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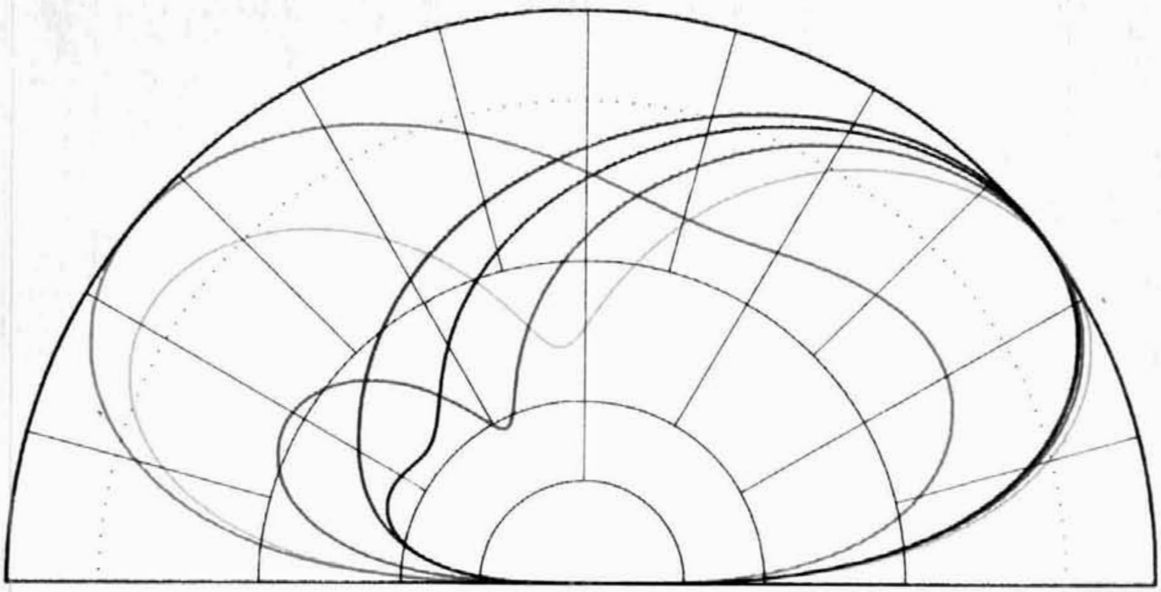
array analysis:



pattern vs. frequency

hr

focus on communications technology

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contents

REFLECTIONS

switch to safety

This is an editorial that I wish never had to be written.

This past Field Day, Mike Mankey, WB0TEE, ARRL North Dakota Section Manager, was killed when the antenna he was erecting came into contact with a power line. According to the news report, the site was unfamiliar to Mike's group, and they didn't see the power lines hidden behind the trees.

I'd like to report that this is the first time something like this has ever happened, but it isn't — and I'm afraid it won't be the last, either. Perhaps as we share, with Mike's family and friends, the sorrow of his loss, it would be appropriate to give some thought to the dangers we face in pursuit of our avocation.

We've all done foolish things while working with electricity. When I was wiring 220 volts for my amplifier, for example, I was certain the circuit was dead; I'd pulled the breaker to de-energize it. But when I clamped my wire cutters and squeezed them shut, POW! Sparks, smoke, a sudden dimming of the house lights, and a wife screaming down the stairs expecting to find the worst. I was stunned and ashamed by my stupidity — I'd pulled out the wrong circuit breaker!

As I calmed both myself and my wife down, I started to analyze what I'd done wrong. It was late. I was tired and in a hurry to get the work done. I *thought* I'd taken all precautions. . . if you pull the breaker, the circuit is dead — isn't it?

I've done other very stupid things over my almost 20 years as a ham. Although I'm not proud of these experiences, I do hope I've learned something from them. WB0TEE's untimely death serves as a reminder to us all that it's imperative to always, *always* think safety, no matter where you are and no matter what you're doing.

If you're climbing a tower, make sure you're safely belted to it. If you're troubleshooting a live circuit, remove all rings, jewelry, and watches that could make you part of a complete circuit; keep one hand in your pocket. Make sure power supplies are properly built with the appropriate bleeder resistors. Don't stick your hand into your amplifier when it's turned on to "adjust" that bent plate choke. And watch out for power lines; they aren't always easy to see.

By the way, if you were to receive an incapacitating shock, would your family know what to do? Would they know not to touch you directly, but to pull you away from the electrical source with a stick or some other nonconductive tool and turn off the power ? Do they know CPR? Do they know how to get qualified emergency help as quickly as possible? Are the phone numbers posted by the phone — or better yet, on it?

We extend our deepest sympathy to Mike Mankey's family. Although we cannot lessen their loss, we can learn from it — and *switch to safety.*

Craig Clark, N1ACH
Assistant Publisher

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Throughout the contest and DX world, the TS-930S is recognized as THE HF rig to own—with the most outstanding performance per dollar ratio!

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Compact all band transceiver with general coverage receiver

Kenwood engineering brings you "Digital DXterity"—QSY from band to band, mode-to-mode, and frequency-to-frequency with ease!

- Easily modified for MARS operation
- Superb interference reduction
- Superior solid state design
- 8 memories store mode, frequency, band. Each channel may be used as a separate VFO
- Programmable scanning
- Dual digital VFOs
- VOX, semi break-in CW with sidetone

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A complete line of accessories is available for these transceivers.
Complete service manuals are available for all Trio-Kenwood transceivers and most accessories.
Specifications and prices are subject to change without notice or obligation.

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presstop de W9JUV

OSCAR 10 IS BACK ON THE AIR ON BOTH MODES B AND L, as a result of some masterful computer analysis and reprogramming! The sophisticated bird had shut down several months ago, apparently from radiation-induced memory damage. After extensive earlier efforts to regain control failed, it seemed almost certain OSCAR 10 would be off the air for good. However, analysis of the limited responses that could be induced by control station commands provided clues to what portions of its memory still seemed intact, and when DJ4ZC uploaded software written for those memory areas the satellite came back to life!

It Now Appears OSCAR 10 Will Be Usable In Both Modes for the foreseeable future, but with some limitations; at this time the most important is a 100-watt ERP limit on uplink signals. The CW/RTTY beacon is apparently gone for good, but attitude control has been restored so the control stations should be able to keep the batteries well charged. There's cautious hope that OSCAR 10 can be kept up and running at least until the Phase 3C satellite goes up, though recent problems with the French Ariane launch vehicle have pushed its launch well into 1987. Check the various AMSAT nets for further updates.

The Japanese JAS-1 Satellite's Launch, Scheduled For Late July, was also pushed back but at presstime was still expected during the first half of August. In addition the launch of two new Russian Amateur satellites, RS-9 and RS-10, is likely in September.

AMSAT Has A New Illustrated Catalog of Membership Supplies, software, and publications. It's available from the AMSAT office (301 589-6062) or at AMSAT hamfest booths.

MIAMISBURG, OHIO'S TOXIC TANK CAR FIRE THAT BEGAN JULY 8 SPARKED one of the nation's largest mass evacuations ever and once more proved conclusively Amateur Radio's value in emergency situations. Almost 400 area Amateurs from about 20 clubs took part during the four-day emergency, providing the essential interconnecting link for participating local, state, and federal agencies. Since most agencies are limited to their own unique frequencies, and those in many cases were jammed with the volume of communications, Amateurs rode police cars, fire trucks, and even a helicopter to provide those working the disaster with the only common communications network that could tie them all together.

In Addition, Amateurs Also Set Up Weather Tracking Nets that provided firefighters with precise rain shower and wind shift information, vital to plotting the toxic cloud's path. Amateurs also coordinated the evacuation of more than 300 nursing home residents to a safe location, monitored hospital emergency room loading, and arranged food shipments to the various evacuation centers. In the aftermath of the 100-hour-long operation the Amateur communicators received very high marks from those they were assisting and as well as plenty of very positive media exposure. Congratulations to all for a very fine job!

ARRL HAS ASKED THE FCC FOR IMMEDIATE ACCESS TO THE 18-MHZ WARC band, based on belief that the U.S. government is no longer using that band. Unfortunately, the League's information wasn't accurate, so don't expect any favorable action on 18 MHz soon.

NEW EIA OPPOSITION TO THE COMMUNICATIONS PRIVACY ACT HAS RAISED HOPES that the bill may not make it through the Senate in its present form after all! In a well-thought out and strongly worded letter sent to all U.S. Senators, the Mobile Communications Divison of the Electronic Industries Association cited a number of reasons for opposing S-1667. For example, with respect to radio communications, the letter says "...it is not reasonable to attempt to legislate privacy..." so that the bill would, in effect, "...instill a false expectation of privacy!" The letter then points out that the bill is inconsistent with the Communications Act of 1934, which recognizes that a prohibition against intercepting radio communications is impractical but establishes severe sanctions against the misuse of intercepted information. It further notes the bill is in itself inconsistent, since it admits that cordless telephone transmissions are easily intercepted -- so can't be protected -- but provides unqualified protection to cellular transmissions! "This discrimination," the letter continues, "certainly cannot be rationalized on a technical basis....There is no justification for this legislation to treat one mode of radio communications differently from others!" Another point: "There can be no true expectation of privacy with radio communications unless the message is encrypted (scrambled)." It concludes, "The nature of radio communications cannot be changed by legislation..." but concedes that the problems cited could be changed by amendment.

Support For The Latter Is Far From Unanimous Within The EIA, and at least one land mobile manufacturer has sent key senators a followup letter stating its opposition to the EIA position. Nevertheless, the EIA makes valid points, and the letter's arrival appears to have seriously compromised the bill's hopes of the bill's supporters for quick Senate passage.

Amateurs And Others Who Oppose S-1667 In Its Present Form should call or write their Senators to register support for the EIA Mobile Communications Division letter.

"CAPTAIN MIDNIGHT," WHO BROKE IN ON AN HBO MOVIE IN APRIL to object to scrambling of satellite TV, has been caught. He's John Mac Dougall, a 25-year-old satellite TV dealer and a part-time operator for an Ocala, Florida uplink station. Unfortunately, he's also KA4WJA, so some news reporters have also been condemning Amateur Radio along with Mac Dougall! In a plea-bargaining agreement he's been fined $5000 and sentenced to one year's probation with his Technician Class license suspended for a year.

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Handy Handful...

TR-2600A/3600A

Kenwood's TR-2600A and TR-3600A feature DCS (Digital Code Squelch), a new signalling concept developed by Kenwood. DCS allows each station to have its own "private call" code or to respond to a "group call" or "common call" code. There are 100,000 different DCS combinations possible.

- **Simple to operate**
  Functional design is "user friendly." Built-in 16-key autopatch encoder, TX STOP switch, REVerse switch, KEYboard LOCK switch, high efficiency speaker.
- **Large LCD**
  Easy to read in direct sunlight or in the dark with convenient dial light that also illuminates the top panel S-meter.
- **Extended frequency coverage**
  Allows operation on most MARS and CAP frequencies. Receive frequency range is 140-160 MHz. (TR-3600A covers 440-450 MHz.)
- **Programmable scan**
  Channel scan or band scan, search for open or busy channels.
- **SLIDE-LOC battery case**
- **10 Channels**
  10 memories, one for non-standard repeater offsets.
- **2.5 watts high power, 350 mW low**
  TR-3600A has 1.5 watts high or 300 mW low.

The Kenwood TR-2600A and the TR-3600A pack "big rig" features into the palm of your hand. It's really a "handy handful"!

Optional accessories:

- TU-35B built in programmable sub-tone encoder
- VB-2530 2-m 25 W RF power amp.
- ST-2 base stand/charger
- MS-1 mobile stand/charger
- PB-26 Ni-Cd battery
- DC-26 DC-DC converter
- HMC-1 headset with VOX
- SMC-30 speaker microphone
- LH-3 deluxe leather case
- SC-9 soft case with belt hook
- BT-3 AA manganese/alkaline battery case
- EB-3 external C manganese/alkaline battery case
- RA-3 2-m telescoping antenna
- RA-5 2-m/70-cm telescoping antenna
- AX-2 shoulder strap w/ant. base
- CD-10 call sign display
- BH-2A belt hook

More TR-2600A and TR-3600A information is available from authorized Kenwood dealers.

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TR-2600A shown. TR-3600A is available for 70 cm operation.
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Meet "Versa Tuner V". It has all the features you asked for, including the new smaller size to match new smaller rigs-only 10¾"Wx4½"Hx14 7/8"D.

Matches coax, balanced lines, random wires—1.8 to 30 MHz. 3 KW PEP—the power rating you won't outgrow (250pf-6KV caps).

Roller inductor with a 3-digit turns counter plus a spinner knob for precise inductance control to get that SWR down to minimum every time.

Built-in 300 watt, 50 ohm dummy load, built-in 4:1 ferrite balun.

MFJ-989 **$329.95**

Accurate meter reads SWR plus forward and reflected power in 2 ranges (200 and 2000 watts). Meter light requires 12 VDC. Optional AC adapter, MFJ-1312 is available for $9.95.

6 position antenna switch (2 coax lines, through tuner or direct, random/balanced line or dummy load). SO-239 connectors, ceramic feed-throughs, binding post grounds.

Deluxe aluminum low-profile cabinet with sub-chassis for RFI protection, black finish, black front panel with raised letters, tilt bail.

MFJ's Fastest Selling TUNER

MFJ-941D **$99.95**

MFJ's fastest selling tuner packs in plenty of new features. New styling! Brushed aluminum front. All metal cabinet. **New SWR/Wattmeter**! More accurate. Switch selectable 300/30 watt ranges. Read forward/reflected power.

New antenna switch! Front panel mounted. Select 2 coax lines, direct or through tuner, random wire/balanced line or tuner bypass for dummy load.

New airwound inductor! Larger more efficient 12 position airwound inductor gives lower losses and more watts out. Run up to 300 RF power output.

Matches everything from 2.8 to 30 MHz! dipoles, inverted vee, random wires, verticals, mobile whips, beams, balanced and coax lines.

Built-in 4:2 balun for balanced lines. 1000 V capacitor spacing. Black. 11 x 3 x 7 inches. Works with all solid state or tube rigs. Easy to use anywhere.

MFJ's 1.5 KW VERSA TUNER III

MFJ-962 **$229.95**

Run up to 1.5 KW PEP and match any feedline continuously from 1.8 to 30 MHz: coax, balanced line or random wire.

Built-in SWR/Wattmeter has 2000 and 200 watt ranges, forward and reflected power. 2% meter movement. 6 position antenna switch handles 2 coax lines (direct or through tuner), wire and balanced lines. 4:1 balun 250 pf 6 KV variable capacitors. 12 position inductors. Ceramic rotary switch. All metal black cabinet and panel gives RFI protection, rigid construction and sleek styling. Flip stand tilts tuner for easy viewing. 5 x 14 x 14 in.

MFJ's Best VERSA TUNER

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MFJ's best 300 watt tuner is now even better!

The MFJ-949C all-in-one Deluxe Versa Tuner II gives you a tuner, cross-needle SWR/Wattmeter, dummy load, antenna switch and balun in a new compact cabinet. You get quality conveniences and a clutter-free shack at a super price.

A new cross-needle SWR/Wattmeter gives you SWR, forward and reflected power—all at a single glance. SWR is automatically computed with no controls to set. Has 30 and 300 watt scale on easy-to-read 2 color lighted meter (needs 12 V).

A handsome new black brushed aluminum cabinet matches all the new rigs. Its compact size (10 x 3 x 7 inches) takes only a little room.

You can run full transceiver power output—up to 300 watts RF output—and match coax, balanced lines or random wires from 1.8 thru 30 MHz. Use it to tune out SWR on dipoles, vees, long wires, verticals, whips, beams and quads.

A 300 watt 50 ohm dummy load gives you quick tune ups and a versatile six position antenna switch lets you select 2 coax lines (direct or thru tuner), random wire or balanced line and dummy load.

A large efficient airwound inductor—3 inches in diameter—gives you plenty of matching range and less losses for more watts out. 100 volt tuning capacitors and heavy duty switches gives you safe arc-free operation. A 4:1 balun is built-in to match balanced lines.

Order your convenience package now and enjoy.

2 KW COAX SWITCHES

MFJ-1702 **$19.95**

MFJ-1702, $19.95. 2 positions. 60 dB isolation at 450 MHz. Less than .2 dB loss. SWR below 1:1.2.

$29.95 MFJ-1701

MFJ-1701, $29.95. 6 positions. White markable surface for antenna positions.

MFJ's Smallest VERSA TUNER

MFJ-901B **$59.95**

MFJ's smallest 200 watt Versa Tuner matches coax, random wires and balanced lines continuously from 1.8 thru 30 MHz. Works with all solid state and tube rigs. Very popular for use between transceiver and final amplifier for proper matching. Efficient airwound inductor gives more watts out. 4:1 balun for balanced lines. 5 x 2 x 6 inches. Rugged black all aluminum cabinet.

MFJ's Random Wire TUNER

MFJ-16010 **$39.95**

MFJ's ultra compact 200 watt random wire tuner lets you operate all bands anywhere with any transceiver using a random wire. Great for apartment, motel, camping operation. Tunes 1.8-30 MHz. 2 x 3 x 4 inches.

MFJ's Mobile TUNER

MFJ-945C **$79.95**

Designed for mobile operation! Small, compact. Takes just a tiny bit of room in your car. SWR/dual range wattmeter makes tuning fast and easy. Careful placement of controls and meter makes antenna tuning safer while in motion.

Extends your antenna bandwidth so you can operate anywhere in a band with low SWR. **No need to go outside and readjust your mobile whip.** Low SWR also gives you maximum power out of your solid state rig—runs cooler for longer life.

Handles up to 300 watts PEP RF output. Has efficient airwound inductor, 1000 volt capacitor spacing and rugged aluminum cabinet. 8x2x6 inches. Mobile mounting bracket available for $5.00.

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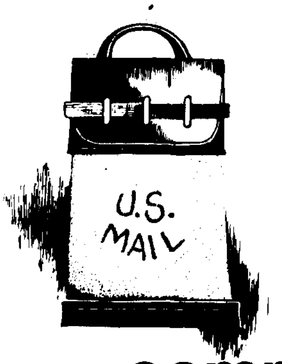


comments

happy endings

Dear HR:

I've been meaning to write for some time now to let you know of the response to my letter published in the October, 1985, issue of *ham radio*. I started a letter several times, but didn't know exactly what I wanted to say. A simple "thank you" wasn't quite enough.

I received many nice cards and letters and have made many new friends. The greatest surprise came late one evening when I received a call from a representative of ICOM America who reported seeing my letter and asked whether I would be interested in an ICOM transceiver. Then she asked the question that left me speechless: if I had a choice of any ICOM radio, which would I choose? "A 751," I replied. When she told me one would be shipped the following day, I honestly didn't believe it. I thought it was some kind of joke.

When the UPS truck arrived with two large packages just two days later, I realized it was no joke, nor was it a dream. I opened the larger box and found a brand-new ICOM 751 complete with a factory-installed PS35 power supply, FL52A filter, voice synthesizer, hand mic, and all the power cables. *WOW!* In the other box was an ICOM 251A, 2-meter, all-mode transceiver with all the accessories and an SM8 Duo Desk microphone. *Double WOW!*

Is this the end of the story? No, far from it. Many hams responded with other equipment and good wishes. I have tried and believe I have responded to each person who contacted me, but I'd still like to express my sincere and deep appreciation to everyone who assisted me in any way, whether it was with equipment or just a kind word of encouragement.

And of course, my sincerest, heartfelt thanks go to those caring people at ICOM America.

My dream, from the beginning, has been to provide phone patches for missionaries in foreign countries. I'm on the air now and able to provide assistance in handling written traffic, but two more items are needed: a phone patch and an amplifier. God has truly blessed me in enabling me to become part of the fraternity of Amateur Radio. I hope that by providing phone patches I'll be able to give someone a small token of pleasure or service they might not otherwise have had.

At 32, I don't know what a toll MS will take on me, but I can assure you it will have a good fight. Somehow I feel that the day I give up or give into the limitations — if there really are any — will be the day my dream ends. That day must not come; I must not let it.

In the two years since I became disabled I've realized that I, like many, once found too many excuses for accepting limitations. But I've also disovered that a limitation is only an obstacle between you and your goal. If you can't go through it, then you'll just have to go around, under, or over it. The point is to reach your goal, any way you can . . .

John Statham, N5HTQ
McComb, Mississippi 39648

no problem!

Dear HR:

How often have you purchased an item that later developed a problem — and then found out that getting the item fixed was an even *bigger* problem?

I bought a Mirage amplifier and was pleased with its performance. But one day, after a particularly long-winded QSO, the power amp in my B3016 2-meter amplifier quit in a puff of smoke, despite its good heat sink and an attached blower.

I sent the unit, which was a couple of years old, back to Mirage for repair. Needless to say, I was surprised to have it returned promptly, with "NO CHARGE" marked on the invoice. I had expected a long exchange of purchase receipts, letters, charge card information, and the like. What a surprise to have a warranty repair done quickly and without a quibble!

I use three Mirage amplifiers, two at home and one mobile, and have found them all to be well made and long-lasting, even in the 100 percent duty cycle of ATV operation. I would recommend Mirage to anyone who wants a quality product.

Henry B. Ruh, KB9FO
Chicago, Illinois

narrowband filters

Dear HR:

Two versions of the program described in my March, 1986, article, "Build Narrowband RF Filters," are now available for computers other than those originally mentioned.

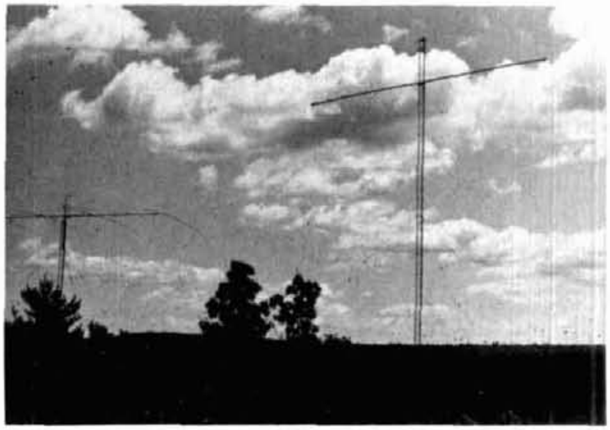
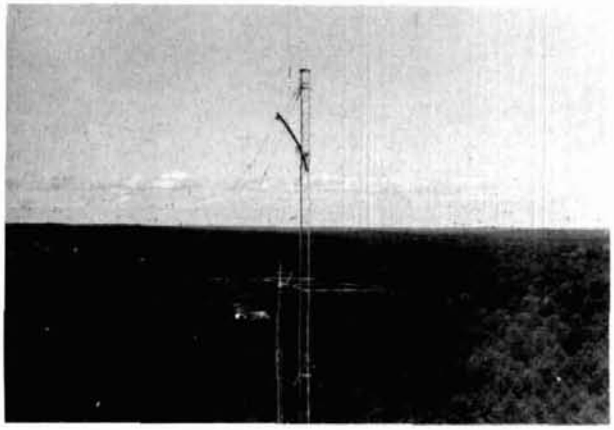
Atari owners may contact Marion D. Kitchens, K4GOK, 2709 Colt Run Road, Oakton, Virginia 22124. Marion will provide a copy (on disk). Owners of the Timex 1000 can contact Rudy Knaack, W7FGQ, 11415-28th S.W., Seattle, Washington 98146. Rudy will provide a listing for an SASE, or will copy the program on cassette tape for $5.

I might add that both versions improve on my method of calculating Chebychev order and save program lines.

The ultimate line-saving version of the program comes from Ken Stringham, AE1X, who uses the equations that derive k and q values that I entered in table form (**lines 1000-1500**). Although Ken didn't mention that he'd provide listings or copies, he did send me a copy. Someone interested in adapting the program to another machine might be interested in getting this listing (written in C-64 BASIC) from me.

I have had inquiries from owners of the IBM PC (and clones), but as yet have no information for them. If anyone is working on translating my program to any other machine, I'd appreciate knowing. I'll act as a "clearing house" for information about the program and sources.

Bob Lombardi, WB4EHS
Melbourne, Florida 32935

Ground and aerial views of two element 80m delta loop array supported by 46′ boom at 115′.

analyzing 80-meter delta loop arrays

NEC program assesses performance in the presence of "real" ground

During the early part of 1985, I finally managed to complete the installation of a "gain" antenna for the 80-meter band: a reflector-driver parasitic array with two equilateral triangular loop elements. Later in the year, I realized another ambition: the ability to analyze HF wire antennas over real ground with a trustworthy computer program. In this article, which describes the results of applying that capability to the analysis of my new antenna system, I'll show the behavior, over poor ground, of the peak gain and "average" front-to-back ratio across the band, along with a number of radiation patterns. I'll describe the antenna system itself in just enough detail to define the item under study.

Of course, the first question one always asks about any project is "How can I make it better?" Toward this end, I'll show, at a single frequency, the performance obtainable with a number of more-or-less feasible variations on the existing design, including the following:

- alternative feedpoints;
- higher boom;
- closer element spacing;
- both elements driven; and
- square loops.

I'll also discuss a few other "gain" parasitic antenna systems, including pairs of dipoles and inverted vees, and the half-wave sloper. Finally, I'll show the effect of a less convenient option — relocating to the seacoast — that provides the best results of all.

As suggested above, this isn't a construction article. Neither is it intended to present a design procedure. Even with the power available in current microcomputers, the number of trials required to find an "optimum" design is prohibitive unless one narrows the scope at the outset. *This is the purpose of this article: to provide data on* which to base an informed selection of basic design choices.

the antenna

After years of careful deliberation (i.e., procrastination), I ultimately decided to build a system very similar to the W2PV array that I discussed in a previous article.[1] The two identical equilateral loops are supported, apex up, by a 46-foot boom at the 115-foot level on a 120-foot guyed tower. The loop's circumference is 264 feet (88 feet per side). I used No. 10 AWG copper wire, primarily because it was already "in stock."

Figure 1, a diagram of the configuration, shows the coordinate system that I'll use in defining radiation patterns. The *x* axis is parallel to the boom from the reflec-

By **Bill Myers, K1GQ**, Box 501, Hollis, New Hampshire 03049.

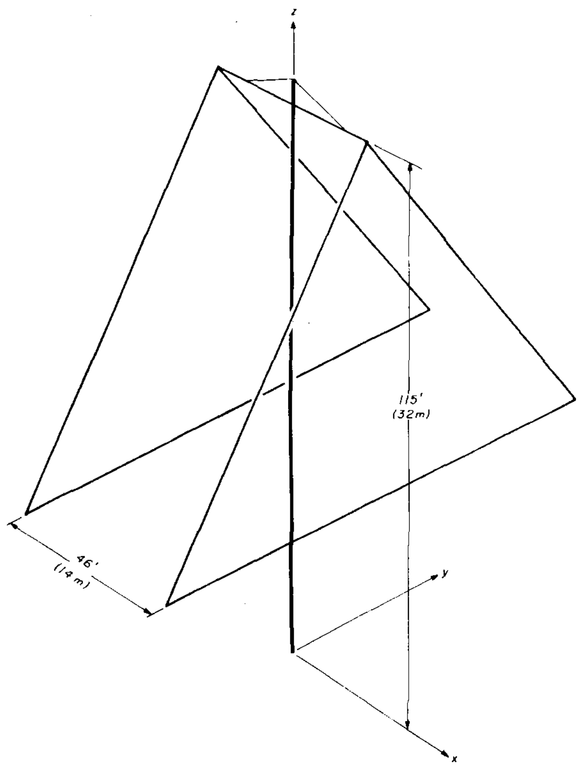


fig. 1. Delta loop array configuration. The perimeter of each equilateral loop is 264 feet. The horizontal side is 39 feet above ground.

tor end toward the driven element. The *y* axis lies in the ground plane and in the plane of the loops, and the *z* axis is positive upward.

The two loops are configured as a reflector plus driver parasitic array by adding a 4 μH coil in series with the reflector element. An additional 12 μH is connected in series with each loop to switch the center frequency from 3.8 to 3.5 MHz. The necessary switching is accomplished using relays in a small box at each loop apex.

Equal lengths of RG-11A/U connect these boxes to a third relay box at the center of the boom. I use chokes (patterned after the W2DU balun[2]) at these feedpoints to reduce currents on the outside of the feedlines. The central switchbox selects either or both loops to be connected to the main transmission line, which is 75-ohm CATV cable.

On 80 meters, transmission line losses are very small, even when the line is operated at high SWR (i.e., mismatched at the antenna). For simplicity, I decided not to attempt any matching at the antenna. Instead I use lumped-reactance networks at the station end, with additional relays to select different networks so that I can instantly switch between matched parasitic or driven configurations.

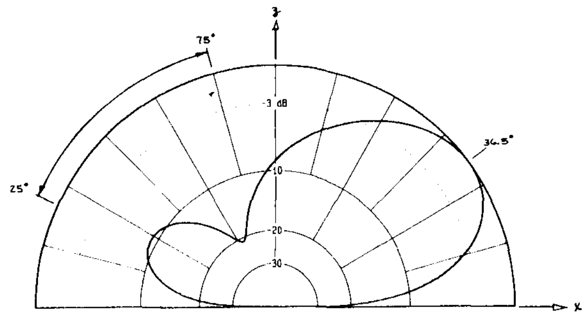


fig. 2. Elevation radiation pattern at 3.8 MHz. Peak gain is 8.69 dBi at 36.5 degrees. Front to back averaged over 25 to 75 degrees (see text) is 11.49 dB. The x and z axes are illustrated in fig. 1.

the computer program

I'm fortunate to have access to the resources needed to run the complete Numerical Electromagnetics Code (NEC).[3] This program is ideally suited to analyzing the performance of wire antennas up to a few wavelengths in size, with arbitrary shapes and excitations, in the presence of "real" ground. For those familiar with the method of moments, I modeled the six straight wires that make up the two-element array with 11 segments each. Excitation was applied at the centers of the two segments surrounding the apex, since the NEC models sources at the segment centers rather than at the segment junctions. The ground characteristics were dielectric constant, 4, and conductivity, 0.001 S/m, the usual values for poor ground such as the rocky, hilly terrain behind my house.

radiation patterns

The NEC program produces an enormous listing of numbers that's difficult to fully assimilate. Fortunately, I've succeeded in compressing much of the information, without too much agony, into a more visual format — namely, polar radiation pattern plots. It's important to understand these plots well, so I'll explain an example of each of the two types of pattern charts in some detail.

Figure 2 shows the chart I'll refer to as the *elevation pattern*. The thick curve on the inside of the grid is the ratio (in dB) of the total radiation intensity, in the direction defined by the angular coordinate of the chart, to the radiation intensity that would be obtained if the antenna input power were uniformly distributed over a sphere. Most folks simply call this ratio "gain relative to isotropic," with the notation "dBi" when the ratio is expressed in decibels. The angular coordinate for this chart is measured in the vertical plane containing the boom; that is, the *xz* plane shown in **fig. 1**. The grid interval on the chart is 15 degrees, although the resolution for pattern data points is *one* degree.

The outermost radial of the elevation pattern grid corresponds to zero dB, *relative to the peak gain in the xz* plane. The value of peak gain is noted in each figure caption. This normalization creates good detail in the pattern characteristics. Notice also that the radial coordinate is non-uniform, as was first recommended by K1TD[4]. *My charts are drawn with the scaling:*

radius = $10^{G/40}$

where G is the normalized gain in dB. This scaling expands variations near zero dB so that the 3-dB beamwidth is easy to identify, without compressing variations in the sidelobe regions excessively.

The second type of radiation pattern plot is the *azimuth pattern*, as illustrated by **fig. 3**. Here the angular coordinate is measured in the horizontal plane — the *xy* plane of **fig. 1**. Although the elevation chart shows only the above-ground hemisphere, the azimuth chart must show a full circle to allow for possible asymmetries in the radiation pattern (for example, those caused by feeding the loop array at one of the lower corners).

Each azimuth pattern corresponds to a particular value of the elevation angle. The obvious choice for the elevation angle is that corresponding to the peak gain on the elevation chart. This angle is 36.5 degrees at 3.8 MHz for my delta loop array, but it varies from case to case. In order to reduce the number of computer runs, I used 36 degrees for the elevation angle in all azimuth charts presented in this article.

Most readers will have encountered the terms "H-plane" and "E-plane" in connection with radiation patterns. I'm avoiding these terms because their definition is more likely to cause confusion than illumination. Also, I've deliberately omitted labels for the angular coordinates in the radiation pattern charts because the standard coordinate system (as defined by the IEEE[5]) is counter-intuitive for those of us who grew up in an azimuth-elevation world.

peak gain

The peak gain of an antenna system is the value of the gain in the direction of its maximum value. For most of the results discussed here, the direction of the maximum occurs in the vertical plane containing the boom. Thus, unless otherwise noted, the values quoted for peak gain are to be understood as the peak in the *xz* plane.

It is not my intent, in this article, to provide an exhaustive discussion of peak gains. There are two reasons for this. First, the number of interesting cases is overwhelming when one considers the range of applicable heights, frequencies, and ground characteristics in addition to *the enormous variety of antenna designs*. Second, there are many well-established myths that must be systematically dealt with in any such undertaking; doing so would expand the scope of this article substantially. Thus, the gains presented herein should not be extrapolated beyond the conclusions stated below.

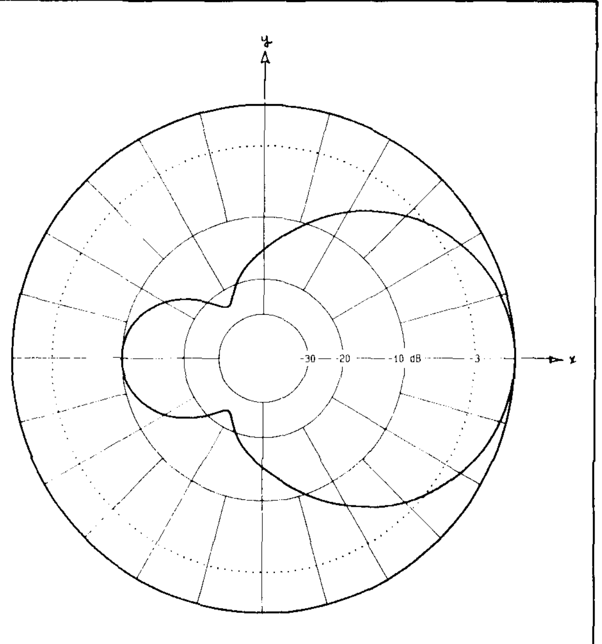


fig. 3. Azimuth radiation pattern at 3.8 MHz for 36 degree elevation angle. The x and y axes are illustrated in fig. 1.

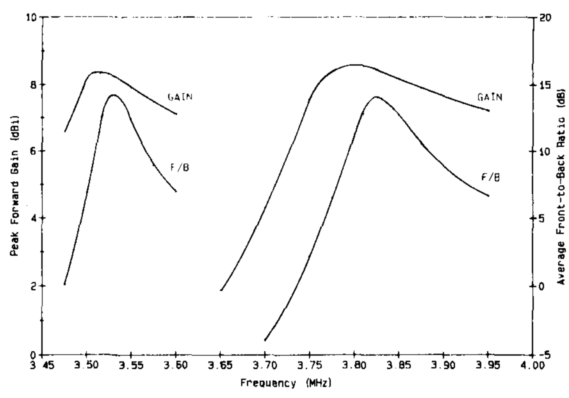


fig. 4. Two element delta loop array performance versus frequency for phone and CW modes. The phone-mode design frequency is 3.8 MHz. The CW-mode is created by series-loading each loop with a 12 μH inductor.

average front-to-back ratio

The concept of front-to-back ratio needs some elaboration to provide a useful measure of 80-meter antenna performance. As suggested by **fig. 2**, the elevation pattern can exhibit deep nulls at selected elevation angles, while showing large lobes at other angles off the back. Thus, the ratio of forward gain at a specified elevation angle to the backward gain at the same angle can vary dramatically for different elevation angles.

On the 80-meter band, *all* of the elevation angles are

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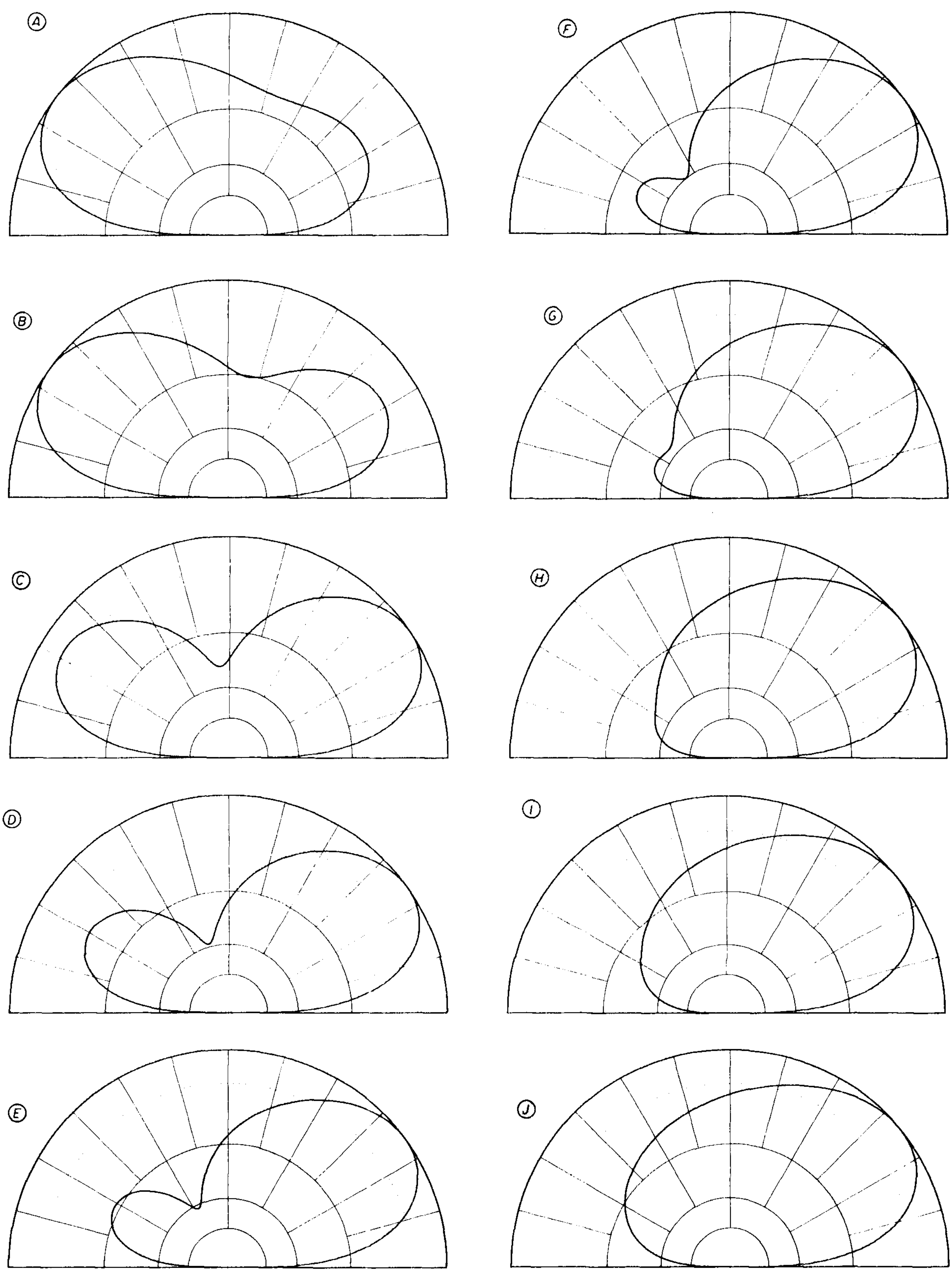


fig. 5. Phone mode elevation patterns from 3.65 (A) through 3.95 MHz (J). See table 1.

significant, from the extremely low angles needed for very long DX paths to the nearly straight-up angles required for accepting (or rejecting) local signals. As far as I can determine, the question of which angles are most important, say for the path from New England to Western Europe, remains unanswered. G6XN[6] claims that the only valid rule is "the lower the better." There seems to be ample evidence to the contrary, however. For example, many DXers in the Northeast have observed that high-angle antennas often perform better than low-angle antennas when the band first opens toward Europe in the evening. (The same observation applies to both 40 and 160 meters, as well.) In any case, 80-meter antenna systems with poor gain near the horizon (such as the delta loop array described here) are good overall performers, suggesting that angles in, perhaps, the 20- to 50-degree region are indeed useful for medium-range DXing.

In assessing the radiation pattern, we're usually interested in the ability of the antenna system to reject strong signals coming from the backward direction, which are most likely to arrive at relatively high elevation angles (the lower angles corresponding to longer paths and thus to weaker signals). Thus, I've chosen to display the ratio of the peak forward radiation intensity to the backward radiation intensity averaged over the elevation angles from 25 to 75 degrees. This power ratio is presented in the customary dB. I'll abbreviate this performance characteristic as "averaged f/b," rather than "peak forward power to backward power averaged over 25 to 75 degrees in the *xz*-plane." I believe this quantity is a more useful indicator of 80-meter antenna performance than the customary f/b ratio; furthermore, the values presented below seem to agree well with on-the-air observations.

impedance

Knowledge of the antenna input impedance is useful for two reasons. First, one can design a matching network to transform the input impedance to the characteristic impedance of the transmission line, thereby minimizing line losses due to mismatch. Second, the NEC calculation of gain requires an accurate value for the input impedance (in order to determine input power).

The fidelity of the NEC input impedance computation is affected by the number of segments specified for the antenna model. More segments improve the impedance result (up to the onset of numerical difficulties), but also increase the run time dramatically. However, if the segment length is held constant from case to case, then the relative results can be trusted even though the absolute values may be suspect. In all of the cases presented here, the number of segments per straight wire section was selected to yield approximately the same physical segment length (8 feet).

Table 1. Phone-mode elevation patterns vs. frequency.

Frequency (MHz)	Peak Gain (dBi)	Angle (deg)	Average F/B (dB)
3.65	7.44*	38.0	−5.35
3.7	7.62*	36.0	−3.69
3.75	7.66	34.5	2.41
3.775	8.48	35.5	6.73
3.8	8.68	36.5	11.49
3.825	8.54	37.5	14.33
3.85	8.27	38.0	12.94
3.875	7.99	38.5	10.73
3.9	7.73	38.5	9.04
3.95	7.30	39.5	6.86

*In the backward direction

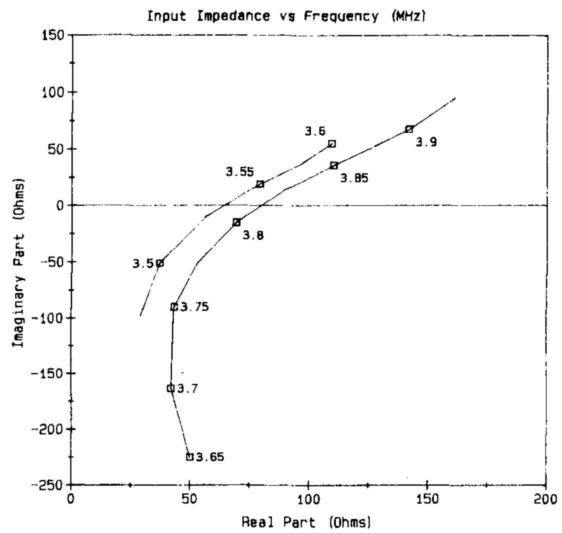


fig. 6. Computed input impedence versus frequency for phone and CW modes. These do not correlate well with measurement (see text).

performance

Figure 4 shows the computed performance versus frequency for my two-element array. The phone-mode peak gain reaches its maximum (8.68 dBi) right at the design frequency, 3.8 MHz. The peak in the average f/b is about 25 kHz higher. The CW-mode gain reaches its maximum just above 3.5 MHz, and the offset to the f/b peak is also about 25 kHz. The overall response appears slightly narrower for the CW mode, as should be expected for loaded loops, but the difference in bandwidth between modes is unimportant. The maximum CW peak gain (8.40 dBi at 3.525 MHz) is slightly below the phone mode maximum.

The gain and f/b peaks can be aligned at the same frequency by at least two methods. The reflector loading

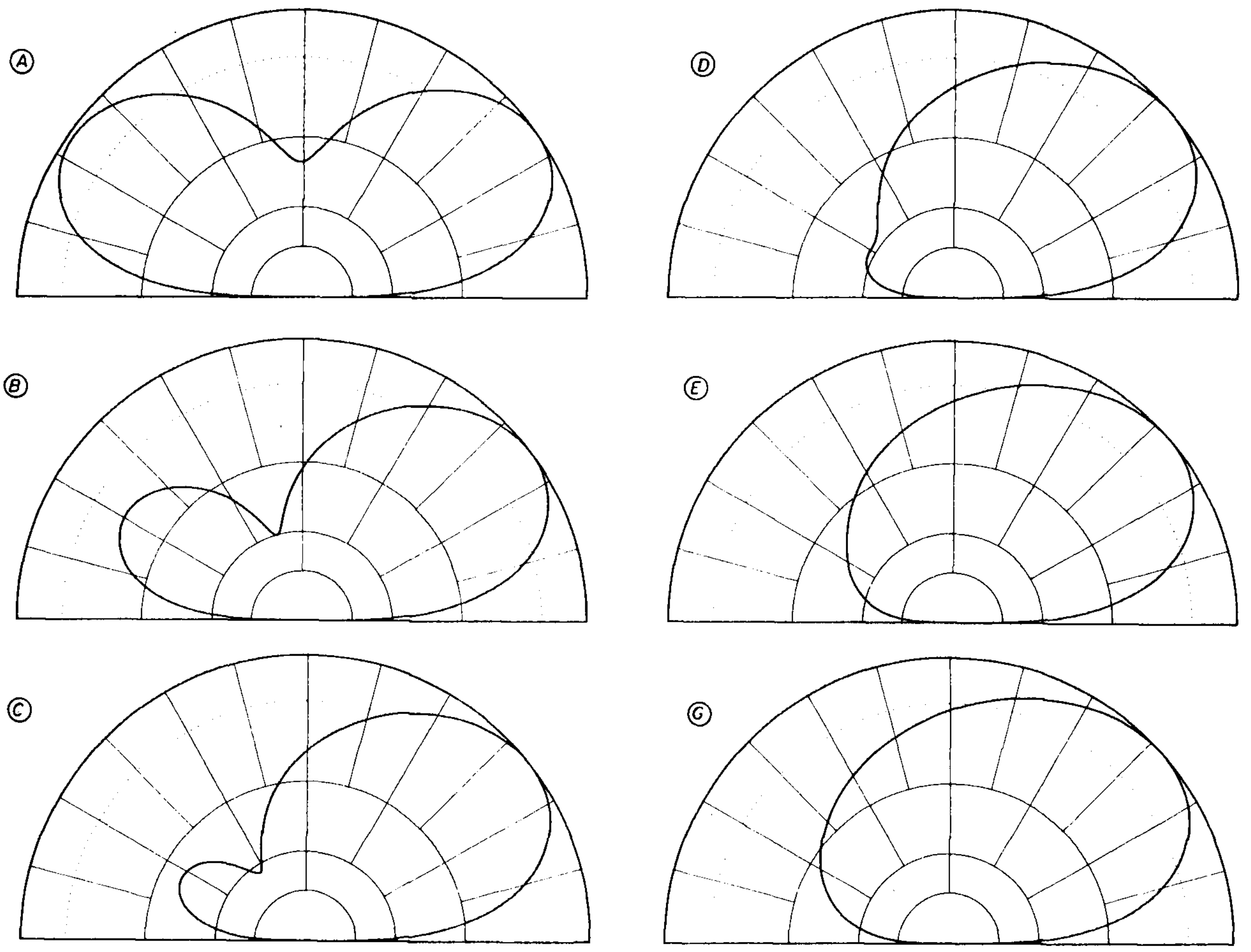


fig. 7. CW-mode elevation patterns from 3.475 (A) through 3.6 (G) MHz. See table 2.

inductance can be varied. Or one can simply redefine the range of angles over which the average is computed. The point here is that the 25-kHz offset is a silly amount to worry about.

A more significant result is the pattern reversal just below 3.75 MHz. Negative f/b ratio means that the direction of the peak gain is toward the reflector. This occurs because the parasitic element is electrically too short to act like a reflector. The potential for disaster caused by too-short loops is obvious; if I ever rebuild the loops I will probably increase the circumference 4 feet to move the design frequency down about 50 kHz.

Figure 5, a series of elevation radiation pattern plots at a number of frequencies surrounding the design frequency, shows the pattern reversal quite nicely (see also **table 1**). Note that the elevation angle of the main lobe is nearly the same at every frequency, increasing uniformly from 34.5 degrees at 3.7 MHz to 38.5 degrees at 3.9 MHz. If we define the *effective height* of an antenna system as the height of a horizontal half-wave dipole, above perfect ground, which yields the same elevation for the first lobe of the ground reflection pattern, then:

Table 2. CW-mode elevation patterns vs. frequency.

Frequency (MHz)	Peak Gain (dBi)	Angle (deg)	Average F/B (dB)
3.475	6.67	34.5	0.38
3.5	8.28	36.5	7.14
3.525	8.40	39.0	14.31
3.55	8.01	40.5	12.42
3.595	7.57	41.5	9.16
3.6	7.21	42.0	7.21

$$h_e = \lambda/(4 \sin\theta)$$

where θ is the elevation angle. The effective height for the parasitic array (at 3.8 MHz) is 0.42λ, or 109 feet. Thus, even though most of the antenna structure is well below the effective height, the array still yields a relatively low angle for the main lobe.

This rather surprising result comes about because of the supression of higher angle radiation by the array free-

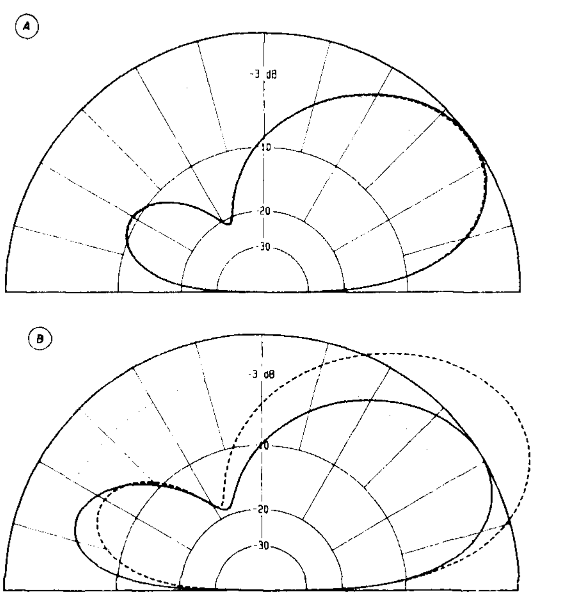


fig. 8. Elevation patterns at 3.8 MHz for alternate feedpoints. Peak gains are 8.80 dBi and 5.48 dBi for (A) bottom and (B) corner feed, respectively. Corresponding average F/B ratios are 11.53 dB and 7.83 dB. The dashed pattern on these charts is for top feed.

space directivity. If the directions for the peak gains of the free-space pattern and the ground reflection pattern were aligned, we could expect gain in the neighborhood of 13 dBi (7 dBi from the array and 6 dB from the reflection). The actual peak gain is lower partly because the lobes are not aligned (the free-space array peak is on the horizon, where the ground reflection pattern has a null) and partly because the reflection isn't perfect.

The input impedances calculated by NEC for the delta loop array are plotted in **fig. 6**. The phone mode system is resonant near 3.815 MHz, with the resistive component equal to about 80 ohms. The CW mode resonance is about 3.535 MHz, at 65 ohms. These results don't correlate with SWR measurements or with admittance measurements at the transmission line input. This isn't too surprising, however, because the antenna model I provided as input to NEC isn't especially realistic in details that can influence impedance, such as adjacent towers and uneven terrain.

Figure 7 shows the CW mode elevation patterns for frequencies at the bottom of the band (see also **table 2**). The elevation angles for the gain peaks are slightly higher than for phone mode, but not enough to be of concern. The best pattern occurs a bit high in the band for an inveterate DXer, but I've found on-the-air performance to be excellent at the very bottom of the band.

In fact, in practice the apparent f/b ratio has been generally consistent with that indicated by the performance calculations. On both modes, S5 stations in Europe disappear into the band noise when the array direction is switched. Louder Europeans decrease in signal strength about 2 to 3 S-units, while US stations come up by the same amount. My receiver is a TS-930; I've checked the S-meter calibration and found it to be about 5 dB per S-unit. The array shows essentially no f/b at 3.75 MHz and is definitely backward (in the phone mode) at 3.7 MHz.

I currently have two other 80-meter antennas, a dipole at 120 feet parallel to the array boom, and a full-size quarter-wave vertical with 12 radials. Neither of these antennas should work well in the directions favored by the delta loop array . . . and they don't. On the other hand, the dipole is better to the Caribbean, South America, and Japan. While the loops do exhibit some rejection "off the side," it's not as much as the dipole exhibits off its ends. Overall, I'm quite pleased with the agreement between the theoretical results and actual performance, especially considering that the terrain surrounding my antenna system is far from planar.

bottom and corner feed

My loops are fed at the top. Full-wave loops can be fed anywhere on the circumference with no appreciable change in the input impedance or in the *free space* directivity. However, the selection of the feedpoint has a potentially devastating effect over real ground. Two interesting alternative feedpoints are at the center of the horizontal bottom side and at either of the two corners. The elevation patterns for these two cases, at 3.8 MHz, are shown in **fig. 8**. The bottom-fed pattern is indistinguishable from the top-fed pattern (the dashed curve) and the peak gains are nearly the same: 8.80 dBi versus 8.68 dBi, respectively. (This small difference may well

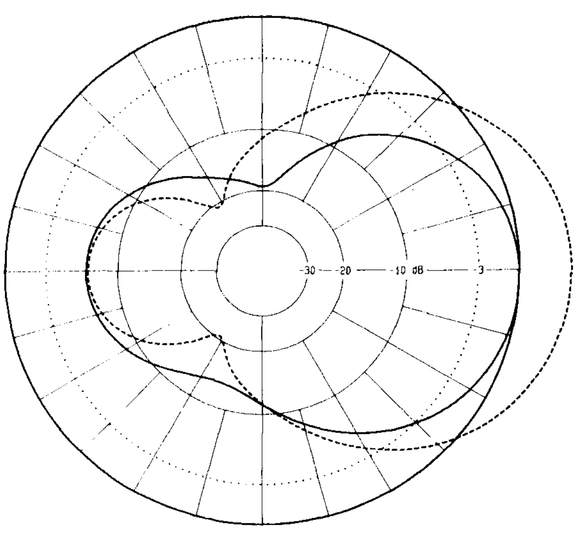


fig. 9. Azimuth pattern at 3.8 MHz with corner feed. The pattern is skewed towards the side of the boom containing the feedpoint. The dashed pattern is for top feed.

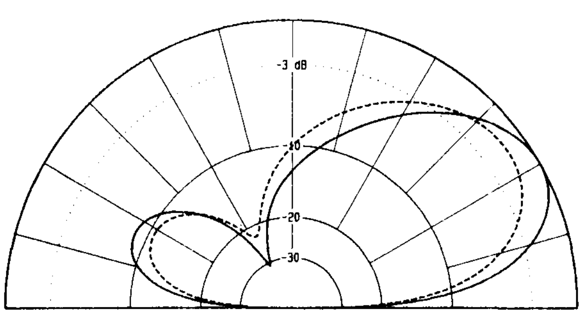


fig. 10. Elevation pattern at 3.8 MHz with the array raised to 145 feet. Peak gain is 9.97 dBi at 30.5 degrees and average F/B is 11.10 dB. The dashed pattern is for boom at 115 feet.

be due to modeling errors that lead to small input impedance errors and thus to peak gain errors.) The corner-fed pattern, on the other hand, is clearly inferior in the backward direction; furthermore, the peak gain is dramatically reduced to 5.48 dBi. The corner-fed azimuth pattern (**fig. 9**) shows that the pattern is skewed and the side null is filled in on the side of the boom corresponding to the driven corner.

The explanation for the inferior performance of the corner-fed arrangement is simple. The amplitude of the reflection coefficient for poor ground is much lower for vertical polarization than for horizontal polarization. Thus, the "gain" produced by ground reflection is smaller for vertically-polarized radiated fields. The corner feed produces a substantial vertically-polarized component in the total field, whereas the top and bottom feeds produce entirely horizontal polarization, so the corner feed has less gain (see Appendix for additional discussion).

increased height

Another feasible modification to my delta loop array would be to raise the antenna. Since I guy my towers every 30 feet, the next "natural" boom height above 115 feet is 145 feet. **Figures 10** and **11** show the elevation and azimuth patterns at 3.8 MHz for this configuration. Interestingly, while the depth of the rearward null is increased, the magnitude of the rearward lobe is also increased and the average f/b is almost unchanged. The peak gain is quite a bit higher, up 1.29 dB to 9.97 dBi, and the elevation angle at the peak is 6 degrees lower, at 30.5 degrees. The change in the angle is not too important, but the potential for increased gain, which is rather hard to come by, may be worth the challenge of constructing and maintaining a 150-foot tower.

closer spacing

I chose an unusually wide spacing for my array because I guessed that the increase in radiation resistance

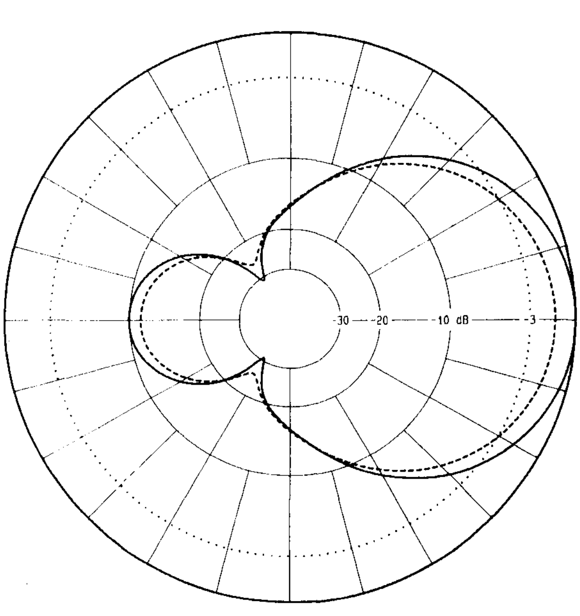


fig. 11. Azimuth pattern at 3.8 MHz with the array raised to 145 feet. The dashed pattern is for boom at 115 feet.

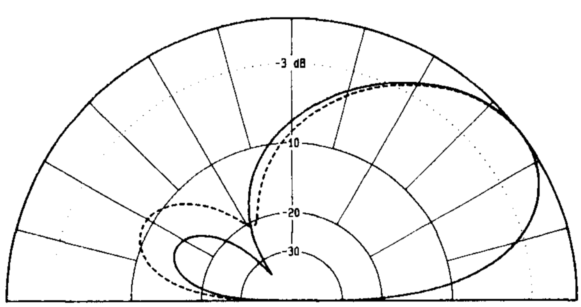


fig. 12. Elevation pattern at 3.8 MHz with spacing reduced to 32.4 feet. Peak gain is 8.70 dB at 36.5 degrees and average F/B is 16.07 dB. The dashed pattern is for 46-foot spacing.

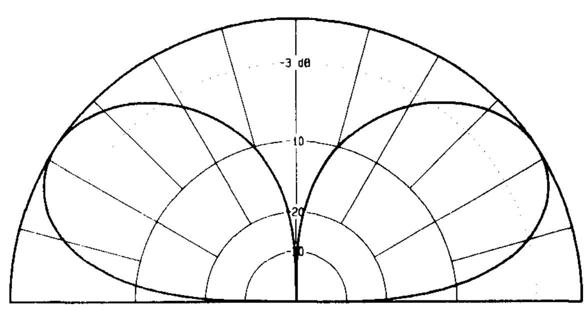


fig. 13. Elevation pattern at 3.8 MHz with both loops driven 180 degrees out-of-phase. Peak gain is 7.05 dB at 33 degrees.

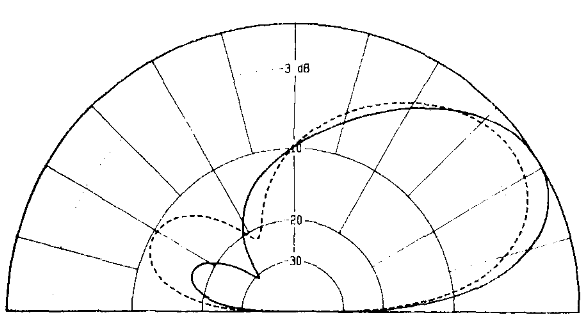


fig. 14. Elevation pattern at 3.8 MHz for square loops with the same perimeter as the triangular loops. Peak gain is 9.71 dBi at 31.5 degrees and average F/B is 16.52 dB. The dashed pattern is for triangular loops.

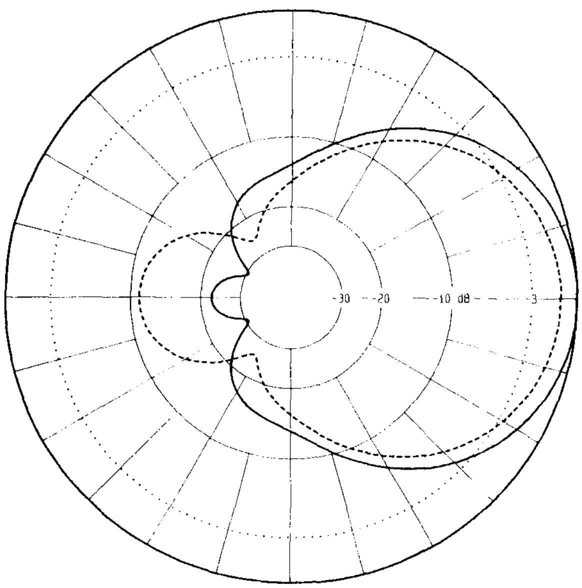


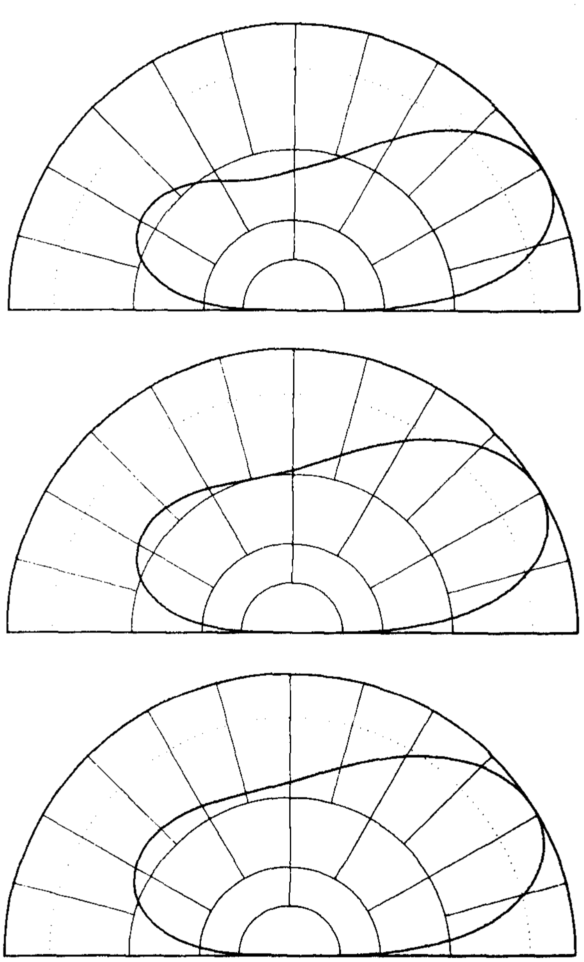
fig. 15. Azimuth pattern at 3.8 MHz for square loops. The dashed pattern is for triangular loops.

with increased spacing would partially offset the relatively lower value created by proximity to ground. Also, I expected that the bandwidth would be somewhat better at the larger spacing. Because the array is parasitic rather than driven, performance isn't terribly sensitive to spacing. Although I haven't verified all of these conjectures, I did examine performance for spacing reduced from 46 feet to 32.4 feet at λ/8 (3.8 MHz). The elevation pattern shown in **fig. 12** has nearly the same peak gain (8.70 versus 8.68 dBi) at the same elevation angle, but the backward pattern is significantly better. The input resistance drops 19 ohms while the input reactance increases 15 ohms.

both loops driven

As mentioned earlier, I designed the remotely controlled switches so that I could drive both loops together if I chose to. The feedpoint boxes are identical, and installed facing each other, so paralleling the feedlines at the center of the boom results in exactly out-of-phase drives to the two loops (with the feedlines from boom center to loop apex being equal in length).

A two-element array driven with 180-degree phase shift produces an end-fire pattern that's independent of spacing over a reasonable range near λ/8. The elevation pattern has a very deep null straight up, as seen in **fig. 13**. I thought this null might produce good effective f/b when listening to Europeans, assuming that signals from



Element Type	Peak Gain (dBi)	Angle (deg)	Average F/B (dB)
dipole	9.26	28.5	6.92
120° vee	8.54	31.0	6.62
90° vee	8.04	32.0	6.47

fig. 16. Elevation patterns at 3.8 MHz for halfwave elements.

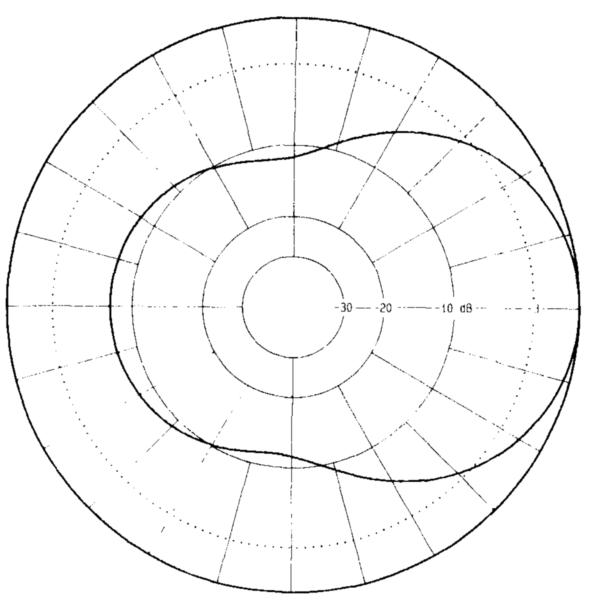


fig. 17. Azimuth pattern at 3.8 MHz for dipole elements. Patterns for inverted vee elements are virtually the same.

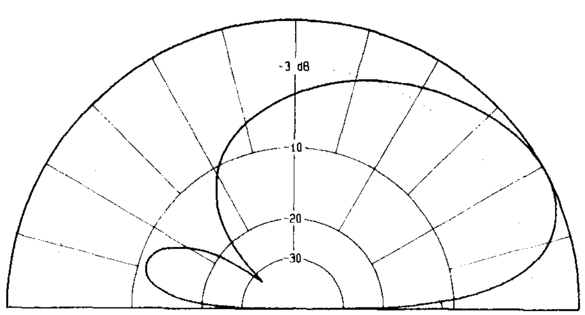


fig. 18. Elevation pattern at 3.8 MHz for a halfwave sloper plus 120 foot grounded tower. Peak gain is 1.56 dBi at 28.5 degrees and average F/B is 11.12 dB. Peak gain without the tower is 0.81 dBi at 31.5 degrees.

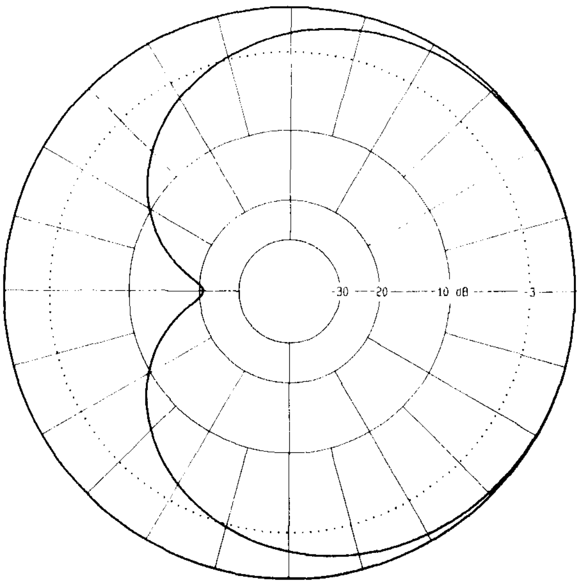


fig. 19. Azimuth pattern at 3.8 MHz for halfwave sloper plus 120 foot grounded tower.

close-in W's would arrive at high elevation angles. However, in practice I found that the pattern of the parasitic array (**fig. 2**) rejected local signals better than the driven array.

The calculated peak gain for the driven array is 7.05 dBi. This is significantly below the gain of the parasitic array. Furthermore, the input resistance is much lower, so that the effect of losses in the CW loading coils becomes more significant (however, these coils aren't required for a driven array). I found that signals from Europe were never better with the driven arrangement, and occasionally were noticeably worse (note that 1.5 dB is generally *not* measurable except with laboratory instrumentation). I've abandoned this setup.

square loops

The mechanical challenges inherent in constructing an array of square loops in place of delta loops are severe but not outrageous. According to G6XN[6], we can't expect that the change in the shape of the elements will yield any appreciable change in gain, but the pattern may be improved (i.e., the side lobes can be decreased) with increased mutual coupling. Changing to square loops with the top horizontal side at the same height as the apex of the delta loops raises the effective height, which will increase peak gain and decrease the elevation angle at the gain peak.

These conclusions are supported by the results. The peak gain for the elevation pattern shown in **fig. 14** is 9.71 dBi, about 1 dB higher than the delta loop array. The elevation angle at the peak is 5 degrees lower, at 31.5

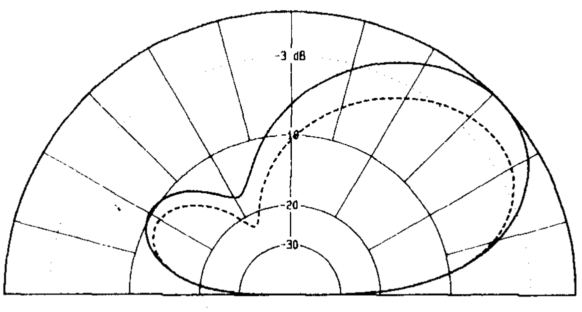


fig. 20. Elevation pattern at 3.8 MHz for sea water ground conditions. Peak gain is 10.47 dBi at 42.0 degrees and average F/B is 11.25 dB. The dashed pattern is for poor ground.

degrees. And the pattern is outstanding; the average f/b for this case is 16.5 dB! The azimuth pattern is shown in **fig. 15**; this pattern is also excellent.

half-wave elements

Erecting closed one-wavelength loops on a guyed tower can be a major hassle when there are trees within shouting distance of the tower. (By the way, I have ample experimental evidence that shouting at trees in hope of convincing them to release captured wires is ineffective.) Because half-wave elements are much simpler to handle, I examined the performance of three two-element parasitic arrays with:

- horizontal half-wave elements at 115 feet;
- inverted-vee half-wave elements from 115 feet, with 120-degree apex angle; and
- inverted vee elements with 90-degree apex angle.

Figure 16 shows the elevation pattern charts for these three cases. There's a tendency for the pattern null to fill in as the apex angle decreases. However, even the horizontal dipole array pattern is inferior to the delta loop pattern (**fig. 2**). It may be possible to "tune up" the pattern by changing the element spacing and the loading inductance for the reflector, but I haven't attempted this analysis. The azimuth pattern for the horizontal dipole case is given in **fig. 17**; the patterns for the two inverted vee cases are almost the same.

On the other hand, the peak gains are competitive with the delta loop array: 9.26, 8.54, and 8.04 dBi, respectively, versus 8.68 dBi for the loops. It appears that the inverted vee array with wires as flat as possible is a good substitute for the delta loops as far as gain is concerned.

the half-wave sloper

My previous 80-meter antenna system was a set of four half-wave slopers, slanting about 30 degrees from the vertical. Unfortunately, I had to dismantle this system before the delta loop array was operational, so I have no on-the-air comparison of the delta loops versus the slopers.

Figure 18 illustrates the elevation pattern for a single half-wave sloper (slanted 30 degrees from vertical), in the presence of a 120-foot tower grounded at its base. The backward rejection is rather good — the average f/b is 11.1 dB. The corresponding azimuth pattern is included in **fig. 19**, even though it's unremarkable.

Now for the bad news: the peak gain (at 28.5 degrees) is a paltry 1.56 dBi. Compare this with a simple inverted vee from 120 feet with 120-degree apex angle, which exhibits a peak gain of 6.18 dBi at 31 degrees. Once again, the source of this inferior performance is polarization. The field in the plane containing the sloper and the tower is entirely vertically polarized, which is disastrous over poor ground (see Appendix). In fact, the peak gain of the sloper over poor ground is *less* than the same antenna in free space (2.16 dBi). One possible explanation might be that the proximity to ground distorts the nominally-sinusoidal current distribution on the sloper so badly that the directivity is degraded. However, examination of the NEC printout for this case shows that the current is symmetrical about the feedpoint (the center) within a few percent in amplitude and within 1 degree in phase. Thus, the degradation must be due to destructive interference between the (attenuated) reflected field and the direct field.

Clearly, the sloper — like the corner-fed loop — is a poor choice for a transmitting antenna at sites with poor ground characteristics. I'm planning to reinstall one of my slopers to verify whether or not this computed 7-dB disadvantage appears in practice.

performance over good ground

I've disparaged the performance of vertically-polarized antennas over poor ground, but the fact is that poor ground degrades the performance of *any* type of antenna for 80 meters at other than grazing angles. **Figures 20** and **21** show the radiation patterns for my delta loop array when moved to an island surrounded by salt water. The pattern nulls are filled in somewhat and the elevation angle for peak gain is *increased* to 42 degrees. However, the peak gain is considerably increased, by nearly 2 dB, to 10.47 dBi. This figure probably represents the maximum gain achievable with a two-element array of delta loops at 115 feet.

summary

I've presented polar plots, gains, and average f/b data for a number of 80-meter antennas. **Table 1** collects all of the results in one place and includes the input impedances computed by NEC. These latter data are not reliable because I did not follow the procedures needed to confirm that enough segments were provided to assure that this calculation had "converged" to the true value. However, all cases were run with comparable segment lengths, so the trends in impedance should be representative of the true behavior.

The significant column in **table 3** is the peak gain; it's possible that the average f/b for any of the variations could be tweaked somewhat by modifyiing the reflector's resonant frequency and the element spacing.

The primary conclusions of this study of 80-meter antennas over poor ground are:

- The delta loop array provides enough gain to be worth the effort, along with truly useful f/b ratios, even though the boom height is too low by conventional wisdom.
- Raising the boom 30 feet would add about 1.3 dB of gain at a slightly lower elevation angle.
- Changing from delta loops to square loops would increase gain about 1.0 dB and would improve the pattern.

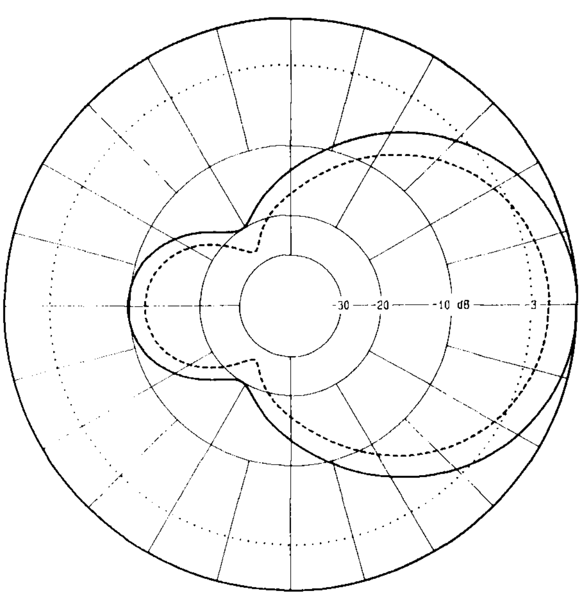


fig. 21. Azimuth pattern at 3.8 MHz and 36 degree elevation angle for salt water ground. The dashed pattern is for poor ground.

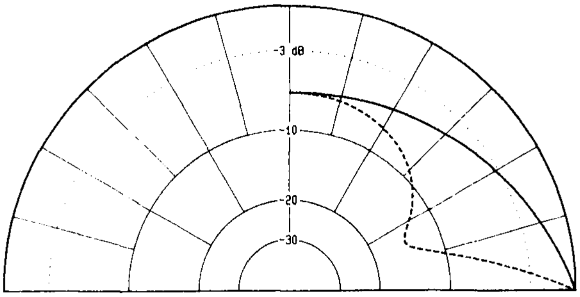


fig. 22. Reflected field intensity amplitude versus angle of incidence for horizontal (solid curve) and vertical (dashed curve) polarization with poor ground ($\epsilon_\rho = 4$ and $\delta = 0.001$ S/m).

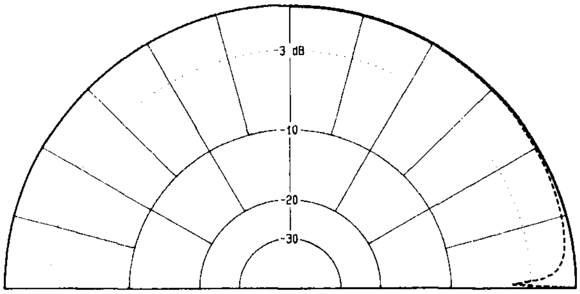


fig. 23. Reflected field intensity amplitude versus angle of incidence for horizontal (solid curve) and vertical (dashed curve) polarization with good ground ($\epsilon_\rho = 80$ and $\delta = 5$ S/m). The solid curve nearly coincides with the 0 dB arc at all angles.

Table 3. Summary of Antenna Cases.

Description	Peak Gain (dBi)	Elevation Angle (deg)	Average f/b (dB)	Input Impedence (ohms)
GQ Delta Loop Array	8.68	36.5	11.5	69.2 − j15.3
GQ at 3.5 MHz	8.28	36.5	7.1	37.0 − j51.3
GQ bottom fed	8.80	36.0	11.5	129.2 − j23.6
GQ corner fed	5.48	33.0	7.8	71.4 − j57.3
GQ 30′ higher	9.97	30.5	11.1	80.1 − j12.0
GQ on 32.4′ boom	8.70	36.5	16.1	50.2 − j 0.0
GQ over salt water	10.47	42.0	11.3	55.5 − j11.5
GQ with square loops	9.71	31.5	16.5	119.5 + j41.0
GQ with both driven	7.05	33.0	0.0	25.2 − j44.3
Two dipoles	9.26	28.5	6.9	78.2 + j20.1
120 deg Inverted vees	8.54	31.0	6.6	64.6 + j 5.2
90 deg Inverted vees	8.04	32.0	6.5	45.8 − j21.3
Sloper & tower	1.56	28.5	11.1	103.1 + j22.3

- Moving the feedpoint to the bottom center would have essentially no effect; moving it to a corner would be disastrous.
- Shortening the boom to $\lambda/8$ would lower the radiation resistance and improve the pattern somewhat, but would not change the gain.
- Replacing the loops with dipoles or flat inverted vees would not affect gain very much, but the pattern would be degraded.
- My half-wave sloper system should not have worked.
- I should retire to an island off the coast of Maine.

acknowledgements

Many thanks are due John Kenny, W1RR, and Doug Grant, K1DG, who constructively reviewed this article.

references

1. Bill Myers, K1GQ, "The W2PV 80-Meter Quad," *ham radio*, May, 1986, page 56.
2. Walter Maxwell, W2DU, "Some Aspects of the Balun Problem," *QST*, March, 1983, page 38.
3. G. J. Burke, and A. J. Poggio, "Numerical Electromagnetics Code (NEC) — Method of Moments," Naval Ocean Systems Center, Technical Document 116, Volumes 1, 2, and 3, January, 1981.
4. G.L. Hall, K1TD, "The New Look for QST's Antenna Patterns," *QST*, July, 1980, page 26.
5. *IEEE Standard Test Procedures for Antennas*, Institute of Electrical and Electronic Engineers, 1979.
6. L. A. Moxon, G6XN, *HF Antennas for All Locations*, Radio Society of Great Britain, 1982.
7. M.T. Ma, *Theory and Application of Antenna Arrays*, John Wiley and Sons, New York, 1974.

appendix
ground reflection amplitudes

The effects of real ground on Amateur antenna installations have been reported many times, so I don't propose to reiterate those analyses. However, I did develop an unusual polar plot which helps in clarifying some of those effects. To understand the chart, a bit of prefatory explanation is needed.

The presence of ground is modeled by constructing a *reflected field* that is vectorially summed with the direct field of the antenna. The reflected field from a given point on the ground is proportional to the field incident from the antenna; the proportionality constant is called the reflection coefficient. The reflection coefficient depends on polarization of the incident wave and on the angle of incidence, as well as the characteristics of the ground (which depend on frequency). This rather complicated modeling problem is simplified somewhat by decomposing the incident field into horizontal (parallel to the ground) and vertical (in a plane normal to the ground) components and applying separate horizontal and vertical reflection coefficients. Expressions for these coefficients are given in many texts; for example, Chapter 4 of Ma's *Theory and Application of Antenna Arrays*.[7]

The two reflection coefficients are complex numbers; that is, the reflected field components are modified in both amplitude and phase. The effect of phase shifts is a modification of the positions of peaks and nulls in the final pattern, which is developed by constructive and destructive recombinations of the incident and reflected fields. The effect of amplitude modification is to change the levels of the peaks and nulls. For example, if the reflected wave amplitude is one-half of the incident wave, the combined field will have peaks no greater than 1.5 times the amplitude of the original field (+3.52 dB). The maximum combined field with perfect reflection is 2 times the original amplitude, or 6.02 dB, so 2.50 dB of "potential" gain has been lost.

The horizontal and vertical reflection coefficients are rather messy functions of angle of incidence, dielectric constant, conductivity, and frequency. To illustrate the behavior of these parameters at 3.8 MHz, I've plotted the reflection amplitude versus angle of incidence in the same format I used for the elevation patterns. That is, the radial coordinate represents the amplitude of the reflected radiation intensity (power) relative to the incident radiation intensity, and the angular coordinate corresponds to the elevation angle for the incident field. **Figure 22** shows this chart for poor ground, with dielectric constant = 4 and conductivity = 0.001 S/m. The solid curve is the amplitude for the horizontal reflection coefficient and the dashed curve is for the vertical reflection coefficient. Note that both are unity (zero dB) for grazing angle incidence, and both are equal for normal incidence. The very pronounced null in the vertical reflection coefficient amplitude shows graphically why vertical polarization is inferior to horizontal polarization over poor ground, except at extremely low angles. (To be fair, it must be noted that at low antenna heights, vertical polarization is superior — even though the amplitude of the vertical coefficient is always less than that of the horizontal component. This is because the phase shift for the horizontal polarization guarantees destructive recombination, whereas the recombination for vertical polarization is constructive in the region above the null.)

This situation changes dramatically over good ground. **Figure 23** shows the same chart for salt water, with dielectric constant equal to 80 and conductivity equal to 5 S/m. Both coefficients are essentially unity for all angles of incidence, except for the narrow null near grazing incidence for the vertical coefficient. The advantage of horizontal over vertical polarization does not occur in this environment.

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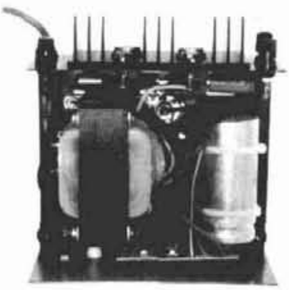

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This brief article describes the construction of a relatively high-performance RF amplifier that uses a Signetics NE5205 wideband RF amplifier. The NE5205[1] is an integrated wideband RF amplifier that serves as an excellent general-purpose RF gain block for applications from a few Hertz to above 600 MHz. It provides a non-inverting 20-dB gain and, although not an LNA, its typical 6-dB noise figure (50-ohm input) is quite good and should be adequate for many RF projects.

The NE5205 is available in either a TO-46 metal package or an eight-pin small-outline (SO) package. Although samples were distributed in the conventional eight-pin mini DIP ("N" package), that package isn't shown in the NE5205 literature and doesn't appear to be available from distributor stock.

The SO package is a very inexpensive plastic unit with the same operating characteristics as the TO-46. A minor problem with the SO package, however, is size; it's about one-twentieth the volume of the more common eight-pin mini DIP. The leads, on 0.05-inch centers and bent at the ends in the form of small feet, are much too short to go through even a thin PC board. This is a surface-mount device (SMD) designed to be mounted on the trace side of the PC board or other substrate. The package is small, but it isn't difficult to handle; you will, however, have to be quite careful and you may have to buy a small tip for your soldering iron.

NE5205 features

The functional schematic for the NE5205, shown in **fig. 1**, is considerably more complex than typical integrated wideband RF amplifier gain blocks. The small die size, offering low propagation delays and low parasitic elements, in part give this component its good operational characteristics. A particularly useful feature is the use of several different feedback loops to stabilize the gain and operating point and provide good input and output impedance matching. While this is too lengthy a topic to be covered here, the NE5205 data sheet provides complete details.[1]

Don't try to build the circuit shown in **fig. 1** from discrete components; such a construction might work to a few tens of megahertz, but in general its performance will be very poor at best. The success of this circuit design depends as much on the small die size and integrated construction as on the actual circuit configuration. In any event, it's much less expensive to use the NE5205 than to build a discrete version.

In a minimum basic circuit, the NE5205 needs only three external components: input and output coupling capacitors and a supply bypass capacitor. Adding a few inexpensive components, however, results in a more versatile amplifier with much better tolerance for the abuse of experimenting than a minimum parts-count amplifier would offer.

By Michael E. Gruchalla, 4816 Palo Duro NE, Albuquerque, New Mexico 87110

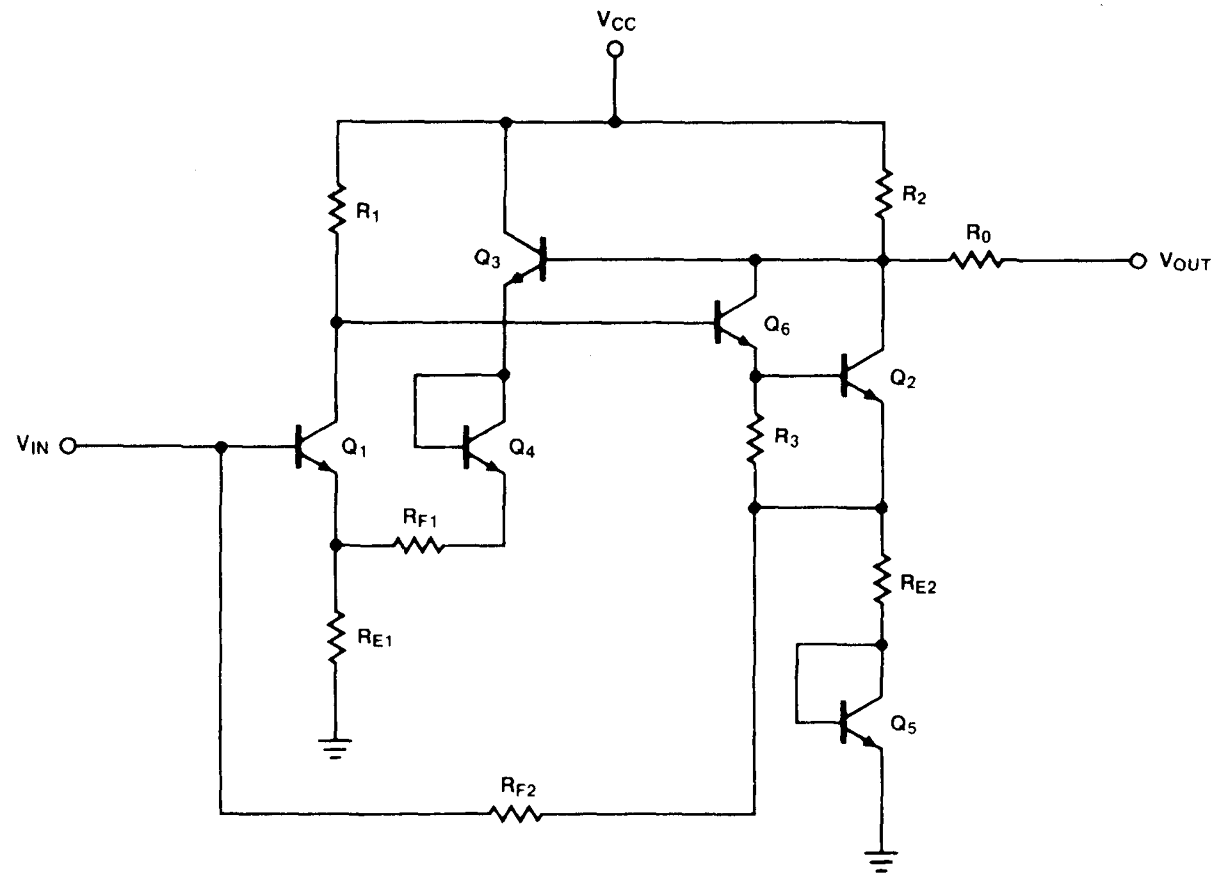

fig. 1. NE5205 functional diagram.[1]
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amplifier circuit

Figure 2 shows the schematic of the complete amplifier. The input diode, CR1, prevents reverse-bias damage to the input transistor of the NE5205. The input can generally tolerate short pulses of high forward bias since the input transistor is simply forward-biased. However, even short pulses of reverse (negative) input bias as low as a few volts will avalanche the input emitter-base junction, totally destroying the part or seriously degrading its noise performance. When CR1 is included, it will conduct with a reverse input drive of about 1.4 volts, limiting the input level to the NE5205 to a safe value. This diode is reverse-biased at about 1 volt by the input potential of the NE5205. Since the maximum usable input of the NE5205 is about 80 mV peak (– 12 dBm), the 1-volt reverse bias of CR1 prevents its conduction with normal signals and helps reduce the diode capacitance to minimize loading of the input. CR1 is a Schottky diode with a faster response speed than the NE5205 and it has minimum capacitance. If you can't find the 1N5711 device specified for CR1, a 1N4148 or 1N914 will work reasonably well; the high-frequency cutoff may be reduced, however. CR1 may simply be omitted, but the finished amplifier will then be quite sensitive to input damage.

Resistors R1, R2, and R3 form a Pi pad to allow a little adjustment of the amplifier gain and input impedance. They also provide some additional input protection. Similarly, R4, R5, and R6 form an output pad for gain and output impedance adjustment. These two pads may be omitted for maximum gain, but I find that keeping about a 0.5-dB pad at each place provides better stability in general applications. The resistors should be a high-quality carbon composition type. Low-noise carbon film or metal film may be used if their high-frequency performance is adequate.

The coupling capacitors, C1 and C2, must be dipped tantalums to minimize the physical size and provide good high-frequency performance. Don't try to use aluminum electrolytics; if you do, you're likely to end up with an oscillator. Capacitors C3 and C4 are supply bypass capacitors. High-frequency bypassing is provided by C3, with C4 providing low-frequency

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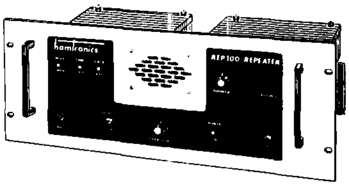

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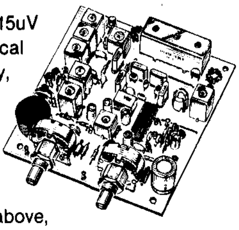

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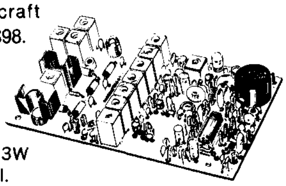

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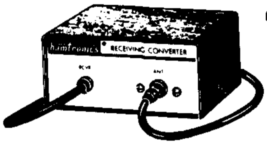

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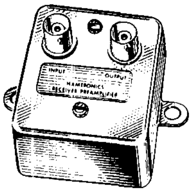

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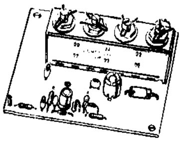

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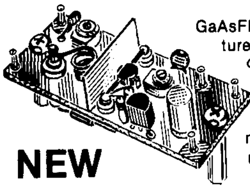

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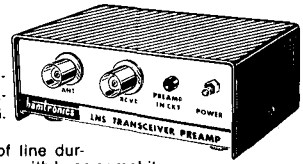

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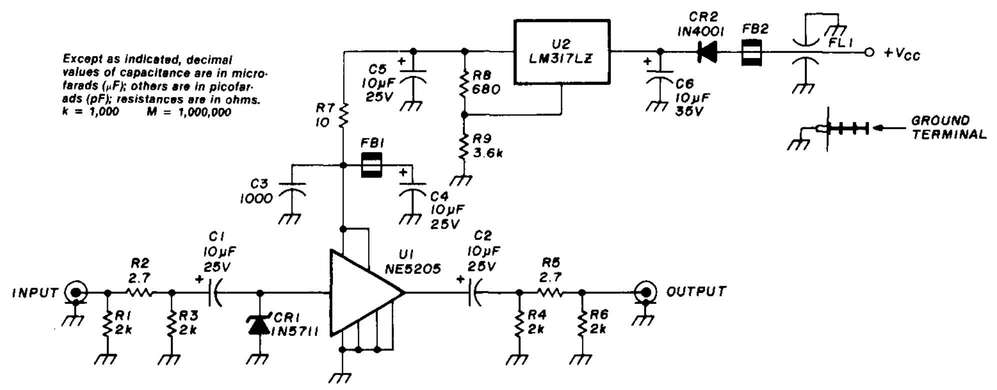

fig. 2. Amplifier schematic diagram.

bypassing. The ferrite bead, FB1, prevents the lead inductance of C4 from forming a parallel resonance with C3. Here the bead is acting like a very lossy inductance that totally destroys the Q of the C3/C4 resonant circuit. Without the bead, the parallel resonant network formed by C3 and the leads of C4 will cause the effective power supply impedance to be high at the resonant frequency. This can cause an artifact in the frequency response and in some cases can cause instability (oscillation) due to coupling into the amplifier's internal circuitry through the power supply paths.

Resistor R7 helps to decouple high frequencies from the power supply pin, improving stability with cascaded amplifiers. With its associated components, regulator U2 protects the amplifier from over-voltage damage and stabilizes operation with unregulated supplies. It too may be omitted if a good 5- to 8-volt regulated supply is available, but it's generally more convenient to provide regulation as part of the basic amplifier design.

Diode CR2 protects the amplifer from the application of a reversed power supply voltage, probably one of the more common types of damage to experimental circuits. The power input filter FL1 prevents noise from coupling into the amplifier from the power supply leads. Bead FB2 on the filter lead provides a little additional filtering of the power supply input.

Box	Pomona 3751 or similar (Newark Electronics No. 34F1260/$18.50)
C1,C2 C4,C5	Capacitor, 10 μF/25V dipped tantalum — Sprague 196D or similar
C3	Capacitor, 1000 pF CK05 or disc
C6	Capacitor, 10 μF/35V dipped tantalum — Sprague 196D or similar
CR1	Schottky diode, 1N5711 (may substitute 1N914 or 1N4148 if the 1N5711 cannot be obtained)
CR2	Rectifier diode, 1N4001 or equivalent
FB1,2	Ferrite bead (Amidon FB-43-101 or equivalent)
FL1	Filter, Erie 1250-003 or equivalent (Newark Electronics No. 10F8145/$3.13)
PCB	PC Board, per fig. 3
R1,R3,R4, R6	Resistor, 2 k, RC07 carbon composition — Allen Bradley or equivalent
R2,R5	Resistor, 2.7 ohm, RC07 carbon composition — Allen Bradley or equivalent
R7	Resistor, 10 ohms, RC07 carbon composition — Allen Bradley or equivalent
R8	Resistor, 680 ohms, RC07
R9	Resistor, 3.6 kilohms, RC07
U2	Regulator, LM317LZ
Terminal	Ground Terminal, (Newark Electronics No. 40F6026/$15.00/100 each)
U1	RF amplifier, Signetics Electronics, NE5205D

Note: Jameco Electronics carries many of the above items and can supply most of the components (except the PC board) on an "After Receipt of Order" basis subject to their line-item and invoice minimums and distributor availability.

A complete kit for this project is available from Radiokit, Box 411H, Greenville, New Hampshire 03048. Contact Radiokit for details.

choosing the correct PC board material

The 3:1 artwork for the amplifier is shown in **fig. 3**. This layout is tailored for installation in the enclosure discussed later; if you choose to use a different enclosure, you'll have to make some alterations to the mounting details, but don't change the basic circuitry unless you're experienced in RF PC board layout.

This board was designed for surface-mounting of all components even though only the SO-package NE5205 is a true surface-mount part. The PC board should be constructed of 1/32-inch, 2-ounce double-clad epoxy-glass material. Standard PC board doesn't make a good substrate for surface mounting because the pads will pull off easily, particularly during soldering. However, if you're careful, you can achieve quite adequate results. The only component holes necessary are those that tie to the ground plane. Since there are no component holes other than those grounded, there's no need to clear the ground plane from any of the component leads on the ground-plane side of the board. Only single-sided PC board construction is then required. A full ground plane is needed on the nontrace side, but no etching is required on the ground plane. This makes the board a bit easier to duplicate and consequently a little less expensive if you have it fabricated.

Though it's easier to have the PC board fabricated, it's actually simple enough to make using a cut-and-peel technique. A small hobby knife can be used to

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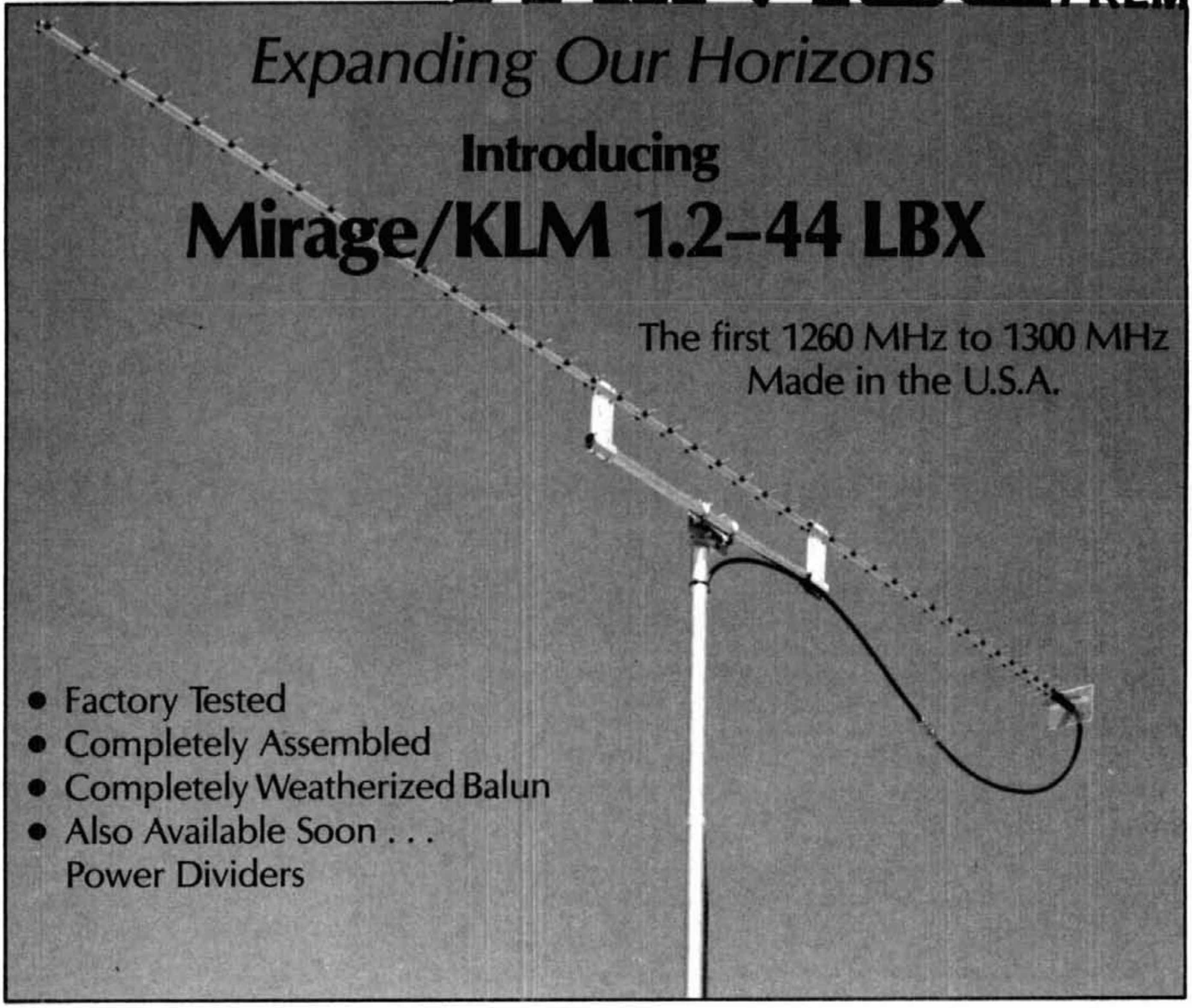

SPECIFICATIONS

Electrical

- Band Width . . . . 1260–1300 MHz
- Gain 18.2
- VSWR . . . . Better than 1.5 to 1
- Feed Imp. . . . . 50 Ohms
- Balun . . . . 4:1 Rigid Coax

Mechanical

- Beam Length . . . . 12′ 4″
- Element Length . . . . 4.5″
- Mast. . . . . 2″ O.D.
- Windload . . . . 1 sq. ft.

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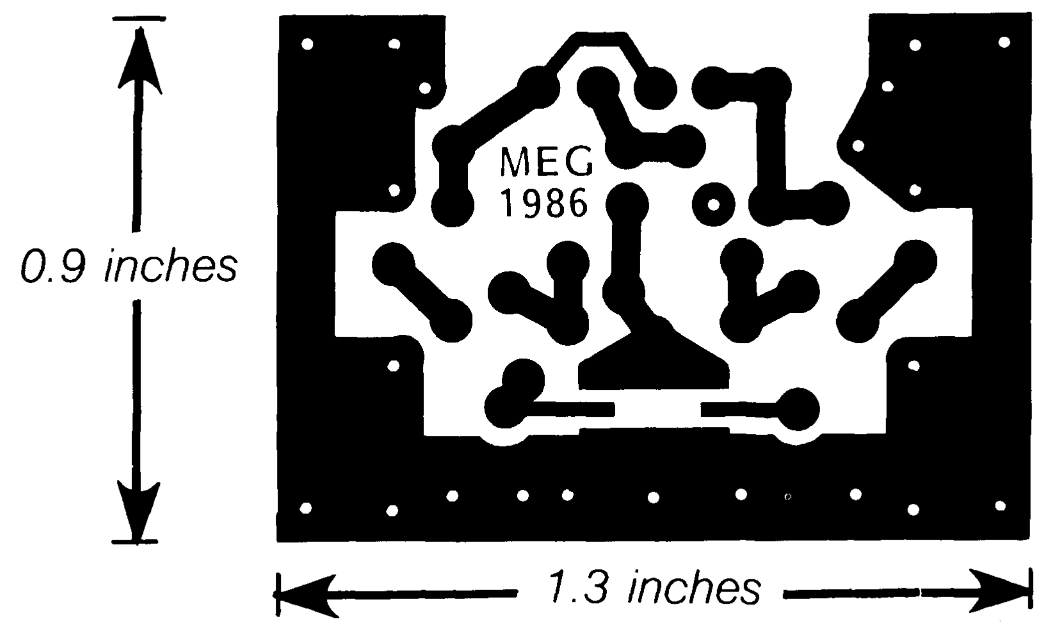

fig. 3. 3:1 PC board artwork.

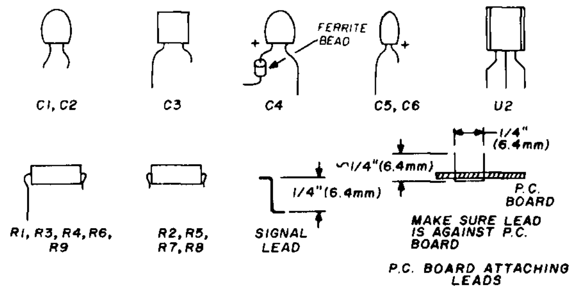

fig. 4. Component lead forming details for surface mounting

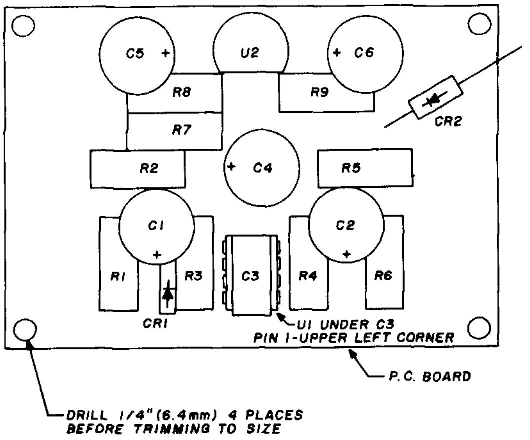

fig. 5. Amplifier assembly drawing.

cut the trace outline through the cladding on one side of a precut piece of double-clad PC board and a needle-nose or heavy tweezer used to peel the unwanted cladding from the board. While peeling, use a soldering iron to soften the adhesive and heat the cladding to be removed.

PC board assembly

As I indicated earlier, the only component of this circuit designed to be surface mounted is the NE5205. The leads of the other components must therefore be bent to allow them to be mounted. **Figure 4** shows how to bend the leads of the various components so that they can be mounted. Try to follow this lead dress carefully since lead length is reasonably critical because of the high maximum frequencies of operation of this amplifier.

Although assembly of the PC board is straightforward, some care is necessary because of the tight packing of the components. You'll need a soldering iron with a 1/16th-inch tip to prevent solder from bridging between pads. Also, be very careful when mounting the five capacitors and the regulator. These are large components and their pads can be lifted very easily from the board when soldering. Both during and after mounting these components, take care not to bend them out of position; this would put considerable stress on the mounting pad and could cause the

Table 1. Component mounting sequence.

1.	NE5205	Pin 1 is at the Signetics "S".
2.	C3	Above the NE5205, solder ground plane.
3.	C4	Observe polarity, remember the bead, solder ground plane.
4.	R3	Solder ground plane.
5.	R4	Solder ground plane.
6.	CR1	Observe polarity, solder ground plane.
7.	C1	Observe polarity.
8.	C2	Observe polarity.
9.	R1	Solder ground plane.
10.	R6	Solder ground plane.
11.	R2	
12.	R5	
13.	R7	
14.	R8	
15.	R9	Solder ground plane.
16.	REG1	Observe mounting orientation.
17.	C5	Observe polarity, solder ground plane.
18.	C6	Observe polarity, solder ground plane.
19.	CR2	Observe polarity, leave anode lead full length.

pad to become separated, particularly after soldering. When soldering to the ground plane, keep the solder buildup to a minimum, since there's very little space under the board in the enclosure.

Figure 5 shows the assembly drawing of the PC board. Because it's probably the most difficult of the board components to mount – and because it will be partly covered by other components – mount the NE5205 first. The pin next to the "S" in Signetics is pin 1. The other components must be mounted in the order shown in **table 1** because of the tight packing. After mounting the amplifier, mount C3 over the top of the amplifier with its leads straddling the NE5205. Then mount the remaining components in the order shown in **table 1**, noting the associated comments.

When all the components have been mounted, bend four pieces of the resistor leads that were cut off during assembly into a "U" shape as shown in **fig. 4** and insert them from the ground plane side into the four pairs of holes at the corners of the board and solder them to the ground-plane side of the board. Make sure that the portion of each of these leads that's on the ground-plane side of the board is flush against the ground plane. They will be used to ground the board and hold it in the box. Finally, solder pieces of cut-off resistor leads to the input and output pads (again, bend as shown in **fig. 4**).

After the board is assembled, clean it in isopropyl alcohol; a 91 percent solution – probably available from your local drug store – works best. Don't use denatured ethanol because the denaturing agent isn't known. I prefer alcohol to trichloroethane for PC board cleaning because it presents no known health hazard. But it is *flammable*, so take appropriate precautions.

Figure 6 shows the assembled PC board before mounting in the enclosure.

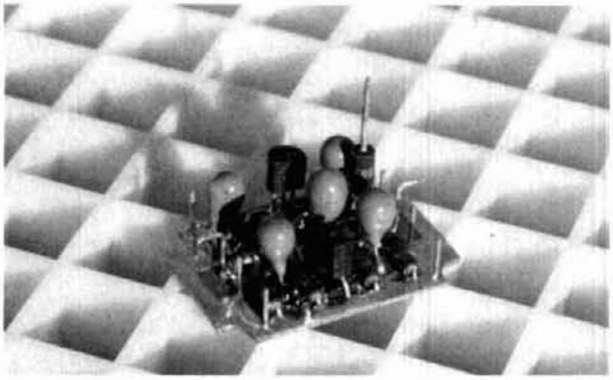

fig. 6. Assembled PC board.

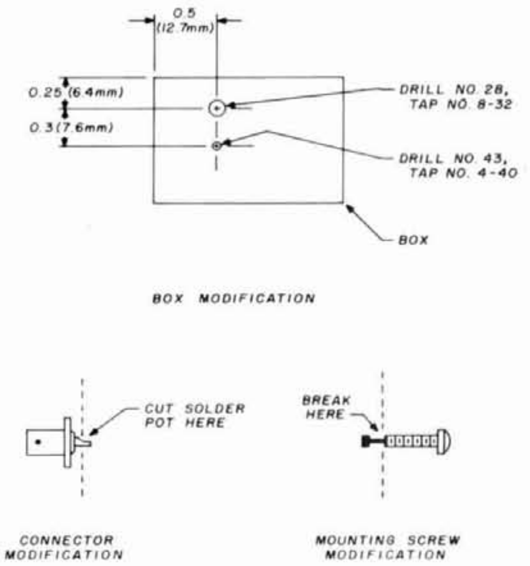

fig. 7. Box and connector modifications.

enclosure modifications

Enclosures for small RF projects are always a problem. The one I used for this amplifier was a small die-cast chassis box. This is a reasonably convenient enclosure; only two additional holes must be added for the power entry filter and the ground terminal. **Figure 7** shows the details of the modifications to the box, the two RF connectors, and the mounting screws. A word of caution here: don't try to cut the screws with a pair of diagonal cutters; the screws are very hard and trying to cut them will damage the cutters. The tips of the screws will break off easily enough if you use a pair of pliers to hold the tip while you bend the screw body with your fingers. Carefully lay out the holes using a precision scale and scribe. Center-punch the hole positions before drilling to prevent the drill from "walking." Tap the holes carefully; the tap is very brittle and will break with only slight side pressure.

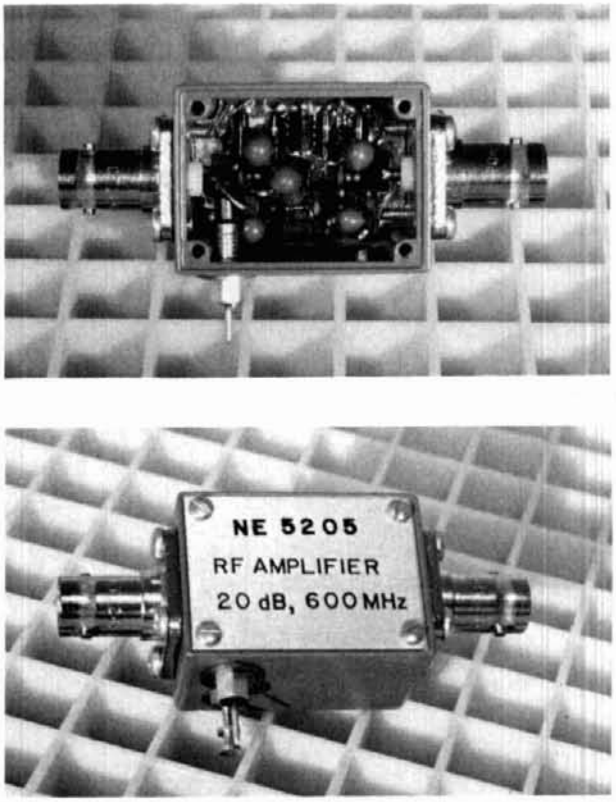

fig. 8. Completed amplifier assembly. A) Internal view, B) with cover on.

While tapping, use plenty of oil on the tap to prevent binding. Every turn or two, back the tap out to clear the chips. This will also help prevent binding.

final assembly

Now for the final task of putting it all together. With the connectors and power filter removed from the box, place the assembled PC board into the box, component side up and oriented so that the regulator is at the side of the box with the power entry filter. Loosely mount the input and output connectors, using only the upper two holes and the two short screws provided with the enclosure. As you place the connectors on the enclosure, be sure that the input and output connecting leads fit inside the connector holes. Now insert the longer screws into the bottom holes and make sure that they're on the component side of the PC board and between the pairs of leads coming up from the ground plane. Tighten all the screws. Now, bend the pairs of leads near each lower screw *over* the screw, laying them in the relief at the end of the screw. Solder all four screws to the wires and PC board. You'll need a larger soldering iron than you used for the board assembly to get enough heat for a good solder joint. Make sure that the tip of each screw has a good solder bead to the PC board; the PC board is grounded to the box only at these four places. Try to avoid getting solder in the screw threads so that the screws can be removed if you have to remove the board for repair later on. Solder the input and output leads to the connectors. Mount the ground terminal and power entry filter. If you cannot find a ground terminal, use a 4-40 brass screw about 1/2 inch long. Place a nut on the screw and screw it into the box until it's just penetrating the inside by a thread or two. Then tighten the nut down against the box to lock the screw in place. Place the bead, FB2, over the filter lead and attach the lead of CR2 to the power filter. Hold the body of CR2 with needle-nose pliers while bending its lead to prevent stressing its PC board mounting pad. Trim off the excess filter and diode lead.

Do a final cleaning by filling the assembled box with alcohol and letting it sit for a few minutes. Place your hand over the open top and shake the unit to stir the alcohol. Pour it out. Rinse with a little more alcohol and pour that out. Let the alcohol evaporate for a few minutes and then fasten the cover.

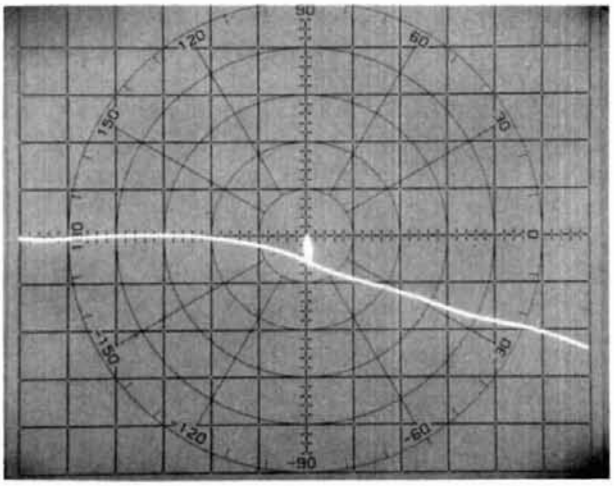

fig. 9. Amplifier frequency response.

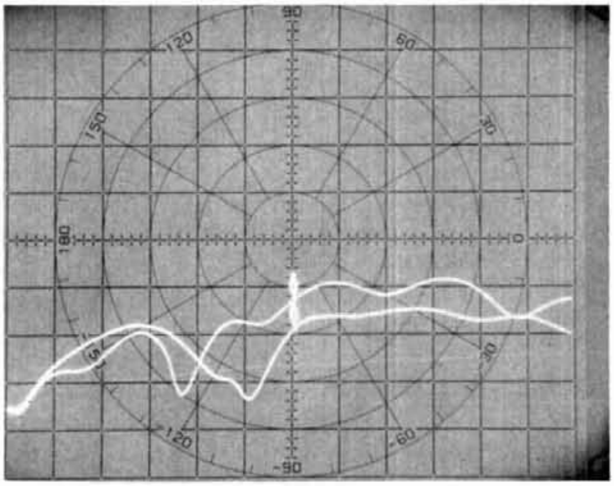

fig. 10. Input (S11) and output (S22) S-parameters.

Figure 8A shows the completed amplifier assembly with the cover removed; **fig. 8B** shows the completed assembly.

performance

Now for the proof test: how well does the amplifier work? If you followed the assembly instructions carefully, it should work rather well. **Figure 9** shows the frequency response of the unit that I built. The gain was 20 dB with a lower 3-dB point of 270 Hz and an upper of 608 MHz with usable gain to beyond 1.2 GHz. The bandpass flatness in the bandpass was better than ± 0.5 dB. The wideband noise figure was about 5 dB — not an LNA but certainly quite good. The output power at the 1-dB compression point at 100 MHz was +6.7 dBm, and the compression was reasonably constant with frequency up to about 600 MHz (the upper 3-dB cutoff frequency). The total supply current was about 35 mA and the minimum operating potential about 10 V. **Figure 10** shows the S-parameters S11 and S22 for the completed unit. These parameters are a ratio of the forward and reflected power at a given port. In **fig. 10** S11 is below about −20 dB up to about 500 MHz. The S11 parameter in this measurement was made at the input port. The −20 dB value shows that the power reflected back from the input is 20 dB below the power incident at the input port. That implies that the input impedance is reasonably close to the 50-ohm impedance of the test system; no power is reflected from a perfectly matched load. With a 20-dB return loss, the input impedance is within about 0.5 ohm of the characteristic 50-ohm impedance. S22 is the output port measurement. Up to about 500 MHz the reflected power from the output port is more than about 20 dB below the incident power at the output port. In this S22 measurement, power is actually applied to the output and the reflected power measured. So the output impedance is also reasonably close to 50 ohms (within about 0.5 ohm).

conclusion

This amplifier, if carefully constructed, provides very good performance for general RF experiments and RF projects where a relatively low cost, stable, low-noise, wide-bandwidth gain block is needed. The characteristics of the NE5205 make it a good choice for this application and the recommended circuit design assures both RF and DC stability as well as protection from typical experimental abuse. The recommended packaging provides good RF shielding and isolation, assuring stable, noise-free operation in most common RF environments. It is also relatively easy to construct. This amplifier should be a very useful addition to your collection of general RF amplfier designs.

references

1. Signetics NE5205 data sheet, January, 1985, Signetics Corporation, 811 East Arques Avenue, P.O. Box 3409, Sunnyvale, California 94088-3409.
2. Newark Electronics, 277 Fairfield Road, Fairfield, New Jersey 07006.
3. Amidon Associates, Incorporated, 12033 Otsego Street, North Hollywood, California 91607.

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ham radio TECHNIQUES

the grounded-grid amplifier

During the last decade a quiet revolution has taken place in Amateur Radio — the vacuum tube has virtually disappeared from the ham shack. I can't think of a new Amateur receiver, exciter, or transceiver using vacuum tubes that's sold in today's market.

But it's a different story in high-power, high-frequency amplifiers. In these, the vacuum tube remains supreme, in spite of several attempts to market a solid-state kilowatt amplifier. Such a device simply isn't cost-effective; I doubt that a practical 2-kW (so-called) solid-state linear amplifier will be available at a modest cost in the near future.

This leaves the power tube as the available high-power device. Today it's primarily a high-μ triode in a cathode-driven circuit (**fig. 1**) that's the popular choice for high-frequency SSB and CW service.

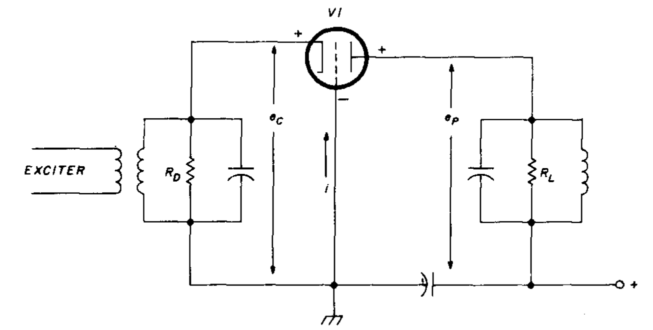


fig. 1. Simplified cathode driven circuit with R_D representing driver load and R_L amplifier load. Polarity of instantaneous RF voltages is indicated.

This circuit is ideal for Amateur service. It has good power gain and usually requires no neutralization in the HF region. Furthermore, it's hard to overdrive, and a certain portion of the drive power shows up as "free" power in the output circuit. The linearity of the grounded-grid amplifier is quite good and, all in all, it's a hard act to beat.

The circuit may be operated either as an amplifier or an oscillator depending on tuning. The tube grid is at (or near) RF ground potential and the driving signal is applied between cathode and ground. In amplifier service, when the cathode is driven positive by the exciting signal (with respect to the grid), the plate becomes more positive with respect to the cathode and also with respect to ground. In effect, the instantaneous plate voltage is developed in series and in phase with the exciting signal voltage. The driver and amplifier may then be considered as operating in series delivering power to the load (see **fig. 2**).

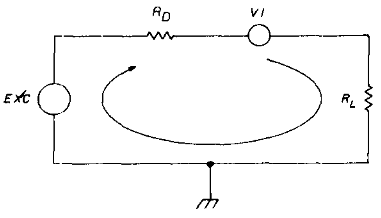


fig. 2. Exciter and amplifier are in series with respect to RF voltages. RF current flows through driver, as indicated by arrow.

In the better-designed cathode-driven amplifiers, a tuned circuit is used in the cathode to improve the regulation of the driver, to provide proper termination of the driver over the operating cycle, and to complete the plate circuit RF return path to the cathode of the amplifier. If the tuned cathode circuit is omitted, the various tasks fall upon the output circuit of the exciter. Many solid-state exciters cannot stand this set of operating conditions and may exhibit instability and undesired oscillation. The operator may jump to the conclusion that the amplifier is oscillating even though the problem is really in the exciter.

neutralize the grounded ground amplifier?

In the HF region, most grounded-grid amplifiers don't require neutralization because the feedback path from plate to cathode is small. However, the feedback path *does* exist and some Amateurs have discovered that the grounded-grid amplifier can become unstable and tricky to tune, especially on 10 meters and above.

It's easy to determine the degree of unwanted feedback in your amplifier. When fully loaded and tuned with carrier injection, maximum power output, minimum plate current, and maximum grid current should all coincide at one setting of the plate tuning capacitor. What? This doesn't happen in your amplifier? Maximum power output and

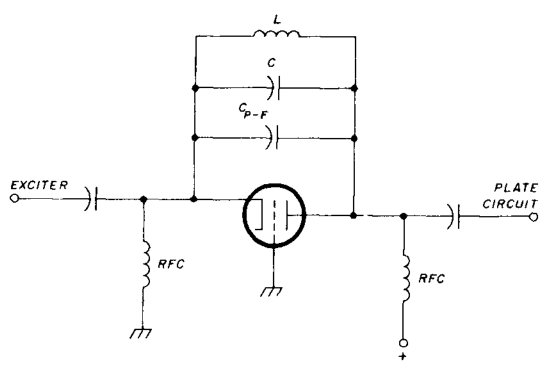


fig. 3. Inductive neutralization of cathode-plate feedback circuit. Resonant circuit is tuned to operating frequency.

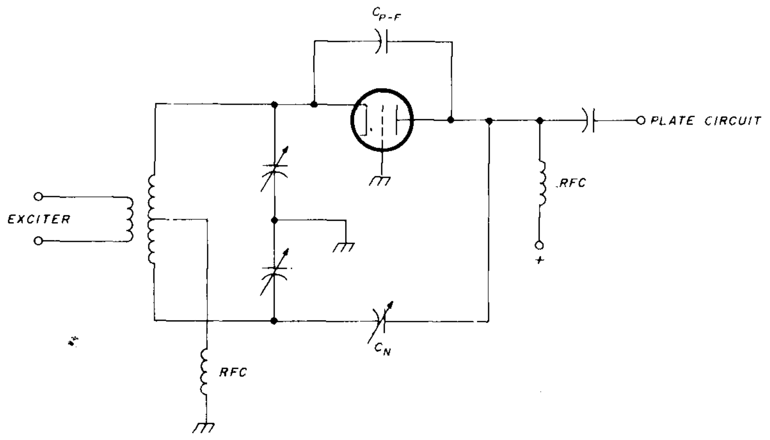


fig. 4. Bridge neutralization of cathode-plate feedback circuit.

minimum plate current don't coincide? You have some unwanted feedback in the amplifier. If the amplifier seems stable, don't worry about it.

the neutralizing circuit

Voltage feedback through the interelectrode capacitances of the tube from output to input can have a deleterious effect on amplifier performance under some circumstances. Control of this feedback is termed "neutralization." The purpose of neutralization is to make the input and output circuits of the amplifier relatively independent of each other during operation. It sounds simple, and it is. A balancing circuit (**fig. 3**), in which the capacitive feedback path is neutralized by making the capacitance part of a high-impedance, parallel-tuned circuit, is used. Another scheme takes a small portion of the RF plate voltage and feeds it back out-of-phase with the input voltage (**fig. 4**). When the value of the neutralizing capacitor C_N is approximately equal to the feedback capacitance of the tube, the circuit is balanced and will remain balanced over a considerable operating range of the amplifier.

VHF neutralization

In the VHF region (above 30 MHz) a second feedback path must be considered in amplifier operation. This path involves the grid-to-plate capacitance, the cathode-grid capacitance, and the grid lead inductance (**fig. 5**). Because the grid isn't truly at ground, because of the inherent grid lead inductance and other factors, a voltage may appear on the grid which can either increase or decrease the driving voltage. With sufficient unwanted grid voltage of the proper phase, the cathode-driven stage may oscillate, even though the tube has been neutralized.

There is, however, a certain frequency at which the two feedback paths tend to be self-cancelling. This is termed the "self-neutralizing frequency" of the tube and is usually found in the lower portion of the VHF band. This frequency is determined by physical tube size and the internal length of the conductors and elements within the tube.

Below the self-neutralizing frequency, the tube can be neutralized by the addition of a small inductance in the grid-to-ground path (**fig. 6**). Above this frequency, the tube can be neutralized by the addition of a series capacitance (**fig. 7**). Each of these neutralizing circuits is frequency-sensitive and the circuit must be adjusted if an appreciable change in operating frequency is made.

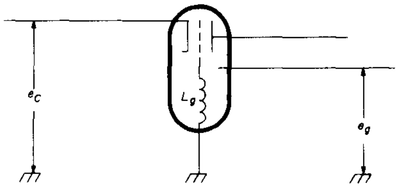


fig. 5. Voltage (e_g) develops across internal grid lead inductance which can increase or decrease driving voltage, e_g.

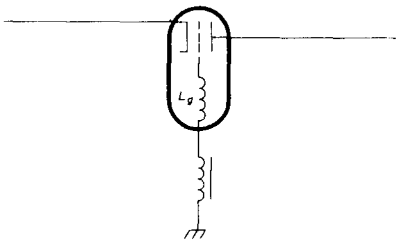


fig. 6. Below self-neutralizing frequency of tube, series inductor shifts point of self neutralization to operating frequency.

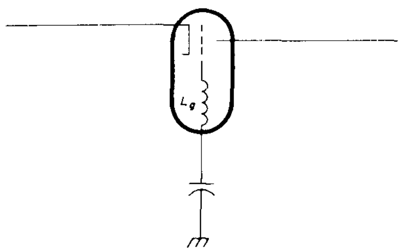


fig. 7. Above self-neutralizing frequency of tube, series capacitor shifts point of self neutralization to operating frequency.

a docile beast

In general, neutralization isn't required in Amateur amplifiers using cathode-driven circuitry below 30 MHz. The cathode-driven amplifier is a docile beast, with relatively low power gain when triode tubes are used and amplifier shielding is adequate. Amplifier instability at the operating frequency can often be cured by careful attention to feedback paths external to the amplifier (proper bypassing of primary power leads) and by ensuring that the exciter and amplifier are operating at the same ground potential. An extra-short, heavy ground strap between exciter and amplifier will often cure an unstable amplifier.

amplifier parasitics

Much has been written about amplifier parasitics. Some of it is true. As I said before, the cathode-driven amplifier is docile, and parasitics, when they occur, are usually mild (amplifier efficiency when oscillating in a parasitic mode is very low) and commonly above the self-neutralizing frequency of the tube.

A sure-fire cure for a parasitic is to load the circuit at the parasitic frequency until the amplifier refuses to oscillate. The tube lead common to all parasitic circuits is the plate; this is where parasitic suppression should take place (**fig. 8**). A simple resistor-inductor circuit will do the job. The inductor places the resistor across an appreciable portion of the plate lead at the parasitic frequency and thus loads the circuit. At the operating frequency, the resistor is across only a small portion of the electrical length of the plate lead and is almost "invisible." Too many turns in the inductor will couple the resistor too tightly at the operating frequency and the resistor will dissipate a portion of the amplifier's fundamental power and will probably overheat. If the parasitic is truly suppressed, then there will be no parasitic power. Too few turns in the inductor and the suppressor won't do its job. Cut-and-try is the keynote to success in this operation.

the "Rocky Point" effect

The vacuum in a modern power tube is on the order of 10 Torr (millimeters of mercury) in order to maintain proper cathode (filament) emission and to provide adequate insulation between the electrodes. In spite of the high vacuum employed, it sometimes happens that the insulation between the anode and other electrodes suddenly breaks down, with flash-over occurring inside the tube.

This phenomenon has been referred to as the "Rocky Point" effect, after the RCA transmitting site where it was first observed in the 1930s. The effect can occur at low voltages and in relatively small tubes. Though it's not attributable to a gradual deterioration of the vacuum, it can be brought about by a small quantity of ions liberated from an electrode. Ionization causes an electrical discharge, whereupon the ions disappear, either because of absorption or action of the getter within the tube. If the equipment is power-supply limited, the discharge usually causes no damage. However, most Amateur equipment makes use of a high-capacitance filter in the power supply, and the energy of this capacitor is "dumped" into the flashover. Since the tube, at that instant, forms a virtual short circuit, the discharge current can run very high, damaging the tube electrodes, metering circuits, and associated components.

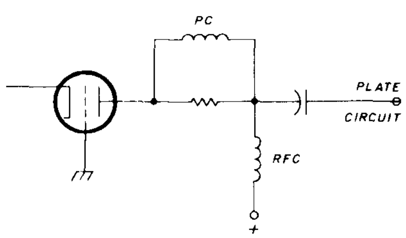


fig. 8. Proper position of parasitic choke is in the plate lead of cathode driven amplifier.

The flashover is very sensitive to a drop in plate potential. The easiest way to control it is to insert a small series resistor in the plate supply (**fig. 9**). The voltage drop across the resistor during a flashover will lower the plate voltage and extinguish the vacuum arc.

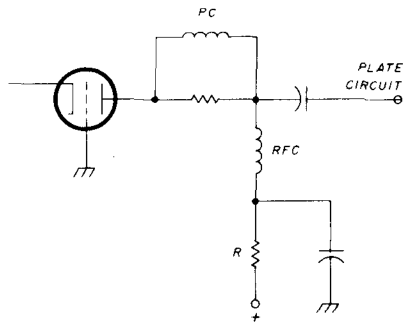


fig. 9. Resistor in series with B-plus protects tube and circuitry in case of flashover.

Without the resistor, substantial damage may occur to tube and amplifier components. With the resistor in place, in the case of a rare flash-over, the operator will be aware only of a soft "pop" or "snap" and amplifier operation will continue as before. The resistor limits the current while the energy in the filler capacitor is being dissipated.

In most cases a 50-ohm, 20-watt resistor incorporated in the B-plus lead after the filter capacitor (either in the amplifier or in the power supply) should provide adequate protection. Inexpensive and easy to install, the resistor can protect a power tube worth many hundreds of dollars.

The resistor is in a high-voltage circuit and should be adequately insulated from ground. Mounting it on ceramic insulating pillars is a good idea.

filament voltage

It's a good idea to check your filament

voltage at the socket in a cathode-driven amplifier. A voltage drop may exist across the filament choke and thus reduce available filament voltage at the tube. The voltage should be checked with an RMS-responding meter (iron-vane type, for example) and not with the garden-variety volt-ohmmeter which, more often than not, employs a DC meter and a series-connected diode rectifier to measure AC voltages. This combination is often inaccurate as the diode ages and its response to the rough waveform of the common AC primary line is questionable.

Filament voltage should be held to the tube manufacturer's specification limits, generally ±5 percent of the designated voltage. For Amateur service, it is generally prudent to remain on the low side of the voltage limit, rather than on the high side. (I generally run my tube filaments about 2 percent below the suggested operating voltage.)

RF feedback

In some cathode-driven amplifiers, a small degree of negative RF feedback is incorporated. This absorbs some excess drive power, tends to make the amplifier more stable, and improves the intermodulation distortion figure slightly. The feedback circuit is made up of the plate-to-grid capacitance, which is set by the equipment manufacturer. A representative circuit is shown in **fig. 10**. Feedback is about 2 to 3 dB in the case illustrated. Decreasing the grid-to-ground capacitance raises the feedback level, but also tends to degrade the grid-filament isolation at the operating frequency. A happy compromise must be found for the circuit to do its job. In the case of an amplifier using two 3-500Z high-μ power triodes, 600 pF seems to be satisfactory. This is accomplished by placing a 200-pF capacitor at each grid pin to ground. The capacitors are shunted by an RF choke to complete the DC ground return for grid current. The choke has nothing to do with the operation of the RF circuit.

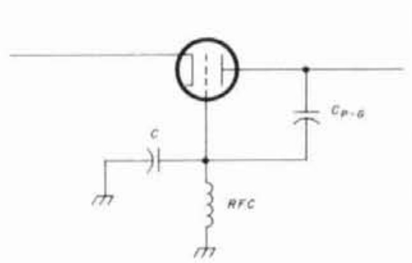


fig. 10. Plate-to-grid capacitance plus capacitor C forms voltage divider to impress negative feedback voltage with respect to cathode. RF choke completes grid DC return.

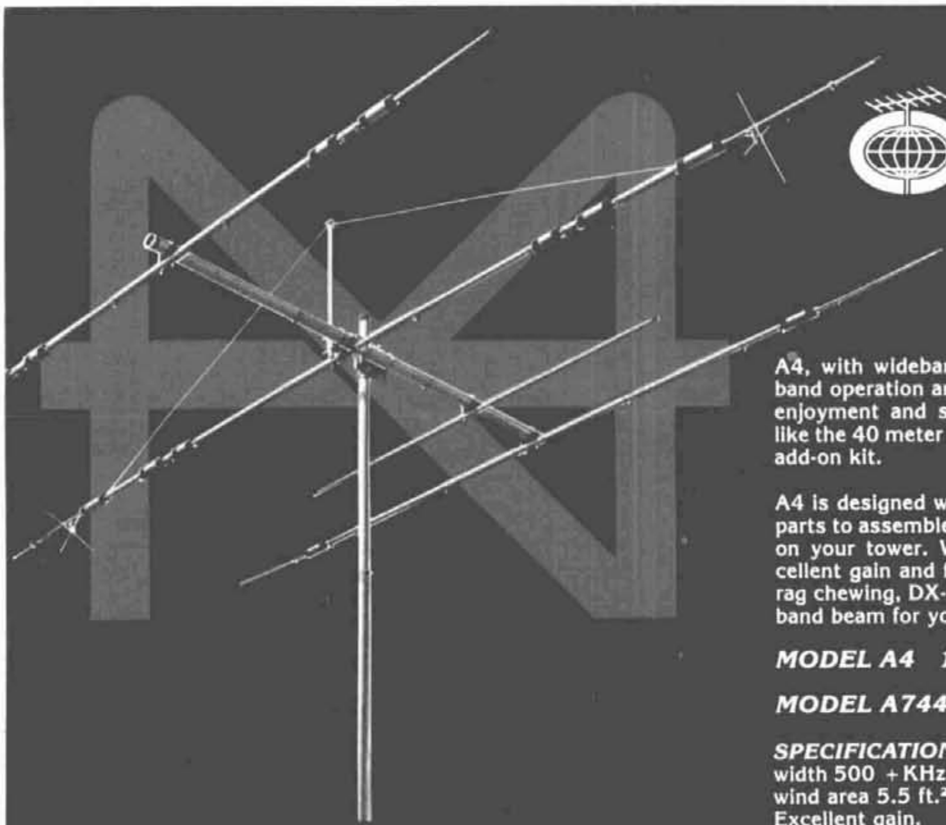
summary

The grounded-grid (cathode driven) configuration is admirably suited to Amateur service in the HF and VHF regions and the circuit performs well in a properly designed and operated amplifier.

the EME directory

A second printing of the *EME 144 MHz Directory* lists active moonbounce stations, their addresses and locations, equipment used, and other pertinent information. For a copy, send five first-class stamps (or IRCs) to me at: Varian EIMAC, 301 Industrial Way, San Carlos, California 94070.

ham radio



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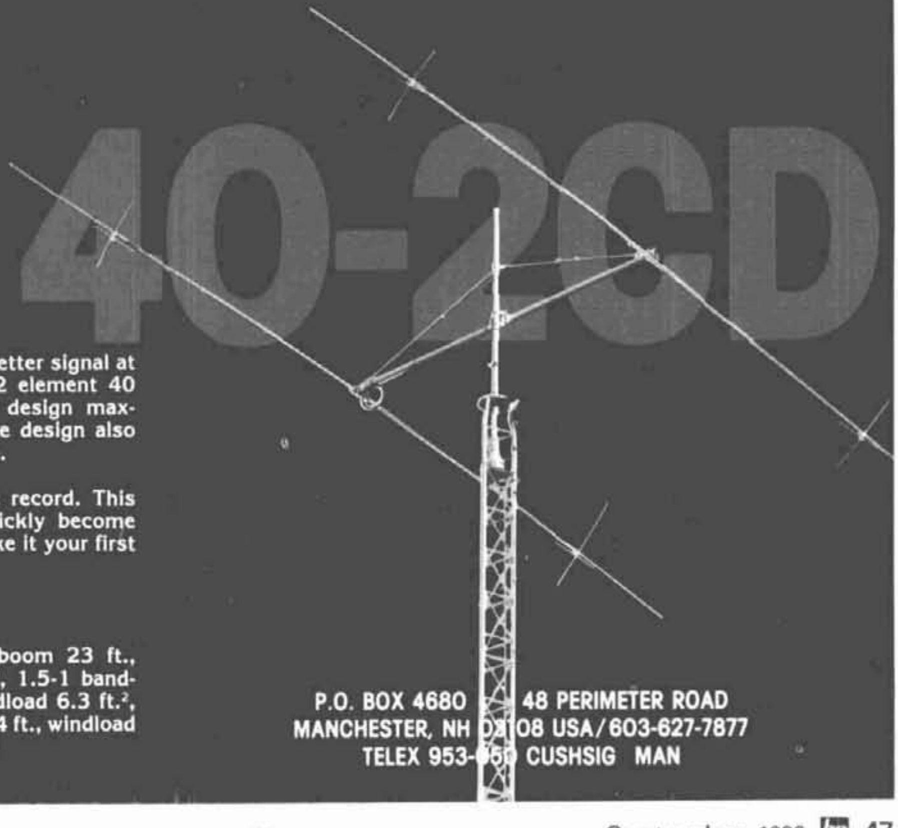

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remotely controlled stations:
a look at a successful remote base

Stuck in an
RF gulch?
Try another site

Imagine having a "big gun" 160-meter station — but with no antenna consuming your back yard. Imagine running 1 kW on 6 meters — with no fear of TVI. Imagine DXing into the next state on 1296 MHz — but the only rig at your QTH is a 450-MHz handheld! All this is possible using a remotely controlled station, commonly known as a "Remote Base" or simply a "Remote."

A Remote may consist of as little as a simple wireline control link operating a single-channel 2-meter rig, or it may be a complex array of computer-controlled gear, covering HF through microwave and controlled via 450 MHz-FM. Ideally, it's positioned on top of a mountain or tall building, like a repeater, but it could be located anywhere — even in the trunk of a car!

Possibly the biggest advantage of a Remote is that it allows antennas to be located at a better site than may be available at home. Many housing developments, for example, don't allow outside antennas. And even where they're allowed, TVI may prohibit HF or 6-meter operation at appropriate transmitter power levels. Or perhaps you just need to get your antennas out of the "RF gulch" you're trapped in.

But a better antenna location isn't the only reason to go Remote. A Remote allows several hams to consolidate their resources into one superior station, accessible to all. A group of operators then needs to purchase only one HF rig, one 1296-MHz station, and a single antenna farm instead of duplicating their efforts individually at great expense.

The sharing of talents is valuable, too. In any group of hams there are likely to be those with specialized knowledge of RF, digital communications, and antennas, for example. Working together and pooling resources, each can contribute his or her skills toward building a station far superior to what each might accomplish separately.

Located on a 2000-foot mountain near Ventura, W6ORE Remote (**fig. 1**), the station described in this article, has been operating successfully for ten years. Using a 450-MHz FM control channel, this Remote allows the users to operate an HF rig covering 160 to 10 meters and an FM VHF/UHF station covering 144 to 148 MHz, 220 to 225 MHz, and 440 to 450 MHz. Also controlled are an X-band beacon and a programmable speech synthesizer, along with other miscellaneous functions.

Every one of these items can be controlled from the user's home QTH or automobile (or boat, in one case), with a rig as simple as a handheld equipped with a rubber duck antenna and a touchtone pad.

The HF rig can be set directly to any frequency, or scanned or stepped up or down the bands in 100-Hz steps. A speech synthesizer reads out the frequency and reports if the transmitter is becoming overheated, or if a band edge has been reached while scanning, and to what portion of the band (Novice, General, Advanced, or Extra) the operator is tuned.

The VHF/UHF station, a Drake UV-3, can also be directly set to any frequency, scanned, or stepped up or down. Repeater splits are set automatically, but any odd split, even cross-band, is possible. All of this is controlled, "on-the-fly" with just a few keystrokes on a touchtone pad!

the computer

As you may have guessed, a computer (**fig. 2**) controls the system. Indeed, the heart of this Remote is a custom designed Z80™ computer built and programmed by Bob Schellhorn, W6ORE. The Z80 CPU was chosen for its rich instruction set and extensive I/O (Input/Output) capacity.

By Steve J. Noll, WA6EJO, 1288 Winford Avenue, Ventura, California 93004-2504

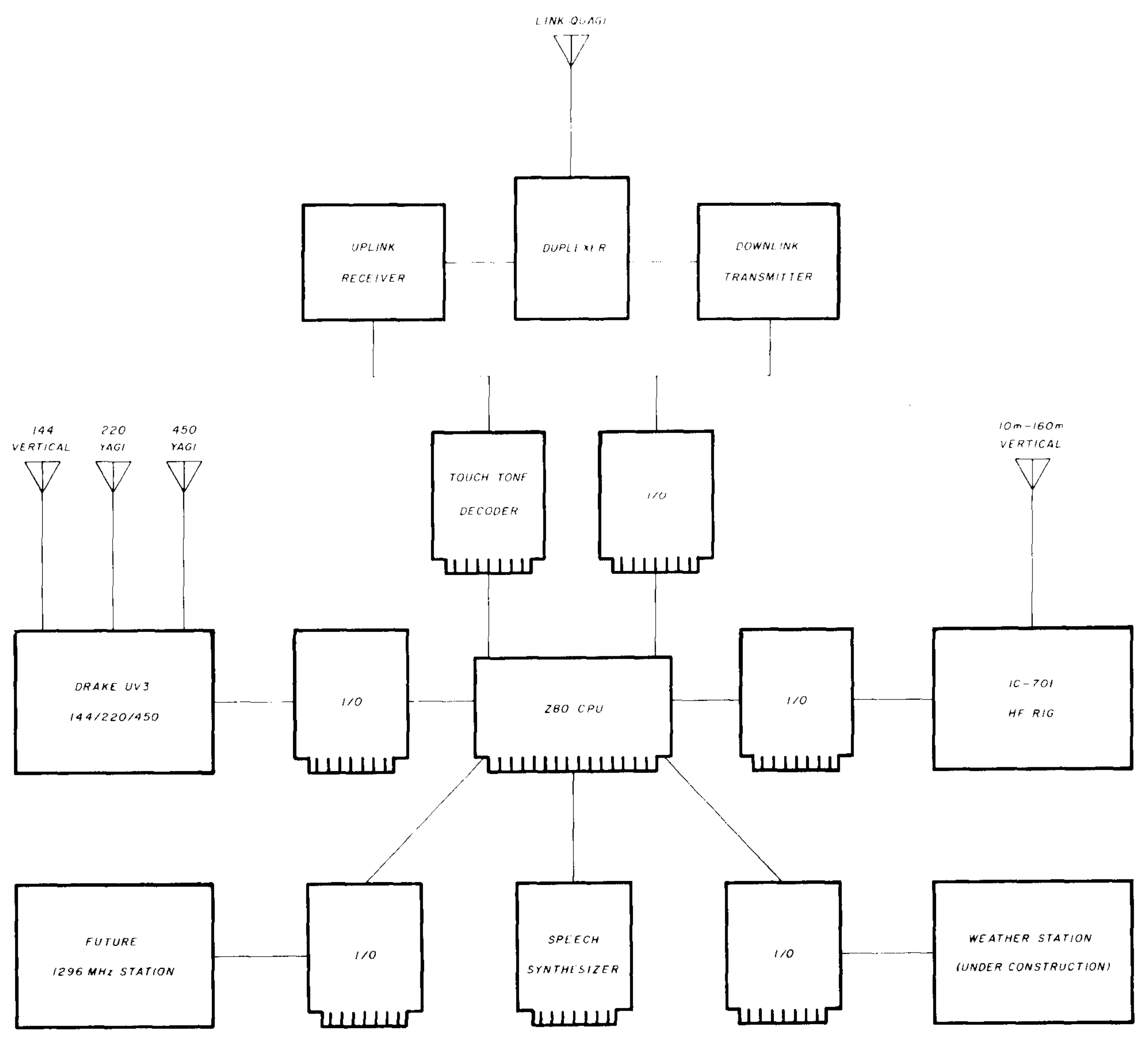

fig. 1. Remote system block diagram illustrates 1.8- through 450-MHz capability.

The software was written entirely in assembly language for speed and efficient use of memory. The software, known as "firmware" at this point, is contained in a 27128 UV EPROM (ultra violet light erasable, programmable, read-only memory). Transient and changeable information is stored in a 6264 CMOS RAM (complementary metal oxide semiconductor random access memory).

The Z80 and memory are built on an S-100 breadboard, although the S-100 bus protocol isn't used. S-100 cards afford generous wiring space and a 100-pin edge connector provides for plenty of I/O and allows the card to be easily removed for modifications (see **fig. 3**).

The CPU card is enclosed in an RF-tight box fashioned from un-etched copper-clad printed circuit board. Custom RF-tight enclosures constructed with surplus printed circuit board are often cheaper than store-bought aluminum chassis, which also never seem to be available in just the right size. An RF-tight CPU box is a must, as computers are notorious for generating excessive radio "trash." And in this case, the computer is mounted within inches of several radio receivers.

The Z80 runs at a fairly low speed to minimize RFI. The I/O is further slowed by a combination of special software and hardware techniques and brought out of the CPU box using feedthrough capacitors. A card cage receives the CPU I/O lines and distributes them to various 5 x 7-inch I/O cards. The card cage isn't shielded, but because the I/O is slowed at this point, no noticeable RFI is generated.

The I/O cards provide the digital and audio interfaces to the HF rig, the VHF/UHF rig, the 450-MHz control up-

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fig. 2. A large double cabinet provides room for future expansion.

link receiver and downlink transmitter. One card contains the speech synthesizer, which is so necessary to the operation of such a complex system.

a speech synthesizer is a must

The speech synthesizer is built around the Votrax SC-01 speech chip. This is a phoneme-based chip, which makes it completely user-programmable. It doesn't provide the latest, state-of-the-art high-quality speech; in fact, it sounds rather like a robot. However, it's far superior to many other speech chips in that it can say absolutely *anything*. No compromises (such as spelling out words not in the limited vocabulary common to other synthesizers) have to be made. It's also very memory-efficient. Only about five phonemes, or five bytes of memory, are required to store an average word.

the HF station

The HF rig **(figs. 4** and **5)** is an ICOM IC-701, a model no longer in production but a natural for computer control because of its 24-pin connector for plugging in a remote control unit. Through this connector the computer can set frequencies, scan or step in 100-Hz increments, and transmit. The computer keeps track of the current frequency, the band edges and the license class boundaries. Of course, frequency can be read at will (a single touchtone on the uplink) and is announced politely on the downlink — i.e., "Fourteen-point-three-one-four."

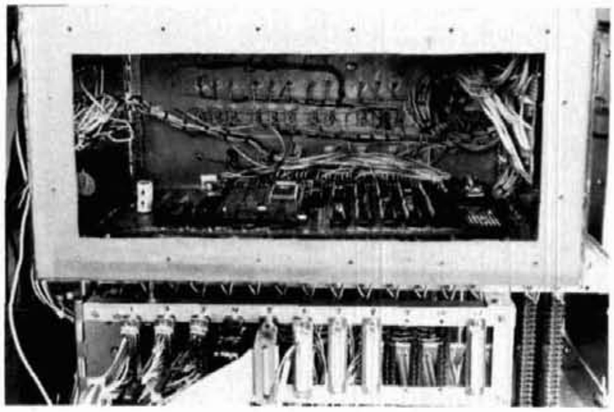

fig. 3. Inside of computer controller. Much of the visible wiring is for the diagnostic front panel.

All is not perfect, though. Outputs weren't provided for mode switching (USB/LSB) or for over-temperature warning. Minor surgery provided these needed outputs — two, in fact, for the over-temperature alert. When the rig's fan comes on, the speech synthesizer announces "Overheat warning" on the 450-MHz downlink. If the PA temperature continues to rise, the transmitter shuts down and the synthesizer announces, "Overheat shutdown."

A ground-mounted Butternut vertical allows 160- to 10-meter coverage without an antenna tuner. Because the Remote is located on cattle grazing land, a small corral was built around the vertical to ward off any itching Elsies. A 160-meter wire antenna is planned for the future; there will be no problem in having the computer switch over automatically when a 160-meter frequency is selected.

the VHF/UHF station

Another out-of-production rig, a Drake UV3, provides the 144/220/450-MHz coverage. This rig was designed with a removable control head to allow the RF section to be located in the trunk of a car, while the head is mounted under the dash — again, a wonderful opportunity for easy computer control. The removable head is replaced by a homebrew interface box allowing the computer full access to frequency setting and band and power level changing.

The VHF/UHF antennas are a simple ground plane on 2 meters and short KLM log-feed Yagis for 220 and 450 MHz. Luckily, most of the action is in one direction from the Remote site so that directional (gain) antennas can be used. The short log-feed Yagis afford wide bandwidth and a not-too-narrow beam shape (see **fig. 7**).

the control link

Primary to the operation of the Remote is the 450-MHz uplink, which allows controlling and talking through the

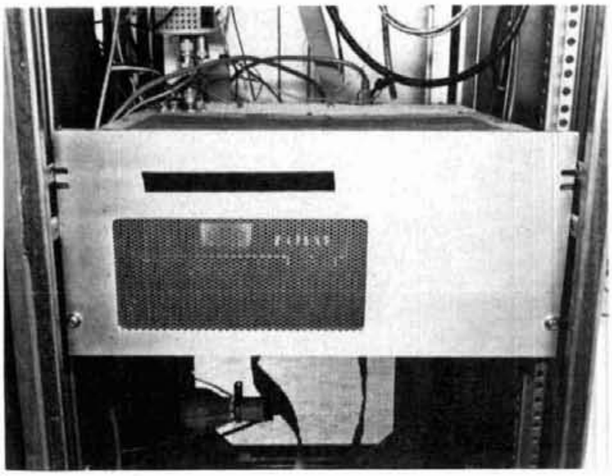

fig. 4. HF rig is in a shielded rack-mount box.

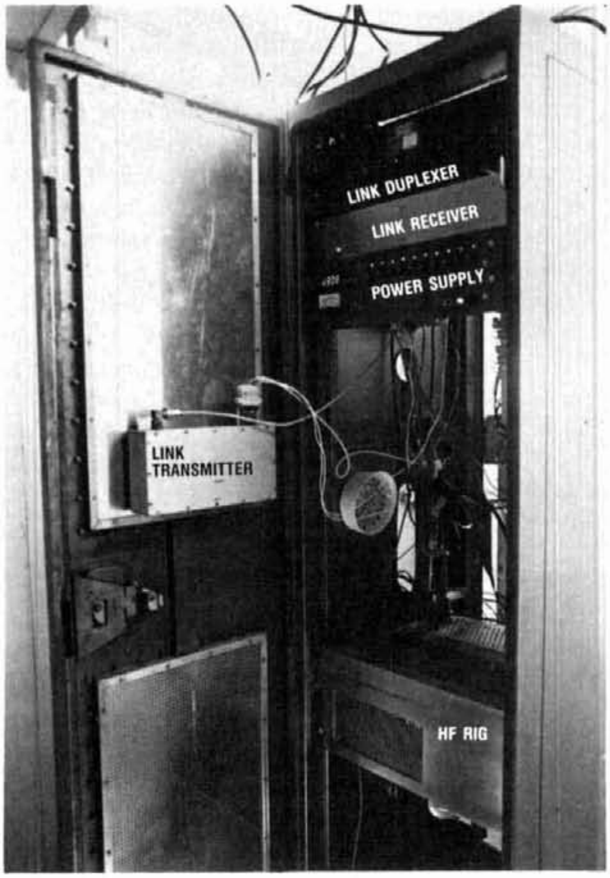

fig. 5. Rear view of cabinet illustrates placement of link components.

HF and VHF/UHF stations. The 450-MHz downlink pipes the HF/VHF/UHF receive audio back to the user.

The uplink receiver is a Yaesu 708R, somewhat modified to accommodate a Motorola squelch chip. The downlink transmitter is a cannibalized ICOM IC-30. Each connect through a four-cavity Phelps Dodge duplexer to a homebrew Quagi. All of the users live and work in the same general direction from the Remote site, which permits the luxury of using a high-gain directional link antenna.

some legal points

The Remote control requirements of Part 97 are often violated or ignored by remotely controlled station users. Because the regulations, which are quite complex and often confusing, require careful study for compliance, some definitions are in order:

- **Auxiliary operation:** *radio communication for remotely controlling other amateur radio stations* (97.31). *All amateur frequency bands above 220.5 MHz, except 431-433 MHz and 435-438 MHz, are available for auxiliary operation* (97.86d).
- **Remote control:** *manual control, with the control operator monitoring the operation on duty at a control point located elsewhere than at the station transmitter, such that the associated operating adjustments are accessible through a control link* (97.3m2).
- **Control link:** *apparatus for effecting remote control*

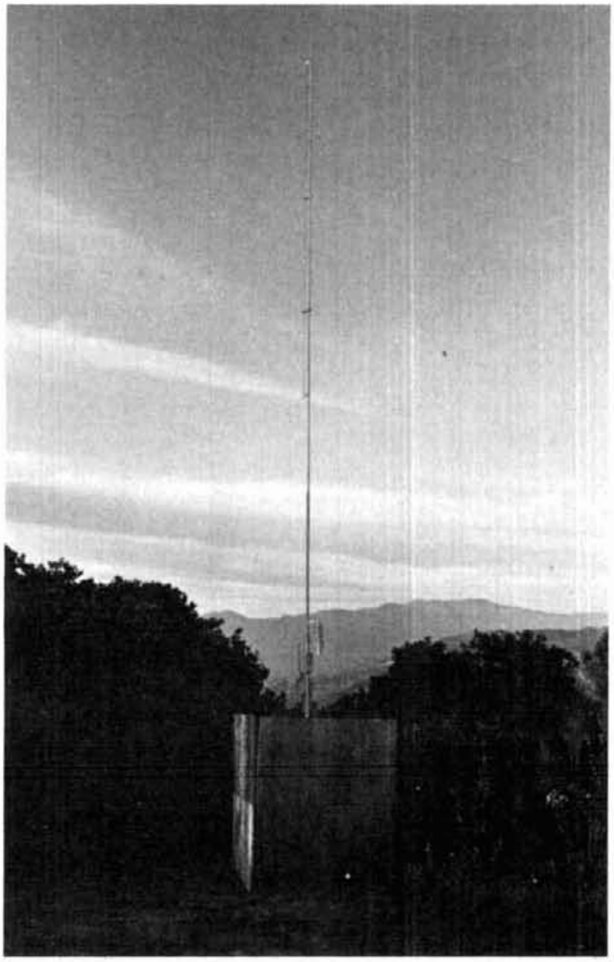

fig. 6. The HF vertical is protected from cattle and deer by a small corral.

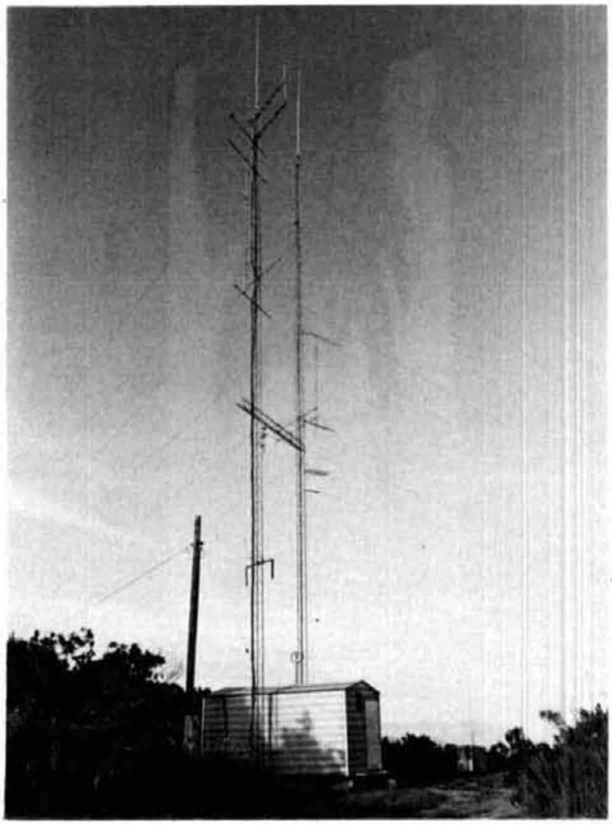

fig. 7. The remote site shares towers and building with commercial services. HF vertical is visible at bottom right.

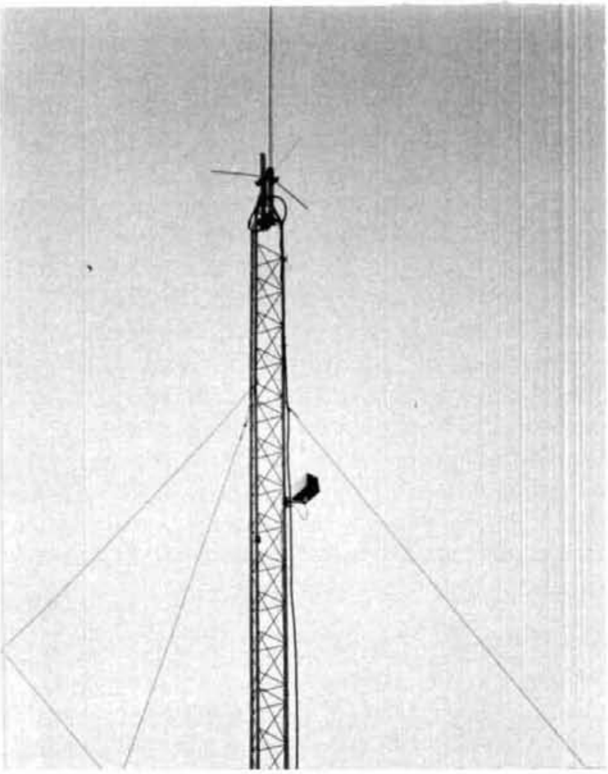

fig. 8. X-band beacon is perched near top of tower.

between a control point and remotely controlled station (97.3n).

Thus, a station can be remotely controlled through a control link; this is considered auxiliary operation. Note that Part 97 never uses the popular terms "Remote" or "Remote Base."

Of course, *"The frequencies available for use by a control operator of an amateur station are dependent on the operator license classification of the control operator. . ."* (97.63c). Even if a Remote is licensed to an Extra, a General class control operator is still restricted to the General bands.

On identification: . . . *a station in auxiliary operation shall transmit the word "auxiliary" at the end of the station call sign*(97.84d2). So on the control uplink, I identify as "WA6EJO AUXILIARY." The control downlink identifies itself as "W6ORE AUXILIARY." When transmitting through the Remote's HF station, however, the only required ID is that of the remotely controlled station licensee.

On control link security: *A station in auxiliary operation shall be used only to communicate with stations shown in the system network diagram* (97.86d). To comply with this regulation, a non-member of a Remote breaking into the link should be informed that it is a control link and politely asked to leave.

On remotely controlled station security: *Each remotely controlled station shall be protected against unauthorized station operation, whether caused by activation of the control link, or otherwise*(97.88g). "Automatic control" is not advisable.

can a remote be used for gaining contest points?

Use of repeaters is usually prohibited for contesting, but a Remote is merely a station operated by remote control, not a repeater. The ARRL has affirmed this and does not differentiate between Remote and "regular" station contacts. Note that users of a given Remote can't make contest points under their own calls. The transmitter(s) of a Remote are licensed to the licensee of the Remote and therefore bear only his or her call sign, not each individual user's.

operating particulars

Nowadays, most 450-MHz rigs include built-in subaudible tones (PL). The ICOM IC-04AT is one example. All PL frequencies are built in and merely selected from the keyboard. The result is increased convenience but at the cost of reduced security. A remotely controlled station isn't very secure if left unattended with only PL protection. And Part 97 *requires* that Remotes be well protected.

For that reason the W6ORE Remote is left off when not in actual use. A user turns the Remote on by sending a touchtone code on the uplink and is responsible for operation of the station until turned off, or until control is passed on to another user. On turn-on, and every 10 minutes thereafter, the synthesized voice IDs the downlink, "W6ORE Auxiliary." At this point, the user can enter modes for controlling the VHF/UHF station, the HF station, or miscellaneous functions.

If VHF/UHF station control is selected, any frequency that the UV3 can cover can be entered via a touchtone pad. Any split, normal, reverse, or odd can be set. Of course, all frequencies and split settings are announced on the downlink by the speech synthesizer. If the UV3 transmitter is enabled, a beep is sent on the downlink every time the user drops his or her uplink carrier to serve as a reminder that the transmission is occurring on another frequency.

Now the computer really proves its worth. Each user is assigned a "scan memory." Each scan memory holds 32 "channels," just like a regular scanner. A user can place any mixture of 2-meter, 220-MHz, and 450-MHz frequencies in his or her scan memory. After turning the Remote on, the user needs to send only a single touchtone on the uplink to activate the scan memory and the UV3 to begin scanning! Scanning, of course, stops on a "talking" channel, but channels can also be "locked out" temporarily or permanently with a keystroke.

Operation of the HF rig is similar. A frequency can be entered directly with touchtones. Then a touchtone code starts the IC-701 tuning up, or down, in 100-Hz steps.
Keying a mike on the uplink briefly will reverse the scan direction and slow it down. Keying the mike a little longer will stop the IC-701 from tuning. At any time a certain touchtone will cause the speech synthesizer to announce the current frequency being monitored. Another touchtone will single-step the rig in 100-Hz steps; yet another will toggle the rig between WWV and the last frequency.

Of course, none of these features are built into the HF rig. The computer controlling the Remote has added them. In addition to the user scan memories, the computer provides 90 single-channel "slots." Each slot can hold any VHF, UHF, or HF frequency. Simply entering a slot number turns on the appropriate rig and sets it to that frequency. For example, one slot holds the 20-meter Maritime Mobile net frequency, a few slots are assigned to local 2-meter repeaters, and one series of slots contains all of the HF W1AW voice bulletin frequencies.

HF apprehensions

There certainly were apprehensions about Remote operation of the HF rig before it was installed. What would tuning a rig several miles away be like without having a frequency display to watch or even a knob to grasp? Would we have to operate duplex, tuning on the uplink while listening on the downlink? The concept of blind operation and computer control was first tested by connecting the HF rig to the author's NorthStar Horizon S-100 computer. A program in BASIC took commands from the computer keyboard and sent them to the rig through parallel ports. It worked great. There were no problems in operating the rig without seeing its front panel. With a little practice a sideband signal could be scanned up to and stopped directly on.

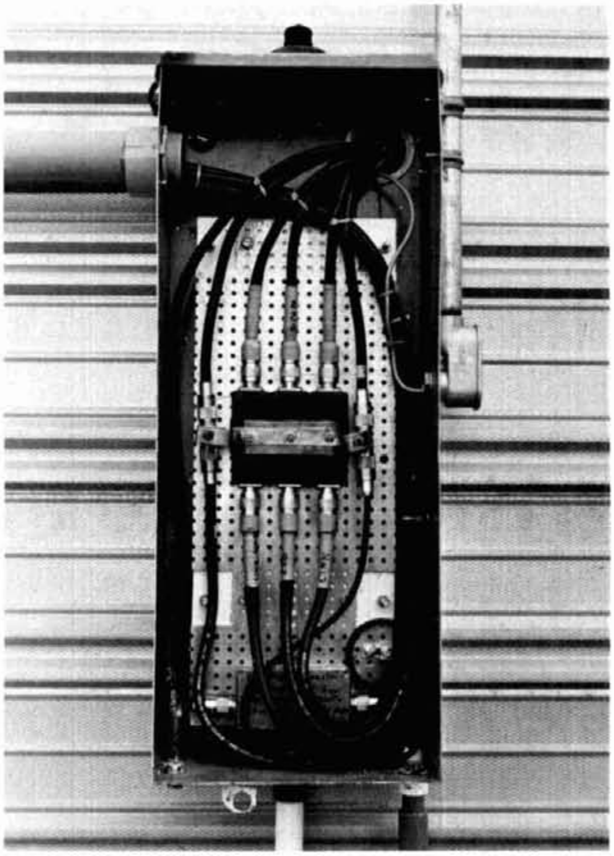

fig. 9. Coax passes through lightning arrestors before entering building.

There is a utility mode that allows users to control a multitude of items. Uplink squelch characteristics can be adjusted. The Remote's battery charger and a 140-mW X-band beacon can be controlled. (See **fig. 8.**) The speech synthesizer can be programmed on the phoneme level to say any word or message. Any portion of the EPROM memory can be read (the speech synthesizer reads out the locations in hex). The static RAM can be read and also written to. The speed that the HF rig tunes can be adjusted. These are just a few of the things that can be controlled.

keeping the commands simple

Even though there are several dozen different touchtone commands, the majority of the most used are only single digit. This makes life much easier. There are no vast tables of long commands to be memorized. This is achieved mainly by dividing major operating areas,

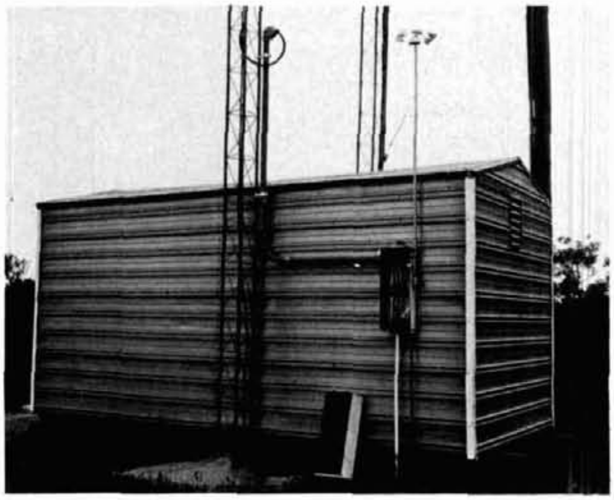

fig. 10. Coax enters building through a weather-proof box. The anemometer is made from a DC motor and recycled air freshener containers.

i.e., HF, VHF/UHF and utility, into separate "modes." The touchtone decoder has to be fairly good to keep uplink voice falsing down when single-digit codes are used. The Mitel MT8860/8865 chip set is used.

bells and whistles (figs. 9 and 10)

A weather station addition is now nearing completion. It is built around a National ADC 0817 16-channel analog to digital (A/D) conversion chip. The chip has 16 analog inputs and an 8-bit digital output. It is quite easy to connect to a computer. The computer needs to send the chip a 4-bit address to set the chip to read the desired channel. The chip then measures the voltage on that channel and presents the data in an 8-bit, 0-255 format. It is then up to the computer to multiply or divide this number by a constant to come up with a meaningful measurement. For example, the home-made anemometer generates 0.027 volt/mile/hour. An op amp amplifies this signal by 2.47. The A/D converter sensitivity is 0.02 volt/bit. Thus, if a 10 mph wind is blowing, the A/D will put out $(10 \times 0.027 \times 2.47)/0.02$ or 33 rounded. The computer then multiplies the A/D output by 0.303 to get 10 mph, which is announced by the speech synthesizer on command. Also measured are inside and outside temperature, humidity, AC line voltage, battery voltage, charger current, and HF antenna VSWR.

summary

Building a remotely controlled station is unquestionably a major project, but the rewards are well worth the effort. Computer control and synthesized speech feedback are a must for all but the simplest systems. There is commercial hardware available for remote control, but you might want to consider "rolling your own" to gain the ultimate in versatility.

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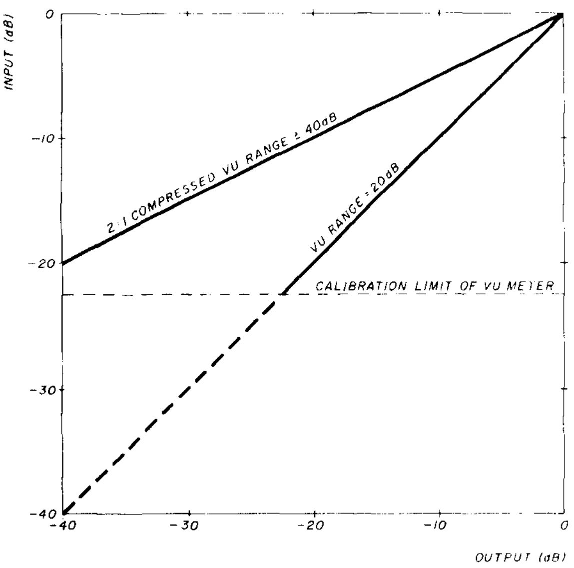

fig. 1. 1:1 VU vs. 2:1 VU range.

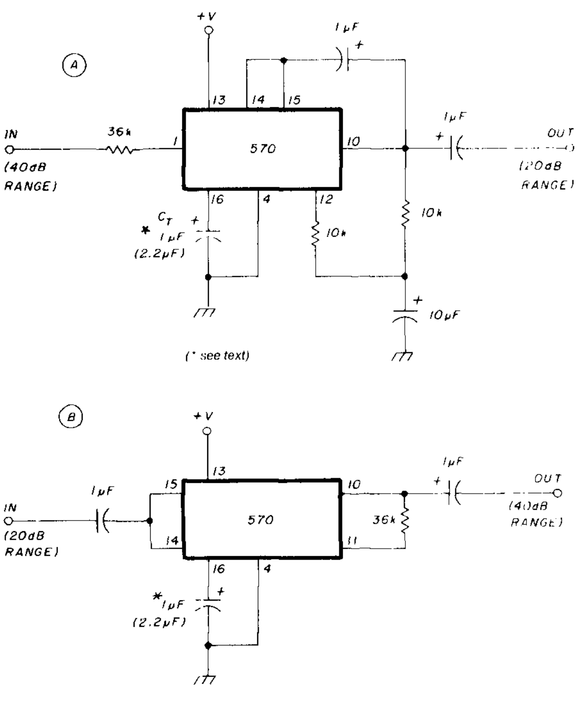

fig. 2. The NE570 used as (A) compressor and (B) 1:2 expander.

NE570 circuit compresses 40 dB-range into 20 dB

In Amateur Radio we're accustomed to signal-to-noise ratios of less than 15-20 dB. On UHF, however, there's sometimes a need to measure SNR higher than 20 dB. An example of this would be in setting up VHF or UHF networks or linking systems to minimize hum, noise, or PL leakage.

One method of extending the range of a standard VU meter from its usual 20-22 dB to 40-45 dB is to use an NE570 or NE571 2:1 compression amplifier between the source signal and the VU meter. This device provides a very accurate 2:1 curve so that accurate SNR readings can be achieved (see **fig. 1**).

circuit description

The NE570 consists of three basic blocks: a 741-like op amp, a gain control amplifier, and a precision detector. It can be set up to compress or expand at a 2:1 ratio, depending on how these elements are connected (see **fig. 2**).

The output of the NE570 is buffered by an MC3403 op amp to provide gain in the unit and better drive to the VU meter (the NE570 is limited in this regard). I chose the MC3403 because it has low crossover distortion and requires only a single voltage supply.

(The circuit board artwork from the Project OSCAR ACSSB Level 1 TX Adapter is shown in **fig. 3**). A layout for the VU Extender and its schematic are also included (**fig. 4**). You may wish to use the extra op amp sections to provide a standard audio weighting curve for some kinds of measurements. There are three op amps still available in the MC3403 to provide this function.

Calibration is accomplished by setting the input attenuator pot (R_A) in **fig. 4** to mid-scale, then adjusting R_B with the selector switch (S1) in the "OUT" position until you read "0" VU with 0.773 volts AC

By James Eagleson, WB6JNN, 15 Valdez Lane, Watsonville, California 95076

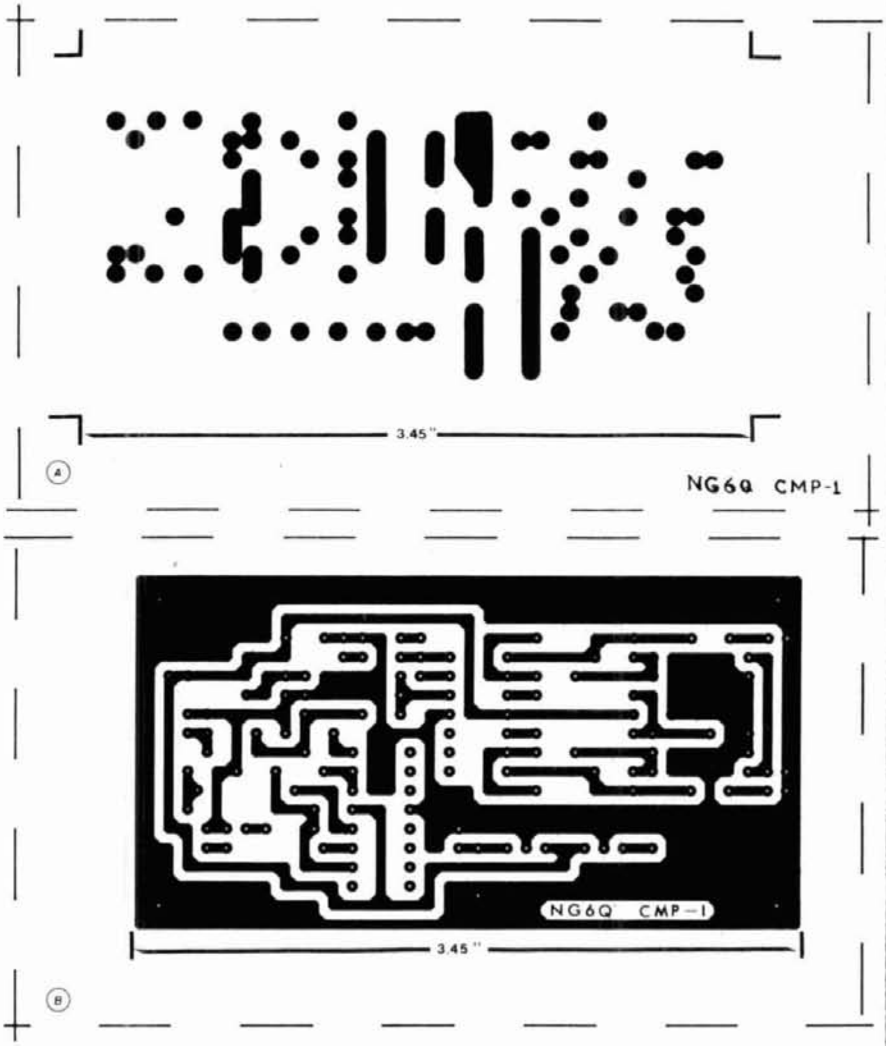

fig. 3. VU extension circuit printed circuit board: (A) component side; (B) solder or ground side. Note: if reader interest warrants, Project OSCAR will prepare printed circuit boards. Address inquiries to author (enclose SASE).

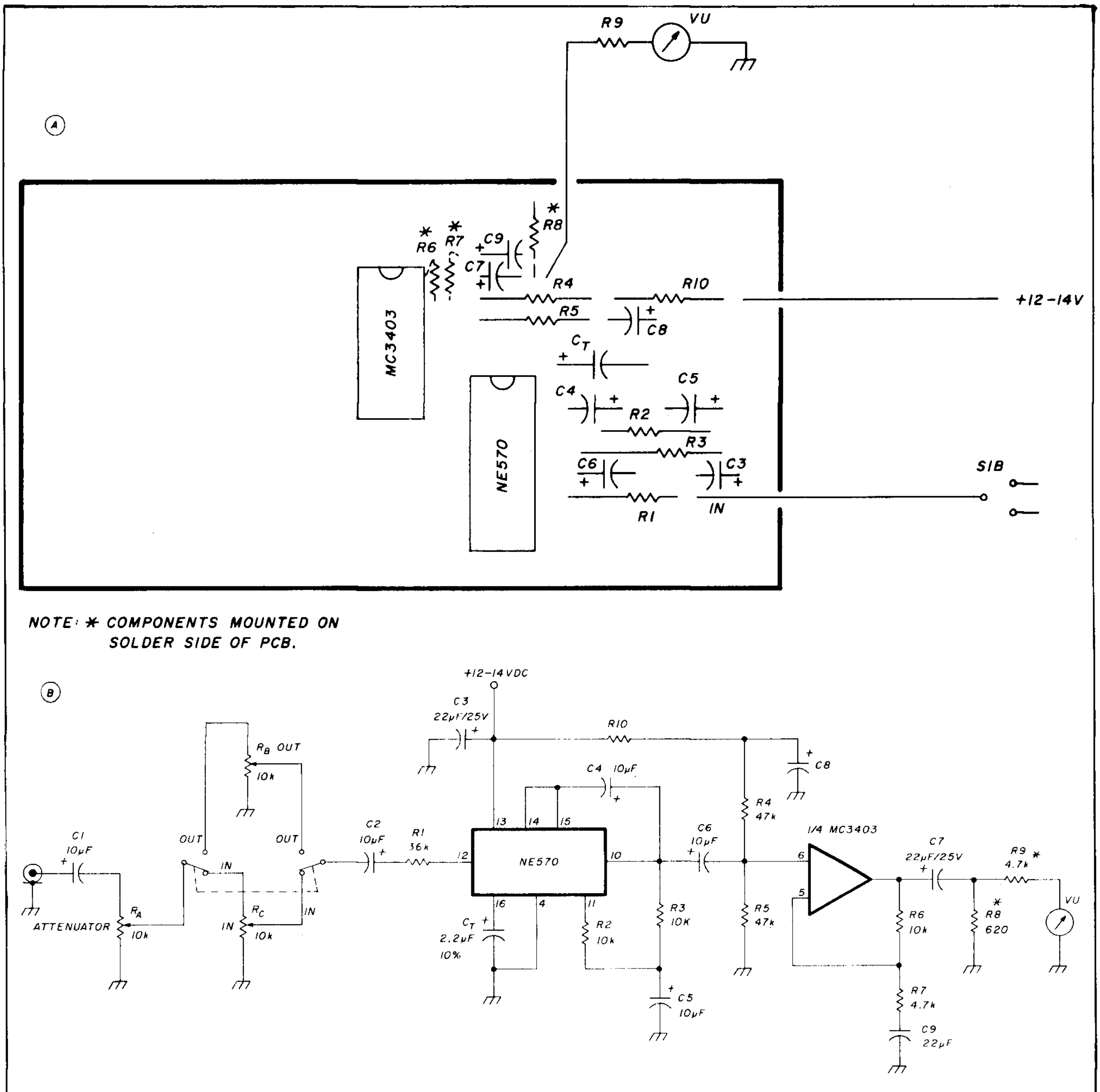

fig. 4. VU extension circuit printed circuit board: (A) component layout; (B) extension circuit.

at the input. This can be checked with a VOM or digital voltmeter. After switching S1 to "IN," adjust R_C for the same reading. You'll now notice that by dropping the input level 10 dB in the "OUT" position, you'll read −5 dB when you switch to the "IN" position.

All readings taken with the adapter "IN" should be multiplied by 2 (i.e., −5 dB = −10 dB) to obtain actual SNR.

performance

The unit works well for normal speech and CW because the time constants have been chosen to complement the usual syllabic rate of voice and CW, which is about the same.

The 2.2 μF capacitor specified for (C_T) gives good performance down to about 100 Hz.

There will be some overshoot and undershoot on the system (no AGC amplifier is perfect), but it will certainly give results within a few dB of correct levels and costs far less than equivalent commercial units capable of measuring the same information. I've found it a useful addition to my shack.

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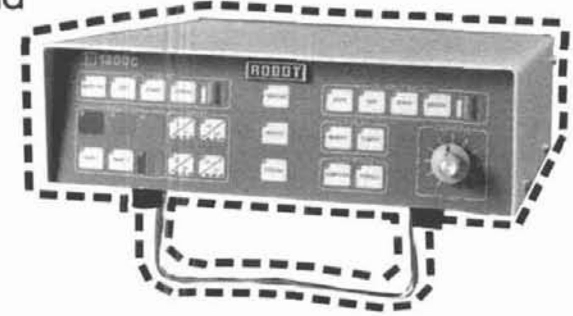

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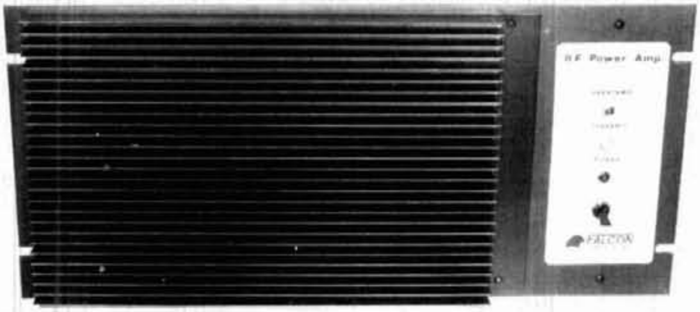

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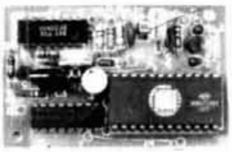

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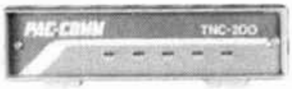

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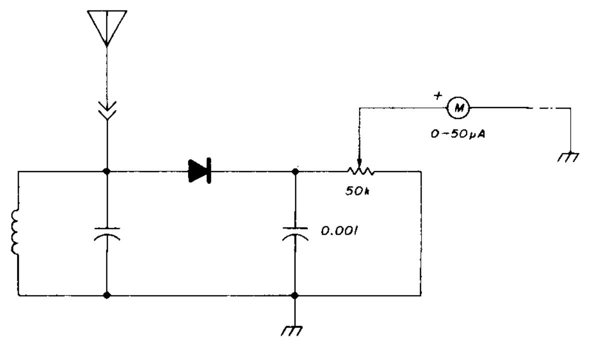

fig. 1. The typical field-strength meter circuit will work for HF medium power applications, but is useless for 1750-meter QRP testing.

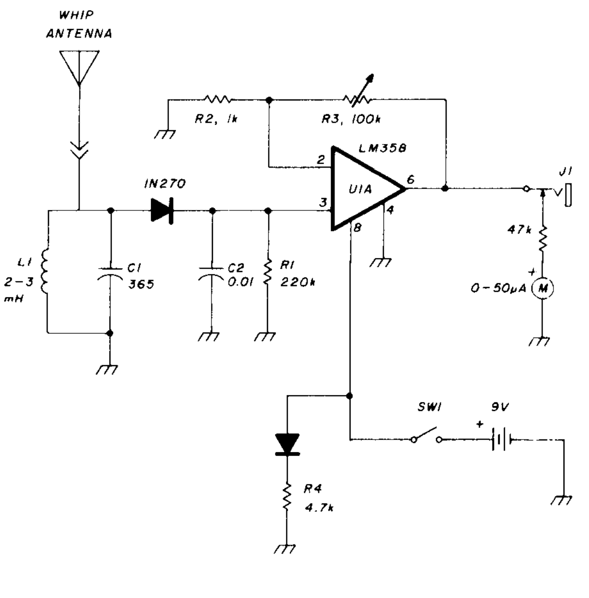

fig. 2. A single 9-volt battery will power the field strength meter, with a total current drain of 3 mA.

Detect small changes with this handy circuit

While the simple resonant tank, diode detector, and microammeter-type field strength meter **(fig. 1)** may be usable for HF signal evaluation, it's almost useless for any reasonable measurements on 1750 meters, where a 1-watt input restriction applies and very low ERP is the rule.

Using the standard diode detector scheme, I found that the usable scale readings for 1750-meter tests were limited to a maximum of 30 feet away from the antenna to be evaluated. To compensate for this insensitivity, a larger antenna connected to a field strength meter would be required. But this would make field-level measurements cumbersome. One solution to this problem would be a DC amplifier at the output of the detector to provide the gain required for driving the meter indicator.

circuit description

In **fig. 2** the complete LF field strength meter circuit is shown. C1 and L1 are made to resonate on the 1750-meter band, with the total coverage being from 150 kHz to 500 kHz. L1 can be slug-tuned for 160-to-190 kHz coverage alone or a 2.5-mH choke can be used for L1, if desired, using C1 for tuning. A 1N270 germanium diode rectifies the RF signal and C2 is charged at the peak RF level. This DC level is amplified by U1, an LM358 operational amplifier requiring only a single 9-volt supply for operation. The gain is determined by R2 and R3. R3 is a 100-kilohm linear potentiometer that varies the DC gain from 1 to 100, driving the 50-microampere meter, which acts as a voltmeter in conjunction with R5. A normally closed 3.5-mm jack is connected in series with the analog 50-microampere meter for remote meter readings and/or a DC level which can power an audio

By S.J. DeFrancesco, K1RGO, 17 Jeffry Road, East Haven, Connecticut 06512

Table 1.

L1	C1 (variable)	Frequency Range	Ham Band
50 μH	30-365 pF	1- 4 MHz	160, 80 meters
3 μH	30-365 pF	5-16 MHz	40, 30, 20 meters
0.9 μH	30-365 pF	9-30 MHz	30, 20, 15, 12, 10 meters
2.5 mH	—	Broadband at reduced gain	

oscillator for CW sidetone operation. An LED was added to indicate the "on" status.

You can expect long battery life because the amplifier will continue to operate even when the battery voltage drops to 4 volts. With 9 volts applied, the total current drain is only 3 mA.

This field strength meter need not be limited to LF use only. **Table 1** shows the L1 and C1 values for HF operation and broadband operation.

operation

At first try, the added sensitivity was a blessing. I could easily make field strength measurements at distances that were impossible with the simple diode detector barefoot meter. At 200 feet from my LF antenna, testing on 186.5 kHz, I could easily get 30 percent scale readings.

I then began checking my 1750-meter antenna system. When the antenna was dry, I noted a 1-dB increase in field strength over readings taken when it was wet. I ran a 600-volt "Megger" test on a dry day and also on a rainy day, noting 10,000 Megohms on the dry day and 3 Megohms on the rainy day. In the past, under similar conditions, I couldn't detect this variation in field strength because of unusable readings. Noticing the substantial difference in field strength, I cut several tree branches that were touching my antenna and found that just doing this increased the field strength by another 2 dB. The field strength meter proved to be quite a useful tool.

ham radio

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VHF Yagi CAD on the C-64

Use the popular VK4ZF program to design up to 40 elements on a single boom

When VK4ZF's article, "Computer-aided Design of Long VHF Yagi Antennas," appeared in the May issue of *ham radio*,[1] I decided to convert his design program, written for the Apple IIE, to run on the Commodore 64. **Figure 1** lists the revised program.

The most significant conversions appear in the section of the main program that reads back data files (**lines 1130-1190**) and in the file saving program shown in **fig. 2**. All the commands to the printer required modification, especially with the addition of **lines 5000-6220** to provide decimal alignment of the numerical results. The data tables from the original article must be typed in using the program shown in **fig. 2**.

reference

1. David G. Hopkins, VK4ZF, "Computer-aided Design of Long VHF Yagi Antennas," *ham radio*, May, 1986, page 28.

By Olin K. McDaniel, Jr., W4PFZ, 1327 Pinckney Avenue, Florence, South Carolina 29501

fig. 1. W4PFZ's revision of VK4ZF's Yagi design program runs on Commodore 64.

```
READY.

5 REM ********************************
10 REM      YAGI DESIGN PROGRAM
15 REM              BY
20 REM    DAVID G. HOPKINS (VK4ZF)
25 REM      #4 HANDSWORTH ST
30 REM          CAPALABA
35 REM        QLD.   4157
40 REM         AUSTRALIA
45 REM --------------------------------
50 REM    MODIFIED FOR COMMODORE 64
55 REM              BY
60 REM     OLIN K. MCDANIEL (W4PFZ)
65 REM --------------------------------
70 REM  PROGRAM BASED ON WORK DONE BY
75 REM       GUNTER HOCK (DL6WU)
80 REM         AND PUBLISHED IN
85 REM       'VHF COMMUNICATIONS'
90 REM  REQUIRES THE USE OF A PRINTER
100 REM
110 REM ********************************
120 REM
160 PRINT"(CLR)":GOSUB 1820
170 PRINT"(CLR)":DIM SP(40),DS(40),TS(40),LE(45),LE$(45),DS$(45):Q$="3333"
180 REM-------------LOAD ELEMENT SPACING DATA--------------
190 DATA.240,.075,.180,.215,.250,.280,.300,.315,.330,.345
192 DATA.360,.375,.385,.390,.395,.400,.400,.400,.400,.400
194 DATA.400,.400,.400,.400,.400,.400,.400,.400,.400,.400
196 DATA.400,.400,.400,.400,.400,.400,.400,.400,.400,.400
200 FOR X=1TO 40
210 READ SP(X)
220 NEXT
230 REM-------LOAD REFLECTOR MULTIPLIER----------
235 DIM RE(16)
240 DATA.4905,.4900,.4885,.4875,.4865,.4855,.4845,.4835
245 DATA.4825,.4820,.4810,.4785,.4770,.4765,.4750,.4740
260 FOR X=1TO16:READ RE(X):NEXT
270 REM-------LOAD RADIATOR MULTIPLIER-----------
280 DIM DR(16)
290 DATA.4675,.4665,.4640,.4620,.4601,.4585,.4575,.4550
295 DATA.4530,.4515,.4500,.4460,.4435,.4430,.4400,.4385
300 FOR X=1TO16:READ DR(X):NEXT
310 REM-------SELECT ELEMENT MATERIAL SIZE--------
315 DIM EL(16)
320 DATA.003,.0035,.0042,.005,.0056,.0063,.007,.0078
325 DATA.0088,.01,.01145,.0131,.015,.0165,.0182,.02
330 FOR X=1TO16:READ EL(X):NEXT
340 REM-------INPUT DESIRED PARAMETERS------------
350 PRINT"(CLR)WHAT IS THE CENTER FREQUENCY OF THE     ANTENNA IN MHZ.":INPUT F
360 PRINT"(C/DN)HOW MANY ELEMENTS DOES THE ANTENNA      REQUIRE" :INPUT N
370 PRINT:IFN<9 OR N>40THENPRINT"(RVON)NUMBER OF ELEMENTS MUST BE BETWEEN 9 AND
40"
375 IFN<9 OR N>40 GOTO 360
380 PRINT"WHAT IS THE DIAMETER OF THE BOOM IN      MILLIMETERS":INPUT BD
390 PRINT:PRINT"ARE THE ELEMENTS TO BE INSULATED FROM   THE BOOM?    Y=YES, N=NO
 ";
400 GET A$:IF A$="" GOTO 400
410 IF A$="Y" THEN I=1:GOTO 450
420 IF A$="N" THEN I=0:GOTO 450
430 GOTO 400
440 REM---------DISPLAY SPECIFICATIONS-------------
450 PRINT"(CLR)":PRINT"SPECIFICATIONS FOR THE ANTENNA TO DESIGN":PRINT:PRINT
455 PRINT"1.  DESIGN FREQUENCY: ";F ;" MHZ"
460 PRINT"2.  DIAMETER OF BOOM: ";BD;" MM"
470 PRINT"3.  NUMBER OF ELEMENTS: ";N
480 IF I=1 THEN PRINT"4.  ELEMENTS ARE TO BE INSULATED FROM        THE BOOM"
484 IFI=0THEN PRINT"4.  ELEMENTS ARE TO BE ELECTRICALLY CON-NECTED TO THE BOOM"
490 IF(BD/1000)/(299.792/F) <.05 GOTO500
491 IF(BD/1000)/(299.792/F)>.05THENPRINT"(C/DN)(C/DN) BOOM DIAMETER TOO LARGE FO
R THIS",
492 PRINT"FREQUENCY":PRINT"(C/DN)(C/DN)":PRINT"ENTER A SMALLER DIAMETER":INPUT B
D:GOTO440
500 REM----------CHECK SPECIFICATIONS--------------
510 PRINT"(C/DN)(C/DN)(C/DN)":PRINT"ARE ALL THE ENTRIES CORRECT, Y=YES, N=NO";
520 GET A$:IF A$=""GOTO 520
530 IF A$="Y" GOTO 650
540 IF A$="N" GOTO 560
550 GOTO 520
560 PRINT"WHAT IS THE NUMBER OF THE INCORRECT ENTRY":INPUT X
570 IF X<>4 GOTO 600
580 IF I=0 THEN I=1:GOTO 440
590 IF I=1 THEN I=0:GOTO 440
600 INPUT"WHAT IS THE CORRECT VALUE";CV
610 IF X=1 THEN F=CV
620 IF X=2 THEN BD=CV
630 IF X=3 THEN N=CV
640 GOTO 450
650 REM----------CALCULATE BOOM DIAMETER WAVELENGTHS----------
660 W=299.792/F
670 BW=BD/1000/W
680 BC=BD*(526.286*BW↑.648831/100)
690 REM----------CALCULATE BOOM LENGTH------------------
700 TL=0
```

```
720 FOR X-1TO N-1
730 DS(X)-SP(X)*W*1000
740 TL-TL+DS(X)
750 NEXT
760 PG-(TL/1000)/W
770 REM----------CALCULATE BEAM WIDTHS AND STACKING DISTANCES---------
780 BH-50.2709*PG↑-.484091:SH-W/(2*(SIN(BH/2*.0174533)))
790 BV-66.5112*PG↑-.617261:SV-W/(2*(SIN(BV/2*.0174533)))
795 PA-INT((7.8*(LOG(PG)/LOG(10))+9.2)*1000+.55)/1000
800 REM----------PRINT PRELIMINARY DATA----------------
810 PRINT"(CLR)"
820 PRINT"          YAGI PRELIMINARY DATA":PRINT
830 PRINT"FREQUENCY                  ";F;" MHZ."
840 PRINT"WAVELENGTH                 ";INT(W*10000)/10000;" METERS"
850 PRINT"# OF ELEMENTS              ";N
860 PRINT"DIAMETER OF BOOM           ";BD;" MILLIMETERS"
870 PRINT"ELECTRICAL BOOMLENGTH ";INT(TL);" MILLIMETERS"
880 PRINT"BOOM WAVELENGTHS           ";PG
890 PRINT"MAXIMUM PRACTICAL GAIN";PA;" DBD"
900 PRINT"HORIZONTAL BEAM WIDTH ";:PRINTINT(BH*100+.5)/100;:PRINT"DEGREES"
910 PRINT"VERTICAL BEAM WIDTH   ";:PRINTINT(BV*100+.5)/100;:PRINT"DEGREES"
920 PRINT"(C/DN)                  STACKING DISTANCES"
930 PRINT"       HORIZONTAL: ";:PRINTINT(SH*1000+.55)/1000;:PRINT" METERS"
940 PRINT"       VERTICAL:   ";:PRINTINT(SV*1000+.55)/1000;:PRINT" METERS"
950 PRINT"(C/DN)(C/DN)":PRINT"DO YOU WISH TO CONTINUE WITH THIS DESIGN      Y-YE
S, N-NO"
960 GET A$:IF A$-"" GOTO 960
970 IF A$-"Y" GOTO 1000
980 IF A$-"N" GOTO 440
990 GOTO 960
1000 PRINT"(CLR)":NU-0
1010 PRINT:PRINT"YOU MAY USE ANY OF THE FOLLOWING TUBING SIZES FOR THE ELEMENTS"
1020 PRINT:PRINT"SELECT THE SIZE CLOSEST TO A COMMERCIAL TUBE SIZE"
1030 FOR X-1TO 16
1040 NU-NU+1
1050 PRINT"#  ";X;:PRINTTAB(15)INT(((EL(X)*W)*1000)*1000+.55)/1000;
1055 PRINT" MM":NEXT
1070 PRINT"(C/DN)(C/DN)(C/DN)":PRINT"ENTER THE # OF THE TUBING SIZE YOU WISH TO
USE":INPUT TS$
1075 TS-VAL(TS$)
1080 IF TS<NU OR TS-NU THEN 1100
1090 IF TS>NU THEN PRINT"(RVON) ERROR (RVOF)":PRINT"HIT ANY KEY TO CONTINUE"
1093 IF TS>NU THEN GET A$:IF A$-"" THEN 1093
1096 GOTO 1000
1100 TT-EL(TS):TD(1)-TT*W*1000
1110 PRINT"(CLR)":PRINT"STAND BY - THIS WILL TAKE A FEW SECONDS"
1120 REM-------------LOAD TUBING SIZE TABLES----------
1125 DIM A$(38)
1130 N$-"CURVE":N2$-N$+TS$
1135 OPEN15,8,15
1140 OPEN2,8,2,"0:"+N2$+",S,R"
1150 FOR X-1TO 38
1160 INPUT#2,TS(X)
1180 NEXT
1190 CLOSE2:CLOSE15:CLOSE8
1200 REM------------CALCULATE ELEMENT LENGTHS-------------
1210 FOR X-3 TO 42
1220 IF I-1 THEN LE(X)-W*TS(X-2)*1000
1225 IF I-0 THEN LE(X)-W*TS(X-2)*1000+BC
1230 NEXT
1240 LE(1)-W*RE(TS)*1000
1250 IF I-0 THEN LE(1)-LE(1)+BC
1260 LE(2)-W*DR(TS)*1000
1270 IF I-0 THEN LE(2)-LE(2)+BC
1280 PRINT"(CLR)"
1290 PRINT"PRESS ANY KEY WHEN PRINTER IS READY"
1300 GET A$:IF A$-"" GOTO 1300
1304 OPEN4,4:CMD4
1306 PRINT#4
1310 PRINT#4,"                  YAGI DESIGN DETAILS:      "
1320 PRINT#4,"-------------------------------------------------------------------"
1330 PRINT#4,"(C/DN)(C/DN)"
1335 GOSUB 5000
1340 PRINT#4,"DESIGN FREQUENCY:     ";SPC(37-AA);F$;" MHZ.":
1350 PRINT#4,"WAVELENGTH:           ";SPC(38-BB);W$;" METERS":
1360 PRINT#4,"NUMBER OF ELEMENTS:   ";SPC(36-NN);NO$:
1370 PRINT#4,"DIAMETER OF BOOM:     ";SPC(36-CC);BD$;" MM":
1380 PRINT#4,"DIAMETER OF ELEMENTS:";SPC(37-DD);TD$;" MM":
1390 IF I-1 THEN PRINT#4,"  'ELEMENTS ARE INSULATED FROM THE BOOM'"
1391 IF I-0 GOTO 1394
1392 GOTO 1400
1394 PRINT#4,"   'ELEMENTS ARE ELECTRICALLY CONNECTED TO THE BOOM'"
1400 PRINT#4,"ELECTRICAL BOOM LENGTH:    ";SPC(28-EE);TL$;" MM":
1410 PRINT#4,"BOOM WAVELENGTHS:              ";SPC(32-FG);PG$:
1420 PRINT#4,"MAXIMUM PRACTICAL GAIN:         ";SPC(30-FF);PA;" DBD":
1430 PRINT#4,"HORIZONTAL BEAM WIDTH:          ";SPC(29-GG);BH$;" DEGREES":
1440 PRINT#4,"VERTICAL BEAM WIDTH:            ";SPC(29-HH);BV$;" DEGREES":
1450 PRINT#4,"HORIZONTAL STACKING DISTANCE:";SPC(30-II);SH$;" METERS":
1460 PRINT#4,"VERTICAL STACKING DISTANCE:  ";SPC(30-JJ);SV$;" METERS":
1470 PRINT#4,"(C/DN)(C/DN)"
1480 PRINT#4,"              ELEMENT LENGTH, MM.     DISTANCE FROM REFLECTOR, MM."
1490 PRINT#4,"--------------------------------------------------------------------
---"
1500 PRINT#4,"(C/DN)"
1510 PRINT#4,"REFLECTOR";SPC(15-KK);LE$(1);SPC(29);"0":
1520 PRINT#4,"DRIVEN ELEMENT";SPC(10-LL);LE$(2);SPC(37-LL-L2);SP$(1):
1530 PS-SP(1)*W*1000
1540 FOR X-3 TO N
1545 PS-PS+SP(X-1)*W*1000
1550 GOSUB 6000
1560 PRINT#4,"DIRECTOR #";X-2;SPC(13-MM-MN);LE$(X);SPC(37-MM-NN);PS$:
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110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314	326	338	350
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315	327	339	
112	124	136	148	160	172	184	196	208	220	232	244	256	268	280	292	304	316	328	340	

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1570 NEXT
1580 PRINT#4
1590 PRINT#4,"    ELEMENT SPACING IN MILLIMETERS   "
1600 PRINT#4,"----------------------------------------"
1610 PRINT#4
1615 GOSUB 6100
1620 PRINT#4,"REFLECTOR TO DRIVEN ";SPC(17-OO);DS$(1):
1630 PRINT#4,"DRIVEN TO DIRECTOR 1";SPC(17-PP);DS$(2):
1640 FOR X-3 TO N-1
1645 GOSUB 6200
1650 PRINT#4,"DIR";X-2;SPC(4-MN);"    TO DIR ";X-1;SPC(17-QQ-MD);DS$(X):
1660 NEXT
1670 PRINT#4:PRINT#4:PRINT#4,"               NOTES"
1680 PRINT#4:PRINT#4,"1. THE DIMENSIONS ARE FROM CENTER TO CENTER IN ALL CASES."
1690 PRINT#4,"     FOR EXAMPLE THIS MEANS THE BOOM MUST BE CUT LONGER THAN THAT"
1700 PRINT#4,"      GIVEN TO BE ABLE TO MOUNT THE ELEMENTS."
1710 PRINT#4,"2. IF YOU WANT WIDE BANDWIDTH, USE A FOLDED DIPOLE AS THE DRIVEN E
LE"
1720 PRINT#4,"3. THE DRIVEN ELEMENT DIMENSION IS THE LENGTH OVERALL."
1730 PRINT#4,"4. YOU MUST WORK TO AN ACCURACY OF <1MM AT FREQUENCIES ABOVE 400 M
HZ.
1740 PRINT#4,"5. ACCURACY BELOW 400 MHZ SHOULD BE WITHIN 1.5MM."
1750 PRINT#4,"6. ELEMENT MOUNTING MUST BE BETTER THAN .5MM OF THE ELEMENT CENTER
."
1760 PRINT"(CLR)":FOR X-I TO 8:PRINT#4:NEXT
1770 END
1810 GOTO 1780
1820 PRINT"(CLR)":PRINT:PRINT"     THIS PROGRAM WILL DESIGN"
1825 PRINT"  YAGI ANTENNAS WITH ANY NUMBER"
1830 PRINT"    OF ELEMENTS FROM 9 TO 40."
1840 PRINT"(C/DN)(C/DN)(C/DN)"
1850 PRINT"  THE PROGRAM IS BASED ON ARTICLES"
1855 PRINT"   BY GUNTER HOCK AND PUBLISHED"
1860 PRINT"     IN 'VHF. COMMUNICATIONS'."
1870 PRINT"(C/DN)(C/DN)(C/DN)"
1880 PRINT"    YOU WILL REQUIRE A PRINTER"
1885 PRINT"     TO OBTAIN USABLE RESULTS."
1890 PRINT"(C/DN)(C/DN)    (RVON) PRESS ANY KEY TO CONTINUE (RVOF)"
1900 GET A$:IF A$-""GOTO 1900
1910 PRINT"(CLR)"
1920 GOTO 170
1930 END
5000 F-INT(F*100+.5)/100
5005 F$-STR$(INT(F))+"."+RIGHT$(STR$(F*100),2):AA-LEN(F$)
5010 W$-STR$(INT(W*1000)/1000):BB-LEN(W$)
5015 NO$-STR$(INT(N))+"."+RIGHT$(STR$(N*10),1):NN-LEN(NO$)
5017 BD-INT(BD*10+.5)/10
5020 BD$-STR$(INT(BD))+"."+RIGHT$(STR$(BD*10),1):CC-LEN(BD$)
5025 TD(1)-INT(TD(1)*100+.5)/100
5030 TD$-STR$(INT(TD(1)))+"."+RIGHT$(STR$(TD(1)*100),2):DD-LEN(TD$)
5040 TL$-STR$(INT(TL)):EE-LEN(TL$)
5042 PG-INT(PG*1000+.5)/1000
5045 PG$-STR$(INT(PG))+"."+RIGHT$(STR$(PG*1000),3):FG-LEN(PG$)
5050 PA$-STR$(PA):FF-LEN(PA$)
5055 BH-INT(BH*100+.5)/100
5060 BH$-STR$(INT(BH))+"."+RIGHT$(STR$(BH*100),2):GG-LEN(BH$)
5065 BV-INT(BV*100+.5)/100
5087 BV$-STR$(INT(BV))+"."+RIGHT$(STR$(BV*100),2):HH-LEN(BV$)
5070 SH-INT(SH*1000+.5)/1000
5080 SH$-STR$(INT(SH))+"."+RIGHT$(STR$(SH*1000),3):II-LEN(SH$)
5085 SV-INT(SV*1000+.5)/1000
5090 SV$-STR$(INT(SV))+"."+RIGHT$(STR$(SV*1000),3):JJ-LEN(SV$)
5095 LE(1)-INT(LE(1)*10+.5)/10
5100 LE$(1)-STR$(INT(LE(1)))+"."+RIGHT$(STR$(LE(1)*10),1):KK-LEN(LE$(1))
5105 LE(2)-INT(LE(2)*10+.5)/10
5110 LE$(2)-STR$(INT(LE(2)))+"."+RIGHT$(STR$(LE(2)*10),1):LL-LEN(LE$(2))
5120 SP$(1)-STR$(INT(SP(1)*W*1000))+"."+RIGHT$(STR$(SP(1)*W*1000*10),1)
5130 LZ-LEN(SP$(1))
5200 RETURN
6000 LE(X)-INT(LE(X)*10+.5)/10
6010 LE$(X)-STR$(INT(LE(X)))+"."+RIGHT$(STR$(LE(X)*10),1):MM-LEN(LE$(X))
6013 EL$-STR$(INT(X-2)):MN-LEN(EL$)
6015 PS-INT(PS*10+.5)/10
6020 PS$-STR$(INT(PS))+"."+RIGHT$(STR$(PS*10),1):NN-LEN(PS$)
6030 RETURN
6100 DS(1)-INT(DS(1)*10+.5)/10
6105 DS$(1)-STR$(INT(DS(1)))+"."+RIGHT$(STR$(DS(1)*10),1):OO-LEN(DS$(1))
6110 DS(2)-INT(DS(2)*10+.5)/10
6115 DS$(2)-STR$(INT(DS(2)))+"."+RIGHT$(STR$(DS(2)*10),1):PP-LEN(DS$(2))
6120 RETURN
6200 DS(X)-INT(DS(X)*10+.5)/10
6205 DS$(X)-STR$(INT(DS(X)))+"."+RIGHT$(STR$(DS(X)*10),1):QQ-LEN(DS$(X))
6210 EL$-STR$(INT(X-2)):MN-LEN(EL$):EB$-STR$(INT(X-1)):MD-LEN(EB$)
6220 RETURN

READY.
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(continued on page 102)

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VHF/UHF WORLD

Joe Reisert W1JR

RF connectors: part 1

Though the subject of RF connectors has been mentioned here many times, time and scheduling have not permitted a detailed discussion of this seemingly simple and straightforward subject.

I often hear Amateurs make all kinds of wild claims, or see them distribute misinformation on the subject. These stories typically involve power handling, impedance matching, and insertion loss. Also, many Amateurs seem unaware of the many types of connectors — besides the so-called "standard" or preferred types — that are available. These same Amateurs would probably also wonder why so many types are required.

This all reminds me of the story circulated in the early 1950s, just after the transistor was invented. The general notion was that all possible applications could be accommodated by the development of just a few types of transistors! Today there are over 10,000 types of numbered transistors, and new ones are becoming available weekly!

While there aren't nearly as many series of RF connectors available as of transistors, there surely must be almost as many types of distinctly different RF connectors and adapters available. Therefore, this month's column will serve as sort of a primer, in which we'll try to sift through the major series of RF connectors. Next month's column will expand on the various tradeoffs, especially in the area of applications. Tables will help put the whole selection of RF connectors in perspective and, I hope, help make selection easier in the future.

overview

RF connectors are designed to join or separate two components or units — such as an antenna and a transceiver — with relative ease. They're also used to gain access to a specific unit.

The proper choice of an RF connector type is particularly important when considering frequency of operation, passing high level RF power, or connecting to a low-noise preamplifier. It's also necessary if you're using a modular approach. Proper connectors permit convenient access to a unit so that adjustments can be made without disassembling or disturbing the circuit under test.

The actual choice of an RF connector depends on many things: application, availability, relative cost, electrical performance, mechanical durability, and environmental conditions. The choice of an optimum RF connector for a specific application, therefore, isn't always possible. Trade-offs are often necessary.

Furthermore, connectors are available in many forms. They may be threaded, bayonet, snap-on, or push-on. They may also be used on standard coaxial line, **Triax**™ (cable with two separately isolated braids for maximum shielding effectiveness), or **Twinax**™ (for connecting to 95-ohm balance line such as RG-22). The connector may be male, female, or neither.

An RF connector may be used either to terminate a transmission line, an in-series or between-series adapter, a panel mount, or feedthrough. What's the method used to attach to the connector to the line? Is it a solder connection, screw-on, push-on, or crimp type? Is the center pin free-floating or captive? Or is it fabricated from the actual transmission line center conductor itself, such as with RG-17 and UT-141 semi-rigid coax.

Basically speaking, RF connectors can be separated into three main families; standard, miniature, and subminiature. Standard connectors are for cables that are larger than 0.25 inches in diameter. Miniature connectors fit cable measuring between 0.10 and 0.25 inches. Subminiature connectors are sized for cables measuring less than 0.10 inches in diameter.

RF connector series

Table 1 is a list of most of the major series in common use, along with some technical data. More data will be provided in next month's column.

The **UHF** connector was the forerunner of most of the modern RF connectors. Developed in the mid-1930s, it was inexpensive and easy to assemble and use. It quickly became an industry standard. The most common types used by Amateurs are the PL-259 plug and the SO-239 chassis mount.

Unfortunately the UHF connector series doesn't have a constant impedance and is therefore usually limited to 500 MHz and below; in fact, I wouldn't recommend using UHF connectors above 150 MHz. What's more, it's not weatherproofed and therefore can't be recommended for outdoor use.

Connector development was spurred on by radar and VHF communications gear designed during WW II. Later progress resulted from the development of more demanding applications, especially at the higher microwave and millimeter-wave regions.

The **type N** connector — supposedly named for its inventor, Paul Neill of Bell Labs — was one of the first developed for both the VHF and UHF frequencies. Its most significant contribution to the state of the art was the addition of the separate outer contact, which wipes against the female body jack.

Table 1. This table contains some of the more pertinent parameters of the major series of RF connectors in common use.

Type	Outer diameter typical (inches)	Impedance Ohms	Thread size (inches)	Maximum Frequency
APC-3.5	0.312	50	1/4-36	34 GHz
APC-7	0.880	50	11/64-24	18 GHz
BNC	0.568	50 or 75	NA	4 GHz
C	0.750	50	NA	10 GHz
EIA	1 to 7	50	Note 1	Note 1
F	0.500	75	3/8-32	500 MHz
GR	0.812	50	NA	4 GHz
HN	0.875	Note 2	3/4-20	10 GHz
JCM	0.312	50	1/4-36	4 GHz
LC	1.500	Note 2	1 1/4-18	1 GHz
LT	1.500	50	1 1/4-18	1 GHz
MHV	0.562	Note 2	NA	50 MHz
N	0.825	50 or 70	5/8-24	11 GHz
RCA Phono	0.375	Note 2	NA	30 MHz
SC	0.812	50	11/64-24	11 GZHz
SM	0.312	50	1/4-32	200 MHz
SMA	0.312	50	1/4-36	12.4 GHz
SMB	0.250	50 or 75	NA	4 GHz
SMC	0.250	50,75,95	10-32	10 GHz
SSM	0.250	50	10-36	26 GHz
TM	0.425	50	5/16-32	10 GHz
TNC	0.625	50	7/16-28	10 GHz
Triax	1.000	Note 2	7/8-20	10 GHz
Twinax	.875	78 to 125	several	200 MHz
UHF	.750	Note 2	5/8-32	300 MHz

Note 1. Depends on diameter.

Note 2. May be used at 50- to 75-ohm impedances if matching is not a problem.

The N connector has a constant impedance and is usable to at least 11 GHz. Its gasket seals were later improved along with the braid clamp, making it an excellent choice for outdoor use. Amateurs usually prefer the UG-21 and UG-58 plug and jack, respectively. *One caution:* N connectors are sometimes made for 70-ohm impedances. To accomplish this, the diameter of the center pin is very small. Inserting a 50-ohm male connector into a female 70 ohm type will break the receptacle pin. Also, if a 70-ohm male "N" is inserted into a 50-ohm female N connector, there may be no electrical contact. I've seen these 70-ohm N connectors at flea markets, so beware. If you're not sure, compare the pin diameters with a known 50-ohm connector.

The **type C** connector, developed by Carl Concelman, is similar to the N connector. It was the first connector to use the bayonet-lock mating system so that it could be easily connected or disconnected. Though it's not as popular as the N connector, it's usable to at least 10 GHz.

Usable to 4 GHz, the **BNC** connector — quite popular with Amateurs, especially in the VHF and UHF region — has a bayonet-lock. Its name is said to derive from its developers, Neill and Concelman; hence its name, BNC, for (B)ayonet, (N)eill, and (C)oncelman [1]. The UG-88 plug and the UG-290 chassis jack are the most common BNC connectors seen in Amateur equipment. BNC connectors are sometimes available as 75-ohm connectors; the cautions about "N" type connectors apply to BNC connectors as well.

The **TNC**, an improved or "threaded" version of the BNC connector, has a more positive contact on the body and hence is recommended over the BNC connector, especially above 500 MHz. It's rated up to at least 10 GHz; a precision version is rated to 12.4 GHz.

Widely distributed by the Omni Spectra Manufacturing Corporation, which called it an "OSM" connector, the **SMA** connector is now manufactured by many companies. This connector, defined as a miniature type, is popular on UHF and above, especially where low-loss, constant impedance, and small size are required.

The SMA connector was primarily developed to mate with 0.141-inch semi-rigid metal jacketed cable[2]. In the early 1970s, the E.F. Johnson Company introduced the **JCM** connector, a lower-frequency version of the SMA connector which is specified to 4 GHz and also mates with RG-174 miniature flexible cable. This low-cost connector is very popular in UHF applications.

SSM subminiature connectors were designed later. Primarily suited for 0.085 semi-rigid coax, these work up to 26 GHz. Improved SSM connectors will work up to 40 GHz!

The **SMB** and **SMC** connector series is primarily used in video and IF equipment, where small-diameter flexible cabling is used. The SMB is threaded; the SMC is a push-on type. Both are relatively inexpensive; SMC is the more common of the two, especially on military equipment.

The **APC 3.5** is the ultimate in precision. Resonance-free through 34 GHz, it will mate directly with the SMA connector series.

The **APC-7** is an expensive precision connector used primarily for 0.250-inch semi-rigid coax. It's a hermaphrodite, which making it an excellent connector for instrumentation.

An **EIA** connector is very unusual in that it doesn't have a threaded or bayonet connection. Instead it consists of body and moveable flange that's bolted to the mating connector. It's primarily used on air lines, where low-loss, high-power 7/8 to 6 1/8-inch lines such as on Heliax (TM) are used.

The inexpensive **"F"** connector is popular on CATV installations, especially for connecting units together with RG-59-type 75-ohm cable. Usually a crimp-type, it often uses the center wire of the cable for the center pin. Unfortunately, it's not rugged, weather-proofed, or very usable above about 300 MHz.

General Radio Corporation designed the **GR** connector primarily for instrumentation — hence its initials. A hermaphrodite push-on type connector most commonly seen as the G-874 or GR900 types, it's especially good on patch panels and where equipment must be frequently connected or disconnected.

The **HN** connector is basically a larger-diameter offshoot of the N connector with a higher voltage rating. It's primarily used with large-diameter (7/16 to 7/8-inch) cables when breakdown voltages up to 5000 volts are required.

LC and **LT** connectors are large and very similar. They're usually seen where high voltages or high power are required. Often used with RG 17-type coax, both of these connector series use the mating cable with its dielectric as the center portion of the connector.

The **MHV** connector may at first appear to be a BNC connector, but that's where the similarities end. The MHV is primarily designed to handle high voltages (up to 5000 volts) with a quick connect/disconnect capability. This feature is especially useful for high-voltage power supplies for tube type amplifiers, as described in reference 3. The MHV is seldom used for passing RF.

Normally I wouldn't even mention **RCA** phono connectors, except that I often see them on older commercial gear through 500 MHz! They're definitely not recommended for RF use above 30 MHz because they have no specific impedance properties. They're best suited for audio and control circuits where shielded cables are required.

The **SC** connector, a screw-on version of the C connector, is often used in applications requiring higher voltage than the C connector can handle and where environmental conditions are more severe.

The **SM** connector isn't too common. It's not weatherproofed and is recommended only for IF work. It may be used at different impedances if match isn't important.

A subminiature version of the SMA connector, the **SSM** is primarily used where the smallest possible size and highest possible frequency are required.

The **TM** series isn't often seen. Basically, it's a 2/3 size version of the TNC connector sometimes seen on IF connections.

The **Triax** and **Twinax** connector series are used when balanced lines are required. The Triax type allows a cable with two insulated shields to be used. The Twinax connector provides for superior shielding. Some Twinax connectors are polarized, while others are not. They're popular on video transmission and computer installations.

adapters

So far we've been discussing only coaxial connectors such as plugs, jacks, and chassis types. But other RF connectors function as adapters, both within and between series adapters.

There may be as many different RF adapter types as cable connectors. The most common ones are probably the female-to-female or male-to-male barrels for connecting cables together in the same series. Between-series adapters are also common. Right-angle and "T" types are popular since they allow flexibility when you want to hook similar connectors together.

It's particularly important to choose the proper adapter. I often see installations with two or even three adapters placed in series even though there's a single adapter available that will make the connection. The loss through each adapter is about two to three times that of a normal connector.

Your best bet is to choose a single adapter with the desired transition between series. Flea markets seem to have just about every imaginable type. If you're in doubt, bring one of your connectors along and check the fit.

Be particularly careful when using adapters outdoors. The more adapters used, the more likely it is that moisture will seep into one of the connections.

next month

Next month's column will go further into the mechanical and electrical aspects of connector design and use. Tips on proper use will also be given. This information should aid in your choice for the optimum connector for your application.

references

1. Allen Nemetz, "A Designer's Guide to RF Connector Selection," *rf design*, September/October, 1980, page 18.
2. Joe Reisert, W1JR, "VHF/UHF World: Transmission Lines," *ham radio*, October, 1985, page 83.
3. Joe Reisert, W1JR, "VHF/UHF Word: High Power Amplifiers — Part 2," *ham radio*, February, 1985, page 38.

Important VHF/UHF Events:

Sept. 6-7	*International Region 1 VHF Contest*
Sept. 12	*EME perigee*
Sept. 13-14	*ARRL VHF QSO Party*
Sept. 26-27	*First ARRL 10 GHz Cumulative Contest, first weekend*
Oct. 4-5	*Mid-Atlantic States VHF Conference, Warminster, PA (contact WA2OMY)*
Oct. 4-5	*International Region 1 UHF/SHF Contest*
Oct. 7	*EME perigee*
Oct. 10-11	*First ARRL 10 GHz Cumulative Contest, second weekend.*
Oct. 20	*Predicted peak of the Orionids Meteor Shower at 1645 UTC*
Oct. 25/26	*International EME contest, first weekend*

ham radio

low-cost spectrum analyzer with kilobuck features

Build WA2PZO's useful instrument for operating position and lab bench

Although laboratory-grade spectrum analyzers cost $4500 or more, you can build a spectrum analyzer offering many features of its costlier cousins for about $50. How can such amazing capabilities be had at such incredibly low cost?

- *Through the use of a commercially mass-produced varactor tuned TV tuner that covers the VHF low, VHF high, and UHF TV bands.* It will tune down through the 2-meter and 6-meter Amateur bands without modification, with better than 1-microvolt sensitivity. By using a crystal-controlled converter and a narrower IF filter, any one of the HF Amateur bands could be viewed as well, by simply upconverting to a TV channel.
- *Through the use of consumer-grade integrated circuits in the oscillator/mixer, dual ceramic filter, IF amplifiers/detector, and audio amplifier (offering audio as well as scope output it is really a spectrum monitor).*
- *Through the use of your own oscilloscope.* Just about any scope may be used; I used a 1951 Heathkit Model OL-1 with its original cathode ray tube.

spectrum analyzer applications

Spectrum analyzers allow the user to observe in real time an adjustable/variable bandwidth of radio frequencies. One of the earliest spectrum analyzers for the ham bands was the "Panadaptor," manufactured by Hallicrafters in the early 1950s. I used one to check for F2 propagation 6-meter band openings in the mid-1950s and credit the panadaptor with my earning the IARU 6-meter WAC award (phone) issued by the ARRL.

The band of frequencies swept by the spectrum analyzer described in this article may be varied from zero up to about 38 MHz on VHF low TV = 50 MHz − 88 MHz, zero up to about 85 MHz on VHF high TV = 135 MHz − 220 MHz, and zero up to about 300 MHz on the UHF TV = 500 MHz − 800 MHz. When the sweep width is set at zero, each of these bands of frequencies may be manually tuned just as in a single-frequency receiver. Both wideband FM and narrowband FM signals, and surprisingly, even amplitude modulated signals are detected quite well by the FM IF amp/detector IC and amplified by the audio IC.

Figure 1 is a block diagram of this spectrum analyzer using a Sanyo varactor tuned TV tuner. A ten-turn, 10k pot with +35 VDC across it is used to adjust the center frequency of the tuner. A low varactor bias yields low frequency and a high varactor bias provides higher frequency on the TV band to which the tuner is set. The sawtooth sweep voltage that is capacitively coupled into the tuner's varactors is the horizontal sweep voltage from the oscilloscope. If your scope doesn't have the horizontal sweep output (the Heathkit OL-1 does not), just mount an RCA phono jack on the front of the scope and bring out the horizontal sweep from the scope's horizontal multivibrator to this point. The 100 kilohm load across the horizontal sweep output should have little or no effect on the scope's operation.

Besides the TV tuner and scope, the rest of the circuit consists of only three integrated circuits. The second mixer/oscillator chip is a Siemens SO42P. The ceramic filter is a Murata SFJ two-section filter at 10.7 MHz. The combination IF amp/detector/AGC amp is a National LM-3089N, and the 1/2-watt audio amp is a National LM-386N.

construction, testing, and alignment

Figure 2 is a schematic of the analyzer. A printed circuit board is available from WA2PZO; I recommend using this and WA2PZO parts kits. (Although the pots, S-meter, and speaker aren't furnished, most are available from Radio Shack.) **Figure 2A** shows the component layout on the WA2PZO printed circuit board (foil side down). Alternatively, you could use perfboard and point-to-point wiring.

Figure 3 is a schematic diagram of the interconnections between the Sanyo tuner, the three-IC printed circuit board, and the scope. Once everything is connected as shown in **fig. 3**, alignment can begin. (It should be easy, since there are only four adjustments,

By Robert M. Richardson, W4UCH, 22 North Lake Drive, Chautauqua, New York 14722

the ferrite cores in L1, L2, L3, and L4.)

With all the parts on hand — and assuming you're using the PCB — assembly time is at most an hour or two. I tuned up my unit using only a grid dip meter as a signal source in about 20 minutes.

Construction of the PCB proceeds as follows:

1. Install the jumper at the lower edge of U3 as illustrated in **fig. 2A**.
2. Install the 11 resistors as shown in **fig. 2A**.
3. Install the 16 capacitors as indicated in **fig. 2A**. Since C6 and C7 are electrolytics, be sure to observe the polarity indicated in **fig. 2A**.
4. Install the Murata ceramic filter, FL1. Because it's symmetrical, it can be installed in either direction.
5. I recommend carefully installing sockets for U1 (16-pin DIP), U2 (8-pin DIP), and U3 (14-pin DIP).
6. Install L1 through L5, carefully bending the pins slightly so that they fit easily into the PCB's pre-drilled

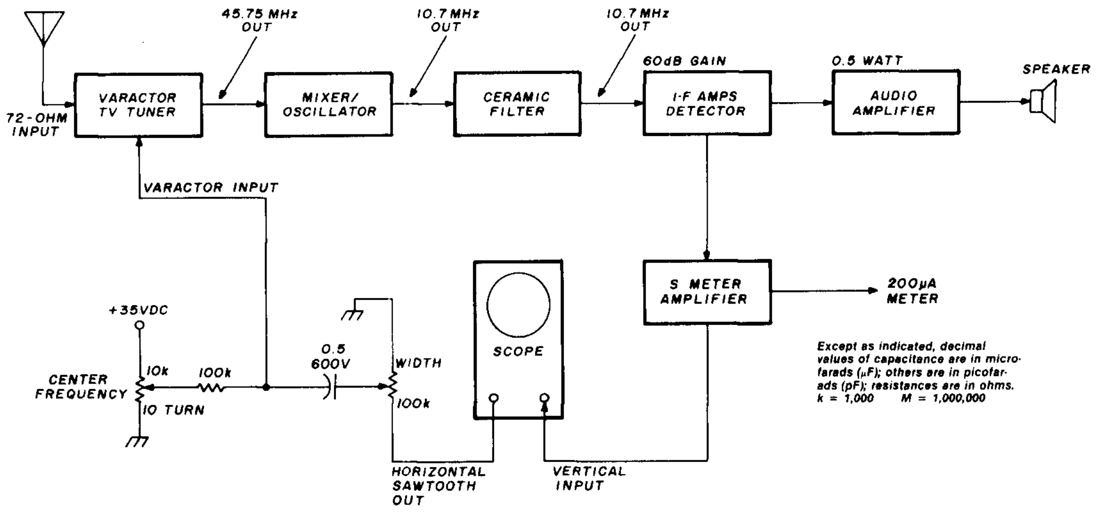

fig. 1. Block diagram of WA2PZO spectrum analyzer.

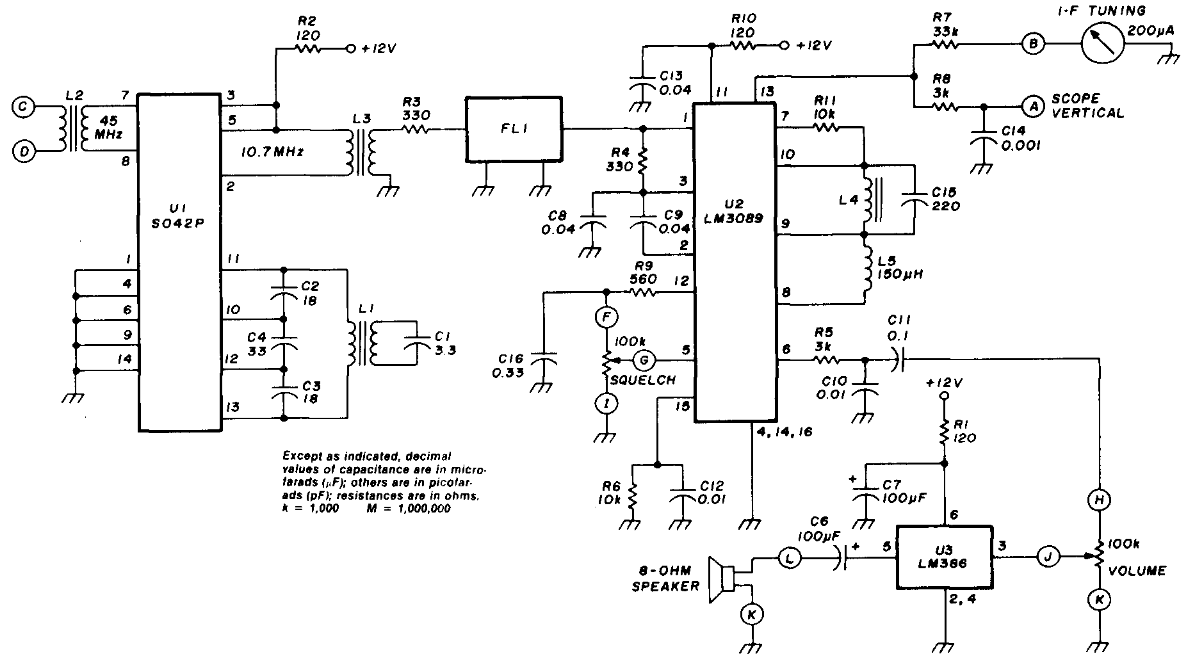

fig. 2. Schematic of WA2PZO spectrum analyzer.

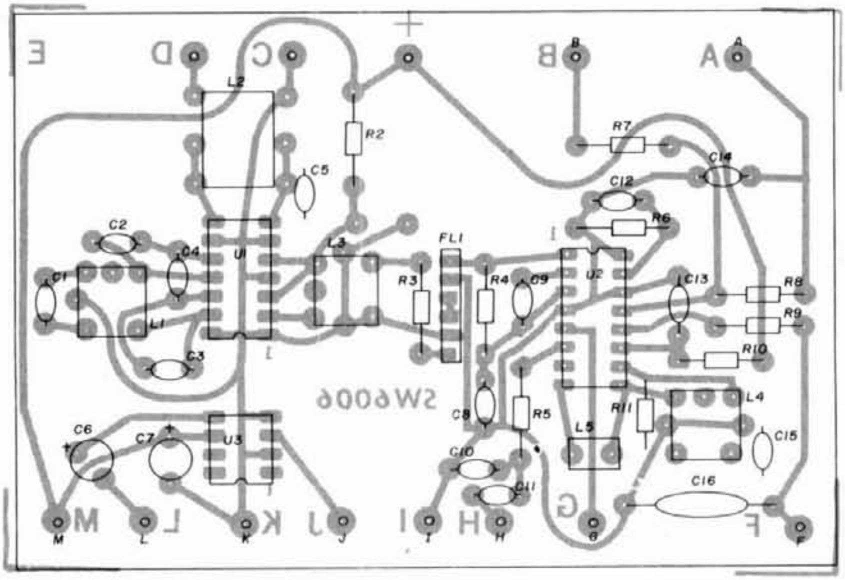

fig. 2A. Component layout on the WA2PZO printed circuit board (foil side down).

holes. Because L5, the 150 μH inductor, is symmetrical it can be installed in either direction.

7. Most important: lubricate the small ferrite cores of L1, L2, L3, and L4 with a drop or two of WD-40 *before* attempting adjustment. These cores are extremely brittle; use a plastic or nylon tuning tool matched to the width of the ferrite slots (using a metal one will guarantee their destruction).

8. If you're not using a 200-μA S-meter, install a jumper from 'A' to ground.

Testing and alignment proceed as follows:

1. Connect the TV tuner's VHF input to your 2-meter antenna.
2. Set the VHF/UHF switch to the VHF position.
3. Set the Hi/Lo switch to *Hi*.
4. Make sure the top of the ferrite core in L1 is exactly even with the top of its shielded housing.
5. Set the squelch control to zero and adjust the volume control for a slight hiss from the speaker with the gain control at maximum resistance (10 kilohms).
6. Set the width control (sawtooth sweep from scope) to zero.
7. Connect a voltmeter to pin 10 of the TV tuner (varactor input). Use the +30-volt voltmeter range (adjust the center frequency 10k-turn pot so that varactor bias is below +30 VDC).
8. Turn the center frequency pot slowly down (reducing varactor bias voltage) until a local TV video carrier is both heard on the speaker (buzz) and seen on the scope. If no TV stations are nearby, use a signal generator with modulated output or a grid dip meter.

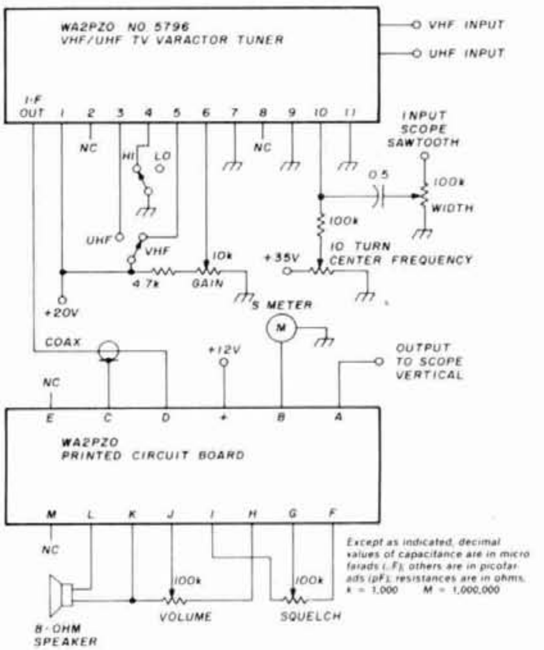

fig. 3. Schematic showing interconnections between tuner, printed circuit board, and oscilloscope. Note: +35, +20, and +12 VDc sources are regulated supplies.

9. Peak the ferrite slugs in L2 and L3 for maximum signal output on the scope.
10. Continue tuning the center frequency pot until a TV audio signal is found, then adjust L4 for maximum

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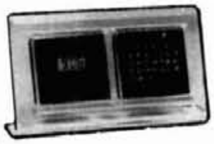

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audio output and minimum background noise from the speaker.

11. Though each varactor tuned TV tuner will have somewhat different voltage versus frequency response, see **fig. 10** to see the response we obtained using a Sanyo varactor tuned TV tuner.

Figure 4 is a photo of our finished spectrum analyzer. The tuner and PCB are mounted on top of a 2 x 5 x 9-inch (5 x 13 x 23 cm) aluminum chassis. The PCB is mounted on 1/2-inch (1.3 cm) threaded standoffs. Left to right, the five pots are: volume, squelch, center frequency, sweep width, and tuner gain. The two mini-toggle switches on the right of **fig. 4** are VHF-UHF (top) and VHF LOW—VHF HIGH (bottom). On the rear of the chassis are six RCA phono jacks: +35 VDC for tuner center frequency; +20 VDC for tuner; +12 VDC for oscillator/mixer, second IF amps, U3 audio amp; horizontal sweep from scope; vertical output to scope; and audio output to the 8-ohm speaker.

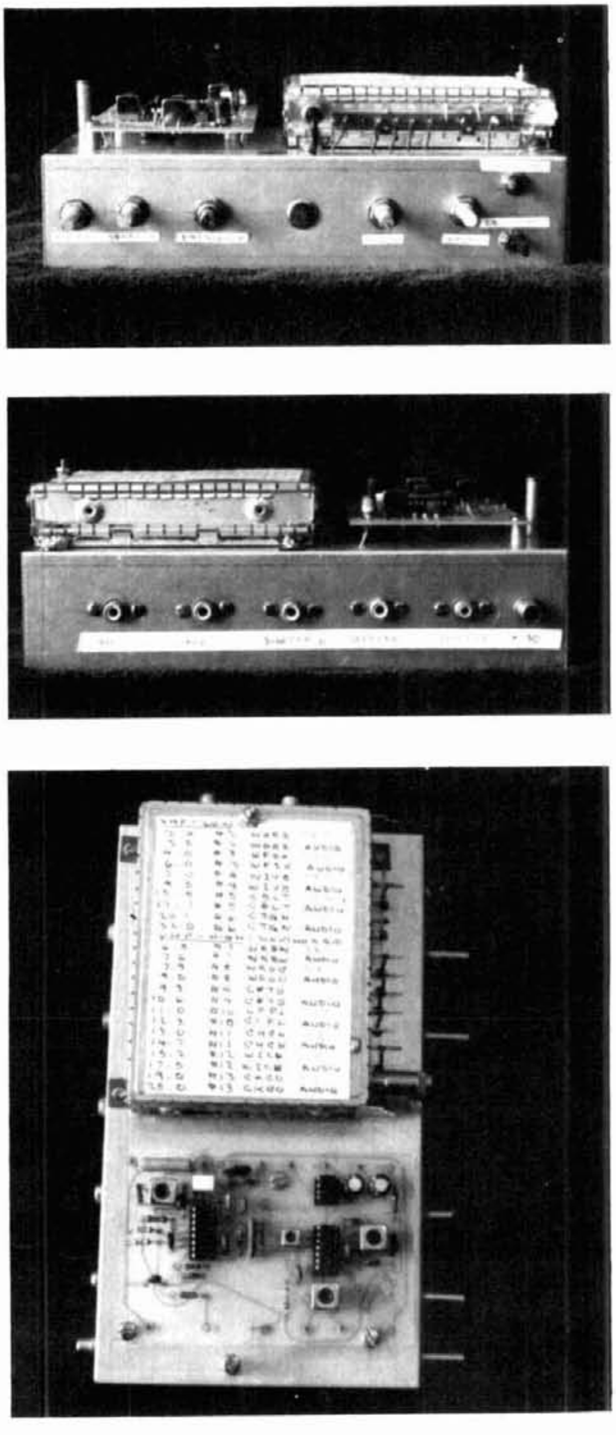


fig. 4. Completed spectrum analyzer: (A) front, (B) rear, (C) top.

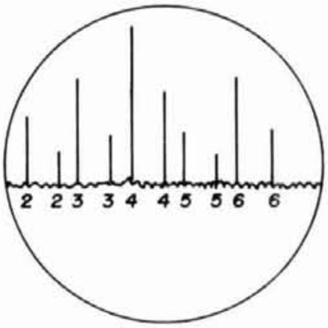


fig. 5. VHF low TV band with horizontal sweep amplitude set to maximum.

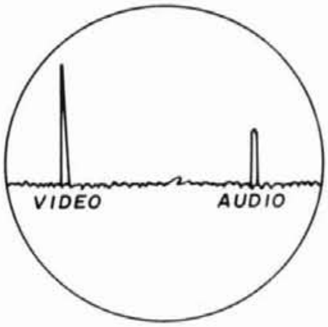


fig. 6. 8-MHz horizontal sweep width, with channel 2 video signal at left and channel 2 audio at right.

operation

Now the fun really begins. For antennas, I used my two 23-element Cushcraft 2-meter "Boomers." (No, I don't bounce signals off the moon with them, but I can work into 2-meter repeaters in Toronto, some 125 miles away. My QTH is on the south shore of Chautauqua Lake, some 65 miles southwest of Buffalo; because of this distance, and the presence of a range of hills about 300 feet (90 meters) high between Buffalo and Chautauqua, TV signals aren't par-

ticularly strong. Nevertheless, all the TV channels on both the VHF low TV and VHF high TV bands were displayed on the first try. Both the vestigial sideband video signal and its accompanying FM audio signal were clearly displayed for each channel.

Figures 5 through **10** are sketches of the oscilloscope display in the noted modes of operation. (Oscilloscope cameras cost about $300; I chose not to add one to my $39.95 Heathkit scope.)

Figure 5 shows the VHF low TV band with the horizontal sweep amplitude set to maximum. Each TV channel pair displayed (video and audio) is noted. The height of each signal is proportional to signal strength; some Canadian TV stations really pack a wallop even though they're 125 miles away.

Figure 6 illustrates about 8 MHz horizontal sweep width (left side of CRT to right side of CRT) with the video signal of Channel 2 on the left and the audio from Channel 2 on the right side.

Figure 7 displays the sweep width reduced to about 2 or 3 MHz with the center frequency set to Channel 2's video carrier. Note the blanking and vertical sync pulse riding on top of the carrier.

Figure 8 is the Channel 2 video carrier with the horizontal sweep set to zero. The blanking pulse with the vertical sync pulse on top is on the left side. The eight squiggles to the right of the vertical sync pulse on top of the blanking pulse are the color burst; all the hazy, wavy signals to the right are the video information. The top of the vertical sync pulse represents 100 percent modulation and the bottom ot the video information represents the white level of video at about 15 percent modulation.

Although some scope photos or sketches show 100 percent modulation at the bottom, I prefer it at the top. If you insist on having it at the bottom, simply turn the figure upside down and view it in a mirror.

Figure 9 illustrates the 2-meter band with horizontal sweep representing about 3 MHz. The left side of the CRT is at 145 MHz and the right side of the CRT is at 148 MHz. Spread between 146 and 148 MHz, we can see about six 2-meter repeaters located in the Buffalo and Toronto areas.

Figure 10 is a plot of varactor tuning voltage versus frequency on my Sanyo TV tuner. The 10-turn, 10-ohm pot used for setting the varactor voltage is an absolute "must" for fine tuning.

By reducing the sweep width to zero and single-signal tuning across each band, I was able to copy the audio on the VHF TV low band from the following stations: WGRZ-TV (Channel 2, Buffalo) WPSX-TV (Channel 3, Rochester), WIVB-TV (Channel 4, Buffalo), CBLT-TV (Channel 5, Canada), and CTGN-TV, (Channel 6, Canada). On the VHF TV high band we copied audio from air-to-ground and air traffic control stations; 2-meter repeaters in western New York and the Toronto area; commercial FM pagers; Toronto Coast Guard marine weather on 161.775 MHz; the Erie, Pennsylvania, weather bureau on 162.40 MHz; the Buffalo, New York, weather bureau on 162.55 MHz; WKBW-TV (Channel 7, Buffalo); WROC-TV (Channel 8, Rochester); CFTO-TV (Channel 9, Canada); CFPL-TV (Channel 10, Canada); CHCH-TV (Channel 11, Canada); WICU-TV, (Channel 12, Erie); and CKCO-TV (Channel 13, Canada). On the UHF TV

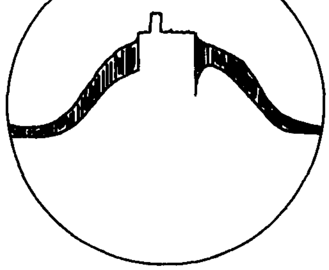


fig. 7. Sweep width reduced to about 2 or 3 MHz with center frequency set to channel 2's video carrier.

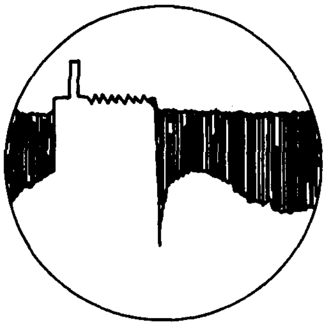


fig. 8. Channel 2 video carrier with horizontal sweep set to zero.

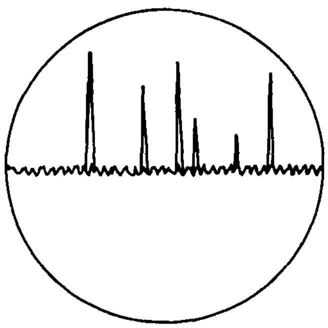


fig. 9. 2-meter band with horizontal sweep representing about 3 MHz.

Fig. 10. Varactor voltage versus frequency (will vary from tuner to tuner).

VHF low band

voltage	frequency MHz
0.5	50.00 6-meter band
2.0	55.25 channel 2 video
3.5	59.75 channel 2 audio
4.0	61.25 channel 3 video
6.0	65.75 channel 3 audio
7.0	67.25 channel 4 video
9.5	71.75 channel 4 audio
13.5	77.55 channel 5 video
17.1	81.75 channel 5 audio
20.1	83.25 channel 6 video
34.8	87.75 channel 6 audio

VHF high band

0.5	135.00 air to ground
1.0	144.00 2-meter band
2.0	148.20 commercial paging
4.0	162.55 Buffalo weather
6.5	175.25 channel 7 video
7.6	179.75 channel 7 audio
7.9	181.25 channel 8 video
9.0	185.75 channel 8 audio
9.3	187.25 channel 9 video
10.6	191.75 channel 9 audio
11.0	193.25 channel 10 video
12.3	197.75 channel 10 audio
13.0	199.25 channel 11 video
14.7	203.75 channel 11 audio
15.2	205.25 channel 12 video
17.5	209.75 channel 12 audio
19.0	211.25 channel 13 video
25.5	215.75 channel 13 audio

band we copied about six TV stations from Channel 17 through Channel 26, including a French language Canadian TV station. The Sanyo TV tuner is one super little box with excellent sensitivity — i.e., much better than 1 microvolt. All these stations were copied using only 2-meter antennas.

other uses

Once you become accustomed to using it, the spectrum analyzer is probably the greatest trouble-shooting aid since Volta invented the voltmeter. With the proper probes, attenuators, and converters it can be used as an RF voltmeter; as a signal tracer in transmitters and receivers; and for transmitter alignment, harmonic measurement, deviation measurement, oscillator injection measurement, IF alignment, and spurious radiation measurement, to name but a few of its applications. If you want to dig deeper, Cushman Electronics (2450 North First Street, San Jose, California 95131) publishes a neat little book entitled *Using The Spectrum Monitor* Priced at $7.25 (postpaid), it's easily understood by the average Radio Amateur.

acknowledgement

I wish I could claim authorship for this unique design, but credit goes entirely to my friend, Murray Barlowe, WA2PZO, who not only created the design but has generously made a partial kit of parts, TV tuner, and printed circuit board available to Amateurs at virtually his cost.

For more information send an SASE to Murray Barlowe, WA2PZO, P.O. Box 393, Bethpage, New York 11714. Once you try it, you'll never understand how you got along without it. **ham radio**

PRACTICALLY SPEAKING . . . Joe Carr K4IPV

substituting transistors part 1: using resources at hand

Every Amateur who spends at least some time at the workbench repairing or building electronic equipment will eventually need a transistor that's not on hand — and perhaps not even available. In some cases, the type number will be found in one of the standard transistor replacement catalogs. In other cases, well . . . you're on your own.

Although the subject of transistor substitution is one that's been talked about to the point of exhaustion among hams, serious problems continue to reappear. The tips given in this two-part series, while most appropriate to the types of transistors normally used in Amateur Radio equipment, are also applicable to a variety of other situations as well.

The main premise is that we are *servicing* Amateur Radio equipment that once worked properly and then failed. While much of what is discussed is also applicable to construction projects, construction project debugging is something of an arcane art and is thus not suitable for general, too-broad guidelines. I can recall several projects over the years that depended for proper operation on selected parameters of specific transistors, and wouldn't even work with all otherwise-working versions of the same "2N" number devices.

There are even cases on record in which only those devices made by certain manufacturers will work properly in the circuit. (Ancient history note: those of us who go back to vacuum tube days recall a very costly ham receiver that would retain its "frequency meter" dial calibration only when RCA tubes were used for the local oscillator; there are transistor equivalents to that situation.) As a result, we must limit our consideration to repair of working — and, one would hope, properly designed — equipment.

exact replacements

The easiest way to obtain a replacement solid-state device that will install easily and operate correctly is to order it from the original equipment manufacturer or an authorized distributor. As we're all painfully aware, however, this is not always either possible or practical.

industry-standard type numbers

If the defective transistor has a standard "2N" type number, then you just obtain a replacement device with the same number, without regard to brand name. Unfortunately, some "Original Equipment Manufacturer" (OEM) transistors aren't marked with these standard numbers. They often have a house code number that's meaningless to anyone except the manufacturer. Sometimes the house number is created because the transistor is specially selected from others for the same "2N" series, so only a similarly tested device will work properly in the circuit. In some cases, the house number is used because it suits the manufacturer's inventory control system; in other cases, manufacturers simply want to ensure replacement parts business.

crossover guidelines

Crossover guides, which would seem to be a nearly perfect source of replacement numbers, should be used whenever possible. But there are gremlins that can pop up unexpectedly. Theoretically, the cross-matching has been done in advance by the use of an "infallible" computer. When we follow those recommendations, however, we sometimes find that suggested replacements have insufficient power or voltage ratings, too narrow a bandwidth, a different physical shape that would cause mounting or space problems, or different mounting dimensions that would require modification of the chassis. Many of these discrepancies occur because the crossovers are compiled from printed lists that sometimes contain errors. It's an open secret that the recommended substitutes are seldom tried in any kind of equipment or circuit, so it's best to test the reasonableness of any selection by looking at the crossover device's specifications and comparing them with what you know about the circuit and its requirements.

During my years in the electronic service business, it was my policy to return, along with a note of explanation, any crossover transistors that either didn't work properly or would require major reworking of the chassis or rewiring of the circuit. If everyone did this, manufacturers might take the hint. The economic impact of a service shop's annual semiconductor purchases makes it easy for them to obtain refunds on bad crossovers; unfortunately, Amateurs rarely have such clout.

Another problem has nothing to do with electrical specifications, but rather with proper identification. In some cases it's relatively easy to guess the required transistor type. But what if two manufacturers have each accidentally assigned the same designation to two

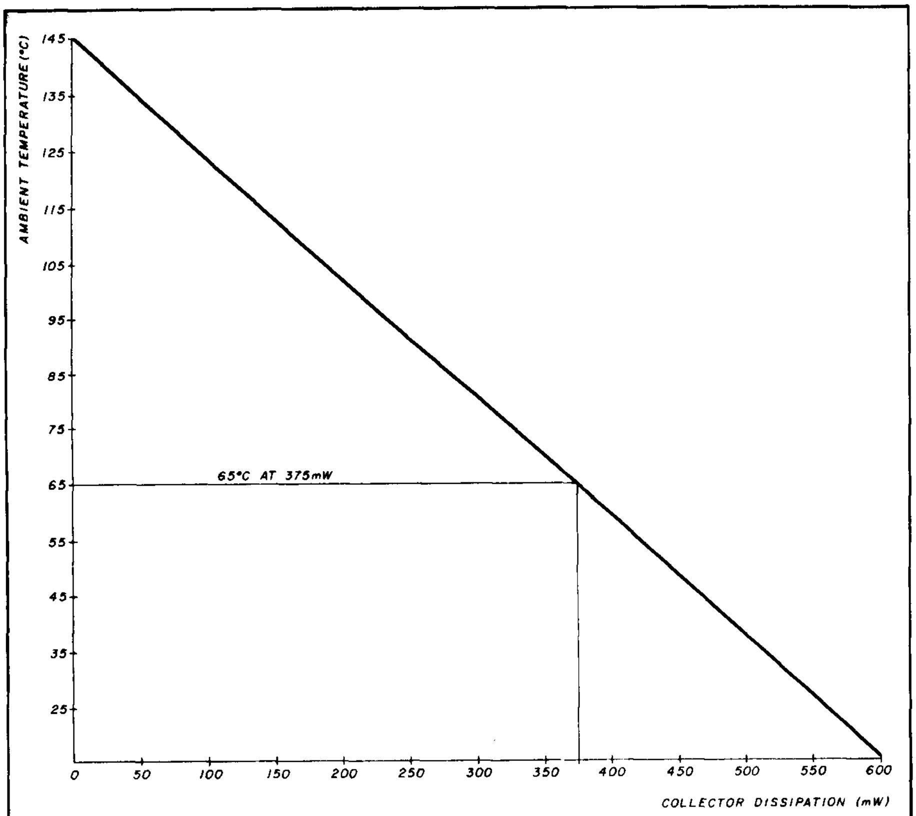


fig. 1. Typical transistor derating curve.

completely dissimilar devices? It's not likely that a crossover guide will solve all such problems, though some do accommodate such ambiguities.

I remember one case years ago where I needed a replacement for a Delco Electronics DS-25. Now, the DS-25 has been around for about 20 years as an RF amplifier, IF amplifier, and converter replacement in Delco-General Motors car radios. The DS-25 germanium transistor was packaged in a "smaller-than-TO-5" case. Unfortunately, a small hi-fi manufacturer also used the DS-25 designation for a medium-power PNP germanium power transistor in a TO-3 case. One crossover guide I consulted at that time listed the TO-3 type without noting that it wasn't the Delco part number, even though it was listed among the various Delco "DS-Series" type numbers.

Remember the old rule from high school math: *Things equal to the same thing are — you hope — equal to each other*. Or, if A = B, and B = C, then A = C. We can use this observation to make crossover selections. Furthermore, we can use this technique in at least two additional ways. First, we can look up the device needed to find the replacement type number. For example, suppose a 2N5xxx is found in the Zotch Electronics Crossover Guide as a "ZE-234." We can look for other "2N" series devices also equal to ZE-234 and use one of those.

This method is especially useful when crossing house numbers to 2N numbers, which is our second way to use the "A = C" theory. Suppose that your Wombat Thunderbolt VI transceiver uses a transistor with the part number "8501234" Well, the Zotch guide calls it a ZE-234. By looking over the "2N" series columns in the *Zotch Guide To Replacement Things*, you find that a 2N5xxx is also equal to a ZE-234. Chances are good that the Wombat engineers selected the 2N5xxx and then relabeled it "8501234." It may not be the exact transistor, but it's a fair bet that it will work unless the 8501234 is a specially selected 2N5xxx. (There are no guar-

antees, however. You still have to check *specs and make an educated guess).*

mobile problems

Up to this point, the problems of obtaining suitable replacements for transistors in mobile rigs are identical to those of home-based rigs. But there's one special problem that's more serious in mobile applications: environmental heat.

One car manufacturer became concerned about the excessive number of failures in his first all solid-state car radio models (circa 1962) and decided to investigate the possibility of passenger cabin heat as the culprit. The company asked its electronics plant employees to leave their car doors unlocked for one day. During that day of 90-degree weather, the engineers measured the temperatures inside many of the closed cars and were surprised to find that the average reading was 160 degrees F on the seat and 180 degrees behind the dashboard.

derating the specs

Published transistor power ratings are usually specified at room temperature, generally accepted to be 25 degrees C (77 degrees F). If transistors are used at higher temperatures, as in mobile applications, then the maximum collector dissipation (in watts) must be reduced to prevent extra failures which could occur even when all the electrical specifications are fulfilled.

A typical derating curve is show in **fig. 1**. Notice that a transistor having a collector dissipation of 550 mW at 25 degrees C can safely dissipate only 375 mW at 65 degrees (142 degrees F). This explains why a transistor that's operating below its maximum published wattage rating could be destroyed by using it in a hot car. Watch for such hazards, especially if you attempt to use "five-for-a-buck" bargain-basement replacements in which the collector dissipation rating was "optimistic."

beyond crossmatching

Often the numbers on a bad transistor seem meaningless. There's no way to crossmatch and you can't locate an OEM replacement from the equipment maker. *The next step is to find a universal* replacement from one of the many convenient sources. To do this, you have to become an electronic detective and find out the following things about *the transistor:*

- Is it a silicon or germanium type?
- Is it a PNP or NPN?
- What is the gain (alpha or beta)?
- What frequencies must it amplify?
- What are the collector power dissipation requirements?
- Are there any special mechanical mounting requirements?

Once you've answered these questions, you can make a satisfactory selection from most any brand of universal replacements.

silicon or germanium?

Silicon transistor junctions measure higher DC resistances than germanium junctions. In fact, silicon transistors usually read "open" on all measurements except with base/emitter and base/collector forward biasing polarity. If even one junction remains intact on a blown transistor, then you can tell which material it is by comparing readings with those of known types in the size and power category.

Forward bias voltages for all stages other than oscillators (and certain pulse circuits used in video equipment) should be 0.2 to 0.3 volts for germanium transistors and 0.5 to 0.7 volts for silicon transistors. Check the schematic, or another of the intact junctions (or a similarly numbered good transistor in the circuit) to see which voltage levels are found. The answer will tell you whether to look for Ge or Si transistor replacements.

PNP *or* NPN?

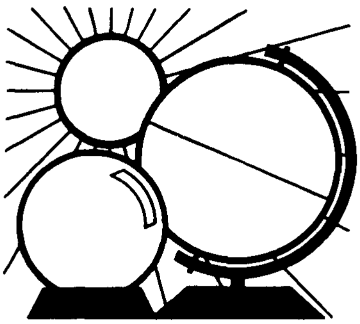
When the collector voltage is more positive (or less negative) than the emitter, then the transistor is an NPN type. If the collector is more negative (or less positive) than the emitter, then the transistor is a PNP type. Most schematics give these voltage readings. On the other hand, you can measure the collector/emitter voltages accurately enough for this purpose, right in the circuit in *most cases.*

Even if only one junction of the defective transistor is intact, you still can determine the polarity by using the ohmmeter. If you obtain a normal low-*resistance diode-type reading with the* positive ohmmeter lead on the base and the negative lead on the collector or emitter, then it's an NPN type. If you must reverse the leads to obtain a low-*resistance reading, the transistor is a* PNP type. This measurement must be made with an old-fashioned VOM/VTVM or a modern digital meter with a "diode" or "high power" ohmmeter *function.*

next month

Next month we'll look at the frequency response of the selected transistor *and certain mechanical considerations.*

ham radio



DX FORECASTER

Garth Stonehocker, KØRYW

equinox season DX

Even though this is a sunspot minimum year, and the sun's activity has decreased, an occasional energy burst (flare) or increase in the solar wind causes a geomagnetic field disturbance. We experienced these phenomena in February and May of this year, and it's likely that we'll have another in September or October. Whenever they occur, you can expect them to affect your DXing.

Geomagnetic disturbances, or storms, affect propagation — and DX — in three ways. First, particles from the sun entering the auroral zone at 50 to 70 degrees North and South latitudes come down into the ionospheric D and E regions, increasing signal absorption. This results in weak east-west path signals and few transpolar signals. Second, the particles form a reflective curtain along the equatorial side of the auroral zone (for those of us in North America, this is south), enhancing VHF auroral scatter propagation. Six-meter openings to Europe are one result of this phenomenon. Third, the F region of the ionosphere (for U.S. stations, this is south of the auroral zone) has a depleted area of electrons that form an electron density trough. The maximum usable frequency (MUF) for paths through this area decreases by 30 to 40 percent. (Tables of MUF statistics were presented in this column in January, 1986.)

However, still further south at ±20 degrees from the geomagnetic equator, an equivalent-size enhancement of the F region occurs, resulting in evening Trans-Equatorial (TE) openings during the equinox and winter seasons. These three effects vary in intensity and time on a short to long basis (seconds through hours), causing what we experience as fading and blackout. These effects continue to occur each night for two to three days before ionospheric equilibrium is re-established. The larger the geomagnetic storm (the higher the value of the K or A indicies), the closer to the equator these effects occur.

Just as the particle density and speed of the solar wind vary, so do the characteristics of the geomagnetic field and ionosphere. Ionospheric variation causes signal reflection focusing and defocusing, which simply means that the signals arriving at your QTH will vary in both strength and angle of arrival. Some directions and locations you haven't heard from in a long time may suddenly be workable.

last-minute forecast

The higher-level 27-day sunspot activity may push the maximum usable frequencies up during the first and last weeks of September, giving better 10-, 12-, and 15-meter DX. September marks the beginning of the return of transequatorial one-long-hop propagation for the winter season; during some evenings, it will probably be useful for DX. Its effect will be enhanced by an equinoxial increase in geomagnetic disturbances, which are more probable near the end of the second week and into the third.

The lower bands will experience less QRN caused by weather storm frontal thunderstorms passing through. But the geomagnetic disturbances will have greater effect on these bands; lower MUFs will occur on east, west, and north paths. Signal strength variability, QSB, is also associated with the disturbances. Listen carefully for new, unusual DX openings at these times.

A full moon will occur on September 26th and its perigee on the 12th. The autumnal equinox will be on the 23rd at 0759 UTC. No significant meteor showers are expected this month.

band-by-band summary

Six meters may have a few sporadic E openings around local noon, but don't count on them this last month of the season.

Ten, twelve, and fifteen meters should provide a few short-skip openings and many long-skip openings to most southern areas of the world, especially if there is any solar flux increase during the daylight hours this month. Some of these openings will result from transequatorial propagation, mainly during disturbed conditions.

Twenty, thirty, and forty meters will support propagation from east, west, and north areas of the world during the daytime and into evening hours almost every day. Distances to 2000 miles via long-skip or some short-skip Es to 1000 miles per hop are usual.

Thirty, forty, eighty, and one-sixty meters are all good for nighttime DX. The bands will be open in the east soon after sundown, swing toward the north and south about midnight, and end in the Pacific areas during the hour or so before dawn. The time-and-frequency stations in England and Hawaii make good band monitors. On some nights these bands will be as good as they are during the winter DX season; on others, QRN may be a problem. Distances will be a little shorter than those mentioned above.

SEPTEMBER

WESTERN USA

	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	GMT
SEPTEMBER	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	PDT
ASIA FAR EAST	20	30	40	40	40	40	40	40	40	30	30	40	40	40	40	40	40	40	30	20	20	20	20	20	N
EUROPE	40	30	20	20	20	20	20	20	20	20	20	20	30	40	40	40	40	40	40	40	40	40	40	40	NE
S. AFRICA	20	20*	15	12	12*	10	10	10	10	10	12	15	20	30	30	20	20	20	20	20	20	20	20	20	E
S. AMERICA	10	10	10	10	10	10	10	12	12	15	20	20	20	30	20	20	20	20	20	20	15	12	12	10	SE
ANTARCTICA	12	12	12	12	15	15	20*	20	20	40	40	40	40	30	30	30	30	30	20	20	15	15	12	12	S
NEW ZEALAND	10	12	12	12	15	20	20	30	30*	30	20	20	20	20	20	20	15	12	12	10	10	10	10	10	SW
OCEANIA AUSTRALIA	10	12	12	15	20	30	20	20	20	20	20	20	20	20	20	20	15	12	12	10	10	10	10	10	W
JAPAN	15	20	20	20	20	30	40	40	40	40	40	40	40	40	40	30	30	30	30	20	20	20	20*	15	NW

MID USA

	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	MDT
ASIA FAR EAST	20	30	40	40	40	40	40	40	40	20	20	20	20	20	40	40	40	40	40	40	40	30	30	20	N
EUROPE	40	30	20	20	20	20	20	20	20	20	20	20	30	40	40	40	40	40	40	40	40	40	40	40	NE
S. AFRICA	20	20*	15	12	12*	10	10	10	10	10	10	12*	12	15	20	20	20	20	20	20	20	20	20	20	E
S. AMERICA	10	10	10	10	10	10	10	10	12	12	15	40	20	20	30	20	20	20	20	20	20	15	12	12	SE
ANTARCTICA	15	15	15*	15	15	15	20*	20	30	40	40	20	40	30	30	30	30	30	30	20	20	15	15	15	S
NEW ZEALAND	10	12	12	12	15	20	20	30	30	30	20	20	20	20	20	20	20	15	12	12	10	10	10	10	SW
OCEANIA AUSTRALIA	10	12	12	15	20	20	20	20	20	20	20	20	20	20	20	15	15	12	12	10	10	10	10	10	W
JAPAN	20	20	20	20	20	40	40	40	40	40	40	30	30	40	40	40	40	40	40	40	40	30	20	20	NW
	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	CDT

EASTERN USA

	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	EDT
ASIA FAR EAST	30	40	40	40	40	40	40	40	40	20	20	20	20	20	20	40	40	40	40	40	40	40	30	30*	N
EUROPE	40	40	30	20	20	20	20	20	20	20	20	20	20	20	20	40	40	40	40	40	40	40	40	40	NE
S. AFRICA	20	20*	15	12	12*	10	10	10	10	10	10	12*	12	15	20	30*	20	20	20	20	20	20	20	20	E
CARIBBEAN S. AMERICA	10	10	10	10	10	10	10	10	12	12	12	15	20	20	30*	20	20	20	20	20	20	15	12	12	SE
ANTARCTICA	15	15	15*	15	15	15	20*	20	20	20	40	40	40	40	40*	30	30	30	30	20	20	20*	15	15	S
NEW ZEALAND	10	10	12	12	15	20*	20	20	20	20	20	20	30*	20	20	20	20	20	20	15	12	12	10	10	SW
OCEANIA AUSTRALIA	10	10	12	12	15	20	20	20	20	20	20	20	30	20	20	20	20	20	20	15	15	12	10	10	W
JAPAN	20	20	20	20	20	40	40	40	40	40	40	40	30	30	40	40	40	40	40	40	40	30	20	20	NW

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.
*Look at next **higher** band for possible openings.

ham radio

NEW products

RS 232-compatible computer interface units

Trio-Kenwood Communications has announced the release of RS 232-compatible computer interface units for the TS-440S, TS-940S, TS-711A, and TS-811A transceivers.

Two units are required to control the transceivers: the IF-232C level translator and the appropriate plug-in computer interface module. The TS-440S requires the IC-10 chip set; the TS-940S, the IF-10B; and the TS-711A or TS-811A, the IF-10A.

All digital functions on the transceivers — including VFO tuning, RIT/XIT, memory input and recall, and voice synthesizer activation — are controllable,. Programming is simple; one program should work with several rigs.

The suggested retail prices are IF-232C, $49.95; IF-10A/IF10-B, $41.95; IC-10, $22.95.

A simplified sample program will be available from Kenwood dealers. Write to Trio-Kenwood Communicatiions, 1111 West Walnut Street, Compton, California 90220, for information.

PCB kits from Kepro

A new line of Kepro pre-packaged materials and kits includes the following:

- a standard manual-resist etched circuit kit for producing basic PC boards;
- a photo-reversing kit for making line negatives from artwork prepared on transparent film or reversing negatives to positives;
- an immersion tin-plating kit to improve solderability by depositing 0.00001 inch of tin on the oxide-free copper surface of etched PCBs;
- photo-resist etched circuit kits, basic artwork or master photo layout kits, screen printing or nameplate kits.

In addition, Kepro also offers KeproClad,™ for the production of industrial quality, negative acting dry film photo-sensitized PCBs. KeproClad is available with foil on one or two sides, in sizes ranging from 4 x 6 through 7 x 12 inches, and is priced as low as $3.50.

For details, contact Kepro, Inc., 630 Axminster, Fenton, Missouri 63026.

Circle #307 on Reader Service Card.

New computer-based instruments from Heath

Models IC-4802 and ID-4850 oscilloscopes from Heath Company are designed to work with personal computers.

The IC-4802 Digital Oscilloscope is a sophisticated interface that attaches to an IBM PC-compatible computer and is available in kit form or assembled. This interface turns an IBM PC-compatible computer into a full-featured 50-MHz dual trace oscilloscope that allows full control of the scope from the keyboard of the computer, harnessing the computer's computational abilities. With the IC-4802, oscilloscope waveforms can be collected and stored on disk for later recall. The digitally stored waveforms may be printed out on the computer's printer.

The ID-4850 Digital Memory Oscilloscope is an interface that may be used with either a personal computer or a 5-MHz or greater bandwidth oscilloscope that has the ability to trigger from an external source and triggered sweep. Used with a computer, the ID-4850 provides a PC-compatible computer with 50-MHz oscilloscope capabilities and allows waveforms to be digitally stored for later recall. When using an oscilloscope, the ID-4850 upgrades it to a full-featured 50-MHz dual trace oscilloscope. The Digital Memory Oscilloscope is available in kit or assembled form.

More information on these and other products is available in Heathkit's free catalog. For a copy, contact Heath Company, Dept. 150-775, Benton Harbor, Michigan 49022.

Circle #309 on Reader Service Card.

personal frequency standard

Wenzel Associates, Inc., offers the new Counter-Mate personal frequency standard that provides stable 1-MHz and 10-MHz reference signals to improve the accuracy of counters and other instruments. A precision third-overtone 10-MHz crystal is mounted in a controlled oven in an installation that provides minimum aging and drift. Both outputs will drive TTL or 50 ohms with 5-ns rise and fall time square waves. The output impedance properly matches power splitters for generating isolated signals to operate several instruments. The price is $350.

Further information is available from Wenzel Associates, Inc., 11124 Jollyville Road, Austin, Texas 78759.

Circle #308 on Reader Service Card.

new Hamtronics catalog

Hamtronics, Inc. has announced publication of their new 40-page, two-color catalog, which features many new products, including several GaAs FET preamps, a five-function DTMF decoder/controller, a transmit/receive relay module, digital FSK equipment, and packet-radio VHF power amplifiers. Also included is a comprehensive listing of FCC type-accepted transmitters, receivers, and repeaters for commercial service. Hamtronics reports that because of recent high volumes of production, it has been able to reduce prices on many products.

To receive a copy by return first class mail, send $1 ($2 for overseas mailing) to Hamtronics, Inc., 65-F Moul Road, Hilton, New York 14468-9535.

surge protector

Alpha Delta has announced availability of a new, improved version of its Transi-trap Electrical Surge Protector.

The new Transi-trap "Arc-plug" has been redesigned to meet government and industry protection standards for Electromagnetic Pulse (EMP) in accordance with the National Communications System report, NCS TIB 85-10. The "ARC-plug" has a DC clamping level of 350 volts to provide proper transmitter protection. The pulse clamping level (per NCS EMP test, 4,500 volts at 50 ohms) is 230 volts. The unit will respond in 80 to 100 nanoseconds and has a very low interelectrode capacitance of less than 1 pF.

The Transi-trap design offers low loss — typically 0.1 dB through 500 MHz for the R-T and 0.3 dB loss through 1 GHz for the units with N connectors.

For more information, contact Alpha Delta, P.O. Box 571, Centerville, Ohio 45459.

Circle #304 on Reader Service Card.

RF test equipment catalog

A new 60-page catalog of Thruline® directional wattmeters, coax load resistors and attenuators, calorimeters and RF components is available from Bird Electronic Corporation.

Included are such items as high-accuracy instruments using plug-in elements with 5000-to-1 power ranges, a frequency/power meter combination and relative field-strength devices, as well as more than 300 standard RF products.

This reference work of RF measurement instrumentation and components from 2 milliwatts to 250 kilowatts in the frequency range of 0.235 to 2300 MHz features triple indexing — by function, power level and model number — making it easy to use as both a desktop reference and specification tool.

Catalog GC-86 is available from Bird Electronic Corporation, Cleveland (Solon), Ohio 44139-2794.

Circle #312 on Reader Service Card.

trailer-mounted towers

Trailer-mounted communication towers, available from Aluma Tower Company, are well-suited for mobile testing, site selection for earth stations, civil defense, or other applications requiring a temporary communication tower. Towers up to 100 feet can be provided with either manual crank mechanisms or 12-V winch operation. Trailers are supplied with a 2-inch ball hitch, spring suspension, and tail lights for day/night service.

Contact Aluma Tower Company, Inc., 1643 Old Dixie Highway, Vero Beach, Florida 32961, for information.

Circle #303 on Reader Service Card.

new multimode xcvr from Yaesu

Yaesu U.S.A. has announced the release of the new FT-767GX, the world's first HF/VHF/UHF multimode transceiver. The FT-767GX comes factory-equipped for HF operation on the Amateur

bands plus general coverage on receive from 100 KHz to 29.99 MHz). Features include are an automatic antenna tuner for 160-10 meters, CW filter, electronic keyer, speech processor, digital wattmeter, IF shift, IF notch filter, CW audio peak filter, and a dual VFO tracking system for OSCAR Mode A or repeater operation. All popular operating modes are included: SSB, CW, AM, FM, and FSK. Optional modules extend coverage to 6 meters, 2 meters, and/or 70 cm, and an optional CTCSS unit is available for tone-access repeater work.

The FT-767GX is compatible with Yaesu's CAT (Computer Aided Transceiver) external computer protocol, for remote control operation and enhanced operating flexibility. For teletype operation, the FT-767GX is rated at 100 watts output continuously for up to 30 minutes.

The introductory price of the FT-767GX is $1759.95, with the 6-meter and 2-meter modules priced at $169.95 each. Prices are subject to change due to the extreme volatility in international exchange rates.

For information, contact Yaesu, Inc., 17210 Edwards Road, Cerritos, California 90701.

Circle #305 on Reader Service Card.

DX beam heading chart

John Daley, KB6JGH, has announced the availability of his DX Beam Heading Chart. Each report is individually calculated by computer and packaged in an attractive 8-1/2 x 11-inch binder. Nine categories of data including callsign area, country, state, city, longitude, latitude, beam heading, Great Circle distance, nautical miles, and statute miles are provided for each of 540 DX locations. All data are are based on the user's exact station location.

Geared to both the ham and SWL, numerous listings are given for the USSR and China, making unknown site estimation easier.

The price of this chart is $9.95. It's available from John Daley, KB6JGH, P.O. Box 4794, San Jose, California 95150.

Circle #302 on Reader Service Card.

(continued from page 75)

fig. 2. W4PFZ's "File Saver" program allows data files to be saved.

```
READY.

10 PRINT"{CLR}"
20 DIM A(39):Z$="CURVE"
30 PRINT"{C/DN}WHAT IS THE NUMBER OF THE CURVE YOU WISH TO ENTER "
35 INPUT C$
40 F$=Z$+C$
50 PRINT"ENTER THE VALUES FOR THE CURVE"
60 FOR X=1 TO 38
70 PRINT"#"; X;:INPUT A(X)
80 NEXT
90 PRINT"{CLR}"
100 PRINT"THESE ARE THE VALUES FOR CURVE";C$
110 PRINT"{C/DN}{C/DN}"
130 FOR X=1TO 38
140 PRINT"#";X;A(X)
150 NEXT
160 PRINT
170 PRINT"ARE ALL THE VALUES CORRECT?                    Y=YES   N=NO"
180 GET A$:IF A$="" THEN 180
190 IF A$="Y" GOTO 250
195 IF A$="N" GOTO 210
200 GOTO 170
210 PRINT"WHICH # IS INCORRECT":INPUT D
220 PRINT"WHAT IS THE CORRECT VALUE FOR :- #";D
230 INPUT A(D)
240 GOTO 100
250 PRINT"{CLR}"
260 PRINT"SAVING TO DISK"
265 OPEN15,8,15
270 OPEN2,8,2,"0:"+Z$+C$+",S,W"
280 FOR X=1 TO 38:PRINT#2,A(X)
300 NEXT
310 CLOSE 2:CLOSE15:CLOSE8
320 PRINT"{C/DN}{C/DN}{RVON}  SAVING COMPLETE  {RVOF}"
330 END

READY.
```

ham radio

NEW products

IC-48A 440-MHz mobile

ICOM has announced the release of the new IC-48A 440-MHz compact mobile. The IC-48A offers the same features as the new IC-28A and IC-28H, with 440-450MHz frequency coverage. Features include compact size (5-1/4 x 5 1/2 x 2 inches); a large LCD readout, with an automatic dimmer; 21 memory channels; scanning; plus an internal speaker and an HM-12 mic. With only 11 front panel controls, the unit is easy to operate.

Options include the IC-HM14 DTMF mic, PS-45 13.8-volt power supply, UT-29 tone squelch unit, SP-10 external speaker, HM-16 speaker mic and HS-15/HS-15B flexible boom mic, and PTT switchbox

For information, contact ICOM America, Inc., 2380 116th Avenue NE, Bellevue, Washington 98004.

Circle #313 on Reader Service Card.

Satellites Today — 2nd edition

Universal Electronics has announced the release of the enlarged second edition of Frank Baylin's popular book, *Satellites Today*, containing the latest satellite information.

Satellites Today, which can be understood by a non-technical reader, reviews satellite history and technology. Topics include uplinking, footprints, programming, home satellilte TV systems, and more.

Retailing for $12.95, *Satellites Today* can be ordered from the publisher, Universal Electronics, Inc., 4555 Groves Road, Suite 13, Columbus, Ohio 43232.

Circle #301 on Reader Service Card.

NEW products

Edek "R" series enclosures

The Edek "R" series enclosures are distinctive, ruggedly-built enclosures suitable for the hobbyist, engineer, or anyone needing an attractive cabinet.

Dark walnut-stained natural wood ends, contrasted with a bright aluminum chassis, are featured. If a different color scheme is desired, the ends and chassis may be painted, or the aluminum chassis may be sanded for a brushed look. The ends may be grooved with a hand saw for PCB mounts; heavy components may be fastened with wood screws. The galvanized steel bottom is easily soldered or drilled. Non-marring rubber feet conceal hidden screws.

Enclosures are available in an unlimited number of sizes, with no minimums and no tooling charge. Delivery is from stock for the most popular sizes. Many variations are possible on the "R" series. A sample is available for $3.00 plus $2.00 shipping. A new slope-front enclosure ("S" series) will be available soon.

For information, contact Energy Engineering, Route 4, Fayetteville, Arkansas 72701.

Circle #310 on Reader Service Card.

9-volt Rechargeable NiCads

Plainview Electronics announces the introduction of its 9-volt rechargeable NiCad "transistor" battery. Unique in a rechargeable transistor battery is its 8.4-volt nominal voltage, 110 mAh, and its low self-discharge characteristic, which will maintain 50 per cent capacity even after a year in storage at room temperature.

For information, contact Plainview Electronics, 28 Cain Drive, Plainview, New York 11803.

Circle #311 on Reader Service Card.

callbook supplement

The new combined *Callbook Supplement* includes all the changes in both the North American and International Callbooks for the six months since the publication of the regular Callbooks. Published once a year on June 1st, it lists thousands of new licensees, address changes, and "then and now" call changes from countries around the world.

Unlike previous updates, this new Supplement is available through regular Callbook dealers and is priced lower than previous Supplements.

For more information, contact Ham Radio's Bookstore or the publisher, Radio Amateur Callbook Inc., 925 Sherwood Drive, Lake Bluff, Illinois 60044.

Circle #306 on Reader Service Card.

HAM MART

Ham Radio's guide to help you find your loca

California

C & A ROBERTS, INC.
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COLLINS WANTED: Inoperative 75S3C or 32S3 for parts. Mike Palmer, K5FZ, 16707 Creeksouth, Houston, Texas 77068. (713) 444-7737

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B&K Precision solid state signal generator, model E-200D, 100 kHz to 220 MHz $75.00. 4CX1000, factory sealed $250.00 or trade for IC-02AT. W7TZO, (503) 267-6064.

TUBES: 4D32 Raytheon $35.00 each. 4-400A $45.00, 5933WA $5.00, 12AT7 $1.00, 12AX7 $1.00. Inquire on others. Levy, 101 East Driftwood #44, FBG, TX 78624. Tel 512-997-2534. W5QJT.

MARCO: Medical Amateur Radio Council, Ltd. operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc.) invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

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COMING EVENTS

Activities — "Places to go . . ."

OKLAHOMA: October 5. The Salt Plains Amateur Radio Club will hold their annual Ham Social, Salt Plains Lake, Northern Alfalfa County. Covered dish dinner. Talk in on 147.30/90. Inquiries to: Gary Gerber, KB0HH, 511 Lincoln, Anthony, KS 67003. (405) 842-5076.

ARIZONA: September 27. CARA – The Cochise Amateur Radio Association's Flea Market at the CARA Training Facility on Moson Road, Sierra Vista. No charge for tailgating. Free overnight RV camping for club members. Talk in on 146.16/76. For more information: CARA, PO Box 1855, Sierra Vista, AZ 85636.

CONNECTICUT: *September 28. The Waterbury ARC will sponsor* a Flea Market, Waterbury State Technical College, off I-84, Waterbury. 10 AM to 3 PM. Admission $2.00 at door. Indoor spaces $10/table and tailgating spaces $5. Dealers, sellers setup 9 AM. Contact Gary Firtick, K1EB, 589 Hamilton Avenue, Watertown, CT 06795 by 9/15/86.

MARYLAND: October 5. The Columbia Amateur Radio Association's 10th annual Hamfest, Howard County Fairgrounds, just west of Baltimore, off I-70. 8 AM to 3:30 PM. Admission $3.00. Spouse and children free. Reserved tables $7.00 prior to September 30. $8.00 after. Outdoor tailgating $3.00 additional. Indoor tailgating $6.00 additional. Food available. Talk in on 147.735/135, 146.52/52. For table reservation and information: Mike Vore, W3CCV, 9098 Lambskin Lane, Columbia, MD 21045. 992-4953.

PENNSYLVANIA: October 4. Pack Rats (Mt. Airy VHF ARC) invites all Amateurs to the 10th annual Mid-Atlantic VHF Conference, Warrington Motor Lodge, Rt 611, Warrington and the 15th annual Pack Rat Hamarama, Sunday, October 5, Bucks County Drive-In theater, Rt. 611, Warrington. Flea market admission $5.00 per car. Selling spaces $6.00 each. Gates open 6 AM rain or shine.

GEORGIA: November 1-2. The Alford Memorial Radio Club of Stone Mountain is sponsoring Ham Radio and Computer Expo '86, Gwinnett County Fairgrounds, 20 minutes NE of Atlanta. 9 AM to 5 PM Saturday; 9 AM to 4 PM Sunday. Admission $4 advance, $5 at door. Forums, awards, VEC exams both days, free cookout Saturday night. Activities for the entire family. Superb dealer facilities, giant undercover flea market. Discount hotel rooms. Free parking, RV sites with full hookups. Talk in on 146.16/76, 449.25/4.25. Information: Alford Memorial ARC, PO Box 1282, Stone Mountain, GA 30086 or call N8LM at 404-925-7615.

NORTH DAKOTA: September 19-21. ARRL Dakota Division Convention sponsored by the Red River Radio Amateurs, Fargo Holiday Inn. Speakers: Dr. Tony England, W0ORE and ARRL President Larry Price, W4RA. *Indoor flea market tables $5.* Seminars, display, VE exams (no walkins). Breakfast and banquet Saturday. Breakfast and flea market Sunday. Talk in on 146.76 repeater. Registration $7. For information SASE to Red River Radio amateurs, Box 3215, Fargo, ND 58108-3215.

CONNECTICUT: *September 14. The Candlewood Amateur radio Association's annual Flea Market, Danbury Elk's Club, 346 Main* Street, Danbury. 9 AM to 3 PM. Dealers 8 AM. Admission $2. Tables $8. Tailgating $5. Talk in on 147.72/12. For table reservations send check or MO to CARA c/o Gene Marino, 27 Valley View Rd, Newtown, CT 06470 or call Gene (203) 426-8852.

CALIFORNIA: September 20. Sonoma County Radio Amateurs fourth annual flea market. 8 AM to 2 PM, Sebastopol Community Center, 390 Morris Street, Sebastopol, 5 miles west of Santa Rosa. Admission and parking free. Tables $5 advance or $7 at the door. Vendor setup 7 AM. VEC exams, radio clinic, refreshments. Auction about noon. Talk in on 146.13/73. For tickets and information: SCRA, Box 116, Santa Rosa, CA 95402.

NEW YORK: September 27. The Elmira Amateur Radio Association's 11th annual International Hamfest, Chemung County Fairgrounds, Elmira. Gates open 6 AM to 5 PM. Tickets available at gate or in advance from Steve Zolkosky, 118 Est 8th Street, Elmira Heights, NY 14903. Outdoor flea market, dealer displays. Breakfast and lunch served on premises.

FLORIDA: September 6-7. The 21st annual Melbourne Hamfest sponsored by the Platinum Coast ARS, Melbourne Auditorium. Saturday 9-5 and Sunday 9-4. FCC exams, exhibits, swap tables, ARRL forum, QCWA, tech, MARS and Net meetings, 2m transmitter hunt. Tickets $3 advance, $4 door. For swap table reservations (limit 2 adj.). For exam information SASE to PCARS, POB 1004, Melbourne, FL 32901.

NEW JERSEY: The Maple Shade ARC is sponsoring its First Annual Hamfest, Saturday, September 20, Maple Shade High School, *Coles Avenue, Maple Shade. 8 AM to 2 PM. Admission* $5.00 per carload, includes one tailgate space. Refreshments, tech forums. Talk in on 146.52 and 223.02/224.62 W2MX Rpt. For more information: K3HW, Howard Weinstein, 15 Lakeside Drive, Marlton, NJ 08053 (609) 596-3304.

MISSOURI: September Swapfest, Sunday, September 28, Harvester Lions Club Park, Harvester. Sponsored by the St. Peters Amateur Radio Club. $1.00 per person to look, swap, sell. Free coffee and donuts for early birds. For information: Joe Riordan, KG0K, 2760 Hwy. 40-61, O'Fallon, MO 63366.

ILLINOIS: September 20-21. Peoria Area Amateur Radio Club is sponsoring Peoria Superfest '86, Exposition Gardens, W. Northmoore Road, Peoria. Gate opens 6 AM. Commercial Building 9 AM. Admission $3.00 advance; $4.00 at gate. Children under 16 free. Amateur Radio and computer displays, hugh flea market, FCC exams *for all classes Saturday and Sunday. Free bus to North* woods Mall Sunday. Fukll camping facilities on grounds. Saturday night get-together Heritage House Smorgasboard, 8209 N. Mt. Hawley Road, Peoria. Talk in on 146.16/76, W9UVI. For information and reservations: SASE to Superfest '86, PO Box3461, Peoria, IL 61614.

CONNECTICUT: *September 21. The 4th annual Natchaug ARA* Giant Flea Market, Elks Home, 198 Pleasant Street, Willimantic.

9 AM. Dealers setup 8 AM. "Bargins Galore". Free parking. Admission $2. Under 16 free. Inside reserved tables $5 each. At the door $7 each. Tailgaters welcome. Outside space $5 and up. ARRL/VEC exams for all license classes. Talk in on 147.30/90 and 52. For information: Ed Sadeski, KA1HR, 49 Circle Drive, Mansfield Center, CT 06250. (203) 456-7029 after 4 PM.

CALIFORNIA: October 4. Scatcon '86. 9 AM to 3 PM, Cortez Park, 2441 Cortez Avenue, West Covina. Tech sessions. Hands-on packet, satellite and more. Swaps, vendors. Donation $2. Talk in on 147.765-600. For more information: Bob, N6NGN. (818) 917-6470.

NEW YORK: September 21. LIMARC sponsors ARRL Long Island Hamfair, New York Institute of Technology, Rt. 25A/Northern Blvd, Old Westbury. Tailgating space $5.00. Hams $3.00 admission. Spouses, kids free. Open 7:30 AM sellers. 9 AM buyers. Food, refreshments available. Talk in on 146.85. For more information: Hank Wener, WB2ALW (516) 484-4322 evenings.

GEORGIA: September 28. The 13th annual Lanierland ARC Hamfest, Holiday Hall, Holday Inn, Gainesville. 8:30 AM. Free tables and inside display area for dealers reserving in advance. Large parking lot for Flea Market. Novice-Extra VE exams beginning 9 AM. Talk in on 146.07/.67. For information and reservations: Paul Watkins, W4FDK, 5435 Mallard Point, Gainesville, GA 30501 (404) 536-8280.

MICHIGAN: September 14. L'Anse Creuse ARC will have its 14th annual Swap and Shop, L'Anse Creuse High School, Mt. Clemens. 0800-1500. Admission $1.00 advance, $3.00 at the door. Plenty of food aed parking. Trunk sales $4.00/space. Inside tables $8.00 each. For Tickets and table reservations SASE to Maurice Schietecatte, N8CEO, 15835 Touraine Ct, Mt. Clemens, MI 48044. (313) 286-1843.

ONTARIO: September 20. Packet Radio Symposium co-sponsored by the Hex-9 Group of the Barrie ARC and Georgian College, Barrie. Flea market in the morning. Guest speakers Harold Price, NK6K, a director of AMSAT and Ed Jackson of Buffalo. Admission $5.00. Talk in on 146.25/146.85 VE3LSR. Inquiries: Hex-9 Group, Box 151, Orillia, Ontario, Canada L3V 6J3.

MASSACHUSETTS: The Chelsea Civil Defense will sponsor Amateur Radio evening classes at Chelsea High School starting September 11, 1986 for those wishing to obtain a Novice, Tech/General license. There will be a minimal fee for materials cost only. Share in a great hobby! For more information: Frank Masucci, 136 Grove Street, Chelsea, MA 02150. Please include your phone number.

1986 "BLOSSOMLAND BLAST" Sunday, October 5, 1986. Write "BLAST", PO Box 175, St. Joseph, MI 49085.

CALIFORNIA: FCC exams, Novice-Extra. Sunnyvale VEC ARC. (408) 255-9000 24 hour. 73, Gordon, W6NLG, VEC

MASSACHUSETTS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday, September 17, 7 PM, MIT Room 1-134, 77 Mass Avenue, Cambridge MA. Reservations requested 2 days in advance. Contact Ron Hoffmann (617) 253-0160/646-1641 or Craige Rodgers (617) 494-1986. Exam fee $4.25. Bring copy of current license (if any), two forms of picture ID and completed form 610 available from FCC in Boston (223-6609)

MASSACHUSETTS: September 28. The Wellesley Amateur Radio Society's annual outdoor Flea Market, Wellesley Senior High School parking lot, Rice Street, Wellesley. 9 AM to 2 PM. Admission $1.00 for buyers and $2.00 for sellers. Light refreshments available. Talk in on 147.63/03 repeater.

NEW YORK: October 5. Electronics Fair and Giant Flea Market, Yonkers Municipal Parking Garage, Nepperhan Avenue and New Main Street. 9 AM to 4 PM. Satellite TV, SSTV, Amateur Radio, Computers and more. Giant Auction 2 PM. Unlimited free coffee all day. Admission $3.00. Children under 12 free. Sellers $7.00 per parking space, one admission. Bring tables. For information call (914) 969-1053.

NEW YORK: September 6. Ham O Rama & Computerfest '86. Niagara Falls International Convention Center, Niagara Falls. 7 AM to 5 PM. Displays, tech programs, computer displays, FCC exams. All enclosed flea market. Sell from your car! General interest programming including tours of the Falls. Registration $3.50 advance by 8/20/86. $5.00 at the gate. Inside tailgating $5.00 for 8' x 20' area. For more information: Nelson Oldfield, W2ZSJ, 126 Greenaway Blvd, Cheektowaga, NY 14225.

NEW MEXICO: September 27 and 28. Camp Stoney, 8 miles east of Santa Fe. Saturday ARRL/VEC exams. Free camping at Camp Stoney Saturday night. No hookups. Sunday, tailgate flea market. Registration $5.00 for adults and $2.00 for kids under 12. Includes Sunday BBQ. Talk in on 146.22-82 repeater of 146.52. For more information SASE to Alan Hill, N5BGC, 2020 Calle Perdiz, Santa Fe, NM 87505.

MICHIGAN: October 12. Ham Fair '86, Michigan National Guard Armory, 2500 S. Washington Avenue, Lansing. 8 AM to 3 PM. Dealer sales, swap shop, handcrafted items, FCC exams starting 1 PM. Register for exams by September 12. Donation $3.00 adults. Handicap facilities on premises. For information and reservations: Rowena Elrod, KA8OBS, 111 Lancelot Place, Lansing, MI 48906. (517) 482-9650.

PENNSYLVANIA: September 20-21. York Hamfest sponsored by the York ARC, Keystone VHF Club, Penn-Mar RC and Hillstop Transmitting Association. York Fairgrounds, Rt 74, NR corner of the city. Seminars, tailgating, displays, banquet and FCC exams Saturday. Tailgating and displays Sunday. Registration $3.00 per day or $5.00 both days. Women and children under 12 free. Banquet $10 per person advance registration only. Tailgating $4 per day or $6 for both days. Indoor area tables $5 and up per day. York Hamfest, Box W, Dover, PA 17315.

NEW JERSEY: October 4. The Orange County ARC wil hold its Hamfest and Auction, John S. Burke Catholic High School. 9 AM to 3 PM. Tailgating $3.00. Setup 8 AM. License exams starting 9 AM. Admission $3.00. Tables $7.00. Talk in on 146.76 Rpt. and 146.52 simplex. For more information call Bob, WB2ENA (201) 767-6698.

MICHIGAN: September 20. GRARA Swap and Shop, Hudsonville Fairgrounds, Hudsonville. Open 8 AM. Admission $3.00. Reserved tables $4.00. For information and reservations: Larry Kozal, K8PUJ, 864 Coldbrook NE, Grand Rapids, MI 49503. (616) 459-8722.

ILLINOIS: September 21. The Chicago ARC will hold an Open House in conjunction with its 60th anniversary. 10 AM to 8 PM at the North Park Village, 5801 N. Pulaski Avenue, Chicago. Special event station on 20 and 40m SSB will operate during those hours. All hams and those interested in Amateur Radio are invited. For information call (312) 545-3622 or write CARC, 5631 W. Irving Park Road, Chicago, IL 60634.

OPERATING EVENTS

"Things to do . . ."

September 4-7: The Stu Rockafellow Amateur Radio Society of Plymouth, MI will be celebrating their 25th anniversary, in conjunction with the Plymouth Fall Festival, operating radio station W3NJH. A certificate will be issued for QSL and SASE. QSL via W8NJH or WD8IAE CBA.

September 6: AT&T Bell Labs Whippany ARC will operate W2TW, 1300Z to 2200Z commemorating its 30th anniversary. Operation in lower portions of 10-80 General phone bands. For a QSL send SASE and QSL to WB2QOQ, Rick Anderson, 243 Mountain Avenue, Murray Hill, NJ 07974.

September 6: The 160 Meter Bulletin SSB Contest. 001Z to 2400Z September 7. Single and multi-operator classes. Send logs to 160 Meter Bulletin c/o R. Koziomkowski, KA1SR, 5 Watson Drive, Portsmouth, RI 02871.

September 6-7: The Radio Association of Erie (W3GV) will commmemorate Commodore Perry's victory at the Battle of Lake Erie during the War of 1812. 9 AM to 9 PM Saturday and 9 AM to 5 PM Sunday local time. A special attempt will be made to contact like vessels of that period and other Great Lakes Historical Vessels Sunday at 1 PM. Special QSL and historical information on Flagship Niagara via W3GV, PO Box 844, Erie, PA 16512 or W3 QSL Bureau for DX Stations. Please send business SASE.

September 13,14 and 20,21: The Valley of the Moon ARC will operate special event station N6KM to commemorate writer, Jack London, author of "Call of the Wild" and "The Sea Wolf" from his home, Wolf House in Jack London State Park, Glen Ellen, California. A beautiful 8x11 certificate suitable for framing, with London's picture and history, is available for a QSL card and $1.00 sent to VOMARC, 358 Patten Street, Sonoma, CA 95476. For an unfolded certificate, please send 9x12 SASE.

September 27: California QSO Party. Sponsored by the Northern California Contest Club. Stations outside California work as many CA stations in as many CA counties as possible. Stations in CA work anyone. CA stations send QSO number and county. Outside stations send QSO number and state/province/country. All logs and summary sheets must be send to NCCC c/o Gary Caldwell, WA6VEF, 1830 Polk Street, Concord, CA 94521 by November 1, 1986.

September 7-14: Southern Counties ARA will operate special event station K2BR during the Miss America Pageant, Atlantic City, New Jersey. QSL SASE via SCARA, Box 121, Linwood, NJ 08221.

September 6: The West Alabama Amateur Radio Society will sponsor a Special Event Station in honor of college football and its greatest coach, Paul "Bear" Bryant. Listen for WD4DAT from 1300Z to 2300Z. To receive the handsome 8x11 certificate SASE with your QSL card to WAARS Special Event, PO Box 1741, Tuscaloosa, AL 35403.

September 28: The Mahoning Valley ARA will operate W8QLY from Boardman Park during the Annual Rotary Octoberfest Celebration. Freq: 40 and 20 phone; 145.01 packet. For a special QSL certificate, send standard SASE to MVARA Octoberfest Station, PO Box 2950, Youngstown, Ohio 44511.

W.E.C.A. (Westchester Emergency Communications Association) initiates Equipment/"Elmer" Banks to help new hams get on the air. More information write the club at PO Box 131, North Tarrytown, NY 10591.

DX CERTIFICATE. Nigerian Amateur Radio Society announces its "NARS at 25 Award". To encourage more contact with Nigerian Amateur Radio stations. DX stations need to work only 5 Nigerian ham stations to obtain this DX certificate. Send proof of contact plus $5.00 to NARS at 25 Award, PO Box 2873, Lagos, Nigeria, West Africa.

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THE GUERRI REPORT by Ernie Guerri, W6MGI

circuit boards keep pace with electronic developments

Many of us may view printed circuits (PC's) as one of the necessary, but less glamourous aspects of modern circuit design. But the people whose job it is to keep pace with developments in circuit evolution have done some rather marvelous work in the PC area. For example, take a look at one of those plug-in cards for your personal computer — you'll see 50 chips, a ton of components, thousands of interconnects, and hundreds of circuit lines on *six* layers of PC! Chances are you're getting all this for a couple hundred bucks.

Manufacturing modern microwave PC's requires a degree of magic just slightly removed from potions using bat wings and butterfly ears.

Because of the very small dimensions associated with frequencies above 2 GHz or so, the stability and dielectric characteristics of the substrate become a limiting consideration. Teflon and ceramic dielectrics are used extensively — but these are very expensive materials and may cost 50-100 times as much (per square unit) as conventional commercial-grade board materials. Because of the dielectric and radiation losses associated with microwave frequencies, it's not uncommon to have the dielectric bonded to a metallic structural member. This provides shielding, thermal conductivity, and all-important dimensional stability. The copper foil used in such applications is electrolytically formed and may be only 50 millionths of an inch thick (remember the "skin-effect" at very high frequencies). Transmission lines, filters, inductors, etc. may have line widths as small as one thousandth of an inch. Since the characteristics of filters at high microwave frequencies will depend on accurate physical dimensions, great care goes into the selection of the piece of PC material that will be used for a given design. At these frequencies it's not unusual for a designer to finalize his design only after he has procured enough material to assure that he can make all of the circuits of a given type that he expects to produce.

Next time you pick up a modern complex circuit card, remember that the card itself is one of the miracles of our current revolution.

signal encryption techniques reach maturity

Recent legislative activities aimed at preventing the reception of certain commercial signals may be less relevant in light of the technical means for security employed by many electronic communications systems. In the early 1970s a data encryption protocol called DES-Date Encryption Standard was developed. This technique is used to protect computer records, financial transactions, diplomatic traffic, and so on. More recently, the operators of broadcast satellites have begun using DES subsets to encode entertainment signals for C-Band satellites.

The basic technique is along the following lines...The data is organized into 64 bit words whose right and left 32 bits are swapped in accordance with a coded scheme. The code is a 56 bit word which organizes the structure and rate at which the 32 bit words are swapped. Additional logic operations are performed to compare the right and left hand words. If they don't match in a certain way, one of the words is replaced and a new sequence generated. This process can be extended to sevral levels, and the code can be changed almost continuously. If you think for a moment about the size of number like 2^{32} times 2^{56} you will quickly see why this system has substantial security — the number of possible combinations is astronomical. At this time there are no validated reports of any person or organization having successfully developed a techinque for decoding DES data without a prior knowledge of the code.

Several companies are already producing both encryption and decoding systems using the DES standard. Although the cost is still a bit high for the very low end of the business communication market, prices are coming down. As it has done for us in so many other areas, the TV market is providing the impetus for mass production of DES decoders. One can only hope that those commercial users who would support highly restrictive legislation on the use of the airwaves, can be equally enthusiastic about using modern technology to protect their customer interests.

The possible amateur uses off these advanced coding techniques is not clear, since encryption is prohibited in amateur communications. However, the basic techniques (and especially the custom chips) might eventually make low cost audio and video digitizers available to the amateur service. This may made possible considerable improvements in spectrum utilization through data compression and frequency/time multiplexing.

ham radio

ADVERTISER'S INDEX AND READER SERVICE NUMBERS

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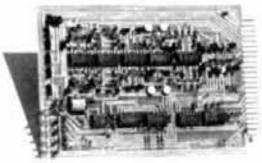

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The SS-32HB is a new hybrid sub-audible encoder plucked from Communications Specialists' Hothouse. It has grown through a cross of the time tested SS-32, the subminiature SS-32M and space age micro circuitry. This programmable 32 tone encoder measures a scant .5 x 1.0 x .15 inches; no small wonder it allows the addition of continuous tone control to a bunch of hand held transceivers that lack space.

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✓ 187

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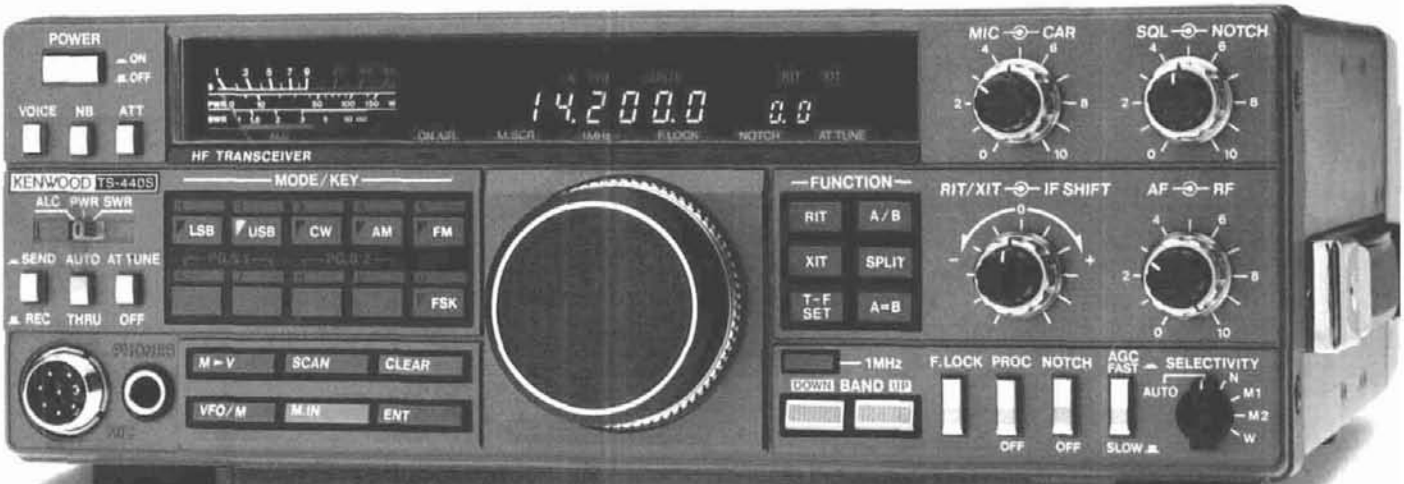

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