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- Separate frequency display for "main" and "sub-band."
- Call channel function. A special memory channel for each band stores frequency, offset, and sub-tone of your favorite channel. Simply press the CALL key, and your favorite channel is selected!
- 30 multi-function memory channels.
- Dual antenna ports.
- TM-621A has auto offset.
- Full duplex operation.
- CTCSS encode/decode selectable from front panel or UP/DWN keys on microphone. (Encode built-in, optional TSU-6 needed for decode.)
- Each function key has a unique tone for positive feedback.
- Illuminated front panel controls and keys.
- 16 key DTMF mic. included.
- Handset/remote, control option (RC-10).
- Frequency (dial) lock.
- Supplied accessories: 16-key DTMF hand mic., mounting bracket, DC cable.

Optional Accessories:
- RC-10 Multi-function handset/remote controller
- PS-430 Power supply
- TSU-6 CTCSS decode unit
- SW-100B Compact SWR/power/volt meter
- SW-200B Deluxe SWR/power meter
- SWT-1 2 m antenna tuner
- SWT-2 70 cm antenna tuner
- SP-40 Compact mobile speaker
- SP-50B Deluxe mobile speaker
- PG-2N DC cable
- PG-3B DC line noise filter
- MC-60A, MC-80, MC-85 Base station mics.
- MA-4000 Dual band 2 m/70 cm mobile antenna (mount not supplied)
- MB-11 Mobile bracket
- MC-42S UP/DOWN hand mic.
- MG-48B 16-key DTMF hand mic.

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See page 17 for the winners of
December's handheld radio
contest.
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 aboard the plane as our personal baggage.

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
The TS-711A 2 meter and the TS-811A 70 centimeter all mode transceivers are the perfect rigs for your VHF and UHF operations. Both rigs feature Kenwood’s new Digital Code Squelch (DCS) signaling system. Together, they form the perfect “matching pair” for satellite operation.

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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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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 Argus, 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 amongst 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 science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished. Youngsters today have grown up with science fiction, and there was a natural curiosity as to how such an amazing feat could be accomplished.

2. Amateur radio has been “curmudgeoned.” 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 157? 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...
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The TS-940S is the standard of performance by which all other transceivers are judged. Pushing the state-of-the-art in HF transceiver design and construction, no one has been able to match the TS-940S in performance, value and reliability. The product reviews glow with superlatives, and the field-proven performance shows that the TS-940S is "The Number One Rated HF Transceiver!"

- 100% duty cycle transmitter. Kenwood specifies transmit duty cycle time. The TS-940S is guaranteed to operate at full power output for periods exceeding one hour. (14, 250 MHz, CW; 110 watts.) Perfect for RTTY, SSTV, and other long-duration modes.
- First with a full one-year limited warranty.
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- Complete all band, all mode transceiver with general coverage receiver. Receiver covers 150 kHz-30 MHz. All modes built-in: AM, FM, CW, FSK, LSB, USB.
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You get a giant two core balun wound with teflon wire for balanced lines and a 6-position antenna switch plus a spinner knob for exact inductance control. Its compact 10x3/4x5 inch cabinet slides right into your station. The MFJ-989C is not for everyone. However, if you make the investment, you'll get the finest 3 KW tuner money can buy -- one that will give you a lifetime of use, one that takes the fear out of high power operation and one that lets you get your SWR down to absolute minimum.

MFJ-989C $349.95

MFJ's Best VERSA TUNER II

MFJ-949C $139.95

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This gives you the precise control you need to get your SWR down to a minimum. After all, isn't that why you need a tuner.

You also get a dual range lighted Cross-Needle SWR/Wattmeter, 6-position antenna switch, 50 ohm 300 watt dummy load, balun for balanced lines and continuous 1.8-30 MHz coverage -- all in a compact 10x3x3 inch cabinet that fits right into your station.

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February 1989

MFJ... making quality affordable
about getting 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 who 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 an 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 QRN on the bands by remarking that we must have more Amateurs. Our choice, in Rod’s terrific phrase, was either QRN 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-policing 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

LOW BAND DX’ING COMPUTER PROGRAMS

by John Devoldere, ON4UN, for
Apple IIe/c, MS-DOS, Commodore C-128 Apple Macintosh and Kaypro

CPM Computers

Here’s a collection of 30 super programs written by ON4UN. Just about every interest or need is covered—from antenna design and optimization to general operating programs. Antenna programs include: shunt and series input L network design, feedline transformer, shunt network design, SWR, calculation, plus 11 more! General Ham programs include: sunrise/sunset, great circle distances, grayline, vertical antenna design program, sunrise calendar plus 9 more!

Phew. When you sit down to use these programs you’ll be amazed at what you have. The best value in computer software available today. © 1986.

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UN-MAC (MACINTOSH) $49.95

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February 1989
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
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.

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.
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, $20 \log \frac{5}{0.0195} = 48$ 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 $20 \log \frac{5}{0.0097} = 54$ dB.

My primary concerns for the active filter design I chose for this project were price and parts availability. I didn’t
Ken Warren, Chief Engineer at KWAV reports that their 10 kW FM transmitter went on the air in November, 1972, equipped with EIMAC power tubes. The original tubes are still in operation after over 15 years of continuous duty!

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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.
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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. Output 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

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.
“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.
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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, 1967 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 4](https://via.placeholder.com/150)

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, Parkesburg, Pennsylvania 19365, manufactures new capacitors. The coil is made of Barker and Williamson coil stock. The coil-capacitor com-
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 saluté (*) to those who really know their rye:

Tony Emanuele, WA8RJF; Lou Axeman, N8LA (*); Bill Wootton, W0J7; Steve Buol, K8BD8; David Raskin, W5TYL; Jim Fox, N7E11; Jack Statin, WF8M; Bob Eslaire, W9UI/8; Larry Walsh, W5SMA; Martha Wilder, N3FZB; Phil Brandt, W3ELJ; Bruce Rossi, NF7J; Jim Lignugaris, N2IDV; Dick Olson, NS9W; Marty Johnson, W3YOZ (*); Marty Davidoff, K2UBC (*); Preston Douglas, WA2IFZ; Roger Leone, K6XQ; Serafini Confiitti, VE3LKN; Eric Nichols, KL7AJ; Bill Calderwood, K1CT; Roger Tobin, N1EY2; 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!
Schematic of 3-tube regenerative receiver. Just the thing for the new Amateur!
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 W9ERU1 was more appealing to me than the laboratory type2 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

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

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

---

1. W9ERU
2. Laboratory type
3. The ARRL Handbook
TABLE 1

Resistor values for R1 and R2.

<table>
<thead>
<tr>
<th>dB</th>
<th>R1 (ohms)</th>
<th>R2 (ohms)</th>
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<tbody>
<tr>
<td>3</td>
<td>34</td>
<td>567</td>
</tr>
<tr>
<td>6</td>
<td>66.8</td>
<td>268</td>
</tr>
<tr>
<td>12</td>
<td>120</td>
<td>108</td>
</tr>
<tr>
<td>20</td>
<td>163.6</td>
<td>40.5</td>
</tr>
<tr>
<td>30</td>
<td>188</td>
<td>12.6</td>
</tr>
<tr>
<td>40</td>
<td>196</td>
<td>4</td>
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TABLE 2

Resistor values in fig. 2

<table>
<thead>
<tr>
<th>ohms</th>
<th>1/4-watt resistors (ohms)</th>
</tr>
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<tbody>
<tr>
<td>Ra</td>
<td>34</td>
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<td>Rg</td>
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<td>Rj</td>
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<td>Rk</td>
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<tr>
<td>Rl</td>
<td>300</td>
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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 (± 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.

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

<table>
<thead>
<tr>
<th>dB</th>
<th>volts</th>
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<tbody>
<tr>
<td>0</td>
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<tr>
<td>3</td>
<td>14.4</td>
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<td>6</td>
<td>10</td>
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<tr>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>0.63</td>
</tr>
<tr>
<td>40</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Appendix — resistor value calculation

Refer to fig. 1; the resistance looking into node 1 must be 200 ohms.
then the attenuation is given by the voltage dividers:

$$\text{eqn. 1}$$

$$V_2 = \frac{(200 + R_1) R_2}{200 + R_1 + R_2} + R_1 = 200$$

after some algebra:

$$R_1 = -R_2 \pm \sqrt{R_2^2 + 200^2} \quad \text{(2)}$$

reject the negative value and define:

$$P = \frac{(200 + R_1) R_2}{200 + R_1 + R_2}$$

then the attenuation is given by the voltage dividers:

$$V_2 = \frac{200}{200 + R_1} \cdot \frac{P}{R_1 + P} \quad \text{(3)}$$

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.

References

Article C

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## RM SERIES

**INSIDE VIEW — RS-12A**

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## RS-A SERIES

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<td>5</td>
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<td>3½ x 6¼ x 7</td>
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<td>7</td>
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## RS-M SERIES

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**MODEL RS-7A**

**MODEL RS-35M**

**MODEL RS-7A**

## VS-M AND VRM-M SERIES

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**MODEL VS-35M**

**MODEL VS-35M**

**MODEL VS-35M**

## RS-S SERIES

**MODEL RS-12S**

**MODEL RS-12S**

**MODEL RS-12S**

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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 anSWR 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 transmitting 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

**FIGURE 1**

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

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

This can be restated as:

\[ R_o R_a + j(R_o X_a + R_o X_{sh}) = jR_a X_s - X_o X_s - X_s X_{sh} + jR_o X_{sh} - X_a X_{sh} \]

From the real terms:

\[ X_s = -\frac{R_o R_a + X_o X_{sh}}{X_a + X_{sh}} \]

From the imaginary terms, substituting the above for \( X_s \):

\[ (R_o - R_a)X_{sh}^2 + 2R_o X_a X_{sh} + (R_o X_a^2 + R_o R_a^2) = 0 \]

Solving for \( X_{sh} \) by the quadratic formula:

\[ X_{sh} = \frac{R_o X_a \pm \sqrt{R_o^2 X_a^2 + (R_o - R_a) (R_o X_a^2 + R_o R_a^2)}}{R_a - R_o} \]

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

\[ L = \frac{1000X}{6.28F} \mu F \]

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

\[ C = \frac{-10^9}{6.28FX} \text{ pF} \]

Derivation of formulas for first configuration.

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 2**

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

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

This can be restated as:

\[ R_o R_a + jR_o (X_a + X_s + X_{sh}) = -X_o X_{sh} - X_s X_{sh} + jR_o X_{sh} \]

From the real terms:

\[ X_s = -\frac{R_o R_a}{X_{sh} - X_s} \]

or

\[ X_{sh} = \frac{R_o}{X_{sh} - X_s} \]

From the imaginary terms, substituting the above for \( X_s \):

\[ (R_o - R_a)X_{sh}^2 - R_o^2 R_a = 0 \]

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

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

Use the formulas for \( L \) and \( C \) as given in fig. 1.

Derivation of formulas for second configuration.
The **Kansas City Tracker** is a hardware and software package that connects between your rotor controller and an IBM XT, AT, or clone. It controls your antenna array, letting your PC track any satellite or orbital body. The **Kansas City Tracker** hardware consists of a half-size interface card that plugs into your PC. It can be connected directly to a Yaesu/Kenpro 5400A/5600A rotor controller. It can be connected to other rotor assemblies using our Rotor Interface Option.

The **Kansas City Tuner** is a companion product that is used in satellite work. It can provide automatic doppler-shift compensation for digital satellite work. Using our new **F-Trak** feature it can also slave the uplink radio frequency to the downlink radio’s frequency.

The **Tracker** is compatible with most rigs including Yaesu, Kenwood, and Icom. It controls your radio thru its serial computer port (if present) or through the radio’s up/down mic-click interface.

The **Kansas City Tracker** and Tuner include custom serial interfaces and do not use your computer’s valuable COMM ports. The software runs in your PC’s “spare time,” letting you run other programs at the same time.

The **Kansas City Tracker** and Tuner programs are “Terminate-and-Stay-Resident” programs that attach themselves to DOS and disappear. You can run other DOS programs while your antenna tracks its target and your radios are tuned under computer control. This unique feature is especially useful for digital satellite work; a communications program like PROCOMM can be run while the PC aims your antennas and tunes your radios in its spare time. Status pop-up windows allow the user to review and change current and upcoming radio and antenna parameters. The **KC Tracker** is compatible with DOS 2.00 or higher and will run under DESQ-VIEW.

### Satellite and EME Work

The **Kansas City Tracker** and **Kansas City Tuner** are fully compatible with AMSAT’s **QUIKTRAK** (3.2) and with **Silicon Solution’s GRAFTRAK** (2.0). These programs can be used to load the **Kansas City Tracker’s** tables with more than 50 satellite passes. We also supply assembled & tested **TAPR PSK** modems with cases and 110v power supplies.

### DX, Contests, and Nets

**Working DX or contests and need three hands? Use the Kansas City Tracker pop-up to work your antenna rotor for you. The Kansas City Tracker is compatible with all DX logging programs. A special callsign aiming program is included for working nets.**

### Packet BBS

**The Kansas City Tracker** comes complete with special control programs that allow the packet BBS user or control-op to perform automated antenna aiming over an hour, a day, or a week. Your BBS or packet station can be programmed to automatically solicit mail from remote packet sites.

### Vision-Impaired Hams

The **Kansas City Tracker** has a special morse-code sender section that will announce the rotor position and status automatically or on request. The speed and spacing of the code are adjustable.

---

**The Kansas City Tracker and Tuner** packages include the PC interface card, interface connector, software diskette, and instructions. Each Kansas City unit carries a one-year warranty.

- **KC Tracker package for the Yaesu/Kenpro 5400A/5600A controller** .................................. $189
- **Interface cable for Yaesu/Kenpro 5400A/5600A** .......................................................... $ 19
- **KC Tracker package with Rotor Interface Option (to connect to ANY rotors)** ......................... $219
- **KC Tuner (must be purchased with KC Tracker)** ............................................................. $ 79
- **Assembled & tested TAPR PSK modem with case & 110v power supply** .............................. $219
- **AMSAT QuickTrak software** .............................................................................................. $ 75

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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 3090 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.
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).
Measuring the input impedance of the line at 1835 kHz shows 95 ohms resistance \( R_0 \) and a small amount (estimated as 5 ohms) of inductive reactance \( X_0 \). The computer calculation shows that a network with 4.5 \( \mu \)H 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.
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, 1989, the Court issued its opinion ordering relief in a variety 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 entry 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 mid-level 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 entry 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 must obtain a claim form, complete it fully, and return it to counsel for the plaintiff class, Bruce A. Fredericksen, Esq., Webster & Fredericksen, 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 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 a OPM office 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. If you have any questions, contact the claim form to the Judge, the Court or the Clerk of the Court, the Judge, the Court and the Clerk of the Court will not accept the claim forms and will not send 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 held, 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 each 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, you must fully complete the claim form 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. Fredericksen
Webster & Fredericksen
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

October 4, 1988

Date

/s/ Judge Charles R. Richey

United States District Court
Judge Charles R. Richey

36 February 1999
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 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 pH (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!

---

**Figure 7**

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

---

**Article D**

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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. 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 multwire 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, WGJKV, 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 M\(^2\) Yagis, each on a 52-foot boom.

The following day (September 8, 1988), Graham ran a schedule with Ray Rector, WA4NJP, Gillsville, Georgia (EM87WI) 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 M\(^2\) Yagis, each on a 52-foot boom.

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**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.\(^2\) 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-
The 12-foot dish at station WA5VJB used for the first ever two-way Amateur contact on 10-GHz EME.

Photronics 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, WCNKI5, 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. 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
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. 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 (DM420K) and Terry Wilkinson, WA7LYI/7, on Mt. Graham, Arizona (DM528Q) 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.
<table>
<thead>
<tr>
<th>Frequency</th>
<th>Record Holders</th>
<th>Date</th>
<th>Mode</th>
<th>DX Miles (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 MHz</td>
<td>W4ANJ(E8MG4DG)-ZLB(GJR7FDX)</td>
<td>88-09-08</td>
<td>CW</td>
<td>8258 (13288)</td>
</tr>
<tr>
<td>144 MHz</td>
<td>K1A2E(F3N3TJ)-W4OTKJ(WB3DRL(E1MB8CT)</td>
<td>86-02-06</td>
<td>CW</td>
<td>1347 (2157)</td>
</tr>
<tr>
<td></td>
<td>VEU(T(FN62XV)-V5KM(CGF02JE)</td>
<td>84-04-07</td>
<td>CW</td>
<td>10,985 (17675)</td>
</tr>
<tr>
<td></td>
<td>W5UH(C6E90G)-W5(U1DM3B2V4A)</td>
<td>83-07-05</td>
<td>CW</td>
<td>1228 (1976)</td>
</tr>
<tr>
<td></td>
<td>K5UR(EM5W5W-KP44(G6KF8BVG)</td>
<td>65-12-13</td>
<td>SSB</td>
<td>1960 (3153)</td>
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<tr>
<td></td>
<td>W4ACQG(EM72FO-W7YOC(CN87VB)</td>
<td>88-06-06</td>
<td>SSB</td>
<td>2172 (3495)</td>
</tr>
<tr>
<td></td>
<td>KP4EQ(FK78AJ-LJUDZ(JG(F111UI)</td>
<td>78-02-12</td>
<td>SSB</td>
<td>3933 (6328)</td>
</tr>
<tr>
<td></td>
<td>K1RHJ(FN31XH)-K5WXZ(EM12QW)</td>
<td>68-10-08</td>
<td>CW</td>
<td>1466 (2262)</td>
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<td></td>
<td>K6GRU(WB1UTXH)-W5URJ(EM13BT)</td>
<td>73-07-29</td>
<td>CW</td>
<td>2596 (4216)</td>
</tr>
<tr>
<td>220 MHz</td>
<td>W3Y(F1FM91HA)-W5BLUA(E8M30CC)</td>
<td>82-07-14</td>
<td>CW</td>
<td>1145 (1842)</td>
</tr>
<tr>
<td></td>
<td>K1WHS(F44MC)-K6BBZ(BL11CJ)</td>
<td>83-11-17</td>
<td>CW</td>
<td>5068 (8136)</td>
</tr>
<tr>
<td></td>
<td>W1JF(T(W42NH)-K4ALL(W160U)</td>
<td>88-06-13</td>
<td>SSB</td>
<td>1274 (2067)</td>
</tr>
<tr>
<td></td>
<td>K5JGJ(E4M12SM)-W4HJU(J4EM90G)</td>
<td>87-06-14</td>
<td>CW/SSB</td>
<td>932 (1469)</td>
</tr>
<tr>
<td></td>
<td>KP4EQ(FK78AJ-LJUDZ(JG(F05GJU)</td>
<td>83-03-09</td>
<td>SSB</td>
<td>3670 (5906)</td>
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<tr>
<td></td>
<td>K1WHS(F44MC)-K5UR(E8M35W)</td>
<td>88-09-09</td>
<td>CW</td>
<td>1267 (2039)</td>
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<tr>
<td></td>
<td>KH6UK(BL11AO)-W9NLZ(DM03TS)</td>
<td>59-06-22</td>
<td>CW</td>
<td>2539 (4066)</td>
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<tr>
<td>345 MHz</td>
<td>W3P(F1MF10D0-W5BLUA(E8M30CC)</td>
<td>86-02-08</td>
<td>CW</td>
<td>1182 (1901)</td>
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<tr>
<td></td>
<td>K2YHJ(FN20GG)-V4KCTG(F57BV)</td>
<td>83-01-29</td>
<td>CW</td>
<td>11567 (18912)</td>
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<tr>
<td></td>
<td>W2AZL(FN20VI)-W4LTER(E8N2E)</td>
<td>72-06-12</td>
<td>CW</td>
<td>1021 (1642)</td>
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<tr>
<td></td>
<td>WB3CZG(FN21AX)-W45UJ(E8M12I)</td>
<td>86-11-29</td>
<td>SSB</td>
<td>3118 (2121)</td>
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<tr>
<td></td>
<td>K6DR(MD313N)-K6H1A(P8K29G)</td>
<td>80-07-28</td>
<td>SSB</td>
<td>2650 (4103)</td>
</tr>
<tr>
<td>303 MHz</td>
<td>K5HJ(E8M15G0)-W5BLUA(E8M30CC)</td>
<td>88-02-07</td>
<td>CW</td>
<td>187 (301)</td>
</tr>
<tr>
<td></td>
<td>K2SMN(FN20EJ)-WS4E(F894FM)</td>
<td>88-09-28</td>
<td>CW</td>
<td>628 (1011)</td>
</tr>
<tr>
<td>1296 MHz</td>
<td>K2HYH(FN20GG)-V5MC(F502JE)</td>
<td>81-12-06</td>
<td>CW</td>
<td>10562 (16995)</td>
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<tr>
<td></td>
<td>WB3CZG(FN21AX)-W45UJ(E8M12I)</td>
<td>86-11-29</td>
<td>SSB</td>
<td>1287 (2070)</td>
</tr>
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<td></td>
<td>K6HME(E8K29G)-W5BMI(6DM102K)</td>
<td>88-06-13</td>
<td>SSB</td>
<td>2542 (4098)</td>
</tr>
<tr>
<td>2304 MHz</td>
<td>K3WJ(F480BC)-ZL2A(CP7E6W)</td>
<td>87-10-18</td>
<td>CW</td>
<td>9565 (13331)</td>
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<tr>
<td></td>
<td>K5ROJ(E8M13PA)-W8YIO(E8N2E)</td>
<td>86-11-29</td>
<td>CW</td>
<td>940 (1513)</td>
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<td>3468 MHz</td>
<td>W7CNK(5F15D1)-K0KE(0DM79NO)</td>
<td>87-04-12</td>
<td>CW</td>
<td>498 (802)</td>
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<td>W8SAF(Y(EM04D)-KX00(0DM87KU)</td>
<td>88-08-07</td>
<td>CW</td>
<td>455.5 (733)</td>
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<tr>
<td>5760 MHz</td>
<td>W8SNY(EM12KV)-W7CNK(5F15D1)</td>
<td>87-04-24</td>
<td>CW</td>
<td>174 (279)</td>
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<tr>
<td></td>
<td>N5JJ2(5F826C)-W5ICW(5DM95L)</td>
<td>88-07-10</td>
<td>SSB</td>
<td>404 (650)</td>
</tr>
<tr>
<td>10.368 GHz</td>
<td>W6AHJ(E8M12Q1)-W47C(01DM3XL)</td>
<td>88-08-27</td>
<td>CW</td>
<td>968 (1397)</td>
</tr>
<tr>
<td></td>
<td>WB7ABP(C8N1BD)-W5BLHC(6DM04MS)</td>
<td>88-06-06</td>
<td>CW/SSB</td>
<td>479 (770)</td>
</tr>
<tr>
<td></td>
<td>NN9W(GICN04X)-X2GHI(DL2VL)</td>
<td>89-08-11</td>
<td>MCW</td>
<td>595 (958)</td>
</tr>
<tr>
<td>24.192 GHz</td>
<td>WA3RMX(7CNB30I)-WB7UNU(7CN95DH)</td>
<td>86-06-23</td>
<td>SSB</td>
<td>116 (186)</td>
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<tr>
<td>47.040 GHz</td>
<td>WA3RMX(7CN82WV)-K7AUO(7CN82PS)</td>
<td>88-06-06</td>
<td>CW/SSB</td>
<td>65.3 (105)</td>
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<tr>
<td>76-149 GHz</td>
<td>None reported.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>300 GHz and above</td>
<td>See note 5.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>474 THz</td>
<td>K6MEP(8DM040)-WA8EJO(6DM04KT)</td>
<td>79-06-09</td>
<td>Laser</td>
<td>15 (24)</td>
</tr>
<tr>
<td>678 THz</td>
<td>KY78/1DM420K(1)-WA7LY(1DM528O)</td>
<td>88-06-12</td>
<td>Laser</td>
<td>56.7 (91.2)</td>
</tr>
</tbody>
</table>

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 center model.

Note 4. Six-meter records, excepting EME, were left off as the primary propagation mode is often hard to distinguish. Long-path QSOs exceeding approximately 12,430 miles (20,000 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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(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
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203 BAS

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155 BAS

153 BAS

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66 BAS

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RG-211/U (2570)... $0.37/ft

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FLC72 1/2" Cablewire corr. copper bkl jct
NM720C N conn 1/2" corr copper myl
NM720C N conn 1/8" corr copper myl

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1110 RG58 95% shield (mini 8)
1120 RG213/U 95% shield mil spec NCV jct
1140 RG214/U dbi shield mil spec
1170 RG142/U dbi shield, teflon ins
1310 RG171/U 50 ohm 5000 watt dbi shield
1450 RG174/U 50 ohm 100% mil spec

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PF259M Amphenol PL259
PF259MT PL259 teflon ins./silver plated
PF259AM Amphenol female-female (barrel)
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UG219S N plug for RG213, 12C Silver
UG30B N jack for PL259 adapter, teflon
UG141SA SO239 to PL259 adapter, teflon
UG255 SO239 to BNC plug adapter, Amphenol
SO239AM UHF chassis mf receptacle, Amphenol

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1.59

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.59

.65

.50

.50

.22

.35

.52

.36

.17

.39

.96

.14

.21

.39

.85

.50

.36

.85

.89

.26

.40

.50

2.00

.36

.14

.85

.50

.36

.85

.89

.26

.40

.50

2.00

.36

.14

.85

.50

.36

.85

.89

.26

.40

.50

2.00

.36

.14

.85

.50

.36

.85

.89

.26

.40

.50

TABLE 3

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

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Record Holders</th>
<th>Date</th>
<th>Mode</th>
<th>Miles (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 MHz</td>
<td>WA4NJP(EM04DR)-ZL2BGJ(RF70DX)</td>
<td>88-09-08</td>
<td>CW</td>
<td>8258 (13288)</td>
</tr>
<tr>
<td>144 MHz</td>
<td>K6MYC/KH6(BK29AO)-Z56ALEG(KG43RC)</td>
<td>83-02-18</td>
<td>CW</td>
<td>12091 (19455)</td>
</tr>
<tr>
<td>220 MHz</td>
<td>K1WHS(FN43MK)-K6HFZI(BL11CJ)</td>
<td>83-11-17</td>
<td>CW</td>
<td>5058 (8139)</td>
</tr>
<tr>
<td>432 MHz</td>
<td>F9FTJ(JO29AG)-ZL3AAD(RE66GR)</td>
<td>80-04-18</td>
<td>CW</td>
<td>11679 (18793)</td>
</tr>
<tr>
<td>902 MHz</td>
<td>K5JL(EM15DO)-W5BLUA(EM13OC)</td>
<td>88-02-07</td>
<td>CW</td>
<td>187 (301)</td>
</tr>
<tr>
<td>1296 MHz</td>
<td>PA0SSB(JO11WI)-ZL3AAD(RE66GR)</td>
<td>83-06-13</td>
<td>CW</td>
<td>11595 (18657)</td>
</tr>
<tr>
<td>2304 MHz</td>
<td>W3IWI/8FM08CK)-ZL2AGE(RE78JS)</td>
<td>87-10-18</td>
<td>CW</td>
<td>8658 (13931)</td>
</tr>
<tr>
<td>3456 MHz</td>
<td>W7CNK/5(EM15FI)-K0KE(DM79N0)</td>
<td>87-04-06</td>
<td>CW</td>
<td>498 (802)</td>
</tr>
<tr>
<td>5760 MHz</td>
<td>WA5TNY(EM12KV)-W7CNK/5(EM15FI)</td>
<td>87-04-24</td>
<td>CW</td>
<td>174 (279)</td>
</tr>
<tr>
<td>10368 MHz</td>
<td>WA5VJB(EM12LQ)-WA7CJO(DM33XL)</td>
<td>88-08-27</td>
<td>CW</td>
<td>868 (1397)</td>
</tr>
</tbody>
</table>

2400 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 become 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, KX0O, and WB0HLO.

Notes

In last September’s column⁶ 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, WA30JX, 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)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Record Holders</th>
<th>Date</th>
<th>Mode</th>
<th>DX miles (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 MHz</td>
<td>EL2AV(IJ46)-H44PT(RI000A)</td>
<td>82-04-04</td>
<td>SSB</td>
<td>11764 (18932)</td>
</tr>
<tr>
<td>50 MHz</td>
<td>G3SHK(I0900P)-GM3WOJ/P(I089KB)</td>
<td>82-08-11</td>
<td>CW</td>
<td>562 (904)</td>
</tr>
<tr>
<td>50 MHz</td>
<td>G3YH(I11C00)-GM3WOJ/P(I089KB)</td>
<td>82-08-12</td>
<td>?</td>
<td>673 (1083)</td>
</tr>
<tr>
<td>50 MHz</td>
<td>GW4ASR(I082GJ)-SS6CY(KM64MR)</td>
<td>81-06-07</td>
<td>?</td>
<td>2153 (3465)</td>
</tr>
<tr>
<td>50 MHz</td>
<td>G4FRE/P(I07000)-GM4UQK/A(I087WB)</td>
<td>86-09-21</td>
<td>SSB</td>
<td>466 (734)</td>
</tr>
<tr>
<td>144 MHz</td>
<td>G4VBG(I094FW)-UA32F(K76WT)</td>
<td>86-02-07</td>
<td>CW</td>
<td>1373 (2209)</td>
</tr>
<tr>
<td>144 MHz</td>
<td>K6MYC/KH6(BK29AO)-Z6ALE(KG46RC)</td>
<td>84-02-18</td>
<td>CW</td>
<td>12091 (19455)</td>
</tr>
<tr>
<td>144 MHz</td>
<td>GW4COT/I081LP-UM6MA(KN97VE)</td>
<td>77-08-12</td>
<td>CW</td>
<td>1927 (3101)</td>
</tr>
<tr>
<td>144 MHz</td>
<td>EA8XS(I128GA)-HG0HO(KM07RU)</td>
<td>83-07-16</td>
<td>SSB</td>
<td>2402 (3865)</td>
</tr>
<tr>
<td>144 MHz</td>
<td>I4EAT/JN54VG-ZS3R(JG730J)</td>
<td>79-03-30</td>
<td>CW</td>
<td>4884 (7860)</td>
</tr>
<tr>
<td>144 MHz</td>
<td>EA8GEX(I127CB)-GI4KIS(I064VR)</td>
<td>88-07-15</td>
<td>WW/SSB</td>
<td>1904 (3064)</td>
</tr>
<tr>
<td>432 MHz</td>
<td>PA0RDF(I022KJ)-RA3LE(KO64AR)</td>
<td>86-02-08</td>
<td>CW</td>
<td>1123 (1807)</td>
</tr>
<tr>
<td>432 MHz</td>
<td>F9FT(JN29AG)-ZL3AAD(RE66GR)</td>
<td>80-04-18</td>
<td>CW</td>
<td>11749 (18907)</td>
</tr>
<tr>
<td>432 MHz</td>
<td>EI2VAH(I043XW)-SK6ABI(J057XO)</td>
<td>80-08-12</td>
<td>CW</td>
<td>891 (1434)</td>
</tr>
<tr>
<td>432 MHz</td>
<td>EA8XS(I128GA)-GW8VH(I081CM)</td>
<td>84-07-05</td>
<td>SSB</td>
<td>1731 (2786)</td>
</tr>
<tr>
<td>1296 MHz</td>
<td>PA0SSB(I011WI)-ZL3AAD(RE66GR)</td>
<td>83-06-13</td>
<td>SSB</td>
<td>11665 (18772)</td>
</tr>
<tr>
<td>1296 MHz</td>
<td>EA8XS(I128GA)-G6LUEII(O70ME)</td>
<td>85-06-29</td>
<td>SSB</td>
<td>1626 (2617)</td>
</tr>
<tr>
<td>2304 MHz</td>
<td>PA0SSB(I011WI)-W6YFC(CM87WJ)</td>
<td>81-04-05</td>
<td>SSB</td>
<td>5506 (8860)</td>
</tr>
<tr>
<td>2304 MHz</td>
<td>EA78VD/P(I1M78JD)-EA8XS/P(I127GW)</td>
<td>84-07-08</td>
<td>SSB</td>
<td>920 (1481)</td>
</tr>
<tr>
<td>3466 MHz</td>
<td>G3LOR(I002O)-SM8HYG(I058RG)</td>
<td>83-07-11</td>
<td>CW</td>
<td>576 (927)</td>
</tr>
<tr>
<td>5760 MHz</td>
<td>G3ZEN(I001MS)-SM6HYG(I058RG)</td>
<td>83-07-12</td>
<td>SSB</td>
<td>610 (981)</td>
</tr>
<tr>
<td>10.368 GHz</td>
<td>I0S7/Y:EA9(I1M751)-I0YLY/I0H(I1M68NR)</td>
<td>83-07-08</td>
<td>FM</td>
<td>1032 (1660)</td>
</tr>
<tr>
<td>24 GHz</td>
<td>I0SNY/IC8JN60WR/IBY0Z/8I7M78WE</td>
<td>84-08-11</td>
<td>FM</td>
<td>206 (331)</td>
</tr>
<tr>
<td>47 GHz</td>
<td>HB9AGE/P(I1N36FS)-HB9MIN/P(I1N36FS)</td>
<td>87-06-06</td>
<td>?</td>
<td>53 (86)</td>
</tr>
<tr>
<td>75 GHz</td>
<td>HB9AGE/P(I1N37RD)-HB9MIN/P(I1N37RD)</td>
<td>87-06-06</td>
<td>FM</td>
<td>0.3 (0.5)</td>
</tr>
</tbody>
</table>

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

References:

Article E

HAM RADIO
NYE Takes the fear out of full power antenna tuners, and the guesswork out of PEP measurement with these two MUST SEE PRODUCTS!!

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Discover this durably built, feature packed MB-V-A Antenna tuner. You’ll find operating conveniences that make antenna tuning a snap and value engineered to do the job over wide operating ranges. Compare quality, features and the NYE VIKING TWO YEAR WARRANTY.

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- 3 KW Balun. Trifier wound triple core torroid gives balanced output to twin feeder from 200 to 1000 ohms and unbalanced output down to 20 ohms.
- Maximum Power Transfer. Match your transmitter output impedance to almost any antenna system for maximum power transfer. Amplifiers only run at their designed Q when properly matched.
- Model Options. MB-IV-A1 includes all MB-V-A features less antenna switch and balun. MB-IV-A2 is identical to MB-V-A1 with the addition of a triple core balun.
- 1.8 MHz will not tune on same antennas.

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Crank-up tower cable guides

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

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)

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.

Arthur L. Bachelor, M.D.  
Article F
Choice Selection.

Now you can have it all! Take all the qualities you've come to depend on in our programmable CTCSS tone equipment: Astonishing Accuracy, Instant Programming, Unequaled Reliability, and add full spectrum tone versatility, multi-tone capability without diodes, a reprogrammable memory...It's our new harvest of CTCSS tone equipment.

The choice is yours! If standard CTCSS EIA tones do not suit your taste, select any 32 tones of your liking from 15.0Hz to 255.0Hz. And if you change your mind, no problem; the memory can be changed in your shop with our HHP-I programmer, or at our factory for free. Your working tone is accessed by a simple DIP switch, so there's no fussing with counters or other test equipment.

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It's all brought to market by the people who introduce the freshest ideas in tone signalling, and of course our customary same day shipping and one year warranty apply.

TS-32P CTCSS ENCODER-DECODER Based on the time proven TS-32, the industry standard for over a decade. The TS-32P gives you the added versatility of a custom, changeable memory base. A low price of $57.95 makes it an even sweeter deal.

SS-32P ENCODER Based on the equally popular SS-32 encoder. Available for CTCSS, or audible burst tones up to 6550.0Hz. Price is $28.95.

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220 MHz & 1.2 GHz
10 MEMORIES
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Reader Service CHECK—OFF Page 110
February 1989
Early Reservation Information

- General Chairman, Bill McNabb, WD8SAY
- Giant 3 day flea market • Exhibits
- License exams • Free bus service
- CW proficiency test • Door prizes

Flea market tickets and grand banquet tickets are limited. Place your reservations early, please.

Flea Market Tickets
A maximum of 3 spaces per person (non-transferable). Tickets (valid all 3 days) will be sold IN ADVANCE ONLY. No spaces sold at gate. Vendors MUST order registration ticket when ordering flea market spaces.

Special Awards
Nominations are requested for 'Radio Amateur of the Year,' 'Special Achievement' and 'Technical Achievement' awards. Contact: Hamvention Awards Chairman, Box 964, Dayton, OH 45401.

License Exams
Novice thru Extra exams scheduled Saturday and Sunday by appointment only. Send FCC form 610 (Aug. 1985 or later) - with requested elements shown at top of form, copy of present license and check for prevailing ARRL rates (payable to ARRL/VEC) to: Exam Registration, 8830 Windbluff Point, Dayton, OH 45458

1989 Deadlines
Award Nominations: March 15
Lodging: April 7
License Exams: March 26
Advance Registration and banquet:
USA - April 4 Canada - March 31
Flea Market Space:
Spaces will be allocated by the Hamvention committee from all orders recieved prior to February 1. Express Mail NOT be necessary! Notification of space assignment will be mailed by March 15, 1989.

Information
General Information: (513) 433-7720
or, Box 2205, Dayton, OH 45401
Lodging Information: (513) 223-2612
(No Reservations By Phone)

Lodging
Please write to Lodging, Dayton Hamvention, Chamber Plaza, 5th & Main Streets, Dayton, OH 45402 or refer to our 1988 Hamvention program for lodging information which includes a listing of hotel/motels located in the surrounding areas of Dayton. Reservations for the surrounding area will then become the responsibility of the Individual.

Hamvention is sponsored by the Dayton Amateur Radio Association Inc.

Advance Registration Form

Dayton Hamvention 1989
Reservstion Deadline - USA-April 4, Canada-March 31
Flea Market Reservation Deadline: February 1

Enclose check or money order for amount indicated and send a self addressed stamped envelope.
Please Type or Print your Name and Address clearly.

Name ___________________________
Address ___________________________
City __________ State __________ Zip ________

How Many

Admission _______ @ $10.00* $_____
(Valid all 3 days)

Grand Banquet _______@ $20.00** $_____

Women's Luncheon
(Saturday) _______@ $7.00 $_____
(Sunday) _______@ $7.00 $_____

Flea Market _______ $25/1 space
(Max. 3 spaces) $50/2 adjacent
Admission ticket must $150/3 adjacent $_____
be ordered with flea market tickets

Total $_____

* $12.00 at door ** $22.00 at door, if available

Make checks payable to - Dayton Hamvention
Mail to - Dayton Hamvention Box 2205 Dayton, OH 45401
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 $r$ 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 ($2\pi$ 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 $d \cos (\phi)$. $\beta$ 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 ($\alpha$). So the final equation for the phase difference between any two elements at point P is: phase difference = $\beta d \cos \phi + \alpha$ where $\beta = (2\pi / \text{wavelength})$.
The geometry used with each element to calculate the field strength at point p.

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

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 reflects 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
3 Element linear array

<table>
<thead>
<tr>
<th>Element</th>
<th>magnitude</th>
<th>phase(DEG)</th>
<th>separation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.662</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>110.33</td>
<td>0.15</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>244.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

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 (\(\varepsilon\)) 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.

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 strength 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.
5-1000 MHz PREAMPLIFIERS

<table>
<thead>
<tr>
<th>Model</th>
<th>NF</th>
<th>G</th>
<th>P(1dB)</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>WLA21m</td>
<td>3</td>
<td>13</td>
<td>8</td>
<td>57</td>
</tr>
<tr>
<td>WLA22m</td>
<td>4</td>
<td>11</td>
<td>12</td>
<td>61</td>
</tr>
<tr>
<td>WLA23m</td>
<td>4</td>
<td>23</td>
<td>12</td>
<td>87</td>
</tr>
<tr>
<td>WLA24m</td>
<td>3</td>
<td>20</td>
<td>18</td>
<td>109</td>
</tr>
</tbody>
</table>

430/500 MHz CONVERTER

RCX431

WLA22m

430/500 MHz

 Cần tính field strength

110 GOTO 3380

"Print main menu"

120 A$=INKEY$:IF A$="=" THEN 120 "Input menu choice"

130 P=VAL(A$)

140 ON P GOSUB 1150,1630,2170,90,2470,2150

150 GOTO 110

160 "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 "If an amp is often convenient, it need only be relative!"

210 INPUT M(1)

215 PRINT "This defines the element currents"

220 PRINT:PRINT "Print each element:":PRINT "0""

310 PRINT "0= a half wave dipole"

320 A$=INKEY$:IF A$="=" THEN 320

330 IF A$="G" OR A$="D" THEN EL=0:GOTO 360

340 IF A$="U" OR A$="O" THEN EL=1:GOTO 360

360 GOTO 300

361 "Print menu choice for the array elements:":PRINT "0=Horizontal"

370 PRINT "Print the array elements:":PRINT "0=Horizontal polarization"

380 IF A$="G" OR A$="D" THEN 400

390 GOSUB 260:RETURN "GP indicates existence of ground plane"

400 GP=1:GOSUB 150

410 PRINT "How many wavelengths below the array is the ground plane?":GPWL

420 PRINT "Print the array elements:":PRINT "0=Horizontal polarization"

430 PRINT "Vertically polarized?"

440 A$=INKEY$:IF A$="=" THEN 440

450 IF A$="H" OR A$="V" THEN POL=0:GOTO 460

460 IF A$="H" OR A$="V" THEN POL=1:GOTO 470

470 GOTO 420

480 "Calculating field strength for each degree of angle"

500 "Output is E=0-359"

510 CLS

520 "FOR DEG=0 TO EEND STEP 0"

530 LOCATE 12, 25:PRINT "Working on":DEG, "degree angle."

540 DEG=DEG+5.72957"

550 "Converting degrees to radians"

560 COS=(AND)

570 IF EL=1 THEN SIN(AND)=1.5708:IF ABS(AND)<.001 THEN RT=0:GOTO 610

580 IF AND=90 THEN RT=90:GOTO 610

590 "If statement defined sintergl=90 degree for later"

600 IF EL=1 THEN GOSUB 1900:RT=R(1)+MID(GOSUB 610

610 "This statement defined the mag of element pattern if dipole"

620 RT=RT+1"

630 "Input image pattern"

640 " mage=1:IF POL=0 THEN THETA=180 'accounts for phase of ref. due to polarity"

650 "If POL=1 THEN THETA=0"

660 "FOR DEG=0 TO 360 STEP 0"

670 "THETA:THETA:1+2.63:0+COS(57,2975"

680 "GOSUB 1010 'changing mag and phase to rectangular"

690 "RT=REAL:IT=IM"

700 NEXT DEG"

710 "REAL:IM:IT"

720 "GOSUB:1050 'changing from rect back to polar"

730 E=DEG:G điện"

740 NEXT DEG"

750 IF GP=0 THEN GOSUB 780 'this gives the ground plane scale"

760 RETURN"

770 "This sub accommodates ground plane in field"

780 "generate image pattern"

800 "MAG=1:IF POL=0 THEN THETA=180 'accounts for phase of ref. due to polarity"

810 IF POL=0 THEN THETA=0"

820 "FOR DEG=0 TO 360 STEP 0"

830 "THETA:THETA:1+2.63:0+COS(57,2975"

840 "'This roteate pattern: -90 deg"

850 "D=2:GOSUB 450:GOSUB 1050 'locate 12,25:PRINT "working on image pattern, I"DEG,"

860 "E=DEG:THETA:THETA:1+2.63:0+COS(57,2975"

870 "GOSUB 1010 'changing mag and phase to rectangular"

880 "RT=REAL:IT=IM"

890 "REAL:IM:IT"

900 "GOSUB 1050 'changing rect to polar"

910 "UNIT:DEG:G điện"

920 NEXT DEG"

930 "we now have image pattern"

940 "multiply image and array patterns"

950 "FOR DEG=0 TO EEND STEP 0"

960 "E=DEG:DEG=DEG+UNIT:DEG"

970 NEXT DEG"

980 RETURN"

990 "This sub accommodates ground plane in field"

1000 "generate image pattern"

1010 "MAG=1:IF POL=0 THEN THETA=180 'accounts for phase of ref. due to polarity"

1020 "IF POL=1 THEN THETA=0"

1030 "FOR DEG=0 TO 360 STEP 0"

1040 "THETA:THETA:1+2.63:0+COS(57,2975"

1050 "'This roteate pattern: -90 deg"

1060 "D=2:GOSUB 450:GOSUB 1050 'locate 12,25:PRINT "working on image pattern, I"DEG,"

1070 "E=DEG:THETA:THETA:1+2.63:0+COS(57,2975"

1080 "GOSUB 1010 'changing mag and phase to rectangular"

1090 "RT=REAL:IT=IM"

1100 "REAL:IM:IT"

1110 "GOSUB 1050 'changing rect to polar"

1120 "UNIT:DEG:G điện"

1130 NEXT DEG"

1140 "we now have image pattern"

1150 "multiply image and array patterns"

1160 "FOR DEG=0 TO EEND STEP 0"

1170 "E=DEG:DEG=DEG+UNIT:DEG"

1180 NEXT DEG"

1190 RETURN"

1200 "Changing polar coordinates MAG and THETA to rectangular REAL and IM"
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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 QTURNO=5+INT(MAX(5)+S "out in the nearest 5th increment
2100 CENT=QTURNO-25
2110 RETURN
2120
2130
2140
2150 SYSTEM "sends execution back to dos
2160 "**
2170 "printing out data
2180 CLS:GOSUB 1930 "logging data
2190 PRINT"Do you want to:" PRINT"S-print on screen"!
2200 PRINT"F-print on printer"!
2210 PRINT"U-quit"!
2220 AS=INKEYS:IF AS="S" THEN 2220
2230 IF AS="F" OR AS="P" THEN GOSUB 2460
2240 IF AS="G" OR AS="P" THEN GOSUB 2560
2250 IF AS="G" OR AS="P" 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 E+(R(1)),0 /n/a
2320 FOR I=1 TO E
2330 PRINT I,(R(I)),0 /n/a
2340 NEXT I
2350 PRINT
2360 IF EL=O 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 IST. degrees."
2390 IF irr=O THEN GOTO 2410
2400 RETURN
2410 "Ground plane is "DPW" wavelengths below the array."
2420 IF POL=O THEN PRINT"Array elements are horizontally polarized."
2430 IF POL=1 THEN PRINT"Array elements are vertically polarized."
2440 RETURN
2450
2460 CLS:PRINT out on screen
2470 GOSUB 2260 "prints out parameters
2480 PRINT:PRINT\ANGLE \FS VOLTBS1 REL GAIN TO 1 ELEMENT (dB)
2490 PRINT
2500 FOR DEG=O TO EEGD STEPST
2510 PRINT DEG,E(DEG) TAB(31) L(J) L(1) DEG
2520 NEXT DEG
2530 PRINT Hit any key to continue!
2540 BA=INKEYS:IF BA="S" THEN 2540
2550 RETURN
2560 "" "
2570 "printing out on printer
2580 CLS:PRINT"Sending to printer"!
2590 PRINT E+" Element linear array"!PRINT
2600 LPRINT Element magnitude phase separation
2610 LPRINT 1 0 N/A
2620 FOR I=1 TO E
2630 LPRINT I,(R(I)),0 N/A
2640 NEXT I
2650 LPRINT LRPRINT\ANGLE \FS VOLTBS1 REL GAIN TO 1 ELEMENT (dB)
2660 LPRINT
2670 FOR DEG=O TO EEGD STEPST
2680 LPRINT DEG,E(DEG) TAB(31) L(J) L(1) DEG
2690 NEXT DEG
2700 RETURN
2710 ""
2720 """"
2730 """"
2740 "change parameters
2750 GOSUB 2260 "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 T+"toggle omnidirectional elements or 1/2 wave dipole elements"
2820 PRINT C+"change step size of analysis"
2830 PRINT T+"analyze"
2840 AS=INKEYS:IF AS="S" THEN 2840
2850 IF AS="F" OR AS="P" THEN GOSUB 2990
2860 IF AS="G" OR AS="P" THEN GOSUB 3160
2870 IF AS="G" OR AS="P" THEN GOSUB 3160
2880 IF AS="G" OR AS="P" THEN GOSUB 3160
2890 IF AS="G" OR AS="P" THEN GOSUB 3160
2900 IF AS="G" OR AS="P" THEN GOSUB 3160
2910 IF AS="G" OR AS="P" THEN GOSUB 3160
2920 CLS:GOTO 2750
2930 ""
2940 "changes step size of analysis
2950 CLS:PRINT Step size is currently IST. degrees."
2960 INPUT WHAT new step size in degrees
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,(R(I)),(R(I)),0 N/A
3030 PRINT
3040 PRINT Do you want to change?"
3050 PRINT M+"magnitudes"!
3060 PRINT"F-phase": PRINT S+"separation in wavelength"!
AL-80A LINEAR AMPLIFIER

The AL-80A will provide a signal output that is within 1/2 "S" unit of the signal output of the most expensive amplifier on the market—and at much lower cost.

The Ameritron AL-80A combines the economical 3500Z with a heavy duty tank circuit to achieve nearly 70% efficiency from 160 to 15 meters. It has wide frequency coverage for MARS and other authorized services. Typical drive is 85 watts to give over 1000 watts PEP and 850 watts CW RF output. A new P.L. output circuit for 80 and 160 gives full band coverage and exceptionally smooth tuning.

Size: 15 1/2"D x 14"W x 8"H. Wgt 52 lbs.

AL-1200 LINEAR AMPLIFIER

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Full legal output with 100 watts drive.

AL-1500 LINEAR AMPLIFIER

8877 TUBE

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The cooling system in both amplifiers keeps the tube safely below the manufacturers ratings even when operating at 1500 watts output with a steady carrier. The filament supply has inrush current limiting to insure maximum tube life.

Size: 18 1/2"D x 17"W x 10"H. Wgt. 77 lbs.

AL-84 LINEAR AMPLIFIER

The Ameritron AL-84 is an economical amplifier using four 5M6 tubes to develop 400 watts output on CW and 600 watts PEP on SSB from 160 through 15 meters. Drive required is 70 watts typical. 100 watts max. The passive input network presents a low SWR input to the exciter. Power input is 900 watts. The AL-84 is an excellent back-up, portable or beginner's amplifier.

Size: 11 1/2" W x 6" H x 12 1/2" D. Wgt. 24 lbs.

ATR-15 TUNER

The Ameritron ATR-15 is a 1500 watt "T" network tuner that covers 18 through 30 MHz in 10 dedicated bands. Handles full legal power on all amateur bands above 18 MHz.

Five outputs are selected from a heavy duty dipole switch allowing the rapid choice of three coaxial lines, one single terminal feed or a balanced output. An internal balun provides 11 or 4:1 ratios (user selectable) on the balanced output terminals.

A peak reading wattmeter and SWR bridge is standard in the ATR-15. It accurately reads envelope powers up to 2KW.

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The program can first look at the vertical (from the side) field strength pattern, as a reference for 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, the element currents are scaled so that the driver current is 1 A. The values for this three-element Yagi are:

<table>
<thead>
<tr>
<th>Element</th>
<th>Current</th>
<th>Rel Phase</th>
<th>Separation in wavelengths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.662</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
<td>110.33</td>
<td>.15</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>244.5</td>
<td>.1</td>
</tr>
</tbody>
</table>

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:

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**


**bibliography**


**Article G**

**SHORT CIRCUIT HOTLINE**

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[See “Publisher’s Log,” April, 1984, page 6, for details.]

**603-878-1441**
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 non-linearity.” 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.

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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.

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.)
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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
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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.
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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A major U.S. Keyboard manufacturer recently released a new model of IBM® compatible keyboard. What they did not mention is that this keyboard is one of the best we have seen in years. The French is 85% compatible with your computer. We are not allowed to advertise the manufacturer's name, but we can tell you that the board does not work with a P.C. XT, 680 or AT 101 keyboard. We are prohibited from ad

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Pictured below is a high reliability power supply. It contains many very useful and expensive parts. We must offer these parts to you individually because, due to the agreement with the manufacturer we can not sell the unit intact.

POWER SUPPLY REGULATOR BOARD
Consists of LM 123 IC regulator or equivalent, TIP 32 transistor, 6 amp bridge, 10,000 uf, 50 volt capacitor. LM 340T12 regulator, a star 6V buzzer, 2 sockets to hold the smaller 2 bands which consist of LM 39N IC, reg. TIP 32 X -ister, 4-1OK 10-turn Pots, tantalum, and loads of other parts.

Shpg. Wt. 2.5 Lbs. SP-2748-51 $5.50

TRANSFORMER made by Signal or Aerospace Systems. Input: 110/220VAC, Output: 24v, 3a; 10v, 3a.

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Shpg. Wt. 0.2 Lbs. SP-275EG $0.35

CASE aluminum chassis rubber feet and carrying handle. 9½ x 5½ x 9½”.

Shpg. Wt. 2 Lbs. SPL-107-51 $7.50

HI VOLTAGE HUMMER
ZZZIP, ZZZIP! It's time to make a Jacobs Ladder or some other hi-voltage device. One of our bird dogs recently found us a few of these adjustable hi-voltage power supplies. The output is 4 kilovolts AC, 35VMA. Each one is fully enclosed and comes with 4.5 feet of hi-voltage wire. The wire terminates in a molded connector. A solid state variac adjusts the output voltage from 0 to 4k VAC @ 75 ma. The front panel has a toggle switch, a red pilot light and the adjustment knob. The power supplies are fully enclosed by a black or blue aluminum case. Made by ANSTO, we hunted to find a compatible device and found they sell it for as much as $850.00! CAUTION! This device uses lethal voltages and care must be taken when using it. We take no responsibility for your actions. New Condition.

Shpg. Wt. 12 Lbs PS-258-51 $50.00

MILITARY M-80/U MICROPHONES
We have another sample of our tax dollars at work. Uncle Sam has recently released these very high quality, weatherproof, push to talk, dynamic microphones. Each one has a cord that can stretch out to feet. For extended life of the cord a spring strain relief is standard. A U229U connector contains 5 gold plated pins to insure a high integrity electrical connection. We provide you with a schematic of the microphone so that you can rewind them for marine radio use. The were originally made for use with the PRC-25 and the PRC-77 transceivers. Used, good condition.

Shpg. Wt. 2 Lbs.. SPL-10-51... $8.00 each.

VARIABLE RATE STROBE KIT
We provide you with all the parts necessary, including the PCB board and schematic so you can make a nice strobe. When finished it will run on 4.5 to 6 VDC. The power can be either from a battery or a wall adapter of about 2 ma.

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Shpg. Wt. 10 Lbs. SPL-322-51 $29.95 4 for $100.00
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 Hamtronsics 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 Hamtronsics, Inc., 65 Moul Road, Hilton, New York 14468-9535, (716)392-9430.


**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. Sig-
nal 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
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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 home-brew. 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.

![Noise bridge circuit.](figure1.png)
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 (\(F_{\text{exp}}\)). 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 (\(F_{\text{exp}}\)) by the actual resonant frequency (\(F_r\), and multiply-
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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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 down the line, 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 x N x V)/FMHz], where N is an integer (1, 2, 3,...), V is the velocity factor of the transmission line used, and FMHz 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.

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 other measures the reflected power. 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.
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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 1

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February 1989
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...
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 pre-dawn 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 sunup and last until sunrise on the path of good nighttime use — except pre-dawn 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 sunup and last until sunrise on the path of interest. Except for daytime short-skip 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

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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.

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 PC 35. 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...
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February 1989
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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COMPUTER CODE Course: Apple II +/c/+/G5. C-64/128. 37 modes, graphics, 1-100 WPM, menus, proportional spacing, variable frequency, more tools. If interested, send SASE, Manual #410 (Check). M/C, LARESCO, PO BOX 2081-H, Calumet City, IL 60409.

COURIER SERVICE. All domestic and foreign wires handled. Prices and schedule available. Contact M. M. Klein, 14520 S. Western Ave., P.O. Box 2036, H. L. Springfield, IL 62702.

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Where's the Beam?
There's a 20 meter antenna with red DX Punch held in this picture. You can't see it, and your neighbors can't either. But the DX beam of anyway. How about a low profile 60/90/20 or 40/30/20/15 m beam? Or a pair of DX grabbing monobanders for the particles? All easily fit the pocketbook—from $20 to $50. Unobtrusive DX Gain Antennas for 60 thru 10
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REVIEW

N6RJ's Computerized Second Op v1.01

Those of you who go back a few years will remember W91OP'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 W91OP 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.

deN1ACH

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 1301 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,
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twenty memory channels, programmable and memory scan, and a built-in 1750-Hz repeater access tone.

The IC-12GAT also includes: built-in battery saver, built-in DTMF keyboard, programmable call channel, all subaudible tones, multi-function LCD readout and DTMF pad. The new "G Series" handhelds are compatible with all ICOM IC-2AT/IC-02AT series battery packs, headsets and speaker mics.

An optional UT-40 beeper silently monitors a busy channel for your calls. When the pre-programmed subaudible tone and frequency is received, the unit beeps and the LCD flashes. The ICOM IC-12GAT is available for a suggested list price of $529.00. For further information, please contact ICOM America, 2360-1 16th Avenue, NE. Bellevue, Washington 98004.

Monitor your local weather conditions

Azimuth's new WeatherStar Model TWR-3 by Digitar gives you the ability to monitor important local weather conditions affecting your antenna system and shack. The TWR-3's stand-alone computer with LCD readout gives wind direction (2 or 10 degree increments) or speed (MPH or KMH), records high wind gusts, external temperature (F or C), and wind chill factor. It also records low and high temp, time, and daily and yearly rainfall with an optional self-dumping rain collector ($49.95). The unit's Scan Mode lets you see the data in any sequence. It operates on 3 AAA batteries. Optional AC adaptor, NiCd Battery Pack and desk stand are available.
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.

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

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.
New Bird Model 43P wattmeter and 4300-400 retrofit kit

The Bird Electronic Corporation Model 43 THRULINE® wattmeter is now available in a true peak power reading version. The 43P lets you measure true peak power of single sideband, AM modulated RF, and certain limited rectangular pulse signals to an 8 percent F.S. accuracy, without affecting CW measurement capabilities. It uses standard Bird plug-in elements. Depending on the element selected, the overall frequency range is 450 kHz to 2.3 GHz, and RF power is 100 mW to 10,000 watts.

The peak power measuring circuitry is powered by two 9-volt NEDA-type 1604 batteries, with an anticipated life of 48 hours in the peak mode.

Owners of the standard Model 43 can modify their units with a retrofit kit, Model 4300-400, to obtain the same peak power measuring capability as the 43P. The kit includes a pc board which mounts inside the Model 43 housing.

For more information contact your Bird distribution, or the Bird Electronic Corporation, 3303 Aurora Road, Solon, Ohio 44139-2794.

Circle #303 on Reader Service Card.
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.

The schematic diagram of the hookup used in the experiment described in the text.

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.

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 x 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

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 source.
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- SENSITIVITY SECOND TO NONE! GaAsFET front end on vhf models gives 12dB SINAD of 0.12uV (vhf), 0.15uV (220). UHF model 0.25uV std, 0.1uV with optional helical resonator preamp.
- SELECTIVITY THAT CAN'T BE BEAT! Both 8-pole xtal filter & ceramic filter for >100dB at only ±12kHz. Helical resonator front end to combat desense & intermod.
- CLEAN, STABLE TRANSMITTER, up to 18W output standard; 50W with accessory power amplifier.
- FCC TYPE ACCEPTED for commercial high band and uhf.
- Courtesy beep, remote control, sub-audible tones, duplexers.
- Full range of options available, such as autopatch, phone line or radio remote control, sub-audible tones, duplexer.

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- TA51 for 10M, 6M, 2M, 150-174, 220 MHz.
- TA451 for uhf.
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- Both crystal & ceramic filters plus helical resonator front end for exceptional selectivity: >100dB at ±12kHz (best available anywhere!)
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- R76 ECONOMY VHF FM RCVR for 10M, 6M, 2M, 220. Without hel res or afc. Kits only $129.
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LNS -(*)
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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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**HAM RADIO**

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**Receivers only**

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency (MHz)</th>
<th>N.F. Gain (dB)</th>
<th>1 dB Gain Comp. (dBm)</th>
<th>Device Type</th>
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**Inline (rf switched)**

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<th>Device Type</th>
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You can store messages or your call sign—in your own voice, not a synthesized replica—or give your friends a private code for leaving messages on your radio. All they need is a DTMF microphone! Then you can play back your messages either in-person, or remotely by using another radio with a DTMF microphone. And you've always got security because you can command your radio to respond only to in-person playback requests.

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And test drive Yaesu's FT-212RH and FT-712RH mobiles. The only radios with the power to keep you in touch. Always.

Yaesu USA 17210 Edwards Road, Cerritos, CA 90701 (213) 404-2700. Repair Service: (213) 404-4884. Parts: (213) 404-4847.

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Multiple scanning functions. Memory channel lock-out is also provided.

ALT—Automatic Lock Tuning—on 1200 MHz eliminates drift!

500 Hz CW filter built-in.

Packet radio terminal.

Interference reduction controls: 10 dB RF attenuator on 2m, noise blanker, IF shift, selectable AGC, all mode squelch.

Other useful controls: RF power output control, speech processor, dual muting, frequency lock switch, RIT.

Voice synthesizer option.

Computer control option.

Optional Accessories:

- PS-31 Power supply • SP-31 External speaker
- UT-10 1200 MHz module • VS-2 Voice synthesizer unit • TSU-5 Programmable CTCSS decoder
- IF-232C Computer interface • MC-60A/MC-80/MC-85 Desk mics • HS-5/HS-6 Headphones
- MC-43S Hand mic • PG-2S Extra DC cable