue, Fort Lauderdale, Florida 33334 (800) 327-5912. (In Florida call (305) 771-2051.) Accessories include the model TA-100S telescoping BNC antenna for $12 and the CC-12 vinyl zippered carry case for $10.

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## New "soft-side" tool kits

Hand Tool Industries has announced the its new soft-side zippered tool kits.

These tool kits are designed for service engineers and technicians who work on data processing equipment and comparable types of electro-mechanical devices.

The kits are available in brown heavy-duty padded vinyl; many are Cordura® material. Each kit has individual tool pockets and heavy-duty zipper.

Soft-side zipper kits may be ordered by calling (800) 652-1234 or contacting Hand Tool Industries, Inc., 1933 Lake Street, Kent, Ohio 44240.

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2) The Trade-In unit must be in good working order and salable.

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# A waveguide flange drilling guide

It's not easy to lay out and drill the flange-hole pattern accurately for waveguide flanges. If you have my luck, the holes will tend to drift or migrate during drilling. You can hand file the holes with a round jeweler's file to bring them back to the proper positions, but the resulting fit is loose and/or sloppy. If you drill the holes right the first time, the next piece of waveguide will be properly positioned when you tighten the four mounting screws.

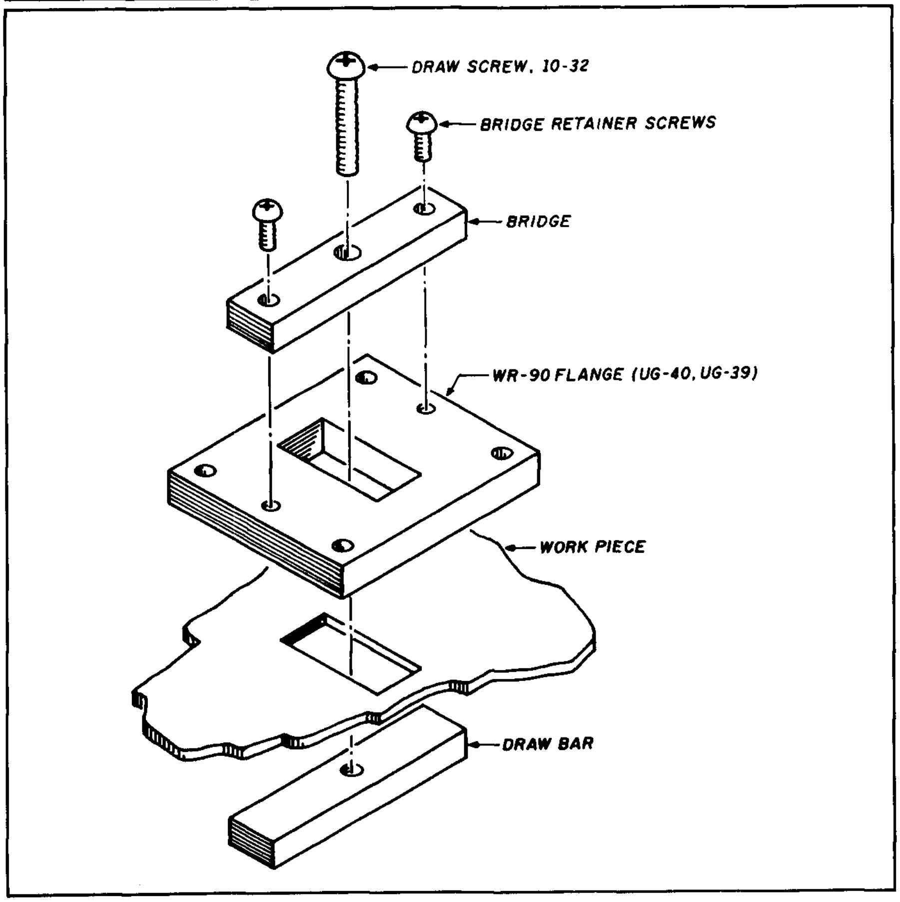
My drilling method is simple: use guide holes that have already been drilled accurately to guide your hand drill. You can use this technique for other flange sizes and connectors.

If you look at **Figure 1**, you'll see that the draw screw performs two jobs. It holds the assembly together and the drill guide motionless while you use the four flange holes as a pattern for drilling the holes in the work piece. I suggest using a 10-32 or 12-24 screw. The bridge bar must be narrow enough to allow easy inspection of the guide opening during attachment and alignment. Note that the bar is perpendicular to the long axis of the guide opening. The center hole is a clearance hole for the draw screw. The two outer holes pass two 6-32 mounting screws. You can use a single mounting screw or sweat solder the bar in place. The screws or solder serve only to hold the bar in a stable position while you position the drill guide. If you use screws, you must make matching threaded holes in the guide flange.

Nibble or machine the guide opening in the work piece before positioning the drill guide. Make sure the dimensions of the opening correspond to the *inside* dimensions of the waveguide. Center the drill guide over the guide opening and secure it by tightening the draw screw in the draw bar. The tapped hole in the draw bar should match the draw screw. Make sure the draw bar is positioned free of the flange holes and is tightened securely before drilling the flange holes.

**John M. Franke, WA4WDL**

FIGURE 1




**Mechanical diagram of the waveguide flange drilling jig.**

# 50-MHz RF bridge

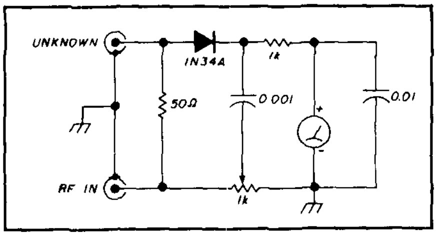
After the 1986 release of the 6-meter band to UK Amateurs, many UK hams found an RF bridge helpful for adjusting the gamma matches on their homebrew antennas.

The basic RF bridge[1] shown in **Figure 1** is difficult to use at the masthead, so I designed a self-contained unit to overcome this problem. Using the American Amateur's experience of the band,[2] I built a low-power transmitter drive source on the same pc board as the bridge. It operates with a 9-volt battery.

## Circuit

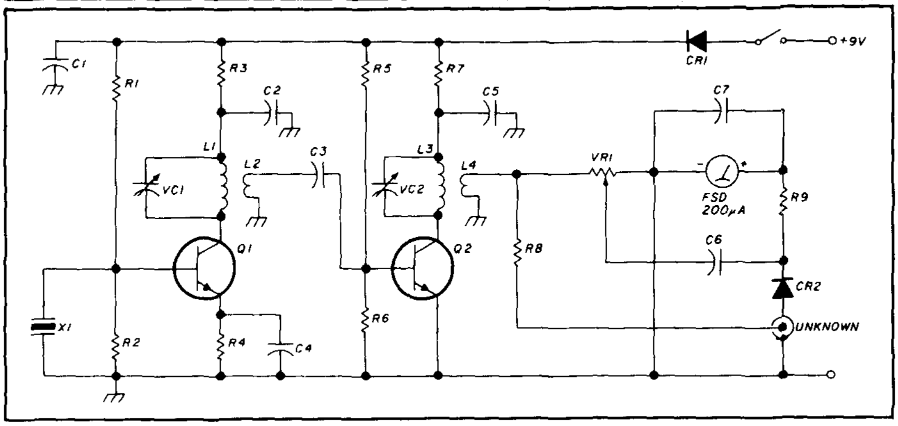
**Figure 2** is the overall schematic. Q1 is an overtone oscillator that uses a 50-MHz third overtone crystal. The collector is tuned to 50 MHz by L1 and C1. The output signal from Q1 is link coupled via L2 and C3 to the base of Q2 — a class A amplifier stage with its collector tuned to 50 MHz by L3 and C2. The gain of this stage is quite high due to the grounded emitter, and the output should be approximately 40 mW. The output signal from Q2 is link coupled to the bridge circuit via L4.

FIGURE 1



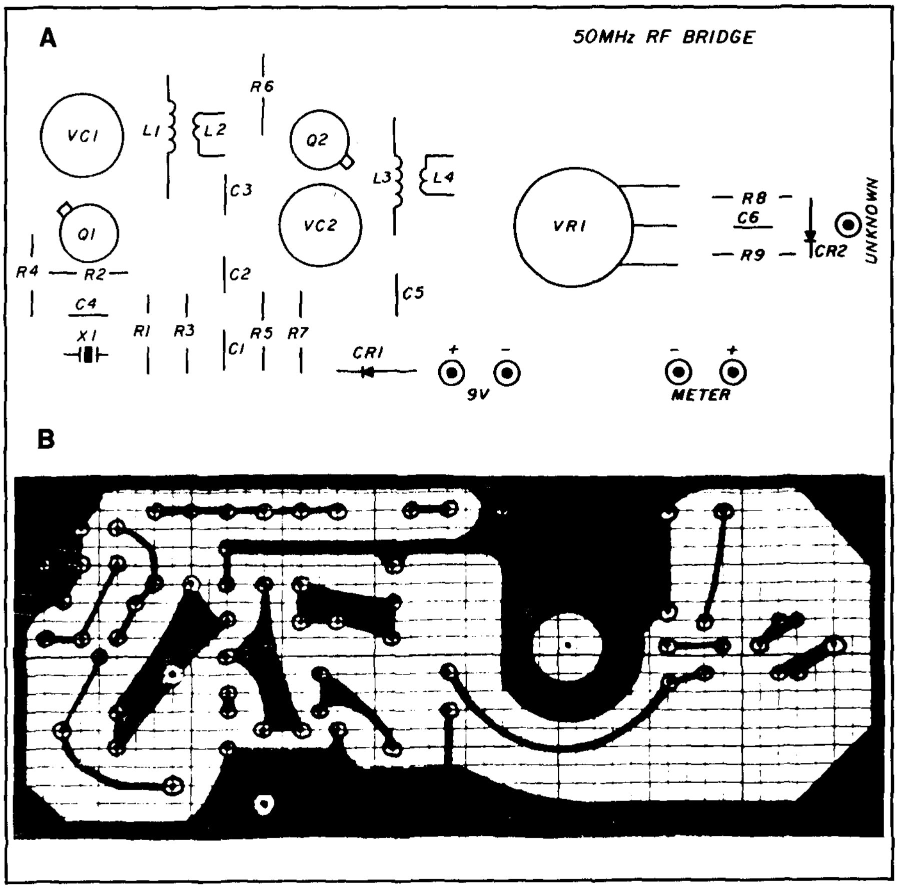

**Schematic diagram of the basic RF bridge.**

FIGURE 2




**Overall schematic including the 50-MHz battery-operated transmitter.**

FIGURE 3




**Printed circuit and parts placement layouts for the RF bridge.**

## Construction

The unit is built on a single-sided 4-3/4" × 2" × 1/16" fiber-glass pc board (see **Figure 3**). Install the components on the board, leaving the potentiometer until last. Secure the pc board into the case using the threaded section of the potentiometer, as shown in **Figure 4**. You'll need to obtain a second nut for this potentiometer.

### PARTS LIST

**RESISTORS**
- R1 10 k
- R2 4.7 k
- R3 100 ohms
- R4 1 k
- R5 680 ohms
- R6 47 ohms
- R7 100 ohms
- R8 51 ohms
- R9 1 k
- VR1 1 k linear miniature potentiometer

**SEMICONDUCTORS**
- Q1 BSX 20 (Europe) 2N2369 (USA)
- Q2 BSX 20 (Europe) 2N2369 (USA)
- CR1 1N4148
- CR2 0A90 (Europe) 1N34A (USA)

**COILS**
- L1 9 turns 22 swg (21 AWG) enameled wire, 1/4-inch diameter, 5/8-inch long
- L2 2 turns thin insulated wire, 1/4-inch diameter, wound in the center of L1
- L3 As L1
- L4 As L2, wound in the center of L3

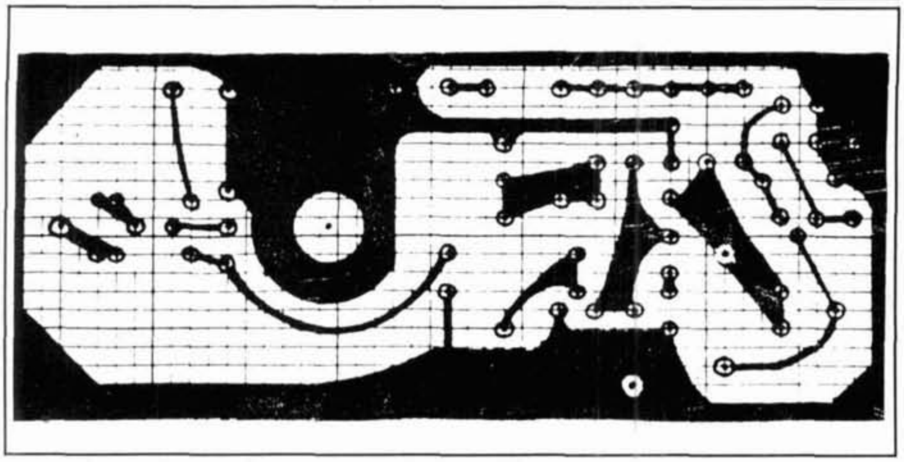
**CAPACITORS**
- C1 0.01-μF ceramic disc
- C2 0.01-μF ceramic disc
- C3 0.01-μF ceramic disc
- C4 15-pF ceramic disc
- C5 0.01-μF ceramic disc
- C6 0.001-μF ceramic disc
- C7 0.01-μF ceramic disc
- VC1 5 to 60-pF trimmer
- VC2 5 to 60-pF trimmer

**MISCELLANEOUS**
- X1 50-MHz third overtone series resonant crystal HC 18/U
- Meter 200 μA FSD
- SPST toggle switch
- SO 239 socket
- PCB terminal pins

## Testing

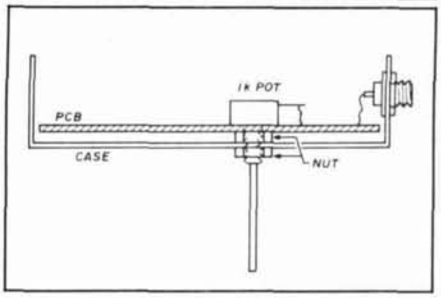
After you've completed the pc board, connect a 51 or 100-ohm resistor from the unknown terminal pin to the negative meter terminal pin. Connect a 9-volt supply to the battery terminal pins, making certain the polarity is correct. Adjust C1 and C2 for a 50-MHz output, using a digital frequency meter or an absorption wavemeter positioned near L1 and L3 in turn. When you have a 50-MHz output, connect the meter to the meter terminal pins and rotate R1 for a dip on the meter. If you get a dip, and all tests are

**FIGURE 3C**



**Printed circuit board layout.**

**FIGURE 4**




***Details for mounting the pc board using the mounting nuts on the potentiometer.***

satisfactory, remove the temporary resistor connected to the unknown terminal pin. You can now install the board in an RF-tight case or diecast box. I placed my prototype in an aluminum box 5-1/4″ × 4″ × 1-1/2″.

## Calibration

To calibrate the bridge, you'll need a number of resistors and a plug to fit the socket. I used resistor values of 5, 10, 20, 30, 40, 50, 70, 75, 100, 150, 200, and 1000 ohms to calibrate the prototype.

Fit a white card scale to the front of the case and solder each resistor, in turn, into the plug. Connect the plug to the unknown socket and rotate R1 for a dip on the meter. When a dip is indicated, mark the scale with the value of the resistor used. The scale values should increase in counterclockwise sequence.

## Conclusion

This RF bridge has simplified the adjustment of gamma matching sections and can be used to find the antenna tapping point on RF input coils of converters. You might also use it to find the input and output tapping points on bandpass filter coils.

For Amateurs in Region 1 (in countries where 4 meters can be used legally), the bridge can be modified by using a 70-MHz crystal, changing C4 to 10 pF, and retuning the resonant circuits.

The same design can be used for lower frequencies by changing the crystal, the resonant circuits, and C4. Capacitor C4, in the emitter of Q1, must have a reactance of 200 ohms at the crystal frequency.

REFERENCES

1. *ARRL Radio Amateurs VHF Manual*, 1968, page 284.
2. *ARRL Solid-State Design for the Radio Amateur*, 1977, page 30.

**A. R. Croft, G8CJM**

*Tom McMullen, W1SL*

**PART 2**

# VISUAL AIDS — LIGHT EMITTING DIODES

When transistors and integrated circuits began to dominate electronic equipment design in the seventies, the amount of power consumed by the equipment decreased rapidly. It got to the point where the power required to light the pilot lamps was greater than that needed to operate the equipment.

Technology continued to move forward, and a little lump of plastic with a couple of wires protruding from it went through a rapid development process. This device, called a light emitting diode (LED) gives us capabilities far beyond the simple incandescent lamp that it replaced. Let's look first at how it works, then at some of the ways it's being used.

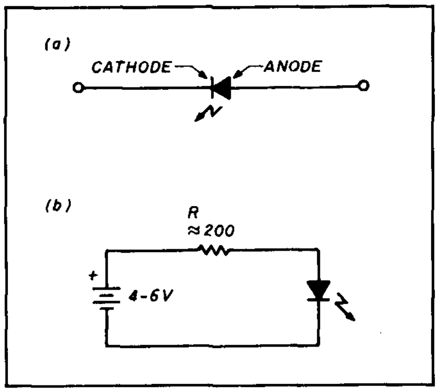
## Where does the light come from?

The LED is shown schematically in **Figure 1** as a diode with adjacent arrows pointing outward to indicate that it is emitting light. (Other devices exist that show the arrows pointing inward, indicating that they are responsive to light.) Some neat tricks of physics are used to obtain light from a small fragment of semiconductor material.

The key ingredients in an LED are usually gallium and arsenide. A diode made from these elements is sometimes referred to as a gallium-arsenide LED. (These same elements are used in Field-Effect Transistors, called GaAsFETS for Gallium Arsenide-Semiconductor Field-Effect Transistors.) The abbreviation LED is used almost universally today without regard for the elements that go into the semiconductor material.

*Figure 2 shows a cross-section of a* typical LED structure. There are many variations, depending on the requirements. Some are made flat to mount on pc boards, while others have wire leads that connect to associated circuitry.

FIGURE 1

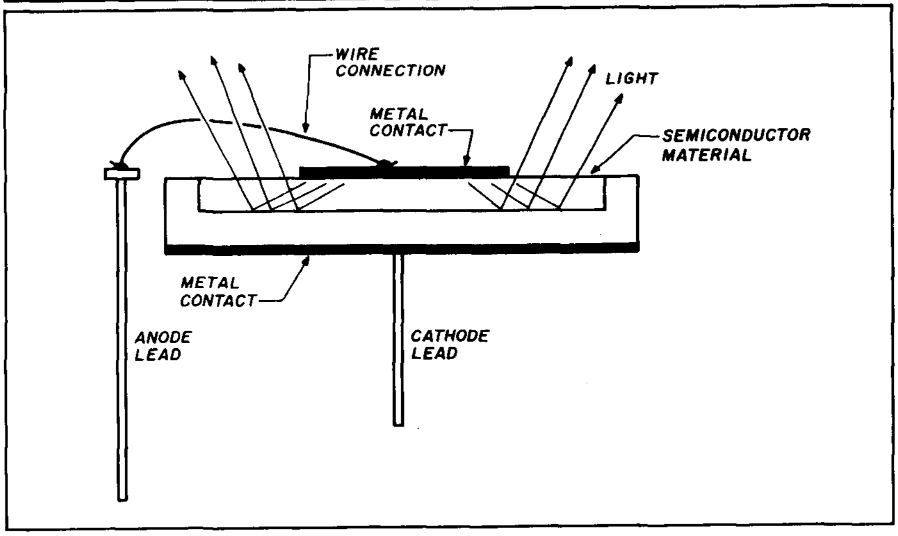




**A schematic symbol for a light emitting diode (LED) shown at (A). Most common LEDs work from a 5-volt supply, which must be applied through a current-limiting resistor of approximately 200 ohms (B).**

To understand how LEDs work, look again at basic semiconductor theory — electrons, holes, barriers, junctions, and all that. The same theory is at work in getting light out of a diode, getting a rectifier to turn AC into DC, or causing a transistor to amplify a signal. It's not really complicated. There's a junction between material with an excess of electrons (N type) and material with a scarcity of electrons (P type). Both types of material are created by impurities that were purposely introduced into the basic elements during manufacture. There is a region between these two materials where nothing much happens under normal circumstances. The extra electrons don't have enough energy to migrate to the other side, and the electron-scarce elements (often called "holes" or places where electrons could be) don't have enough energy to go the other way. There's a sort of trap zone in between, and any electron or hole that ventures into it gets stuck. To get things moving, a voltage must be applied across the junction. The voltage increases the "energy

FIGURE 2





**A cross-section view of LED structure. This whole assembly is usually placed in a plastic dome or cap which protects the assembly as well as diffusing the light for greater visibility.**

level" of the electrons enough that they can move across the barrier to the "other side" where they combine with the "holes." As you might expect, when the free electron combines with a hole, each ceases to exist as a distinct entity. When they combine in this way, the excess energy they had must go somewhere, and it is emitted as "photons." The word photon can be roughly translated to mean "particles of light."

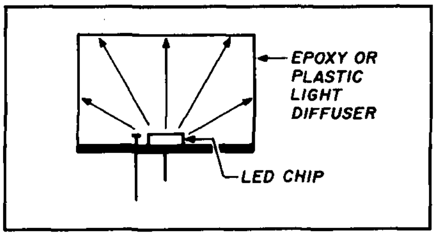
Of course, not all semiconductor diodes emit light. Many of them get rid of the excess energy as heat. Semiconductor manufacturers make sure that most of the energy is released as light by selecting the correct impurities to put into the material. That's where the materials gallium and arsenide come in, instead of the silicon and germanium used for rectifier or signal diodes. Some LEDs use a combination of gallium, arsenide, and phosphorus (called GaAsP semiconductor material), and others have some indium or antimony or other elements thrown in. Variations of these impurities can change the basic color (wavelength) of the light emitted and affect the efficiency of the LED. Currently available colors range from infrared to red, amber, and green. There are materials that emit light in the blue range, but not with great efficiency or brightness; research continues in that area.

## Putting the light to work

One of the earliest uses of the LED was as a replacement for the simple pilot light. It showed that a piece of equipment was on or off, or indicated some other function of the equipment by being illuminated or not.

Physically, an LED is very small; its size can work for or against its use. Because it is so small, you can place several LEDs close together for an array that takes up very little space. Most inexpensive incandescent lamps are between 1/4 and 3/8 inch across, so you are limited in the number of devices per inch. On the other hand, the LED's size limits the indicator's brightness and the width of the angle from which it can be viewed. This obstacle has been overcome in a couple of ways. One or more diodes can be made to illuminate a plastic lens that diffuses the light over a wider area, thus increasing visibility. Also, recent developments in diode technology have created LEDs with much greater light output.

FIGURE 3




**A rectangular plastic enclosure for the LED element diffuses the light across its surface and can serve as a segment of a numeric readout as shown in *Figure 4*.**

The plastic lens or light diffuser can be shaped to create the exact effect desired — rectangular (see **Figure 3**), triangular, round, square, or diamond shaped. These devices are very useful when used in conjunction with different colors to "foolproof" a readout device, or help the user determine what action to take or see what is happening. An example is the arrow-shaped indicator on some Amateur equipment front panels that shows which VFO is being used. On some receivers, a green LED shows that a signal is being received; several green LEDs can show the signal strength. Some indicator panels that use green for receive indications also use red LEDs to show that the transmitter is on, and to give an indication of how much power is being transmitted. Infrared LEDs are commonly used in remote controls for television sets and video cassette players.

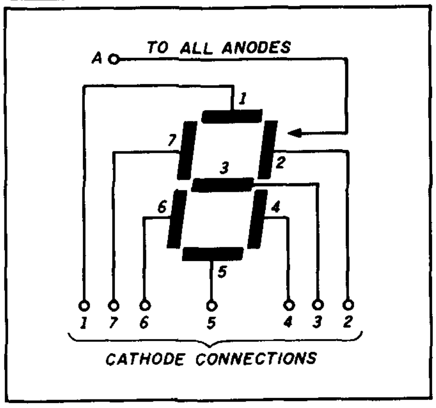
## More than just light

You find LEDs in frequency readouts, digital panel meters, and many calculator displays. By placing one or more LEDs behind carefully shaped pieces of plastic, you can create letters or numbers. They are used in what is often called a seven-segment readout, shown in **Figure 4**. Some of these can be tiny, with three or four complete readouts on the top of an integrated circuit that plugs into a socket or mounts on a circuit board. Others can be quite large, like those in some clocks which have numbers 2 or 3 inches high.

An individual seven-segment readout device usually has eight connecting leads for power application — one common lead and one for each segment to be illuminated. You select the desired segment manually (with a switch) or (as is more often the case) with a special driver IC that interprets data from a computer, calculator chip, etc., and then illuminates the proper segment(s). For example, the number 3 can be created by applying a voltage between the common lead and the leads to segments 1, 2, 3, 4, and 5 shown in **Figure 4**. On many readout devices, there are also provisions for showing a period (decimal point), a colon (on clocks), and plus or minus signs.

Most readouts that produce numbers will also work for letters if a few compromises can be accepted. For example, in **Figure 4** a capital Q won't work, nor will an X of either case, but a lower case q will. With only slightly more complexity, a readout with diagonal segments can be made which will allow something close to a capital Q and will differentiate between a zero (0) and a capital O by placing a slash through the zero. It also allows creation of the letter X.

FIGURE 4




**The common 7-segment LED readout can have a common anode connection and a connection to each individual cathode or it can be just the opposite, with all cathodes common. Other elements, such as a period, colon, or plus and minus symbols require additional LEDS and more connections.**

Measuring a voltage (or current) with a conventional analog meter is a relatively simple process — you apply the voltage through appropriate resistors to the meter terminals, and the pointer moves in response. Its resting position is read against a scale to indicate the

# AT-300™ Antenna Tuner

**An affordable antenna tuner from a name you can trust**
**The AT-300™ from AEA**


## Low Pass Design

The low-pass design of the AT-300 is what you would expect from a company where Engineering Makes the Difference. The low-pass design of this AEA tuner means harmonic attenuation for lower TVI potential. This design also allows matching a much wider range of antenna impedances than the common high-pass designs.

## Larger Size

One look at the AT-300 lets you know this tuner is different, it's bigger. While some manufacturers promote the small size of their tuners, AEA knows that performance is most important. The simple reason for the larger size is that smaller sizes degrade the inductors' Q (Quality factor), which results in less efficiency. Less efficiency means that for a given power output from your transmitter, less power will actually get to your antenna.

## Easy Operation

The AT-300 tuner features a precision frequency compensated dual- movement SWR meter for ease of tuning. The high and low power front panel switch selects the proper range for the SWR meter. The AT-300 is rated for 300 watt operation. The internal balun and front panel selector switch allows for balanced and unbalanced outputs.

Get maximum performance from your transceiver and antenna by using the AT-300 antenna tuner from AEA. See your local AEA dealer today or contact:

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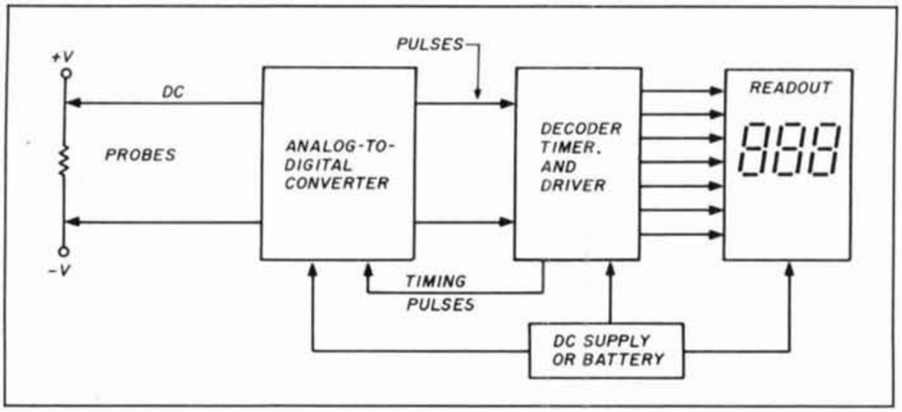
**FIGURE 5**




**A simplified block diagram of a digital voltmeter using 7-segment LED readouts. Multiple-readout panels can be found in many instruments including: frequency counters, clocks, calculators, watches, and many Amateur receivers.**

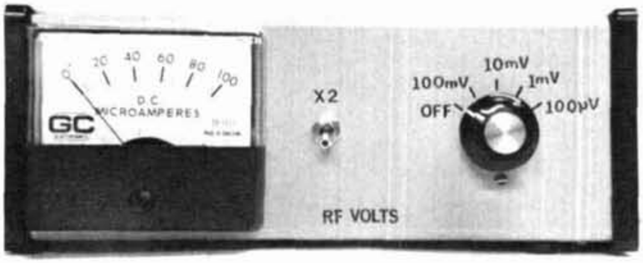
amplitude of the voltage being read. Doing the same thing with an oscilloscope (see last month's column) requires slightly more circuitry — power supplies, a sweep circuit, and an amplifier to deflect the electron beam proportionately to the voltage being measured.

A volt/ohm/milliammeter which uses LED indicators is also more complex, but not mysterious enough to scare you away. The circuit to drive the segments requires only low-voltage DC, like 5 or 12 volts, and current of a few milliamperes. However, these driver circuits require a digital input, and the quantities they are measuring are almost always DC (or analog). But this isn't a formidable task because there are specific integrated circuits that convert a given DC voltage into a digital output signal. These ICs are called analog-to-digital converters, or ADCs. (There are also digital-to-analog converters, or DACs, that do just the opposite.) The quantity to be measured is applied to the input of the ADC IC, which provides a series of pulses at its output to represent a number for that particular input. The LED driver IC then interprets this string of pulses and determines which segments to illuminate. **Figure 5** is a simple block diagram of a digital voltmeter using these elements.

Using LEDs, you can reduce power consumption when you have several devices — like five or six readouts on a panel. By feeding the voltage to the LEDs in short pulses instead of DC, you can reduce the average current consumed by 50 percent or more. The trick is to make the pulses fast enough so that your eye doesn't know when the LEDs are off. This trait, called visual persistence, keeps you from seeing the 60-Hz flicker from devices like light bulbs and TV screens. hr

# A SENSITIVE RF VOLTMETER

## Read RF levels down into the microvolts




*By John Pivnichny, N2DCH, 3824 Pembrooke Lane, Vestal, New York 13850*

If you like experimenting with receivers, you need a way to measure low-level RF signals. This weekend project is a voltmeter with microvolt sensitivity. It covers a range of 20 $\mu$V to 200 mV, or an 80-dB range. You can use it to measure the output of RF and IF amplifiers, oscillators, crystal filters, and measuring bridges. An external attenuator[1,2] lets you read transmitter signal sources, like multiplier stages, mixers, and amplifiers.

The bandwidth is designed to cover from 0.5 MHz to over 30 MHz. It's also useful for comparison readings up to 100 MHz. Overall, I find it a very useful instrument to have on my construction bench.

Internal batteries supply the 20-mA current required at 15 volts DC, and provide isolation from AC line noise. The batteries also allow portable operation.

### Circuit description

The schematic in **Figure 1** shows a peak-reading diode voltmeter driven by two stages of amplification. I used a germanium diode 1N34A in the voltmeter circuit because it has a lower threshold voltage than the popular 1N914 silicon "glass diode" in many RF probe circuits. Those RF probes are intended for higher voltages than the undistorted $\pm$1 volt or so available from the MC1350P amplifier output.

A 100-$\mu$F capacitor provides a fairly large time constant. This results in satisfactory meter damping. The limited differential output voltage coupled with an overdamped meter prevents a lot of hard "needle pinning" when you select an incorrect range position, or make other errors. An SPST toggle switch selects additional series resistance. This X2 function gives some more overlap of the sensitivity ranges. The resistance values shown are correct for the 100-$\mu$A meter I chose (1500-ohm internal resistance).

### Amplifier

I selected the MC1350P amplifier circuit because it's inexpensive and available from many sources. You can also use another, newer version — the MC1590. Although the schematic is identical, the MC1590 has a different set of pin assignments, so take care if you make a substitution.

The MC1350P is an RF/IF amplifier with a typical power gain of 40 dB, and a 60-dB AGC range. It has differential input and output. I used two stages in cascade. The first is driven as a single-ended input by bypassing the negative input to ground. The second stage is operated in true differential fashion. In the differential mode, there is an additional 6-dB gain and the available undistorted output swing is doubled.

Coupling capacitors of 4700 pF limit the low-frequency response below 500 kHz. I selected this value intentionally to keep out audio frequencies, including 60-Hz noise.

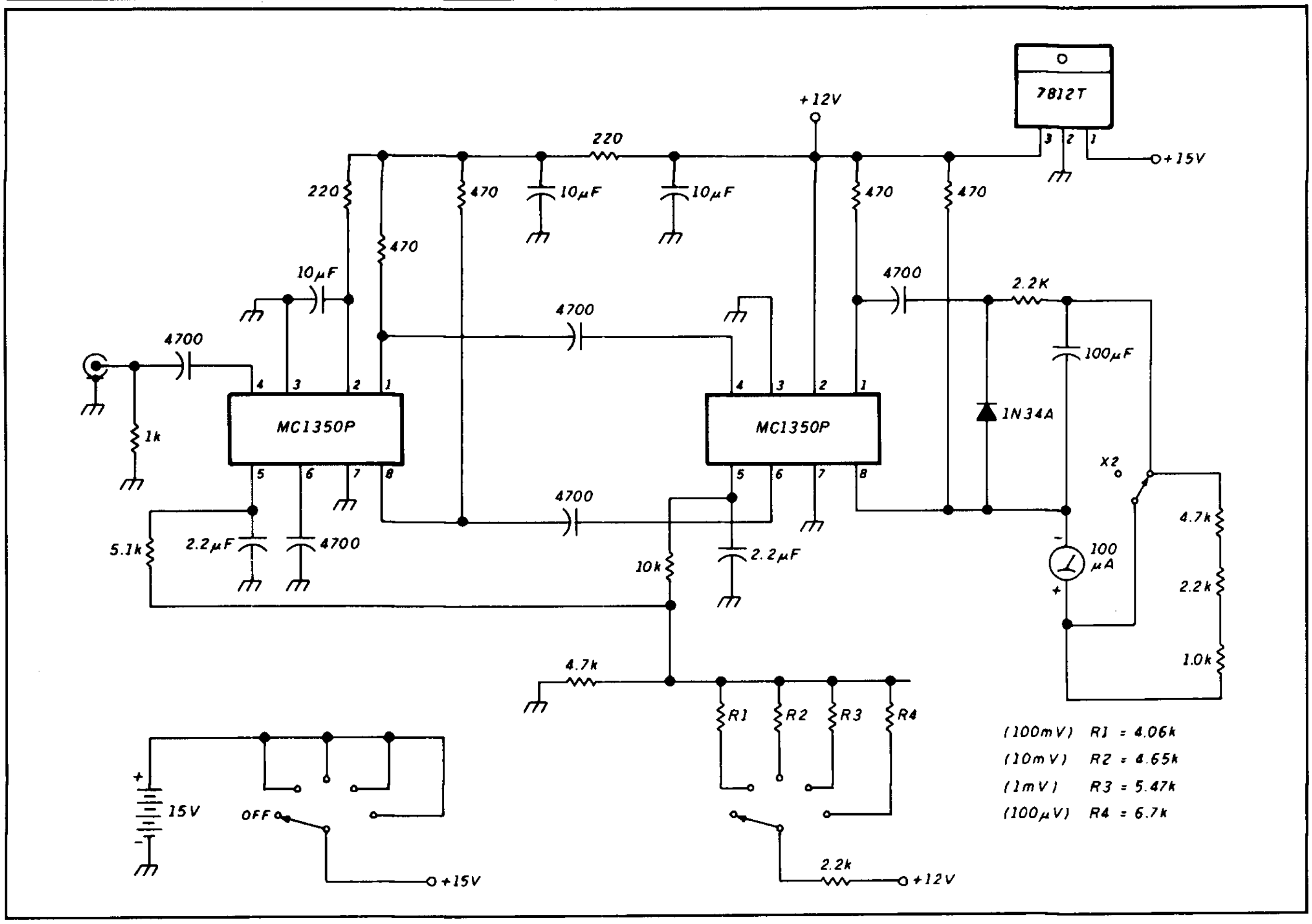
A popular voltage regulator keeps the supply at exactly 12 volts as the batteries wear down. It also provides a fixed voltage for the gain (AGC) control voltage dividers.

### Voltage ranges

The MC1350P amplifier gain is controlled by applying a positive potential between 5 and 7 volts to pin no. 5. As the potential increases, the gain is reduced. When two stages are cascaded, it's important to decrease the gain of the first stage further. This prevents the first stage from overdriving the input of the second one. The application note[3] recommends series resistors of 5.1 k for the first stage and 10 k for the second one.

Actual full-scale voltage ranges are set by carefully selecting resistor values for the voltage dividers which feed these series resistors. I chose ranges of 100 mV, 10 mV, 1 mV, and 100 $\mu$V. The resistor values I used are shown on the schematic. These may vary somewhat based on the actual MC1350P parts used, as well as the meter internal resis-

FIGURE 1




**Schematic of the RF voltmeter.**

tance. The values shown are good starting points for the calibration described later in the article.

Input impedance is set by the 1-k resistor at the input connector. This is the largest value you may use if you want to have an unconditionally stable amplifier. You can reduce this to 50 ohms if you intend to use this voltmeter in 50-ohm systems only. I prefer the 1-k value; I shunt it with a 51-ohm resistor for 50-ohm systems, or a 240-ohm resistor for my 200-ohm crystal filters.

## Construction

With the high gain and low signal levels present, I wanted no problems with instability. Consequently, I built the circuit on a 2″ × 4″ single-sided copper-clad board. Mount the components on the copper side and make ground connections directly to the copper ground plane, with essentially zero length ground connections. Pass component leads which don't connect to ground through a hole in the circuit board, countersunk on the copper side to form a clearance. Connect them on the bottom side as directly as possible. Usually the component lead will be long enough to reach its destination. Use short pieces of no. 30 gauge insulated wire to complete the connections in places where you need additional length. A hole location diagram and component placement sketch are shown in **Figures 2** and **3**.

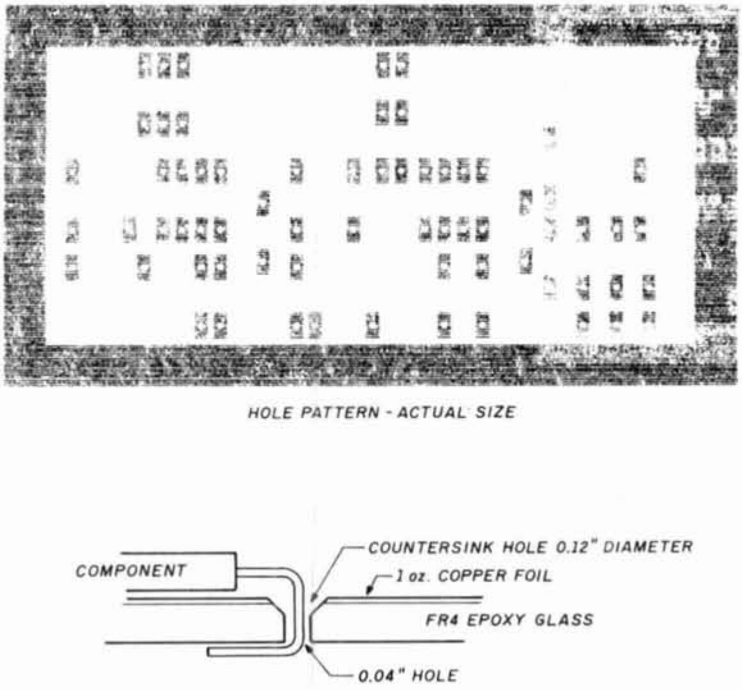
Next, mount the circuit board on the bottom of a metal case. Use two 4-40 sheet metal nuts as spacers on each of the mounting screws. This sandwiches the interconnection wires effectively between two ground planes, preventing coupling between wires which are about 1/4″ apart. It also shields the components from the interconnection wires. As a result of the efforts I put into shielding and the care I took with the input impedance, I have never observed any instability or oscillation — even on the most sensitive range.

There is room inside the case for the battery holder. Hold it in place by clamping it to the bottom with a 3-1/8″ length of 1/2″ aluminum angle stock and two screws. Mount the meter and switches on the front panel. Add a BNC coax connector to the rear panel directly over the input connection to the circuit board. Use dry transfer lettering covered with clear acrylic to mark the switch positions. See **Photo A** for details.

## Calibration

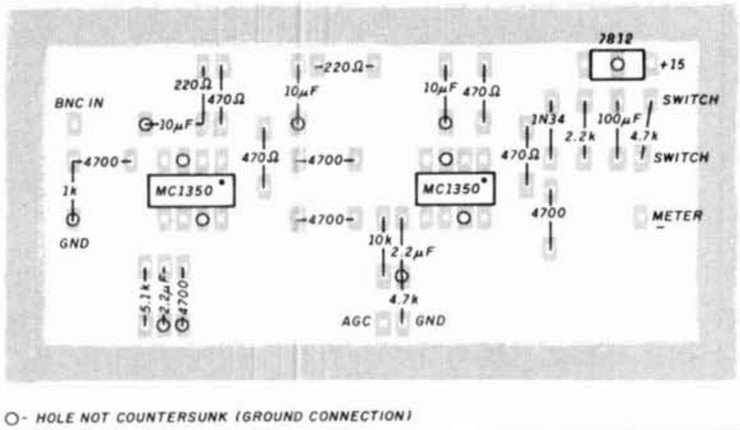
I used the bootstrap procedure for calibration described by Hayward.[4] But I used a 200-ohm system; that is, I sol-

## FIGURE 2




**Component mounting and actual size hole pattern guides.**

## FIGURE 3




**Component location diagram.**

## PARTS LIST

| | | | |
|---|---|---|---|
| 1 LM340T-12 | 12-volt positive regulator — JimPak | 3 10-μF | Electrolytic, 50 volts |
| 1 JG-6 | Cabinet 2-3/8" × 6-3/16" × 5-7/8" — Ten-Tec | 2 2.2-μF | Electrolytic, 50 volts |
| 1 BH-107 | Battery holder for ten AA size — Caltronics | 1 100-μF | Electrolytic, 20 volts |
| 1 20-1111 | 0 to 100 microampere meter — GC Electronics | 2 220 ohm | 1/4 watt |
| 1 | SPST miniature toggle switch | 4 470 ohm | 1/4 watt |
| 1 | Rotary switch 2 pole, 6 position | 2 1000 ohm | 1/2 watt |
| 1 | Panel mount BNC connector | 3 2.2 k | 1/4 watt |
| 10 | Batteries — AA size | 2 4.7 k | 1/4 watt |
| 1 | 2" × 4" single-sided circuit board | 1 5.1 k | 1/4 watt |
| 2 MC1350P | IF amplifier | 1 10 k | 1/4 watt |
| 1 1N34A | Diode — Radio Shack 276-1123 | | Dry transfer letters — Datak Corp K59B |
| 5 4700-pF | Disc ceramic | | Spray lacquer — Sherwin Williams 14-0969 |

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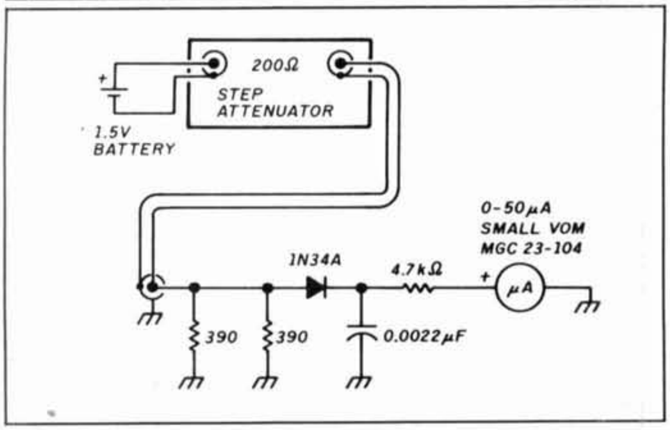
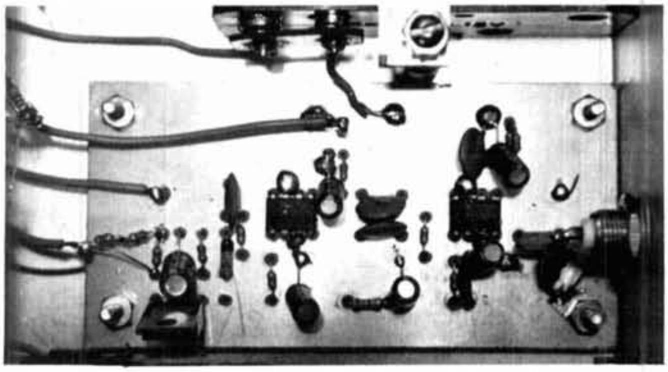
**FIGURE 4**




**Calibration circuit schematic.**

**PHOTO A**



**Circuit board details.**

dered a 240-ohm resistor in parallel with the 1-k input resistor. Using the simple circuit in **Figure 4**, I found that a 0.36-volt DC signal (step attenuator in the 12-dB position) read 30 mA on the meter. Then I injected RF from my 8-MHz oscillator into the same circuit, and read 36 mA with the attenuator in the 0-dB position.

$$v_{peak} = 36/30 \times 0.36v = 0.432v$$

The signal is 432/4 = 108 mV in the 12-dB position. I used this signal to calibrate the 100-mV scale. That is, I increased the resistor values for R1 until the meter read 108 mV. Then I connected a number of fixed resistors in series, and soldered them in place.

Next, I increased the signal level by adjusting the voltage on my oscillator circuit until it read 100 mV with the attenuator in the 20-dB position. I switched the attenuator to the 40-dB position and the voltmeter to the 10-mV range. I selected resistors for R2 for a full-scale reading on this range. I performed this procedure two more times until all ranges were calibrated, but with error accumulation at each step.

## Other uses

This meter has many uses around the shack besides reading low-level RF signals. Is that new oscillator circuit oscillating? Just connect a few turns of wire at the end of a coax, and connect the other end to the meter. Hold the loop near the oscillator circuit for a quick check for RF. Can't hear that crystal calibrator? Is it working? Hook its output to the RF voltmeter and see. What's the signal level on your TV cable? Mine reads 600 μV with a 200-ohm load before it's split two ways going to my two television receivers. A paper clip inserted in the BNC jack is enough of an antenna to pick up the signal from my grid-dip meter when it's several inches away.

Next to my frequency counter, this is the most useful homebrew project I've ever built. Try one for your next weekend project. **hr**

**dB Chart.** Many Amateurs have difficulty converting from millivolts to dBm power figures. Remember that 0dBm is usually meant to represent a power of 1 mW into a 50-ohm load. See the chart below for rapid conversion from one set of units to the other (for 50-ohm systems).

The numbers below show the approximate ranges of this meter and the (more accurate and linear) one described by G4COL.[5]

| Power | | Millivolts | |
|---|---|---|---|
| dBm | milliwatts | RMS | peak |
| G4COL's meter | | | |
| 20 | 100 | 2240 | 3170 |
| 10 | 10 | 707 | 1000 |
| 0 | 1 | 224 | 317 |
| −10 | 0.1 | 70.7 | 100 |
| N2DCH's meter | | | |
| −10 | 0.1 | 70.7 | 100 |
| −20 | 0.01 | 22.4 | 31.7 |
| −30 | 0.001 | 7.07 | 10 |
| −40 | 0.0001 | 2.24 | 3.17 |
| −50 | 0.00001 | 0.707 | 1.0 |
| −60 | 0.000001 | 0.224 | 0.317 |
| −70 | 0.0000001 | 0.071 | 0.100 |
| −80 | 0.00000001 | 0.022 | 0.032 |
| −90 | 0.000000001 | 0.007 | 0.010 |

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3. Brent Trout, "A High Gain Integrated Circuit RF/IF Amplifier with Wide Range AGC," Motorola Application Note AN-513, Motorola Semiconductor Products, Inc.
4. Wes Hayward, W7ZOI, "Defining and Measuring Receiver Dynamic Range," *QST*, July 1975, page 15.
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# A HIGH-PERFORMANCE 2-METER TRANSVERTER

## Modular approach makes construction and modification easy

*By Bob Lombardi, WB4EHS, 1874 Palmer Drive, Melbourne, Florida 32935*

It seems that many VHF/UHF enthusiasts say they became interested in this part of the spectrum after having worked just about all of the DX available on HF. This wasn't the case for me. The possibilities of 2-meter operation appealed to me on their own merits. There is OSCAR, moonbounce, meteor scatter, SSB, CW, and a host of propagation modes to explore.

My interest in these modes of communication led me to review their requirements. I realized that commercial rigs available at the time didn't have the two main features I was looking for — a low noise figure and a selectable CW filter. Like many before me, I decided to build a transverter for my HF rig. These were my design goals:

- low noise figure, in keeping with the state of the art;
- output power in the range of 5 watts, with excellent linearity (third-order IMD at least 30 dB down);
- good rejection of a nearby NOAA weather radio relay (at least 40 dB down);
- moderate gain (enough to overcome the front end noise of the HF rig);
- good dynamic range.

I adopted a modular design approach advocated by Joe Reisert, W1JR, and others. I like this design because it gives me the ability to get sections working and tied together quickly. This, in turn, makes the project seem less like a constant uphill battle. Also, the modular method with its replaceable sections is a great benefit when you come up with a better design. The block diagram of the transverter appears in **Figure 1**.

### Receive strip

The receive side input (**Figure 2**) is a GaAsFET low-noise amplifier (LNA) that uses a circuit similar to Reisert's[1] and to those in general FET applications notes. The device is a single gate MGF-1402 made by Mitsubishi; it's available from several sources.* The 10-k resistor on the input bleeds off static buildup. Any value around 10 k will work, as long as you use a carbon composition resistor. (I had a persistent and elusive oscillation; it was caused by the metal film resistor I was using!) I used diodes around the regulator to protect against regulator latch-up or inductive spikes from the T/R relay. The amplifier had a noise figure of under 0.75 dB and a gain of 23 dB, as measured on an Ailtech noise figure meter and HP network analyzer.

The filter (shown in **Figure 3**) was described in an earlier article.[2] I wanted the filter to be narrowband enough to pass all 4 MHz of the band, and still provide over 40 dB of rejection at 162.55 MHz. It provides nearly 55 dB, at a cost of about 5 dB of insertion loss. At this point, however, there was gain to burn to meet the design goals of about 10 dB of gain in the complete transverter.

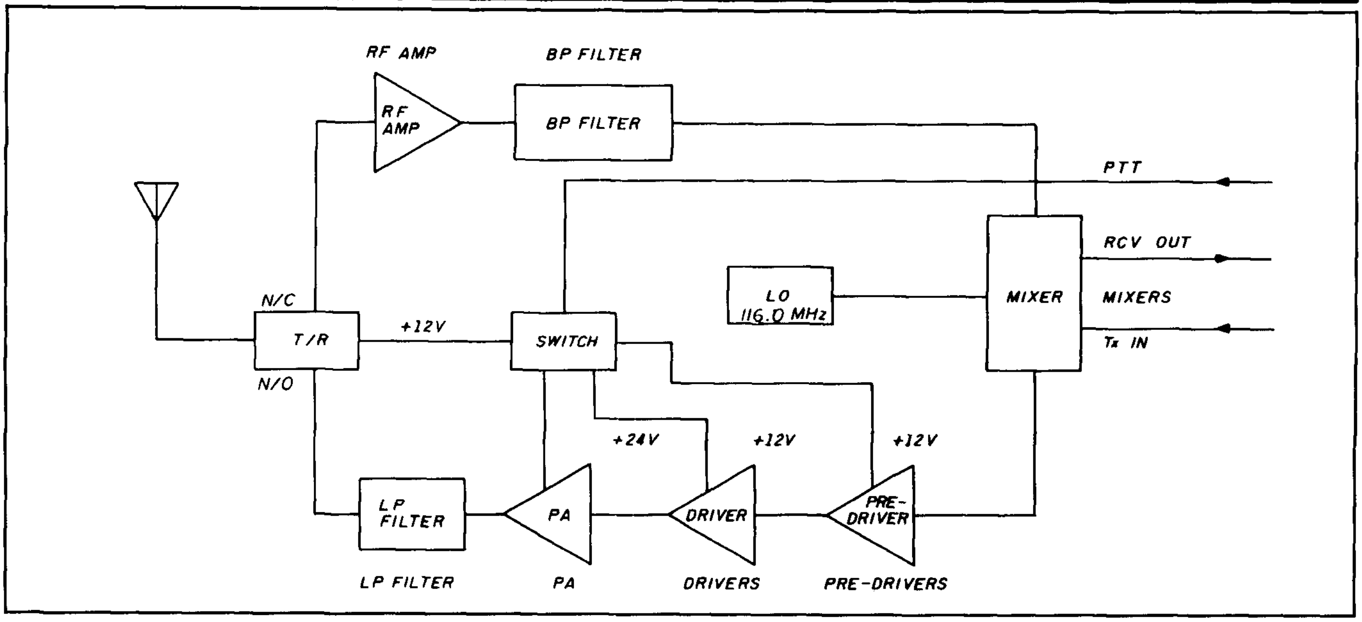
A 116-MHz overtone crystal oscillator provides the LO function for both sides of the transverter (**Figure 4**). The oscillator is a common base design, largely based on Reisert.[3] The output was measured at +13 dBm, allowing the use of a two-way power splitter to provide LO to both mixers.

The receive mixer is a Mini-Circuits SRA-1000 (see **Figure 5**). It is essentially the same as their SRA-1 in this application. The IF output goes into a diplexer and 24 to 34-MHz bandpass filter. In band, the diplexer (the parallel-resonant circuit and 51-ohm resistor) presents an open circuit, and no signal flows in the resistor. As the frequency changes the reactive components tend to short out the tank circuit, allowing signal to flow into the termination and to ground. The mixer sees the 51-ohm resistor at these frequencies.

The receiver input stage is largely responsible for determining the system noise figure, and the noise figure is degraded by any losses in front of it. If you're new to the field of low-noise design, this explains what must seem like the unconventional design of the transverter; i.e., the amplifier ahead of the filter. (This is a common design technique in microwave receiver

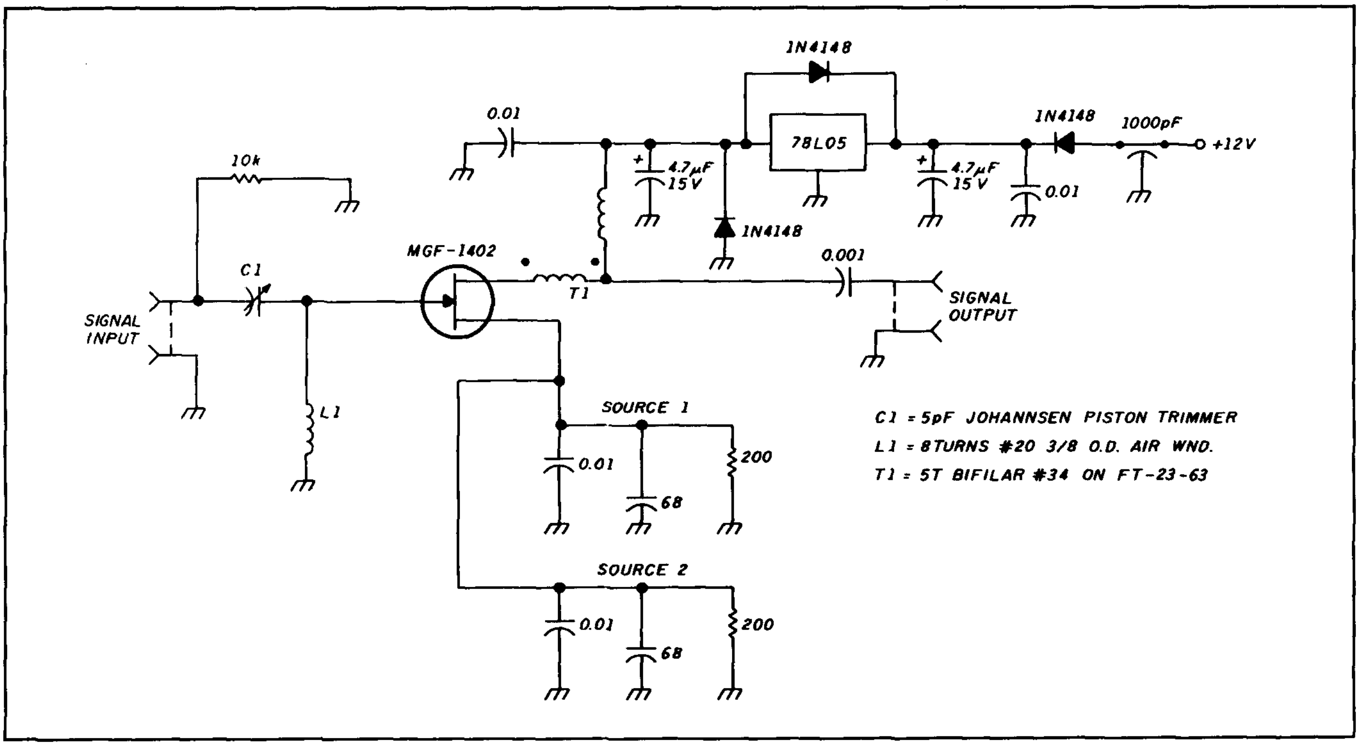
*See parts sources at the end of the article. *Ed.*

FIGURE 1




**Block diagram of the complete transverter.**

FIGURE 2

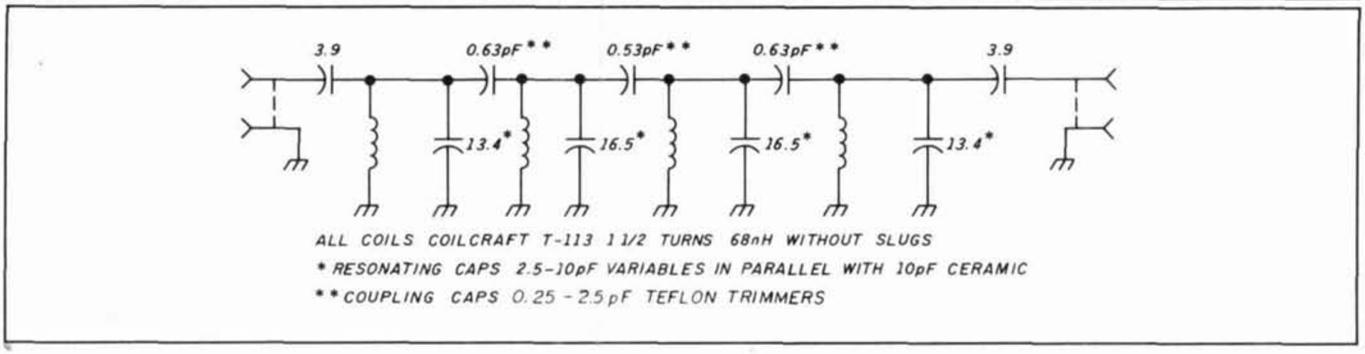



**Schematic of the receive input RF amplifier.**

design, like TVROs.) To minimize the effects of losses in front of the amp, I used foam-flex (hardline) coax as the feedline, with short flexible jumpers of RG-214/U where required.

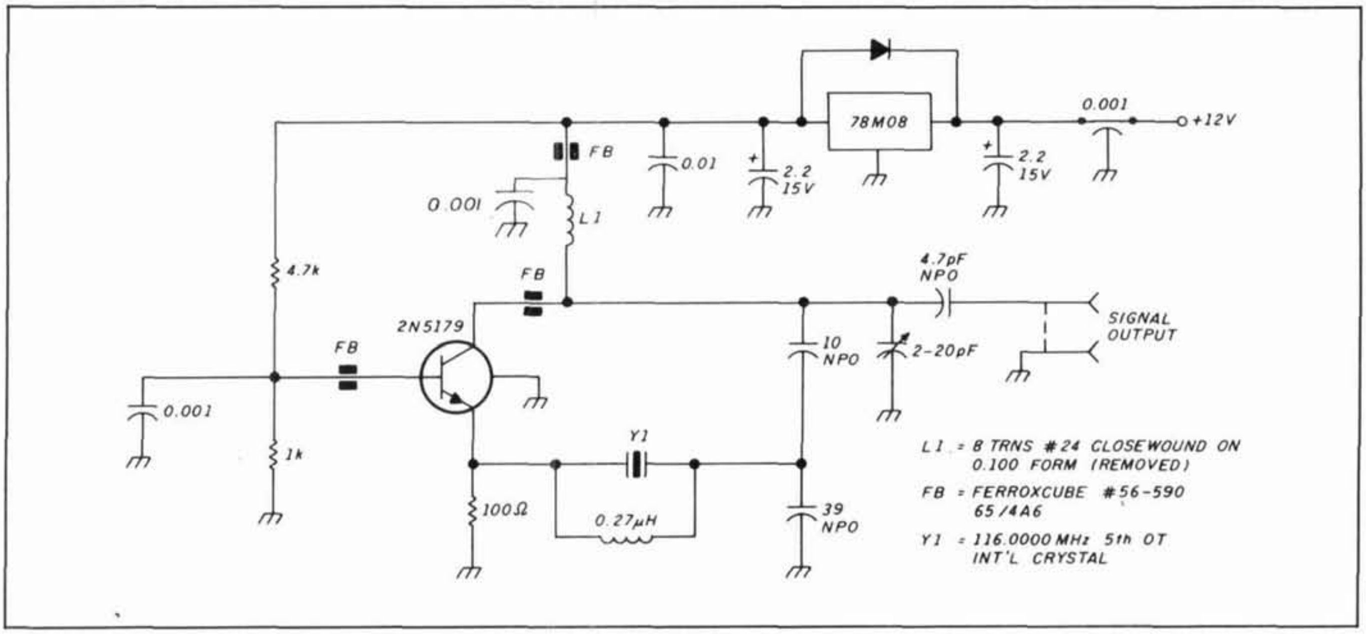
Other hams have told me on the air that my low noise figure is unnecessary in 2-meter SSB because ground noise predominates. While this maybe true, my idea all along was that receiver noise shouldn't be a limiting factor if I wanted to swing my antennas up for OSCAR — or anything else I might try. When you add that to the high intercept point of the GaAsFET front end, and the resulting improvement in dynamic

## FIGURE 3




Details of the BP (bandpass) filter on the receive line.

## FIGURE 4




Local oscillator using a 116-MHz overtone crystal.

*Parts list*

**CAPACITORS**

**Electrolytic or tantalum**

| | | |
|---|---|---|
| 1.5 μF/15 volts | 1 each | |
| 2.2 μF/15 volts | 1 | Radio Shack 272-1435 |
| 4.7 μF/15 volts | 3 | 272-1024 |
| 10 μF/35 volts | 1 | 272-1025 |
| 330 μF/16 volts | 1 | 272-1030 (470 μF) |

**Ceramic, monolithic dipped, 50 volts (Z5U or X7R)**

| | |
|---|---|
| 68 pF | 2 |
| 470 pF | 1 |
| 0.001 μF | 20 |
| 0.01 μF | 10 |
| 0.1 μF | 1 |

**Ceramic, monolithic dipped, 50 volts (COG or NPO)**

| | |
|---|---|
| 3.9 pF | 4 |
| 4.7 pF | 1 |
| 10 pF | 8 |
| 27 pF | 1 |
| 39 pF | 1 |
| 47 pF | 2 |
| 270 pF | 2 |

**Trimmers—all values in pF**

| | | |
|---|---|---|
| 0.25-2.5 Teflon | 4 | BP filters |
| 0.5-5 glass/air | 1 | GaAsFET amp |
| 1-5 pF ceramic | 5 | |
| 2-20 ceramic | 5 | |
| 2-8 mica | 2 | PA |
| 2.4-50 mica | 2 | PA |
| 2.5-10 ceramic | 5 | |
| 9-35 ceramic | 4 | |
| 5.5-18 | 1* | |

*Most of these came from my junkbox, the result of years of hamfest buying. Try Communications Concepts, Inc., and other Some of these could be made into more parts of one value.

**RESISTORS**

**1/4-watt carbon composition, 5 percent**

| | |
|---|---|
| 51 ohm | 1 |
| 100 ohm | 1 |
| 200 ohm | 2 |
| 1 k | 2 |
| 1.5 k | 1 |
| 4.7 k | 1 |
| 5.6 k | 1 |
| 10 k | 4 |
| 100 k | 1 |

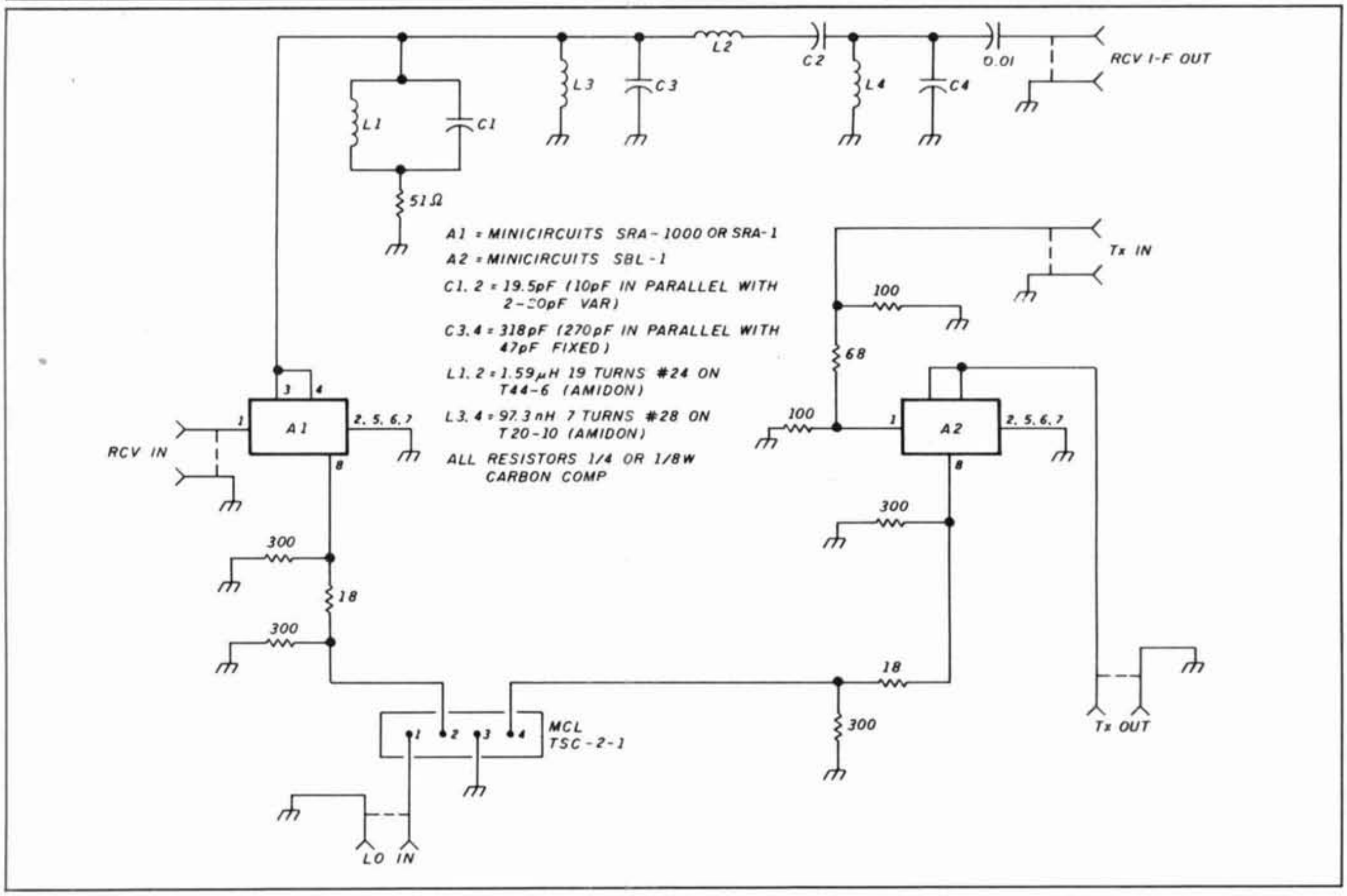
**1/2-watt carbon composition, 5 percent**

| | |
|---|---|
| 100 ohm | 2 |
| 750 ohm | 1 |

**1-watt carbon composition, 5 percent**

| | |
|---|---|
| 62 ohm | 2 |
| 68 ohm | 1 |

**FIGURE 5**




Receive and transmit mixer schematic.

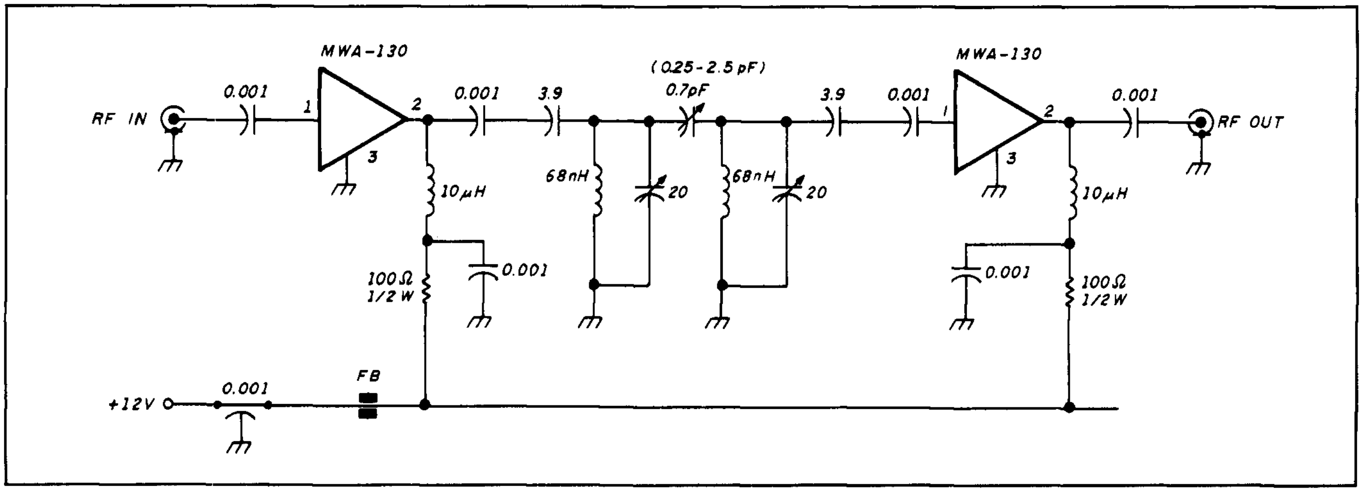
| | |
|---|---|
| 2-watt carbon composition | |
| Any value over 100 k (used as coil form) | |
| 1/8-watt carbon composition, 5 percent | |
| 18 ohm | 2 |
| 300 ohm | 4 |
| 68 ohm | 1 |
| 100 ohm | 2 |
| **SEMICONDUCTORS** | |
| Diodes | |
| 1N4148 general purpose | 6 (widely available) |
| 1N4004 rectifier | 1 |
| 1N757 9-volt zener | 1 |
| 1N751 5-volt zener | 1 |
| Transistors | |
| 2N2222 NPN | 1 |
| 2N3553 NPN | 1 RF Parts Company |
| 2N5109 NPN | 1 RF Parts Company |
| 2N5179 NPN | 1 RF Parts Company |
| MGF-1402 GaAsFET | 1 RF Parts Company |
| MRF-134 powerFET | 1 RF Parts Company |
| **OTHERS** | |
| MWA-130 amplifier modules | 2 Communications Concepts |
| 78L05 5-volt regulator | 1 (widely available) |
| 78L08 or 78M08 8-volt regulator | 1 (widely available) |
| LM-311 comparator | 1 (widely available) |

| | |
|---|---|
| **MISCELLANEOUS PARTS** | |
| Ferrites | |
| FT-23-63 | 1 Amidon |
| Beads, Ferroxcube type 4A6 | 4 Amidon (cross-reference) |
| Two-hole balun (for RFC on driver assembly) | |
| BLN 43-2402 | 3 Amidon |
| Ferroxcube VK200-19/4B | 1 Amidon (cross-reference) |
| **TOROIDS** | |
| T44-6 | 2 Amidon |
| T20-10 | 2 Amidon |

*Note: The exact ferrite bead used in most cases isn't critical. It should present several microhenries of inductance at the operating frequency.*

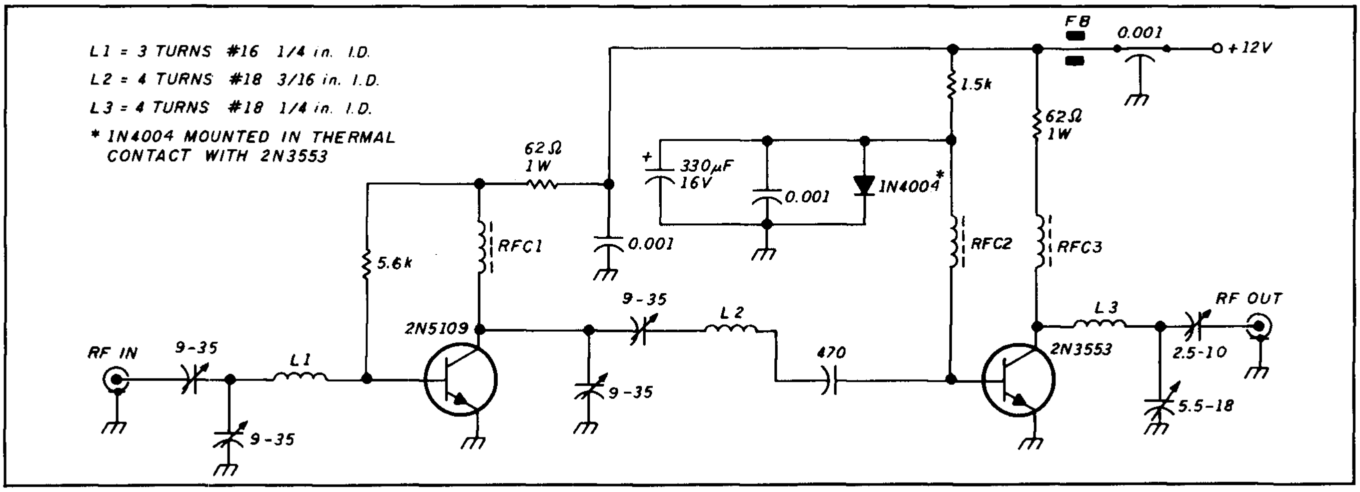
| | |
|---|---|
| **OTHER PARTS** | |
| SBL-1 mixer | 1 Mini-Circuits, others |
| SRA-1 | 1 |
| TSC-2-1 power splitter | 1 Mini-Circuits, others |
| 116-MHz fifth overtone crystal | 1 ICM |
| 5-k multiturn pot | 1 Radio Shack |
| T/R power switch relay 12 volt | 1 Radio Shack |
| T/R coaxial relay 12 volt | 1 Communications Concepts |
| RF coaxial connectors | 15 SMA female (as required) |
| Coaxial jumpers | (as required) |
| Boxes | (as required) |
| Feedthrough capacitors | 0.001 μF 50 volts (as required, 1 per box) |
| 10μH molded chokes | 2 |

FIGURE 6




**Transmit predriver schematic.**

FIGURE 7




**Driver chain schematic. RFC 1-4 = 4 turns of no. 20 wire through a two-hole ferrite balun. Amidon no. BLN 43-2402.**

range, the GaAsFET still seems the most logical choice.

My initial test of the receive side yielded good results. While conducting tests with WA4GHK (15 miles south), it was easy to copy K4DZP in Miami (over 160 miles south) — despite my makeshift indoor antenna!

## Transmit chain

The transmit portion of the transverter presents its own problems; the biggest is linearity. A rule of thumb for diode ring mixers (like the SBL-1 used here) is to have the input signal at least 10 dB below the LO for best linearity (see **Figure 5**). Because one of my design goals was to achieve very good linearity from the transmitter, the first thing I did was pad the input drive (+3 dBm) from my HF rig. The resulting level was about −7 dBm, 14 dB lower than the LO drive. Since all the pads were made with the closest value resistors, and the mixer itself contributes loss, I measured the conversion loss of the transmit mixer. It was 17.7 dB.

The pre-driver stage in **Figure 6** is suppposed to recover all of the signal lost in the conversion, provide enough filtering to remove significant power on the image frequency, and reduce LO feedthrough. I used MWA-130 amplifiers, modular 50-ohm in-and-out devices in TO-5 cans, because they are easy to use and were available on a surplus board that I scavenged. The power out at this point is 4 mW (+6 dBm).

The actual drivers are two transistors, a 2N5109 and a 2N3553 (see **Figure 7**). The first device is a well-known VHF linear transistor; the second is a 28-volt, TO-5 can device capable of 2 watts if run class C. This was originally to have been a three-transistor strip with 1 watt out from a third 2N3553, but I was never able to get them to more than 500 mW and still remain linear with a 12-volt supply. I tried many variations of bias circuits, matching networks, and pc layouts. The two-device strip I settled on produces 18 dB of gain, or about 250 mW out.

The final amp is a Motorola MRF-134 TMOS powerFET that delivers just over 4 watts out and a clean, linear signal (third-order intermod down just over 30 dB). See **Figure 8** for details.

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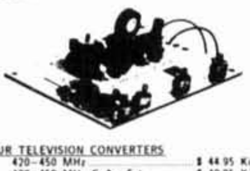

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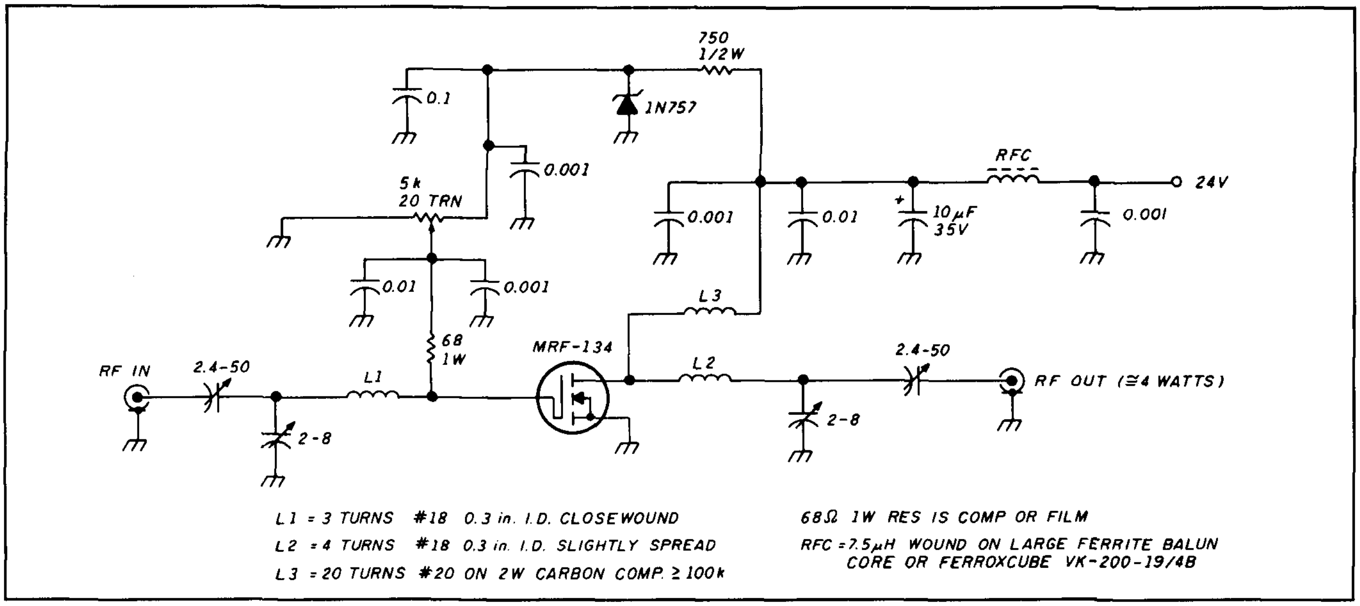
FIGURE 8




**Final amplifier using an MRF-134.**

All design decisions are tradeoffs. For example, using the MRF-134 created the need for a small 24-volt supply — but I gained advantages in other areas. First, the FET is guaranteed to deliver rated power into a 30:1 VSWR at any phase angle (no delicate device here!); second, it's capable of more gain in one package than a bipolar; and last, it worked the first time I tried it — a very enjoyable experience after my trials and tribulations with the '3553s.

The circuit is taken largely from the *Motorola RF Data Book* applications note.[4] Component changes are based on availability and personal preferences. In any RF power amplifier it's essential to keep the ground leads of the device as close as possible to ground on the board. I connected top and bottom foil with a strip of copper shim stock at the point where the source leads leave the device package. The FET itself is on an extremely overrated heat sink; after extended key down periods everything remains at ambient temperature.

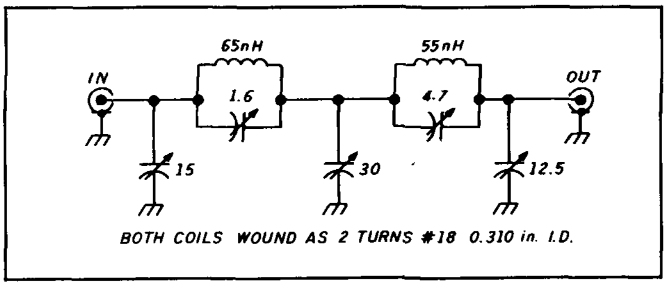
The output filter in **Figure 9** is an elliptical low-pass design. The two parallel resonant circuits are tuned to 313 and 487 MHz with a grid-dip meter; the other caps are adjusted for minimum insertion loss while you watch output power on a wattmeter. My version had a measured insertion loss of under 0.2 dB.

I used a simple comparator on the PTT line from the HF rig to do the T/R switching (see **Figure 10**). The relay is DPDT. It switches 12 and 24 volts to the transmit amplifiers and 12 volts to the antenna relay (a Dow-Key relay I picked up at a local hamfest). The relay provides over 40 dB of isolation during transmit; the GaAsFET sees −4 dBm, well within its capabilities. (I leave it powered on continuously.) This relay should be adequate at power levels of up to 100 watts.

## Construction and alignment

This is a sophisticated project and you'll need building experience. If you've had experience with other RF circuitry, you'll find it presents few special challenges. I used pc boards for the GaAsFET RF amplifier, filters, and all transmit stages. The LO, mixers, and the T/R switching boards are built "dead bug" style; they function quite well that way. If you are an experienced builder who uses point-to-point techniques at these frequencies, you may want to use that method. I used SMA connectors on small-diameter coax (RG-188) for signal interconnects. You may prefer to use BNCs. Likewise, I used pc board material for housing circuits — you may prefer commercially made enclosures.

FIGURE 9




**Schematic of the transmit LPF (low pass filter).**

I've already mentioned the need to keep grounds short on the final amplifier; the same holds true for the driver stages. This is the strongest argument for using pc boards for these stages. The emitters of the driver transistors are grounded immediately, with minimal lead length.

There are no "peculiarities" of alignment. Align the filters separately, tuning them as desired. It's best to align the transmit stages with a spectrum analyzer. Tune the drivers for best output while observing third-order intermod. This will not occur at maximum power out. The same applies to the final amplifier.

Ideally, the GaAsFET should be aligned with noise figure instrumentation. If that isn't available, tune for maximum noise level by ear, and then detune slightly. The optimum noise fig-

124



125

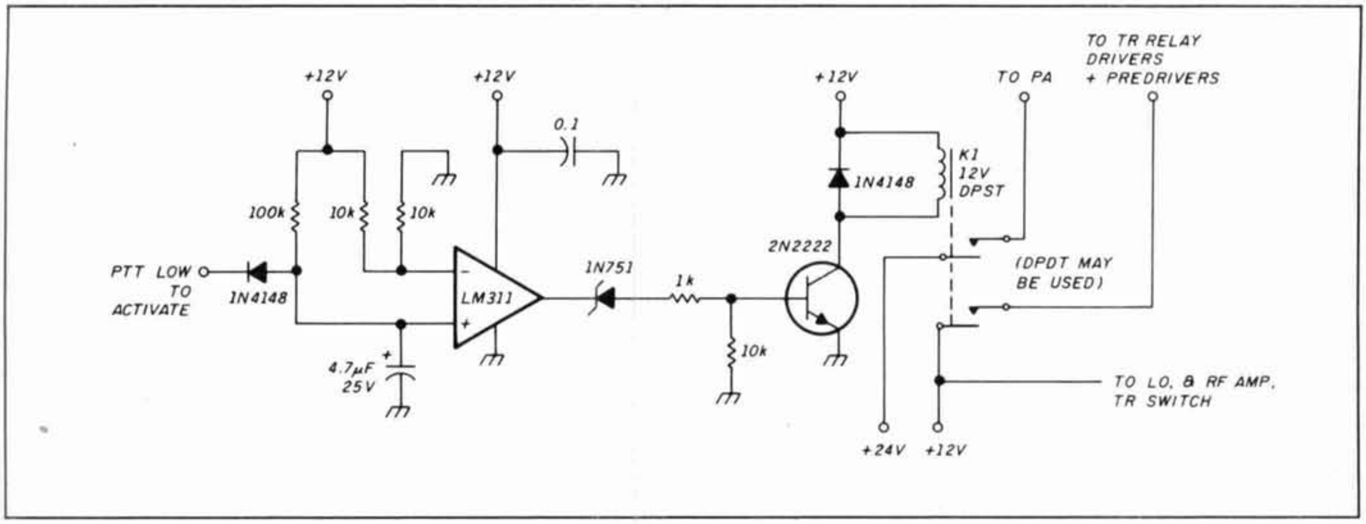


126



127

**FIGURE 10**




**T/R switch schematic.**

ure match isn't far from max gain, but that's about as quantitative as I can get.

## Performance

On-the-air results have been good. I actually used the transverter for quite a while at the 250-mW level, and surprised myself by working most of peninsular Florida. I made some of my best contacts with an indoor antenna and the pieces of my project spread across my desk. Moving up to 4 watts put me within 3 dB of the mainstream of off-the-shelf 2-meter SSB rigs (that's about half of one S-unit), and to a level that could be used with commercial amplifiers. It also netted me contacts with five southeastern states using a small antenna at rooftop height.

I'd like to thank Jim Hagan, WA4GHK, for his part in the conceptual design of this circuit and for helping me with on-the-air tests.

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REFERENCES


1. Joe Reisert, W1JR, "Low Noise GaAsFET Technology," *Ham Radio*, December 1984, pages 99-112
2. Bob Lombardi, WB4EHS, "Build Narrowband Filters," *Ham Radio*, March 1986, pages 10-21
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# Practically Speaking

*Joseph J. Carr, K4IPV*

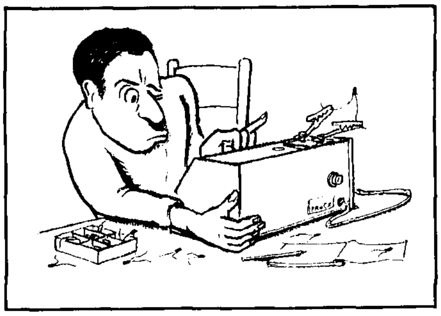
## MORE DIGITALLY GENERATED SAWTOOTH, PLUS TRIANGLE WAVES

I've dealt with methods for generating sawtooth waveforms, and discussed them in this column on several occasions. I became interested in this topic quite a while ago — right after I built the Science Workshop's "Poor Man's Spectrum Analyzer." The project uses a sawtooth waveform to sweep the DC tuning control voltage of a varactor-tuned TV front end. In an article reviewing the analyzer, I mentioned that it was possible to build a digitally generated sawtooth waveform that was quite a bit better than the op amp version used in the original project. The response was staggering; I'm still receiving requests for the circuit. I've already published one version of the circuit in this column. This month I'm going to take a look at an updated version that allows control over sweep width, and superimposes the sawtooth on top of a DC level that sets the center frequency of the spectrum analyzer.

I'll also discuss an even newer version of the circuit that allows several options including negative-going sawtooth, positive-going sawtooth, and a triangle wave. In all three cases, the waveform is generated by applying the output of a binary counter to the input of a digital-to-analog converter (DAC).

The circuit for the original digitally synthesized sawtooth generator is shown in **Figure 1**. The heart of this circuit is IC1, a DAC0806 eight-bit DAC. This converter is an inexpensive IC, based on the MC-1408 family of DACs. I selected the DAC0806 because it's appropriate to the application and easily available through mail-order sources like Jameco Electronics, or in blister packs through Jameco's local distributor line — Jim-Paks.

A "multiplying" DAC like the DAC0806 produces an output current that is proportional to: **a)** the reference



voltage or current, and **b)** the binary word applied to the digital inputs. The controlling function for the DAC selected for this article is:

$$I_o = I_{ref} \times \frac{A}{256} \quad \textbf{(1)}$$

Where:

$I_o$ is the output current from pin no. 4

$I_{ref}$ is the reference current applied to pin no. 14

A is the decimal value of the binary word applied to the eight binary inputs (pins 5 through 12)

The reference current is found from Ohm's law. It is the quotient of the reference voltage and the series resistor at pin no. 14. In data acquisition systems, where the DAC is most used, the reference voltage is a precision, regulated potential. But in this case you don't need the precision, so use the V+ power supply as the reference voltage. This means the reference current is +12 volts DC/R1. With the value of R1 shown (6800 ohms), $I_{ref}$ is 0.0018 A, or 1.8 mA. Values from 500 $\mu$A to 2 mA are permissable with this device. If you elect to change the reference current, be sure to keep R1 equal to R2.

The reference current sets the maximum value of output current $I_o$. When a full-scale binary word (11111111) is applied to the binary inputs, output current $I_o$ is:

$$I_o = (1.8\ mA) \times \frac{255}{256} \quad \textbf{(2)}$$

$$I_o = (1.8\ mA) \times (0.996)$$
$$I_o = 1.78\ mA$$

Because the DAC0806 is a current output DAC, you must use an op amp current-to-voltage converter to make a sawtooth voltage function. Such a circuit is an ordinary inverting follower without an input resistor. The output voltage ($V_o$) will rise to a value of $I_o \times$ R5.

The actual output waveform from the circuit of **Figure 1** is "staircased" in binary steps equal to the least significant bit (LSB) current of IC1 (or the LSB voltage of $V_o$). The LSB voltage is the smallest step change in output potential caused by flipping the least significant bit (B1) either from 0 to 1, or 1 to 0. The reason you don't see the steps in **Photo A** is that the frequency response of the 741 operational amplifier used for the current-to-voltage converter acts as a low-pass filter to smooth the waveform. If you use a higher frequency op amp, a capacitor shunting R3 will serve to low pass filter the waveform. A −3 dB frequency (F) of 1 or 2 kHz will suffice to smooth the waveform. The value of the capacitor is calculated from:

$$C_{\mu F} = \frac{1{,}000{,}000}{6.28\ R3\ F} \quad \textbf{(3)}$$

Where:

$C_{\mu F}$ is the capacitance in microfarads

F is the −3 dB cut-off frequency in hertz (Hz)

R3 is expressed in ohms

This circuit is synchronized by a clock oscillator consisting of a single 555 IC timer. Although not a TTL device, the 555 is TTL-compatible when the V+ potential applied to pins 4 and 8 is limited to +5 volts DC. The 555 is connected in the astable multivibrator configuration, causing it to output a chain of pulses with a +4 volt amplitude. The operating frequency is set by three resistors (R3, R4, and an external potentiometer) and a capacitor selected by the user. The actual clock frequency is:

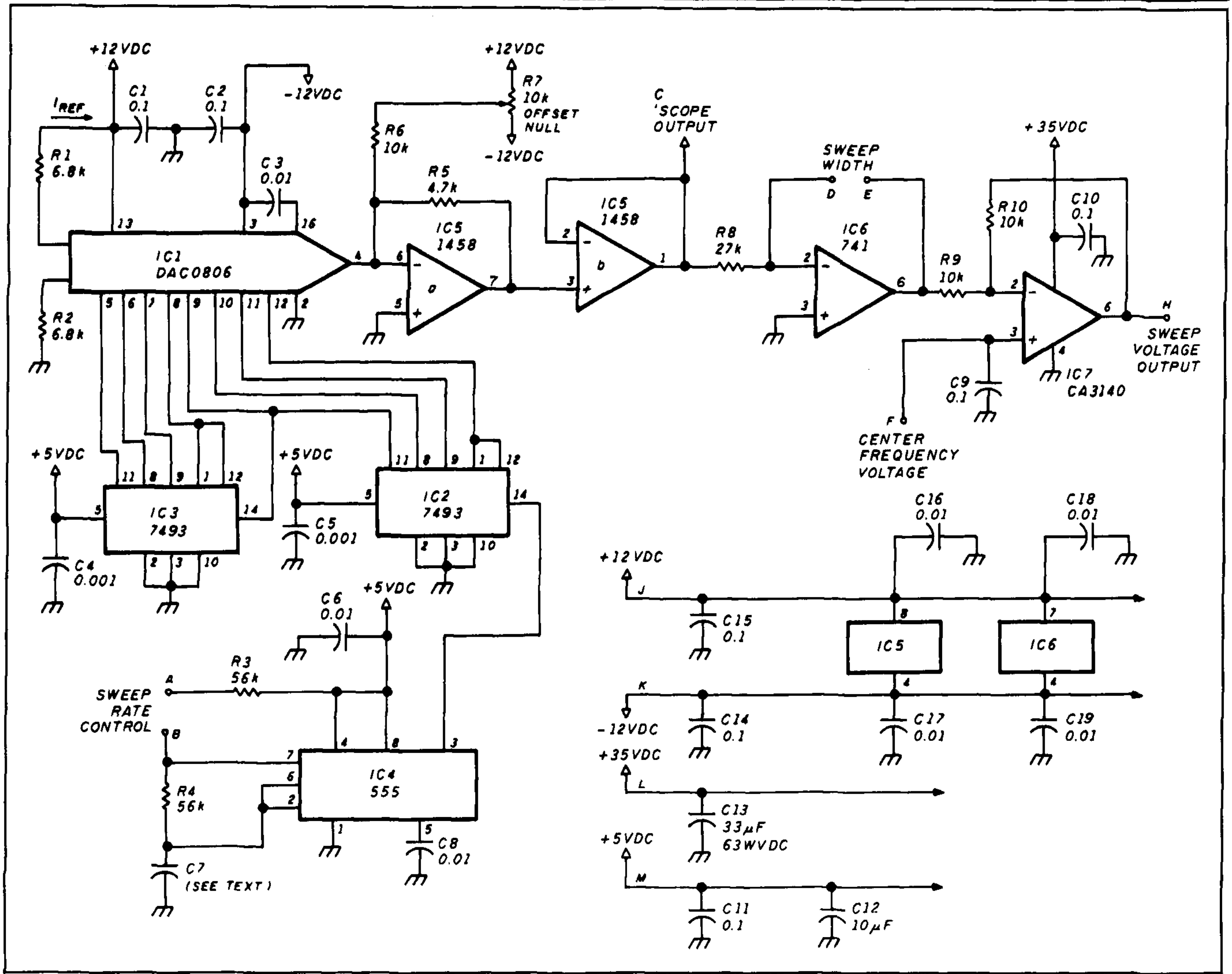
$$F = \frac{1.44}{((R3 + R12) + 2R4)\ C} \quad \textbf{(4)}$$

Where:

F is the frequency in hertz (Hz)

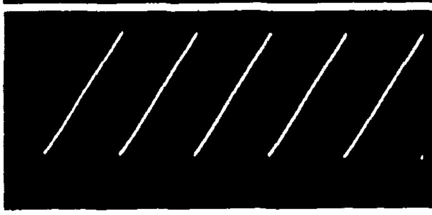
C is in farads

FIGURE 1




**Schematic of the circuit for generating the digital sawtooth output.**

PHOTO A



**The "normal" output of the sawtooth generator.**

R3, R4, and R12 are in ohms

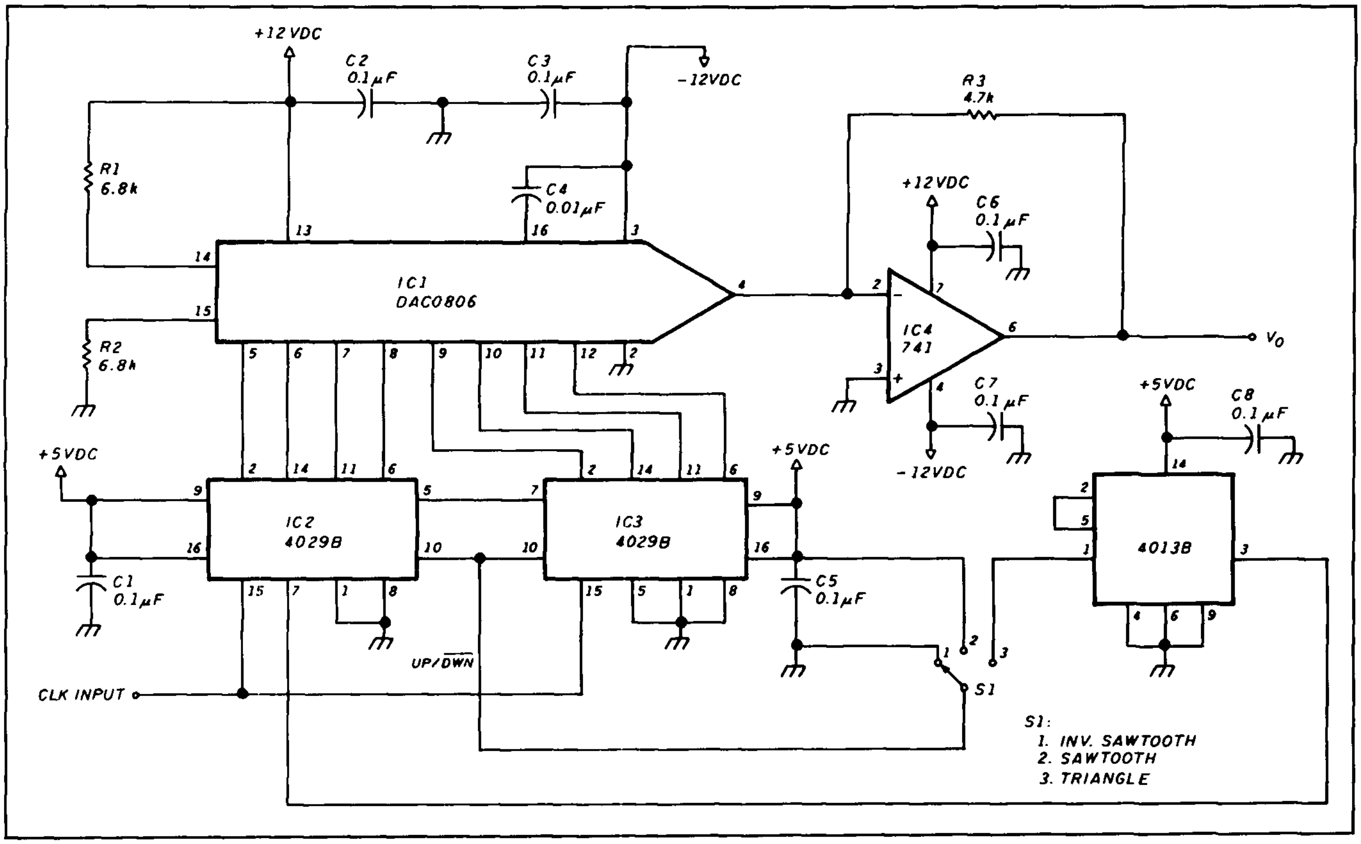
Select a clock frequency that's 256 times the desired sawtooth fundamental frequency. For example, if you want to sweep the spectrum analyzer at 30 Hz, select a clock frequency of 30 × 256, or 7680 Hz.

I selected two outputs for this project. Point "C" is a fixed positive-going output of about 1.5 volts. For purposes of the spectrum analyzer, this output drives the horizontal input of the oscilloscope used with the project. The signal present at this output is shown in **Photo A**.

You'll see a positive-going sawtooth riding on top of a DC level at point "H." The DC control voltage that sets the center frequency of the spectrum analyzer is applied to point "F," which is also the noninverting input of the operational amplifier. Because the noninverting input sees a gain of 2, the voltage applied to point "F" should be one-half the maximum fixed tuning voltage. The op amp used for the output stage is an RCA/GE CA-3140 device chosen because it can tolerate a power supply differential between V+ and V− of 44 volts DC. However, in this circuit the supply voltage for the output stage is limited to about 35 volts DC, which is the maximum tuning voltage required of the spectrum analyzer.

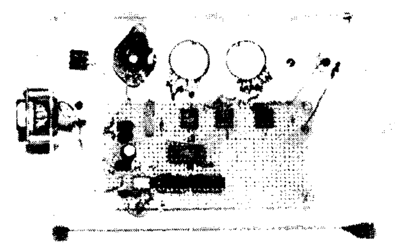
After building a version of the circuit shown in **Figure 1** for use with my spectrum analyzer, I decided that it would be nice to have a sawtooth generator on the workbench. My interest was heightened by the fact that I'm working on an RF sweep generator for the HF Amateur bands and need to do some additional development work. **Photo B** shows the finished project. It has both positive and

FIGURE 2




**Partial schematic of the digital sawtooth generator with the modification to allow normal, inverted, and triangle wave outputs.**

PHOTO B



**The completed circuit in its enclosure.**

negative-going outputs, as well as the ability to select internal and external clocks. If you want a copy of the circuit, just send me a no. 10 SASE.

## Sawtooth/triangle generator

Because of several letters I've received, and the requirements of the "bandsweeper" signal generator that I'm building, I designed and built a new generator circuit. This circuit (shown in **Figure 2**) is made to output one of the following waveforms: **a)** positive-going sawtooth, **b)** negative-going sawtooth, and **c)** triangle wave. Once again, the heart of the circuit is a DAC0806 digital-to- analog converter chip (IC1). This part of the circuit, including the operational amplifier (IC4) current-to-voltage converter stage, is the same as the previous designs. The difference lies in the binary counter stages.

The circuit in **Figure 1** used a pair of 7493 base-16 counters in cascade to drive the DAC binary inputs. The outputs of these counters increment from 00000000 to 11111111, and return to 00000000 on the next step. Thus, the DAC output is a positive-going sawtooth. However in this circuit, the counters are CMOS 4029B devices. The 4029B is an up/down, binary/decade synchronous counter. Pin 9 is the BIN/DEC control. When pin 9 is **low**, the 4029B is a decade (base-10) counter. But because you need a binary counter, pin 9 is tied **high**. Pin 10 on the 4029B is the **direction** control. When pin 10 is **high**, the 4029B acts as an ordinary up counter and increments "forward" from 00000000 to 11111111, and then goes back to 00000000 on the next count. When pin 10 is **low**, the 4029B becomes a down counter. In this mode it decrements from 11111111 backwards to 00000000, and recycles to 11111111 on the next count. The key to the operation of the circuit in **Figure 2** lies in the control of the direction of counting:

- **Positive-going sawtooth**: Use the 4029B as an up counter (pin 10 **high**).
- **Negative-going sawtooth**: Use the 4029B as a down counter (pin 10 **low**).
- **Triangle waveform**: Use the 4029B both as an up and down counter, controlling direction with external logic.

An SP3T switch (S1) does the switching between the output waveforms. The switch's wiper drives the up/down control line. In position 1, the up/down line is connected to ground, producing a negative-going "inverted" sawtooth waveform from the DAC. In position 2, it's connected to +5 volts DC, producing a regular positive-going sawtooth. In position 3, the switch up/down line is connected to the output of the direction control logic — a single CMOS 4013 chip.

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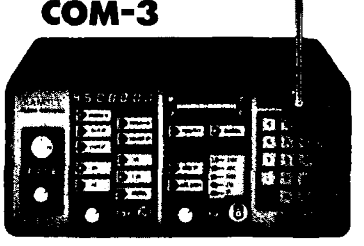

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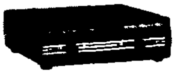

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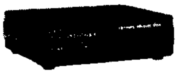

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Operate a mini ham shack. These little CW rigs are ideal mates to our 40 and 80 meter receivers. Features include smooth variable tuning, one watt output and excellent keying characteristics. Runs on 12 VDC and is VSWR protected. See how far you can stretch your signal with one of these mini rigs. Optional ABS cases are available.

40 meters QRP rig, QRP-40 **$24.95** 80 meters QRP rig, QRP-80 **$24.95** Case kit, CQRP **$12.95**

### AIRCRAFT RECEIVER KIT

Hear exciting aircraft communications—picks up planes up to 100 miles away. Receives 110-136 MHz AM air band, varactor tuned superhet design with AGC, ceramic filter and adjustable squelch. Runs on 9V battery, 50 mw audio output, 1 μv sensitivity. Optional matching ABS plastic case lets you take it anywhere, features screened graphics and machined aluminum knobs for a real professional look. Compact—great for airshows or for just plain hanging around the airport.

Complete kit, AR-1 **$24.95** Receiver case kit, CAR-1 **$12.95**

### SHORTWAVE RECEIVER KIT

A fantastic receiver that captures the world with just a 12" antenna! Receives 4–11 MHz in 2 MHz bands, varactor tuned superhet design with AGC, RF gain control, and 50 mw audio output. Uses new Signetics mixer chip for less than a microvolt sensitivity, runs on 9V battery. This is a fascinating scout, school or club project, and will provide hours of fun even to the most serious DX'er. Add the optional case kit and you have a real nice looking shortwave set.

Complete kit, SR-1 **$24.95** Receiver case kit, CSR-1 **$12.95**

### PACKET RADIO

Commodore C64/128 packet radio interface. Uses famous German Digicom software. Features EXAR IC chip set for reliable operation—runs HF or VHF tones. Includes FREE disk software. PC board, all necessary parts and full documentation.

Complete kit, PC-1 **$49.95**

### FM COMMUNICATIONS/2 METER RECEIVER

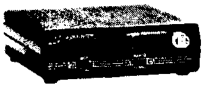
Sensitive superhet FM receiver tunes any 5 MHz segment from 135–175 MHz. Listen to 2 mtr ham operations, high band police calls, weather or mobile phone calls! Easy to build receiver features varactor tuning, IC mixer stage, ceramic IF filters and dual conversion design with adjustable squelch. Less than 1 μv sensitivity, runs on 9 V battery, with 50 mw audio output. Optional ABS case with screened graphics and machined aluminum knobs provide a nice professional look.

Complete kit, FR-7 **$29.95** Receiver case kit, CFR-7 **$12.95**

## FREQUENCY COUNTERS

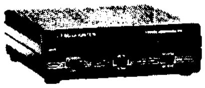
Ramsey Electronics has been manufacturing electronic test gear for over 10 years and is recognized for its lab quality products at breakthrough prices. All of our counters carry a full one year warranty on parts and labor. We take great pride in being the largest manufacturer of low cost counters in the entire USA. Compare specifications. Our counters are full featured, from audio to UHF, with FET high impedance input, proper wave shaping circuitry and durable high quality epoxy glass, plated-thru PC Board construction. All units are 100% manufactured in the USA.

### CT-70 7 DIGIT 525 MHz



**$139.95** WIRED, INCLUDES AC ADAPTER

### CT-90 9 DIGIT 600 MHz



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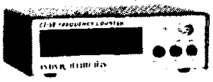
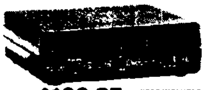
### CT-50 8 DIGIT 600 MHz



**$189.95** WIRED INCLUDES AC ADAPTER

### CT-125 9 DIGIT 1.2 GHz



**$189.95** WIRED INCLUDES AC ADAPTER

### ACCESSORIES FOR COUNTERS

| | |
|---|---|
| Telescopic whip antenna—BNC plug | $ 8.95 |
| High impedance probe, light loading | 16.95 |
| Low pass probe, audio use | 16.95 |
| Direct probe, general purpose use | 13.95 |
| Tilt bail for CT-70, 90 & 125 | 3.95 |
| Nicad pack for CT-70, 90 & 125 | 8.95 |

| MODEL | FREQ RANGE | SENSITIVITY | ACCURACY | DIGITS | RESOLUTION | PRICE |
|---|---|---|---|---|---|---|
| CT-70 | 20 Hz-550 MHz | < 50 mv To 150 MHz | 1 PPM | 7 | 1 Hz, 10Hz, 100Hz | 139.95 |
| CT-90 | 10 Hz-600 MHz | < 10mv To 150 MHz<br>< 150mv To 600 MHz | 1 PPM | 9 | 0.1Hz, 10Hz, 100 Hz | 169.95 |
| CT-50 | 5 Hz-600 MHz | LESS THAN 25 mv | 1 PPM | 8 | 1Hz, 10Hz | 189.95 |
| CT-125 | 10 Hz-1.25 GHz | < 25mv @ 50 MHz<br>< 15mv @ 500 MHz<br>< 100mv @ 800 MHz | 1 PPM | 9 | 0.1Hz, 1Hz, 10Hz | 189.95 |
| CT-90 WITH OV-1 OPTION | 10 Hz-600 MHz | < 10mv To 150 MHz<br>< 150mv To 600 MHz | 0.1 PPM | 9 | 0.1Hz, 1Hz, 10Hz | 229.90 |

## MINI KITS—EASY TO ASSEMBLE—FUN TO USE

**TONE DECODER**
A complete tone decoder on a single PC board. Features: 400-5000 Hz adjustable range via 20 turn pot, voltage regulation, 567 IC. Useful for touch-tone burst detection, FSK, etc. Can also be used as a stable tone encoder. Runs on 5 to 12 volts.
Complete kit, TD-1 **$5.95**

**COLOR ORGAN**
See music come alive! 3 different lights flicker with music. One light each for, high, mid-range and lows. Each individually adjustable and drives up to 300 W, runs on 110VAC.
ML-1 Kit **$8.95**

**VIDEO MODULATOR**
Converts any TV to video monitor. Super stable, tunable over ch 4-6. Runs on 5-15V, accepts std. video signal. Best unit on the market! Complete kit, VD-1 **$7.95**

**FM WIRELESS MIKE**

Transmits up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9V. Type FM-2 has added sensitive mike preamp stage.
FM-1 Kit **$3.95**
FM-2 Kit **$4.95**

**LED BLINKY KIT**
Alternately flashes 2 jumbo LEDs. Use for name badges, buttons, warning panel lights. Runs on 3 to 15 volts.
BL-1 Kit **$2.95**

**MAD BLASTER**
Produces LOUD ear shattering and attention getting siren like sound. Can supply up to 15 watts of obnoxious audio. Runs on 6-15 VDC.
MB-1 Kit **$4.95**

**40 WATT 2 mtr PWR AMP**
Simple Class C power amp features 8 times power gain. 1 W in for 8 out, 2 W in for 15 out, 5 W in for 40 W out. Max output of 50 W, incredible value, complete with all parts, less case and T-R relay.
PA-1, 40 W pwr amp kit **$27.95**
TR-1, RF sensed T-R relay kit **6.95**

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Voice activated switch kit provides switched output with current capability up to 100 mA. Can drive relays, lights, LED or even a tape recorder motor. Runs on 9 VDC.
VS-1 Kit **$6.95**

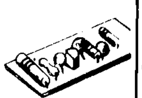
**UNIVERSAL TIMER**
Provides the basic parts and PC board required to provide a source of precision timing and pulse generation. Uses 555 timer IC and includes a range of parts for most timing needs.
UT-5 Kit **$5.95**

**WHISPER LIGHT**
An interesting kit, small mike picks up sounds and converts them to light. The louder the sound, the brighter the light. Includes mike, controls up to 300 W, runs on 110 VAC.
WL-1 Kit **$6.95**

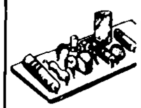
**SIREN**
Produces upward and downward wail. 5W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.
Complete kit, SM-3 **$2.95**

**SUPER SLEUTH**
A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker.
BN-9 Kit **$5.95**

**60 Hz TIME BASE**
Runs on 5-15 VDC
Low current (25ma)
1 min/month accuracy
TB-6 Kit **$5.50**
TB-6 Assy **$9.95**



**TELEPHONE TRANSMITTER**
Low cost with professional performance. Features include self phone line powered, tunable from 76 to 100 MHz, polarity antisensitive, compact size 1" x 1". Easily installs anywhere on the phone line or inside the instrument itself.
PB-1 KIT **$14.95**



**FM RECEIVER**
For built-in applications or hobby experimentation. Full fledged superhetrodyne receiver, microvolt sensitivity, 10.7 MHz IF, integrated Circuit detector, 50 mw audio amplifier, 9V external power source, operation on standard FM broadcast band as well as large portions on each side, compact (6" square) for bug detection or reception.
FR-1 KIT **$14.95**

**FM MINI MIKE**
A super high performance FM wireless mike kit! Transmits a stable signal up to 300 yards with exceptional audio quality by means of its built in electret mike. Kit includes case, mike, on-off switch, antenna, battery and super instructions. This is the finest unit available.
FM-3 Kit **$14.95**
FM-3 Wired and Tested **19.95**

NEW

**MICROWAVE INTRUSION ALARM**
A real microwave doppler sensor that will detect a human as far as 10 feet away. Operates on 1.3 GHz and is not affected by heat, light or vibrations. Drives up to 100 ma output, normally open or closed, runs on 12 VDC.
Complete Kit, MD-3 **$16.95**

NEW

**SPEECH SCRAMBLER**
Communicate in total privacy over your telephone or radio. This scrambler kit features full duplex operation using frequency inversion. Runs on a 9 volt battery. Both mike and line or speaker output/inputs. Easy to connect to any radio—telephone use requires no direct connection! Easy to build, uses IC DBM circuitry. Can also be used to descramble most com. scramblers.
Complete kit, SS-7 **$29.95**
Case kit, CSS-7 **12.95**

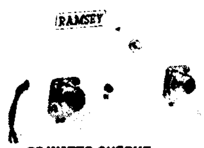
## NEW MINIKITS—NEW MINIKITS

**BROADBAND PREAMP**
A sensitive all purpose preamp, ideal for scanners, TV sets, VHF, UHF rigs, counters, etc. Features low noise, 4 db NF, 20 db gain, 100 KHz—1 GHz operation. Runs on 9–12 VDC, 50 ohms input.
Complete kit, SA-7 **$12.95**

**LIGHT BEAM COMMUNICATORS**
Transmits modulated infrared light up to 30 feet without lenses, up to 1/4 mile using lenses. Uses 30 KHz carrier for hum-free operation. Transmits thru windows, etc. Ideal for "bugs" or listening to IR remote controls. Transmitter has sensitive mike input, receiver uses PIN detector and drives speaker output. Units operates on 9-12 VDC.
Transmitter kit LB-6 **$8.95**
Receiver kit LB-5 **$9.95**

**HIGH POWER FM WIRELESS MIKE**
A high power unit that will transmit up to 1/2 mile to any FM broadcast radio. Sensitive input accepts any type of mike, will pick up normal voices 10 feet away using the available mini-electric mike cartridge. Operates on 9–12 VDC.
FM-4 kit **$9.95**
Sensitive microphone cartridge **$2.95**

## 2 MTR & 220 BOOSTER AMP



Here's a great booster for any 2 meter or 220 MHz hand-held unit. These power boosters deliver over 30 watts of output allowing you to hit the repeaters full quieting while the low noise preamp remarkably improves receptions. Ramsey Electronics has sold thousands of 2 mtr amp kits but now, we offer completely wired and tested 2 mtr as well 220 MHz units. Both have all the features of the high priced boosters at a fraction of the cost.

- 30 WATTS OUTPUT
- LOW NOISE PREAMP
- LOW COST
- RUGGED CAST ALUMINUM CASE
- ONE YEAR WARRANTY

**PA-10 2 MTR POWER BOOSTER** (10 X power gain) Fully wired & tested ........... $59.95
**PA-20 220 MHz POWER BOOSTER** (8 X power gain) Fully wired & tested ........... $59.95

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TERMS: • satisfaction guaranteed • examine for 10 days; if not pleased, return in original form for refund • add 6% for shipping and insurance to a maximum of $10.00 • foreign add 15% for surface mail • COD add $2.50 (COD in USA only) • orders under $20.00 add $1.50 • NY residents add 7% sales tax • 90 days parts warranty on all kits • 1 year parts & labor warranty on all wired units.

## PHONE ORDERS CALL 716-586-3950

FAX 716-586-4754

RAMSEY ELECTRONICS, INC., 2575 Baird Rd., Penfield, N.Y. 14526

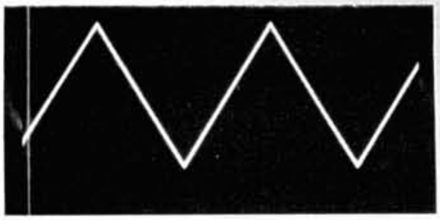
**PHOTO C**

**Positive going sawtooth waveform.**

**PHOTO D**

**Negative-going (inverted) sawtooth waveform.**

**PHOTO E**



**Triangle waveform at a frequency of one-half of the sawtooth output.**

The 4013B is a dual type D flip-flop (only one used). The 4013B has two modes, clocked and direct (use the clocked mode). In the clocked mode, the **reset** (pin 4) and **set** (pin 6) inputs are grounded to hold them **low**. The rule of operation for a clocked type D flip-flop is simple. When the clock (pin 3) is **high**, whatever logic state appears on the D input (pin 5) is transferred to the Q output (pin 1), and its complement appears on Q-NOT (pin 2). Cross-coupling Q-NOT and D provides binary division (the mode needed), so strap pins 2 and 5 together.

The **out** terminal (pin 7) on the 4029B counter has a very interesting action. The counter goes **low** momentarily on count 1111, so it's normally used for cascading stages of 4029B devices. It's used in this way to cascade IC3 to IC2. The **out** terminal of IC2 goes **low** momentarily when the total eight-bit count is 11111111, so it's used to drive the **clock** input on the 4013. When the **out** terminal of the 4029 toggles, it causes the 4013 output to change state. Because the 4013 Q output is used to drive the **up/down** input on the 4029B devices, this action forces the counter direction to reverse. Thus, in this mode, the 4029B cascaded counters increment 00000000 to 11111111, and then decrement 11111110, 11111101, and so forth, back to 00000000 — where still another reversal takes place.

The output waveforms of the circuit in **Figure 2** are shown in **Photos C, D,** and **E**. These oscilloscope photos were taken with a clock frequency of approximately 100 kHz, and represent sawtooth frequencies of just under 400 Hz. The positive-going sawtooth is shown in **Photo C**, while the negative-going version is shown in **Photo D**. The sawtooth output is shown in **Photo E**. This waveform has a frequency of one-half the sawtooth frequency, taken with exactly the same clock frequency. Note that the photos were not taken with the same ocilloscope timebase setting. Thus, the sawtooth waveform is $F_{clk}/256$, while the triangle waveform is $F_{clk}/512$.

## Conclusion

Digitally generated sawtooth and triangle waveforms are simple and easy. I suppose the next trick is to generate square waves, variable width pulses, and sine waves without using read-only memory chips. Anyone have any ideas? If so, my QTH address is below.

I can be reached at POB 1099, Falls Church, Virginia 22041; I'd like to have your comments and suggestions for this column. **hr**

# VHF/UHF ANTENNA TUNERS

## An easy, inexpensive project

*By Bill Schreiber, NH6N, 73-4327 Imo Street, Kailua-Kona, Hawaii 96740*

Some time ago, I succumbed to the lure of satellite operation and proceeded to acquire equipment. I selected the Yaesu FT-726R as my base station and cobbled up antenna rotators out of cheap, readily available components. I found the Cushcraft Oscar pair 416-TB and A144-20T to my liking (the price was right), and mounted them on my homebrew rotator combo. I also bought the Kenwood SW-200 SWR and Power Meter, plus its three sensors.

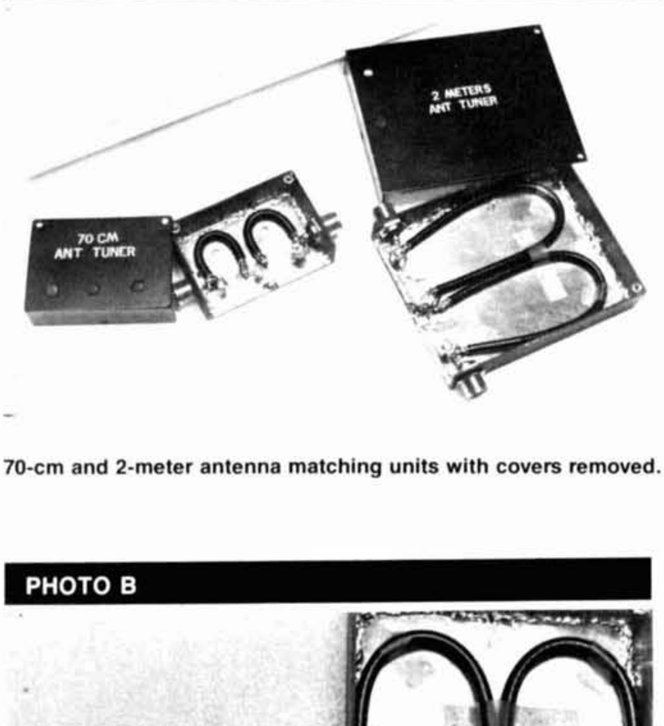
I set up the antenna system, but was unhappy with its bandwidth performance. It occured to me that a VHF/UHF antenna tuner would be a worthwhile addition to the overall system. When I was unable to locate any that I liked in my magazines, I resigned myself to spotty satellite operations. But I continued to research the literature for suitable devices.

I finally found my answer in a *Ham Radio* article by Joe Reisert, W1JR, called "Impedance Matching Techniques."[1] I have been a fan of Joe's for years and always look forward to his coverage of the spectrum above the humdrum HF bands.

Pages 33 and 34 of his article contain a description and outline of tunable antenna matchers suitable for my 2-meter and 70-cm Cushcrafts. They were easy and inexpensive to build, which was a key consideration for me. My out-of-pocket expenses for the trimmer capacitors for each unit were less than $2. The rest of the parts came out of my junkbox.

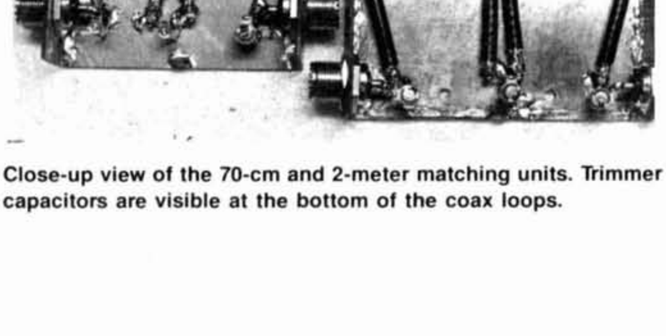
Photo A shows the two units. Dimensions of the RG-8X coaxial cable elements and boxes are indicated in Table 1. They are based on Reisert's suggested 3/16 wavelength multiplied by the 0.65 velocity factor of the coax. I used this cable because it was on hand. RG-58 would work as well. In fact, you can use RG-8 if you can bend it into shape and clamp it in position. More details are shown in Photo B (side-by-side views of the two units). Figure 1 is the schematic of the matchers from W1JR's article.

**PHOTO A**



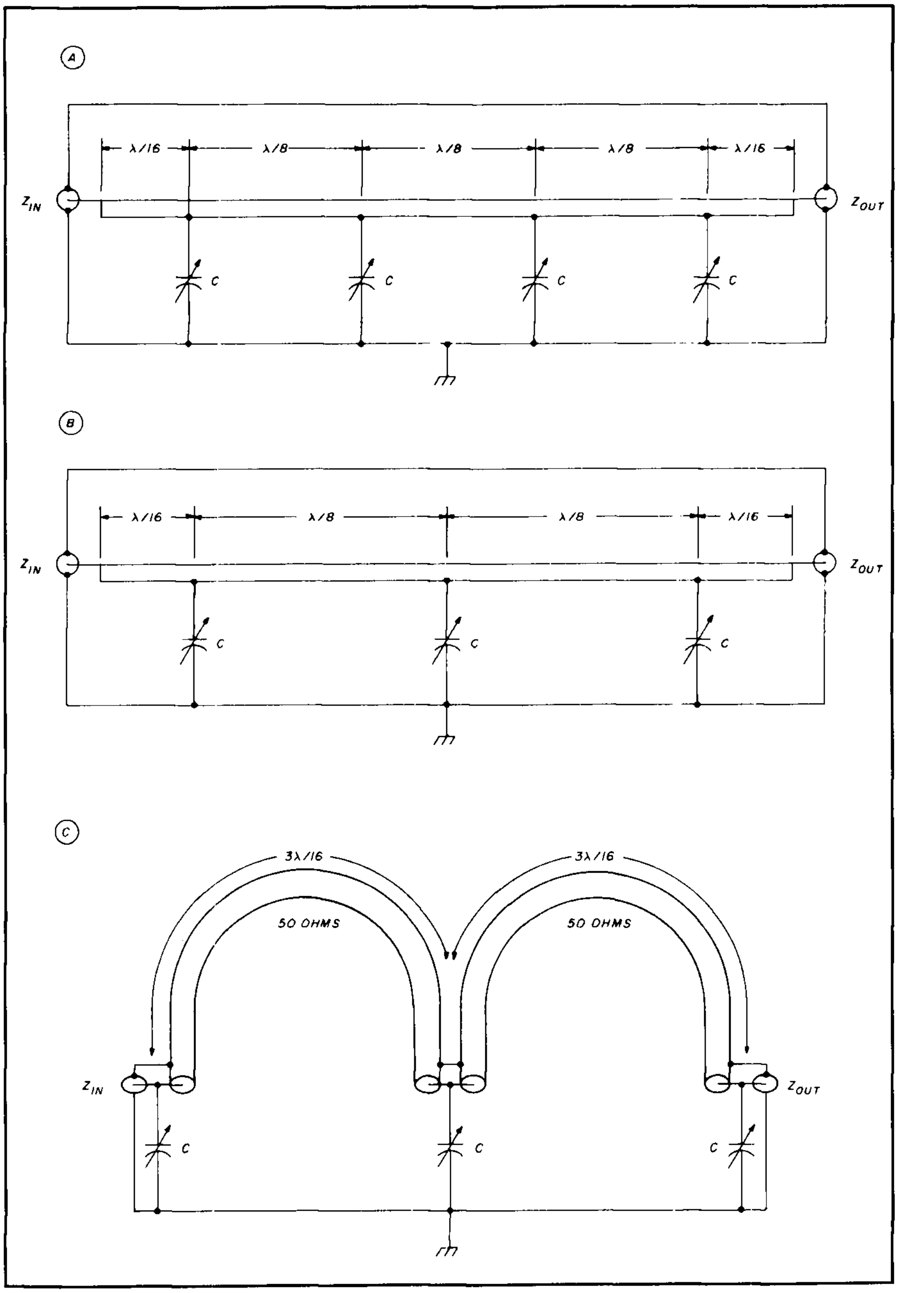

**70-cm and 2-meter antenna matching units with covers removed.**

**PHOTO B**



**Close-up view of the 70-cm and 2-meter matching units. Trimmer capacitors are visible at the bottom of the coax loops.**

FIGURE 1




**Examples of coaxial-type antenna tuners: (A) half-wavelength adjustable transformer; (B) three-eighths wavelength adjustable transformer; (C) three-eighths wavelength adjustable transformer using coaxial cable.**

TABLE 1

| | Dimensions 2 meters | 70 cm |
|---|---|---|
| Box | 5.75″ x 4.5″ x 1″ | 3.5″ x 2.5″ x 1″ |
| Coax | 15.275″ | 5.165″ |
| Trimmers | 6 to 60 pF | 2 to 20 pF |

Before mounting the coax, prepare each end by stripping off 0.5″ of the insulation and 0.25″ of the shield. Take 1″ of no. 20 bare wire, wrap part of it around the exposed shield, and solder it carefully in place. Too much heat here will melt the insulation. This should leave about 0.5″ of free end for attaching the assembly to the chassis. Solder a 0.5″ piece of the same type wire to the center conductor. Perform this cable preparation at each end of the four pieces of coax you've cut to length.

Your next step is to construct the combination chassis/box for the tuners. I gave up on the prefabricated metal boxes offered for construction projects years ago, in favor of using double-sided circuit board. These boards are widely available from electronics catalogs, as well as "surplus" electronics stores. They're inexpensive, tough, and easy to work. They also let you make enclosures which fit your exact requirements. I cut the circuit board with a carbide saw blade in my scroll saw. A word of caution here: the fiber glass core of the circuit board is murder on conventional steel saw blades, but the carbide ones seem to last forever. Once they are cut to size, it's a simple matter to solder the overlapping sections together. I also soldered 6/32 brass nuts in the corners so I could use a removable lid.

Cut the large holes for the SO 239 sockets prior to assembly. Be sure to keep the coax off the chassis at a height equal to the SO 239 center pin. In my first configuration, the coax was almost flush with the chassis and arcing occurred whenever the power level got over about 5 watts.* You must mount the trimmers with due regard for short leads and stiffness, since you will be pushing against them when they are being tuned. They should also be positioned directly under the holes cut in the lid to permit accurate insertion of the tuning tool.

Connect the tuners to the antenna on one side and the SWR/Power Meter on the other. Hook the rig into the SWR/Power Meter on the opposite side. Set the rig in its tune or CW position, reduce the drive to a very low level, and fire it up. I started with the trimmers in their minimum capacity position, and proceeded to adjust them progressively from the antenna side for minimum SWR. Once the SWR is at a tolerable level, increase the drive to max slowly, tweaking the trimmers as necessary. Don't panic if you seem to run out of adjustment room with the trimmers in either maximum or minimum position. Bend the coax gently up or down towards the chassis and you'll find a spot where the trimmers have sufficient range to permit a deep null in the SWR as read off the meter. Balancing all of the adjustments is particularly sensitive on 70 cm. Keep the relative fragility of the trimmers in mind, and don't use too much muscle.

I found that my setup stays at about 1.2:1 from 144 to 148 MHz on 2 meters. I acheived comparable results in the 435-MHz band. **hr**

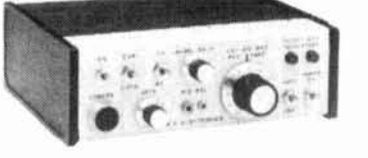
REFERENCE

1. Joe Reisert, W1JR, "VHF/UHF World: Impedance Matching Techniques," *Ham Radio*, October 1987, page 27.

*For power levels greater than ≈ 10 watts, I recommend using the following trimmers from Fair Radio Sales Co., P.O. Box 1105, 1016 E. Eureka St., Lima, Ohio 45802: 3D9025V-99 (3.2 - 25 pF) and 3D9100V (10 - 100 pF).







# New Products

## Nady EasyTalk™ Two-Way Radios

Nady Systems' line of VHF portable radios brings high-quality transceivers to all two-way radio users. The full-featured portables all list for under $300.

The VHF-40 is a 5-watt/six-channel transceiver with a 5 to 7-mile range, priced at $249. It uses a diode matrix to synthesize the signal from one crystal, and then programs it to function on up to six different frequencies. It can be programmed using the silicon diodes and the instructions included. The transceiver is powered by a battery pack that uses either rechargeable NiCd or standard AA batteries.

The VHF-30 is a miniature 5-watt/four-channel radio that transmits at a 5 to 7-mile range. It sells for $299. The unit weighs just 15 ounces and has a rugged, impact-resistant case which resists weather and contaminants.

Nady's VHF-20 is a 2-watt/two-channel model listing for $249. The pocket-sized unit has a high/low switch that changes the signal from 2 to 0.5 watts, conserving the battery pack when maximum range isn't needed.

Nady VHF radios come with a "rubber duck" antenna with a BNC connector, an AC/DC wall charger, a stainless steel belt clip, a holster-style carrying case, and a NiCd rechargeable battery pack. Nady also offers customizing options for the transceivers, including a Continuous Tone Coded Squelch System (CTCSS), a remote microphone/speaker, a high-speed desk charger, and a heavyweight leather carrying case.

For more information contact Nady Systems, Inc., 1145 65th Street, Oakland, California 94608. Phone: (415)652-2411.

**Circle #307 on Reader Service Card.**

## New catalog from Contact East

A complete source book of products for testing, repairing, and assembling electronic equipment is now available from Contact East at no charge. The new, 132-page *1989 General Catalog* contains products for engineers, managers, and technicians. All products are guaranteed. Contact East's "same-day shipment" policy assures fast delivery; orders received by 3 p.m. are shipped by 5 p.m. For your free copy and one year of technical supplements, write to Contact East, PO Box 786, 335 Willow Street, North Andover, Massachusetts 01845.

**Circle #308 on Reader Service Card.**

## MFJ-850 AC Line Voltage Monitor

The new MFJ-850 provides protection from low-voltage "brown-out" conditions that can damage your electrical equipment. Just plug it in; it tells you at a glance when your line voltage is at a low brown-out level. The expanded scale reads from 95 to 135 volts; color coding makes across-the-room reading easy. Leave it plugged in permanently for constant monitoring. It comes with MFJ's one-year unconditional guarantee.

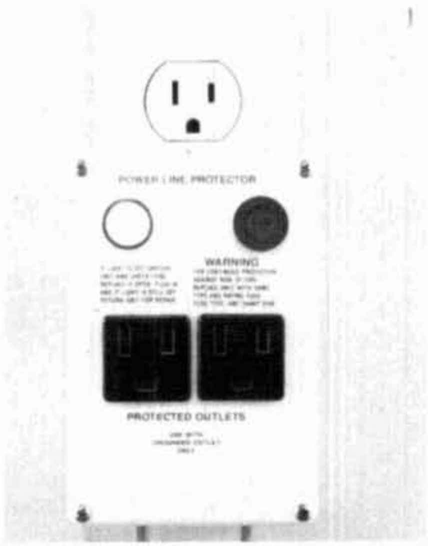
The monitor's compact size (2-1/4 × 2-1/4 × 1-1/2 inches) allows for at-home or mobile use. Use it to check computer/peripheral or video setups, portable generators, and temporary electrical setups.

For more information contact MFJ Enterprises, Inc., PO Box 494, Mississippi State, Mississippi 39762. Phone: (601)323-5869. To order call toll free at (800)647-1800.

**Circle #309 on Reader Service Card.**


## New Surge Protection from Kalglo

Kalglo Electronics Company, Inc. announces the new TeleSpiker™ series surge suppressors/power line filters with integral protection for RJ45/RJ11 modular telephone jacks. They are specially engineered to meet the protection needs of FAX machines, modems, electronic telephones, and other devices using modular jacks.




The "Mini-T" is a compact, two-outlet plug-in system complete with modular extension cord. Using Kalglo's Premium Protection™ circuitry, the Mini-T has full series/parallel load-bearing filtering for maximum EMI/RFI protection. The Mini-T is rated at 140 volts clamping, with a total of 436 joules energy absorption. The suggested list price is $85.95.

For more information contact Kalglo Electronics Company, Inc., Dept. Mini-T, 6584 Ruch Road, East Allen Township, Bethlehem, Pennsylvania 18017-9359. Phone: (215)837-0700.

**Circle #310 on Reader Service Card.**

## ICOM's new wideband SSB filter for the IC-781

ICOM announces the FL-103 wideband SSB filter for the IC-781 HF transceiver. The 2.8-kHz SSB filter fits in the 9-MHz IF of the IC-781 and provides improved SSB audio fidelity.

The FL-103 is currently available for $72.50. Contact ICOM America Inc., 2380 116th Avenue N.E., P.O. Box C-90029, Bellevue, Washington 98009-9029.

**Circle #311 on Reader Service Card.**

*PRESENTING*

## THE K1FO 22 ELEMENT 432 MHz YAGI

Model FO-22-432
ATV version is available

*$88.95*

**ELECTRICAL SPECIFICATIONS:**

| | |
|---|---|
| Measured gain | 15.8 dBd |
| E-Plane beamwidth | 23 deg |
| H-Plane beamwidth | 24 deg |
| Sidelobe attenuation | |
| 1st E Plane | -17.5 dB |
| 1st H Plane | -15.5 dB |
| SWR | 1.14:1 typical |
| ATV version | <1.4:1 422-439MHz |
| F/B ratio | 22 dB |
| Impedance | 50 ohm |

**MECHANICAL SPECIFICATIONS:**

| | |
|---|---|
| Length | 14ft. |
| Boom | 1" 6061 T-6 Aluminum |
| Elements | 3/16" Aluminum rod |
| Wind survival | 90+ MPH |
| Mast | up to 1.5" diameter |
| Element Insulators | Black Delrin |
| Stainless Steel hardware (except U bolts) | |
| Coax connector | N type |

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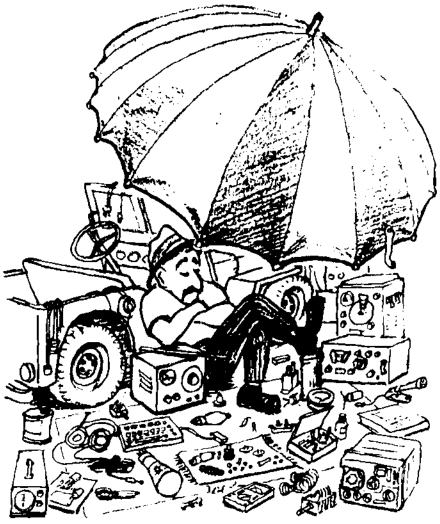

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"**HAMLOG" COMPUTER PROGRAM.** Full features, 17 modules. Auto-logs, 7-band WAS/DXCC. Apple $19.95. IBM, CP/M, KAYPRO, Tandy, C128 $24.95. HR-KA1AWH, POB 2015, Peabody, MA 01960.

**WANTED:** ARC-5 and SCR-274 equipment, parts and accessories, any condition. Ken, WB9OZR, 362 Echo Valley, Kinnelon, NJ 07405. (201) 492-9319.

**WANTED:** Ham equipment and other property. The Radio Club of Junior High School 22 NYC, Inc. is a nonprofit organization, granted 501(C) (3) status by the IRS, incorporated with the goal of using the theme of Ham Radio to further and enhance the education of young people. Your property donation or financial support would be greatly appreciated and acknowledged with a receipt for your tax deductible contribution. In Dayton, meet the crew from 22 and relax at our flea market tables, check in on 144.30 simplex. Please write us at: PO Box 1052, New York, NY 10002. Or call our round the clock hotline: (516) 674-4072. Thank you!

**WANTED:** Drake Linear Amp Model MN4439- 1000W (2000 PEP), 1.8-30 MHz. Call Bruno Molino, VE2FLB, 26 Rue Des Anciens, Gatineau, Quebec J8T 3T2. (819) 561-3689.

**RECONDITIONED TEST EQUIPMENT** $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

# COMING EVENTS

## Activities — "Places to go . . ."

**SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS:** PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC. ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD BE GREATLY APPRECIATED BY OUR BROTHER/SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

**July 1: COLORADO:** Hamfest sponsored by the Western Colorado ARC, Colorado National Guard Armory, Grand Junction. 8 AM to 3 PM. For information contact Randy Martens, N0TN, PO Box 3422, Grand Junction, CO 81502. (303) 242-4205.

**July 8-9: BRITISH COLUMBIA:** Maple Ridge Hamfest sponsored by the Maple Ridge ARC, St. Patricks Center, 22589 121 Avenue, Maple Ridge. For information Bob Houghton, VE7BZH, Box 292, Maple Ridge, BC V2X 7G2.

**July 9: ILLINOIS:** The DuPage ARC's 17th annual Hamfest/Computer Show, American Legion Post 80, 4000 Saratoga, Downers Grove. Gates open 8 AM. For tickets or reserved tables SASE to Hamfest, W9DOP, PO Box 71, Clarendon Hills, IL 60514 or call (312) 985-0527 evenings or weekends.

**July 9: NEW YORK:** The 9th annual Batavia Hamfest sponsored by the Genesee Radio Amateurs, Alexander Firemen's Grounds, Rt 98, Alexander. 6 AM to 4 PM. For information contact G.R.A.M., PO Box 572, Batavia, NY 14021.

**July 9: NEW YORK:** LIMARC ARRL Long Island Hamfair, New York Institute of Technology, Rt 25A, Northern Blvd, Old Westbury. Starts 9 AM. For information Mark Nadel, NK2T (516) 796-2366 or Hank Wener, WB2ALW (201) 694-1811.

**July 10: ILLINOIS:** The DuPage ARC's 7th annual Hamfest Computer Show, American Legion Post grounds, 4000 Saratoga Avenue, Downers Grove. Handi facilities. Tickets $2/advance; $3/gate. For tickets or table reservations SASE to Hamfest Chairman, DuPage RAC, PO Box 71, Clarendon Hills, IL 60514.

**July 15: NORTH CAROLINA:** 17th annual Mid-Summer Swapfest sponsored by the Cary ARC, VFW Building, Reedy Creek Rd, Cary. 9 AM to 3 PM. For information Cary ARC, PO Box 53, Cary, NC 27512.

**July 15: MAINE:** Union Hamfest, Union Fairgrounds, Union. Starts 8 AM. Sponsored by the Maine Hamfest Association, c/o KA1RFB, PO Box 84, East Vassalboro, ME 04935.

**July 16: NEW JERSEY:** SCARC '89 sponsored by the Sussex County ARC, Sussex County Fairgrounds, Plains Road, off Rt 206, Augusta. Doors open 8 AM. For information write Don Stickle, K2OX, Weldon Road, RD 4, Lake Hopatcong, NJ 07849. (201) 663-0677.

**July 22-23: COLORADO:** Mountain Amateur Radio Club is sponsoring a Hamfest, Red Rocks Campground in Pike National Forest, Woodland Park. Free admission. For camping information/reservations write MARC, Box 1012, Woodland Park, CO 80866 or phone Joe Tafoya, N0CMD (719) 687-3641.

**July 23: ILLINOIS:** The Amateur Cross Link Repeater's annual Hamfest, "The Hall", 1535 S. Harlem Avenue, Berwyn. 8AM to 1 PM. For information SASE to ACLR, PO Box 348257, Chicago, IL 60634 or call (312) 712-5100.

**July 28-30. ILLINOIS:** The Central States VHF Society's 23rd conference in Rolling Meadows. For information: Chuck Clark, AF8Z, 4N560 Powis Road, W. Chicago, IL 60185.

**July 28-30: OKLAHOMA:** Ham Holiday sponsored by the Central Oklahoma Radio Amateurs, Lincoln Plaza Hotel Conference Center, 4445 Lincoln Blvd, Oklahoma City. For information contact CORA, PO Box 850625, Yukon, OK 73085. July 30: ILLINOIS: 55th annual Hamfest, sponsored by the Hamfesters Radio Club, Will County Fairgrounds, Peotone. 6 AM to 3 PM. Admission $3/advance; $4/door. For tickets SASE with payment to Hamfesters RC, Donald Burch, N9DWI, 8438 S. Kolin Ave, Chicago, IL 60652. (312) 582-9776.

**August 5-6: FLORIDA:** The 16th annual Greater Jacksonville Amateur Radio and Computer Show, Prime Osborn Convention Center, 9 AM to 5 PM Saturday and 9 AM to 3 PM Sunday. For information Greter Jacksonville Hamfest Association, PO Box 10623, Jacksonville, FL 32207. Phone (904) 350-9193.

**August 6: VIRGINIA:** The 39th annual Winchester Hamfest sponsored by the Shenandoah Valley ARC, Clarke County Ruritan Fairgrounds, Rt 7, 2 miles west of Berryville. 7 AM to 3 PM. For information contact Joanne Blaker, WB2CMV at (703) 869-4878 or write SVARC, PO Box 139, Winchester, VA 22601.

**October 1: NORTH CAROLINA:** JARSFEST '89, Benson American Legion Complex, 301 N. Benson NC 27504. 8 AM to 4 PM. For flyer SASE to Johnston Amateur Radio Society, PO Box 1154, Smithfield, NC 27577. (919) 934-0486, 894-5479.

# OPERATING EVENTS

## "Things to do . . ."

**July 7-8:** Special event station VE4IHF will operate from the International Hamfest, International Peace Garden on the border of North Dakota and Manitoba. For QSL card send 1 IRC and SASE to VE4XN, Dave Snydal, 25 Queens Crescent, Brandon, Manitoba Canada R7B 1G1.

**July 8:** Hobbs, New Mexico. KD5RZ will operate the 1st annual National Royal Ranger Special Event (NRRSE), 1300 to 0100 UTC. Sponsored by the New Mexico Dist. Royal Rangers, a Christian Scouting Organization. For certificate send QSL and large SASE to KD5RZ, 1420 N. Tasker, Hobbs, NM 88240.

**July 15:** Governor John McKernan has signed a proclamation designating July 15 Amateur Radio Day in the State of Maine. Special event station W1TLC will operate from the Union Hamfest to commemorate Amateur Radio Day.

**July 15-23:** Fort Amherst Historic Park on P.E.I. The Boy Scouts of Canada are holding Jamboree '89 and will operate fomr the Jamboree site all modes/bands including packet and satellite.Listen for CJ1PEI 24 hours a day, conditions permitting. QSL via Bureau upon receipt of QSL card.

**July 16:** Fishers Island Sound, NY. Tri-City ARC will operate from Flat Hammock Island, its sixth expedition to this uninhabited island. Listen for KA1BB from 1300Z to 2000Z, General phone and CW, 2m SSB. QSL w/letter size SASE via Tri-City ARC, Box 686, Groton, CT 06340.

**July 22:** The Falls City ARC will operate K0JKS, 1300Z to 2300Z to commemorate the 4th annual Hot Air Balloon Extravanganza from Brenner Air Field in Falls City. Send 9x12 SASE and QSL to Bob Eis, WA0W, 1702 Fair Avenue, Falls City, NE 68355.

**July 22:** The Reservoir ARA will operate K8QYL, 1300Z-2000Z July 22 and 1600Z-2000Z July 23 to commemorate the 20th anniversary of Neil Armstrong's walk on the moon. Operation will be from the Neil Armstrong Air & Space Museum in Wapakoneta, Ohio. General class bands, CW, SSB and RTTY. Novice SSB operation on 10m. For a certificate send QSL and No. 10 SASE to K8QYL, 1005 Linden Avenue, St. Marys, OH 45885-1327.

**July 23-27:** The REACT ARC will operate a special event station in conjunction with the 2nd annual meeting of REACT ARC and the 14th annual convention of the REACT International. Lower 80, 40, 20m and 10m Novice. For certificate send 9x12 SASE and QSL to REACT ARC, c/o WB3FQY, POB 1033, Lancaster, PA 17603.

**July 19-24:** Fairbanks, Alaska. The Arctic ARC will operate special event station KL7KC, 0000Z July 15 to 0900Z July 24 in celebration of the discovery of gold by Fedrix Pedro in the Fairbanks area. For QSL card SASE to the Arctic ARC, PO Box 81389, Fairbanks, Alaska 99708.

**July 29-Aug 7.** Eugene, Oregon. The Valley ARC will operate W7PXL 0100Z July 29 to 0100Z Aug 7 to commemorate the VIII world Veteran's Track and Field Championships. For QSL or certificate SASE to Valley ARC, PO Box 70314, Eugene, OR 97401.

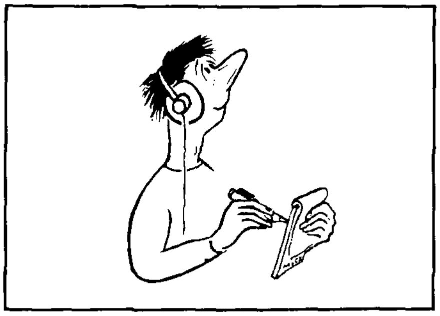
**LAUREL ARC** monthly (except December) Amateur exam sessions for all license classes. No fee is charged. Pre-registration is required. Call (301) 725-1212, Maryland Radio Center, 8576 Laureldale Drive, Laurel, MD 20707.

**NORTH COAST ARC 1989 LICENSE EXAMS.** 12:30 PM, Saturdays February 11, April 15, June 10, August 12, October 14, December 9. N. Olmsted Community Cabin, S of Lorain on W. Park. Novice thru Extra. Walkins allowed. Talk in 145.29 repeater. For information Dan Sarama, KB8A, 15591 Rademaker Blvd, Brookpark, Ohio 44142. 267-5083 or Pauline Wells, KA8FOE, Rick Wells, K8SCI, 777-9460/779-8999.

**AMATEUR RADIO CLASSES:** For those people interested in obtaining a Novice (basic level) Ham license or upgrading to Tech/General, the Chelsea Civil Defense, in cooperation with QRA Radio Club, will sponsor Amateur Radio Communications classes evenings at Chelsea High School starting MARCH 7, 1989. For more information write Frank Masucci, K1BPN, 136 Grove Street, Chelsea, MA 02150. Please enclose your telephone number.

**THE MIT UHF REPEATER ASSOCIATION** and the MIT Radio Society offer monthly HAM EXAMS. All classes Novice to Extra. Wednesday, JULY 19, 7 PM, MIT Room 1-150, 77 Mass Avenue, Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann at (617) 484-2098. Exam fee $4.50. Bring a copy of your current license (if any), two forms of picture ID, and a completed form 610 available from the FCC in Quincy, MA (617) 770-4023.

# DX Forecaster



*Garth Stonehocker, KØRYW*

## KNOW SPORADIC-E SKIP

As patches of Sporadic-E ($E_S$) ionization cross the United States — from southeast to northwest, for example — it's possible for short-skip and multiple propagation modes to exist on 6 meters. Surprisingly, they can be found occasionally on the 2-meter band. Openings appear quickly; they may stay in for just a few minutes, or remain open for hours. Sometimes in June or July DX signals may be heard around the clock. Signals can be received from distances of 500 to 1200 miles, and may at times be heard from distances as far away as 2500 miles on multiple hop paths.

How do you recognize such $E_S$ openings? Suppose you're monitoring a beacon frequency and the band is quiet. Suddenly, you hear a build-up of "received noise." Almost instantly there are DX stations all over the band. Signal levels fluctuate rapidly as the session opens and as it declines. When the signal is there it usually pegs your S-meter, but it's also subject to rapid fades on the order of 60 dB or more that may chop it into a garbled mess.

George Jacobs, W3ASK, discussed one way to recognize the probable opening of $E_S$ on 6 meters in the June 1962 issue of *CQ*. When you're on a lower frequency band, say 15 or 10 meters, listen to the stations being worked. If the minimum skip distance is decreasing, the skywave geometry is such that the maximum usable frequency (MUF) will be increasing by reflection from an $E_S$ cloud (more dense than F2 and lower in height). W3ASK's rule of thumb states that when stations are heard less than 500 miles away on 10 meters, or less than 350 miles on 15 meters, the chances are good that 6 meters will open in that same direction.

A directional (not too narrow beam width) rotatable antenna with a low take-off angle is a definite advantage in finding and using the $E_S$ short-skip propagation mode.

### Last-minute forecast

The lower frequency bands (mainly nighttime DXing), will be best the first two weeks of July. Expected lower MUFs from a lower solar flux in those two weeks will raise signal strengths in the evenings to help overcome thunderstorm noise during those hours. The best low-band conditions will occur in the early morning hours. The higher band DXers will have to wait until the last two weeks of the month when long-skip openings with higher MUFs are expected. Geomagnetic disturbances are expected near the 6th and 16th, and on the 24th when they will be the most intense. Look for DX from unusual places on the disturbed days.

A full moon occurs on the 18th; perigee is on the 23rd. The Aquarids meteor shower begins on July 18th, peaks on the 28th, and lasts until August 7th. (All dates are approximate, but should be close.) The radio-echo rate at maximum is about 34 per hour.

### Band-by-band summary

Six-meter paths will open for half an hour to a couple of hours on some days around local noon. Sporadic-E propagation will make this short-skip path possible out to nearly 1200 miles per hop.

Ten, 15, 17, 20, and 30 meters will support DX propagation to most areas of the world during the daylight hours and into the evening, with long skip out to 2000 miles per hop. Sporadic-E short skip will also be available on many days for several hours around local noon. The direction of propagation will follow the track of the sun across the sky: east in the morning, south at midday, and west in the evening. The longer period of daylight provides many hours of good DXing. Solar flux is high this year, so daytime absorption gives lower signal strengths than usual on these bands during this month.

Thirty, 40, 80, and 160 meters are the nighttime DXer's bands. On many nights, 30 and 40 meters will be the only usable bands because of thunderstorm QRN. Try the pre-dawn hours for best DX. The direction of propagation follows the darkness path across the sky: to the east in the evening, south around midnight, and toward the west in the pre-dawn hours. Skip distances will decrease to 1000 miles. Sporadic-E openings will be observed most frequently around sunrise and sunset. These may be the only signals getting through the noise in the evening. hr

# JULY

## WESTERN USA

| GMT | 2300 | 2200 | 2100 | 2000 | 1900 | 1800 | 1700 | 1600 | 1500 | 1400 | 1300 | 1200 | 1100 | 1000 | 0900 | 0800 | 0700 | 0600 | 0500 | 0400 | 0300 | 0200 | 0100 | 0000 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PDT | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | |
| ASIA FAR EAST | 15 | 15 | 18 | 20 | 18 | 18 | 18 | 15 | 15 | 15 | 15 | 18 | 20 | 18 | 18 | 18 | 15 | 15 | 12 | 12 | 10 | 10 | 12 | 12 | N |
| EUROPE | 18 | 15 | 12 | 12 | 10 | 10 | 10 | 10 | 12 | 12 | 12 | 15 | 15 | 18 | 18 | 30 | 15 | 15 | 18 | 20 | 20 | 20 | 20 | 18 | NE |
| S. AFRICA | 15 | 12 | 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 18 | 15 | 12 | 10 | 10 | 15 | 18 | 18 | 18 | 15 | 15 | E |
| S. AMERICA | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 15 | 20 | 18 | 18 | 18 | 15 | 15 | 15 | 12 | 12 | 10 | 10 | 10 | SE |
| ANTARCTICA | 10 | 10 | 10 | 12 | 12 | 15 | 18 | 30 | 30 | 30 | 30 | 30 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 18 | 15 | 12 | 12 | 10 | S |
| NEW ZEALAND | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 20 | 18 | 15 | 15 | 15 | 15 | 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | SW |
| OCEANIA AUSTRALIA | 10 | 10 | 10 | 10 | 12 | 20 | 20 | 18 | 18 | 18 | 18 | 18 | 15 | 15 | 15 | 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | W |
| JAPAN | 10 | 10 | 10 | 10 | 10 | 18 | 20 | 30 | 18 | 18 | 20 | 30 | 18 | 18 | 15 | 15 | 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | NW |

## MID USA

| MDT | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | |
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| ASIA FAR EAST | 15 | 20 | 18 | 18 | 15 | 12 | 10 | 10 | 12 | 12 | 15 | 15 | 15 | 18 | 20 | 20 | 18 | 18 | 15 | 15 | 15 | 15 | 12 | 12 | N |
| EUROPE | 18 | 18 | 15 | 15 | 12 | 10 | 10 | 10 | 12 | 12 | 12 | 15 | 15 | 18 | 20 | 15 | 18 | 20 | 20 | 18 | 20 | 30 | 20 | 18 | NE |
| S. AFRICA | 15 | 12 | 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 12 | 12 | 18 | 15 | 15 | 18 | 18 | 18 | 18 | 15 | 15 | E |
| S. AMERICA | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 15 | 20 | 18 | 18 | 15 | 15 | 15 | 15 | 12 | 12 | 10 | 10 | 10 | SE |
| ANTARCTICA | 12 | 12* | 12 | 12 | 15 | 15 | 18 | 20 | 30 | 30 | 30 | 30 | 30 | 30 | 20 | 20 | 20 | 20 | 20 | 20 | 18 | 15 | 15 | 12 | S |
| NEW ZEALAND | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 20 | 20 | 18 | 18 | 15 | 15 | 15 | 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | SW |
| OCEANIA AUSTRALIA | 10 | 10 | 10 | 10 | 12 | 20 | 20 | 20 | 18 | 18 | 18 | 18 | 18 | 15 | 15 | 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | W |
| JAPAN | 10 | 10 | 12 | 12 | 15 | 15 | 18 | 18 | 20 | 18 | 20 | 30 | 20 | 18 | 18 | 15 | 15 | 15 | 15 | 12 | 12 | 10 | 10 | 10 | NW |
| CDT | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | |

## EASTERN USA

| EDT | 7:00 | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | |
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| ASIA FAR EAST | 15 | 18 | 20 | 18 | 18 | 18 | 15 | 15 | 12 | 12 | 10 | 12 | 12 | 15 | 15 | 18 | 20 | 20 | 18 | 18 | 15 | 15 | 12 | 15 | N |
| EUROPE | 15 | 15 | 12 | 12 | 12 | 12 | 12 | 12* | 12* | 12 | 12 | 12 | 15 | 15 | 15 | 18 | 20 | 30 | 18 | 18 | 20 | 40 | 15 | 15 | NE |
| S. AFRICA | 15 | 12 | 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 18 | 15 | 15 | 18 | 18 | 18 | 18 | 15 | 15 | E |
| CARIBBEAN S. AMERICA | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 15 | 20 | 18 | 15 | 15 | 15 | 12 | 12 | 10 | 10 | 10 | SE |
| ANTARCTICA | 15 | 15* | 15* | 15 | 15 | 15 | 15 | 20 | 30 | 30 | 30 | 30 | 30 | 30 | 30* | 20 | 20 | 20 | 20 | 20 | 20 | 18 | 15 | 15 | S |
| NEW ZEALAND | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 18 | 18 | 18 | 15 | 15 | 15 | 15 | 15 | 12 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | SW |
| OCEANIA AUSTRALIA | 10 | 10 | 10 | 10 | 10 | 20 | 20 | 20 | 18 | 18 | 18 | 18 | 18 | 20 | 15 | 15 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | W |
| JAPAN | 10 | 12 | 12 | 15 | 15 | 15 | 18 | 20 | 18 | 15 | 15 | 15 | 15 | 15 | 18 | 20 | 18 | 18 | 15 | 15 | 12 | 12 | 10 | 10 | NW |

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