FEBRUARY 1989 / $2.50

HAM RADIO


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TONE
WRITE
VFO
MR
DOWN
UP
SET
T/D.SQL
ICOM
VHF FM IC-38A
VOL/PWR
PUSH-ON
SQL/CHK
HI/LO
UP/DN
OFF

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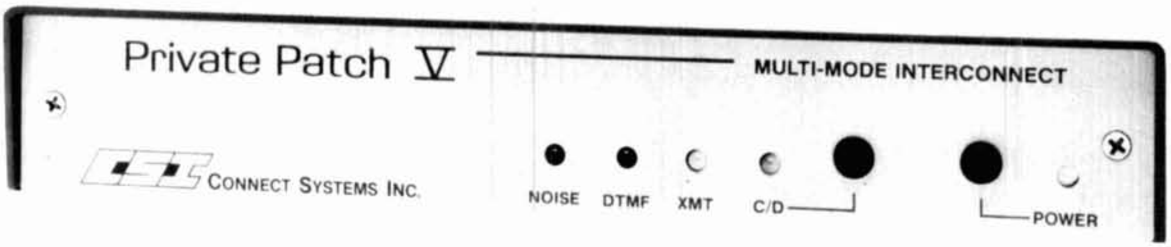

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TM-721A shown with optional RC-10.

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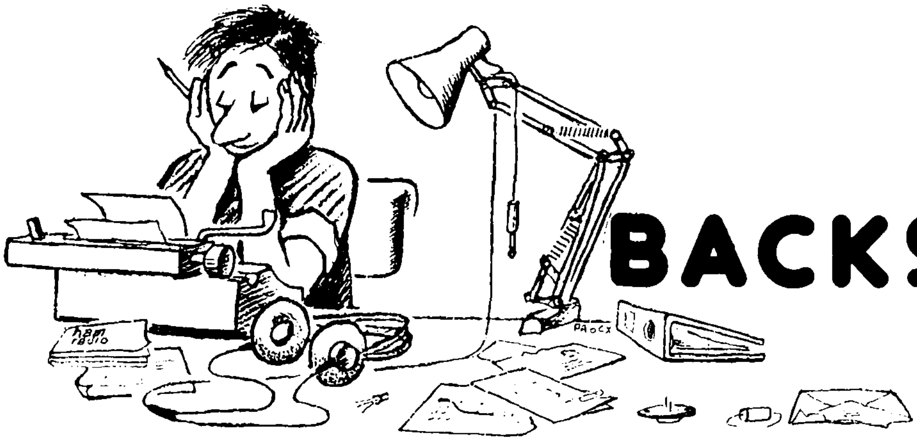
See page 17 for the winners of December's handheld radio contest.

DEPARTMENTS



BACKSCATTER

Glasnost and Amateur Radio

It's fascinating how the "Iron Curtain" has opened in the past few months. First a group of Russian and Finnish hams operated from Malyj Vysotskij Island; then jamming of several shortwave broadcasters stopped. Now, there's the amazing story of how the International Amateur Radio Network (IARN) was able to get two operators and $10,000 worth of radio gear into the Soviet Union to help with the Armenian relief effort! This would have been unheard of 10 years ago. Today, it could signal the beginning of a new era of cooperation between the USSR and the rest of the world.

Recently, the ARRL participated in assembling portable battery-operated packet stations. The first complete stations were shipped to Moscow on December 19th. The RSGB's Raynet Organization activated its International Emergency Center, and has been cooperating with the British Red Cross and the UK Overseas Development Agency. We thought you'd enjoy the following piece as a sample of some of the ham activities you'll read more about shortly.

(Thanks Westlink and W9ELR)

de N1ACH

A Christmas Present To Armenia

On December 14, 1988 the IARN, an all-volunteer Amateur Radio organization, asked for people to go to Moscow and help the Soviet Amateur Radio Operators set up much-needed radio circuits between earthquake-ravaged Armenia and the rest of the world. Nearly $10,000 of sophisticated radio communication equipment had been donated by various manufacturers and charitable organizations for this purpose.

Charles Sheffer, KJ4TY, of Apalachicola, Florida and I flew to Cleveland, Ohio to meet with a handful of dedicated Amateur Radio operators (headed by Dave Speltz, KB1PJ) to coordinate and finalize plans for this humanitarian effort.

Glenn Baxter, K1MAN, of Belgrade Lakes, Maine, head of the IARN, had obtained permission from the Soviet Union for this person-to-person assistance. This was a tremendous breakthrough between two great powers.

KJ4TY and I finally left JFK Airport in New York on December 17th. Aeroflot, the U.S.S.R.'s airline, had agreed to fly us (and all of our radio equipment) to Moscow, at no expense. The Aeroflot personnel were very helpful and put all the radio equipment aboard the plane as our personal baggage.

After an 8-hour flight, we arrived in Moscow and were met at the airport by Soviet officials and representatives of the Soviet Union Amateur Radio community. The officials helped us through customs, waiving all red tape so we could enter the country. We were greeted cordially and, after the proper introductions, were taken to our hotel. During our stay, we had a car, driver, and an interpreter at our disposal.

We eagerly awaited an appointment with the local Amateur Radio organization to finalize plans for assisting them in setting up the emergency communications links between Armenia, Moscow, and the rest of the world.

On our third day in Moscow, we were called into a meeting and told that we must leave the following day. Officials explained that the Aeroflot had reservations booked for nearly a year. They also explained that there were so many foreign assistance personnel in Armenia already, that it was beginning to interfere with the total relief program. They felt that their own Amateur Radio operators could set up the necessary communication links. Having met with some of the local Amateurs, we heartily agreed that they could do the job.

Early the next morning, Soviet officials picked us up at our hotel and drove us to the airport. We left all the radio equipment for use in the emergency networks.

The Soviets seemed extremely grateful for the equipment. They gave us a parting gift and thanked us time and time again for our efforts.

Amateur Radio operators worldwide had been rooting for us, and had assisted with communications in preparation for this trip. This was the first time that anything of this magnitude had been attempted with the Soviet Union. As our efforts were purely humanitarian, we feel that a great stride forward has been made for closer and peaceful cooperation between two great countries.

Our Christmas present to the Soviet Union will prove, in a small way, that people on this planet can work together for a better, more peaceful world.

Al Vayhinger, W9ELR

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- IF-10A computer interface
- IF-232C level translator
- CD-10 call sign display
- SP-430 external speaker
- VS-1 voice synthesizer
- TU-5 CTCSS tone unit
- MB-430 mobile mount
- MC-60A, MC-80, MC-85 deluxe desk top microphones
- MC-48B 16-key DTMF, MC-43S UP/DOWN mobile hand microphones
- SW-200A/B SWR/power meters:
  SW-200A 1.8-150 MHz
  SW-200B 140-450 MHz
- SWT-1 2-m antenna tuner
- SWT-2 70-cm antenna tuner
- PG-2U DC power cable

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COMMENTS

Attracting or discouraging newcomers

Dear HR

Your editorial and some letters in the August issue raised some good points why Amateur Radio still has problems attracting newcomers, but I feel the major reasons were not really addressed.

Forget the old excuse about ham equipment costing too much today—gear has always been too expensive for younger amateurs! My first rig was a Heath HW-16, which ran for a little over $100. That might sound like a terrific bargain, but $100 was my parents' monthly mortgage payment.

I think you can make a good case that new hams today have an easier time of equipping their stations than newcomers did two decades ago. There are plenty of used rigs around from the late 1970s, which do an excellent job on CW and SSB and can be had for well under $500. These are tube rigs, to be sure, but it doesn't take long to properly tune one up when changing bands. You can also get on 220 or 10 with a new rig for well under $500. Cost clearly isn't the problem.

Is there really any demand at all for a "bare bones" transceiver at about $500? The folks at Ten-Tec have marketed a very similar rig, the Argosy, for several years with only modest sales; I hear rumors that it's been discontinued. In the August issue, W1FB asked what happened to the concept of high volume and low per-unit profit. What happened is that there's no "high volume" to speak of today in the ham radio market — by its very nature, it's a low volume, high markup business. Using W1FB's reasoning, *HAM RADIO* could really increase its circulation by lowering the subscription price to $5 per year! If W1FB *thinks* there's money to be made by manufacturing a $500 transceiver, he should do it and get rich. (Or go broke...)

The problem is not a lack of technical interest or smarts amoung young people. If you're one of those rare hams with an interest in computing above the Commodore-64 level, you've seen how rapidly teenagers can master C and assembly programming and discuss the intricacies of the MicroChannel data bus. They're learning and having fun, and being a computer whiz is "cool" in a lot of circles. Many of these youngsters would have been attracted to Amateur Radio in the past. (As an aside, the microcomputer industry has quite a few former Amateurs who left the hobby for computing. The most famous of these is Steve Wozniack, the co-founder of Apple Computer.)

So why are we not seeing the expected influx of newcomers from Novice enhancement? Consider the following:

1. Radio is no longer something mysterious or exciting. This is the era of instant worldwide communications by satellite. Even in the mid-1960s, the idea of being able to talk to someone thousands of miles away seemed like science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with live television from the moon, direct-dialing to foreign countries, and cordless telephones. Radio is an accepted fact of their lives, not an exciting innovation. They have little reason to get excited about owning or operating a radio station. (If they only want to engage in aimless chatter by radio with a group of friends, there's always CB.)

It's interesting to look at some old technical magazines in a good library. At the turn of the century, electricity was the big thing and entire magazines were devoted to experiments with it. As electricity became commonplace, interest in experimenting with it died out — and so did the magazines. We're doubtlessly seeing a similar phenomenon (hopefully to a smaller degree) with radio.

2. Amateur radio has been "curmudgeonized." In the August issue, W1FB wrote that "...a large portion of the fraternity consists of retirees who must exist on fixed incomes." That's obvious to anyone who listens to the General portion of 75 meters. Suppose you're a teenager. Would you want to talk to a bunch of people old enough to be your grandfather? I'm 35 and have a hard time finding someone interesting stateside to have a ragchew with. Can you imagine what it must be like for someone who's 15? Moreover, I have a feeling that a lot of older (in a mental, if not chronological, sense) Amateurs dislike youngsters. There's a letter in the August issue complaining about a generation of "gimmies" who "...are accustomed to essentially getting everything that they want." I don't think I'd have much to say to such a person on the air, and I doubt if many young potential Amateurs would either.

3. A lot of Amateurs don't want growth. This is Amateur Radio's dirty little secret. I recently spoke with a non-ham who had been instrumental in producing the licensing materials now sold through Radio Shack stores. He attended Ham-Com in Dallas and sat in on a session about attracting newcomers. He was shocked at the number of hams there who were quite vocal in their desire for fewer, not more, Amateurs. I told him he should listen to our bands sometime!

4. The ham industry isn't involved as it must be for its own future. One of my hobbies is scuba diving. Go into a dive shop and ask about becoming certified. They won't let you go until you've signed up for a course! Now walk into your local ham dealer and ask

about geting licensed. You might be referred to a local club.

The diving industry recognizes it has to take the initiative to train new divers, thereby increasing its customer base and assuring future profits. Major manufacturers and local ham dealers must adopt a similar attitude instead of leaving it up to an overloaded ARRL and local clubs.

5. We need some form of code-free license. Actually, this would merely restore an old tradition to Amateur Radio, since many (if not most) people who obtained a Conditional or Technician license prior to 1976 never really learned CW. (Don't take my word on it; look at the results of those the FCC called in for re-testing!) What is so terrible about substituting stiffer theory for CW above 144 MHz, or maybe having a modified form of the old Novice ticket authorizing FM on 220 but with a expiration limit of one or two years? A no-code license is not a panacea for slow growth, but it would help.

The most interesting thing about the idea of a code-free license is the hypocrisy it brings out in the Amateur ranks. Ever notice how many of the strongest defenders of the code don't have the Extra? If CW is that essential (and easy), may I humbly suggest they take some of the energy they use opposing no-code and get their CW speed up to 20 WPM?

I got interested in Amateur Radio early enough to enjoy Rod Newkirk's DX column in *QST*. He ended one column devoted to increasing QRM on the bands by remarking that we must have more Amateurs. Our choice, in Rod's terrific phrase, was either QRM or QRT. His words are just as applicable today. I want to enjoy Amateur Radio for several more years. But it will not be possible without a sustained flow of younger recruits in the ranks and changes in the structure of the service. We need realistic thinking, not chimeras or warm nostalgia.

Harry Helms, AA6FW,
San Diego, California 92126

Applause for Net Control Operators

Dear HR

As I sit here, for the third day, monitoring the FCC Emergency Frequencies of 14.325 and 14.275, I am appalled at what I hear. There are not only the overly enthusiastic hams who try to assist when no assistance is asked for by Net Control, but those who intentionally and with malice cause interference. Then there are those who think that their questions and messages are the most important ones and should be answered without regard to, and before all others.

For those who fall into the category of causing malicious interference there is no solution other than trying to identify them and suspend their licenses. If they think that they can not be identified they are mistaken. Fellow Amateurs, let's do our thing and self-police the bands.

As to the over enthusiastic hams, please follow the instructions of the net control operator. It is obvious from monitoring the nets that the net control operators not only know what they are doing, but are doing an outstanding job under the circumstances. Let's NOT add to their problems.

As far as those who have health and welfare (H & W) traffic, remember LIFE and DEATH traffic M U S T come first. I also have H & W traffic and have a deep interest in seeing that it gets into the system. However, I wait and follow the instructions of the Net Control.

Having been an Amateur for over 25 years and a net control operator for a good number of years, while serving in the military, I know how demanding the job is. My hat off to all those who served as net control operators during the Hurricane Gilbert emergency. Thank you for your outstanding devotion to Amateur Radio.

David L. Schwein, N4OBU,
Sebring, Florida 33870

A $40 DIGITAL VOICE
STORAGE ID'ER

By Carl Lyster, WA4ADG, 4412 Damas Road, Knoxville, Tennessee 37921

Use this device to reproduce up to 6.4 seconds of voice

I have designed and built a digital voice storage device capable of reproducing up to 6.4 seconds of human voice. The basic design can be expanded to provide longer and/or multiple messages.

Theory of operation

To understand digital voice storage, first assume that you want to record a 1000-Hz, zero to 5-volt sine wave. If you were to "freeze" the sine wave for an instant, you would observe a DC voltage somewhere between zero and 5 volts. You'd record the readings in a notebook and plot them on a piece of graph paper. Then you would "release" the sine wave and freeze it again 1/10,000th of a second later. The recording and plotting of this new value would show it to be slightly different in amplitude. If you were to repeat this process 10,000 times, you would have a written record composed of 10,000 voltage data points representing 1000 cycles of the sine wave, and a graph to prove it! Now try the experiment using real world electronics to accomplish the same results.

In place of a voltmeter, use an analog-to-digital converter (ADC) chip — an IC that measures a DC voltage and converts it to a binary number. Store the data points on some RAM memory chips (instead of in a notebook) and use a quartz crystal timebase to accurately time the 1/10,000th of a second sampling intervals. Before running the experiment, make one last change. This time try sampling the output of an amplified microphone instead of recording a sine wave.

Speak into the microphone until you use all of the RAM storage space. You now have a digitized human voice stored in the RAM memory. Program a ROM memory chip with the exact data contained in the RAM memory chips to make a permanent copy of the recorded voice. An *almost* indestructible voice recording is stored in the ROM memory chip!

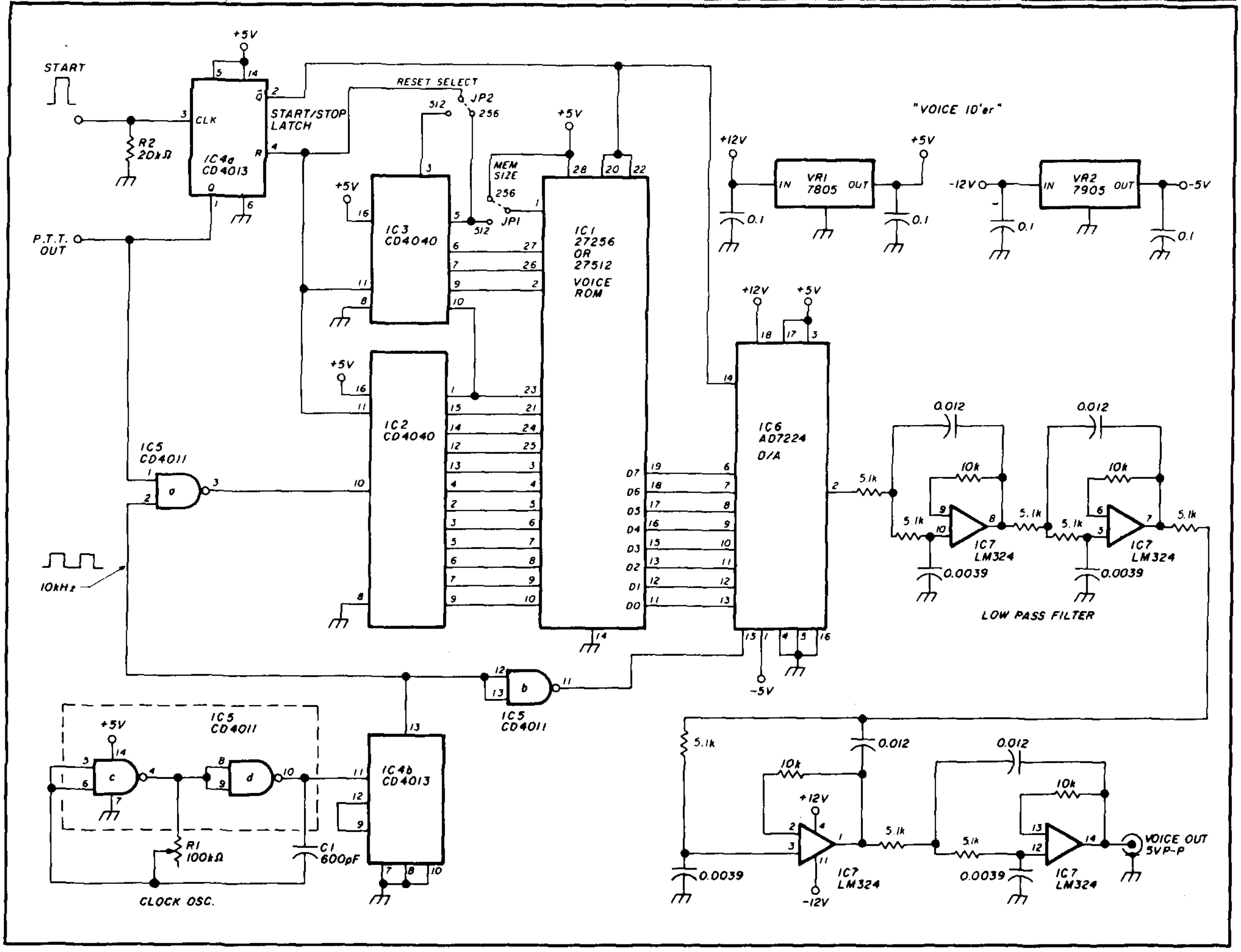
How do you recreate the voice stored in ROM? Retrieve the data from the ROM chip one data point at a time, with a spacing of exactly 1/10,000th of a second between data points. Feed each data point one after the other to an IC called a digital-to-analog converter (DAC). This chip takes a binary number representing a voltage and generates that voltage as its output. The data points entering the DAC cause a varying voltage output which is an exact duplication of the amplified microphone's output.

Now let's get to the ones and zeros of how this $40 wonder works.

Technical description

Assume that the ROM chip has already been programmed with the desired voice passage (more on this later). Refer to **fig. 1**. IC4 is a CD 4013 dual flip flop. One flip flop is used as the start/stop latch. A positive going 5-volt input pulse toggles the Q output high and the Q bar output low. The Q output of the start/stop latch is used as an active high PTT signal to key external repeater logic. The Q output also gates the 10-kHz sampling clock at IC5a, and the Q bar signal enables the chip select lines of both the ROM and DAC. Two gates of IC5 (c and d) form an adjustable oscillator running at 20 kHz. Pot R1 sets the frequency of the oscillator and can be used as a "pitch adjustment" to fine tune the voice tone. The 20-kHz clock is divided by 2 in IC4b, which gives the required 10-kHz sampling clock and ensures a 50-percent duty cycle. The 10-kHz clock is inverted by IC5b and used to clock data into the DAC. The sequential addressing of the ROM is performed by two CD 4040 12-stage binary counters, IC2 and IC3. The gated 10-kHz clock pulses are fed to the first 12-stage counter, IC2. This counter addresses the first 12 bits (A0-A11) of the voice ROM. When IC2 overflows, a pulse is sent to the clock input

FIGURE 1



Complete schematic for the digitized voice ID'er.

of the next counter IC3, which handles the remaining address bits A12-A16.

There are two popular ROMs suitable for this circuit, the 27256 32K by 8 ROM and the 27512 64K by 8 ROM. At a sampling rate of 10 kHz the 27256 gives 3.2 seconds of voice; the 27512 delivers 6.4 seconds. These chips cost about $7 and $15, respectively.

The 27256 requires 15 address bits, A0-A14. The 27512 needs 16 bits, A0-A15, to address all memory locations. Two jumpers provided in the binary counter chain accommodate these differences. Jumper JP1 is connected to pin 1 of the ROM socket. If you use a 27256 ROM, you must select JP1 to provide a +5 volt level on pin 1 of the ROM. With a 27512, JP1 must apply counter address bit A15 to pin 1 of the ROM. The remaining jumper, JP2, controls the reset lines of the binary counters and the start/stop latch. This jumper selects the run time of the circuit. If you are using a 27256, you must connect JP2 to address bit A15 of the counter chain. A15 goes high after 3.2 seconds of run time. A high level on the reset lines clears the counters and the start/stop latch.

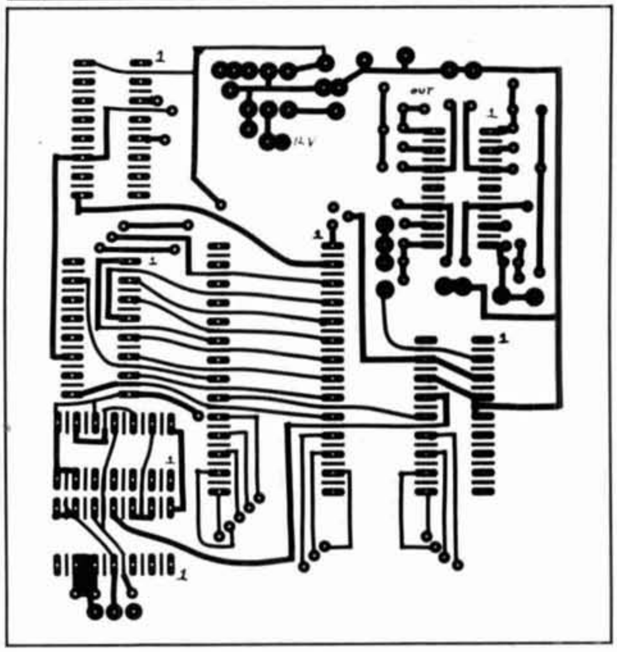
PARTS LIST

IC1	27256 or 27C256 300ns or faster EPROM-3.2 seconds of voice 27512 or 27C512 300ns or faster EPROM-6.4 seconds of voice
IC2	CD4040 binary counter
IC3	CD4040 binary counter
IC4	CD4013 dual flip flop
IC5	CD4011 quad nand gate
IC6	AD7224KN DAC from Analog Devices Corp., Two Technology Way, Box 280, Norwood, Massachusetts 02062-0280
IC7	LM-324 quad op amp
VR1	7805 +5 volt regulator
VR2	7905 −5 volt regulator
R1	100-k 10-turn pot, top adjust
R2	20-k 1/4-watt carbon resistor
C1	600-pF (approximately) silver mica or disc capacitor
10 ea.	0.1-μF 25-volt monolithic by-pass caps: 2 for VR1, 2 for VR2, and 1 by-pass cap from Vcc to ground for each IC
8 ea.	0.012-μF 25-volt monolithic or mylar caps
4 ea.	0.0039-μF 25-volt monolithic or mylar caps
8 ea.	5.1-k 1/4-watt carbon resistors
4 ea.	10-k 1/4-watt carbon resistors

When using a 27512, connect JP2 to A16 of the counter chain, which goes high after 6.4 seconds of run time.

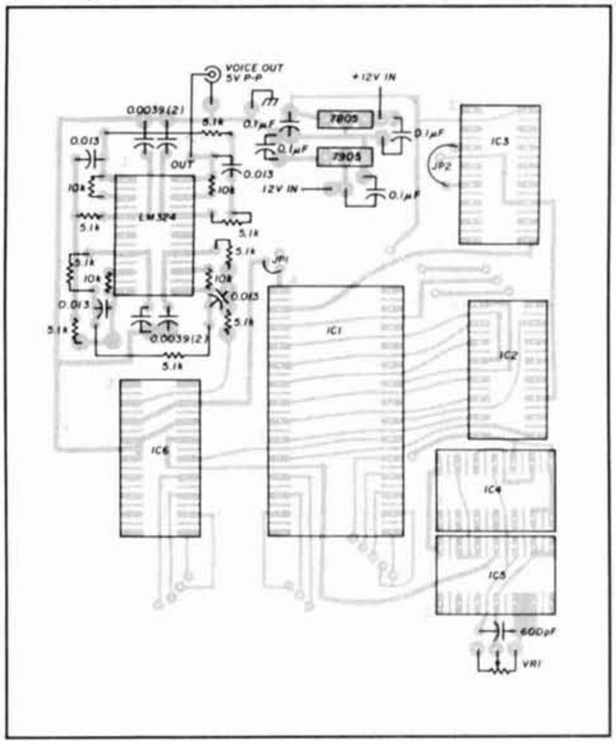
As the counters address each of the ROMs' memory locations sequentially, the 8-bit data output is clocked into the DAC. The DAC produces a voltage at pin 2 proportional to the magnitude of the binary number data point output by the ROM. A value of zero gives zero volts

FIGURE 2



Foil-side pc layout of the circuit.

FIGURE 3



Component placement for the component side of the pc board.

out, binary 10000000 gives 2.5 volts out and binary 11111111 gives 5 volts of output. This device can deliver 5 volts p-p of audio output, a substantial signal that needs to be reduced by a pot or fixed resistor network for most applications.

The power supply requirements are + 12 Vdc at 40 mA and − 12 Vdc at 15 mA. The + and − 12 Vdc supplies are used in the low-pass filters and are also regulated down to + and − 5 Vdc. The + 5 Vdc is used as the basic logic supply while the − 5 Vdc is used as a reference for the DAC. See **figs. 2-5** for pc board layouts and parts placement.

Bandwidth, sampling rate, and low-pass filters

When designing a digital voice storage device, pay careful attention to the interrelationship between audio bandwidth, digital sampling rate, and low-pass filter roll-off characteristics.

Audio bandwidth is usually determined by the frequency response of external electronics — in this case a typical narrowband FM voice channel. Assume a maximum frequency response of 5 kHz and you have just cast in concrete the minimum requirements for sampling rate and low-pass filter roll-off characteristics.

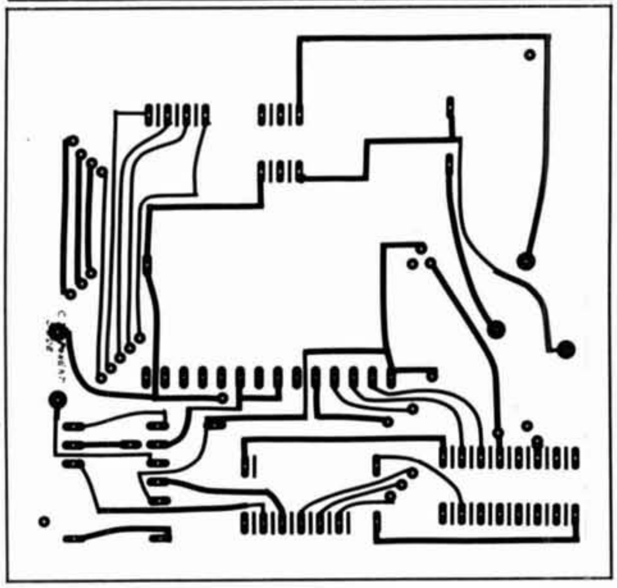
According to the Nyquist sampling theorem, a sine wave must be sampled a minimum of two times per cycle to be faithfully recreated. This project demonstrates this basic theorem. Because you've chosen 5 kHz as the maximum audio frequency, you must sample the signal at least 10,000 times per second and the low-pass filters must roll off at 5 kHz. Roll-off is usually measured in dB per octave; how much is needed?

When you violate the sampling theorem, a phenomenon known as aliasing results if you attempt to reproduce a frequency higher than the sampling rate allows. This makes the sine wave sound like a bucket of rusty bolts! Consequently, the low-pass filters must remove any detectable signal level in the frequency range above the Nyquist limit. The minimum detectable signal level is related to a property known as dynamic range, which is also expressed in dB and represents the amplitude range between the minimum and maximum reproducible levels.

This circuit uses an 8-bit DAC which gives 256 possible voltage level outputs with a maximum of 5 Vdc and a minimum of $5/256 = 0.0195$ Vdc output. The formula for figuring dynamic range in dB, 20 log out/in, shows that this circuit has $20 \log 5/0.0195 = 48$ dB of dynamic range. Figure the dB roll-off for the filter. Remember that the low-pass filters must attenuate the nonreproducible audio frequencies (in this case above 5 kHz) below the minimum signal level out (0.0195 Vdc). By convention, roll-off is chosen to produce a maximum reproducible output of one half the minimum reproducible level, or $0.0195/2 = 0.0097$ Vdc. The required roll-off is then dB $= 20 \log 5/0.0097 = 54$ dB.

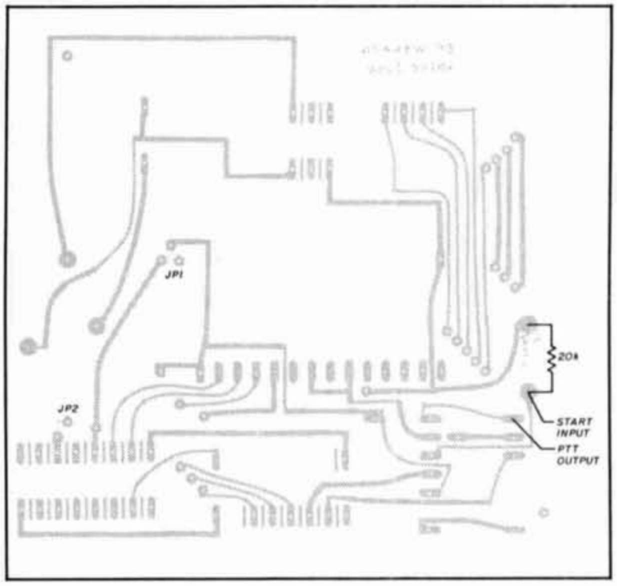
My primary concerns for the active filter design I chose for this project were price and parts availability. I didn't

FIGURE 4



Component-side foil pattern for the circuit.

FIGURE 5



Foil-side component placement guide.

rule out performance compromises in order to keep the construction simple. Active filter design is somewhat of a "black art" at best, even with the help of *The Active Filter Cookbook.* Design work often requires oddball, impossible-to-locate resistor and capacitor values, which I refused to accept.

The filter I settled on may not suit the taste of a mathematical purist but, at the cost of $1.00 each in parts, it can't be beat! I tested standard "off the shelf" 5-percent component values; they yielded very satisfactory results.

I needed a 54-dB roll-off, 5-kHz filter. The *Active Filter Cookbook* showed that a series of 5 second-order, equal component Sallen-key low-pass sections would fit the bill. Each second-order section gives 12 dB of roll-off. For economic reasons, I wanted to implement the entire filter on one LM-324 quad op amp. I designed a 4-section filter string which yielded about 48 dB per octave roll-off. The performance of the 48-dB filter was unacceptable so I changed the component values to the next higher 5-percent value. This, in effect, lowered the cut-off frequency of the filter below 5 kHz (a necessary compromise in order to give a 54-dB roll-off at 5 kHz). The final filter is pure simplicity: 2 resistor values, 2 capacitor values, and one 30-cent op amp!

Programming the voice ROM

You can program the voice ROM only with the aid of a personal computer. I plan to write another article on digital voice storage on the IBM PC. The hardware to implement voice storage on the PC is simple and provides the ability to directly program ROMs. The capability to store and retrieve voice on the PC offers a myriad of possibilities for automating the ham shack.

If you can't wait to find out how to program your ROM with the PC, I'll program it for you if you send me your EPROM, a good quality cassette recording of the voice passage you want programmed, and $10 to cover postage and handling.

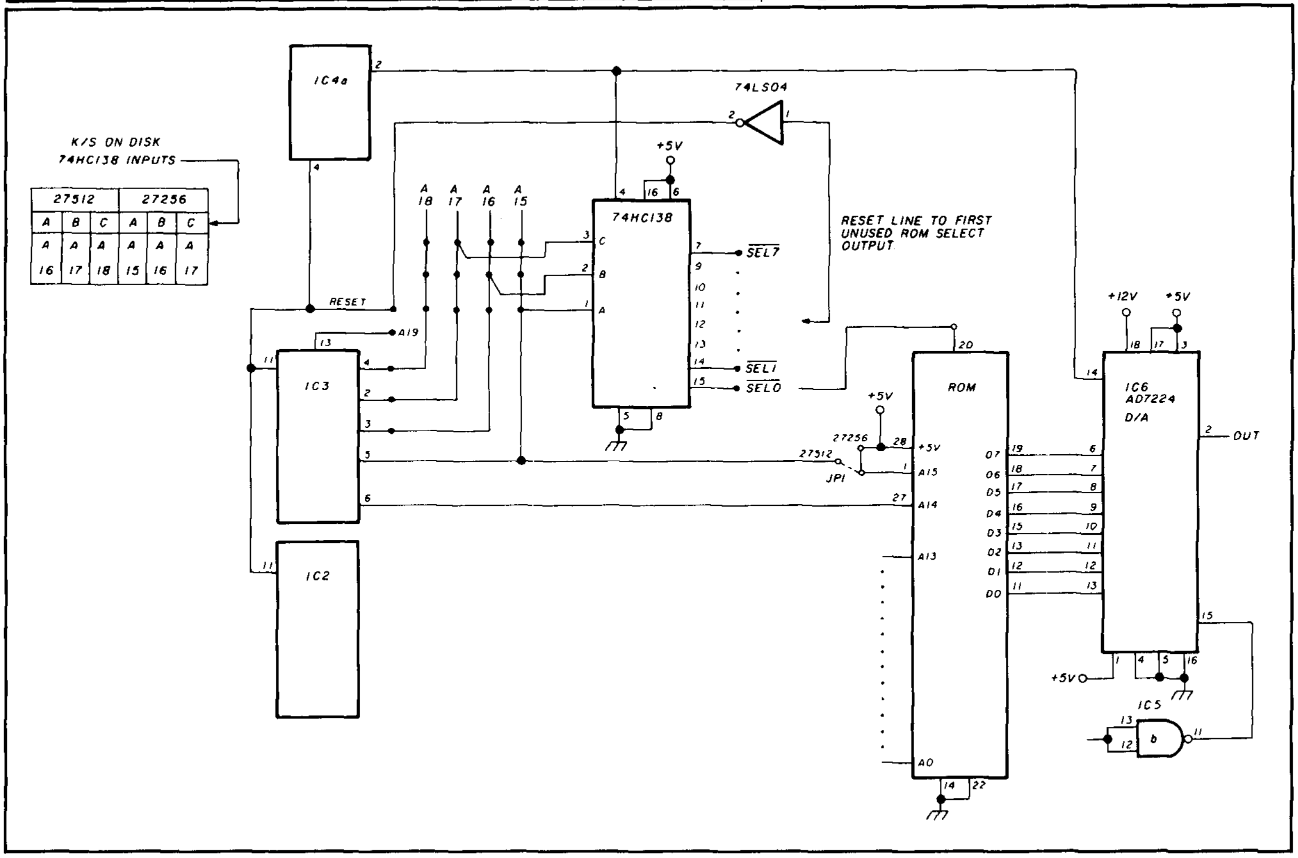
Modification of other ideas

This basic circuit has many uses beyond a repeater ID'er. You can prepare a canned message CQ caller for contests, create a beacon ID'er, or use the circuit as an instant touch-tone dialer for your favorite phone numbers. You can store any audio signal with frequency components under 5 kHz, including packet and SSTV transmissions. Because all the low-pass filter stages are DC coupled, the device can also store a serial TTL-level digital signal, provided that you keep the rate below 5K baud. I've used a similar unit to store digital test messages previously obtained from cassette tape in my professional work. Some useful changes you may wish to make include:

- Provide the ability to store two short messages in one ROM.
- Increase the length of storage time by adding more ROMs.

Both of these changes can be added easily. If you'd like to place two messages with a length of up to 3.2 seconds each into a 27512 ROM, simply select JP2 to provide a run time of 3.2 seconds and remove JP1. You can select two messages by way of an external ground applied to pin 1 of the ROM, if you place a 4.7-k resistor from pin 1 of the ROM to +5 volts. This divides the ROM space in half because pin 1 of the ROM is address bit A15. The 4.7-k pull-up resistor normally supplies a logic 1 to the A15 bit of the ROM; this selects the first message.

FIGURE 6



Schematic of the multi-ROM modification to allow expansion for up to 8 ROMs.

Select the second message by grounding A15 from an external source like a switch. I've used this scheme several times for repeaters by placing the normal callsign in the first half and a burglar alarm message in the second. I control the choice of messages with a switch on the door of the repeater building.

You can increase the length of the stored message by adding extra ROMs. All you need is an additional decoder chip to select them in sequence. Each additional ROM is wired in parallel with the first one, except for the chip select line pin 20 which is tied to one of the decoder outputs. Pin 22 of all ROMs must go to ground.

One 74HC138 octal decoder allows expansion of up to 8 ROMs; more than this will require extra buffering for the counter address bits. Using 27512 ROMs will give a maximum of 51.2 seconds of voice; 27256 ROMs will give you 25.6 seconds. When you use an extra decoder, the reset signal is derived from the next unused ROM select output of the decoder. For example, assume that you need a circuit containing 5 ROMs. The 74HC138 decoder has 8 outputs labeled from 0 to 7. Ouput 0 would go to the first ROM, output 1 to the second ROM, output 2 to the third, output 3 to the fourth, and output 4 to the fifth and last ROM. Output 5 of the decoder goes low after the last ROM is triggered, so output 5 must be inverted and used as the reset signal for the run/stop latch and the binary counters. (See **fig. 6**.)

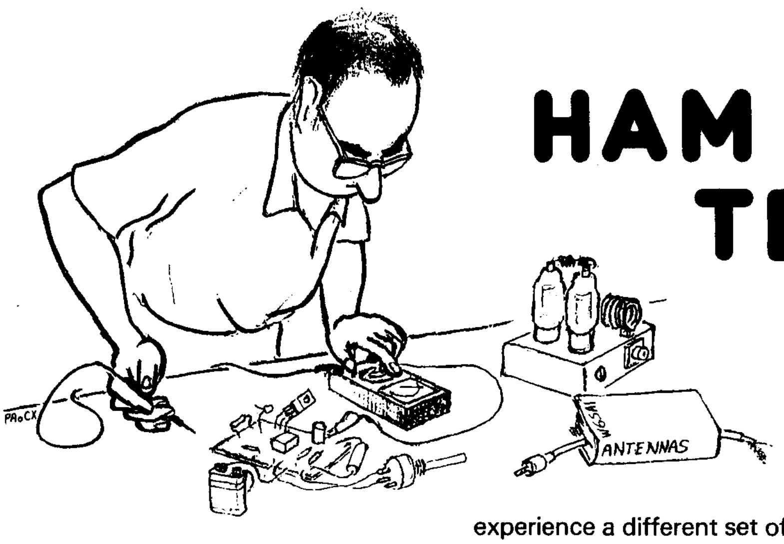
I hope I've helped give you a basic understanding of digital voice storage principles, and that you're eager to apply this device to your own projects. With a little ingenuity and logic you can modify the circuit to meet your own needs. Next time I'll discuss adding voice to the IBM series of computers and clones and the PROM programming procedure.

Article A **HAM RADIO**

A circuit board and parts kit are available from the author for $50.00 (ROM not included). Price includes one free programming of a ROM.

DECEMBER WINNERS

Congratulations to J.H. Defriend, WD6DTD, our December sweeps winner and W.C. Cloninger, Jr., K3OF, author of December's most popular WEEKENDER — "Get the Most from Your NiCds." Both will receive a handheld radio. To enter for February's drawing, send in the evaluation card bound into this issue, or submit a WEEKENDER project. You could be our next winner! *Ed.*



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

"Son of Woodpecker," or, more of what we don't need!

The good news is that the sunspot cycle is rapidly rising and the MUF is increasing. Ten meters is now a *real* DX band. The bad news is that the rising MUF has revealed some noxious interference in the Amateur bands, and it's bound to get worse before it gets better.

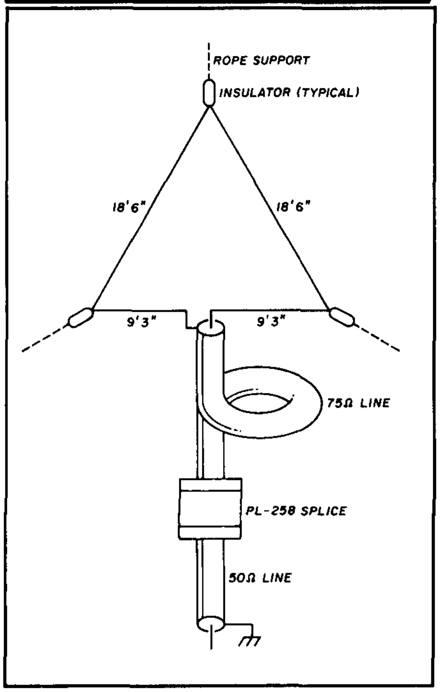
The interference I'm referring to is the "son of Woodpecker" radar signal in the 12-meter band. This buzzing source of interference is centered around 24.95 MHz and seems to be missile-tracking radar. It has a high repetition rate and sounds like a bumblebee. The signal peaks during the afternoon hours, indicating it's to the west of the Continental United States. When propagation is good, the buzzing noise blankets a large portion of the 12-meter band.

Direction-finding exercises have spotted the radar in the vicinity of Lake Baikal, and south of the city of Ulan-Ude, Siberia. I don't know if the radar runs continuously; I've only heard it at those times of the day when the MUF is high enough to support a propagation path between Central Asia and the United States. Unfortunately, the radar signal will become more disruptive as the MUF rises. And when the radar is absent, the "Woodpecker" takes over! What's next?

"Quickie" antennas for 18 MHz

It's fun to get on a new band and experience a different set of operating conditions. When the 24-MHz band was opened for general Amateur use, I found this band's propagation modes quite different from those on either the 21 or 28-MHz bands. As more Amateurs gain experience on 18 MHz, they'll find the propagation different from that on 14 or 21 MHz. I have monitored 18 MHz for years and have run transmissions using an experimental license (KM2XDW). Propagation experiments with the Cocos-Keeling Islands and India show that 18 MHz will quickly earn a reputation as a first class DX band!

FIGURE 1



Delta loop for 18 MHz. Coax transformer is 9 feet long, plug tip to plug tip. It's wound into a coil about 6 inches in diameter.

You can't do much on any band without an antenna. Here are several "quickie" antennas specifically for 18 MHz that are easy to build and put into service. They're designed to be hung from a yardarm on an existing tower. Because these antennas have their own feedlines, you don't need to disturb anything in the primary antenna system. The tower doesn't affect their operation, and the wire antennas don't interact with the antenna atop the tower.

The 18-MHz delta loop

The delta loop in **fig. 1** is a good "first" antenna for 18 MHz. It has a slight gain over a dipole and is very "user friendly." The feedpoint impedance of the loop is about 120 ohms. Use a 75-ohm quarter-wave transformer to provide a reasonable match to a 50-ohm coax line. The transformer is wound into a coil to choke off RF currents that might flow on the outside of the coax shield.

The feedpoint of the loop terminates in an SO-239 coax connector mounted on a small insulator plate. The transformer has PL-259 plugs on both ends. Make the splice between the transformer and the 50-ohm line with a PL-258 splice adapter. After making the connection, weatherproof the plugs and adapter with coax tape or heat-shrink tubing.

The loop is supported at the apex and the side insulators are tied off to objects nearby. The radiation pattern is similar to that of a dipole and is horizontally polarized.

A multiband version of the delta loop

You can operate the delta loop on the 18, 21, 24, and 28-MHz bands if

America's Communications Leader Presents Its All-New 10-Meter SSB/CW Mobile Transceiver

Realistic, America's premier brand of scanners, CB radios and satellite TV systems introduces the HTX-100, the perfect first rig for a beginning Ham and a superb 10-meter mobile radio for any amateur. It's compact, yet loaded with "big rig" features.

Pushbutton Memory Tuning

An easy-to-program memory stores 10 favorite frequencies and mike-mounted pushbuttons permit safe and easy up/down frequency selection while you drive. A front-panel lock control prevents accidental frequency changes. You can fine-tune reception with the ±1.5 kHz RIT control. Coverage is 28.0 to 29.6999 MHz, USB or CW. Convenient semi break-in keying and CW sidetone are built in.

Ultracompact and includes everything you need for underdash installation

Selectable Power Output

You can select 25-watt or 5-watt QRP power output from the front panel. The HTX-100 has a backlit LCD frequency display with mode and tuning-step indicators. You also get a 5-step LED signal/RF power meter, noise blanker, hefty 3-watt audio output, high-quality built-in speaker, front-panel headphone jack and a rear-panel jack for adding an external speaker.

Join the Action on "10"

With improving band conditions and new Novice voice and digital privileges, the 10-meter fun is just beginning. Be a part of it with this affordable, top-quality transceiver! Only $259.95 and in stock today at our store near you.

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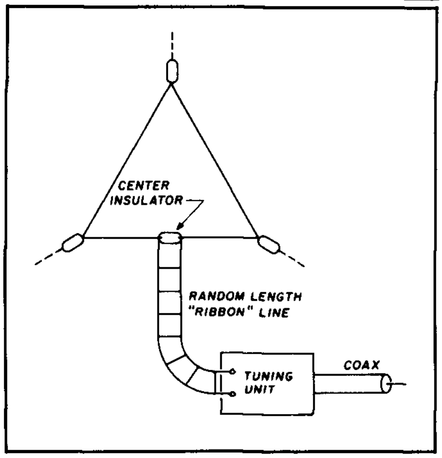
FIGURE 2



Balanced line feed with antenna tuning unit at station permits multiband operation of delta loop shown in *fig. 1*.

you feed it with a two-wire balanced line as shown in **fig. 2**. Transmitting-type 300-ohm ribbon line is satisfactory. You can also use open-wire style line. Match the line to a coax feed system by way of an antenna tuner (ATU or Transmatch) located at the station.

If you have difficulty loading the antenna on a band, change the length of the line between the antenna and the ATU. There is a standing wave on the line, and a particular line length may present an unacceptable load to the tuning unit. To solve this problem, add a few feet of line (a foot at a time) until you get a satisfactory match.

The bi-square array for 18 MHz

The diamond-shaped bi-square beam is much larger than the delta loop, but provides about 3-dB gain. This is a great antenna to try if you have the space. It's shown in **fig.3**.

The loop is a half wavelength on a side and open at the top. The feedpoint impedance at the bottom of the loop is about 2900 ohms; I use a two-wire 600-ohm quarter-wave stub to provide a more reasonable impedance value of about 122 ohms. Match it to a 50-ohm coax line by adding a quarter-wave transformer made of 75-ohm coax. Wind the 75-ohm line into a coil about 6 inches in diameter to reduce RF currents flowing on the outside of the coax. Under these conditions, the SWR on the transmission line is less than 1.2:1 across the band once the antenna is adjusted for resonance.

Tuning the antenna

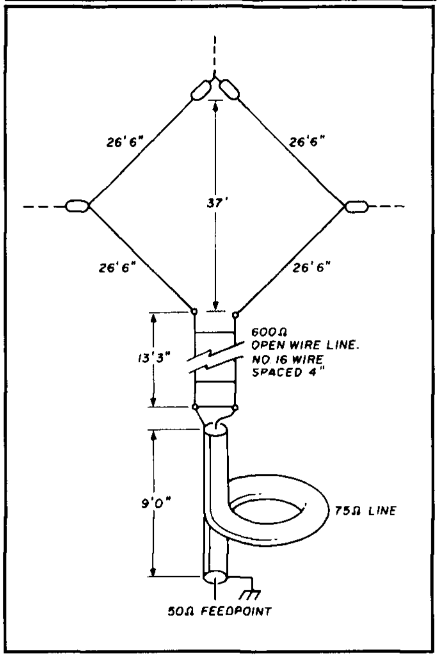
Resonate the loop and stub to 18.1 MHz with a dip meter. Temporarily close the stub at the bottom using a movable short with a 1-turn loop in the middle. I made mine with two copper alligator clips so I could move it up and down the stub a few inches. I adjusted the position of the short until I achieved antenna resonance with the dip meter, as monitored in a nearby receiver. As soon as you find the resonance, remove the short and place an SO-239 coax receptacle across the bottom of the line.

You'll need to waterproof the coax receptacle and all plugs and splices in the system. It's imperative to use coax tape or other weatherproofing compounds to keep water out of the line.

An extended dipole for 18 and 28 MHz

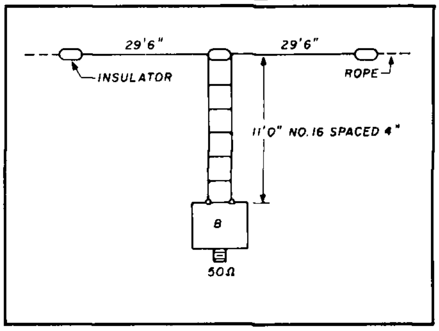
The extended dipole in **fig. 4** will work on the 18 and 28-MHz Amateur bands. I discussed the theory behind this antenna in my April, 1987 *Ham Radio* column. The antenna consists of two extended half waves in phase on 18 MHz, fed by an open-wire matching stub. The total wire length of antenna and stub on 10 meters is about 2-1/2 wavelengths. You can achieve a good resonance on both bands. The feedpoint impedance is close to 50 ohms.

FIGURE 3



"Bi-square" beam provides a bi-directional pattern and about 3-dB gain over a dipole. Note that top of loop is open.

FIGURE 4



Dual-band dipole is fed with open-wire section and 1:1 balun (B). Antenna may be mounted in inverted-V configuration.

The antenna presents a typical dipole radiation pattern on 18 MHz; on 28 MHz the pattern has a cloverleaf shape.

Use a 1:1 balun at the feedpoint or coil the coax line into a 5-turn RF choke, as described for the previous antenna.

A trap dipole for the 18 and 24-MHz bands

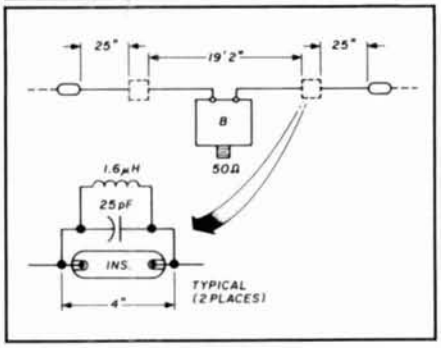
This simple trap antenna covers the 18 and 24 MHz bands and makes an ideal companion to a tribander beam. The two antennas cover all bands between 20 and 10 meters at the flick of a coax switch.

A practical design is shown in **fig. 5**. The trap is designed around a 25-pF 5-kV ceramic capacitor. You can find some of the older Centralab-type 850 capacitors at flea markets. High Energy Corporation, Lower Valley Road, Parkesburgh, Pennsylvania 19365, manufactures new capacitors. The coil is made of Barker and Williamson coil stock. The coil-capacitor combination is mounted to a short ceramic insulator, as shown in the illustration.

Before placing the traps in the antenna, check their frequency with a dip meter and a calibrated receiver. The design frequency is 24.95 MHz. Place the trap in an area free of metallic objects and couple it loosely to the dip meter. Note the resonant frequency; it should be within ± 100 kHz, of the design frequency.

One end turn of each trap can be broken free of the coil bars, and moved about or trimmed to set the exact point of resonance. Do this after attaching the trap to the insulator — the capacitance across the insulator influences the resonant frequency of the trap to a degree.

FIGURE 5



Trap antenna for 18/24 MHz. Trap is mounted across ceramic insulator. Coil consists of 12-3/4 turns, no. 20, 5/8-inch diameter, 16 turns/inch. (Barker and Williamson 3007.)

You can trim the end sections "on the nose" by erecting the antenna in the clear about 6 feet above the ground. Place a half-turn coil across the center insulator of the antenna and check the 18 and 24-MHz resonances with a dip oscillator. Removing 1 inch on each side of the center sections moves the resonant frequency 100 kHz at 24.9 MHz. You must adjust the inner sections before resonating the tip sections. I cut my tip sections about a foot long and twisted the extra length back on the antenna. I took off the extra length upon reaching the right resonant point at 18.1 MHz. The SWR across either band will be less than 1.5:1 when the antenna is in place.

A really simple shortwave receiver

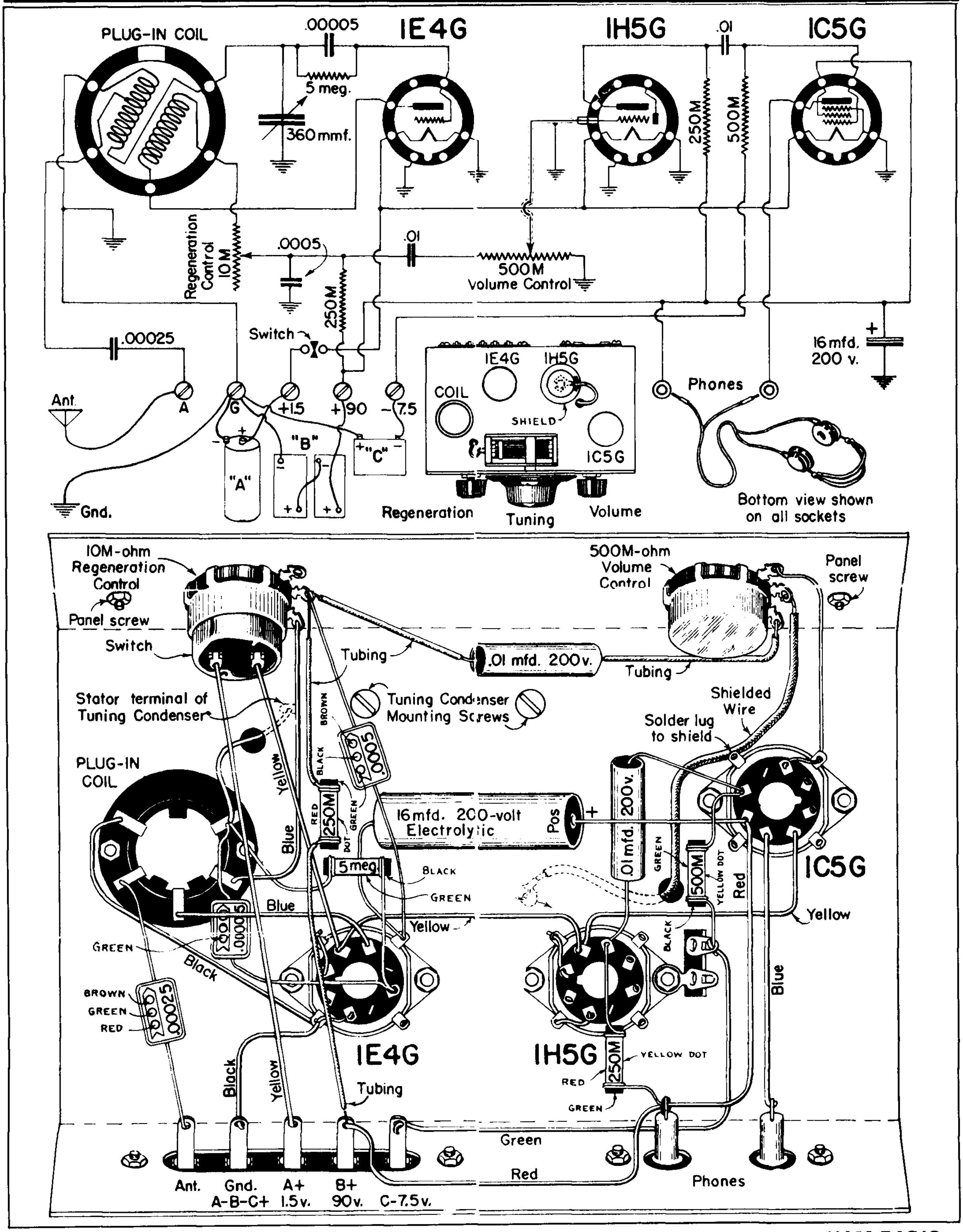
Are you tired of modern high-tech radios? Do you yearn for the good old days when radios had only a couple of knobs? Well, **fig. 6** shows the receiver for you. The radio uses only three tubes and runs on inexpensive A, B, and C batteries. I've included a layout of the aluminum chassis to help you build this little set. You say your local ham store doesn't carry plug-in coils, radio tubes, tube sockets, tuning capacitors, etc? Well, what does it carry?....Oh!

The W6SAI "Dead Band" contest

I salute my readers who spotted the quotation from *Catcher in the Rye*, by J. D. Salinger. The remark was made by the anti-hero, Holden Caulfield. Kudos to the following with a special salute (*) to those who really know their rye:
Tony Emanuele, WA8RJF; Lou Axeman, N8LA (*); Bill Wootton, WO7J; Steve Buol, KBØBDS; David Raskin, W5TYL; Jim Fox, N7ENI; Jack Starin, WF8M; Bob Eslaire, W9UI/8; Larry Walsh, W5SMA; Martha Wilder, N3FZB; Phil Brandt, W3ELJ; Bruce Rossi, NF7J; Jim Lignugaris, N2IDV; Dick Olson, NSØW; Marty Johnson, W3YOZ (*); Marty Davidoff, K2UBC (*); Preston Douglas, WA2IFZ; Roger Leone, K6XQ; Serafino Conflitti, VE3LKN; Eric Nichols, KL7AJ; Bill Calderwood, K1CT; Roger Tobin, N1EYZ; and Frank Smith, W4EIN. Congratulations to all!

School is out and this is winter break. No quiz this month. Instead, I want to recommend a great book. It has nothing to do with Amateur Radio, but it's the best adventure story I've ever read. It covers territory from Vladivostok to Odessa in an exciting tale about two great men. *The Cowboy and the Cossack*, by Clair Huffaker was published by Trident Press, New York (1973). Unfortunately the book is out of print, but it's worth your time to check in a second-hand book store. This is a wonderful book to read when the band is dead!

FIGURE 6



Article B **Schematic of 3-tube regenerative receiver. Just the thing for the new Amateur!** **HAM RADIO**

THE WEEKENDER

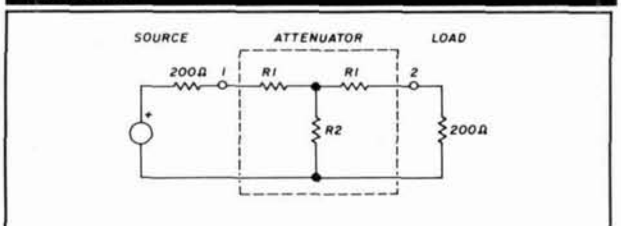
High-impedance rotary step attenuator

Need a step attenuator? I was building ladder crystal filters and wanted an attenuator to help in making the passband measurements. I only needed a few steps, and a rotary switch similar to one made by W9ERU[1] was more appealing to me than the laboratory type[2] with banks of slide switches. A 200-ohm impedance level is appropriate for the filters. But you can construct any impedance level by using resistors scaled to the values shown here.

Switch

You'll need a 3-deck rotary switch to select the proper resistors for the T-Network shown in **fig. 1**. My junkbox yielded a 7-position one. I selected attenuation values of 0, 3, 6, 12, 20, 30, and 40 dB as convenient values for my crystal filter work. You can duplicate these if your switch has 7 positions, or calculate the resistors for any other number of positions or dB values using the information at the end of this article. Tables of resistor values (50 ohms) also appear in recent editions of *The ARRL Handbook*.[3]

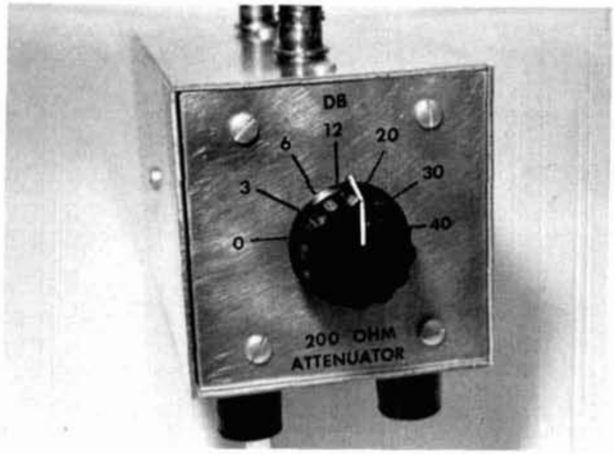
FIGURE 1



Schematic of the basic T-Network on which the step attenuator is based.

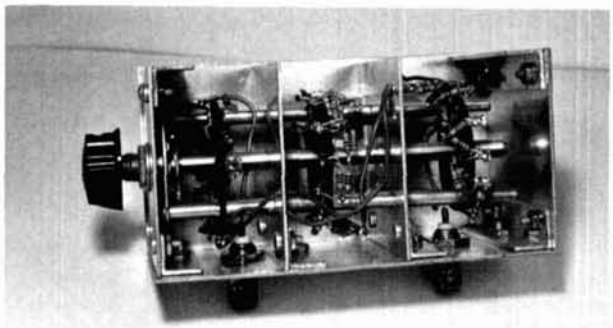
By John Pivnichny, N2DCH, 3824 Pembrooke Lane, Vestal, New York 13850

PHOTO A



Front panel view of the step attenuator. Note attenuation values labeled on the front.

PHOTO B



Internal view of the step attenuator showing partitions used for additional RF shielding.

Enclosure

You can mount the switch in a 2-1/2″ × 2-1/2″ × 5″ homebrew box. Sheet aluminum 0.05″ thick, cut on a metal shear makes a neat box. I also included two shield partitions (also 2-1/2″ × 2-1/2″) to prevent stray coupling between switch decks. One-half inch aluminum angle stock, 1/16″ thick, holds the sheet metal pieces together forming a rigid and rugged box. See **photos A** and **B** for details. Note that the bottom plate is exactly 2-1/2″ × 5″, but the top and sides are cut slightly wider (2-9/16″ × 5″) to provide proper overlap of the adjoining edges. I fastened four rubber feet to the bottom plate. As a finishing touch, I applied dry-transfer letters and India Ink to the front panel after buffing with emery paper. I used clear spray lacquer to protect the letters and keep them from rubbing off.

Resistors

The necessary resistance values for R1 and R2 in **fig. 1** are listed in **table 1**. The power rating is also important. For example, in the 3-dB position half of the input power

TABLE 1

Resistor values for R1 and R2.

dB	R1 (ohms)	R2 (ohms)
3	34	567
6	66.8	268
12	120	108
20	163.6	40.5
30	188	12.6
40	196	4

TABLE 2

Resistor values in *fig. 2*

	ohms	1/4-watt resistors (ohms)
Ra	34	68 P 68
Rb	34	15 S 18
Rc	53	100 P 110
Rd	43	22 S 22
Re	25	47 P 56
Rf	8	15 P 15
Rg	4	12 P 12 P 12
Rh	8.5	15 P 15
Ri	28	56 P 56
Rj	65	150 P 120
Rk	157	330 P 330
Rl	300	150 S 150

S = series connection
P = parallel connection

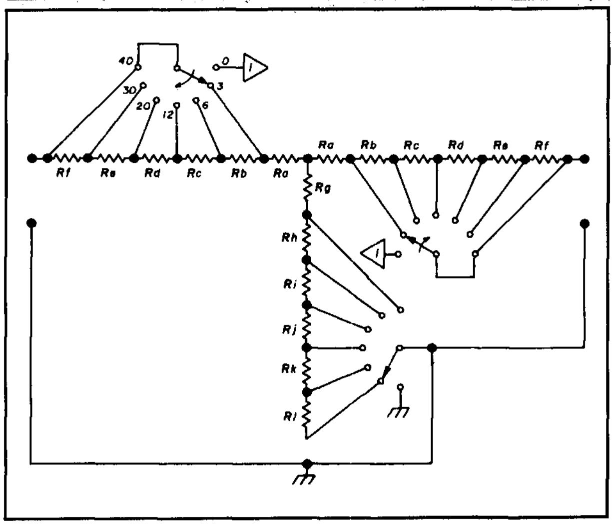
is delivered to the load and the other half must be dissipated by the resistors in the T-Network. At 6 dB, 75 percent of the power is dissipated in the T-Network; at 40 dB, only 0.01 percent goes to the load.

With power in mind, use a series connection of resistors so the power is shared. **Figure 2** shows the final schematic and **table 2** lists the series resistor values. These aren't standard values, so make a reasonable approximation to Amateur accuracy ($\pm$ 2 percent or so) by selecting two nearly equal standard values and connecting them in parallel or series to obtain the values in **table 2**. (The 4-ohm value is made with 3 12-ohm resistors in parallel.)

I used 1/4-watt resistors as indicated in the last column of **table 2**. Each individual resistor of **fig. 2** can therefore dissipate 1/2 watt. A careful calculation of power shows that this attenuator handles up to a 20-volt RMS (56 volts p-p) input voltage, or 2 watts. At that level the 53-ohm resistor will dissipate almost 0.53 watt at 12 dB and greater positions. The remaining 1.5 watts is dissipated in the other resistors, all of which are safely below a half watt each.

Crystal filters can be damaged by excess voltage. I don't recommend putting 20 volts into one. This attenuator will easily handle the signal levels you normally encounter.

FIGURE 2



Schematic of the step attenuator using a 7-position 3-deck rotary switch.

Checkout

After completing the attenuator, make two tests to ensure that there are no wiring errors. First, attach a 200-ohm load to one of the connectors (I used two 390-ohm, 1-watt resistors in parallel). Measure the resistance at the other connector with your ohmmeter. It should read 200 ohms at all switch positions. Repeat this test with the connections reversed.

Second, apply a 20-volt DC potential at one connector with the load attached at the second connector. Read the voltage across the load at each switch position and compare it to **table 3**. As before, repeat this test with the connections reversed.

Conclusion

You now have a rotary step attenuator for crystal filter measurements. It's a handy accessory that takes only a weekend to build.

TABLE 3

Output voltage readings with 20 volts at the input

dB	volts
0	20
3	14.4
6	10
12	5
20	2
30	0.63
40	0.2

Appendix — resistor value calculation

Refer to **fig. 1**; the resistance looking into node 1 must be 200 ohms.

$[(200 + R1) \| R2] + R1 = 200$

$$\frac{(200 + R1)\,R2}{200 + R1 + R2} + R1 = 200 \qquad (1)$$

after some algebra:
$R1^2 + 2R2R1 - 200^2 = 0$
by the quadratic formula:

$$R1 = -R2 \pm \sqrt{R2^2 + 200^2} \qquad (2)$$

reject the negative value and define:

$$P = \frac{(200 + R1)\,R2}{200 + R1 + R2}$$

then the attenuation is given by the voltage dividers:

$$\frac{V2}{V1} = \frac{200}{200 + R1} \cdot \frac{P}{R1 + P} \qquad (3)$$

The procedure for calculating resistor values is as follows:

- Pick a value for R2.
- Compute R1 using **eqn. 2.**
- Compute P.
- Compute attenuation V2/V1 using **eqn. 3.**
- Compute dB from $dB = -20 \log_{10}(V2/V1)$.

You can write a short BASIC program with any small home computer to perform these calculations. A for-next loop with values of R2 from 1-400 ohms will generate R2 values to the nearest ohm. Use additional loops in 0.1-ohm steps to calculate more accurate values.

Note: Not all versions of BASIC have the base 10 logarithm function. To convert from the base e natural logarithm to base 10, multiply the base e result by 0.43429.

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1. Eugene A. Hubbell, W9ERU, "A Step-Type R.F. Attenuator," *QST*, vol. 43, no. 12, December 1959, pages 20-22.
2. Bob Shriner, WA0UZO, and Paul K. Pagel, N1FB, "A Step Attenuator You Can Build," *QST*, vol. 66, no. 9, September 1982, pages 11-14.
3. *The ARRL Handbook*, Newington, Connecticut, 62nd edition, 1985, page 25-44.

Article C **HAM RADIO**

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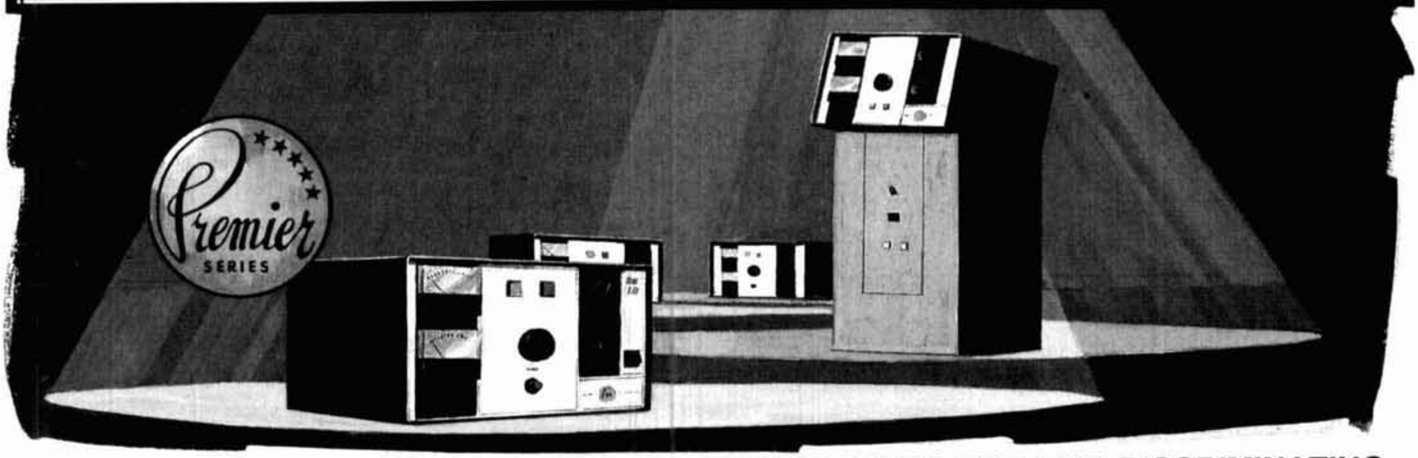

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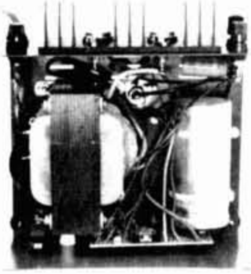

INSIDE VIEW — RS-12A

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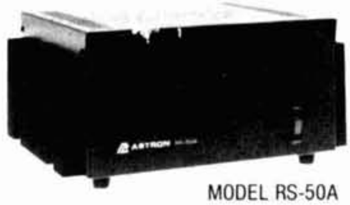
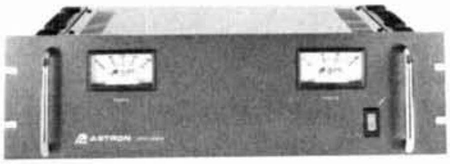


MODEL RS-50A

MODEL RS-50M

MODEL VS-50M

RM SERIES



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RM-35A	25	35	5¼ × 19 × 12½	38
RM-50A	37	50	5¼ × 19 × 12½	50
• Separate Volt and Amp Meters				
RM-12M	9	12	5¼ × 19 × 8¼	16
RM-35M	25	35	5¼ × 19 × 12½	38
RM-50M	37	50	5¼ × 19 × 12½	50

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RS-3A	2.5	3	3 × 4¾ × 5¾	4
RS-4A	3	4	3¾ × 6½ × 9	5
RS-5A	4	5	3½ × 6⅛ × 7¼	7
RS-7A	5	7	3¾ × 6½ × 9	9
RS-7B	5	7	4 × 7½ × 10¾	10
RS-10A	7.5	10	4 × 7½ × 10¾	11
RS-12A	9	12	4½ × 8 × 9	13
RS-12B	9	12	4 × 7½ × 10¾	13
RS-20A	16	20	5 × 9 × 10½	18
RS-35A	25	35	5 × 11 × 11	27
RS-50A	37	50	6 × 13¾ × 11	46

RS-M SERIES

MODEL RS-35M

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

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VS-12M	9	5	2	12	4½ × 8 × 9	13
VS-20M	16	9	4	20	5 × 9 × 10½	20
VS-35M	25	15	7	35	5 × 11 × 11	29
VS-50M	37	22	10	50	6 × 13¾ × 11	46
• Variable rack mount power supplies						
VRM-35M	25	15	7	35	5¼ × 19 × 12½	38
VRM-50M	37	22	10	50	5¼ × 19 × 12½	50

RS-S SERIES

MODEL RS-12S

- Built in speaker

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

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

THE L-MATCH

A useful tool for improving your SWR

By Robert C. Cheek, W3VT, 29 Center Drive, Briarcliffe Acres, Myrtle Beach, South Carolina 29572

How often have you carefully calculated the length of a dipole antenna, cut it to just the right length, used coax cable which should have given you a reasonably good match, and then found that the SWR just wouldn't go below 2:1? And how often did the SWR rise to an unacceptably high level in the phone portion of the band even though you had an acceptable match in the CW portion (or vice versa), especially on the 3.5 and 7-MHz bands? If your experience has been anything like mine, the answer is: "Almost always!" If you like to operate both phone and CW, the same experience probably applies to your Yagis on the higher frequency bands. You may have a good SWR in one segment of a band, but elsewhere it rises to a point where a modern transistorized rig automatically starts cutting down on power output.

Many modern transceivers have built-in automatic antenna tuners, and I suspect that's why we hear more on-the-air tuning these days. They are a lazy man's solution to poor SWR. Unfortunately, those already in contact with someone on the chosen tuning frequencies must continually pay for this practice.

Power amplifiers usually don't have built-in tuners. Even if you tune your amplifier into a dummy load first, you must touch up the tuning with your antenna connected if the SWR is more than about 1.3:1 (another excuse for on-the-air tuning). Wouldn't it be much better to have an SWR close to 1:1 in both the phone and CW segments of the band so all your tuning could be done with a dummy load? Then you could switch your rig to the antenna without further tuning and unnecessary QRM.

A universal antenna tuner with predetermined and carefully marked settings could solve these problems, if you had the patience to reset it each time you made a substantial frequency change. But a simpler, more compact, and less expensive answer to these and many other impedance-matching problems is a well-known, old-fashioned, but infrequently used technique — the L-match. This application of the L-match is mentioned very briefly in the *ARRL Antenna Book*.

I use several fixed L-match configurations; all are built into miniboxes (although I sometimes run 1500 watts PEP). One of these is permanently inserted at the input end of several different coax cables, each feeding a different antenna. Some have a switch to by-pass the network for operation on a frequency range over which the SWR is acceptably close to 1:1. The switches are within reach of my operating position.

This article shows derivations of formulas for calculating the reactances, and corresponding capacitance and inductance values, needed in an L-network to make a mismatched line appear to have 1:1 SWR. This makes it look like a desired pure resistance (normally you'll want 50 ohms) to the transmitter at a specified frequency. I've included a program in GW-BASIC for IBM PC compatible computers, but you can also use the formulas and a calculator with a square-root function to make the necessary calculations. The program selects all the possible capacitance and inductance configurations that provide a match for a given case and does the necessary calculations for each configuration. (There may be as many as four different combinations that will do the job for one set of conditions.) The program checks its own results by calculating independently the input impedance of the line with the matching network added, and comparing it to the desired input resistance. I've described a few actual networks to show the design procedure, some possible construction approaches, and the "before" and "after" results.

Some application notes

The L-match is more versatile than is generally recognized and understood. Theoretically an L-type network consisting of only two elements (a shunt element and a series element) can match any two complex impedances to each other at a given frequency, as long as the elements are perfectly lossless. Of course you can't have either inductors or capacitors of infinite "Q", and for applications involving very large impedance transformations there are some limitations. But in the application discussed here, the impedances to be matched aren't different enough to present a problem.

There are other limitations that should be considered in this application. One limitation is that although an antenna tuner (or any other matching device at the transmitting end of a coax line) may make the transmitter see a 1:1 SWR, it doesn't in any way affect the SWR in the line beyond the device. Losses in a mismatched line are higher than if the impedance were matched at the antenna end. Fortunately, this effect isn't serious if you use good quality cable in good condition — unless you have lines several hundred feet long at the higher frequencies (28 MHz or higher).

As SWR departs from the ideal 1:1, the voltage and the current at some points on the line become greater than those that exist uniformly on a matched line at the same level of power transfer. For example, at an SWR of 4:1 the voltage and current at some places along the line will be twice what they would be if the line were matched at the antenna end with the same power going into the antenna. Pay attention to the voltage rating and the current-carrying capacity of the line. The 5000 volt rating of the RG-213 cable gives plenty of margin for poor SWR, compared with the 275 volts present at 1500 watts when the line is matched. A cable connection is far more likely to break than the cable itself if the voltage is excessive at a connection point. The current rating (imposed by the possibility of cable damage due to internal heating) is a more important limitation. The same cable is rated at 3500 watts at 10 MHz, or about 8.4 A when the SWR is 1:1. With a 4:1 SWR, the current will reach about 11 A at 1500 watts. In our intermittent types of service, peak currents of this level at widely separated points on the line should cause no damage. But there's probably some cause for concern somewhere not too far above 4:1 SWR and above 10 MHz. These considerations apply to any input-end matching system.

To summarize: If you are running maximum legal power and using RG-213 or similar cable, I *do not* recommend that you use an antenna tuner or any other matching device at the transmitter end of a line to correct an SWR that exceeds 4:1. If your SWR is higher than that, you need to do some work on the antenna or the matching device at its end of the line!

The bandwidth of acceptable SWR is another important thing to consider for this application. The higher the SWR on the line, the greater will be the effect of the individual elements in the matching network at a specific frequency. This means that the effects of frequency variations will be more pronounced, and the bandwidth over which reasonable SWR correction can be obtained will be more limited. However, the overriding bandwidth effect will usually be that caused by the variation of the input impedance of the line. This is due to changing load (antenna) characteristics and the changing electrical length of the line as the frequency is varied. Because each antenna system has its own characteristics, it's impossible to generalize about this problem. I've found that with most antennas, the frequency ranges over which the SWR is acceptable are about the same with the networks in operation as they are in different parts of the same bands where the lines are properly matched. One exception to this is my 40-meter Yagi, on which the parasitic elements are optimized for the CW band. The self-resonant frequency of the director is quite near the upper end of the phone band, and the input impedance of the line varies rapidly as I approach that end of the band. So with a matching network designed to optimize the SWR in the phone segment, the bandwidth of acceptable SWR is slightly less than the entire phone band.

The calculation of the network elements' reactances, whether by the formulas or the computer program, first requires that the input impedance (resistance and reactance) of the line be measured fairly accurately. Do this at the frequency for which the SWR is to be corrected. To make the measurement you'll need either an RF impedance bridge (like the one described in the *ARRL Handbook* and the *ARRL Antenna Book*) or a high-quality noise bridge calibrated for reactance measurements. I've used both with good results, but you can use the noise bridge only when the frequency of interest is very quiet, so that the null is unmistakable.

Make the measurement at the exact point in the line where the matching network is to be inserted. Use any convenient length of cable from the network back to the transmitter. This cable length can be changed, but the length of the line between the antenna and the matching device must remain the same.

Formulas for calculating the L-match

An L-network consists of just two elements — a series element and a shunt element. The shunt element may be on the load side or the generator side of the series element, but there are certain conditions under which only one of these configurations provides valid solutions.

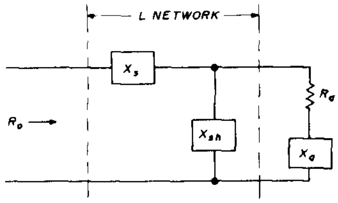
In the derivation of the formulas (shown in **figs. 1** and **2**), the desired impedance as viewed from the generator (transmitter) side is designated as R_o. The derivations assume that this impedance is to be purely resistive. The impedance of the load (the input to the coaxial cable terminated at its far end by the antenna) will have a resistive component (always positive), designated as R_a, and a reactive component (positive, negative, or in some cases zero), designated as X_a. The shunt element of the network is designated as X_{sh}.

Figure 1 shows the derivation of the formulas for the first configuration in which the shunt element is on the antenna side of the series element. The transmitter is connected through the series element to the parallel combination of the shunt element and the load. The real components are extracted to form one equation from the complex algebra expression of this circuit. The imaginary components that remain (with the "j" operators dropped) constitute a separate equation. The first equation is solved to get a formula for X_s, the series element. This formula can't yet be used for final calculation of X_s because it involves X_{sh}, which is still unknown at this point.

Next the equation derived from the imaginary components is solved for X_{sh}. The expression for X_s is substituted where X_s appears in this equation. This gives a quadratic equation for X_{sh}, which is solved by the quadratic formula to give X_{sh} in terms of the known resistances and reactances. After X_{sh} is calculated, X_s can be determined from the first formula.

There are always two mathematical solutions for X_{sh}, as indicated by the plus and minus signs before the square root. However, the configuration doesn't have a valid (real) solution for combinations of the variables that lead to a negative quantity under the square root sign. In such cases, the configuration is not physically realizable and can't be used.

FIGURE 1



R_o, the impedance seen by the transmitter, is the parallel combination of $R_a + jX_a$ and jX_{sh}, in series with jX_s:

$$R_o = jX_s + \frac{jX_{sh}(R_a + jX_a)}{R_a + j(X_a + X_{sh})}$$

This can be restated as:

$$R_oR_a + j(R_oX_a + R_oX_{sh}) = jR_a X_s - X_aX_s - X_sX_{sh} + jR_aX_{sh} - X_aX_{sh}$$

From the real terms:

$$X_s = -\frac{R_oR_a + X_aX_{sh}}{X_a + X_{sh}}$$

From the imaginary terms, substituting the above for X_s: $(R_o - R_a)X_{sh}^2 + 2R_oX_aX_{sh} + (R_oX_a^2 + R_oR_a^2) = 0$

Solving for X_{sh} by the quadratic formula:

$$X_{sh} = \frac{R_oX_a \pm \sqrt{R_o^2X_a^2 + (R_a - R_o)(R_oX_a^2 + R_oR_a^2)}}{R_a - R_o}$$

For either configuration, if X_s or X_{sh} (denoted as X below) is positive, calculate its inductance as follows, with F in kHz:

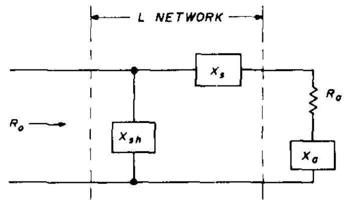
$$L = \frac{1000X}{6.28F}\ \mu H$$

If X_s or X_{sh} is negative, calculate its capacitance as follows:

$$C = \frac{-10^9}{6.28FX}\ pF$$

Derivation of formulas for first configuration.

FIGURE 2



R_o, the impedance seen by the transmitter, is jX_{sh} in parallel with the series combination of $R_a + jX_a$ plus jX_s:

$$R_o = \frac{jX_{sh}(R_a + jX_a + jX_s)}{R_a + j(X_a + X_s + X_{sh})}$$

This can be restated as:

$$R_oR_a + jR_o(X_a + X_s + X_{sh}) = -X_aX_{sh} - X_sX_{sh} + jR_aX_{sh}$$

From the real terms:

$$R_oR_a = -X_aX_{sh} - X_sX_{sh}$$

or

$$X_s = -\frac{R_oR_a}{X_{sh}} - X_a$$

From the imaginary terms, substituting the above for X_s:

$$(R_o - R_a)X_{sh}^2 - R_o^2R_a = 0$$

Solving for X_{sh} by the quadratic formula gives:

$$X_{sh} = \pm R_o\sqrt{\frac{R_a}{R_o - R_a}}$$

Use the formulas for L and C as given in **fig. 1**.

Derivation of formulas for second configuration.

In **fig. 2** an identical procedure is used to derive the formulas for the second configuration, in which the shunt reactance is on the transmitter side of the series element. Again there are two mathematically valid solutions, and again there are combinations of variables for which there is no real solution. This configuration has real solutions only when R_a, the resistive component at the cable input, is less than R_o, the resistive load to be seen by the transmitter.

Despite the range of variables for which there is no usable solution in one or the other of the configurations, one of them always has a real solution for a given set of variables. In many cases both configurations are applicable, and for such cases there are four different possible combinations of reactive elements to choose from.

Generally, the best choice is the one involving the most practical values of inductance and capacitance. From the standpoint of physical size and losses, a lower value of inductance is preferable to a higher one. For harmonic attenuation, a combination using shunt capacitance and series inductance is preferable to one using shunt inductance and series capacitance.

The L-match computer program

The computer program (**fig. 3**) uses the formulas derived in **figs. 1** and **2** to compute the reactance values and corresponding capacitances and inductances in all the usable configurations for a given set of conditions. The program is written in GW-BASIC and should run successfully on any IBM-compatible personal computer.

The two configurations are examined in turn. The first to be examined is the one with the shunt reactance on the antenna side of the series reactance (the first configuration). An error-trapping routine detects situations in which the square-root calculation would involve a negative quantity, or where there is an attempted division by zero. In these situations there is no real solution for the configuration. The error-trapping routine reports this fact and routes the program to the calculation of the second configuration, for which similar error trapping is provided.

As the reactances for each case are determined, a subroutine (lines 3000 through 3110) checks their values by using them to calculate and display the impedance seen by the transmitter with the matching network in place. Line 3080 compensates for small rounding and computing inaccuracies (up to 0.1 percent) in comparing the resistive component of the result with the desired resistive load. In the result, line 3090 rounds to zero any final reactive component of less than 0.1 percent of the resistive component. If single-precision computation were used, these inaccuracies (which occur primarily in the checking routine) might exceed the limits in rare cases where the computations involve small differences in large quantities. All computation is done in double precision. But the checking routine is correspondingly accurate only if the program is run with BASIC loaded with the double-precision transcendental math package (BASIC/D) that improves the precision of the trigonometric functions used. If you don't use BASIC/D, a reactive component exceeding 0.1 percent of R_o (but still negligible) may appear in rare cases in the check result.

In any case, results stated in single precision are more than adequate for your purposes. So all computed values to be displayed are converted to single-precision numbers before they are presented.

Some practical L-network matching devices

In the networks I'll describe, all parts except the miniboxes are from flea markets or my junkbox.

I avoid using variable capacitors because they're bulky, expensive, and hard to find. Also, once you've determined the capacitance, no further change is required in this application.

When winding the coils, I estimate the number of turns required from the formulas given in the *ARRL Handbook*, and then wind about 20 percent more. With the network completed (except for final connection of a flexible lead to one end of the coil), I install the device in the line and connect it directly at the output of my SWR meter. Using very low power at the design frequency, I move the lead across the coil to find the tap point that gives minimum SWR. The minimum is usually quite close to 1:1; if it's not, I may need to do some trimming of the capacitance by adding small values in parallel with it or changing to a slightly lower value. When I find the proper combination, I solder the tap and clip off most of the unused coil turns. Before removing all the unused turns, I check the final combination with the box cover installed. Sometimes the coil inductance is lowered by the proximity of the shielding, and the final coil may require an additional turn or two to provide the same inductance as with the cover off.

I have also used manufactured coils (e.g., Miniductors) with equal success. The *ARRL Handbook* also gives information for estimating the inductance of these coils for different diameters and turns per inch.

160-meter dipole

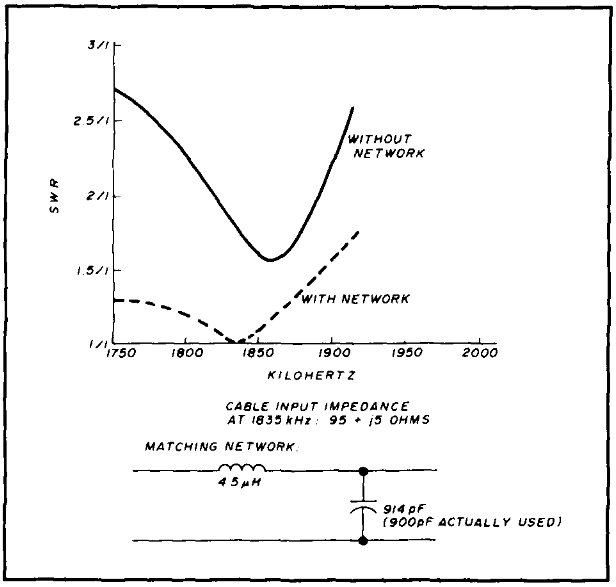
Figure 4 shows the original SWR curve at the input end of the 50-ohm line to my 160-meter dipole. The minimum SWR is 1.6:1 at 1860 kHz. I normally confine my 160-meter operation to the CW and DX portions of the band (1800 to 1850 kHz). I do most of my operating around 1835 kHz. The SWR on this frequency is 1.8:1. It's actually impossible to tune the amplifier properly with this antenna, because the range of its loading capacitor is severely limited by the heavy padding it requires on this band. As a result, it runs out of range very quickly as the load impedance departs from 50 ohms resistive.

FIGURE 3

```
1000 RO=0:RA=0:XA=0:XSH=0:XS=0:DEFDBL A-Z
1010 CLS:INPUT"FREQUENCY (KHZ)";F
1020 INPUT "DESIRED LOAD RESISTANCE";RO
1030 INPUT "RESISTANCE LOOKING TOWARD ANTENNA";RA
1040 INPUT "REACTANCE LOOKING TOWARD ANTENNA";XA:PRINT
1050 IF RA=RO THEN PRINT TAB(5)"NO SHUNT REACTANCE REQUIRED":XS=-XA:PRINT:GOSUB
2030:GOTO 4500   'Special Case. Calculate XS and go directly to end.
1060 PRINT "WITH SHUNT REACTANCE ON ANTENNA SIDE OF SERIES REACTANCE:"
1070 ON ERROR GOTO 4000   'Set up error trapping for next calculation
1080 XSH=((RO*XA)-(SQR(((RO^2*XA^2))+((RA-RO)*((RO*XA^2)+(RO*RA^2)))))))/(RA-RO)
  'Calculate shunt reactance for first case, first configuration
1090 GOSUB 2000:GOSUB 3020   'Calculate series element, display results and
   check them
1100 PRINT"OR:";
1110 ON ERROR GOTO 4010   'Set up error trapping for next calculation
1120 XSH=((RO*XA)+(SQR(((RO^2*XA^2))+((RA-RO)*((RO*XA^2)+(RO*RA^2)))))))/(RA-RO)
  'Calculate second case, first configuration
1130 GOSUB 2000:GOSUB 3020   'See remarks for 1090
1140 PRINT:PRINT "WITH SHUNT REACTANCE ON TRANSMITTER SIDE OF SERIES REACTANCE:"
1150 ON ERROR GOTO 4020   'Set up error trapping for second configuration
1160 XSH=RO*(SQR((RA)/(RO-RA))):XS=-(RO*RA/XSH)-XA   'Calculate first case, 2nd
   configuration
1170 GOSUB 2010:GOSUB 3000   'Calculate inductance and capacitance, display
  results and check them
1180 PRINT"OR:";
1190 XSH=-XSH:XS=-(RO*RA/XSH)-XA   'Calculate second case,second configuration
1200 GOSUB 2010:GOSUB 3000   'See remarks for 1170
1210 PRINT:GOTO 4500
2000 XS=-((RO*RA)+(XA*XSH))/(XA+XSH)   'Calculate series reactance, first
  configuration
2010 X=XSH:IF X>0 THEN GOSUB 2510:X!=X:PRINT TAB(5)"Shunt Inductive Reactance is
 ";X!;" ohms (";L!;CHR$(230);"H)"   'If shunt reactance is inductive, go calcu-
  late inductance and display both in single precision
2020 IF X<0 THEN GOSUB 2500:X!=X:PRINT TAB(5)"Shunt Capacitive Reactance is ";X!
;" ohms (";C!;"pFd)"   'If shunt reactance is capacitive, go calculate capaci-
   tance and display both in single precision
2030 X=XS:IF X<0 THEN GOSUB 2500:X!=X:PRINT TAB(5)"Series Capacitive Reactance i
s ";X!;"ohms (";C!;"pFd)"   'Same procedure as for shunt element (line 2020)
2040 IF X>0 THEN GOSUB 2510:X!=X:PRINT TAB(5)"Series Inductive Reactance is ";X!
;"ohms (";L!;CHR$(230);"H)"   'Same procedure as for shunt element (line 2010)
2050 IF X=0 THEN PRINT TAB(5)"No Series Reactance Required"   'Special case
2060 IF RO=RA THEN PRINT TAB(10)"(Transmitter sees ";RO;"ohms resistive.)"
  'Special case
2070 RETURN
2500 C=-1E+09/(2*3.141593*F*X):C!=C:RETURN   'Calculate capacitance and convert
  to single precision
2510 L=X*1000/(2*3.141593*F):L!=L:RETURN   'Calculate inductance and convert
  to single precision
3000 Z=SQR(((RA^2*XSH^2)+(XSH^2*(XA+XS)^2))/(RA^2+(XA+XS+XSH)^2))   'Calculate
  magnitude of impedance at network input (second configuration)
3010 A=ATN(-RA/(XA+XS))-ATN((XA+XS+XSH)/RA):XS=0:GOSUB 3080:RETURN   'Calculate
  phase angle of impedance at network input. Continue at 3080
3020 Z=SQR(((XA^2*XSH^2)+(RA^2*XSH^2))/(RA^2+(XA+XSH)^2))   'Calculate magnitude
   of impedance beyond series element (first configuration)
3030 IF XA=0 THEN R1=-3.141593/2:GOTO 3050   'Avoid division by zero in next step
3040 R1=ATN(-RA/XA)   'Get phase angle of numerator, first configuration
3050 R2=ATN((XA+XSH)/RA)   'Get phase angle of denominator, first configuration
3060 A=R1-R2   'Phase angle of input impedance, first configuration
3070 IF COS(A)<0 THEN R1=3.141593+R1:GOTO 3060   'Check for ambiguity in arctan
  calculations and correct if necessary
3080 ZRE=Z*COS(A):IF ZRE>RO*.999 AND ZRE<RO*1.001 THEN ZRE!=RO ELSE ZRE!=ZRE
  'Calculate resistive component and ignore inaccuracies under 0.1 percent
3090 ZIM=(Z*SIN(A))+XS:IF ABS(ZIM)<.001*RO THEN ZIM=0:PRINT TAB(10)"(Transmitter
 sees";ZRE!;"ohms resistive.)":RETURN   'Calculate reactive component, add series
  element. If total is under 0.1 percent of RO round to zero and print results.
3100 ZIM!=ZIM:PRINT TAB(10)"(Transmitter sees ";ZRE!;"+j";ZIM!;"ohms.)"   'If
  reactive component is significant, print check result in complex notation
3110 RETURN
4000 IF ERR=5 OR ERR=11 THEN PRINT TAB(5)"No First-Case Solution":PRINT:RESUME 1
110   'Error handling for first case, first configuration
4010 IF ERR=5 OR ERR=11 THEN PRINT TAB(5)"No Second-Case Solution":PRINT:RESUME
1140   'Same for second case, first configuration
4020 IF ERR=5 OR ERR=11 THEN PRINT TAB(5)"No Solution for This Configuration":RE
SUME 4500   'Same for second configuration
4500 LOCATE 23,1,0:PRINT"CALCULATE ANOTHER (Y OR N)?":K$=INKEY$:IF K$=""THEN 450
0
4510 IF K$="Y"OR K$="y"THEN 1000 ELSE END
```

Program in GW-BASIC for calculation of L-match configurations. For maximum accuracy in the checking routine (lines 3000 through 3100) the program should be run under BASIC loaded with the double-precision transcendental math package (load BASIC/D instead of normal BASIC).

FIGURE 4



SWR curves and matching network for 160-meter dipole.

Measuring the input impedance of the line at 1835 kHz shows 95 ohms resistance (R_a) and a small amount (estimated as 5 ohms) of inductive reactance (X_a). The computer calculation shows that a network with 4.5 μH of series inductance and 914 pF of shunt capacitance would provide a match to 50 ohms.

The shunt capacitor in my device is a 700-pF mica transmitting capacitor from a war surplus TU-10B tuning unit. It has a 200-pF high-voltage disk ceramic in parallel to give 900 pF. This is close to the calculated 914 pF — closer, in fact, than the probable accuracy of the measurements.

The coil in this unit is wound of no. 12 soft-drawn bare copper wire using a piece of 1-inch PVC pipe as a mandrel. Wire this large isn't necessary, but I had it on hand. It makes a coil that's virtually self-supporting, and it's easy to solder a tap anywhere on the bare wire.

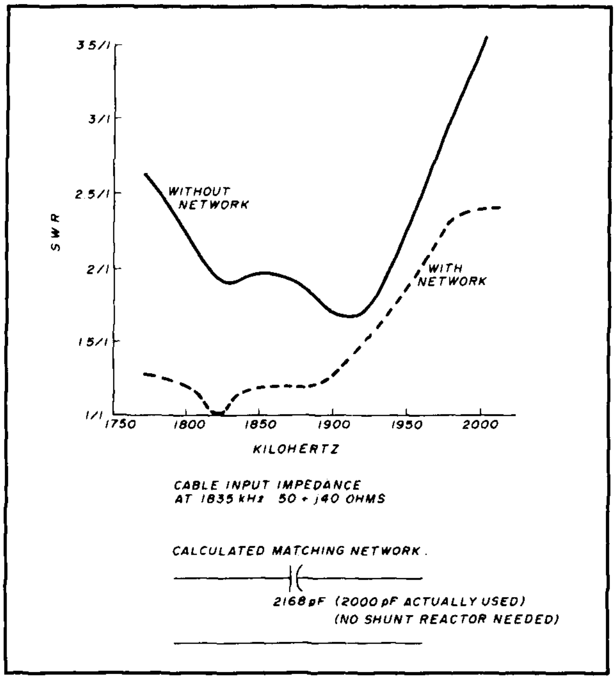
The SWR curve taken with the final network in place shows a perfect 1:1 at the design frequency of 1835 kHz, and a major improvement in the SWR seen by the transmitter over the entire range from 1800 to 1900 kHz. This network is permanently connected in the line and not equipped with a by-pass switch, as are some of the others I'll describe.

Quarter-wave 160-meter sloper

Figure 5 shows a network consisting of a single capacitor, which I use to correct the SWR of the line to a quarter-wave 160-meter sloper.

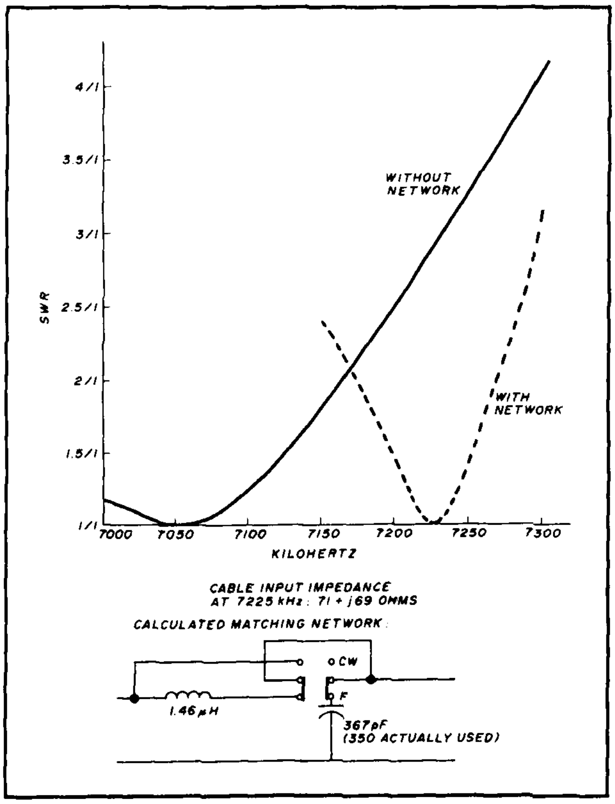
At first, there was no sign of resonance or a match to the cable anywhere in the band with the sloper alone in its original installation on a 70-foot tower. The SWR was extremely high — a disappointing but common situation

FIGURE 5



SWR curves and L-network for 160-meter sloper.

FIGURE 6



SWR curves and L-network for 40-meter Yagi.

ATTENTION: WOMEN WHO SOUGHT EMPLOYMENT WITH THE VOICE OF AMERICA (VOA), THE UNITED STATES INFORMATION AGENCY (USIA), OR THE UNITED STATES INTERNATIONAL COMMUNICATION AGENCY (USICA) BETWEEN OCTOBER 8, 1974 AND NOVEMBER 16, 1984.

YOU MAY BE A VICTIM OF SEX DISCRIMINATION ENTITLED TO A MONETARY AWARD AND A POSITION WITH THE AGENCY.

UNITED STATES DISTRICT COURT FOR THE DISTRICT OF COLUMBIA

CAROLEE BRADY HARTMAN, et al., Plaintiffs, v. CHARLES Z. WICK, Defendant	Civil Action No. 77-2019 Judge Charles R. Richey

PUBLIC NOTICE

On November 16, 1984, the United States District Court for the District of Columbia found in this class action lawsuit that the United States Information Agency (USIA or the Agency), including the Voice of America (VOA), is liable for sex discrimination against female applicants for the following positions at the Agency. The USIA was also formerly known as the United States International Communication Agency (USICA). On January 19, 1988, the Court issued its opinion ordering relief in avariety of forms to potential class members. Accordingly, this case is now in the remedial phase.

JOBS COVERED

Specifically, the Court has found that the Agency has discriminated against women in hiring in the following jobs:

- Electronic Technician (Occupational Series 856)
- Foreign Language Broadcaster (Occupational Series 1048)
- International Radio Broadcaster (Other) (Occupational Series 1001)
- International Radio Broadcaster (English) (Occupational Series 1001)
- Production Specialist (Occupational Series 1071)
- Writer/Editor (Occupational Series 1082)
- Foreign Information Specialist/Foreign Affairs Specialist/Foreign Service Information Officer/Foreign Service Officer (Occupational Series 1085 and 130)
- Radio Broadcast Technician (Occupational Series 3940)

WHO IS INCLUDED

All women who sought employment with the Agency in any of the jobs listed above between October 8, 1974 and November 16, 1984 and were not hired may be eligible for relief. Also included are those women who were discouraged from applying for these positions during that time period. Even those women subsequently hired by the Agency in some capacity may be entitled to participate in the remedial phase of this case.

Women who sought employment with the Agency as Foreign Service Officers or Foreign Service Information Officers may be eligible for different kinds of relief depending upon the date of application and whether they sought employment at the entry level or mid-level. Women who sought employment with the Agency as <u>entry</u> level Foreign Service Officers or Foreign Service Information Officers in the years 1974-1977 must use the procedure outlined below. Women who sought employment with the Agency as <u>mid-level</u> Foreign Service Officers or Foreign Service Information Officers in the years 1974-1984 must also use the procedure outlined below. However, women who sought employment with the Agency as <u>entry</u> level Foreign Service Officers or Foreign Service Information Officers in the years 1978-1984 cannot use the procedure outlined below, since the Court has ordered an alternative form of relief for them and selected women in this group will be notified individually as to their rights.

RELIEF AVAILABLE AND HOW TO OBTAIN IT

Relief available to class members may include a monetary award and/or priority consideration for a current position with the Agency. If you think you may be entitled to relief, you <u>must</u> obtain a claim form, complete it fully, and return it to counsel for the plaintiff class, Bruce A. Fredrickson, Esq., Webster & Fredrickson, 1819 H Street, N.W., Suite 300, Washington, D.C. 20006 (202/659-8515), postmarked no later than July 15, 1989.

You may obtain a claim form in person and/or in writing from several sources: counsel for the plaintiff class, whose address is listed above; in person from USIA, Front Lobby, 301-4th Street, S.W., Washington, D.C. (8:15am-5:00pm), Office of Personnel Management (OPM), Federal Job Information Center (First Floor, Room 1425), 1900 E Street, N.W., Washington, D.C. (8:30am-2:30pm), or from area OPM offices throughout the country; in writing, VOA-Hartman, P.O. Box 400, Washington, D.C. 20044. You should carefully consider all questions on the claim form, <u>sign</u> it, and return it to counsel for the plaintiffs. <u>Do not, under any circumstances</u>, return the claim form to the Judge, the Court or the Clerk of the Court. The Judge, the Court and the Clerk of the Court <u>will not accept</u> the claim forms and <u>will not forward</u> claim forms to plaintiffs' counsel.

PROCESSING OF CLAIMS

The process for handling claims has not been finally decided. Thus far, the Court has ordered that responding class members demonstrate their potential entitlement to relief at an individual hearing to be scheduled at a later date. However, the Court has reserved the right to reconsider this procedure in the event the number of claims filed makes this approach unmanageable.

Should individual hearings be used, you will be fully informed as to the date and time of your hearing. Moreover, you will be entitled to legal representation by counsel for the plaintiff class or his designee at no cost to you. Legal counsel will discuss your claim with you prior to your hearing, help you prepare your case and represent you at your hearing. You may, of course, retain your own attorney to represent you, if you so desire.

At the individual hearing, you will be asked to demonstrate your potential entitlement to relief by showing that you applied for one or more of the covered positions during the period October 8, 1974 and November 16, 1984 and that you were rejected, or that you were discouraged from applying. Evidence may be required in the form of testimony, documents, or both. Once you have demonstrated these facts, USIA is required to prove, by clear and convincing evidence, that you were not hired (for <u>each</u> position for which you applied) for a legitimate, non-discriminatory reason, such as failure to possess requisite qualifications. Should USIA make such a showing, you would then be entitled to demonstrate that the Agency's reason is merely a cover for sex discrimination or unworthy of belief.

Following the hearing, the Presiding Official will decide whether you are entitled to relief and, if so, what relief is appropriate. You may be entitled to wages and benefits you would have earned if you had been hired (back pay) from the date of your rejection until the date relief is approved. Under the law, back pay is offset by earnings you may have had during the period. In addition, you may be found to be entitled to front pay (that is, compensation into the future until an appropriate position is afforded you). Similarly, you may be found to be entitled to priority consideration for employment with the Agency. If hired, you may further be entitled to retroactive seniority with the associated benefits and the value of any promotions you would likely have had if you had not suffered discrimination.

REQUIRED STEPS TO FILE YOUR CLAIM

To participate in the remedial phase, <u>you must fully complete the claim form</u> and return it, POSTMARKED NO LATER THAN July 15, 1989, to counsel for the plaintiff class. Your failure to do so will result in your losing all rights you may have in this lawsuit. If you have questions about your rights or procedures available to you, you may contact counsel for the plaintiff class:

Bruce A. Fredrickson
Webster & Fredrickson
1819 H Street, N.W., Suite 300
Washington, D.C. 20006
(202/659-8515)

October 4, 1988
Date

/s/ Judge Charles R. Richey
United States District Court
Judge Charles R. Richey

with quarter-wave slopers. I installed a quarter-wave counterpoise, grounded to the top of the tower, at a right angle to the sloper. By carefully trimming the lengths of both the antenna and the counterpoise, I brought the SWR to a minimum of 1.9:1 at 1830 kHz. Minimum SWR was still rather poor — 1.6:1 at 1910 kHz. Measurement of the input impedance of the cable at 1835 kHz showed very nearly 50 ohms of resistance and about 40 ohms of inductive reactance. The computer calculation showed that 2168 pF in series with the line would provide a match, with no shunt reactor. Eureka! I mounted a 0.002-μF 2500-volt mica capacitor from the junkbox in a minibox. This "network" is shown in **fig. 5**, with the resulting SWR curve — a perfect 1:1 at 1820 kHz, and very low SWR from 1800 to 1900 kHz. For obvious reasons, this network is permanently installed in the line and there's no by-pass switch.

40-meter Yagi

Figure 6 shows the SWR curve at the input end of the cable to my 3-element 40-meter Yagi, which is tuned and matched for the CW portion of the band. The SWR is 1:1 at 7045 kHz, but rises radically in the phone portion of the band. At 7225 kHz, the center of the phone band, the SWR is 2.9:1. The measured input impedance of the cable at this frequency is 71 ohms of resistance and 69 ohms of inductive reactance.

For this situation, the formulas give 1.46 μH of series inductance with 367 pF of shunt capacitance on the antenna side for a match to 50 ohms at 7225 kHz.

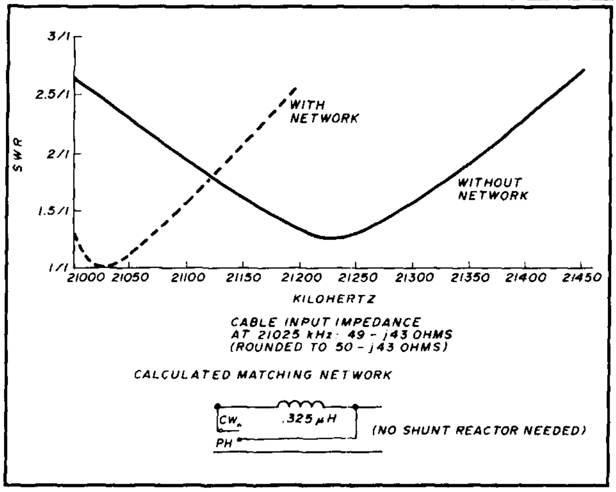
The capacitors in the resulting matching unit are two transmitting ceramic capacitors (one 200 pF and one 100 pF) and a 50-pF high-voltage disk ceramic capacitor, all connected in parallel to give 350 pF. The matching unit has a slide switch so I can by-pass it for CW operation. The SWR seen by the transmitter is 1:1 at 7225 kHz with the network in operation, but for reasons mentioned previously it rises above 2:1 beyond 7270 kHz.

15-meter Yagi

My 4-element 15-meter Yagi was originally cut and matched for a compromise between the phone and CW portions of the band. **Figure 7** shows that the minimum SWR on the cable is a fairly acceptable 1.28:1 at 21,220 kHz, but rises to 2.7:1 at the high (phone) end of the band and 2.6:1 at the low (CW) end. The high SWR at the band ends presented no compensation problem for the loading capacitor used on my amplifier for this band, and I seldom operate above 21,350 kHz. Touching up the tuning on the air after first tuning into a dummy load for CW not only took extra time, but bothered my conscience as well.

Measurement of the input impedance of the cable at 21,025 kHz showed a resistive component just under

FIGURE 7



SWR Curves and L-network for 15-meter Yagi.

50 ohms (close to 49 ohms) and a capacitive reactance of about 43 ohms. One of the solutions given by calculations for the first configuration for this impedance was a series inductance of 0.324 μH (42.9 ohms) and a shunt inductance of 32.2 μH (a very high 4250 ohms of inductive reactance). It was apparent that I needed the shunt reactance just to raise the resistive component of the load from 49 to 50 ohms, a mere 2-percent change. Another calculation showed that with the resistive component of the load rounded to 50 ohms, a 0.325-μH series inductor would provide a match with the shunt element omitted. This simpler network was adequate, as indicated by the resulting SWR curve. The SWR is a perfect 1:1 at 21,025 kHz and is quite low over all of the first 100 kHz of the band.

This must be one of the smallest 1-kW antenna tuners in existence! It consists of only an 8-turn 1/2-inch diameter coil and contains a 2-position rotary selector switch to by-pass the coil for phone operation.

Now when I QSY to 15-meter CW, I tune the amplifier into the dummy load, switch to the antenna with the network in, and proceed without causing any tuning QRM. It's a much better feeling!

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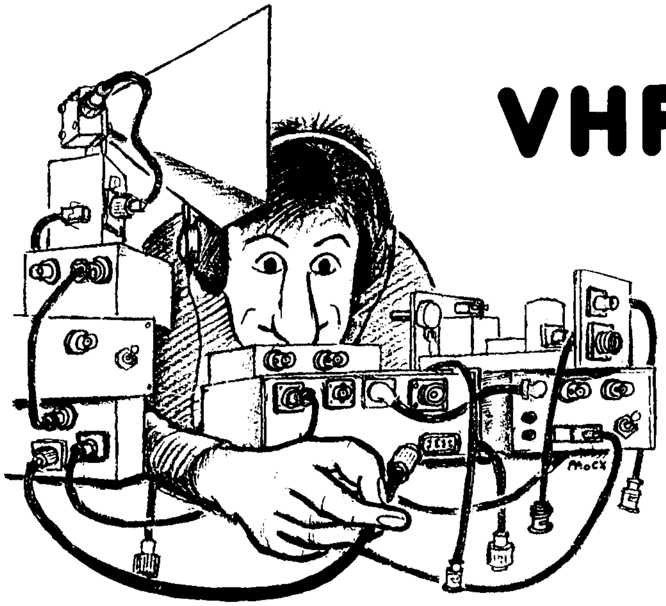


VHF/UHF WORLD

Joe Reisert, W1JR

DX records on 50 MHz and above: part 2

Last month's column[1] discussed how VHF/UHF and above DX records are made, and their relative importance to Amateur Radio and the state of the art (SOA). I also reviewed some of the most recent record-breaking contacts using ionospheric and tropospheric propagation.

This month I'll continue along on the same subject with emphasis on EME and tropospheric propagation records. The updated DX record tables will appear at the end of the column.

EME

There are still lots of challenges to using EME communications. Although the EME DX records on 144, 432, and 1296 MHz extend virtually halfway around the world, other bands are wide open for increased DX records.

As you'll see shortly, some of these opportunities have not gone unnoticed. Records and technology march on, but don't be discouraged. If you look at the EME records you'll find some interesting opportunities for getting into the record tables.

50 MHz

For over a decade, 6-meter EME was in the doldrums. However, as I've reported in "VHF/UHF World" lately, that interest has not only been rekindled — it has proliferated — and several new stations have joined the fun.

Stations outside North America are now active. The most recent station to participate is Graham Jonas, ZL2BGJ, near Wellington, New Zealand (RF70DX). He's built a huge multiwire rhombic antenna with an estimated gain of 25 dB. The antenna's radiation center intercepts the moon whenever it passes through about 16.5 degrees north declination and 130 degrees Greenwich Hour Angle. This rhombic can be steered a few degrees if necessary.

ZL2BGJ's first big 6-meter EME test was on September 7, 1988 between 1800 and 1815 UTC when he worked Jim Treybig, W6JKV, Los Altos Hills, California (CM87WI) for a new world record of 6704 miles (10,787 km). Graham was running about 650 watts. Jim was running 1500 watts to a quad of 10-element M² Yagis, each on a 52-foot boom.

The following day (September 8, 1988), Graham ran a schedule with Ray Rector, WA4NJP, Gillsville, Georgia (EM84DG) between 1900 and 1915 UTC and they completed a contact extending the worldwide DX record to 8258 miles (13,288 km). Ray was running 1500 watts to a quad of 8-element W1JR-type Yagis, each on a 34-foot boom.[2] I propped a similar 8-element Yagi up on a small tower and was able to hear portions of both sides of this contact.

10 GHz

For some time, a 3-cm EME contact has been considered one of the last big EME "plums." As I mentioned in a recent column, several stations have been diligently working towards that goal.[3] Several one-way contacts have been reported, but the two-way contact eluded most aspirants.

Well, it finally happened, and by a different group than was reported in **reference 3**. Several schedules had been run during August, but bad weather ruined the final contact because water vapor is an attenuator at these frequencies.[4]

Finally on August 27, 1988 at 0935 UTC an EME contact was completed on approximately 10.368 GHz between Greg Raven, KF5N, and Kent Britain, WA5VJB, operating under the callsign WA5VJB from Grand Prairie, Texas (EM12LQ) and Dave Chase, KY7B and Jim Vogler, WA7CJO operating under the callsign WA7CJO from Cave Creek, Arizona (DM33XL) over a terrestrial distance of about 868 miles (1937 km).

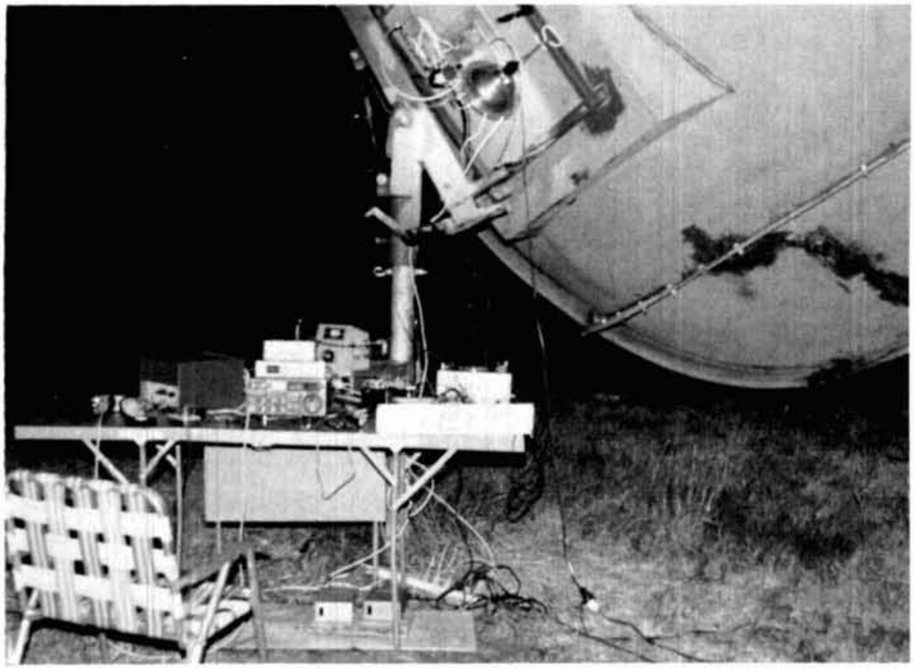
Signals were Q5 but weak and broad, almost auroral in quality, and spread out over perhaps 1 kHz (probably due to libration fading). Because most of the schedules were conducted with the moon south of the path, doppler was observed up to ± 20 kHz. Both stations aimed their antennas by peaking on "moon noise," which ran close to 1 dB.

The WA5VJB station used a 12-foot dish with a linear polarized waveguide splasher feed that can be rotated to align polarity on the incoming signal. Kent estimated the dish gain to be 49 dBi with a beam width of 0.56 degrees (this gain figure may be optimistic). The transmitter delivered 50 watts of output from a surplus TWT. The receiver was a modified SSB Elec-

PHOTO A

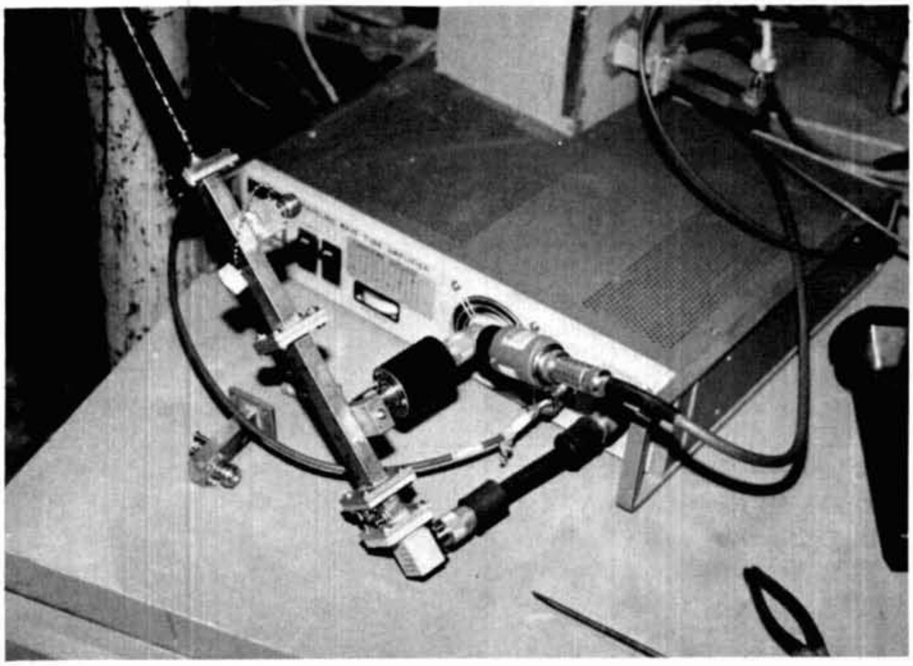
The 12-foot dish at station WA5VJB used for the first ever two-way Amateur contact on 10-GHz EME.

PHOTO B



Gear set up in the backyard just below the dish.

PHOTO C



The TWT power amplifier connected to the waveguide feedline.

tronics transverter preceded by five stages of low-noise Avantek AT-13135 GaAsFETs that downconvert to 144 MHz. The overall system noise figure is approximately 2.1 dB. Some of the station equipment is shown in **photos A, B,** and **C**.

The WA7CJO station used a 16-foot dish with an estimated gain of 51 dBi and a beam width of 0.42 degrees with a scalar feed. The transmitter ran 85 watts of output power from a surplus TWT. The receiver was completely homebrew, with an image rejection mixer feeding a 28-MHz IF. The preamplifier was similar to WA5VJB's with an overall system noise figure of 1.5 dB.

A few weeks after the first-ever 3-cm Amateur EME contact was completed, I received a telephone call from Rick Fogle, WA5TNY. He reported that Lucky Whitaker, W7CNK/5, Oklahoma City, Oklahoma (EM15FI) had also completed a two-way contact on 10.368-GHz EME with WA7CJO on September 25, 1988.

Lucky runs 32 watts from a solid-state amplifier to a 16-foot fiber glass TVRO dish.[3] Lucky and Rick now feel that, due to surface inaccuracies, the performance of his dish probably puts him in the class of an equivalent 11-foot dish with good surface accuracy.

On September 26th Rick completed not one, but two, contacts with WA7CJO. Rick is located in Grapevine, Texas (EM12KV) and runs 14 watts from a solid-state amplifier. Rick recently upgraded to a 10-foot "spun

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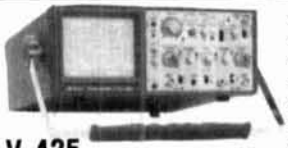

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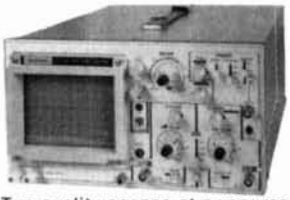

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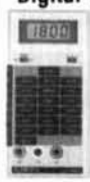

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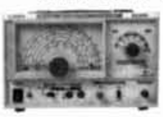

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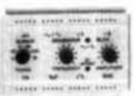

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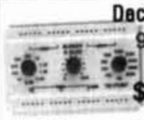

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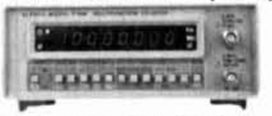

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aluminum" dish. Apparently the extra surface accuracy helped. His sun noise increased from 9.5 to 13.2 dB over that which he received from the older 10-foot TVRO-type dish he used to set the first-ever 3.4 and 5.6-GHz EME contacts.

The EME contacts made by Rick and Lucky were both just short of the distance of the WA5VJB/WA7CJO contact. There are lots of solid-state transverters out there on 10.368 GHz. Likewise, 10-foot spun aluminum dishes are available. It seems the only things holding up contacts are the lack of participants and suitable power amplifiers. When the amplifiers become available, there may be many more 3-cm EME contacts.

300 GHz and up

As most SHFers know, all frequencies above 300 GHz are open for Amateur Radio. "And then there was light" is a better explanation of many of these frequencies, because some of this spectrum covers the "visible light" range.

When Amateurs first obtained this frequency spectrum, some were quick to respond. They submitted contest contacts when the only communication involved was two people sending code to each other with flashlights. But these early contacts may not have been possible over the minimum 1 mile unless telescopes were used, and that really wasn't what was intended for contest contacts!

As a result, the ARRL modified the contest rules to require that all contest contacts in this frequency spectrum be made between licensed Amateurs using coherent radiation on transmission (eg., laser) and employing at least one stage of electronic detection on receive. Furthermore, in July 1988 the ARRL announced that effective September 1, 1988, there would be a separate VUCC Award for anyone submitting proof of contacts with five grid squares fitting the above mentioned definition.

"VHF/UHF World" has recognized such contacts since the first North American DX Record table was published in July 1985.[5] Until recently, only two contacts had been reported. The record was 15 miles on 474 THz. But I recently received a contact report at 678 THz! The contact was made between Dave Chase, KY7B/7, operating from Mt. Lemmon, Arizona (DM42OK) and Terry Wilkinson, WA7LYI/7, on Mt. Graham, Arizona (DM52BQ) at a distance of 56.7 miles (91.25 km).

All the equipment used for this contact was homebrew. It included surplus lasers, a micrometer positioning system, and a "muffin fan" modulator! The signals were MCW at a power level of 24-48 milliwatts.

The receiver used a Fresnel lens, photo multiplier tube, and an audio amplifier. **Photos D, E,** and **F** show parts of the system. I'm sure we'll be hearing more about their equipment shortly.

Interestingly enough, the biggest problem Dave and Terry encountered in making this contact was "finding" each other. It took three hours. At 56.7 miles, the beam width of the transmitted signal was only 50 feet! They already have plans to break their own record.

For now, I'll show both long DX contacts made above 300 GHz since they were made in different portions of the visible spectrum. Should the records in this spectrum be subdivided? Perhaps one of you can come up with a more equitable way to list these records. I'd appreciate any suggestions.

Last-minute update

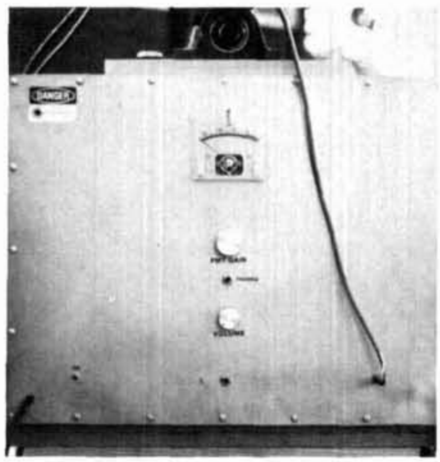
It happened again! Another new record came in just as I was finishing this column. The record is on 33 cm (903 MHz).

On September 28, 1988, there was excellent tropo propagation between New Jersey and Georgia on 2 meters and 70 cm. At 0413 UTC, Roger Amidon, K2SMN, near Princeton, New Jersey (FN20EJ) completed a CW contact on 903.1 MHz with Steve Adams, WS4F, Cornelia, Georgia

PHOTO D

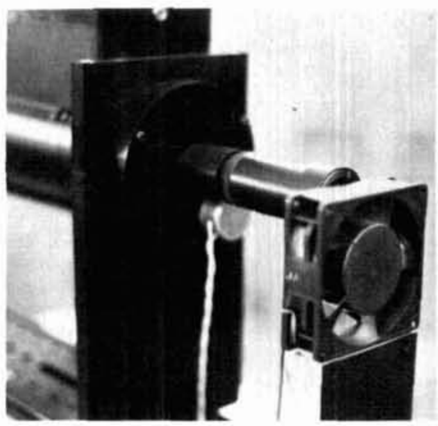
An overall view of the receiver (the engine hoist is not part of the receiver!) used to set the new 678-THz DX record.

PHOTO E



A closeup of the receiver.

PHOTO F



The 1-kHz modulator, a muffin fan!

TABLE 1

North American VHF and above claimed DX records. (Revised 88-10-27)

Frequency	Record Holders	Date	Mode	DX Miles (km)
50 MHz	*See note 4.*			
EME	WA4NJP(EM84DG)-ZL2BGJ(RF70DX)	88-09-08	CW	8258 (13288)
144 MHz				
Aurora	KA1ZE(FN31TU)-WA0TKJ/WB0DRL(EM18CT)	86-02-08	CW	1347 (2167)
EME	VE1UT(FN63XV)-VK5MC(QF02EJ)	84-04-07	CW	10,985 (17676)
FAI	W5HUQ/4(EM90GC)-W5UN(DM82WA)	83-07-25	CW	1228 (1976)
MS	K5UR(EM35WA)-KP4EKG(FK68VG)	85-12-13	SSB	1960 (3153)
Spor. E	WA4CQG(EM72FO)-W7YOZ(CN87VR)	88-06-06	SSB	2172 (3495)
TE	KP4EOR(FK78AJ)-LU5DJZ(GF11LU)	78-02-12	SSB	3933 (6328)
Tropo OL	K1RJH(FN31XH)-K5WXZ(EM12QW)	68-10-08	CW	1468 (2362)
Tropo OW	KH6GRU(BL01XH)-WA6JRA(DM13BT)	73-07-29	CW	2586 (4161)
220 MHz				
Aurora	W3IY/4(FM19HA)-WB5LUA(EM13QC)	82-07-14	CW	1145 (1842)
EME	K1WHS(FM43MK)-KH6BFZ(BL11CJ)	83-11-17	CW	5058 (8139)
MS	W1JR(FN42HN)-K0ALL(EN16OU)	88-08-13	SSB	1274 (2057)
Spor. E	K5UGM(EM12MS)-W5HUQ/4(EM90GC)	87-06-14	CW/SSB	932 (1499)
TE	KP4EOR(FK78AJ)-LU7DJZ(GF05RJ)	83-03-09	CW/SSB	3670 (5906)
Tropo OL	K1WHS(FM43MK)-K5UR(EM35WA)	88-09-09	CW	1267 (2039)
Tropo OW	KH6UK(BL11AQ)-W6NLZ(DM03TS)	59-06-22	CW	2539 (4086)
432 MHz				
Aurora	W3IP(FM19PD)-WB5LUA(EM13QC)	86-02-08	CW	1182 (1901)
EME	K2UYH(FN20QG)-VK6ZT(QF78VB)	83-01-29	CW	11567 (18612)
MS	W2AZL(FN20VI)-W0LER(EN35IE)	72-08-12	CW	1021 (1642)
Tropo OL	WB3CZG(FN21AX)-WA5VJB(EM12LQ)	86-11-29	SSB	1318 (2121)
Tropo OW	KD6R(DM13NI)-KH61AA/P(BK29GO)	80-07-28	CW	2550 (4103)
903 MHz				
EME	K5JL(EM15DQ)-WB5LUA(EM13QC)	88-02-07	CW	187 (301)
Tropo OL	K2SMN(FN20EJ)-WS4F(EM84FM)	88-09-28	CW	628 (1011)
1296 MHz				
EME	K2UYH(FN20QG)-VK5MC(QF02EJ)	81-12-06	CW	10562 (16995)
Tropo OL	WB3CZG(FN21AX)-KD5RO(EM13PA)	86-11-29	CW	1287 (2070)
Tropo OW	KH6HME(BK29GO)-WB6NMT/6(DM12KU)	86-08-13	SSB	2528 (4068)
2304 MHz				
EME	W3IWI/8(FM08CK)-ZL2AQE(RE78JS)	87-10-18	CW	8658 (13931)
Tropo OL	KD5RO(EM13PA)-W8YIO(EN82BE)	86-11-29	CW	940 (1513)
3456 MHz				
EME	W7CNK/5(EM15FI)-K0KE/0(DM79NO)	87-04-12	CW	498 (802)
Tropo OL	WB5AFY(EM04ID)-KX0O/0(DM78KU)	88-08-07	CW	455.5 (733)
5760 MHz				
EME	WA5TNY(EM12KV)-W7CNK/5(EM15FI)	87-04-24	CW	174 (279)
Tropo OL	N5JJZ/5(EM26CB)-WA5ICW/5(DM86LR)	88-07-10	SSB	404 (650)
10.368 GHz				
EME	WA5VJB(EM12LQ)-WA7CJO(DM33XL)	88-08-27	CW	868 (1397)
Tropo OL	WB7ABP/P(CN81QB)-WB0HLC/6(DM04MS)	88-08-06	CW/SSB	479 (770)
Tropo OW	NN6W/6(CM94XM)-XE2GFH(DL27VL)	88-09-11	MCW	595 (958)
24.192 GHz				
LOS	WA3RMX/7(CN93IQ)-WB7UNU/7(CN95DH)	86-08-23	SSB	116 (186)
47.040 GHz				
LOS	WA3RMX/7(CN82VW)-K7AUO/7(CN82PB)	88-08-06	CW/SSB	65.3 (105)
76-149 GHz	*None reported.*			
300 GHz and above	See note 5.			
474 THz				
LOS	K6MEP/6(DM04IO)-WA6EJO/6(DM04KT)	79-06-09	Laser	15 (24)
678 THz				
LOS	KY7B/7(DM42OK)-WA7LYI/7(DM52BQ)	88-06-12	Laser	56.7 (91.2)

Note 1. The records are listed alphabetically by mode. Tropo OL is over land. Tropo OW is over water (at least 75 percent of the path).
Note 2. The information within the brackets () following the callsign is the grid square locator.
Note 3. Distances have been calculated assuming a spherical earth model using the actual latitude and longitude rather than using the less accurate grid square centers model.
Note 4. Six-meter records, excepting EME, were left off as the primary propagation mode is often hard to distinquish. Long-path QSOs exceeding approximately 12430 miles (20000 km) have been reported during solar cycles 19, 21, and 22.
Note 5. There have been very few reports of contacts in the wide open frequency allocation above 300 GHz. Therefore, at least for the time being, we will list those records that show considerable distance at widely different frequencies.

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TABLE 2

Worldwide claimed VHF/UHF/SHF terrestrial DX records. (Revised 88-10-27)

Frequency	Record Holders	Date	Mode	Miles (km)
50 MHz	Note 3			
70 MHz	GW4ASR/P(IO82JG)-5B4CY (KM64MR)	81-06-07	Es	2153 (3465)
144 MHz	I4EAT(JN54VG)-ZS3B(JG73OI)	79-03-30	TE	4884 (7860)
220 MHz	KP4EOR(FK68XM)-LU7DJZ(GF05RJ)	83-03-09	TE	3670 (5906)
432 MHz	KD6R(DM13NI)-KH6IAA/P(BK29GO)	80-07-28	Duct	2550 (4103)
903 MHz	K2SMN(FN20EJ)-WS4F(EM84FM)	88-09-28	Tropo	628 (1011)
1296 MHz	KH6HME(BK29GO)-WB6NMT(DM12KU)	86-08-13	Duct	2528 (4068)
2304 MHz	VK5QR(PF95HD)-VK6WG/P(OF85WA)	78-02-17	Duct	1170 (1883)
3456 MHz	VK5QR(PF95HD)-VK6WG(OF85WA)	86-01-25	Duct	1171 (1885)
5760 MHz	G3ZEZ(JO01MS)-SM6HYG(JO58RG)	83-07-12	Duct	610 (981)
10.3 GHz	I0SNY/EA9(IM75IV)-I0YLI/IE9(JM68NR)	83-07-08	Duct	1032 (1660)
24 GHz	I0SNY/IC8(JN60WR)-I8YZO/8(JM78WE)	84-08-11	LOS	206 (331)
47 GHz	WA3RMX/7(CN82VW)-K7AUO/7(CN82PB)	88-08-06	LOS	65.3 (105)
75 GHz	HB9AGE/P(JN37RD)-HB9MIN/P(JN37RD)	85-12-30	LOS	0.3 (0.5)
474 THz	K6MEP(DM04IO)-WA6EJO(DM04KT)	79-06-09	LOS	15 (24)
678 THz	KY7B/7(DM42OK)-WA7LYI/7(DM52BQ)	88-06-12	LOS	56.7 (91.2)

Notes:
1. The information within the brackets () after the callsign is the grid square locator.
2. Distances have been calculated assuming a spherical earth model. The actual latitude and longitude are used rather than the less accurate grid square centers model.
3. Six meters has been left blank on this listing because long-path QSOs (those exceeding approximately 12430 miles or 20000 km) have been reported during solar cycles 19, 21, and 22.

(EM84EM), over a distance of 628 miles (1011 km). This extends the previous record by about 5 miles and shows why it's good to know exact station coordinates.

Roger was running 80 watts to a quad array of 23-element Tonna Yagis. Steve was running 130 watts to a single 33-element loop Yagi. Both stations had system noise figures below 1.0 dB. Signals were several dB out of the noise.

Latest DX record tables

Here are the latest record tables; they've all been updated. Note changes in grid squares since the last time these tables were published. Many locations have been more accurately determined.

I made a few typographical errors in the previous tables. I hope they didn't cause any grief. If you find mistakes or have questions on the data shown in any of the tables, please let me know. After all, this is a process of evolution and you can't challenge a record that has incorrect data.

Table 1 shows the latest North American DX records, **table 2** the latest worldwide DX records, and **table 3** the latest EME records — including the first-ever 3-cm contact.

Region 1 DX Records

Up until now, the tables published in "VHF/UHF World" have only recognized North America and worldwide DX records. There are other long distance contacts that, while not records on these tables, are still rather interesting and impressive.

Some of these contacts include the records made in Region 1, which includes Europe, Africa, and the Soviet Republics. These records reflect the SOA in other parts of the world and I think they're important. Also, several VHF and above devotees have been questioning me on what our peers outside North America are doing.

For several years Region 1 DX records have been carefully

✓ 118

✓ 119

TABLE 3

Worldwide claimed VHF/UHF/SHF EME DX records. (Revised 88-10-27)

Frequency	Record Holders	Date	Mode	Miles (km)
50 MHz	WA4NJP(EM84DG)-ZL2BGJ(RF70DX)	88-09-08	CW	8258 (13288)
144 MHz	K6MYC/KH6(BK29AO)-ZS6ALE(KG43RC)	83-02-18	CW	12091 (19455)
220 MHz	K1WHS(FN43MK)-KH6BFZ(BL11CJ)	83-11-17	CW	5058 (8139)
432 MHz	F9FT(JO29AG)-ZL3AAD(RE66GR)	80-04-18	CW	11679 (18793)
902 MHz	K5JL(EM15DQ)-WB5LUA(EM13QC)	88-02-07	CW	187 (301)
1296 MHz	PA0SSB(JO11WI)-ZL3AAD(RE66GR)	83-06-13	CW	11595 (18657)
2304 MHz	W3IWI/8(FM08CK)-ZL2AQE(RE78JS)	87-10-18	CW	8658 (13931)
3456 MHz	W7CNK/5(EM15FI)-K0KE(DM79NO)	87-04-06	CW	498 (802)
5760 MHz	WA5TNY(EM12KV)-W7CNK/5(EM15FI)	87-04-24	CW	174 (279)
10368 MHz	WA5VJB(EM12LQ)-WA7CJO(DM33XL)	88-08-27	CW	868 (1397)
24000 MHz and above	None reported.			

Notes:
1. The information within the brackets () following the callsigns is the grid square locator.
2. The distances shown have been calculated assuming a spherical earth model. The actual latitudes and longitude are used rather than the less accurate grid square centers model.

documented by Folke Rosvall, SM5AGM, who updates them annually. Most, but not all, of the DX records shown in **table 4** are from the list published by Folke. However, I reserve the right to update them myself. I plan to include some impressive tropo and aurora claims that don't appear in Folke's table, or are very recent. Some Region 1 DX records, like FAI, aren't included or available, but I hope they will be in the near future.

I must make one final point about **table 4**. Folke determined most of the distances on this table using the new "ellipsoidal" earth model for distance determination. In some cases, interpretation may be necessary when comparing these records with those shown in **tables 1, 2,** and **3**. What are your impressions of **table 4**? Do you find it valuable?

Summary

January and February's columns are dedicated to those who have tried as well as those who have succeeded in setting new VHF and above DX records — an important aspect of Amateur Radio.

In a sense these columns have been like an anatomy of how the records are achieved and how they improve the SOA. I hope that this background material and the challenges I've described will encourage you to try to improve the SOA and/or make an attempt at one of the many records available to those who operate above 50 MHz.

In the meantime, please keep me informed of your progress on new record attempts or challenges. Remember to write to me for a "VHF/UHF/SHF Propagation Record Verification Form," or fill out a copy of **table 4** on page 47 of the June 1988 column.[3]

Acknowledgments

I'd like to thank all who submitted DX record information — especially for January and February's columns. In particular I'd like to thank (and I hope I don't miss anyone): K1WHS, WA3RMX, WA4NJP, KB4WM, WA5ICW, K5UR, WA5VJB, N6XQ, KY7B, W7YOZ, KXØO, and WBØHLO.

Notes

In last September's column[6] I listed the addresses of several VHF publications. I've recently been informed that two have changed as follows:

2-Meter EME Bulletin, c/o R.E. Turner, 14826 Daisy Lane, Tampa, Florida 33613.

MidWest VHF/UHF Society, c/o Steve Whitefield, WA3OJX, 400 S. Main Street, Springboro, Ohio 45066. This monthly publication is available for $6.00 per year.

Important VHF/UHF Events

February 6	*New Moon*
February 7	*EME perigee*
February 20	*Total lunar eclipse*
March 7	*New moon with partial solar eclipse*
March 8	*EME perigee*
March 21	±2 weeks. Optimum time for TE propagation

TABLE 4

IARU Region 1 VHF and above claimed DX records. (Revised 88-10-27)

Frequency	Record Holders	Date	Mode	DX miles (km)
50 MHz				
F2	EL2AV(IJ46)-H44PT(RI00OA)	82-04-04	SSB	11764 (18932)
70 MHz				
Aurora	G3SHK(IO90DX)-GM3WOJ/P(IO89KB)	82-08-11	CW	562 (904)
MS	GJ3YHU(IN89XI)-GM3WOJ/P(IO89KB)	82-08-12	?	673 (1083)
Spor. E	GW4ASR/P(IO82JG)-5B4CY(KM64MR)	81-06-07	?	2153 (3465)
Tropo	G4FRE/P(IO70PP)-GM4ZUK/A(IO87WB)	86-09-21	SSB	456 (734)
144 MHz				
Aurora	G4VBG(IO94FW)-UA32FI(KO76WT)	86-02-07	CW	1373 (2209)
EME	K6MYC/KH6(BK29AO)-ZS6ALE(KG46RC)	84-02-18	CW	12091 (19455)
MS	GW4CQT(IO81LP)-UW6MA(KN97VE)	77-08-12	CW	1927 (3101)
Spor. E	EA8XS(IL28GA)-HG0HO(KN07RU)	83-07-16	SSB	2402 (3865)
TE	I4EAT(JN54VG)-ZS3B(JG73OI)	79-03-30	CW	4884 (7860)
Tropo	EA8BEX(IL27GX)-GI4KIS(IO64VR)	88-07-15	CW/SSB	1904 (3064)
432 MHz				
Aurora	PA0RDY(JO22KJ)-RA3LE(KO64AR)	86-02-08	CW	1123 (1807)
EME	F9FT(JN29AG)-ZL3AAD(RE66GR)	80-04-18	CW	11749 (18907)
MS	EI2VAH(IO43XW)-SK6AB(JO57XQ)	80-08-12	CW	891 (1434)
Tropo	EA8XS(IL28GA)-GW8VHI(IO81CM)	84-07-05	SSB	1731 (2786)
1296 MHz				
EME	PA0SSB(JO11WI)-ZL3AAD(RE66GR)	83-06-13	CW/SSB	11665 (18772)
Tropo	EA8XS(IL26GA)-G6LEU(IO70ME)	85-06-29	SSB	1626 (2617)
2304 MHz				
EME	PA0SSB(JO11WI)-W6YFK(CM87WJ)	81-04-05	CW/SSB	5506 (8860)
Tropo	EA7BVD/P(IM78JD)-EA8XS/P(IL27GW)	84-07-08	SSB	920 (1481)
3456 MHz				
Tropo	G3LQR(JO02QF)-SM6HYG(JO58RG)	83-07-11	CW	576 (927)
5760 MHz				
Tropo	G3ZEZ(JO01MS)-SM6HYG(JO58RG)	83-07-12	CW/SSB	610 (981)
10.368 GHz				
Tropo	I0SNY/EA9(IM75IV)-I0YLI/IE9(JM68NR)	83-07-08	FM	1032 (1660)
24 GHz				
Tropo	I0SNY/IC8(JN60WR)-I8YZO/8(JM78WE)	84-08-11	FM	206 (331)
47 GHz				
Tropo	HB9AGE/P(JN36FS)-HB9MIN/P(JN36SX)	87-06-06	?	53 (86)
75 GHz				
LOS	HB9AGE/P(JN37RD)-HB9MIN/P(JN37RD)	87-06-06	FM	0.3 (0.5)

Notes:
1. The records are listed alphabetically by mode.
2. The information within the brackets () following the callsign is the grid square locator.
3. The distances are calculated using an ellipsoidal earth model.

References

1. Joe Reisert, W1JR, "VHF/UHF World-DX Records on 50 MHz and Above-Part 1," *Ham.Radio*, January 1989, page 48.
2. Joe Reisert, W1JR, "VHF/UHF World-Optimized 2- and 6-Meter Yagis," *Ham Radio*, May 1987, page 92.
3. Joe Reisert, W1JR, "VHF/UHF World-Propagation Update-Part 2," *Ham Radio*, June 1988, page 39.
4. Joe Reisert, W1JR, "VHF/UHF World-Microwave and Millimeter-wave Propagation, Part 2," *Ham Radio*, August 1986, page 69.
5. Joe Reisert, W1JR, "VHF/UHF World-Propagation Update," *Ham Radio*, July 1985, page 86.
6. Joe Reisert, W1JR, "VHF/UHF World-More Loose Ends," *Ham Radio*, September 1988, page 53.

Article E **HAM RADIO**

THE HAM NOTEBOOK

Crank-up tower cable guides

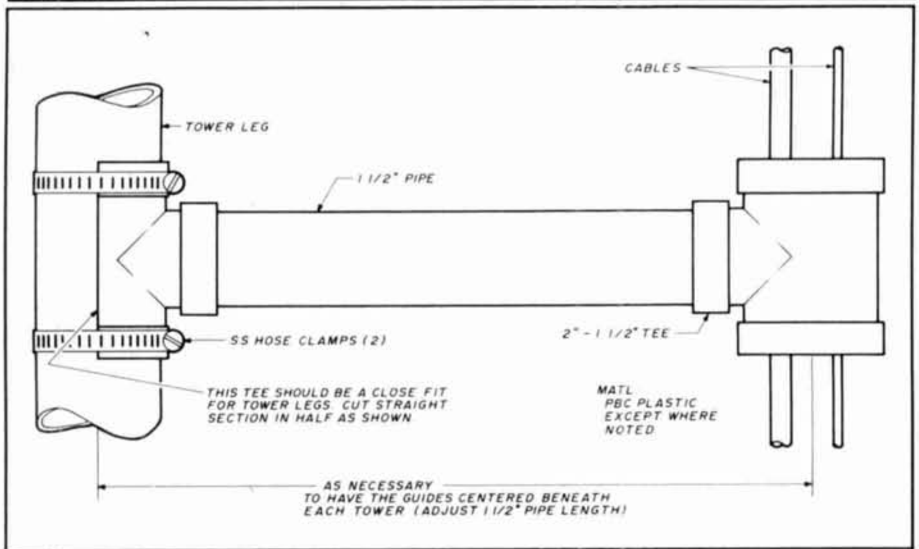
PHOTO A

One of the cable guides installed on my tower.

When I set up my new crank-up tower, I installed the cable guides shown in **photo A** and **fig. 1**. Phil Malmberg, W4NOO, of Cocoa Beach, Florida designed the guides. He has used them successfully on his 60-foot crank up for years. The guides control the motion of the cables from the rotator and antennas. They prevent excess sway in the wind when the tower is cranked up and help make a neat pile at the foot of the tower when it's cranked down. Use two guides on the bottom tower section and one at the top of each movable section.

George Wilson, W1OLP

FIGURE 1

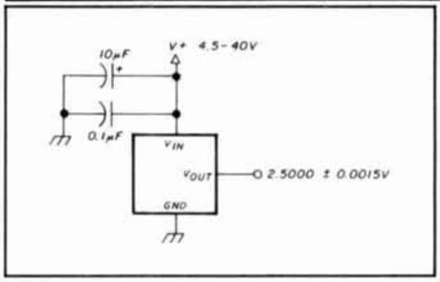


Details for assembling and installing the cable guides.

Simple inexpensive check for voltmeter accuracy

Do you have an old voltmeter that you'd like to check for accuracy or recalibrate? This can present problems if you don't have a standard cell or access to some other sophisticated test gear. Here's a simple inexpensive solution built around a Precision Monolithics REF 43F voltage reference IC.* (see **fig. 1**)

FIGURE 1



Schematic of a simple, high-accuracy voltage source.

The 43F is guaranteed to have a maximum error of 0.06 percent from its normal 2.50-volt reference point (i.e., between 2.4985 to 2.5015 volts). It will operate with a DC voltage source between +4.5 and +40 volts and supply a minimum of 10 mA into a load. The quiescent supply current at no load is 450 μA, maximum.

These characteristics indicate that the 43F can be run from a battery or power supply source, and that a precision voltage divider can be used to supply an output of less than 2.5 volts.

It's probably a good idea to put the unit in a small box to reduce the thermocouple effects on the leads and to prevent sudden temperature changes.

*The REF 43F is available from: Allied Electronics, 401 E. 8th Street, Fort Worth, Texas 76102. *Ed.*

Arthur L. Bachelor, M.D.

Article F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VISA

ANTENNA ARRAY PATTERNS
WITH A PERSONAL COMPUTER

By Dennis D. King, KC7MT, 2204 East 10225 South, Sandy, Utah 84092

Program generates data for tabular or graphic display

I have enjoyed many of the antenna articles presented in *Ham Radio* magazine, but a practical grasp of the basic dynamics of antenna patterns always remained elusive. "ARRAY" gives you hands-on experience in antenna array basics and ground effects.

The computer program, written in BASIC for an IBM PC compatible, runs in Microsoft BASIC. Commands are generic and the program is easily modified to work with other BASIC interpreters.

program description

The operator loads in the currents, phase relationships, and spacings of any number of elements. The elements can be either omnidirectional or half-wave dipoles. If desired a perfect ground plane can be located parallel to the array. Next, the operator enters the distance to the ground plane as well as the antenna polarization. The resulting antenna pattern is then calculated and plotted in BASIC graphics on the screen. Two automatically scaled plots are available — field strength, and a log plot showing 25 dB of the pattern. This flexible program can look at both the vertical and horizontal electric field patterns of a beam located a fixed distance above a ground plane. It is menu-oriented with continuous prompts. A parameter change section allows for quick substitutions of any parameter without reloading all of the array information.

Program speed varies with the number of elements chosen. Most plots take less than 30 seconds to calculate. The program was written to be compatible with IBM/Microsoft BASIC compilers; using a compiler can speed things up significantly.

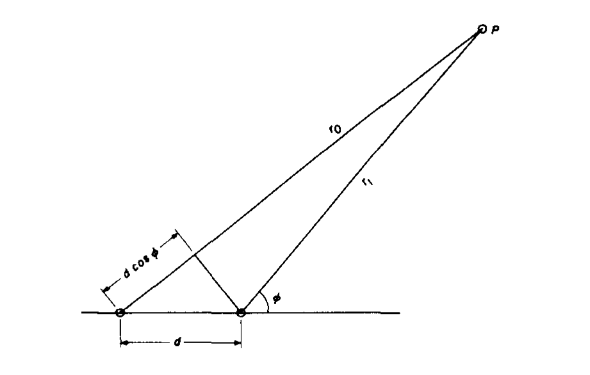
program construction

"ARRAY" is divided into several subroutines that perform different functions. The array pattern is calculated in a subroutine at line 490. The program computes the field strength at each angle by summing the E-field generated by each element of the array. The E-field contains both amplitude and phase information. **Figure 1** shows the geometry involved in calculating the field strength at a distant point P.

As you see in the drawing, if P is far enough away, r_0 and r_1 are almost the same length. Since the signal strength varies slowly as a function of 1/r, the relative signal strengths at P are proportional to the currents in the elements.

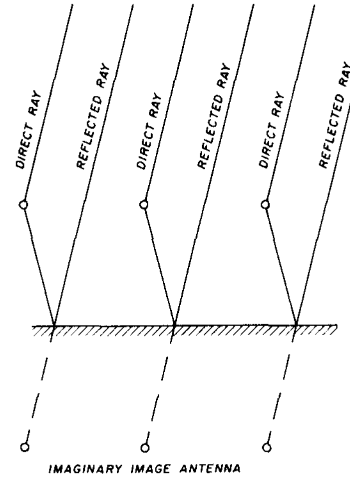
Phase changes rapidly with r — 360 degrees (2π radians) for every wavelength P is from an element. However, at P we are concerned only with the relative phase difference. **Figure 1** shows that the path length difference to P between two elements is d cos (ϕ). β is defined as the rate of phase change, where $\beta = (2\pi/\text{wavelength})$. The amount of phase difference is therefore $\beta d\cos\phi$. Now we must add one more factor — the phase difference between the original element currents (α). So the final equation for the phase difference between any two elements at point P is: phase difference $= \beta d\cos\phi + \alpha$ where $\beta = (2\pi/\text{wavelength})$.

FIGURE 1



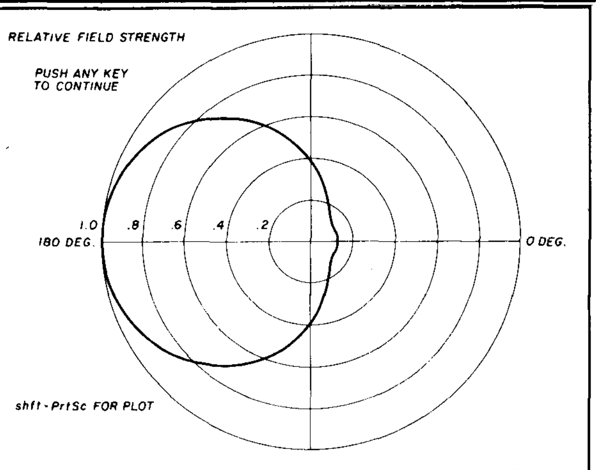
The geometry used with each element to calculate the field strength at point p.

FIGURE 2



Directed and reflected components from antenna elements. The latter appears to original form elements within the ground.

FIGURE 3



Three-element Yagi antenna pattern using omnidirectional elements.

For each radiation angle the program determines the relative magnitude and phase of each element, adds up the total, and places the result in array E. Because you can't add magnitude and phase in polar notation, the E-field values are first converted to rectangular coordinates, added, then reconverted back to polar magnitude.

Where elements are half-wave dipoles instead of omnidirectional elements, a factor is multiplied into each element to simulate the pattern and phase of dipole elements.

simulating ground effects

A ground plane relects the downward directed energy from the elements. At point P there are *two* components from each element: the direct path signal and the reflected path signal. **Figure 2** illustrates this geometrical relationship. While a routine could be incorporated to add the magnitudes and phases of all the signals as in the original array calculations, there is an easier process that uses the concept of an image antenna and the method of antenna pattern multiplication.

If an array at distance h above the ground is replaced with two identically driven arrays spaced 2h apart, the signals arriving at point P are the same in both cases. The second imaginary antenna is called the image antenna.

Pattern multiplication is another method of antenna analysis. All the elements of an array are replaced with a single point antenna having the array's pattern. The image antenna is also replaced by this single point antenna. There are now two antenna "elements" spaced vertically 2h apart. Calculate the pattern of these two omnidirectional elements using pattern multiplication. Simply multiply the pattern of this two-element vertical array with the pattern of the original horizontal array to produce the overall antenna pattern. This method is rigorously correct and significantly reduces computation time.

When an electromagnetic wave hits a perfectly conducting ground, the horizontal (or tangential) component of the E-field cannot exist (must equal zero). Consequently the reflected wave must have an equal value and opposite phase horizontal component to produce this "zero" result. In other words, in the reflection process the E-field phase is reversed by 180 degrees — similar to an incident wave in a coax encountering a short circuit. In a vertically polarized incident electromagnetic wave, the E-field is vertical and *not* shorted out by the conducting plane. The phase is not reversed upon reflection — similar to an incident wave in a coax encountering an *open* circuit. Therefore, the polarization of incident signals significantly affects the phase of the reflected signal. To compensate for this, the program adds 180 degrees

FIGURE 4

```
 3  Element linear array

Element     magnitude        phase(DEG)  separation
 1              .662           0              n/a
 2             1               110.33         .15
 3              .5             244.5          .1

Array elements are omnidirectional.
Step size for analysis is currently  1  degrees.
Ground plane is  1  wavelengths below the array.
Array elements are horizontally polarized.

Do you want to change:
E-element parameters
G-toggle presence or absence of ground plane
P-toggle polarization of elements
H-change distance from array to ground plane
D-toggle omnidirectional elements or 1/2 wave dipole elements
S-change step size of analysis
A-analyze
```

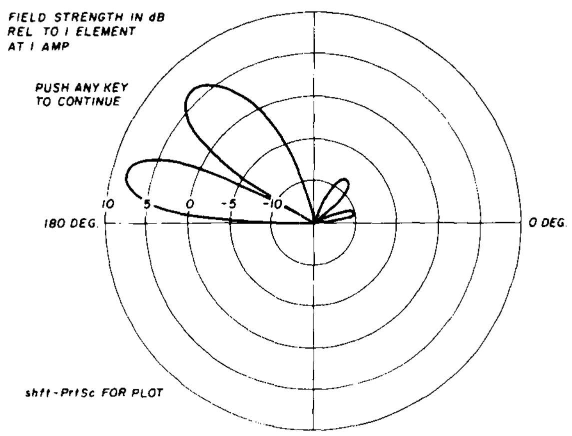
Screen display of change menu.

to the image antenna drive when the polarization is horizontal.

The "ARRAY" program assumes that the ground plane is an ideal conductor. In practice this is never true. The reflectivity of the earth is a function of the local complex dielectric constant (ϵ) for a given frequency. While it varies geographically, in general the lower the frequency the more ideal the earth appears. The reflectivity also varies with the incident angle. For horizontal polarization, the closer the angle is to the horizon, the closer the earth appears as an ideal conductor and the more accurate the program. Below 10 degrees or so it is virtually always accurate. For vertical polarization, the higher the angle is above the horizon, the more accurate the program. Something strange happens with vertical polarization at low angles. At angles below 20 degrees or so, the phase of the vertically polarized reflected wave is actually shifted 180 degrees, just as one would expect with horizontal polarization! As the angle increases, the reflected signal phase quickly shifts 180 degrees back to nearly 0. Therefore, for low angles, it is actually more realistic to model real-world vertical polarization patterns by specifying horizontal polarization. This is one reason why it is so important for a vertically polarized antenna to have a good ground plane if you want significant signal energy gain at low angles.

Even though the earth is not an ideal ground plane, the program is still useful in determining the location of peaks and nulls. In general, with the non-ideal earth, the location of the peaks and nulls will remain approximately correct but the amplitude of the peaks and depth of the nulls will be diminished.

FIGURE 5



A log plot of the vertical pattern of the 3-element Yagi mounted 1 wavelength above a ground plane.

plotting

Plotting routines are provided by lines 1150 and 1630. They are polar plotters converting the angle and magnitude to x,y coordinates and plotting the results on the screen. Both contain auto-scaling. The field strength plot routine scales the field strenth amplitudes so that the highest level is 1.0. The log plotter logs the data and scales it so that the highest 25-dB range is plotted.

FIGURE 6

The "ARRAY" program.

```
10 '***************************************************************
20 '!                          "ARRAY"                              !
30 '!          A linear array antenna pattern plotter               !
40 '!                     by Dennis D. King                         !
50 '!                      VERSION 1.0             11/87            !
60 '***************************************************************
70 'Main Program
80  DIM E(361),UNIT(361),L(361),M(25),THETA(25),D(25)
90  GOSUB 170      'Get input parameters
100  GOSUB 490      'Calculate field strength
110 GOSUB 3380     'Print main menu
120 A$=INKEY$:IF A$="" THEN 120 'Input menu choice
130 P=VAL(A$)
140 ON P GOSUB 1150,1630,2170,90,2740,2150
150 GOTO 110
160 '***************************************************************
170 'Getting input parameters
180 CLS:INPUT"How many elements in this linear array";E
190 CLS:PRINT"What is the magnitude of element 1 current"
200 PRINT"(1 amp is often convenient, it need only be relative)"
210 INPUT M(1)          'M(?) defines the element currents
220   FOR J=2 TO E
230      PRINT"What's the magnitude of element current ";J;" rel to element 1?"
240      INPUT M(J)
250      PRINT"What is the phase(in deg) of element ";J;" rel. to element 1?"
260      INPUT THETA(J)
270      PRINT"How many wavelengths from element ";J;" to element ";J-1;"?"
280      INPUT D(J-1)
290   NEXT J
300 CLS:PRINT:PRINT"Is each element:":PRINT"O-omnidirectional  or;"
310 PRINT"D-a half wave dipole"
320 A$=INKEY$:IF A$="" THEN 320
330 IF A$="o" OR A$="O" THEN EL=0:GOTO 360
340 IF A$="d" OR A$="D" THEN EL=1:GOTO 360
350 GOTO 300
360 CLS:INPUT"What step size in degrees for the anaysis";ST
370 CLS:PRINT:INPUT"Is there a ground plane beneath the array(Y/N)";A$
380 IF A$="Y" OR A$="y" THEN 400
390 GP=0:EEND=360:RETURN 'GP indicates existence of ground plane
400 GP=1:EEND=180
410 INPUT"How many wavelengths below the array is the ground plane";GPWL
420 PRINT:PRINT"Are the array elements:":PRINT"H-Horizontally polarized   or;"
430 PRINT"V-Vertically polarized?"
440 A$=INKEY$:IF A$="" THEN 440
450 IF A$="h" OR A$="H" THEN POL=0:RETURN
460 IF A$="v" OR A$="V" THEN POL=1:RETURN
470 GOTO 420
480 '***************************************************************
490 'Calculating field strength for each degree of angle
500 'Output is E(0-359)
510 CLS
520   FOR DEG=0 TO EEND STEP ST
530      LOCATE 12,25:PRINT"Working on ";DEG;" degree angle."
540      ANG=DEG/57.2975     'converts degrees to radians
550      CO=COS(ANG)
560      IF EL=1 THEN SI=SIN(ANG+1.5708):IF ABS(SI)<.001 THEN RT=0:GOTO 610
570       that statement defined sin(angle+90 degrees)for later
580      :IF EL=1 THEN GOSUB 1090:RT=M(1)*MDIP:GOTO 610
590 '    that statement defined the mag.of element pattern if dipole
600      RT=M(1)
610      IT=0:D=0
620        FOR I=2 TO E
630           D=D+D(I-1)
640           IF EL=1 AND ABS(SI)<.001 THEN MAG=0:GOTO 670
650           IF EL=1 THEN GOSUB 1090:MAG=M(I)*MDIP:GOTO 670
660           MAG=M(I)
670           THET=THETA(I)+6.283*D*CO*57.2975
680           GOSUB 1010 'changing mag and phase to rectangular
690           RT=RT+REAL:IT=IT+IM
700        NEXT I
710      REAL=RT:IM=IT
720      GOSUB 1060 'changing from rect back to polar
730      E(DEG)=MAG
740   NEXT DEG
750 IF GP=1 THEN GOSUB 780 'this does the ground plane calcs
760 RETURN
770 '---------------------------------------------------------------
780 'this sub accommodates ground plane in field
790 'generate image pattern
800  MAG=1:IF POL=0 THEN THETA=180 'accounts for phase of ref.due to polarity
810  IF POL=1 THEN THETA=0
820   FOR DEG=0 TO 360 STEP ST
830      CO=COS((DEG-90)/57.2975)'this rotates pattern -90 deg
840      D=2*GPWL
850      LOCATE 12,22:PRINT"Working on image pattern,";DEG;" degrees."
860      MAG=1:THET=THETA+6.283*D*CO*57.2975
870      GOSUB 1010 'polar to rect
880      RT=1+REAL:IT=IM
890      REAL=RT:IM=IT
900      GOSUB 1060 'changing rect to polar
910      UNIT(DEG)=MAG
920  NEXT DEG
930 'we now have image pattern
940 'multiplying image and array patterns
950   FOR DEG=0 TO EEND STEP ST
960      E(DEG)=E(DEG)*UNIT(DEG)
970   NEXT DEG
980 RETURN
990 '---------------------------------------------------------------
1000 'changing polar coordinates MAG AND THET to rectangular REAL AND IM
1010 REAL=MAG*COS(THET/57.2975)
```

```
1020 IM=MAG*SIN(THET/57.2975)
1030 RETURN
1040 '-----------------------------------------------------------------
1050 'changes rectangular coordinates REAL AND IM to magnitude MAG
1060 MAG=(REAL^2+IM^2)^.5 'changes rectangular to magnitude
1070 RETURN
1080 '-----------------------------------------------------------------
1090 'this sub returns a value MDIP which is the gain factor of dipole element
1100 MDIP=((COS(1.57*COS(ANG+1.5708)))/SI)
1110 RETURN
1120 '-----------------------------------------------------------------
1130 '
1140 '*****************************************************************
1150 'plotting field strength data
1160 SCREEN 2:CLS
1170 CIRCLE (320,100),239
1180 CIRCLE (320,100),192
1190 CIRCLE (320,100),144
1200 CIRCLE (320,100),96
1210 CIRCLE (320,100),48
1220 LINE (80,100)-(560,100)
1230 LOCATE 23,1:PRINT"shft-PrtSc for plot"
1240 LOCATE 3,2:PRINT"Push any key"
1250 LOCATE 4,2:PRINT"To continue"
1260 LINE (320,0)-(320,200)
1270 LOCATE 13,72:PRINT"0 deg"
1280 LOCATE 12,10 :PRINT"1"
1290 LOCATE 12,15:PRINT ".8"
1300 LOCATE 12,21:PRINT".6"
1310 LOCATE 12,27:PRINT".4"
1320 LOCATE 12,33:PRINT".2"
1330 LOCATE 1,2:PRINT"Relative Field Strength"
1340 LOCATE 13,3:PRINT"180 deg."
1350 GOSUB 1470 'sizing data, finding min and max
1360 SCALE=1/MAX 'scale factor to make max=1
1370 X1=320:Y1=100
1380   FOR DEG=0 TO EEND STEP ST
1390      M=SCALE*E(DEG):A=DEG
1400      GOSUB 1550
1410      LINE (X1,Y1)-(X,Y) 'draws lines between x1 y1 points
1420      X1=X:Y1=Y
1430   NEXT DEG
1440 A$=INKEY$:IF A$="" THEN 1440
1450 RETURN
1460 '-----------------------------------------------------------------
1470 'this sub sizes the data, finds min and max
1480 MIN=1000000!:MAX=-1000000!
1490   FOR DEG=0 TO EEND STEP ST
1500      IF MAX<E(DEG) THEN MAX=E(DEG)
1510      IF MIN>E(DEG) THEN MIN=E(DEG)
1520   NEXT DEG
1530 RETURN
1540 '-----------------------------------------------------------------
1550 'this sub returns x,y coordinates for unit plot
1560 'given inputs of magnitude M and angle A in degrees
1570 X=320+240*M*COS(A/57.2975)
1580 Y=100-100*M*SIN(A/57.2975)
1590 RETURN
1600 '-----------------------------------------------------------------
1610 '
1620 '*****************************************************************
1630 'Plotting in dB the highest 25 db of magnitude data
1640 GOSUB 1990 'logging data
1650 GOSUB 2080 'determines scale
1660 SCREEN 2:CLS
1670 CIRCLE (320,100),239
1680 CIRCLE (320,100),192
1690 CIRCLE (320,100),144
1700 CIRCLE (320,100),96
1710 CIRCLE (320,100),48
1720 LINE (80,100)-(560,100)
1730 LOCATE 23,1:PRINT"shft-PrtSc for plot"
1740 LOCATE 5,2:PRINT"Push any key"
1750 LOCATE 6,2:PRINT"To continue"
1760 LINE (320,0)-(320,200)
1770 LOCATE 13,72:PRINT"0 deg"
1780 LOCATE 12,10 :PRINT OUTRING
1790 LOCATE 12,15:PRINT OUTRING-5
1800 LOCATE 12,21:PRINT OUTRING-10
1810 LOCATE 12,27:PRINT OUTRING-15
1820 LOCATE 12,33:PRINT OUTRING-20
1830 LOCATE 1,2:PRINT"Field Strength in db "
1840 LOCATE 2,2:PRINT"Rel to 1 element"
1850 LOCATE 3,2:PRINT"At 1 amp"
1860 LOCATE 13,3:PRINT"180 deg."
1870 SCALE=1/25
1880 X1=320:Y1=100
1890   FOR DEG=0 TO EEND STEP ST
1900      M=SCALE*((L(DEG)-OUTRING+25)):A=DEG 'this scales data
1910      IF M<0 THEN M=0
1920      GOSUB 1550
1930      LINE (X1,Y1)-(X,Y)
1940      X1=X:Y1=Y
1950   NEXT DEG
1960 A$=INKEY$:IF A$="" THEN 1440
1970 RETURN
1980 '-----------------------------------------------------------------
1990 'this sub changes the data to db's rel to single element
2000 MIN=1000000!:MAX=-1000000!
2010   FOR DEG=0 TO EEND STEP ST
2020      IF E(DEG)=0 THEN L(DEG)=-100:GOTO 2040
2030      L(DEG)=8.686*LOG(E(DEG))
```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2040      IF MAX<L(DEG) THEN MAX=L(DEG)
2050      IF MIN>L(DEG) THEN MIN=L(DEG)
2060   NEXT DEG
2070 '-----------------------------------------------------------------
2080 'this sub determines the scale
2090 OUTRING=5*INT(MAX/5)+5 'outring is the nearest 5db increment
2100 CENT=OUTRING-25
2110 RETURN
2120 '-----------------------------------------------------------------
2130 '
2140 '*****************************************************************
2150 SYSTEM 'sends execution back to dos
2160 '*****************************************************************
2170 'printing out data
2180 CLS:GOSUB 1990 'logging data
2190 PRINT"Do you want to:":PRINT" S-print on screen":
2200 PRINT" P-print out on printer"
2210 PRINT" Q-quit"
2220 A$=INKEY$:IF A$="" THEN 2220
2230 IF A$="s" OR A$="S" THEN GOSUB 2460
2240 IF A$="p" OR A$="P" THEN GOSUB 2580
2250 IF A$="q" OR A$="Q" THEN RETURN
2260 GOTO 2170
2270 '-----------------------------------------------------------------
2280 'this sub prints the parameters on the screen
2290 PRINT:PRINT E;" Element linear array":PRINT
2300 PRINT"Element      magnitude        phase(DEG)   separation"
2310 PRINT" 1",M(1)," 0              n/a
2320   FOR I=2 TO E
2330      PRINT I,M(I),THETA(I),D(I-1)
2340   NEXT I
2350 PRINT
2360 IF EL=0 THEN PRINT"Array elements are omnidirectional."
2370 IF EL=1 THEN PRINT"Array elements have 1/2 wave dipole pattern."
2380 PRINT"Step size for analysis is currently ";ST;" degrees."
2390 IF GP=1 THEN 2410
2400 RETURN
2410 PRINT"Ground plane is ";GPWL;" wavelengths below the array."
2420 IF POL=0 THEN PRINT"Array elements are horizontally polarized."
2430 IF POL=1 THEN PRINT"Array elements are vertically polarized."
2440 RETURN
2450 '-----------------------------------------------------------------
2460 CLS'printing out on screen
2470 GOSUB 2280 'prints out parameters
2480 PRINT:PRINT"ANGLE       FS(VOLTS)      REL GAIN TO 1 ELEMENT(DB)
2490 PRINT
2500   FOR DEG=0 TO EEND STEP ST
2510      PRINT DEG,E(DEG);TAB(31) L(DEG)
2520   NEXT DEG
2530 PRINT"Hit any key to continue"
2540 B$=INKEY$:IF B$="" THEN 2540
2550 RETURN
2560 '-----------------------------------------------------------------
2570 'printing out on printer
2580 CLS:PRINT"Sending to printer"
2590 LPRINT E;" Element linear array":PRINT
2600 LPRINT"Element     magnitude          phase          separation"
2610 LPRINT" 1              1               0               N/A"
2620   FOR I=2 TO E
2630      LPRINT E,M(I),THETA(I),D(I-1)
2640   NEXT I
2650 LPRINT:LPRINT"ANGLE       FS(VOLTS)      REL GAIN TO 1 ELEMENT(DB)
2660 LPRINT
2670   FOR DEG=0 TO EEND STEP ST
2680      LPRINT DEG,E(DEG);TAB(31) L(DEG)
2690   NEXT DEG
2700 RETURN
2710 '-----------------------------------------------------------------
2720 '
2730 '*****************************************************************
2740 'change parameters
2750 GOSUB 2280 'prints out current parameters
2760 PRINT:PRINT"Do you want to change:"
2770 PRINT"E-element parameters"
2780 PRINT"G-toggle presence or absence of ground plane
2790 PRINT"P-toggle polarization of elements
2800 PRINT"H-change distance from array to ground plane
2810 PRINT"D-toggle omnidirectional elements or 1/2 wave dipole elements"
2820 PRINT"S-change step size of analysis"
2830 PRINT"A-analyze"
2840 A$=INKEY$:IF A$="" THEN 2840
2850 IF A$="e" OR A$="E" THEN GOSUB 2990
2860 IF A$="g" OR A$="G" THEN GOSUB 3160
2870 IF A$="p" OR A$="P" THEN GOSUB 3210
2880 IF A$="h" OR A$="H" THEN GOSUB 3260
2890 IF A$="a" OR A$="A" THEN CLS:GOTO 100
2900 IF A$="d" OR A$="D" THEN GOSUB 3310
2910 IF A$="s" OR A$="S" THEN GOSUB 2940
2920 CLS:GOTO 2750
2930 '-----------------------------------------------------------------
2940 'changes step size of analysis
2950 CLS:PRINT"Step size is currently ";ST; "degrees."
2960 INPUT"What new step size in degrees";ST
2970 RETURN
2980 '-----------------------------------------------------------------
2990 'changes element parameters
3000 CLS:INPUT"Which element to change";R
3010 CLS:PRINT:PRINT"element      magnitude        phase(deg)     separation"
3020 PRINT R,M(R),THETA(R),D(R-1)
3030 PRINT
3040 PRINT"Do you want to change:"
3050 PRINT"M-magnitude"
3060 PRINT"P-phase":PRINT"S-separation in wavelengths"
```

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```
3070 PRINT"F-finished"
3080 A$=INKEY$:IF A$="" THEN 3080
3090 IF A$="m" OR A$="M" THEN INPUT"What is new magnitude";M(R):GOTO 3010
3100 IF A$="p" OR A$="P" THEN INPUT"What new phase(in deg)";THETA(R):GOTO 3010
3110 IF A$="s" OR A$="S" THEN INPUT"What new separ.(in wvlths)";D(R-1):GOTO 3010
3120 IF A$="f" OR A$="F" THEN RETURN
3130 GOTO 3010
3140 RETURN
3150 '-------------------------------------------------------------------
3160 'toggles presence of ground plane
3170 IF GP=1 THEN GP=0:EEND=360:RETURN
3180 IF GP=0 THEN GP=1:EEND=180:RETURN
3190 RETURN
3200 '-------------------------------------------------------------------
3210 'toggles polarization of elements
3220 IF POL=0 THEN POL=1:RETURN
3230 IF POL=1 THEN POL=0:RETURN
3240 RETURN
3250 '-------------------------------------------------------------------
3260 'changes distance from ground
3270 PRINT
3280 INPUT"What is new distance from array to ground in wavelengths";GPWL
3290 RETURN
3300 '-------------------------------------------------------------------
3310 'toggles omni or dipole element patterns
3320 IF EL=1 THEN EL=0:RETURN
3330 IF EL=0 THEN EL=1:RETURN
3340 RETURN
3350 '-------------------------------------------------------------------
3360 '
3370 '*******************************************************************
3380 'This sub prints the main menu
3390 CLS:PRINT"Do you want to :":PRINT" 1-plot field strength data"
3400 PRINT " 2-plot data in db"
3410 PRINT " 3-print out data":PRINT" 4-start over"
3420 PRINT" 5-Change Parameters":PRINT" 6-quit"
3430 RETURN
3440 '*******************************************************************
```

printing

The calculated patterns can be displayed on the screen or sent to a printer. The output contains each data point in both field strength and dB.

changing parameters

The change parameters routine, located at line 2740, is most worthwhile feature of "ARRAY". It allows the operator to change any of the antenna parameters easily and analyze the new data quickly.

BASIC compatibility

These are the only non-generic basic statements used: "Screen 2", which places Microsoft BASIC in high resolution graphics mode; "LINE", which draws lines between two screen coordinates; and "CIRCLE", which draws a circle of a given radius at a designated screen location. The plot routines are written around standard IBM graphics providing a resolution of 640 by 200. These commands should be easily adaptable for noncompatible forms of BASIC. The circles routine is not essential.

example

There have been some great articles in *Ham Radio* on Yagi antennas. While somewhat difficult, it is possible to derive the driven and induced currents in a Yagi array. Walter Schulz[2] described a three-element Yagi and calculated the element currents. Since the log plotter in the program uses 1 A in one element as a reference for 0 dB, the element currents are scaled so that the driver current is 1 A. The values for this three-element Yagi are:

Element	Current	Rel Phase	Separation in wavelengths
1	0.662	0	N/A
2	1.0	110.33	.15
3	0.5	244.5	.1

The program can first look at the vertical (from the side) field strength pattern in free space. Omnidirectional elements are used because each dipole element appears omnidirectional from the side of the Yagi.

Figure 3 is the resulting field strength plot. An ideal ground plane can now be added. Assume the Yagi is horizontally polarized and mounted 1 wavelength off the ground. (This is equivalent to 65 feet for a 20-meter beam.)

Figure 4 is the menu displayed for adding the ground plane and associated parameters.

Figure 5 shows the resulting field strength plotted with the log plot routine. On the plot, 0 dB is the field strength that one element in free space would have with the same drive current of 1 A. On 20 meters the Yagi's primary lobe fires upward about 14 degrees.

conclusion

The "ARRAY" program, **fig. 6**, was primarily developed as an educational tool and will help anyone with a personal computer gain insight into antennas and resulting patterns. I'd be interested in receiving any comments, corrections to the program, or suggestions on possible improvements.

A written copy with comments and a 5-1/4 inch MS-DOS DSDD floppy containing the program is available from the author for $15.00.

reference

1. Walter Schulz, Jr., "Key to 3-Element Yagi Design," *Ham Radio*, March 1984, pages 48-51.

bibliography

Edward Jordan, Keith Balmain, "Electromagnetic Waves and Radiating Systems," Prentice-Hall, Inc., 1968.

Article G **HAM RADIO**

A 220-MHZ 9600-BAUD DATA RADIO SYSTEM FOR PACKET

By Fred B. Cupp, W2DUC, 27 Crescent Road, Fairport, New York 14450

Techniques, equipment, and software for Amateur Packet Radio evolved in response to the medium's emerging needs. In packet's early days, the development of a dedicated controller, or TNC, presented a major stumbling block. Once this problem was overcome, the TNC was used with conventional 2-meter FM radios and telephone-type 1200-baud modems to get stations on the air and communicating.

The Packet Bulletin Board System, or BBS, was the next innovation. The WØRLI operating system, developed for the Xerox 820 computer board, has set a "de facto" standard for BBS software running on other machines — usually an IBM PC or clone. These BBS's have made mail forwarding on VHF a practical reality. They serve as local information centers and Amateur electronic mail networks.

Now there's interest in the formation of true electronic networks which will use intelligent node controllers to handle the traffic between distant stations automatically. There are still many questions to be answered, but at least three distinct groups are working on particular networking methods. But in the midst of all this activity, there's one item which seems to have been overlooked.

Dedicated high-speed radio links will be needed for network support, no matter what protocol finally emerges as the standard. There have been several complete radio modems advertised in ham magazines recently, but the cost of these units is rather steep compared to what we pay for the rest of our packet gear. In search of a low-cost alternative, N2AMK and I began experimenting with high-speed packet in the spring of 1987. Here are the methods and equipment we tried for running 9600 baud on 220 MHz using modified commercially available equipment.

One of the ways used to encode digital data on an RF carrier, Audio Frequency Shift keying (AFSK), is rather wasteful of bandwidth. Audio Phase Shift Keying (APSK) is better, but still isn't the ultimate. Current literature indicates that direct frequency modulation of the carrier by a digital signal is the most efficient method, especially in the presence of noise as the signal gets weaker.

To reduce the bandwidth of the transmission, you can filter the digital signal to limit the spectrum without significantly reducing the effectiveness of the received signal. Actually, this may be considered "rate-limited frequency shift keying." The trick is in the receiving end, where it's necessary to establish references for decoding the digital signal and regenerating the original TTL level signals.

For more information read "The TEXNET Packet Switching Network-part 2," published in *Ham Radio*, April 1987. Another good reference is the paper by Steve Goode, K9NG, in the fourth ARRL networking conference book. These articles provide good background on digital transmission and the problem of envelope or group delay. We've also included our own "Layman's Guide to Data Transmission" at the end of this article.

Group delay is also called "frequency/phase nonlinearity." Simply stated, digital signals are comprised of a variety of frequencies depending on the number of "ones" and "zeros" in the data stream. If the higher frequencies pass through the system with different time delays than the lower frequencies, the clock recovery and the decoding of the bit stream will be poor. There are two possible methods of correction.

The first method (used in TEXNET) is to insert frequency-variable time-delay circuits in the receiver output to correct or compensate for the distortion caused by the receiver IF filters. The second is to use a class of filters which have been designed for "flat" group delay. The advantage in using the second method is that it doesn't require adjustment to match the particular receiver IF.

We looked through several manufacturers' catalogs and found a class of IF filter intended for use in the digital control links of cellular telephones. The filters are produced by Murata-Erie, which also manufactures the filters used in the Hamtronics radios. The filter pinout and physical size are identical.

Armed with some sample filters, we got our project underway and built two systems – one at W2DUC, another at N2AMK. The test path was about 18 miles and over enough hills to require 10-watt "afterburners," especially during the summer when the trees were in leaf.

Design goals

In planning our tests, we decided not to use surplus equipment because we couldn't be sure others would be able to find the same parts. Instead, we used relatively standard parts and easy-to-obtain modules. Modular units let you make modifications without reworking a large unit.

Because we wanted a system that could be set up with a minimum of special test equipment, we had to keep the number of adjustments to a minimum.

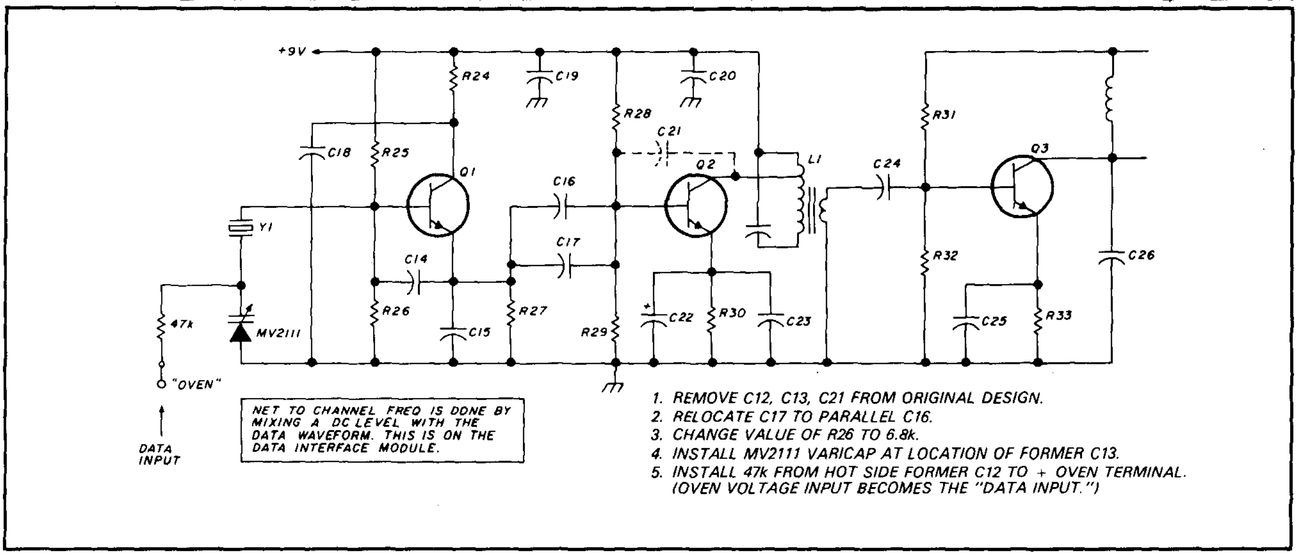
Although TEXNET used the Hamtronics FM-5 transceivers, they've received some poor reviews when used in 9600-baud links. After talking with WA2GCF, Jerry Vogt of Hamtronics, we decided to choose separate modules for the exciter and receiver. These modules were better suited to the modifications we wanted to perform and were more stable than the earlier FM-5.

Our plan was to remove the phase modulator in the Hamtronics TA-51 exciter module. FM modulation is obtained by using a voltage variable capacitor (varicap) in the crystal oscillator circuit. Netting to frequency is achieved by summing the data with a DC voltage. You can use the optional speech input, as well as the digital data.

The receiver was very nearly "stock." We modified the squelch circuit to remove the hysteresis. The squelch signal was brought out to be used as the carrier detect input to the TNC. The discriminator output was brought out to the modem board, with the receiver audio left intact for voice use. For packet operation, simply turn down the volume control.

For the application in this article it's assumed that you are modifying a completely assembled pair of modules. If you're building a new kit, simply leave out the parts mentioned in the following changes.

FIGURE 1



Changes to Hamtronics TA-51 220-MHz exciter for 9600-baud data transmission.

Exciter module changes

The exciters (from Hamtronics, Inc.) were originally built in the normal voice form. The radios were then tested on voice to assure proper operation. We discovered that the path was a little too rough and built a pair of 10-foot homebrew Yagis, which brought the signals up to usable voice quality. While some 9600-baud operation was possible, there was still enough noise on the signal to prevent perfect transmissions without retries. The 2 watts of the exciters just wasn't enough.

Adding the power amplifiers solved all the signal strength problems and also took care of the antenna switching (originally external to the modules). Antenna switching is included in the power amplifier modules.

As mentioned earlier, the major change was the conversion from phase modulation to direct FM. In the original circuit, Q2 was the phase modulator. The RF signal had two possible paths, one through Q2 and the other through capacitor C21. Varying the bias on Q2 caused a variation in the contribution of the two paths, which in turn caused a variation in the phase of the RF. Q2 was converted to a straight-through buffer by removing C21. C17 was part of a voltage divider in the drive path to Q2. This was relocated to parallel C16, increasing the drive to the stage (see **fig. 1**).

We modified the oscillator by removing two capacitors which were in series with the crystal to ground and installed an MV2111 varicap in place of C13. A 47-k resistor connected to the junction of the crystal and the varicap provides the injection of the control voltage. We used a terminal normally used with the crystal oven as a connection point for the 47-k resistor and the incoming control signal.

Because we were operating the radios inside a heated ham shack, we didn't need the optional crystal ovens. However, you should use them in hilltop applications. In this case you need some other means of connecting to the 47-k resistor. (You can solder a terminal strip to the underside of the pc board near the oscillator circuit.)

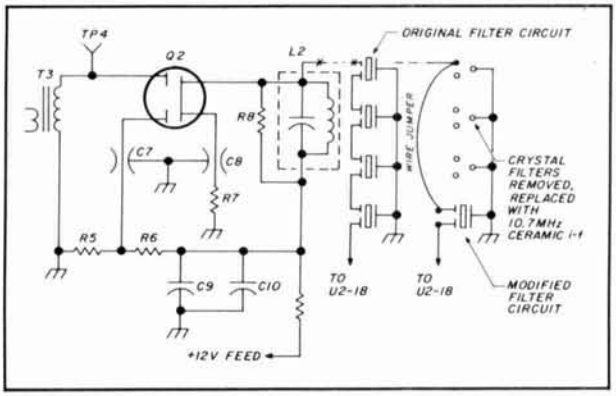
Initial netting to the desired frequency must be done without the data connected to the modem board. If the voice option is available, just switch to voice; this will leave a carrier for setting the frequency. If you don't use a switch, disconnect (leave open) the data input.

The final modification involves bringing out the audio signal from the microphone preamp to the voice-data switch. Remove R21, the first resistor in the audio roll-off filter. (You may insert a wire in the now empty pad which connects to C9.) This picks up the signal at the deviation control. To get full deviation on voice, we raised the clipping level by changing R10 to a 3.3-k resistor.

Receiver module changes

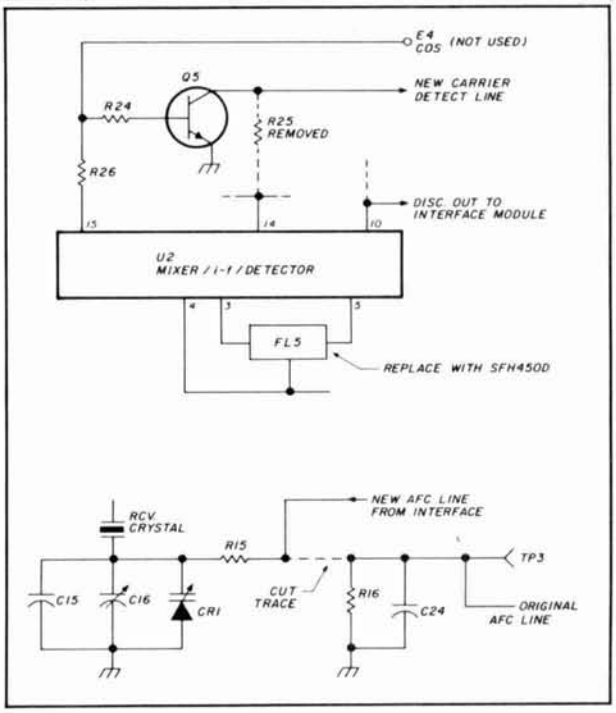
The receiver modifications are made primarily to correct the group delay in the IF strip. We performed several tests to determine the necessity of changing both the 10.7-MHz crystal filters and the 455-kHz IF filter. We tried several combinations of crystal filters with very poor results. It's necessary to increase the 10.7-MHz IF bandwidth by replacing the crystal filters with a conventional FM broadcast-type IF ceramic filter. The original filter consists of four crystal filters (FL1 through FL4), so you must use a wire jumper to bridge across the three empty positions that remain. (See **fig. 2.**)

FIGURE 2



Partial schematic of 10.7-MHz filter change.

FIGURE 3



Partial schematic of receiver-module changes.

We replaced the 455-kHz second IF (FL5) with the Murata-Erie digital IF filter. This unit has a center frequency of 450 kHz instead of the conventional 455 kHz. We encountered no problems netting to frequency, because the 5-kHz difference was well within the "tweaking" range of the receive crystal trimmer. This filter fits the Hamtronics board with no modifications. (See **fig. 3**.)

Next, unsolder and lift the end of R15 at the junction with C24 and R16. This disables the normal AFC. Connect the "fast" AFC (terminal E6) from the modem board to the open end of R15. The direction of AFC action is right for centering an incoming signal. A wire

✓ 132

✓ 133

✓ 134

3 New Publications

"A terrorist agent, representing an unknown foreign power or an internal subversive group, is bent on crippling or destroying America's space program by operating an illicit radio station from somewhere inside our Lost Padres National Forest wilderness area. A terrorist who has somehow gained access to our secret digital codes, launching schedules and classified radio frequencies required to cause our birds to self-destruct, during or after launch." And so begins a new adventure for Tommy Rockford, K6ATX.

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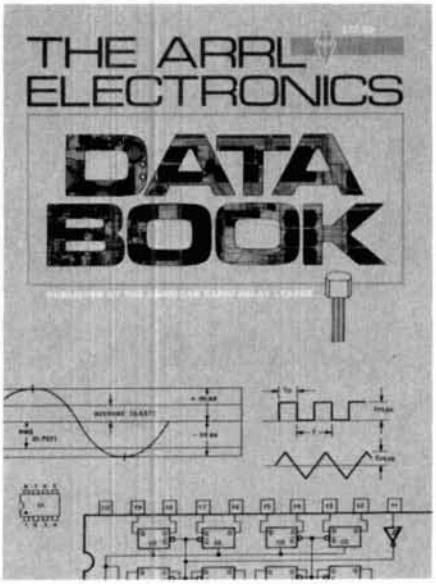
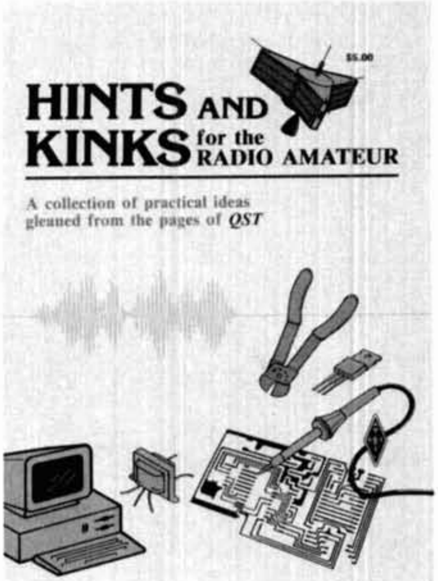


parameters. This book can be used alone or to complement **The ARRL Handbook** and belongs in every technical library. Here's a brief summary and chapter lineup: **Symbols, Conversion Factors and Tables**; **Components and Materials** includes color codes, standard values, toroid selection charts; **Inductors and Transformers**; **Time and Frequency Measurement**; **Networks and Filters** covers attenuators and matching network design information; **Digital Basics** is 88 pages of logic, TTL Circuits, specific device descriptions, linear ICs, op-amp applications, and regulators; **Antennas and Transmission Lines**; **Catalog of Circuit Building Blocks** including audio amps, RF and IF small-signal amplifiers, mixers, FM detectors, oscillators, dc switches and amps, and frequency doublers; **Workshop and Lab Practices**. 234 pages, $12.00*



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107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311	323	335	347
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
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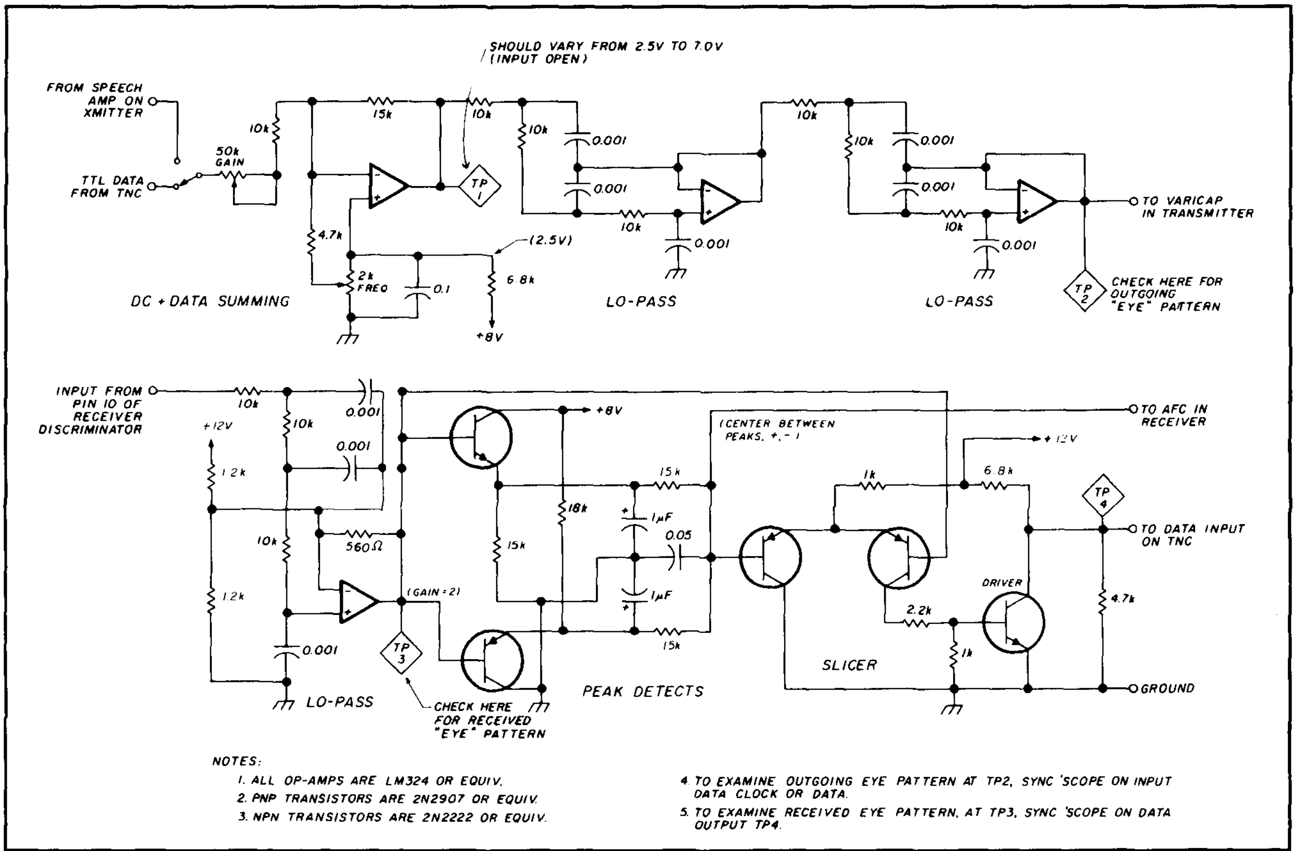
FIGURE 4



Schematic of 9600-baud packet radio interface.

from pin 10 of the discriminator (U2) brings the FM output to the modem board, terminal E4.

Finally, remove R25 in the squelch circuit. This leaves the collector of Q5 open. Connect a wire from the collector to the squelch input of the TNC. This will operate the carrier detect light on the TNC and hold back transmission when the channel is busy.

The various receiver connections won't inhibit normal receiver use for either data or voice. The squelch action will, however, be "softer" because there's no longer any hysteresis in the detector.

Modem board

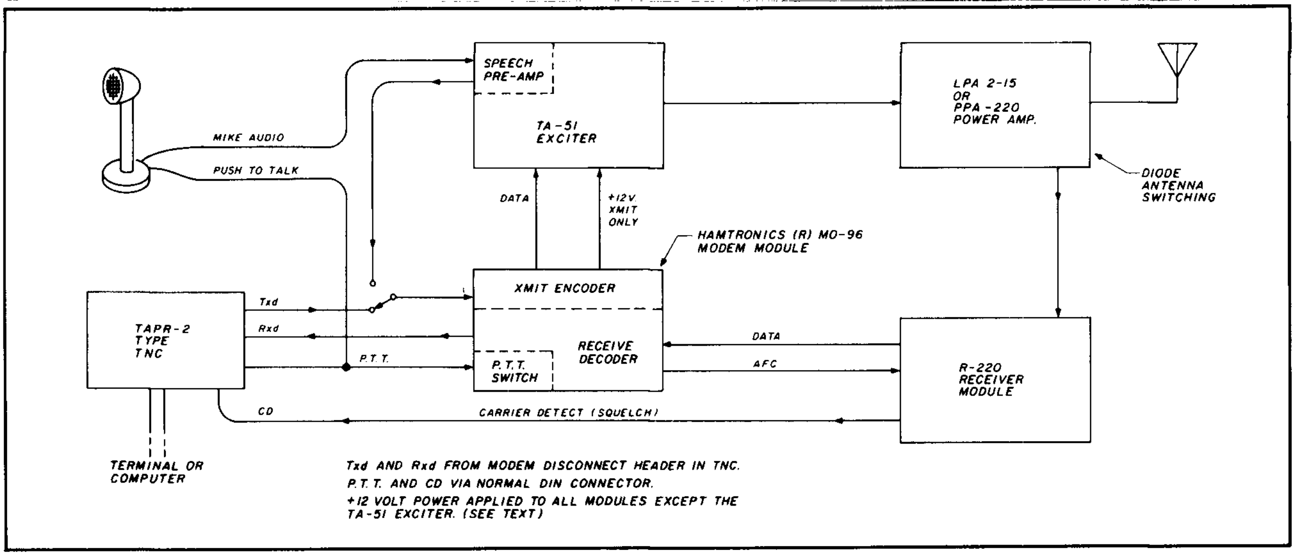
Figure 4 is a schematic diagram of the modem or interface between the TNC and the radio. As you'd expect, there are two distinct sections — the transmit encoder and the receive decoder.

The transmit section uses three sections of a quad op amp, (LM-324). The first stage combines the data or optional voice signal with the DC offset voltage. Varying the frequency adjust pot setting shifts the bias or center value of the output voltage. This then establishes the carrier center frequency. The fixed voltage at the noninverting input is +2.5 volts; when data is applied (5-volt logic levels) it will shift the output of the op amp equally above and below the desired output point. This causes an equal carrier shift above and below the center frequency.

The signal at TP1 is still a square wave, so two stages of active low-pass filtering follow. After filtering, the output at TP2 will be nearly sinusoidal in shape. This reduces the bandwidth of the transmitted signal. The DC level injected at the first stage is unaffected by the filters and also serves as the filter bias. The signal at the output is next applied to the varicap in the transmitter circuit, through a series resistor. The nominal voltage at TP2 will be about 5-6 volts with ± 2 volts deviation when data is present.

The receive section is a bit more complex. The output of the receiver discriminator is first applied to another filter similar in function to those used in the transmit section. The intent is to reduce the bandwidth of the received audio, removing high-frequency noise which would interfere with data decoding. A gain-adjusting resistor is added to the network to boost the signal level by a factor of 2. This raises the low signal level from the discriminator output to improve the operation of the level detectors.

FIGURE 5



Block diagram of complete packet radio system.

Two transistors are used as peak level detectors. The NPN "follows" the positive excursions of the signal, charging up the 1-μF capacitor to near the peak positive value. In like manner, the PNP follows the negative peaks, charging another 1-μF capacitor. The discharge time constant is equal to about 20 bit periods at 9600 baud. A pair of equal (15 k) resistors bridges the two level detectors. The voltage at the center tap of the resistors is the value of the midpoint between the two peaks.

This voltage serves two purposes. Because it has a very fast attack and represents the center of the modulation swings, it can be applied to the AFC circuit in the R-220. This helps the receiver to center rapidly on an incoming signal during the preamble or "flags" period.

The voltage is also used as a reference voltage applied to one input of a differential comparator or "slicer," using two PNP transistors. With the reference applied to one input and the raw data signal applied to the other, the resulting output is a digital representation of the instantaneous received signal frequency. The signal is buffered and shaped to TTL logic level by the NPN transistor and the resistive voltage divider. Note that this isn't an RS-232 signal, but a logic level to be applied to the external modem connector of the TNC.

System interconnections

Figure 5 is a block diagram of the complete system showing the Hamtronics modules, the interface or modem board, and the interconnections to the TNC. The TNC must have a modem disconnect header or connector. It must also be set for 9600-baud operation. The RS-232 port from the TNC isn't shown; it may be operated at whatever data rate you desire.

Twelve-volt power is applied to all of the modules except the exciter. Because the power amplifier module is class C, it isn't necessary to switch the power — only the drive. When the TNC pulls down on the PTT line, the transistor switch on the modem board applies the 12 volts to the exciter. This drives the power amplifier into conduction, drawing current from the 12-volt supply, which in turn operates the diode antenna switch.

The receiver module is powered at all times. When you transmit, your signal will be received, decoded, and passed back to your TNC. This permits a built-in "loopback test" function. Depending on the cable layout and the isolation of the T/R diode switching, you may have enough overload on the receiver to prevent clean reception of your own signal. Usually a good match to the antenna, decent cable connections, and grounding of all modules will tame any overload.

We brought the microphone preamp on the Hamtronics TA-51 exciter out to a switch and wired it to select either data or voice signal. The push-to-talk switch on the mike is wired in parallel with the PTT line from the TNC. This provides a voice mode which we used as an "intercom" during testing. This may even be helpful in a remote backbone digipeater situation, for use during setup and maintenance visits.

Summary — where do we go from here?

In the year that our on-the-air testing has been in

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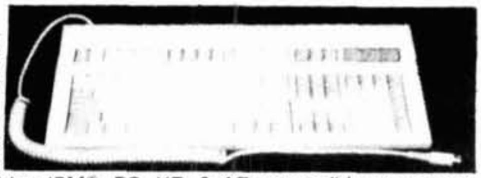

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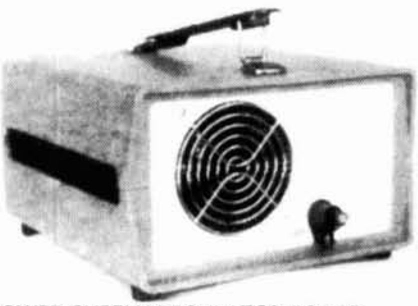

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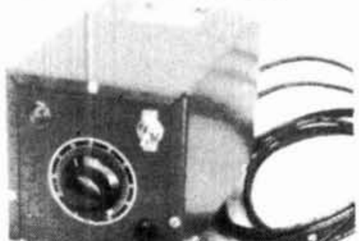

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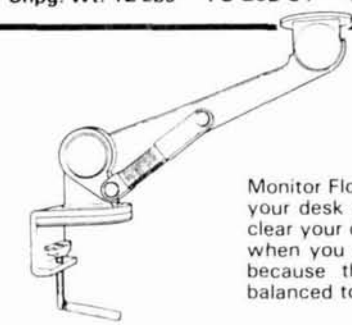

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progress, there has been little published on the topic of higher speed packet operation. Everyone seems to be waiting to see what sort of equipment will emerge as the de facto standard. It seems that no one wants to be the first kid on the block to jump in. There are a few group efforts under way, but little information of a solid technical nature has appeared to let us know what's going on.

The system we've described here is a "Minimum Shift, Bandwidth Limited, Frequency Modulation System." Although I have not contacted AEA or GLB, an examination of their spec sheets indicates use of a very similar modulation method. The data rate is higher, so the bandwidth is wider but still in the same general relationship.

Naturally, each designer begins with a set of assumptions and builds from there. We assumed 9600 baud, since a standard (unmodified) TAPR-2 TNC will run only that fast. It can be pushed up by altering the taps on the clock divider, but we felt 9600 baud without cutting into the TNC would be attractive to most hams.

We arbitrarily chose a bandwidth of 8-10 kHz as a compromise. It's approximately the lower limit of Shannon's rule of thumb (1 Hz/bit/sec of bandwidth) and at reasonable "Amateur" signal-to-noise ratios. We also considered the availability of the Murata-Erie IF filters. Because the signal isn't crowded into a very narrow filter, phase distortion isn't a serious problem and frequency stability is less critical. In a year of operation, we haven't had to adjust the frequency of either unit.

We also considered the inclusion of a data "scrambler/descrambler" to reduce the DC content of the data signal. This lessens the tendency of the level detector or slicer to shift during periods of DC unbalance. In testing, the bit stuffing done by the TNC appeared to be adequate to survive even deliberate long strings of null characters or FFs in transparent mode. If you're a purist, you can still add a shift register scrambler in the data lines at each end of the circuit.

The standards we chose are loose enough to permit some latitude in matching to other system standards, within reasonable limits. We'd like to have an opportunity to see if our system is truly compatible with a GLB or AEA running at 9600 baud and with some similarity in the deviation. It should fly, but we won't know until we have a chance at one.

Just as I was finishing this article, I received the May 27th issue of the *Gateway*, volume 4, no. 18. It contains the specifications for the 9600-baud modem project, designed by James Miller, G3RUH. I was most interested in comparing the standards he used with the standards we have described. It appears that the approach is very similar. The major difference is that we have a "cheapie" version — sort of a Model T compared to a Cadillac.

The modulation scheme is identical. Direct FM is applied to a varactor diode. Miller shaves the deviation a little tighter, using 3-kHz deviation as opposed to the 4 kHz we used. The bandwidth low-pass filtering is done with a very classy digital "finite impulse response" transversal filter. While it's very sharp on the sides, the cut-off frequency is also 4800 Hz. He also included a shift register scrambler to remove any long strings of zeros or ones. Another interesting difference is the use of precompensation (or predistortion in the opposite direction), to correct the system phase distortion at the transmitter instead of the receiver.

Up to this point, the differences are quite minimal. The major difference seems to be in the complexity of the respective systems. I certainly agree that the super high-quality filters and digital PLL clock detectors can do nothing but improve performance. Our intent was to break some fresh ground and get some action started in 9600-baud networking. It will be interesting to check out our system in real over-the-air tests with the G3RUH modem. From the standpoint of compatibility, they should get along fine together.

Naturally, it's our hope that some packeteers in our area, or our neighbors in Canada, might try some tests with us. We've passed thousands of bytes of data back and forth, but it sure would be nice to do more than tests!

In conclusion, we want to thank Jerry Vogt, WA2GCF, of Hamtronics for his help on the modifications to the transceivers and for making pc boards available. Murata-Erie was also helpful in supplying several different filters, permitting a choice of the best bandwidth for this data rate.

The following modules are available from Hamtronics, Inc., 65 Moul Road, Hilton, New York 14468-9535, (716)392-9430.

MO-96 Packet Radio Networking Modem Module
TA-51-220-HS High-speed Data Exciter Module
R-220-HS High-speed Data Receiver Module
LPA 2-15 (220) 15-watt PA Module with diode antenna switch
PPA-220 50-watt Packet PA Module with pin diode antenna switch

Appendix A

Layman's (simplified) guide to data transmission

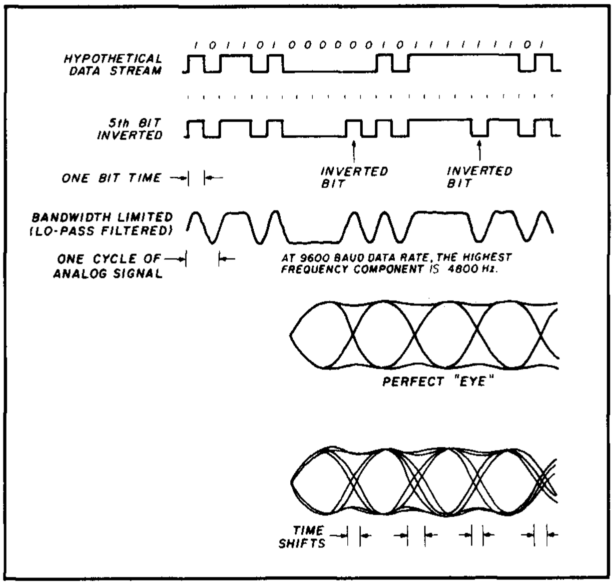
The following is admittedly not technically correct, but is presented to help you understand the basic methods used in transmitting data on VHF radio. Signal preparation will be shown up to the point of application to the FM modulator, and then as received from an FM discriminator or PLL detector.

If a random data signal is displayed on a scope and triggered at the bit rate, successive sweeps will overlap, creating what is known as an "eye" pattern. This pattern serves as a means of estimating the quality of the transmission/reception system, or path.

To determine whether a signal represents a "one" or a "zero," you must make a decision at a time interval related to past zero crossings. The absence or presence of zero crossings at the bit intervals indicates a change of the digital state. There are other more sophisticated methods for making the decision, but zero crossings are commonly used. Whatever method you use, the time between changes of state will always affect the error rate. "Jitter," or random time variations, make it more difficult to decode the data accurately.

If a signal is corrupted by noise, both the levels and the zero crossing times will be affected.

Even when the signal is not noisy, phase distortion or delay will alter the zero crossing times. This also causes errors in the data. This effect is caused by differences in the time delays of the different frequency components of the signal as they pass through filters, like the IF filters in the radio. This also is known as "Envelope Group Delay," or "Group Delay Time."



Conclusions

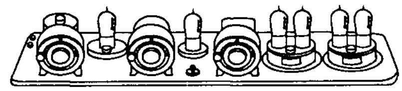
1. To send digital data at high speed over radio links, you must pay attention to signal quality (noise, distortion, and phase shift) in the communications channel.

2. A rule of thumb for FM is that the signal deviation should be about half the data bit rate. Another way to state this is: "The bandwidth is about equal to the data rate," since the channel bandwidth is twice the deviation.

3. The digital data must not have strong DC components. Either "bit stuffing" or a "shift register scrambler" should be used to prevent long strings of zero or one bits.

4. The receiver bandwidth should be reasonably matched to the signal bandwidth for best signal-to-noise ratio and lowest error rate.

Article H **HAM RADIO**



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CT-90	10 Hz-600 MHz	<10mv To 150 MHz <150mv To 600 MHz	1 PPM	9	0.1Hz, 10Hz, 100 Hz	169.95
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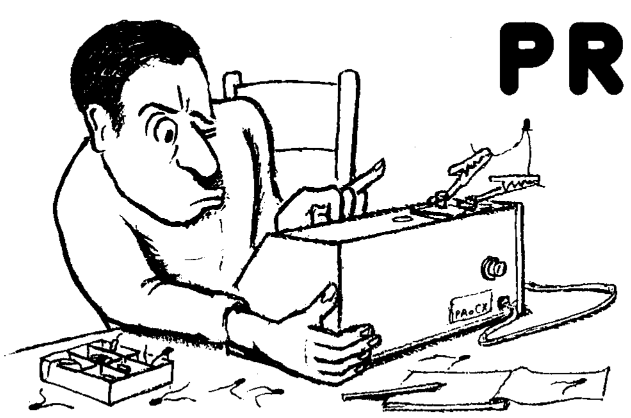


PRACTICALLY SPEAKING

Joe Carr, K4IPV

Antenna system instruments

One of the perennial topics addressed by Amateur Radio articles is the instrumentation needed for antenna systems. This isn't because there's nothing else to write about, but because readers continually request information about things like impedance bridges, noise bridges, and dip oscillators. This month I'll take a look at some of the basic instruments you might want to consider owning.

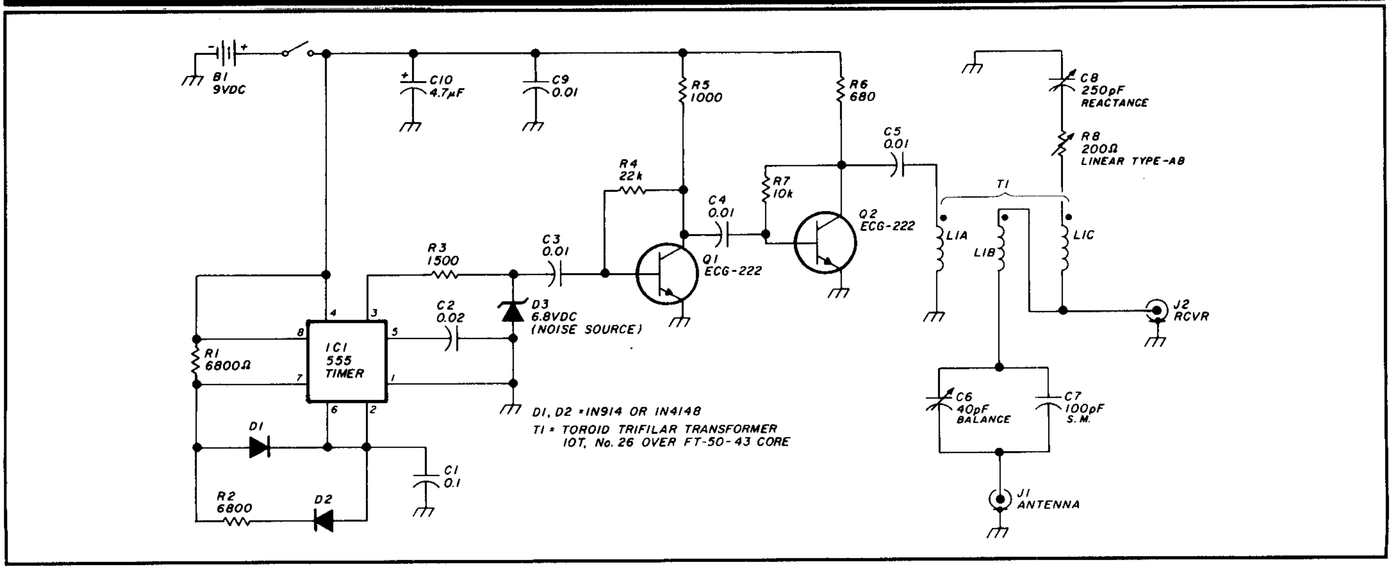
There are two main things to worry about when designing and installing Amateur Radio antenna systems. First, you need to know the frequency on which the antenna is resonant (hopefully, inside an Amateur band). Second, you need to know the feedpoint impedance, to make impedance matching easier (or, for that matter, possible). Let's take a look at some impedance bridges: noise types, VSWR bridges, and dip oscillators. There are more sophisticated instruments available, but these few are all most of us need for our antenna testing requirements.

The RF noise bridge

The RF noise bridge is a device that was once associated only with engineering laboratories, but it has Amateur Radio applications as well. Amateurs have been using noise bridges for many years, although at one time most of them were homebrew. The noise bridge is one of the most useful, low-cost, and often overlooked test instruments available.

Several companies have produced low-cost noise bridges: Omega-T, Palomar Engineers, and most recently, the Heath Company. The Omega-T and the Palomar Engineers models are shown in **photos A** and **B**. The Omega-T device (**photo A**) is a small cube with one dial and a pair of BNC coax connectors (ANTENNA and RECEIVER). The dial is calibrated in ohms and measures the resistive component of impedance only. The Palomar Engineers device does everything the Omega-T does. It also lets you make a rough measurement of the reactive component of impedance. The Heath Company added their Model HD-1422 to the line-up; it's a "one-evening" kit. I reviewed the HD-1422 in my May 1986 column, so I won't elaborate on it here.

FIGURE 1

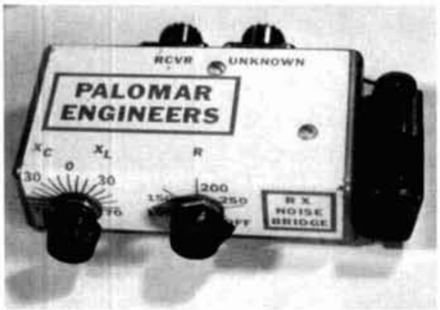


Noise bridge circuit.

PHOTO A

Omega-T noise bridge.

PHOTO B



Palomar Engineers noise bridge.

Over the years, some people have found the noise bridge useful for a variety of test and measurement applications — especially in the HF and low VHF regions. Its applications are not limited to antenna testing (the main job of the noise bridge). The two-way technician or Amateur Radio operator may use the device to measure antennas, tuned circuits, and resonant cavities.

Figure 1 shows a noise bridge circuit. The bridge consists of four arms. The inductive arms, L1b and L1c, form a trifilar-wound transformer over a ferrite core with L1a, so a signal applied to L1a is injected into the bridge circuit. The measurement consists of a series circuit made up of a 200-ohm potentiometer (R8) and a 250-pF variable capacitor (C8). The potentiometer sets the range (0-200 ohms) of the resistive component of measured impedance, while the capacitor sets the reactance component. Don't use a wire-wound potentiometer for R8. Capcitors C6/C7, in the unknown arm of the bridge, balance the measurement capacitor and should have a total value equal to one-half C8 (or about 125 pF). The bridge is balanced when C8 is in the center of its range and R8 is set to the resistance connected across J2, with C6/C7 in the circuit. This arrangement accommodates both inductive and capacitive reactances, which appear on either side of the "zero" point — the midrange capacitance of C8. When the bridge is in balance, the settings of R and C reveal the impedance across the unknown terminal.

A reverse-biased zener diode (zeners normally operate in the reverse-bias mode) produces a large amount of noise because of the avalanche process inherent in zener operation. While this noise is a problem in many other applications, it is highly desirable in a noise bridge; the richer the noise spectrum, the better the performance. The spectrum is enhanced because of the 1-kHz square-wave modulator that chops the noise signal. An amplifier boosts the noise signal to the level needed in the bridge circuit.

The detector used in the noise bridge is a tunable receiver which covers the frequencies of interest. The preferred receiver uses an AM demodulator, but both CW and SSB receivers will do in a pinch. The type of receiver you need depends on how precise an operating frequency is required for the device under test.

Adjusting antennas

Finding the impedance and resonant points of an HF antenna is perhaps the most common use for the antenna noise bridge. Connect the RECEIVER terminal of the bridge to the ANTENNA input of the HF receiver with a short length of coaxial cable. This length should be as short as possible, and the characteristic impedance should match that of the antenna feedline. Now, connect the coaxial feedline from the antenna to the ANTENNA terminals on the bridge. You're now ready to test the antenna.

Finding impedance. Set the noise bridge resistance control to the antenna feedline impedance (usually 50 or 75 ohms for most common antennas). Set the reactance control to midrange (zero). Next, tune the receiver to the antenna's *expected* resonant frequency (F_{exp}). Turn the noise bridge on, and look for a noise signal of about S9 (will vary on different receivers).

Adjust the *resistance* control (R) on the bridge for a null; i.e., minimum noise as indicated by the S-meter. Next, adjust the *reactance* control (C) for a null. Continue adjusting the R and C controls for the deepest possible null, as indicated by the lowest noise output on the S-meter (there is some interaction between the two controls).

A perfectly resonant antenna will have a reactance reading of zero ohms, and a resistance of 50 to 75 ohms. Real antennas may have some reactance (the less the better), and a resistance that is somewhat different from 50 or 75 ohms. You can use impedance-matching methods to transform the actual resistive component to the 50 or 75-ohm characteristic impedance of the transmission line. Here are the results you can expect:

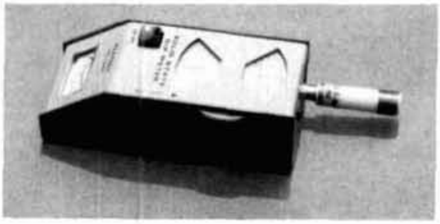
1. If the resistance is close to zero, suspect that there's a short circuit on the transmission line; suspect an open circuit if the resistance is close to 200 ohms.
2. A reactance reading on the X_L side of zero indicates that the antenna is too long, while a reading on the X_C side of zero indicates the antenna is too short.

Adjust an antenna that's too long or too short to the correct length. To determine the correct length, you must find the actual resonant frequency, F_r. To do this, reset the *reactance* control to zero and then **slowly** tune the receiver in the proper direction — downband if it's too long and upband if it's too short — until you find the null. On a high-Q antenna the null is easy to miss if you tune too fast. Don't be surprised if that null is out of band by quite a bit. Find the percentage of change by dividing the expected resonant frequency (F_{exp}) by the actual resonant frequency (F_r), and multiply-

✓ 143

✓ 144

PHOTO C



Heath dip oscillator ready for use.

PHOTO D

Heath dip oscillator in case.

ing by 100: Change $= (F_{exp} \times 100$ percent$) / F_r$).

Resonant frequency. Connect the antenna, noise bridge, and receiver as you did before. Set the receiver to the expected resonant frequency — approximately 468/F for half-wavelength types and 234/F for quarter-wavelength types. Set the resistance control to 50 or 75 ohms, as appropriate for the normal antenna impedance and the transmission line impedance. Set the reactance control to zero. Turn the bridge on and listen for the noise signal.

Slowly rock the reactance control back and forth to find on which side of zero the null appears. Once you've determined the null's direction, set the reactance control to zero and tune the receiver towards the null (downband if the null is on the X_L side and upband if on the X_C side of zero).

A less than ideal antenna won't have exactly 50 or 75-ohm impedance, so you'll have to do some adjustment of R and C to find the deepest null. You'll be surprised how far off some dipoles and other forms of antennas can be if they aren't in "free space;" i.e., they're close to the ground.

Dip oscillators

One of the most common instruments for determining the resonant frequency of an antenna is a "dip oscillator," or "dip meter" (see **photo C** and **D**). This instrument was originally called the "grid dip meter." The meter works because its output energy can be absorbed by a nearby resonant circuit, or antenna (which electrically is a resonant LC tank circuit). When the inductor of the dip oscillator is brought into close proximity with a resonant tank circuit, and the oscillator is operating on the resonant frequency, a small amount of energy is transferred. This energy loss appears on the meter pointer as an extremely sharp dip; you can miss it if you tune the meter frequency dial too rapidly.

Antennas are resonant circuits and can be treated in a manner similar to LC tank circuits. **Figure 2A** shows one way to couple the dip oscillator to a vertical antenna radiator. Bring the inductor of the dipper into close proximity with the base of the radiator. **Figure 2B** illustrates the way to couple dip oscillators to systems where the radiator is not easily accessible (as when the antenna is still erected). Connect a small 2 or 3-turn loop to the transmitter end of the transmission line, and then bring the inductor of the dipper close to it. A better way to do this is to connect the loop directly to the antenna feedpoint.

There are two problems to be aware of when using dip meters. As I said before, the dip is very sharp — it's easy to tune past it and miss it. To make matters worse, it's normal for the meter reading to drop off gradually from one end of the tuning range to the other. But if you tune very slowly, you'll notice a very sharp dip when you reach the resonant point.

The second problem concerns the dial calibration. The dial gradations of inexpensive dip meters are too close together and often erroneous. You'll be better off if you monitor the output of the dip oscillator on a receiver, and depend upon the receiver calibration for data.


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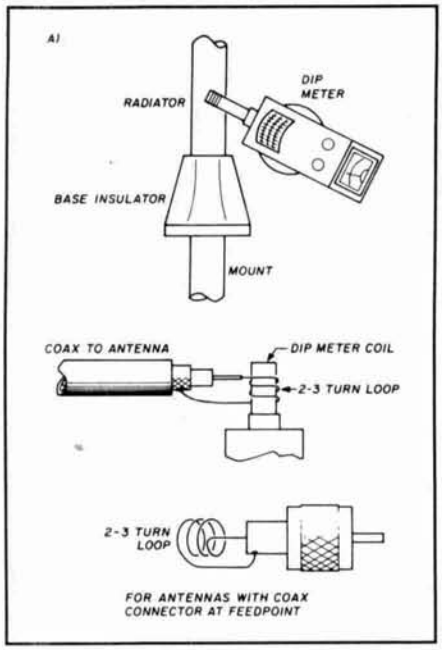
FIGURE 2

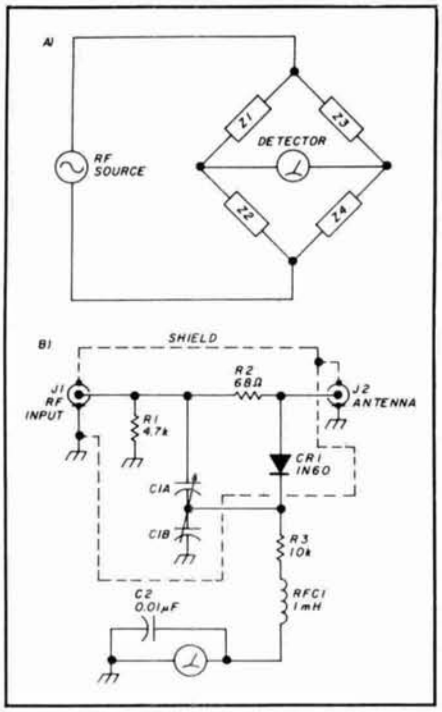


Coupling the dip oscillator to antennas. (A) directly, (B) indirectly.

Impedance bridges

It's important to know the antenna feedpoint impedance when designing and developing tactics for impedance-matching networks. Although it's best to measure the impedance exactly at the feedpoint of the antenna, it's very difficult to do. It isn't possible to measure the impedance on the ground and then expect it to be the same "at altitude" after you've erected the antenna. But there's hope for good measurements. Remember your basic transmission line theory? The load impedance value is reflected every half wavelength down the line. In other words, if you make the transmission line exactly an integer multiple of a half wavelength, the impedance measured at the input end will be the load impedance at the other end. The length of the line (in feet) should be $[(492 \times N \times V)/F_{MHz}]$, where N is an integer (1, 2, 3,...), V is the velocity factor of the transmission line used, and F_{MHz} is the frequency in megahertz. Although there's error involved because some coaxial transmission lines don't exhibit precisely the advertised velocity factor, the error is small enough to be ignored in most cases.

FIGURE 3



(A) Universal bridge circuit, (B) Amateur impedance bridge project.

Figure 3A shows the basic form of a simple impedance bridge. There are four arms, each representing an impedance. In general, two will be fixed, one will be variable and connected to a calibrated dial, and one will be the antenna. Another common arrangement is to have one fixed, two in the same "stack" (e.g., Z1/Z2) that are differentially variable, and the other as the antenna impedance. The bridge is in null (detector reads zero) when $[Z1/Z2] = [Z3/Z4]$.

Figure 3B shows an impedance bridge construction project you can build. The heart of this instrument is C1A/B, which is a 200 or 250-pF *differential* capacitor. The exact value isn't critical, but the range is affected. You can purchase these capacitors from Radiokit in Pelham, New Hampshire.* In order to read impedance values you'll need to supply a calibrated dial for the capacitor.

The value of resistor R2 is ideally 50 or 75 ohms. Select it to match the impedance of the antenna being measured. Selecting 68-ohm, 2-watt, carbon composition for R2 is a reasonable compromise. If you build this project, be sure to shield the RF components from the DC ones. The entire project is built in a shielded box, but the RF components should be shielded separately from the others.

Calibration is simple. Select a handful of carbon composition resistors with values ranging from about 1 to 300 ohms. These are connected across J2, each in its turn. Make sure to represent 50 and 75 ohms in your collection so that you can find exact points on the dial. Find the null for each resistor using a low-power source, and mark its spot on the dial. Now calibrate the dial for the values you've selected.

The Leader Electronics commercial impedance bridge model shown in **photo E** is intended for Amateur applications. It contains an internal amplifier so that it can be used with ordinary signal generators, or in the "straight through" mode for use with low-power Amateur Radio transmitters.

VSWR bridges

Voltage Standing Wave Ratio (VSWR) indicates how well an antenna is matched to its source. **Photo F** shows a simple, low-cost bridge that will measure forward and reflected "relative" power. Although there's a calibration setting on the sensitivity potentiometer for measuring the output power of low-power transmitters, it's not too accurate for measuring RF power. However, it is good as a VSWR meter. One meter measures the forward power, while the

PHOTO E

Commercial impedance bridge.

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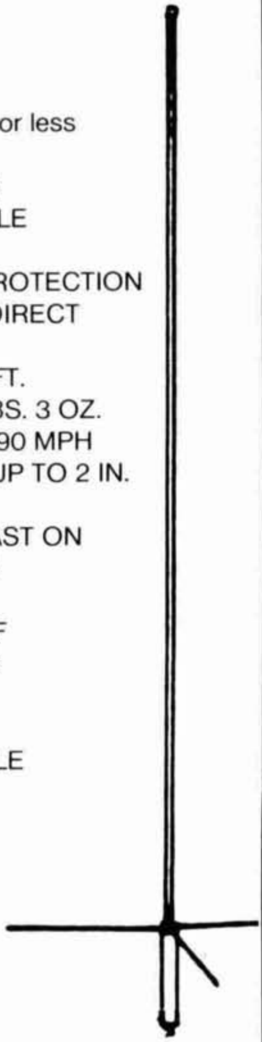

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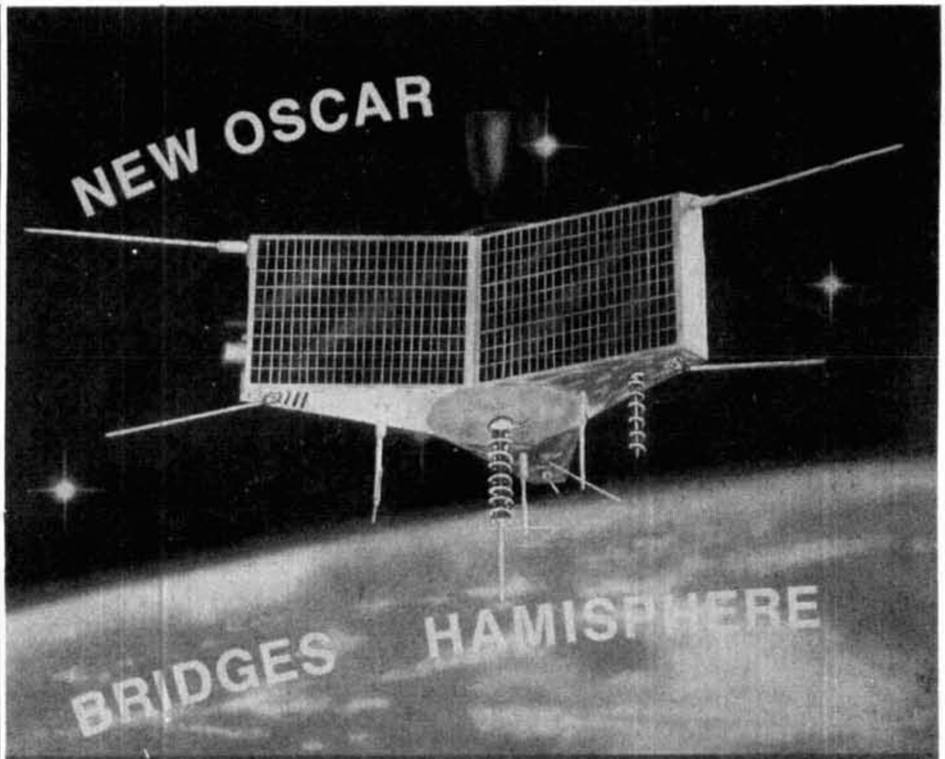

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PHOTO F

Two-indicator VSWR bridge.

other measures the reverse power. Once again, it's relative power that's being measured. Using the calibration knob, set the forward meter to exactly full scale with RF power applied. You can then read the VSWR from the reverse meter. In a future column I'll deal with the construction of various RF wattmeters and VSWR meters.

Conclusion

Antenna instruments are generally inexpensive, especially when compared with the cost of some antennas and transceivers on the market today. Some Amateurs feel they don't need to own such instruments. Yet they are so useful in "doping out" antenna systems, both when designing new installations and troubleshooting existing ones, that you'll find one handy. If you don't believe you need antenna instruments, then I've got a bridge up in K2-land to sell you.

Special note

The toroids column was suggested to me by a reader who must be a very special guy. Next time you buy a bottle of wine that bears the Bully Hill label, remember it's made by Walter Taylor, K2MLT. Because of legal problems with the Taylor Wine people, he can't use his own name — so call him Walter ______________. The artwork labels are a treat! Thanks, Walter.

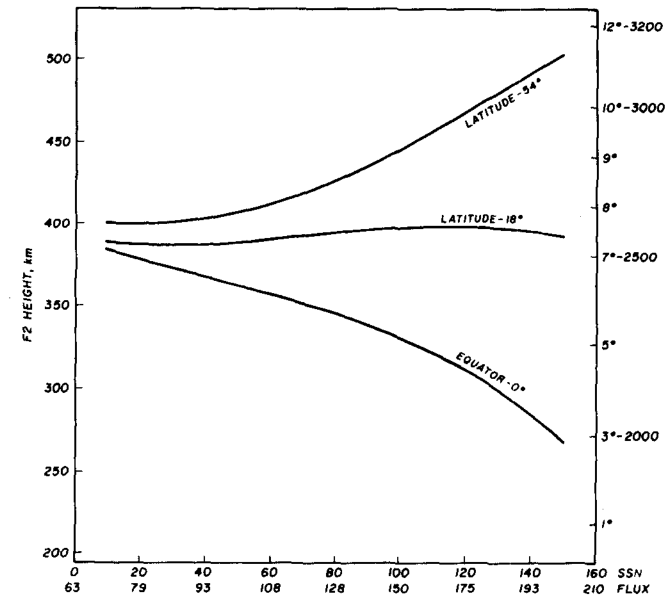
You can reach me at POB 1099, Falls Church, Virginia 22041. I'd like to have your comments and suggestions for this column.

Article I **HAM RADIO**

DX FORECASTER

Garth Stonehocker, KØRYW

FIGURE 1



Cycle 22's increasing sunspot numbers and their effect on the F2 layer's average height.

More new cycle 22 DX

The new sunspot cycle nears its maximum by the end of 1989, causing some changes in signal propagation. The lower ionosphere (D & E) regions will increase by 30 percent, but the F region changes are more involved. Up there the geomagnetic field defines and controls the electron-ion density and altitude changes. Ion density will be generally increased, but the amount will vary with location. **Figure 1** shows the changes in height, both up and down. See the left ordinate scale at the latitude regions.

The height of refraction in the ionosphere determines the geometrical conditions of the maximum distance for DX. The earth tangent points spread out as the height increases. The figure's right-hand ordinate scale shows this change in hop length at a 10 degree take-off angle. If you have a favorite DX spot, the distance is fixed. For the signal to get to this same spot, the take-off angle will have to change as the height of the ionosphere moves. The angle change is also shown on the **fig. 1** right-hand ordinate scale for 3000-km distance.

Figure 1 is based on theory and geometry backed up by some research measurements. The solar flux and sunspot numbers change daily, and so do the relationships shown in **fig. 1**. On the average, the graph gives a good idea of what to expect by the end of 1989 or so. The hop distance, long skip, should increase by about 400 km on the northern paths to Europe or Japan while decreasing to countries in South America, South Africa, and the South Pacific.

Last-minute forecast

The best days for long-skip openings on the higher frequency bands are the first 12 days of February. Openings of one-long-hop transequatorial skip are probable near the 3rd and 10th to South Africa, South America, and South Pacific areas. Maximum usable frequencies (MUF) are expected to be highest because of high solar flux on these days. The lower bands are expected to be their best during the last two weeks. Disturbed periods from solar flare effects may be evident near the 3rd, 10th, and 21st with unsettled conditions. As a result of these effects, you can hear decreases in MUF with weak and variable QSB signals on east-west DX paths to Europe and Japan on the lower bands. Shorter nighttime hours will also be evident.

No significant meteor-showers are scheduled to appear in February. A full moon occurs on the 25th; its perigee is on the 13th.

Band-by-band summary

Ten, 12, 15, 17, and 20 meters will be open from morning to early evening almost daily to most areas of the world. Expect the higher band openings to be southerly, shorter, and closer to local noon. Transequatorial propagation on these bands is likely to be toward evening during times of high

FEBRUARY

WESTERN USA

GMT	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	
PST	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	4:00	
ASIA FAR EAST	*30*	*30*	*30*	*30*	*30*	30	30	30	30	*30*	*30*	*30*	*30*	30	30	30	30	30	30	30*	20	20	20	20	N
EUROPE	30	30	30	30	20	20	15	15	15	20	20	*30*	*30*	*30*	*30*	30	*30*	*30*	*30*	*30*	*30*	*30*	30	30	NE
S. AFRICA	15	12	12	10	10	10	10	10	10	12	12	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20	15	15	E
S. AMERICA	10	10	10	10	10	10	10	12	12	12	15	*20*	*20*	*20*	*20*	*20*	*20*	*15*	15	15	12	12	10	10	SE
ANTARCTICA	10	10	10	10	10	12	12	15	15	*20*	*30*	*20*	*20*	*20*	*15*	15	12	12	12	12	10	10	10	10	S
NEW ZEALAND	10	10	12	12	12	15	15	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	15	15	15	12	12	10	10	10	10	SW
OCEANIA AUSTRALIA	10	12	12	12	15	*20*	20	20	*20*	*20*	*20*	*20*	*20*	*20*	20	20	15	15	12	12	10	10	10	10	W
JAPAN	12	15	15	20	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	30	30	30	30	30	20	15	15	12	12	NW

MID USA

MST	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	
ASIA FAR EAST	*30*	*30*	*30*	*30*	30	30	30	30	30	20	20	*30*	*30*	*30*	*30*	30	30	30	30	30	30	30	20	20	N
EUROPE	30	30	30	30	20	20	20	15	15	15	20	20	20	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	NE
S. AFRICA	15	12	12	10	10	10	10	10	10	10	12	12	15	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	15	E
S. AMERICA	10	10	10	10	10	10	10	10	12	15	15	*20*	*20*	*20*	*20*	*20*	*20*	*15*	15	15	15	12	12	10	SE
ANTARCTICA	10	10	10	10	12	12	12	15	15	15	15	*20*	*20*	*20*	*20*	*20*	*15*	15	15	12	12	12	10	10	S
NEW ZEALAND	10	10	12	12	12	12	15	15	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	15	15	15	12	12	10	10	10	SW
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CST	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	

EASTERN USA

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

solar flux and disturbed geomagnetic field conditions.

Thirty and 40 meters will be useful almost 24 hours a day. Daytime conditions will resemble those on 20 meters, but skip and signal strength may decrease during midday on days with high solar flux values. Look for good nighttime use — except predawn after days of very high MUF conditions. Usable distances on these bands should be somewhat greater than that achieved on 80 at night.

Eighty and 160 meters, the nighttime DXer's bands, will open just before sunset and last until sunrise on the path of interest. Except for daytime short-skip signal strengths, high solar flux values have little effect. Geomagnetic disturbances, more evident at the equinoctial periods, cause signal attenuation and fading on polar paths. Noise increases noticeably on these lower frequency bands in the coming months. Please remember the DX windows.

Article J **HAM RADIO**

THE WEEKENDER

A transmit timer for the KPC-2

One of life's most embarrassing moments is finding your packet TNC has glitched and tied up a busy packet channel for several hours. My TNC, an older Kantronics KPC-2, doesn't have a transmitter time-out timer. Several circuits have been published as solutions to this problem, but I feel mine is a novel approach because it uses existing circuitry to incorporate a timer. You add only two diodes, a resistor, and a single capacitor.

The KPC-2 is a fine TNC, but as with many devices with internal microprocessors, erratic supply voltage fluctuations can cause the internal program to "crash" and the TNC to go into continuous transmit mode. Besides the embarrassment, you also run the risk of burning out your transmitter PA.

Before you start

All of the modifications are performed on the KPC-2 pc board. You should have some expertise doing minor pc board modifications before attempting this one. I also advise you to use a *grounded soldering station* and take the necessary precautions against static discharge. Your Kantronics warranty and factory service options may be adversely affected by this installation.

Opening the TNC

Remove the pc board through the front of the case. The bezel and front panel are held in place by two screws. Before you can slide out the board, you *must* remove the screw mounting the 7805 to the case. Attempting to slide the board forward before removing this screw will damage the regulator. Avoid disturbing the LED indicators or they won't mate with the panel cutouts during reassembly.

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

Timer length

Most packet operations require transmit times of 10 seconds or less. For file transfers, transmit times of 20 seconds or more are common. Some packet conference systems use TX times of up to a minute. Using a 100-k resistor value for R1 yields a 10-second time limit; a value of 560 k for R1 allows 60 seconds before time-out.

Preparing the board

Using your KPC manual pictorial layout, locate IC U14. This a 74HC04 14-pin device. Locate pin 13 and carefully cut the trace to the pin on the solder side of the board. *Verify that you have the correct pin before cutting the run!*

Now install diode D2 and resistor R1 between pin 13 and Vcc (5-volt bus). Pin 14 of U14 is the Vcc supply for the chip. I elected to mount the diode on the solder side of the board, and tacked the resistor directly to the IC pins topside. *Observe diode polarity* — the cathode (bar) must go to pin 14!

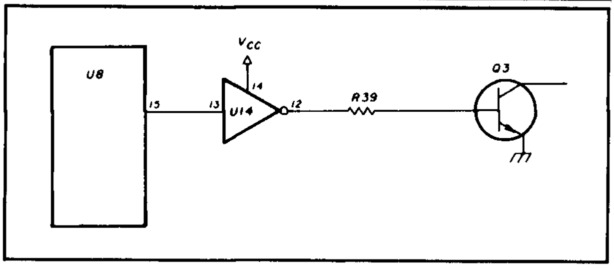
Locate the solder pads for U13. This device is not used on the KPC-2. On the component side of the board you'll find two or three pads for U13 that are connected to the ground bus. Select one of these pads and carefully cut it free of the ground connection. Next prepare diode D1 and capacitor C1. You'll mount these components between pin 13 of U14 and the open pad on U13. Cut the leads to length and put spaghetti over the exposed leads before soldering. Again, note the polarity. The positive lead of C1 and the cathode (bar) of D1 must go to pin 13 of U14. There will be three leads connected to pin 13 of the IC at this point, so solder carefully! Now, trace the cut run from pin 13 of U14. You'll find it goes to one of two solder-through connections in the vicinity of U8. Solder a short piece of wire-wrap wire from this point back to the freed pad of U13, where capacitor C1 and diode D1 were terminated.

This completes the modification. Carefully recheck your work to be sure everything is right before you put the KPC-2 back together. Note that my pc board is version PC35. Your KPC may use a different revision level, and have a different parts layout than mine.

Checking it out

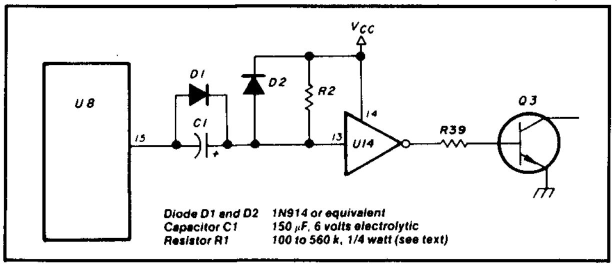
Put your station back together and select a quiet packet frequency. Monitor your transmissions on another receiver. Select the calibrate mode for the TNC; refer to the manual if you're not familiar with this command mode. Your terminal will give you an R, T, or X prompt. Hitting the T key should key your transmitter. You'll hear a calibration tone on the monitor receiver if

FIGURE 1



Partial schematic of unmodified TNC.

FIGURE 2



Addition of timer components to TNC circuitry.

everything's working correctly. Hitting the R key should immediately drop the transmitter. Toggle back and forth between the R and T keys several times to confirm that the TNC is keying and unkeying the radio properly. Now select the T key and wait — the TNC should time out eventually. After time-out, immediately hit the R and T keys again. The transmitter should come back on until you hit the R key, or until the next time-out. The X prompt is supposed to terminate the calibration mode, but you'll find that you have to turn the TNC off and back on to resume normal operation.

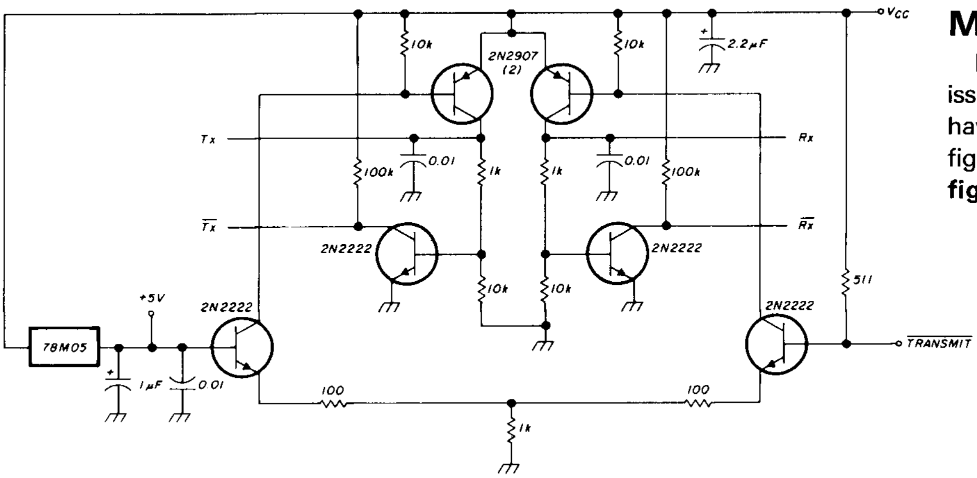
Theory of operation

Look at **figs. 1** and **2**. Normal TX keying is started by a low-going signal from the microprocessor on pin 15. This signal is inverted to a high-going one by way of an inverter section in U14. The high-going signal drives Q3 into conduction through current-limiting resistor R39. The open-collector output of Q3 provides the ground-return keying for the transceiver.

In the modified circuit, capacitor C1 is normally discharged. During transmit, the negative lead of C1 is brought low. The charging current for C1 maintains a low state on pin 13 of U14, until C1 reaches a charge voltage equal to the threshold of pin 13 on U14. The value of R1, in conjunction with the source current provided by the inverter input, and the value of C1 determine the actual time interval before time-out. D1 forces an immediate high level to the inverter when going to receive. Diode D2 provides a discharge path for C1 during the receive state; this prevents consecutive packet exchanges from causing a cumulative time-out. I suspect this circuit might be adaptable to other TNCs, although I haven't investigated that possibility. Purists may wish to include a small resistor, under 100 ohms, in series with C1 to limit the inrush current on pin 15 of the microprocessor.

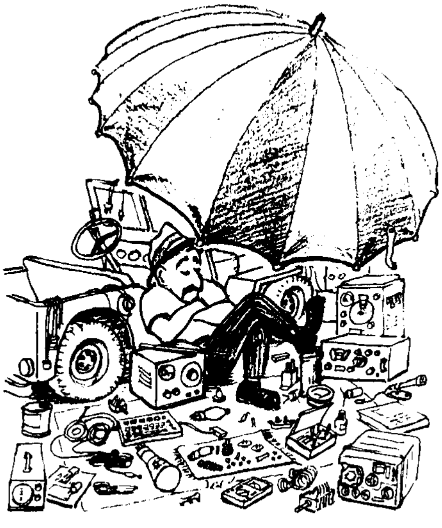
Article K **HAM RADIO**

short circuit



Missing figure

Please note that in the October 1988 issue, **fig. 7** shown on page 26, should have been included in **fig. 9**. The figure shown here should have been **fig. 7** in Part Three of N6GN's article.



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GOOD BEGINNER RIG. Heath SB-101 transceiver with HP-23 supply, SB-600 speaker, CW filter, extra tubes, manual $250. Contact WA7GVT (406) 365-2261.

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ELECTRONIC KITS & ASSEMBLIES. For our latest catalog send SASE (45 cents) to: A & A ENGINEERING, 2521 W. LaPalma, #K, Anaheim, CA 92801.

IBM-PC SOFTWARE FOR PK-232. New CompRtty II/PK is the complete communications program for the PK-232/HK-232. Uses host mode of PK-232 for complete control. Text entry via built-in screen editor! Adjustable split screen display, including optional Triple Split (TM) in Packet mode. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages, mailbox facility. Ideal for MARS and traffic handling. Requires 256k PC compatible. $65. Non-PK-232 version still available. Send call letters (including MARS) with order. David A. Rice, KC2HO, 144 N. Putt Corners Rd, New Paltz, NY 12561.

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COMMODORE/AMIGA chips, (eg. 6510—$11.55, 6526—$12.50, 6567—$19.95, 6581—$13.85, PLA/82S100—$14.75, 901 ROM series—$11.50), parts, diagnostics, hard to find items. Authorized service center. Fast repairs, low cost (eg. C64-$49.49 plus UPS). Heavy duty power supplies for the C64-$28.00 plus UPS. KASARA MICROSYSTEMS, (Division of QEP), Rt. 9W/Kay Fries Drive, Stony Point, NY 10980. 1-800-248-2983 (outside NY) or 914-942-2252.

COMPUTER CODE COURSE: Apple II +/c/e/GS. C-64/128. 37 modes, graphics, 1-100 WPM, menus, proportional spacing, variable frequency, more ($29.95). With word processor ($39.95). Manual ($10). Check/MO. LARESCO, POB 2081-HR, Calumet City, IL 60409. 1-312-891-3279.

UHF PARTS. GaAs Fets, mmics, chip caps, feedthrus, teflon pcb, high Q trimmers. Moonbounce quality preamps. Electronic sequencer boards. Send SASE for complete list or call (313) 753-4581 evenings. MICROWAVE COMPONENTS, PO Box 1697, Taylor, MI 48180.

KITS*PARTS*PLANS. We have hard to find parts! Variable tuning capacitors, tuning coils, crystal and magnetic headphones, germanium diodes, crystal, shortwave and tube type kits. Very inexpensive. Send 25 cent stamp for catalog. Yeary Communications, 12922 Harbor #800HR, Garden Grove, CA 92640.

$50 PACKET Digicom 64—software based PACKET system for Commodore 64. Software is public domain and requires a modem for the C64 which is provided by our kit. Board plugs directly into cassette port or remote mounted via cable, both connectors included. Watchdog timer, reed relay PTT and PTT inversion options included. Power derived from computer. Uses 7910 chip—no alignment required. Switch allows HF or VHF operation. Order Kit #154 for $49.95 or Assembly #154 for $79.95 both include FREE DISK. Add $2.50 s/h. A & A ENGINEERING, 2521 W. LaPalma #K, Anaheim, CA 92801. (714) 952-2114. MC or VISA accepted.

DIGITAL AUTOMATIC DISPLAYS. Any Radio. Be specific. GRAND SYSTEMS, POB 2171, Blaine, WA 98230.

QUALITY HAM SOFTWARE for the IBM-PC and compatibles. Many shareware and public domain disks for all aspects of ham radio. Business SASE for catalog. JK&S Dept HE, PO Box 50521, Indianapolis, IN 46250-0521.

MAGAZINES WANTED: "Microwave Systems News" (MSN), "RF Design", "PCIM (Power Conversion & Intelligent Motion)" and "QEX" (1980-present). Call collect 519-742-4594 (Ontario) after 6 PM Eastern time.

IMRA International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 1-3 PM Eastern. Nine hundred Amateurs in 40 countries. Rev. Thomas Sable, S.J., University of Scranton, Scranton, PA 18510.

MACINTOSH Ham Software. MacTrak® tracks satellites, sun, moon. Graphic or tabular outputs. Compatible with Mirage Tracking Interface for rotor control, $59.95. DX Helper™ provides DX info including distance, bearing, sunrise, sunset, propagation MUF, great circle display, more, $34.95. SASE for info from R. Stegemeyer, PO Box 1590, Port Orchard, WA 98366.

BACK ISSUES OF HAM RADIO. Have most issues from 1969 to 1974. Mint condition. $3.00 for single issues. WN0G, 319-377-3563.

MICROWAVE GENERATORS: All checked, working: HP-626A, HP-628A, HP-8690A sweep gen, $150/ea. FXR L772A 1-2 GHz, $75. GR-1218A 1-2 GHz, GR-1021A VHF/Gen 40-250 MHz, $100/ea. GR-1601A VHF bridge $125. Also test equipment: HP-410C meter w/out probe, $100. GR-1611A capacitance bridge $100. GR-650A impedance bridge, $55. All $75: Tektronix 190B generator; C-27 camera; type-82; type-M plug-in units; Measurements 188 FM/Gen; Sorensen QSB28-8 DCPS, 10-40V, 8Amps, Var/Reg, metered; Alfred HVPS .2-3.5KV, 23mA, Var/Reg, metered; Heath EU-205 2-Pen Chart Recorder Hi-Sens w/access; GR-1672A Digital System Control; Theta Resolver Test Set; Military SRR-11 VLF receiver 14-600 kHz. ALL $35: GR-1604A; Krohn-Hite 330A Var/Lab Bandpass Filter; HP-412A DC-VOM; HP-130C; HP-416A Ratiometer; Ballantine 3600 DVM w/TRMS. Also H-V Plate Transformers, 4400V/CT 235mA; 3500V/CT 275mA, $75/ea. Giant Powerstat 220V/28A, 0-280V, 7.8KVA $145. SASE list. Joseph Cohen, 200 Woodside, Winthrop, MA 02152. 617/846-6312.

ANTENNA PARTS AND CATALOG. Lowest costs. Dipole/Quad/Ground Radial Wire, insulators, center feeds, open wire feed line, coax, relays, (#14 multistrand dipole/quad wire, nonstretch, very flexible, $34 per 275' (minimum), $.12/ft. thereafter, includes shipping. Catalog $2.00. DAVIS RF, PO Box 230-H, Carlisle, MA 01741. (508) 369-1738.

HAM TRADER YELLOW SHEETS. In our 27th year. Buy, swap, sell ham radio gear. Published twice a month. Ads quickly circulate—no long wait for results. Send No. 10 SASE for sample copy. $13 for one year (24 issues). PO Box 2057, Glen Ellyn, IL 60138-2057 or PO Box 15142, Dept HR, Sattle, WA 98115.

VHF-UHF-SHF. Large SASE. West Coast VHFer, POB 685, Holbrook, AZ 86025.

CHASSIS & CABINET KITS. SASE. K3IWK, 5120 Harmony Grove Rd, Dover, PA 17315.

ANALOG AND RF CONSULTING for the San Francisco Bay area. Commercial and military circuits and systems. James Long, Ph.D., N6YB (408) 733-8329.

RTTY JOURNAL—Now in our 36th year. Read about RTTY, AMTOR, PACKET, MSO'S, RTTY CONTESTING, RTTY DX and much more. Year's subscription to RTTY JOURNAL $10.00, foreign slightly higher. Order from: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

WANTED: Hammarlund HQ170AC vhf, and HQ180AC, prefer Mint Cond. Mike Matich, PO Box 515, Cedar Ridge, CA 95924. (916) 477-0622.

RUBBER STAMPS: 3 lines $5.00 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

CASH OR TRADE for all types of transmitting or special purpose tubes. M & S COMMUNICATIONS ENGINEERING 160 So. Auburn Street, Suite 200, Grass Valley, CA 95945. (916) 272-5500.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. DAILY ELECTRONICS, PO Box 5029, Compton, CA 90224. (213) 774-1255.

MOTOROLA MAXAR 80. 800 MHz 2-way w/mike/PL. Good condition $250. Heathkit 20 SSB mobile $125. Hallicrafter SX101A $125. Bob Shuman, 725 S. Chocolay, Clawson, MI 48017.

EXPLORE the license free 160-190 kHz band. Communications over 100 miles have been achieved and our kits will help you get on the air fast! Send stamp for brochure to: SEDEN COMMUNICATIONS, 1272 Harold Avenue, Simi Valley, CA 93065

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

WANTED: Ham equipment and other property. The Radio Club of Junior High School 22 NYC, Inc. is a nonprofit organization, granted 501(C) (3) status by the IRS, incorporated with the goal of using the theme of Ham Radio to further and enhance the education of young people. Your property donation or financial support would be greatly appreciated and acknowledged with a receipt for your tax deductible contribution. We sponsor the classroom net on 7.238 at 1200 UTC daily and encourage your QSL for our weekly award. Please write us at: PO box 1052, New York, NY 10002 or call our round the clock hotline: (516) 674-4072. Thank you!

CLEANING OUT LIBRARY. Send SASE for big list of ham radio and electronic books and magazines (HR, CQ, 73, QST, Wireless World, Popular Electronics, etc). Joe Holstein, N8EA, 1515 Sashabaw, Ortonville, MI 48462.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

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

SCHOLARSHIP. The Dayton Amateur Radio Association is now accepting applications for its 1989 Scholarship Program. The program is open to any licensed Amateur graduating from high school in 1989. For information and application forms write Scholarship Committee, 317 Ernst Avenue, Dayton, OH 45405.

COMING EVENTS

Activities — "Places to go . . ."

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

KENTUCKY: February 11. Ham Radio & Computer Fest, Cave City Convention Center, Cave City. Setup 6 AM. Doors open 8 AM. Admission $3/advance. DX, Packet, Antennas forums. VE exams. Activities for the entire family. Talk in on 145.410 or 146.52.

MICHIGAN: The Cherryland ARC's 16th annual Swap-N-Shop, East Bay Elementary School, 3962 Three Mile Road N., Traverse City. 8 AM to 2 PM. Admission $3.00. Tables $6.00. Talk in on 146.850 repeater. For information Mike Hubbard, N8JXY, 5772 Vance Road, Interlochen, MI 49643. (616) 276-9143.

OHIO: February 12. The Mansfield Mid-Winter Hamfest/Computer Show, Richland County Fairgrounds, Mansfield. Doors open 7 AM. Tickets $3/advance; $4/door. Tables $6/advance; $8/door. For additonal information, tickets or tables SASE to Dean Wrasse, KB8MG, 1094 Beal Road, Mansfield, Ohio 44905 (419) 589-2415 after 4 PM EST.

COLORADO: February 19. The Aurora Repeater Association's 8th annual Swapfest, Jefferson County Fairgrounds, 15200 W. 6th Avenue, Golden. 8 AM to 3 PM. For information contact Judi, WD0HNP (303) 460-1413 or Jan, KA7TYU, PO Box 39666, Denver, CO 80239.

MINNESOTA: February 25. Midwinter Madness Hamfest, Medina Ballroom, Median. 7 AM to 2 PM. Admission $3/advance; $5/door. For information contact Dennis Pollard, KZ01. (612) 535-7189 evenings.

FLORIDA: February 25. The 7th annual Hernando County Hamfest, Hernando County Fairgrounds Auditorium, US 41 South (4 miles south of Brooksville). Doors open 8 AM. Advance registration $2.00; at the door $3.00. Swap tables $8.00. Free parking. Overnight parking permitted. No facilities. For advance registration SASE to Hamfest Chairman, PO Box 1721, Brooksville, FL 34605.

SOUTH CAROLINA: February 25. The Charleston Amateur Radio Society's annual Hamfest, National Guard Armory, 89 Hagood Avenue, Charleston. For information E.L. Sikes, N4LS, 16 Trumbo Street, Charlston, SC 29401 or call (803) 723-4000.

TEXAS: February 25. The Orange ARC's 4th annual Hamfest-Flea Market, National Guard Armory Buildong, Meeks Drive, Orange. 9 AM to 5 PM. Setup time 7 AM. Tables $4.00. Dealers $10. Talk in on 147.180.

GEORGIA: February 25. The Dalton ARC's annual Hamfest, North Georgia Fairgrounds. For information write DARCI, POB 143, Dalton, GA 30722-0143. Or contact members via GA cracker net or GA SSB net.

OHIO: February 25 and 26. ARRL Ohio section convention, Cincinnati Gardens Exhibition Center, Langdon Farm Road and Seymour Avenue, Cincinnati. 8:30 to 5 both days. For information contact Stan Cohen, WD8QDQ, 2301 Royal Oaks Ct, Cincinnati, Ohio 45237. (513) 531-1011.

INDIANA: February 26. The LaPorte ARC's Hamfest, LaPorte Civic Auditorium. Admission $3.50. Reserved tables $3. Talk in on 146.520 or 146.610 with PL of 131.8. Contact SASE LPARC, PO Box 30, LaPorte, IN 46350.

OHIO: February 26. The Cuyahoga Falls ARC's 35th annual Hamfest, Akron North High School. 8 AM to 3 PM. Tickets $3/advance; $4/door. Reserved tables $5. Or bring your own. For information Bill Sovinsky, K8JSL, 2305—24th Street, Cuyahoga Falls, OH 44223. (216) 923-3830.

VIRGINIA: February 26. Vienna Wireless Society's Winterfest. Vienna Community Center, 120 Cherry Street, Vienna. Setup 6 AM. General public 7:30 AM. Admission $4/door; $7/tailgate. Talk in on K4HTA/R 146.085/146.685 or W4LBL/R 146.190/146.790. For information Harry Kaklikian, W4ACN, 4941 Andrea Avenue, Annandale, VA 22003.

MICHIGAN: February 26. The 19th annual Livonia ARC's Swap 'n Shop, Dearborn Civic Center, Dearborn. 8 AM to 4 PM. ARRL/VEC exams. Free parking. Talk in on LARC Repeater 144.75/5.35 and 146.52. For information SASE to Neil Coffin, WA8GWL, Livonia ARC, POB 2111, Livonia, MI 48151.

KENTUCKY: March 4. The 13th annual Glasgow Swapfest, Cave City Convention Center, Cave City. Sponsored by the Mammoth Cave ARC. 8 AM to ??? Admission $3. Tables $3. Flea market, VE exams. Talk in on 146.34/94. For additional information N4HCO, 1379 Whites Chapel Road, Glasgow, KY 42141.

TEXAS: March 4 and 5. South Texas Amateur Repeater Society Hamfest, Casa de Amistad (Civic Center) on Fair Park Blvd, Harlingen. Saturday 9-4. Sunday 9-2. Flea market, VE exams RACES/ARES meeting, ARRL forum and more. Talk in on 147.99/.39 English. 146.10/.70 Spanish. Admission $5/advance; $6/door. Tables $7/advance; $10/door. For information K5RAV, 2210 S. 77 Sunshine, Harlingen, TX 78550. (512) 425-7744.

PENNSYLVANIA: March 5. The 2nd annual York Springfest (Ham & Computer), Dover Firehall, York. Free tailgating, indoor tables $10. Registration $4. Unlicensed spouse and under 12 free. VE exams. General admission 8 AM. talk in on 146.37/97 and 147.93/33. For information and registration (301) 239-3878 or write YORK Springfest, PO Box 50, Shrewsbury, PA 17361-0050.

PENNSYLVANIA: March 5. The Two Rivers ARC's Hamfest, Rostraver Fire Hall, PA 51, McKeesport. 8 AM to 3 PM. Admission $1.00 at door. Full table $6. Half table $4.00. Talk in on 146.13/73, WA3PBD/R Repeater. For information Louis H. Zimmerman, N3GPJ, 911 Roland Road, Wilkins Twp, PA 15221. (412) 351-1562 10 AM to 10 PM.

MASSACHUSETTS: March 5. Mt. Tom Amateur Repeater Association Amateur Radio and Electronics Flea Market, Smith Vocational School, Rt 9, Northampton. Setup 7 AM. Doors open 9 AM to 2 PM. Admission $2. Under 12 free accompanied by adult. Tables $10/advance; $12/door. VEC walkin exams. Talk in on 146.94, 223.82 and simplex 146.52. Handicapped parking and access. Reservations: Bob, WB1EQS (413) 532-6411 days. Mickey, N1CDR (413) 562-1027 evenings. Or write MTARA Flea Market, 6 Laurel Ter, Westfield, MA 01085.

NEW JERSEY: March 12. The Delaware Valley Radio Association's 17th annual HAMCOMP '89, New Jersey National Guard 112th Field Artillery Armory, Eggerts Crossing Road, Lawrence Township. 8 AM to 2 PM. Admission $3/advance; $4/door. Indoor spaces $7 and $10. Outdoors $6. Sellers bring own tables. Setup 6 AM. Public 8 AM. Talk in on 146.07-.67. For information and space reservations write HAMCOMP '89, c/o KB2ZY, RD 1, Box 259, Stockton, NJ 08559. Please SASE. Handicap parking and wheelchair accessible.

INDIANA: March 12. The Morgan County Repeater Association's Indiana Hamfest, Indiana State Fairgrounds Pavilion Building, Indianapolis. Starts 8 AM. Admission $5. 8' tables $8. Free parking. VE exams. Talk in on 145.25. For information or table reservations SASE before 2/24/89 to Aileen Scales, KC9YA, 3142 Market Place, Bloomington, IN 47403. (813) 339-4446.

FLORIDA: March 18 and 19. The Playground ARC's 19th annual North Florida Ham/Swapfest, Shrine Fairgrounds, North Ft. Walton beach. Doors open 8 AM both days. Admission $3/advance; $4/door. Tables $10 one day or $15 for both days. Flea market, exhibits, ARRL, MARS and QCWA meetings. Saturday night banquet. Free parking. RV parking $10 with hookup. Talk in on 146.79 and 52. For information write PARC, PO Box 873, Ft. Walton Beach, FL 32548.

ILLINOIS: March 19. The Sterling-Rock Falls ARS 29th annual Hamfest, Sterling High School Field House, 1608 Fourth Avenue, Sterling. Doors open 7:30 AM. Tickets $3/advance; $4/door. Dealers, large flea market, VE exams. Talk in on 146.25/146.85 W9MEP Repeater. for information, tables or tickets contact Sue Peters, PO Box 521, Sterling, IL 61081 or call AC (815) 625-9262.

NEW JERSEY: April 15. "Flemington Hamfest 89", sponsored by the Cherryville Repeater Association, 8 AM in the Hunterdon Central High School Field House. Admission: $4 advance, $5 door. Children under 12 and XYLs free. Refreshments available from 6:30 AM. Advance tickets: Dave Hickson, KD2RC, 125 South Main St, Lambertville, NJ 08530. Tables: Marty Grozinski, NS2K, 6 Kirkbridge Rd, Flemington, NJ 08822. Information: (201) 788-4080 before 11 PM EST. VE testing begins at 10 AM, send FCC form 610, photocopy of current license, and a check for $4.75 (payable ARRL/VEC) to: Cherryville Repeater Association, VE Test Team, Box 308, Quakertown, NJ 08868. Talk in: 146.52, 147.975/375, 145.615/015, 222.52/224.12 and 449.85/444.85 MHz.

DAYTON HAMVENTION: April 28, 29, 30.

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OPERATING EVENTS

"Things to do . . ."

AMATEUR RADIO DAY. February 25. Hams will call all nations from Official Center of the World. A special event station, WA6BEZ, will be set up for one day and manned by licensed volunteers from the Yuma Amateur Radio Emergency Service. For more information contact, KC0KV, Yuma ARES.

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

THE MIT UHF REPEATER ASSOCIATION and the MIT Radio Society offer monthly HAM EXAMS. All classes Novice to Extra. Wednesday, February 15, 7 PM, MIT Room 1-150, 77 Mass Avenue, Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann at (617) 484-2098. Exam fee $4.50. Bring a copy of your current license (if any), two forms of picture ID, and a completed form 610 available from the FCC in Quincy, MA (617) 770-4023.

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✓ 162

product REVIEW

N6RJ's Computerized Second Op v1.01

Those of you who go back a few years will remember W9IOP's manual Second Op. This handy operating aid was updated by *HR* and N6RJ in the early 80's to reflect the latest postal rates, callsign assignments, and other helpful information.

N6RJ and KL7GRF have taken the next logical step by integrating the power of the MS-DOS computer with the Second Op. Their new computerized version has just been made available.

This new program isn't a rehash of the old Second Op. It surpasses the older version and offers almost every feature you could want in a data base type program. Here's what you get:

Logging and scanning of log capabilities, oblast, QSL bureaus, bearing-sunrise-sunset, and add and edit notes on countries. Print functions include a DXCC country list with distance, bearing, DXCC "need" list, Oblast worked/confirmed, Oblast log, and many other different log printing capabilities. In summary mode you can show: DXCC worked/confirmed on all bands, one band, one band and one mode, by mode, detailed spreadsheet worked/confirmed for each band, and mode with mixed totals; WAZ by band, mode or both, and 6-band WAZ summary; and total station entries in log. In the log print mode you can print your DXCC need list (by mode or mixed), or your entire log in almost any format imaginable. The Second Op supports most printers and includes laser printer drivers.

One of the most maddening aspects of operating is keeping an up-to-date country list handy for all the different prefixes in use. This is where the Second Op really shines. Ask the computer to find a country by prefix and you have the information you need in a flash (see **fig. 1**). Have only an old prefix and want to cross it to the new ones? Second Op can do that too!

Oblast hunters will find that the new Second Op is a great addition to their shack. (Working Oblasts on 160 is difficult so I don't have much experience here.) After reviewing this function, I found that I understood more about Oblasts than I ever did before. You can find Oblasts by entering either callsign or Oblast number. You can also keep a running record of worked and confirmed Oblasts.

The owner's manual is one of the best I have ever seen. It clearly documents each and every feature, and gives full and complete installation instructions. Novice computer users may be interested to know that KL7GRF is available to help with any problems running the Second Op. I must admit that, as MS-DOS is still an enigma to me, I had problems getting the program to work properly myself. A quick phone call to GRF brought plenty of helpful hints and a full explanation of what I had done wrong. Within minutes I was able to correct my mistakes and get the program to run flawlessly.

This value-packed program is a welcome addition to the ham shack. All hams, from contesters and honor roll DX'ers to casual operators, will find that the new Second Op adds greatly to their computing capabilities. I'm sure that W9IOP would be proud to see what his Second Op has become and would have one in his shack.

The New Second Op is available from the **HAM RADIO** Bookstore for $59.95 plus $3.50 shipping and handling.

de **N1ACH**

FIGURE 1

```
                      N6RJ 2ND OP 17:09 UTC

Prefix.........VU       DXCC Country..INDIA

CQ Zone........22       Kilometers....14021     Location...BOMBAY
Continent......AS       Long Path.....167       Sunrise....00:59 UTC
Direct Bearing.347      Return Path...10        Sunset.....13:11 UTC
Nautical Miles.7571     Latitude......  19.00 N 3rd Party..NO
Statute Miles..8712     Longitude.....  72.80 E Reciprocal.YES

Air Mail.......0.45     N6RJ Notes...
Air QSL Card...0.36     Notes line 1.
IRC............4        Notes line 2.
ARRL Bureau....YES      Country......Worked:Y   Confirmed:Y

               DISPLAYING/SEARCHING BY PREFIX

F1    F2    F3    F4     F5    F6      F7     F8   F9    F10
FIND  NEXT  PRIOR ORDER  EDIT  BEARING BUREAU LOG  HELP  MENU
```

This is the print screen display of what you'd see when you enter VU (by prefix). For the larger countries additional bearing and sunrise/sunset information is available. When you hit the F6, or bearing key (displayed here), you'll see what's printed on the next page.

NEW products

New switch design

Alpha Delta's model Delta-4/4N switch incorporates several significant design improvements.

The new switch allows Easy Arc-Plug cartridge access through the front panel. The previous design required the removal of the back-plate.

Front panel access makes permanent switch mounting possible. The pill can be removed with a magnetized screwdriver blade, after you unscrew the hex retainer. The Delta-4 also has a redesigned roller bearing drive for a smoother "feel" during rotation.

Because many people mount the switch on a desk top, all the connectors run along one side so that the coax cables can run back behind the desk.

Models are available with UHF (SO-239) or type "N" connectors.

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

Circle #301 on Reader Service Card.

1.2-GHz handheld transceiver

ICOM has introduced the new 1.2-GHz IC-12GAT handheld transceiver. It features: wideband coverage, one-watt power output,

HAM MART

Ham Radio's guide to help you find your loc

California

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ELMER's NOTEBOOK

Tom McMullen, W1SL

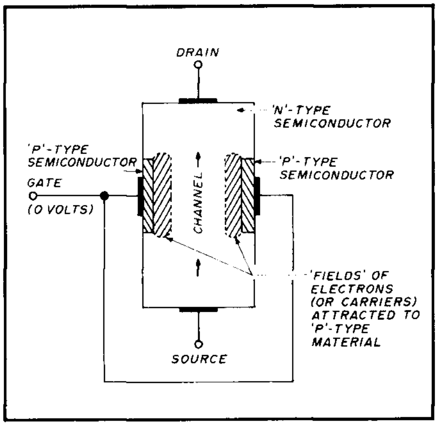
FETs—the other transistors

When I discussed bipolar transistors in last month's column, I made reference to Field-Effect Transistors (FETs). Let's look at a few ways that these transistors differ from their bipolar cousins in both construction and operation. Field-effect and bipolar transistors share a common chemistry — both use "N" or "P"-type semiconductor material. The type designations tell you whether there is a surplus of electrons (N type) or a scarcity of electrons (P type) in the basic make-up of the material. The transistors differ in their manner of operation and how the N or P material is made to control the flow of electrons.

Putting the pieces together

Let's use a FET that is constructed of N-type material to explore what happens inside. The body of the transistor is made of material having a surplus of electrons. This body, called a "channel," must have connections at each end for application of the external power source. One connection is made to the negative (–) terminal of a supply or battery and one to the positive (+) terminal. In FET terminology, one of these connections is a "source," and the other is a "drain." It makes sense when you consider that the source is where the electrons come from and the drain is where they go (see **fig. 1**). In order to control the current flow between the drain and source, you must add another element — a "gate." The gate is another terminal connected to the body of the FET, but not in exactly the same way as the source and drain.

FIGURE 1



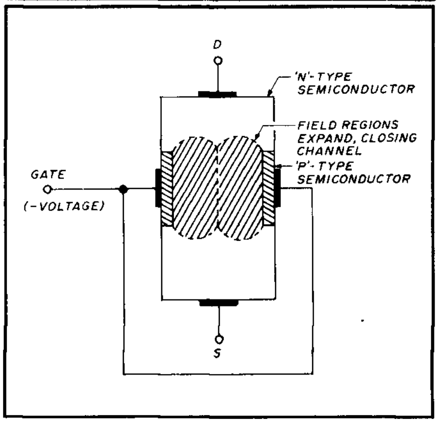
A simple FET has basically two parts: a channel for electron flow, and a gate to control that flow. The channel here is N-type material, and the gate is P-type. The shaded region near the gate area indicates "depletion" zones that affect the current flow in the channel. With zero volts on the gate, the zones are small, allowing current to flow.

The gate terminal is attached to P-type material that is deposited on the N-type channel. This P-type material has a scarcity of electrons, and the lack of electrons creates a "field" that extends into the channel material. Electrons (carriers) in the N-type channel are attracted to the gate material, but are stopped from getting through by a very thin barrier between the two. When the field caused by this attraction is small, and confined to an area near the gate, current can flow easily from source to drain. (Actually, that's a gross simplification of what happens. Theoretical purists talk about things like minority and majority carriers, valence bonds, enhancement and depletion modes. I prefer to keep it simple.) In the FET's normal resting state, full current flow takes place with the gate at zero volts. The shaded area in **fig. 1** shows the "field" at minimum, with the channel open for current flow.

Putting on the pinch

Things start to happen when a voltage is applied to the gate. If the voltage is positive, the field shrinks, opening the channel more than normal. If the voltage is negative, the field becomes larger. The enlarged field decreases the current flow between source and drain. If the field becomes large enough it blocks the flow completely, as shown in **fig. 2**. This blocking of a path between the source and

FIGURE 2



When a voltage of the correct polarity is applied to the gate, the depletion zone expands, decreasing current flow. In this case, a negative (–) voltage has increased the depletion zone to the point where all current is stopped. This is called the "pinch-off" effect.

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For more information contact your Bird distributor, or the Bird Electronic Corporation, 30303 Aurora Road, Solon, Ohio 44139-2794.

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drain is called the "pinch-off" effect because it pinches off, or closes, the channel so that current can't flow.

Think of the channel as a rubber hose connected between a water faucet (the source) and your kitchen sink (the drain). If you squeeze the hose between your thumb and finger, you "pinch off" the flow of water. When you relax your thumb and finger, some water will flow. You control the flow by changing the pressure exerted by your fingers.

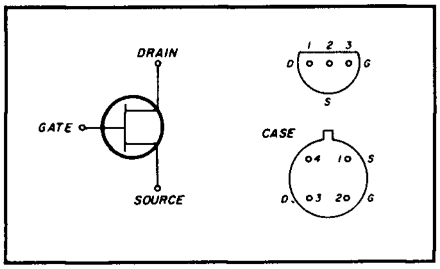
The FET works in much the same way. The depth of the field near the gate material can be altered to change the current flow by adjusting the voltage (voltage is the electrical equivalent of pressure). When more voltage is applied to the gate terminal, the pinch-off region gets larger, and less current flows through the channel.

These relatively simple FETs are sometimes called JFETs, for Junction Field-Effect Transistors. The gate and channel material and the junctions resemble a diode, and the "boundary" separating the N and P material is very thin. Once the gate voltage is high enough to overcome that boundary, the device acts just like a diode, and the field-effect performance is lost.

This limitation is overcome in some FETs by the introduction of a thin insulator between the gate and the channel material. The insulator prevents diode action and, at the same time, increases the input resistance of the gate tremendously. These devices are sometimes called IGFETs (Insulated Gate Field-Effect Transistors) or MOSFETs (Metal-Oxide Semiconductor Field-Effect Transistors). Still other varieties have more than one gate, and some contain exotic materials (like sapphire). These transistors are tailored to a specific industry need or purpose; we don't need to get into their physics and chemistry at this point.

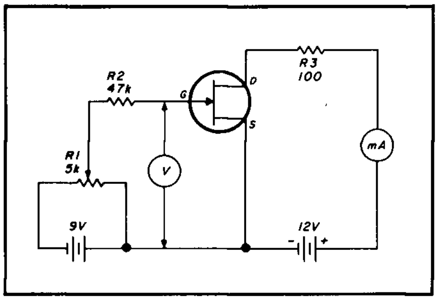
The schematic symbol for a FET is shown in **fig. 3**. The direction of the arrowhead on the gate connection indicates whether the device is an "N-channel" type or "P-channel" type. Some manufacturers place the arrowhead on the source lead instead of the gate. There are no easy "clues" for using the direction of the arrow to determine the type of device, but I have noticed that the majority of manufacturers have the arrow pointing in for N-channel FETs.

FIGURE 3



The schematic symbol for a FET, and two common base diagrams. The direction of the arrow on the gate connection tells whether the FET is an "enhancement" or "depletion" type, but is not as useful to us for identification as was the emitter symbol in bipolar transistors. Please note that there are many different base diagrams, so be sure to find the correct one before hooking up any device.

FIGURE 4



Schematic diagram of the hookup used in the experiment described in the text.

Checking the theory

Now that I've discussed how FETs are supposed to work, it's time to get out the meters, batteries, resistors, etc., and see what really happens. First, look at a specifications sheet to see what you should expect. I have a plastic parts drawer full of miscellaneous FETs; one of them has a label I can still read — 2N5486. This is an RF-amplifier device, so a change in gate voltage should produce a somewhat linear response in the drain current (as opposed to a switching-type device where the change would be abrupt). The specifications sheet tells me that maximum voltage between drain and source is 25Vdc, the maximum drain current (I_D) is 30 mA, and that the device maximum dissipation is 310 mW, so I'll keep those limits in mind. One column on the sheet shows that the gate reverse current at 15 Vdc is 1 nA! That's 1×10^{-9} A (0.000,000,010 A). I don't have a meter that will measure such a small current, so I'll take their word for it! **Figure 4** shows the setup used for measurement in this experiment.

Because a FET is supposed to be a voltage-operated device, the 47-k resistor (R2) connected to the gate should have no effect other than limiting current flow in case something shorts in the night. The 100-ohm drain resistor, R3, provides drain short-circuit protection. Gate voltage is adjusted by means of a 5-k potentiometer, R1.

If things work the way the numbers predict, the FET should show current flow as soon as I complete the circuit between source and drain, with no voltage on the gate. Sure enough, that's what happens. The meter shows 18 mA, which is within the range of 8-20 mA listed for this FET. The voltage from drain to source is 12, so the device is dissipating 0.216 watts, or 216 mW — comfortably below the 310-mW limit given in the spec sheets.

Theory says that if I place a negative (−) voltage on the gate, the channel should close, decreasing current flow. I decided to give it a try. At −0.5 volt on the gate, drain current started to drop. The reading was 14 mA. Increasing the gate voltage caused drain current to decrease even more, until at 4.5 volts the current was too small to measure with my simple milliammeter. The graph in **fig. 5** shows the results of measuring gate voltage versus drain current at several points along the way. Incidentally, a 0-50 μA meter placed in series with R2 showed only a tiny flicker of movement, indicating that little or no current was flowing in the gate circuit.

What about applying a positive voltage to the gate? After I reversed the 9-volt battery, a gate voltage of + 0.1

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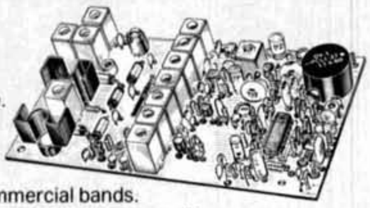

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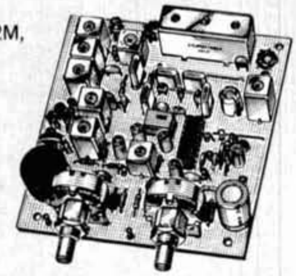

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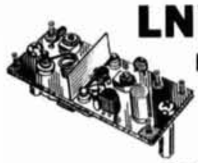

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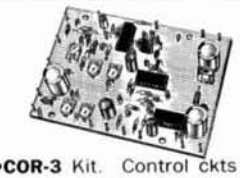

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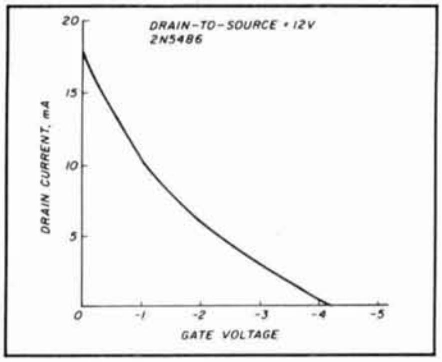
FIGURE 5



The measurements obtained in the setup of *fig. 4* are shown in this graph.

produced current flow of 19 mA; going to +2 volts increased drain current to 21 mA. Increasing the gate voltage to the full +9 volts produced no further increase in drain current. This indicates that the channel is wide open at approximately +2 volts on the gate, and passing all the electrons it can when the supply is 12 volts. Higher supply voltages will, of course, allow higher current to flow. If you replace the 100-ohm current-limiting resistor with a suitable load resistance (or transformer, RF choke, etc.), you can develop a respectable output voltage across the resistor in response to gate voltage changes. Thus, a small voltage change at the input can create a large voltage swing at the output, providing useful amplification.

There are other FETs that have the opposite characteristics. With these FETs, the channel is "pinched off" with zero voltage on the gate, and application of the proper polarity voltage opens the channel to current flow. You can best determine which device does what by looking at its specifications, but you can also hook up a few simple instruments and components to see for yourself.

Keep in mind that the components and meters that I've used are not precision devices, and the results may not agree exactly with those published by the manufacturers. They are, however, accurate enough for exploring the theory of operation in an inexpensive way.

The numbers I've come up with in both this experiment and that of last month's column on bipolar transistors measure only a small sample of the many transistors available. Some devices work at voltages and currents much smaller than I used; others, like power amplifiers, work with higher voltages and with currents of many amperes. The devices I've worked with here are linear — they provide a smooth change in output in response to a change in input. Others behave like switches — a change in input produces an abrupt change in output, which remains relatively constant until the input voltage is removed.

Some of the bargain packs or grab bags provide many interesting experiments at low cost, and you'll be hard pressed not to learn something from them! Why not join in the fun?

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