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PACKET RADIO

ham radio magazine

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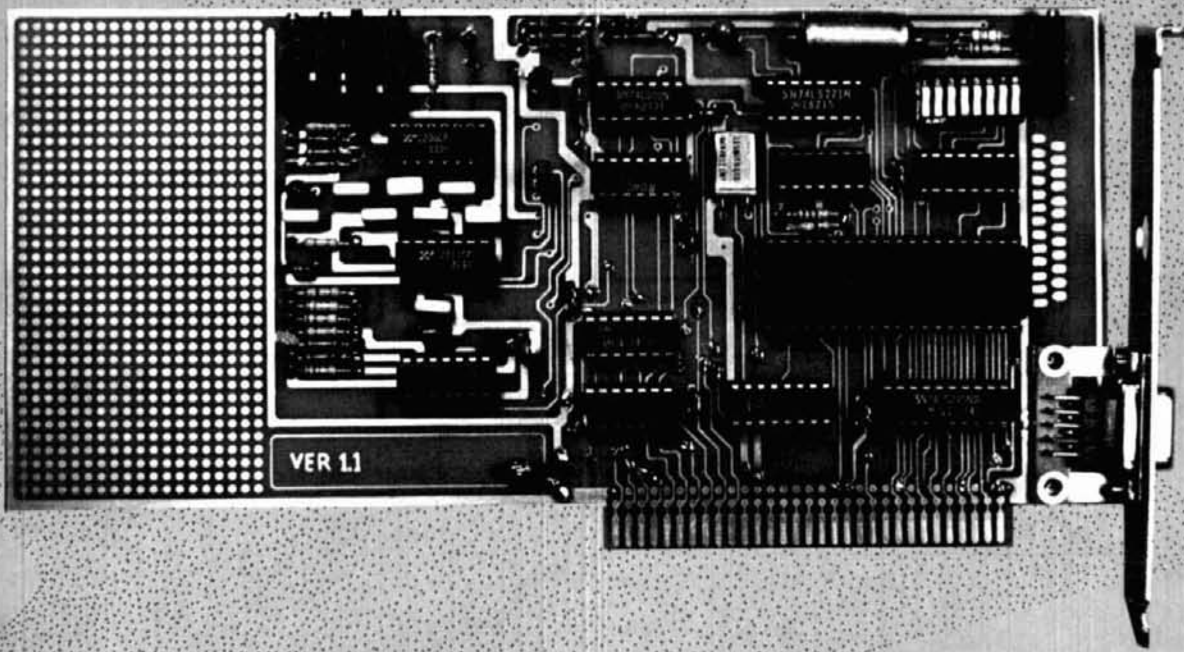

TNC for the IBM PC

hr

focus on communications technology

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ham radio magazine

contents

W6MGI's column, "The Guerri Report," will appear next month.

REFLECTIONS

making history

It wasn't Chernobyl — just a few small-town hams meeting over dinner to plan the first use of Packet Radio in an evacuation simulation in the towns surrounding a local nuclear power plant. While packet had been used in similar exercises elsewhere with some success, this was a "first" for our rural area.

Even though the task — handling incoming and outgoing health and welfare traffic — seemed straightforward enough, there were plenty of problems to work out. There was the familiar challenge of finding volunteers for a weekday drill during normal working hours. There were also problems peculiar to packet itself. Given the relative newness of the medium, convincing the planning agencies of the viability of packet hadn't been easy; the drill would be a test not only of the emergency response system as a whole, but of the local Packet Radio system under pressure.

Although there's plenty of packet activity in this part of New Hampshire, it isn't what you'd call a high-traffic area. Digipeaters are few and far between, and hilly to mountainous terrain can make propagation quirky at best. Then there's the complexity of the medium itself: even experienced operators have been known to stare at their CRTs for embarrassingly long moments of uncertainty. (The popular W0RLI software includes an incredulous "What?" response for those occasions when an operator's instructed the packet board to do something incomprehensible or just plain silly. But while the operator may not be willing to admit complete and utter discombobulation, the equipment, or at least the software, is refreshingly frank in this regard.)

The evacuation simulation — and its packet component — were successful. Time-critical traffic was received and passed immediately; less urgent traffic was received, stored on a packet bulletin board, and then forwarded to the National Traffic Service (NTS) or other packet stations well within deadlines.

Packet radio is *here*. It's hot, growing like crabgrass, and becoming both more accessible and affordable by the day. How hot? The first printing of Jim Grubbs, K9EI's book, *Get *** Connected to Packet Radio*, was sold out in only 60 days. Manufacturers say they're just barely keeping up with demand for new equipment. Experienced packeteers upgrading to new equipment have no trouble selling their old TAPR-1's at hamfests. There's no question that younger hams, particularly in urban areas, are turning to packet in impressive numbers. Senior hams maintain a smaller but conspicuous and growing presence.

There is help for newcomers: Jim's book, for example, and instructional videotapes available from Kantronics and TAPR go a long way toward demystifying Packet Radio. And like the legendary Scout who escorted the elderly woman across the street against her will, Packet operators bring missionary zeal to their avocation. It isn't difficult to get them talking about Packet Radio; it *is* difficult to make them stop.

Sometimes we'll hear someone who's read about Packet but not tried it say that it just doesn't make any sense. And sometimes somebody who's tried it will insist that it *still* doesn't make any sense. Packet is new and anything but simple; it has been suggested that if some operators, particularly in high-traffic urban areas, were more patient with newcomers — at least as patient as W0RLI's software, with its endearing "What?" response — Packet Radio might experience less attrition.

It's one thing to get Amateurs into Packet Radio and another to keep them there. Affordable equipment and accessible technology will get them there; patience will keep them.

Dorothy Rosa, KA1LBO
Assistant Editor

presstop de W9JUV

A "NEW" ELECTRONIC COMMUNICATIONS PRIVACY ACT WAS PASSED by the House and sent to the Senate June 12. The new act, HR-4952, is essentially a somewhat tempered rewrite of the bill approved by Rep. Kastenmeier's subcommittee May 14 (see July Presstop). This version, which received House Judiciary Committee approval June 10, is much less "hardline" than the previous HR-3378 which, for example, would have made the mere "interception" of a protected transmission illegal -- even if it were scrambled and thus unintelligible to the person who'd tuned it in! Under this new version, no crime occurs unless there is an "acquisition of the contents" -- a change suggested by the Association of North American Radio Clubs.

The Definition of "Readily Accessible To The General Public" has also been improved and clarified. To be off-limits under HR-4952, a transmission would either have to be scrambled or encrypted, use "secret" modulation techniques, be carried on a subcarrier or via satellite, transmitted by a common carrier (but not paging), or on broadcast link frequencies. Specifically not protected are government, law enforcement, public safety, aeronautical, marine, CD, cordless telephones, and of course, Amateur, CB, and CMRS.

Unfortunately, Even Though This Bill Is Much Less Objectionable than its predecessor, it still suffers from the same basic defects discussed at length in the February, 1986 ham radio editorial. It takes away an established right, that of tuning a radio wherever one wishes, and then restores it piecemeal. And it's still an unenforceable attempt to provide an illusion of privacy (by Congressional mandate) to a private industry, cellular radio.

The Bill Has Now Gone To The Senate Where It's Been Adopted, word-for-word, as S-2575. Though one Senate aide has said he expects the bill "to move pretty quickly" now that it's received House approval, it's sure to receive some critical Senate scrutiny. Nevertheless, full Senate approval could come as early as late July after the Senate returns from its July 4th recess. ANARC has asked the Senate Subcommittee on Patents, Copyrights, and Trademarks to hold at least one additional hearing before bringing the bill to a vote.

Even If This Version Of The Communications Privacy Act Becomes Law in its present form, ANARC, in particular, along with SCAN, several Amateur Radio publishers, and many others who wrote their legislators still deserve most of the credit for making the bill's provisions far less onerous and restrictive than they almost certainly would have otherwise been.

OSCAR 10 IS OFF THE AIR, QUITE POSSIBLY FOR GOOD. Its problem surfaced as a major memory malfunction in the satellite's Integrated Housekeeping Unit (IHU) on May 17, and since then attempts to communicate with OSCAR 10 and perform damage control procedures have had little success. The best hope now is that battery discharge during an early fall eclipse period may permit the IHU problem to correct itself so at least some control can be regained when the solar panels come back into sunlight and recharge the batteries.

Launch of JAMSAT's JAS-1 Satellite Is Still On Schedule for July 31 at 2030 UTC. Real-time launch coverage will be provided by WA3NAN on 3855 and 14280 kHz. JAS-1 has two Mode J transponders, one for CW/SSB and the other providing four channels for Manchester-coded FM digital communications. Uplink for CW/SSB is 145.9-146.0 MHz; downlink will be 435.8-435.9 MHz. Beacon frequency is 435.795 MHz; estimated period 120 minutes.

Two New Russian Satellites, RS-9 And RS-10, are now thought to have successfully passed pre-launch checkout procedures and will probably be launched sometime this summer.

FCC IS MOVING TOWARD IMPLEMENTING LAND MOBILE ON 421-430 MHz near Detroit, Cleveland, and Buffalo. Last fall Land Mobile became the primary 421-430 MHz service within a 50-mile radius of the center of each of these cities, so as secondary users Amateurs below "Line A" (the line marking the area along the Canadian border that protects its land mobile from possible U.S. Amateur interference) must avoid interference with operations in those cities.

ARRL Has Asked The FCC To Require Land Mobile Users in those cities to keep base and satellite receivers within 30 miles of each city's center and use tone-coded squelch, in order to minimize interference from Amateurs operating legally outside the protected area.

THE "ARCHIE AND HIS FRIENDS" AMATEUR RADIO COMIC BOOK is nearly finished, and should be ready for distribution when school opens in September. Developed by Archie Comics, it's aimed at 9- to 15-year-olds and features Archie and his pals sharing the fun of Amateur Radio. Half the funding for the 32-page promotion was provided by the Amateur Radio Industry Group that's been working on boosting Amateur Radio, with ARRL picking up the other half.

RESPONSIBILITY FOR MAINTAINING THE AMATEUR RADIO EXAMINATION QUESTION POOL is likely to pass to the Amateur Radio community as the result of imminent FCC action on that proposal. Though the proposal drew concerns that it could compromise VEC program integrity, or that it would result in a lack of uniformity between different VEC's exams, cutbacks in government spending and the consequent need to reduce FCC staff workload make delegation almost certain.

A "YOUNG HAM OF THE YEAR" AWARD HAS BEEN ESTABLISHED by the Westlink Report to be presented at the "Ham-West" Amateur Radio Convention in Las Vegas each November. Any U.S. licensed Amateur under is eligible, and selection will be based upon his or her contributions to community, nation, communications technology, and/or the promotion of the Amateur Radio service. Yaesu has joined Westlink Report in sponsoring the award, and will provide the winner with a Yaesu transceiver plus transportation to and a room at the convention. Nominations should go to Westlink Report, 28197 Robin Avenue, Saugus, California 91350.

comments

odd antennas

Dear HR:

In his letter to the editor (February, 1986, page 9) C.N. Francis, W0MBP, posed a number of interesting but soluble questions about what he calls "odd antennas." I will attempt to answer his questions in the order he presents them.

His first query deals with what is commonly called the Extended Double Zepp antenna. While the extension principle involved in the Extended Double Zepp is a cost-effective means of achieving gain in the high frequency bands, the antenna does have faults. First, the boresite lobe has poorly suppressed (i.e. less than 10 dB) adjacent lobes at about ± 53 degrees.[1] Second, as a non-resonant antenna it will always present a complex impedance at the driving point. At VHF and UHF, where wavelengths represent small physical distances, far more tractable antennas can be built using half wavelength segments. For instance, a two-element, half wavelength, parasitic beam can yield about 5 dB of forward gain, a front to back ratio, and a reasonably clean pattern. Alternatively lengthening the Extended Double Zepp to three half wavelengths and bending it forward slightly about its midpoint will produce a radiator with almost 3 dB of forward gain, a good pattern, and being resonant present a convenient driving point impedance.[2]

Next Mr. Francis describes three antennas which are composed of asymmetric dipoles which he confuses with the Windom Antenna. While this mistake is commonly made it should be noted that there is no relationship between them.The asymmetric dipole[3] has a number of faults, among which are: (1) The pattern is skewed. (2) Due to the lack of symmetry there is a strong tendency to develop antenna currents on the transmisison line. (3) The feedpoint position can't be predicted but must be found experimentally — this can be a difficult job. In addition to the above problems the three arrays described have progressive phase shift across their surfaces. Thus each element will have a different mutual impedance acting on it, and each element will then have unique impedance characteristics. Under these conditions locating the proper driving points is much like adjusting the length of a chair leg.

In his final group of antennas, Mr. Francis uses a hybrid arrangement of a Windom feed and a 225 degree loading section. Probably much of the problem at this point is confusion about Windom principles. Some recitation of history may help.

In the early days of radio, communication was carried on at low frequencies. At these low frequencies (long wavelengths) the propagation mode is surface wave, which mandates vertical polarization. At that state of the art, vertical radiators long enough to achieve first resonance simply did not exist. Thus most antennas were operated as electrically short radiators with all the commensurate problems of poor efficiency and poor current distribution. Somewhere along the line it was discovered that a horizontal conductor, connected symmetrically to the end of the vertical member, would raise the radiation resistance and improve the current distribution on the vertical radiator. This of course was the birth of the "T" antenna. Since the currents in the loading section were equal and opposite, its radiation was suppressed. Later when higher frequencies and ionospheric propagation modes came into use more interest developed in horizontal polarization. In 1929 Everitt and Byrne [4] described a modification to the "T" in which a resonant horizontal section is fed about 13-1/2 degrees off center with a random length of single wire feeder. Radiation is suppressed in the lead about 3 dB, and due to the lack of symmetry useful radiation was obtained from the flattop. This antenna was described in QST[5] by Loren Windom W8GZ, and inherited his name. Unfortunately Mr. Francis misses the point that the superstructure must be of resonant length and not 225 degrees. What are described in the letter are radiating single wire transmission lines, top loaded with pathological superstructures. For instance in the BBBC arrangement radiation from the top half of the loading section would be cancelled by the out of phase radiation from the lower half.

In short, all of these antennas could be made to radiate in some fashion, however, they all lack practicality, which could be solved by using simpler and more conventional structures.

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1. John Kraus, *Antennas,* McGraw Hill Book Company, New York, 1950, page 317.
2. Y.T. Lo, "TV Receiving Antennas," in Jasik's *Antenna Engineering Handbook,* McGraw Hill Book company, New York, 1961.
3. R. W. P. King, *Theory of Linear Antennas,* Harvard University Press, Cambridge, Massachusetts, 1956.
4. W. Everitt and J. Byrne, *Proceedings of the I.R.E.*, October, 1929.
5. L. Windom, "Notes on Ethereal Adornments," *QST,* September, 1929.

Robert B. Sandell, W9RXC
Urbana, Illinois 61801

short circuit

VHF/UHF world

References 8 and 9 were omitted from W1JR's July column. They should read as follows:

8. Joe Reisert, W1JR, "VHF/UHF World; Stacking Antennas - Part 1", *ham radio,*April, 1985, page 129.
9. Joe Reisert, W1JR, and Gary Field, WA1GRC, *RF-CAD Version 3.6 × : Computer-Aided Design Package for Radio Frequency and Microwave Circuits and Antennas,* available from Ham Radio's Bookstore, $39.95 plus $3.50 postage and handling.

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603-878-1441

a packet radio TNC
for the IBM PC

Single plug-in board extends usefulness of popular pc to digital communications

The advent of the IBM Personal Computer, with its open and well-documented architecture, has made it possible for hobbyists to extend the use of the microcomputer into many varied and challenging areas. This article describes a complete packet radio terminal node controller which can be implemented on a single circuit board that plugs into one of the slots in the PC. All that's required to get on the air is to connect up an Amateur Radio transceiver (**see fig. 1**).

the TNC: basic packet building block

Traditionally, packet radio has been achieved through the use of a device called a *terminal node controller*, or TNC. A TNC consists of a processor (such as the 8085 or Z80), a serial or parallel port to connect the TNC to a terminal or microcomputer running a terminal emulation program, and a synchronous port for the communications channel. A certain amount of RAM (random access memory) is available, and the necessary programming is provided on ROM (read only memory).

Because a TNC contains many components that are already present in our microcomputers, merging the function of the TNC into the microcomputer is an effective way to reduce the cost of a packet radio system. With suitable programming, the function of the TNC can be implemented in the microcomputer at a fraction of the cost of a separate TNC. There's a bonus, too, in that a higher level of function is available to the user because of the close coupling of the channel to the host processor.

In this implementation, an Intel 8273 programmable SDLC/HDLC protocol controller chip is interfaced to the bus in the IBM PC. This can be built on a prototype card or on a custom-printed circuit board. It's also possible to construct, on the same card, a simple but effective 1200-bps Bell 202-compatible half-duplex modem, a device in widespread use among packet radio enthusiasts. Software that runs the standard AX.25 packet radio protocol is available. The adapter is called the HAPN-1 adapter; HAPN stands for "Hamilton and Area Packet Network," the name of our packet radio club.

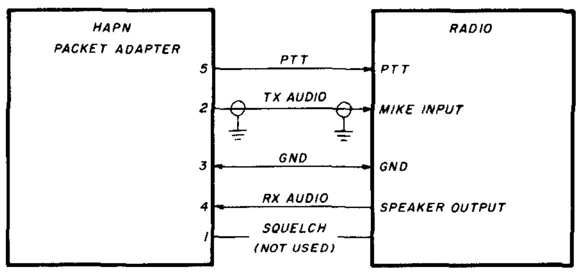

fig. 1. Simple radio hookup via microphone plug and speaker output. Note: Jumper J2 should be installed and J1 removed on adapter board.

hardware

The circuit shown in **fig. 2** uses an 8273 (U6) interfaced to the PC bus and a 1200-bps modem which can be connected to an Amateur Radio transceiver. The

By Jack Botner, VE3LNY, Ron Bradshaw, VE3IUV, Max Pizzolato, VE3DNM, and **John Vanden Berg, VE3DVV,** Hamilton and Area Packet Network, Box 4466, Station D, Hamilton, Ontario, Canada L8V4S7.

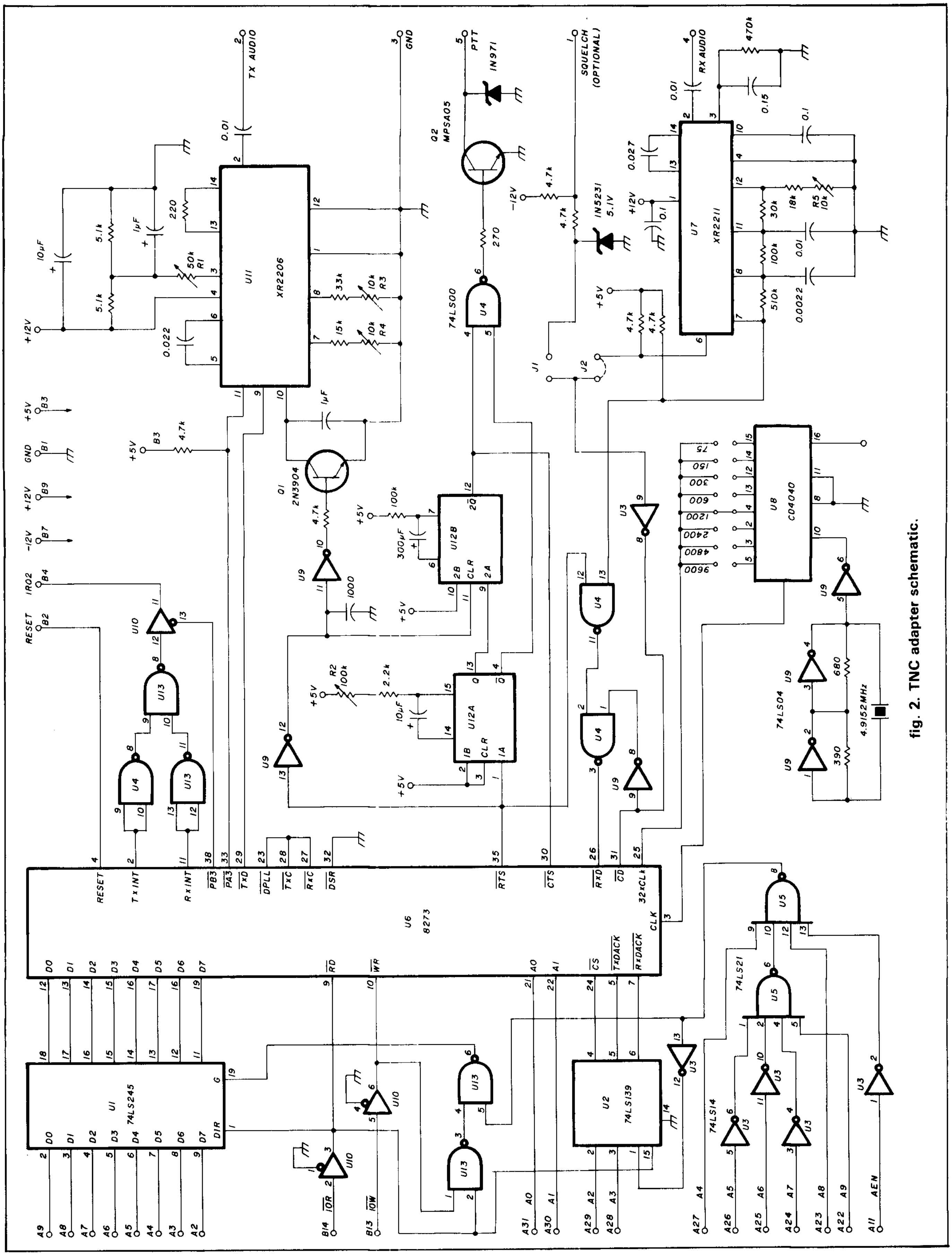

fig. 2. TNC adapter schematic.

8273 chip, called the *protocol controller*, is the most important part of the adapter.

The 8273 data lines are connected to the PC bus using a 74LS245 three-state buffer U1. The state and direction of the 74LS245 are controlled by the I/O Read and I/O Write lines and the I/O decode logic. The I/O decode circuit, made up of U2, part of U3, and U5, responds to addresses in the range of 310 through 31F (hexadecimal notation). The 8273's address requirements are met by a 74LS139 two- to four-line decoder (U2).

Data transfers to and from the 8273 may be done using polling, interrupts, or Direct Memory Access (DMA). This design uses interrupts, because they're easy to implement and permit a form of background operation that doesn't require running the packet application program constantly. The 8273 provides separate interrupt signals for transmit and receive (Tx Int and Rx Int, pins 2 and 11, respectively). The two interrupt lines are ORed together (part of U13) so that the adapter uses only one of the PC's hardware interrupt lines. The software can easily distinguish between transmit and receive interrupts by reading the 8273 status register. The combined interrupt line is buffered to the PC bus with a 74LS125 three-state bus buffer (part of U10) and is wired to the PC's IRQ2 interrupt line. IRQ2 was chosen because it is the least frequently used interrupt line in the PC. The circuit allows the interrupt line to float on the bus until the 8273 is initialized and the PB3 control port on the 8273 is activated. This means that the card can share IRQ2 with other hardware as long as the other device also floats its IRQ2 line when not in use and the two devices are not used at the same time.

clock signal

The 8273 features a digital phase-locked loop which makes it possible to derive the synchronous clock signal from the receiver data stream, a feature that greatly simplifies the design of the hardware. Pins 27 and 28 of the 8273 (Tx Clock and Rx Clock) are tied together to pin 23 (DPLL output). The 32X clock signal is provided by a 4040 binary counter (U8), giving a selection of data rates from 75 to 9600 bps by jumper or dip switch. A 4.9152-MHz crystal oscillator (U9) provides the clock signal for the 8273 and U8, the baud rate divider.

modem

The modem uses a pair of Exar chips, the 2206 function generator (U11) and the 2211 FSK demodulator (U7). The 2206 generates the two tones, 1200 and 2200 Hz, used for transmit; the 2211 decodes the two tones from the receiver audio. Two control signals are required by the 8273: Carrier Detect (CD, also known as DCD or RLSD in various contexts), indicating that the radio channel is busy, and Request to Send (RTS), indicating that the 8273 wants to transmit.

channel busy indication

The CD signal (channel busy indication) can be derived two ways, either internally by using the data carrier detect (DCD, pin 5) from the 2211 or externally by using the squelch from the receiver. Using the squelch to indicate the radio channel busy condition is superior but usually requires modifications to the radio. It guarantees, however, that the system will not transmit when another signal — possibly voice or some other non-data signal — is present on the channel. The internal DCD from the 2211 signals only when actual data is being received. This is the recommended way when no squelch line is available or the QRM level is high, such as 20-meter operation.

To use the internal DCD, install jumper J2. The 2211 checks the incoming signals for data and signals DCD to the 8273. To use the squelch CD, install jumper J1. The two resistors and zener diode convert the squelch signal from the radio to a TTL level. The signal is debounced by using a 74LS14 Schmidt trigger inverter gate (part of U3). An example of the squelch pickup from the radio is given in **fig. 3.**

transmit mode

To transmit, the 8273 brings up RTS, which triggers U12a (CTS-delay single shot) and brings up PTT via U4 pin 5 (negative or gate) and the 2MPS-A05 switching transistor (Q2). The U12a single shot allows the radio to stabilize when going into transmit before sending data; this function is called the *clear-to-send delay*. When U12a times out, the watchdog timer U12b starts, bringing up the CTS line for the 8273. This signals the 8273 to send the data. At the same time, it continues to activate the PTT line via U4 pin 4. When the 8273 is finished transmitting it drops RTS, which applies a reset to the watchdog single shot, causing it to drop the PTT line. If for any reason the RTS line stays up too long (as in a crash of the system, for example) the watchdog times out after about 22 seconds and shuts down the transmitter, releasing the radio channel to other users. Transistor Q1 enables the tones on the 2206 only when RTS is up (i.e., when 8273 is transmitting), so that there's no interference audio from the modem when the microphone is used for normal voice conversation.

Figure 1 shows how the adapter can be hooked up to a handheld radio. The TX-audio line is connected to the microphone audio input by means of a shielded cable. The receiver audio and PTT are taken from the speaker plug. Remove jumper J1 and install it at J2 to use the DCD line from the demodulator. For best performance, adjust R1 (a 50 k trimpot) for about 3-kHz deviation.

Integrated circuit voltage and ground pinouts.

IC	Type	Gnd	+5	+12
U1	74LS245	10	20	—
U2	74LS139	8	16	—
U3	74LS14	7	14	—
U4	74LS00	7	14	—
U5	74LS21	7	14	—
U6	8273	20	40	—
U7	XR2211	4	—	1
U8	CD4040	8	16	—
U9	74LS04	7	14	—
U10	74LS125	7	14	—
U11	XR2206	12	—	4
U12	74LS221	8	16	—
U13	74LS00	7	14	—

TNC to 2-meter radio interconnections

Figure 3 shows a hookup to an IC22s 2-meter radio. Here the TX-audio is inserted after the audio pre-amp, Q29, in the IC22s. If a DTMF (touchtone) input is available, it could be used instead. A 390-ohm resistor takes off the RX-audio before the volume control. The PTT goes to the front panel microphone connector. Transistor Q100 inverts and buffers the radio squelch. All the connections are brought out via the utility connector on the back of the radio. An audio output of about 1000 mV will give you about 3-kHz deviation on transmit. Remove jumper J2 install it at J1 on the packet adapter board. Set the CTS delay (R2) for about 300 msec; if it's set too short, the beginning of the transmitted frame will be missing and therefore impossible to copy. If it's too long, time will be wasted transmitting idle flag characters.

combining TNC with the host computer simplifies system design

In the traditional TNC, the programming is supplied on a ROM IC chip, and is relatively invisible to most users. In the HAPN implementation, the software is supplied as programs on a diskette, which are run like any other program on the PC.

One of the limitations of the traditional TNC is the loose coupling, or distance, between the TNC and the microcomputer acting as the terminal. By necessity the TNC strips the packet data down to the most elemental level, that of a serial stream of characters. This makes it difficult for the host computer to learn anything about what's going on in the TNC at the packet level. On top of this is placed a layer of commands, escape characters, and flow control, making even the best of packet host programs appear clumsy and unfriendly.

But including the packet hardware in the PC itself overcomes all of these problems. The programmer is free to design the software — particularly the end-user interface — in any way desired, without the need to compromise for the TNC interface. The result is a high-function packet system with a friendly user interface.

HAPN packet software implementation

In order to make effective use of the 8273, the following must be included:

- a BIOS (Basic Input/Output System)-like hardware driver that can be loaded as an extension to the system to drive the 8273;
- a protocol manager with an application program interface; and
- an application program that is run at the discretion of the user.

In addition, the 8273 must be made to operate in the background so that the node represented by the 8273 can be active all the time.

These requirements can be met by developing the software in at least two programs. The first program, M25, contains the hardware driver, protocol manager, and application program interface. The second program, C25, makes up an end-user application program. Since the 8273 operates on interrupts, no application program assist is necessary to receive or transmit data. Total independence from the application program has been achieved by using the PC's timer tick hardware interrupt exit as the protocol manager's dispatcher for scheduling events.

M25, the hardware driver module, contains a number of distinct functions and is made up of several routines. These routines have been link-edited to make up one program, which is run once after the system has been booted to become a resident operating system extension.

The application program, C25, contains a set of end-user functions primarily concerned with the sending and receiving of data. It can be used to activate the hardware functions in M25 via the application program interface. C25 would be run any time the user wishes to access the packet node; otherwise the PC can be used to run other application programs.

The main function of M25 is to service interrupts from the 8273, so that data can be transferred into and out of the channel. The interrupt handling routine is divided into two parts, one that handles transmit and one that handles receive interrupts. During its operation the 8273 generates interrupts for each byte transmitted or received, as well as for various transmit and receive frame complete events. Also a variety of error conditions may be reported to the processor — for example, when a frame has been received with an invalid CRC (cyclic redundancy check) field, generally caused by noise.[1]

The receive interrupt handler stores each byte of a frame in a buffer. When the frame is complete the 8273 generates another interrupt. At that point the frame may be inspected to make sure it's free of errors and is valid by the rules of protocol in use. Frames that

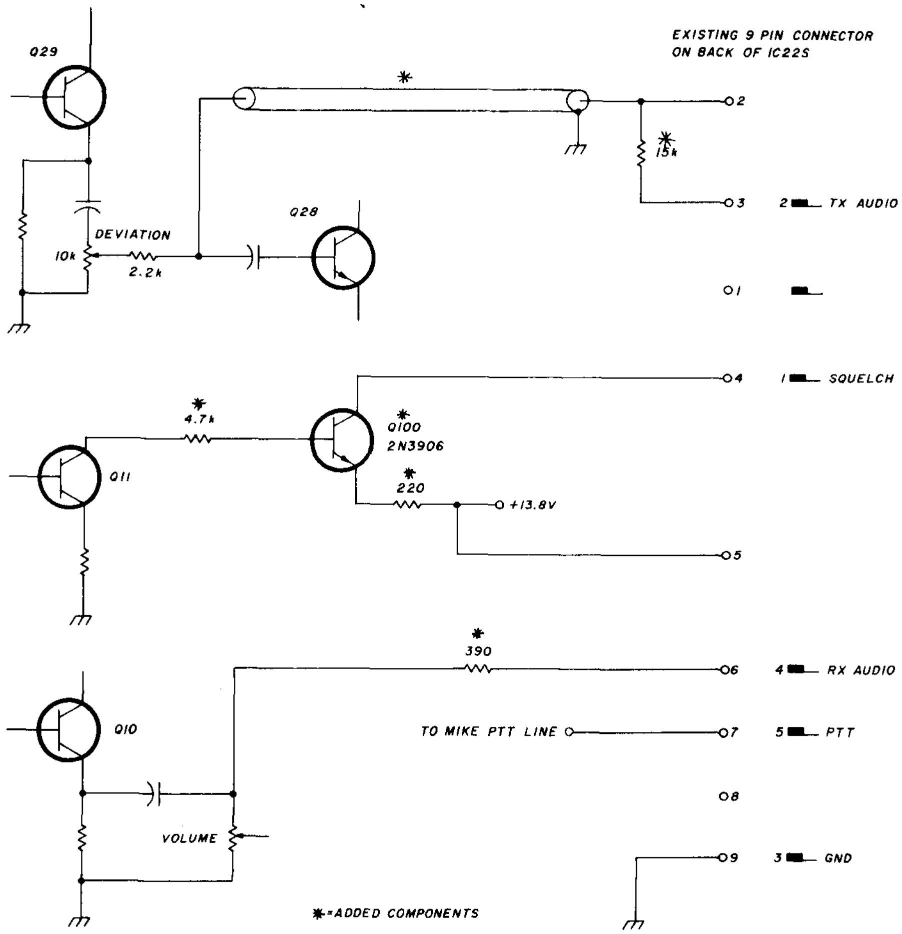

fig. 3. Example of squelch pickup.

contain errors are simply discarded. If a valid frame is received, some link-level protocol management is performed on the frame before exiting the interrupt routine. An example of this processing would be to look for connect requests and queue a response when one is received. It's also possible to delete request frames from the transmit queue after a valid response has been received.

The transmit interrupt routine passes each byte of the frame from a buffer to the 8273 as required. When the frame has been completely transmitted, the 8273 generates an early frame complete interrupt. At this time the software can decide if another frame should be transmitted in the same packet. In the AX.25 protocol, up to seven frames may be transmitted in one packet. If another frame is available, a command is issued to the 8273 to transmit another frame during the current transmission. The 8273 automatically inserts a byte of flags between frames sent in this way.

When the packet is complete the 8273 generates a transmit complete interrupt. The software uses this interrupt to do some protocol management on the transmit queue. For example, because request frames may have to be retransmitted at a later time, they're left on the transmit queue until they're acknowledged; response frames, on the other hand, are transmitted only once and may be deleted from the transmit queue at this time.

In this implementation an OR gate is used to drive both transmit and receive interrupts on the same IRQ line to the PC's 8259 interrupt controller. M25 distinguishes between them by reading the 8273's status register, which contains two bits that specify which type of interrupt was generated. It's interesting to note that because of noise on the channel, the 8273 occasionally becomes confused and generates interrupts that cannot be identified by the status register. When this kind of error occurs, M25 issues a software reset command and then re-initializes the 8273 to ensure correct operation. Statistics are kept on the various events that occur in the packet system, and may be displayed by the user.

TNC adapter parts list (fig. 2).

R1	50k trimpot	CR1	1N5231 (5.1 volts 5 percent zener)	C1	10 µF tantalum
R2	100k trimpot	Xtal	4.9152 MHz	C2	330 µF tantalum
R3	10k trimpot	Q1	2N3904	C3	.001 µF
R4	10k trimpot	Q2	MP5-A05	C4	10 µF tantalum
R5	10k trimpot	J1/J2	2 pin jumper connector	C5	.022 µF
R6	5.1k	J3	8-position DIP switch	C6	1 µF tantalum
R7	5.1k	DB-9	(male) printed circuit board connector	C7	.01 µF
R8	220			C8	1 µF tantalum
R9	15k			C9	.1 µF
R10	33k	U1	74LS245	C10	.15 µF
R12	2.2k	U2	74LS139	C11	.027 µF
R13	100k	U3	74LS14	C12	.0022 µF
R14	1k	U4	74LS00	C13	.01 µF
R11, 15, 16, 18, 19	4.7k	U5	74LS21	C14	.1 µF
R17	470k	U6	8273	C15	.01 µF
R20	510k	U7	XR 2211		
R21	100k	U8	CD 4040		
R22	30k	U9	74LS04		
R23	18k	U10	74LS125		
R24	390 ohms	U11	XR 2206		
R25	680 ohms	U12	74LS221		
		U13	74LS00		

All resistors 5 percent 1/4 watt
10-turn trimpots recommended for R3, R4, and R5

I.C. Sockets: Seven 14-pin
Four 16-pin
One 20-pin
One 40-pin

M25 contains a dispatcher routine that runs periodically. Its purpose is to manage timeouts and initiate events as they're required by the protocol. The timer tick interrupt, which is issued every 55 milliseconds on the PC, is a convenient way to give control to the dispatcher for this purpose. The dispatcher monitors the channel for activity and initiates frame retransmissions when timeouts occur. A random number generator produces the timeout value so that repeated collisions with another station can be avoided. The dispatcher also keeps track of the number of retransmissions and produces a loss of contact condition when a preset limit is reached. Because it's driven from the timer hardware interrupts, the dispatcher runs independently of any programs on the PC.

M25 also contains the application program interface. This interface allows a program running on the PC to access the 8273 channel. Interface functions include open, read, write, inquire, modify, and close. Note that the application program issuing the open does not have to close before terminating; this means that the packet node will continue to operate regardless of what program is run next on the PC. An alarm feature is also included so that the user is alerted if a connect request is received. The application program interface uses a software interrupt, level 84 (hex), for access by programs.

M25 includes an installation routine for loading itself into memory and becoming resident. Storage is reserved for transmit and receive buffer pools and a trace table. The application program interface vector is loaded so that the 8273 driver interface can be accessed. However, packet operation doesn't begin until it's initiated by an open request from an application program such as C25.

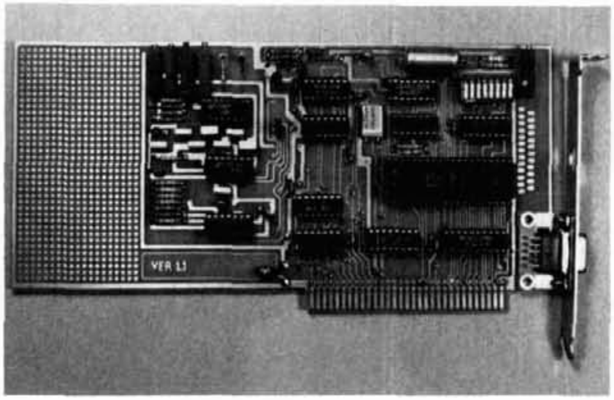

fig. 4. HAPN adapter board plugs into IBM PC slot.

C25, the end-user application program, is an ordinary DOS program designed as an interface between the user (keyboard, display) and the packet channel. It tests to see if the 8273 driver is installed and issues various requests to the 8273 driver application program interface.

data entry

The user of a packet node is mainly interested in sending and receiving data. This data may be entered through the keyboard or read from a disk file. Received data is displayed on the screen and may be saved to a disk file if desired. Other control functions include initiation of a connect request and specification of repeater linking information.

viewing the screen

The screen is divided into three areas: one for displaying received data, another for displaying typed

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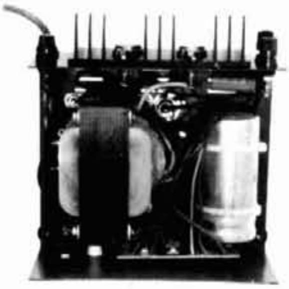

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RM-50A	37	50	5¼ × 19 × 12½	50
RM-35M	25	35	5¼ × 19 × 12½	38
RM-50M	37	50	5¼ × 19 × 12½	50

RS-A SERIES

MODEL RS-7A

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

RS-M SERIES

MODEL RS-35M

• Switchable volt and Amp meter

MODEL	Continuous Duty (Amps)	ICS* (Amps)	Size (IN) H x W x D	Shipping Wt (lbs)
RS-12M	9	12	4½ x 8 x 9	13
RS-20M	16	20	5 x 9 x 10½	18
RS-35M	25	35	5 x 11 x 11	27
RS-50M	37	50	6 x 13¾ x 11	46

VS-M SERIES

MODEL VS-20M

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

MODEL	Continuous Duty (Amps) @13.8VDC	@10VDC	@5VDC	ICS* (Amps) @13.8V	Size (IN) H x W x D	Shipping Wt (lbs)
VS-20M	16	9	4	20	5 x 9 x 10½	20
VS-35M	25	15	7	35	5 x 11 x 11	29
VS-50M	37	22	10	50	6 x 13¾ x 11	46

RS-S SERIES

MODEL RS-12S

• Built in speaker

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

input, and a third for indicating status. The receive data display area, the largest of the three, scrolls when it fills up. The typed-input area is two lines (160 characters) long. No data is transmitted until the return key is pressed, and a comprehensive set of editing functions is provided so that the user gets an opportunity to change the typed data before it's transmitted. The status area shows information such as lock key status, active function keys, and node callsign and linking repeater information.

other user-friendly features

C25 includes several convenient features. One, the scroll lock key, temporarily stops the screen from scrolling. Another automatically generates, upon request, a test message containing your callsign, the date, and time.

C25 also contains a self-customizing routine so that the program options can be set by each user. Program options are stored inside the program module rather than in a separate file, making C25 more convenient to run. A pop-down menu is provided for entering and displaying repeater information.

There are two exit options from C25: one issues a close to terminate packet operation and one does not. In the latter case the packet node is left operational while other programs are run on the PC. When C25 is run again later it will pick up the status of the packet node using an inquiry call to the application program interface.

Two utility programs are provided in addition to the basic functions described above. S25 formats either the packet trace table or the packet statistics counters. The trace table is useful for analyzing events such as protocol violations, in which two nodes appear to misbehave for no apparent reason. T25 is a test program with a number of functions for testing and setting up the 8273 adapter. It can be used to test the 8273 and bus interface hardware and to perform adjustments on the modem.

building the adapter

The adapter shown in **fig. 2** can be constructed on a readily available prototype board for the IBM PC. Consult the technical reference for details of the board's edge connector.[4] Although any suitable connector may be used, a DB-9 male connector was used for the transceiver interconnection. The only critical components are the frequency control trimpots in the modem, R3, R4, and R5. It's a good idea to use multiturn trimpots for these components. You should also use stable mylar or polyester capacitors in the circuits around the 2206 and 2211.

When connecting the adapter to a transceiver, be careful to use good quality shielded wire for the transmit audio lead. It's also a good idea to bypass each end of the cable with a 0.001 μF capacitor and place a ferrite bead over the center conductor at each end. This will prevent RF pickup, which can cause erratic operation of the system and transmission of garbled signals, into the transmit audio circuit of the transceiver.

It's good practice to bypass the +5-volt supply lead to each IC with a 0.1 μF tantalum capacitor. Otherwise, layout and wiring are not critical, if good construction practice is used. For those who prefer not to wire their own boards, both bare boards and assembled and tested boards are available from HAPN.

adjusting the adapter

After the board has been assembled and checked for shorts, it's ready for testing. The first test is an internal loopback test of the 8273 using T25.EXE, the test program supplied with the software. This tests the data buffers (U1), the 8273, address decoding, and the clock circuit.

Now adjust the modem. Start by setting up the two transmit frequencies, F1 and F2. Float U11 pin 10 to enable the tones. Then float U11 pin 9 and adjust R3 for 1200 Hz (use a frequency counter or an accurate scope). Next ground U11 pin 9 and adjust R4 for 2200 Hz. If the output is too low for the frequency counter, adjust the level control, (R[1]).

Next adjust the CTS delay by putting a scope on U12 pin 13 and key up the transmitter (using C25.EXE). Adjust R1 for 100-500 milliseconds, depending on how fast your rig switches from receive to transmit; a value of 300-400 milliseconds works well for most rigs.

Demodulator adjustment is a bit more tricky. You have to jumper the connecter pin 2 (Tx audio) to pin 4 (Rx audio) and float U11 pin 10 to enable the tones. When C25 has initialized the 8273 it will transmit flags as 1's and 0's. Adjust R5 so the waveform at U7 pin 7 looks the same as on U11 pin 9.

The remaining adjustment is of the audio level (R1) going to the radio. The level varies widely with the type of hookup into the radio. Adjust this level so the deviation is approximately 3 kHz on the transmitter. This completes the adjustments.

a note on HAPN

The following items may be ordered from HAPN. All prices are in United States dollars and include postage and handling.

- Software only (four programs and documentation), $40.
- Software and bare board (includes set-up program and assembly instructions), $75.
- Software and assembled and tested board (see **fig. 4**), $199.

Please add $3 for overseas orders.

The HAPN adapter will run on any IBM PC, XT, AT, or compatible computer with at least 128K memory and a display capable of 80-column text. The card is 8.5 inches (21.6 cm) long.

Orders should be addressed to HAPN, Box 4466, Station D, Hamilton, Ontario, Canada, L8V4S7.

Dedicated to furthering the state of packet radio, HAPN is currently involved in the design of a station node controller. The station node controller is capable of unifying a packet radio network by providing message routing, gateways, and high-speed links to other station nodes.

HAPN is also involved in experimentation with 4800-baud modems and with V3, the newly developed VADCG protocol. HAPN has experimental V1 and V2 software that runs on the adapter described in this article; for more information, contact HAPN at the above address.

references

1. Intel "8273, 8273-4, 8273-8 Programmable HDLC/SDLC Protocol Contoller," *Peripheral Design Handbook*.
2. J. Botner, "A Packet Radio Adapter for the IBM PC," *QEX: The ARRL Experimenter's Interchange*, January, 1985.
3. T. Fox, "AX.25 Amateur Packet Radio Link Layer Protocol," Version 2.0, October 1984, American Radio Relay League.
4. IBM *Technical Reference*, Personal Computer Hardware Reference Library.

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annunciator bell
for the Kantronics KPC-2

No more missed connections on packet radio

Some computers or terminals can't respond to the bell command. So if you've used one of these machines in a packet radio setup, you may find yourself missing connections with other stations — unless, of course, you're willing to stay glued to the screen watching for attempts to connect.

When a successful connect is made, the Kantronics KPC-2 responds by sending three CNTRL-G ($07 hex) ASCII characters to the terminal or computer. The CNTRL-G character combination is commonly used as the bell command to produce an audible signal. But obviously this works only if your terminal or computer is equipped with the hardware needed to produce an alarm. My computer, a Xerox 820, has no internal bell circuitry. As a result, I was missing connections. By the time I noticed that someone had tried to talk to me, they were often long gone. After only a few weeks on the air I discovered that I wasn't alone in this experience; other packet operators with similar hardware were missing connects, too.

solving the problem

It took only three hours and less than $10 to find a simple solution to the problem. The circuit shown in **fig. 1** doesn't respond directly to the bell character; instead, a piezo buzzer fires for about half a second as the KPC-2 enters a connected condition. There are some advantages to this; my buzzer, for example, will not respond to hidden bell commands that may be embedded in text or files received by my station and the annoying end-of-margin alarm produced by some computers and terminals is also neatly avoided.

circuit

The KPC-2 has a connect status indicator on the front panel. This LED is lit only when a connected link status exists. Data line P-22 from the 63B03 processor drives a 74HC04 inverter to power this indicator. The added circuitry shown in **fig. 2** and external to the KPC-2, uses this output to activate the piezo buzzer to audibly announce the connect status. The alarm is limited to about a half second's duration by a CMOS timer circuit. The exact time may be varied by changing the values of either the 68k resistor or 5 μF capacitor. Note that two inverter stages are used to drive the buzzer. Although they may at first appear to be superfluous, they're needed to produce a well-defined off/on transition for the bell.

The transducer operates from 3 to 20 VDC. Despite being driven directly from a CMOS output, it may provide more volume than necessary. Adding a resistor, up to about 47k, in series with the transducer will reduce the volume. A manual off-on switch removes power from the bell for silent late-night operation.

construction

Table 1 lists the required materials. Assembly is done using point-to-point wiring techniques on the IC perfboard. Be sure to use a socket for the No. CD4001. Don't insert the IC until after all wiring is completed. Note that this board won't fit into the specified enclosure unless some of the phenolic material is carefully trimmed from one of the 2.83-inch edges. I used a nibbling tool for this task, and then dragged the board over the surface of a large file to smooth off

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

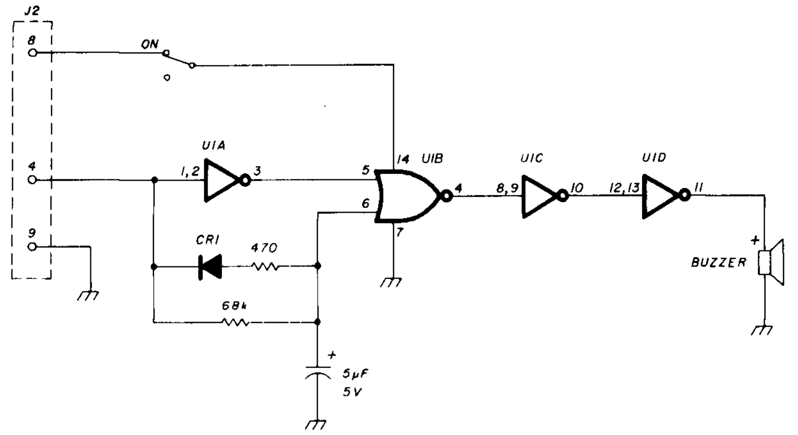

fig. 1. Circuit for the Kantronics KPC-2 bell annunciator. Parts values not specified in the schematic are shown in table 1. The duration of the bell timer may be varied by changing the values of the 5 μF capacitor or 68k resistor. Diode CR1 is a silicon device; a 1N4148, 1N914, or 1N4001 may be used.

Table 1. Bell annunciator parts list.

part	*description*	*Radio Shack part number*
U1	*quad 2-input NOR gate CD4001*	*276-2401*
buzzer	*piezo buzzer, 3-20 volts DC*	*273-065*
case	*4 x 2 x 0.844 inches*	*270-220*
perfboard	*2.83 x 1.85 inches*	*276-150*

the rough edge. After the board is assembled and inserted into the enclosure, be sure to drill a hole directly above the buzzer to make its output more audible.

bell-to-KPC-2 interface

This is the tricky part: chances are your KPC-2 is less than a year old. *Performing this modification will void your warranty.* Note also that this circuit will work only with the KPC-2 hardware. Versions of the KPC-1 — regardless of the software revision level — use an MC6803 processor which does not support the connect-status indicator.

I used J2, the nine-pin D-connector located on the rear apron of the KPC-2, to bring out 5 VDC and connect signals to operate the bell. Pins 4 and 8 were unused. A jumper wire was connected from pin 6 of U14 to pin 4 of the D-connector. Another short jumper ties the regulated 5-volt output from VR-1 to pin 8 of the connector.

Because of possible production changes, manufacturing assembly parameters change, be sure to verify — before work begins — that these pins are unused in your particular KPC-2! I found a jumper, not shown on the schematic, from the pin 4 circuit trace to ground that I had to remove.

A two-conductor shielded cable should be used to interconnect the bell device to the TNC. The plastic hood (supplied with the J2 connector and harness assembly from Kantronics) will have to be removed, reassembled and carefully drilled out to enlarge the cable passageway to allow the bell cable to enter.

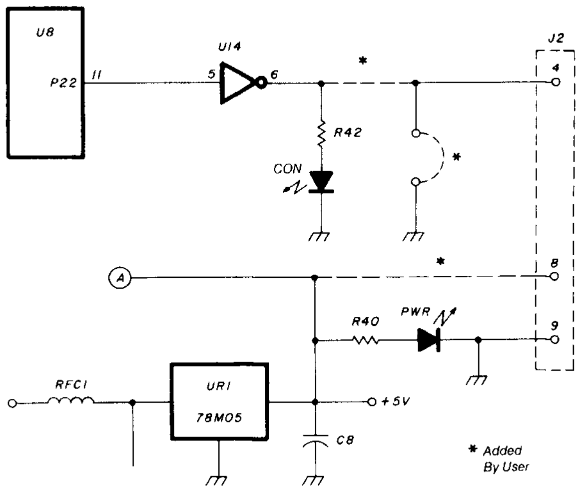

fig. 2. Partial schematic of the KPC-2 shows the wiring added to pins 4 and 8 of connector J2. The connect signal is fed to pin 4, Ground is already present on pin 9, and the 5-volt VCC bus is tied to pin 8. Note the presence of a jumper that originally grounded pin 4; this jumper must be removed from the PC board.

operation

Carefully check your wiring for errors before applying power to the TNC. If everything looks good, hook it all up and connect either to a local ham or to yourself via a local digipeater. A short, pleasant "beep" should reward you as the connect is made.

ham radio

low-noise phase-locked UHF VCO

part 2: construction and testing

This VCO's noise level is over 60 dB below the carrier — great for microwave applications

In part 1 of this article I described what I believe is an answer to the noise problem in voltage-controlled oscillators and showed that most Amateur UHF VCO applications can probably be satisfied by using a single-frequency, dedicated UHF phase-locked loop. This part presents construction information, describes testing, and provides performance characteristics.

construction and circuit characteristics

The UHF PLL is built on a standard 4-1/2 x 6-1/2-inch G-10 (glass epoxy) PC board, as shown in **fig. 1**. The edge connector shown in **table 1** provides for 15 volts DC, frequency select, and an unlock circuit. The latter drives an LED out-of-lock warning indicator. The RF output connector, an inexpensive SMA type,* is soldered to the PC board. Another SMA connector can be added if an external reference signal is to be used.

Oscillator and phase detector. The UHF oscillator and its buffer-amplifier stage are mounted on the trace side of the board with the component side acting as the ground plane. These circuits are enclosed in a simple shield box soldered to the PCB. The box is made of 0.5-inch wide X 0.015-inch thick brass strip, which is available at most hobby shops. The strip is formed into a 1.75 X 2.75-inch rectangle. Before soldering the box to the board, cut slots with a nibbling tool wherever PC lines enter or leave the box area. A partition is soldered inside the box to shield the oscillator from the buffer. An aluminum cover is fitted over the shield box.

The phase detector uses a pair of Schottky diodes. Several kinds of diodes that will work in the phase detector are listed in **table 2**. The traces on the board will accept any of these types, but the Alpha D5486 is recommended as the first choice because it is a dual diode in one package and therefore costs less than a pair of diodes.

The PC board includes five integrated circuits: an RCA CA3179 prescaler, a 74LS191 programmable divide-by-N, a CD4046 phase/frequency detector, and a pair of 74LS93 reference dividers. Also included are two voltage regulators, a 7808 and 7805.

The quartz crystal for the reference oscillator was obtained from ICM under the code number 471360. This is a shear mode, third-overtone AT-cut crystal. The code number includes information relating to ambient operating temperature, frequency range, type of holder, and operating load. The crystal oscillator coil is a Coilcraft vertically-mounted 12-turn helical "Unicoil" with a 6-32 threaded tuning slug, 1/4 inch long, for inductance adjustment. The inductance without the slug is approximately 0.28 μH. You can wind your own on a surplus coil form if it includes a tuning slug. For example, a 3/16 inch OD coil form 1/2 inch long with a 6-32 powdered iron slug (1/4) inch requires ten close-spaced turns of No. 26 enameled copper magnet wire.

Plated-through board. The PC board is quite special because it is solder-plated and plated through. The through-plating feature is a must for the UHF circuits. Not many Amateurs or experimenters have facilities for through-plating, but there is an alternate approach

* Type 142-0298-001, available from E.F. Johnson, Waseca, Minnesota 56093.

By Norman Foot, WA9HUV, 293 East Madison Avenue, Elmhurst, Illinois 60126

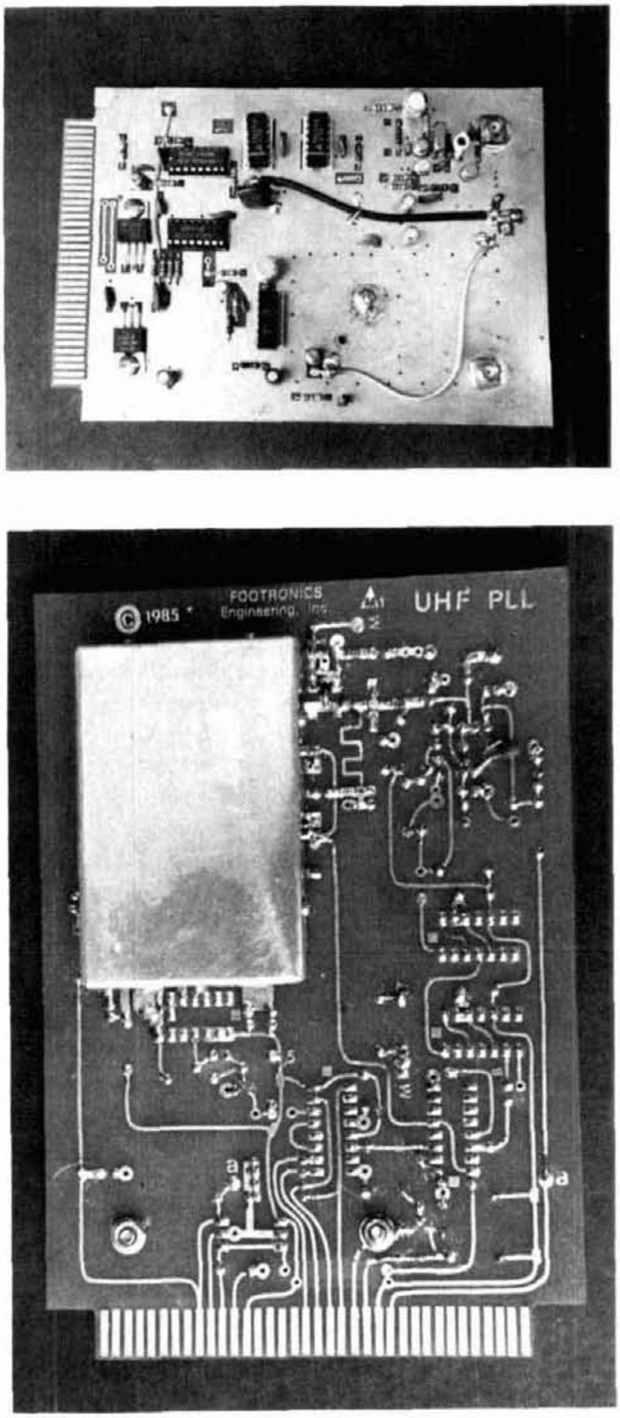

fig. 1(A). UHF PLL pc board component/groundplane side. (B). UHF PL pc board trace side. Enclosure in upper left hand corner contains VCO, buffer and loop amplifier circuits.

table 1. Edge connector terminals.

1 gnd	19 D
2 nc	20 A
3 nc	21 B
4 nc	22 gnd
5 nc	23 unlock
6 nc	24 +5
7 nc	25 +15
8 nc	26 nc
9 +15	27 nc
10 gnd	28 nc
11 +8	29 nc
12 gnd	30 nc
13 +5	31 nc
14 nc	32 nc
15 nc	33 nc
16 nc	34 nc
17 nc	35 nc
18 C	36 gnd

table 2. Diodes that can be used in the phase detector.

Alpha	D5486	1 required
Alpha	D5845	2 required
Alpha	D4787	matched pair
HP	5082-2818	matched pair
HP	5082-2816	matched pair
MaCom	Ma41513	2 required
MaCom	Ma4882	matched pair

that I have used with good success. I insert a 0.094-inch long x 0.043-inch diameter brass eyelet in each ground hole. Then I roll the eyelets over with a fine punch, hammer them flat, and solder them to ground on each side of the board. While this is admittedly a rather tedious procedure when there are over 100 ground holes, it works very well. . . if you have the patience. I use this approach for preliminary breadboards.

The cost of having a single plated-through PC board fabricated at a commercial plant is very high — as much as $230.00. However, in quantities of 100, the price drops to less than 20 percent of this figure. If you're interested in obtaining a board for your project, get in touch (just be sure to include an SASE). If there are enough inquiries, I may be able to provide a board at a very reasonable price.

Avoiding pitfalls. Before heating up your soldering iron in anticipation of assembling this PLL, there are some subtle characteristics that you'll want to know about.

While there's nothing unusual about the component side of the PC board, the trace side includes a number of chip resistors as well as some chip capacitors, particularly inside the oscillator and buffer compartments. To be more exact, the trace side of the board contains 11 chip resistors and 12 chip capacitors.

The chip resistors are used where threading a pair of pigtails through the board from the ground plane

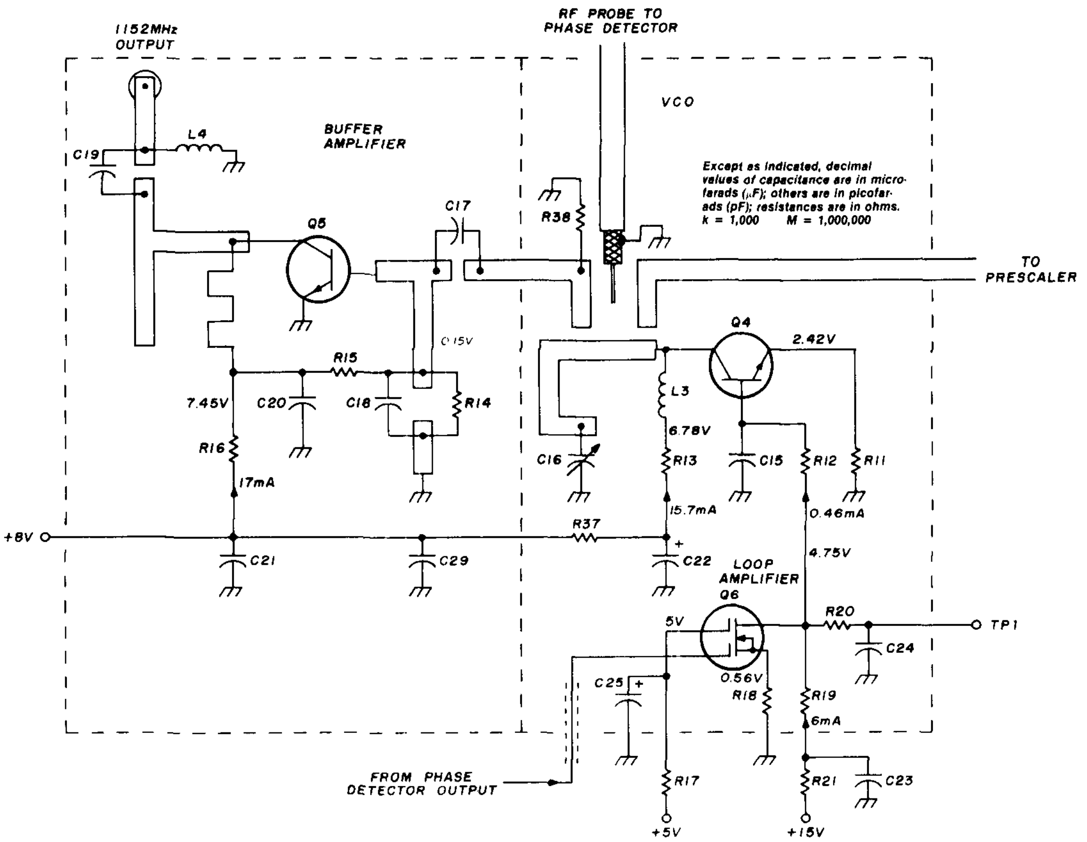

fig. 2. VCO, buffer and loop amplifier schematic.

side would seriously degrade performance. This is particularly true if the resistor is part of an RF circuit, such as an RF termination. Parasitic inductances are close to zero for these devices, which makes their use mandatory in UHF applications.

Chip resistors are now available at reasonable price — typically 6-1/2 cents each in lots of 100 — in standard values from 2.2 ohms to 2.0 megohms. Chip resistors are generally specified at 5 percent tolerance, but since they're laser-trimmed, they're usually more accurate than that. My chip resistors, purchased from Mouser Electronics in Santee, California, are 60 x 130 mils and 0.025 inches thick, or slightly larger than a typical chip capacitor, and easily installed.

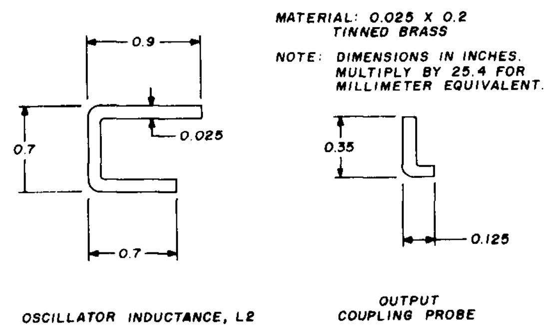

fig. 3. Details of oscillator inductor and output coupling probe.

the oscillator circuit

An article by G. D. Clock and associates[1] describes a means for tuning a VCO by varying the base-emitter current. Television Receive Only (TVRO) and other oscillators have used this principle for a number of years.

Base-emitter tuning. This technique involves adjusting the oscillator base-emitter current to produce frequency changes. Base-emitter and collector capacitances increase with base current. I have produced high-to-low frequency tuning ratios of over 12-1/2 percent by using this method at frequencies as high as 5 GHz. The 1152-MHz VCO described here uses base-emitter tuning, which avoids the need for some-

times difficult-to-find UHF varactor tuning diodes. The oscillator circuit is shown in **fig. 2.**

The base-emitter driving circuit for the oscillator is also shown in fig. 2. The dual-gate MOSFET is a relatively quiet, inexpensive device. It represents the loop amplifier shown in **fig. 4** (see part 1, page 37). TP1 is included to monitor the loop amplifier output voltage for tuneup.

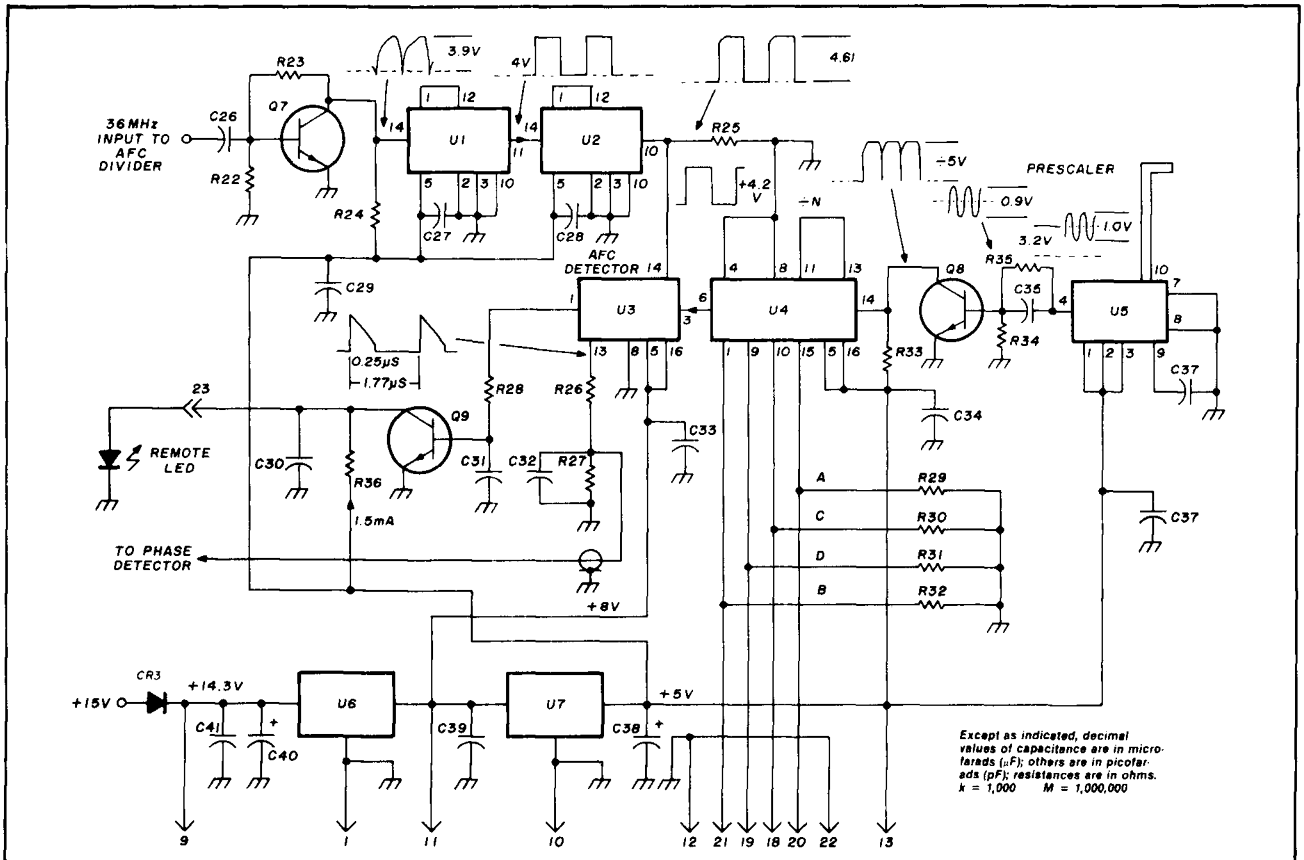

fig. 4. Automatic Frequency Control schematic.

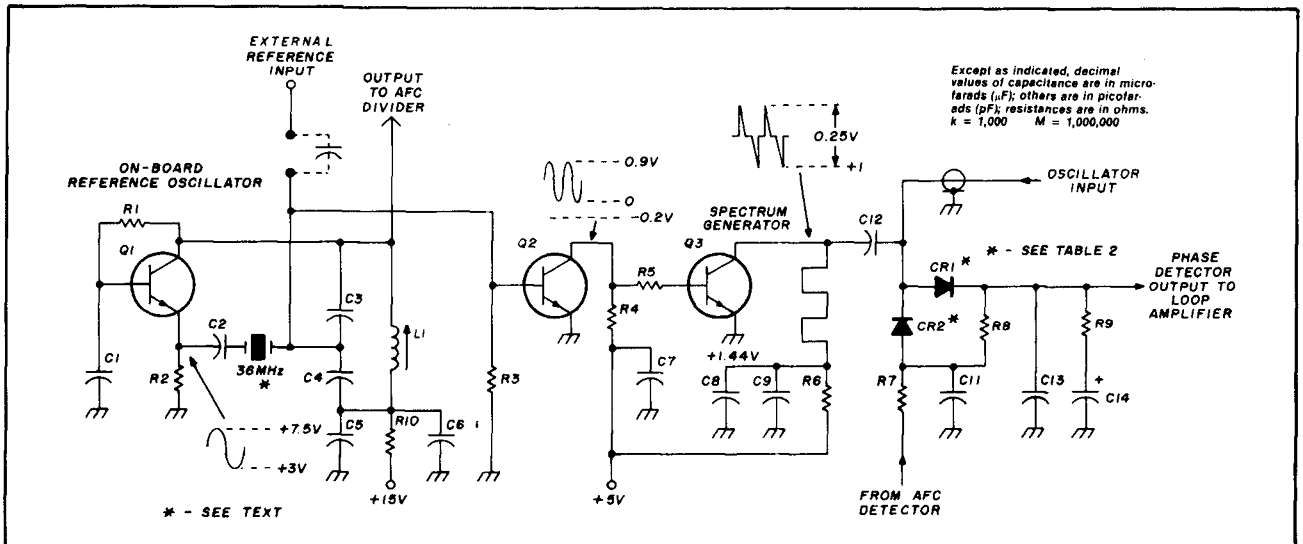

fig. 5. Reference oscillator, spectrum generator and phase detector schematic.

Parts list

C1	*51 pF disc*
C2	*4.7 pF disc*
C3	*51 pF disc*
C4	*100 pF disc*
C5	*0.001 disc*
C6	*22 μF/35-volt*
C7	*15 μF/35-volt Tantalum*
C8	*10 μF/16-volt*
C9	*1000 pF chip*
C10	*10 μF/16 volts*
C11	*1000 pF chip*
C12	*22 pF chip*
C13	*47 pF chip*
C14	*1.0 μF/35-volt Tantalum*
C15	*4.7 pF chip*
C16	*Erie No. 560-013, 0.5-5 pF chip*
C17	*47 pF chip*
C18	*470 pF chip*
C19	*47 pF chip*
C20	*470 pF chip*
C21	*1000 pF chip*
C22	*1.0 μF/35-volt Tantalum (inside oscillator compartment)*
C23	*2.2 μF Tantalum*
C24	*1000 pF chip*
C25	*1 μF/50 volts*
C26	*5 pF disc*
C27	*0.1 μF 10-volt disc*
C28	*0.1 μF 10-volt disc*
C29	*0.1μF 10-volt disc*
C30	*0.01 μF disc*
C31	*0.001 μF disc*
C32	*0.1 μF mylar*
C33	*0.1 μF 10-volt disc*
C34	*0.1 μF 10-volt disc*
C35	*0.001 μF disc*
C36	*47 pF chip*
C37	*1.0μF/35-volt Tantalum*
C38	*100μF/16 volts*
C39	*0.1 μF 12-volt disc*
C40	*22 μF/25 volts*
C41	*0.1 μF 50-volt disc*
CR1	*See table 2*
CR2	*See table 2*
CR3	*1N4002*
L1	*crystal oscillator coil*
L2	*oscillator inductance*
L3	*deleted*
L4	*5 turns No. 26 tinned busbar, 1/16-inch diameter, 1/4-inch long*
PCB	*printed circuit board shield box and cover*
Q1	*2N2369A*
Q2	*2N2369A*
Q3	*AT-41435-5*
Q4	*MRF-901*
Q5	*AT-41435-5*
Q6	*40673*
Q7	*2N2369A*
Q8	*2N2369A*
Q9	*2N2222*
R1	*33 kilohms*
R2	*820 ohms*
R3	*22 kilohms*
R4	*6.8 kilohms*
R5	*51 ohms chip*
R6	*680 ohms chip*
R7	*150 kilohms, 1/8 watt or chip*
R8	*47 kilohms, 1/8 watt*
R9	*2.2 kilohms chip*
R10	*100 ohms*
R11	*150 ohms chip*
R12	*4.7 kilohms chip*
R13	*22 ohms 1/8 watt*
R14	*910 ohms 1/8 watt*
R15	*6 kilohms, 1/8 watt (adjust value for IC20 mA if necessary)*
R16	*33 ohms*
R17	*2.2 kilohms*
R18	*100 ohms chip*
R19	*1.5 kilohms, 1/8 watt (inside amplifier compartment) chip*
R20	*4.7 kilohms chip*
R21	*100 ohms*
R22	*15 kilohms*
R23	*8.2 kilohms*
R24	*330 ohms*
R25	*1 kilohms*
R26	*10 kilohms*
R27	*10 kilohms*
R28	*4.7 kilohms*
R29	*1.2 kilohms*
R30	*1.2 kilohms*
R31	*1.2 kilohms*
R33	*330 ohms*
R34	*150 kilohms*
R35	*39 kilohms*
R36	*330 ohms*
R37	*51 ohms (in oscillator compartment) chip*
R38	*51 ohms (in oscillator compartment) chip*
U1	*74LS93*
U2	*74LS93*
U3	*CD4046*
U4	*74LS191*
U5	*CA3179*
U6	*7808*
U7	*7805*

Frequency adjustment. The VCO uses an MRF-901 transistor. Except for minor details, the circuit is similar to the one used in a previous article.[2] A buffer amplifier provides isolation between the oscillator and the outside world, thus making the job of the PLL easier. It also provides more output power. The buffer employs an Avantek AT-41435-5 bipolar transistor.** An Erie 560-013 piston trimmer, used to adjust frequency, is located at the far end of the line where a tuning varactor might otherwise be located. Although ceramic trimmers also work well, some of them tend to seize after extensive use; the Erie trimmer is more expensive, but can take more abuse. This is an adjustment that needs to be made only once. Thereafter, small changes in oscillator circuit parameters will be compensated for by the AFC circuit.

Coil and coupling probe. To allow the VCO to be used for other purposes, the oscillator "coil" is suspended above the PC board ground plane rather than being printed. This also provides higher *Q*, which is needed to maintain low phase noise. The inductance for 1152 MHz is formed out of 0.025-inch thick by 0.2-inch wide brass strip bent into a U-shape as shown in **fig. 3**. It's mounted by soldering one end to the piston trimmer and the other to the MRF901 collector lead. The collector lead is bent up at right angles to meet the coil.

Coupling to the buffer is accomplished by means of an L-shaped probe located near the transistor end of the oscillator inductance. A 50-ohm chip resistor terminates the buffer input circuit to avoid instability. The coupling probe is an L-shaped bracket made from the same kind of material as the inductance and soldered to the end of the buffer input PC trace. Space the probe about 1/8 inch away from the oscillator induc-

** Available from Peak Technology, Inc., Arlington Park, Illinois tance. An identical probe drives the prescaler, with very light coupling.

The oscillator's emitter is left unbypassed. This imposes some negative feedback, which in turn tends to suppress low-frequency flicker noise in a manner discussed in reference 9 (see part 1, page 38).

Frequency division. Referring to **fig. 4**, note that a

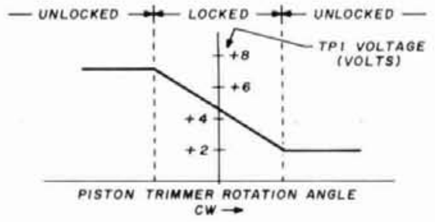

Fig. 6. AFC tuning curve.

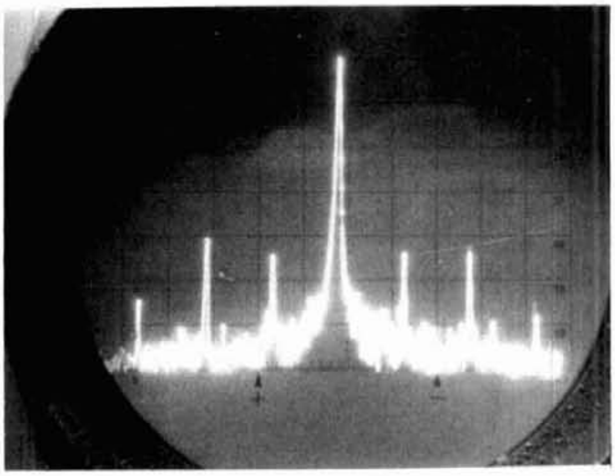

fig. 7. Oscillogram of VCO spectrum with the 4046 as phase detector. Horizontal = 30 kHz/cm; vertical = 10 dB/cm.

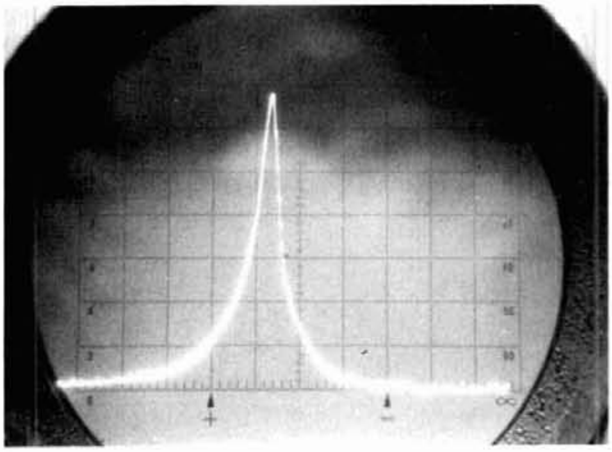

fig. 8. PLL spectrum. Vertical = 10dB/cm; horizontal = 30kHz/cm; BW = 1kHz.

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pair of 74LS93s connected in cascade divide the crystal frequency by 64, to 562.5 kHz. The prescaler, U3, together with the divide-by-N stage, U4, provides division by 2048, which is also 562.5 kHz when the VCO is phase-locked to 1152 MHz. These two signals represent the scaled-down reference and VCO that drive AFC detector U3.

The circuit of U4 is somewhat unusual because the RC output resets the counter to a preprogrammed value. This creates a modulo-N circuit that will divide by any integer from 1 to 16; the most useful numbers are 7, 8, and 9. For 1152 MHz, N = 8.

The AFC output from U3 is fed over a shielded wire to the DC return of the phase detector as shown in **fig. 5**. This wire is located on the component side of the board and its shield is soldered to the ground plane.

Phase detector inputs. Q3 is a UHF bipolar transistor used as the spectrum generator. Like the RF buffer, it's an Avantek type 41435-5. A "picket-fence" of harmonically-related signals, spaced 36 MHz apart across the band from 36 to 1400 MHz or more, drives the phase detector. One of these harmonics represents the desired phase-detector signal which, for an 1152-MHz VCO, is the crystal oscillator's 32nd harmonic.

The phase detector also requires a sample of RF from the oscillator. While initially the VCO frequency may be incorrect, the AFC circuit will steer it to 1152 MHz to effect phase lock. Coupling from the oscillator is achieved over a short (1-1/2 inch) piece of miniature coaxial cable such as RG-174 or equivalent. The braid is stripped back on each end and soldered to the ground plane at the points of entry. One center conductor end is soldered to the input of the phase detector; the other end acts like a probe, extending about 1/2 inch into the oscillator compartment. The insulation is left on the probe end.

noise and spurious sidebands

The original crystal oscillator multiplier built in 1969 included a cavity resonator at the step-recovery diode (SRD) output. The *Q* of this cavity is relatively low

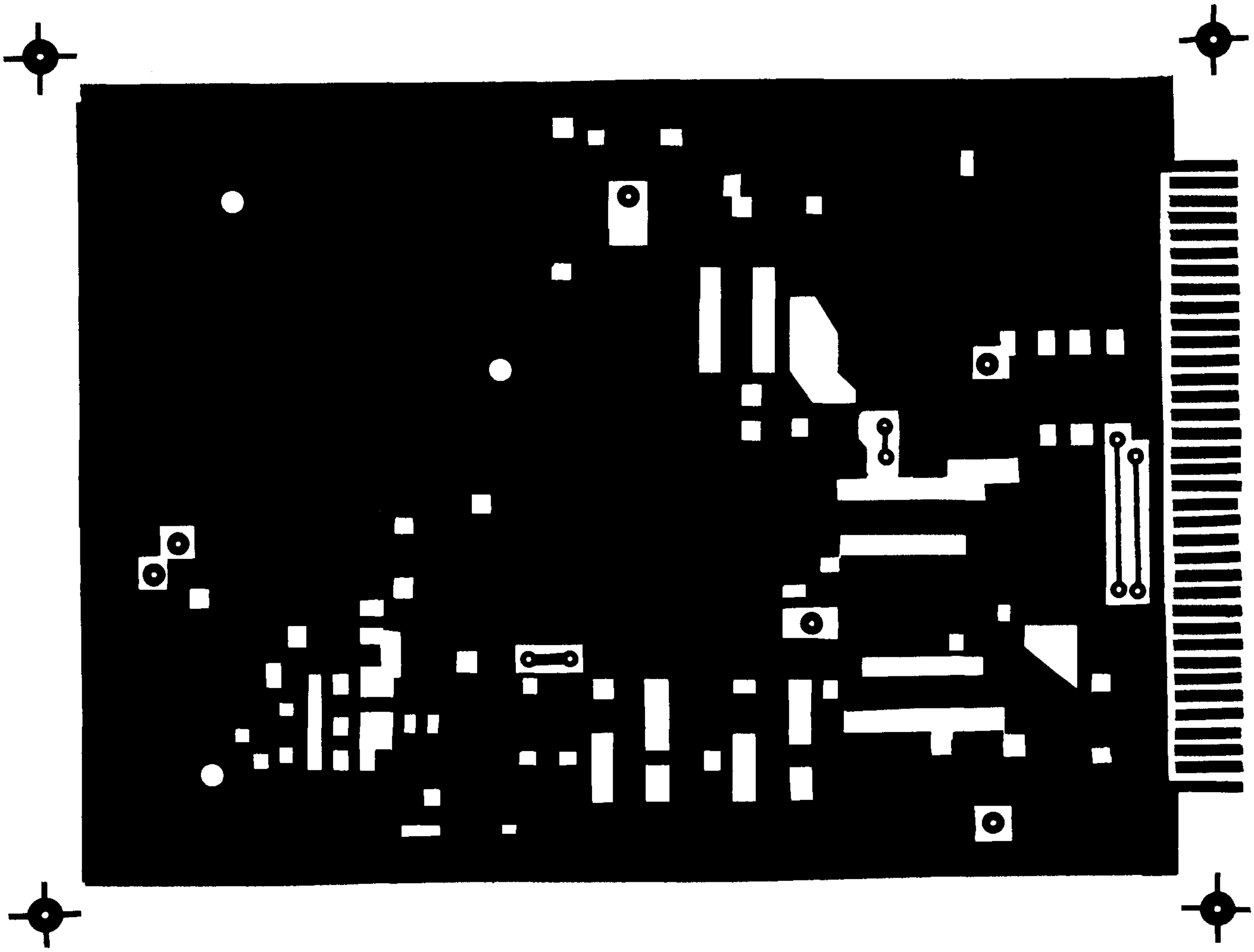

fig. 9(A). Completed UHF PLL double-sided printed circuit board artwork Groundplane side.

because it was tightly coupled in an effort to get maximum power out. Filtering of unwanted sidebands is therefore limited. The strongest set of sidebands appears 384 MHz away from the carrier on each side (384 MHz is the SRD driving frequency). These sidebands are 28 dB below the carrier; all others are over 30 dB below. This represents reasonable performance for narrowband purposes when the first IF is less than 384 MHz, but the spurious sidebands may produce "birdies" at the output of the second mixer in a wide-open (block down-conversion) system.

The UHF PLL described in this article has filtering qualities resulting from the loop filter instead of a cavity. The only significant coherent spurious signals are located 562.5 kHz from the carrier on each side and are over 60 dB below the carrier. No phase noise was detectable on the HP-8551 spectrum analyzer. The calculated level is −145 dBc/Hz at 1 kHz and beyond.

preliminary adjustments

Before applying power, check the component side of the board for insulated holes that don't have components in them. Ignore unfilled plated-through ground holes. All the other holes, with the exception of four pairs of component-side jumpers, should be filled. Then proceed as follows:

• Connect a 100-ohm, 2-watt resistor in series with the 15-volt power supply to limit the current in case of a short; otherwise the current should be about 90 mA.

• Remove the 100-ohm resistor and monitor the current to the board. Depending on the status of tune-up, the current should be between 190 and 230 mA.

• Using a CRO, monitor the waveform on pin 14 of UI. (It's best to use a 50-MHz oscilloscope for this measurement.) Tune the crystal oscillator coil for maximum peak-to-peak voltage. The positive peak should

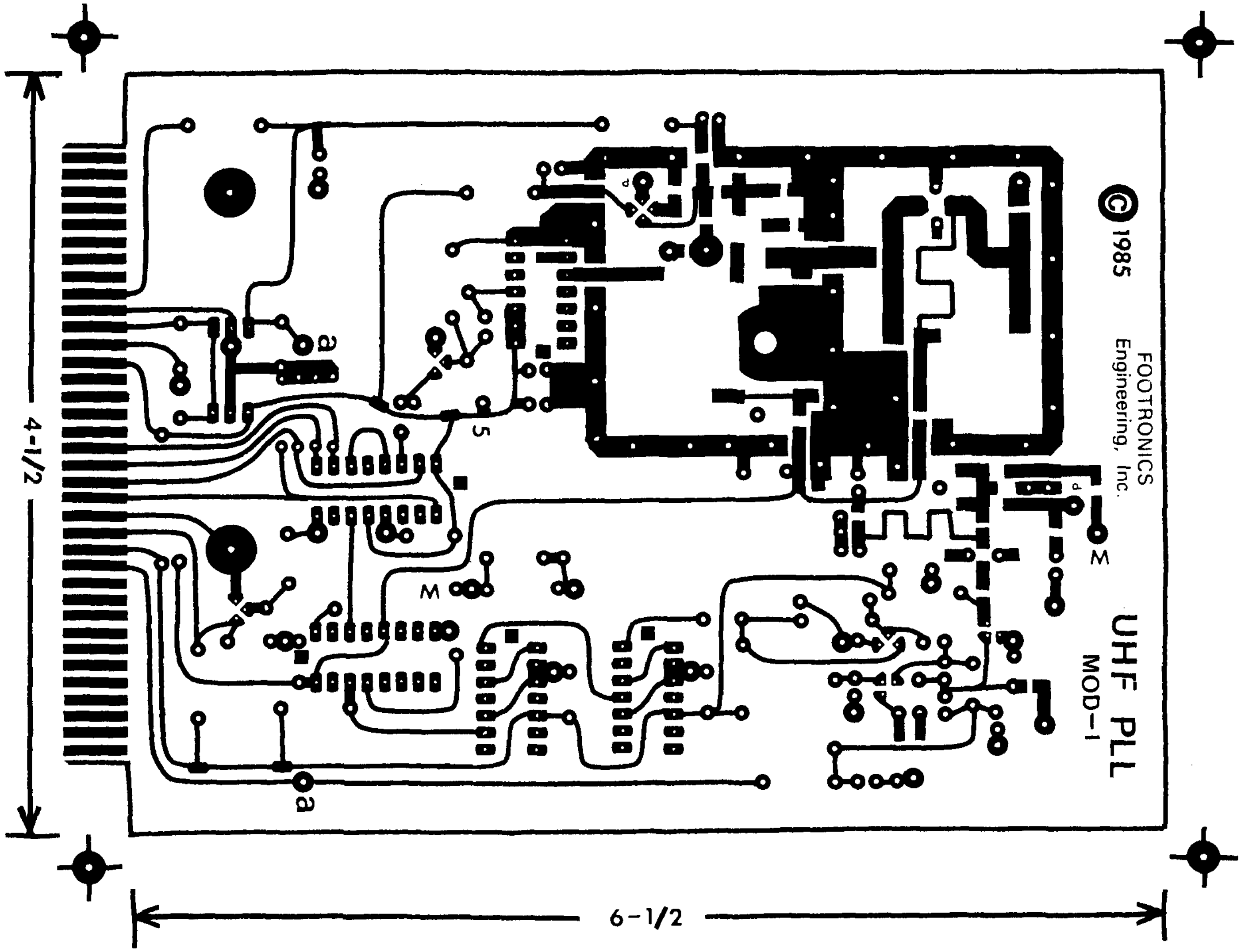

fig. 9(B). Completed UHF PLL double-sided printed board artwork Trace side.

AEA announces $1000 award for Amateur Radio outreach

A new award designed to recognize Amateurs who have effectively promoted Amateur Radio to those outside the hobby will be presented by AEA at the ARRL National Convention in San Diego on September 6, 1986.

The award will be based on dedication to Amateur Radio, influence on others outside Amateur Radio, and initiation of special projects or programs designed to promote Amateur Radio. A panel of judges selected by AEA will choose the winner and others selected for honorable mention.

The winner will receive $1000 in cash, round-trip air fare to San Diego, hotel accommodations, and meals.

Any licensed Amateur can nominate any other licensed Amateur for consideration. All nominations must be made on the AEA Amateur Ambassador Award nomination form, available from AEA, PO Box C-2160, Lynnwood, Washington 98036 (a SASE should be enclosed). Nominations will be accepted until August 15, 1986.

The goal of this award is to encourage all active Amateur Radio Operators to promote and share Amateur Radio with others.

ham radio

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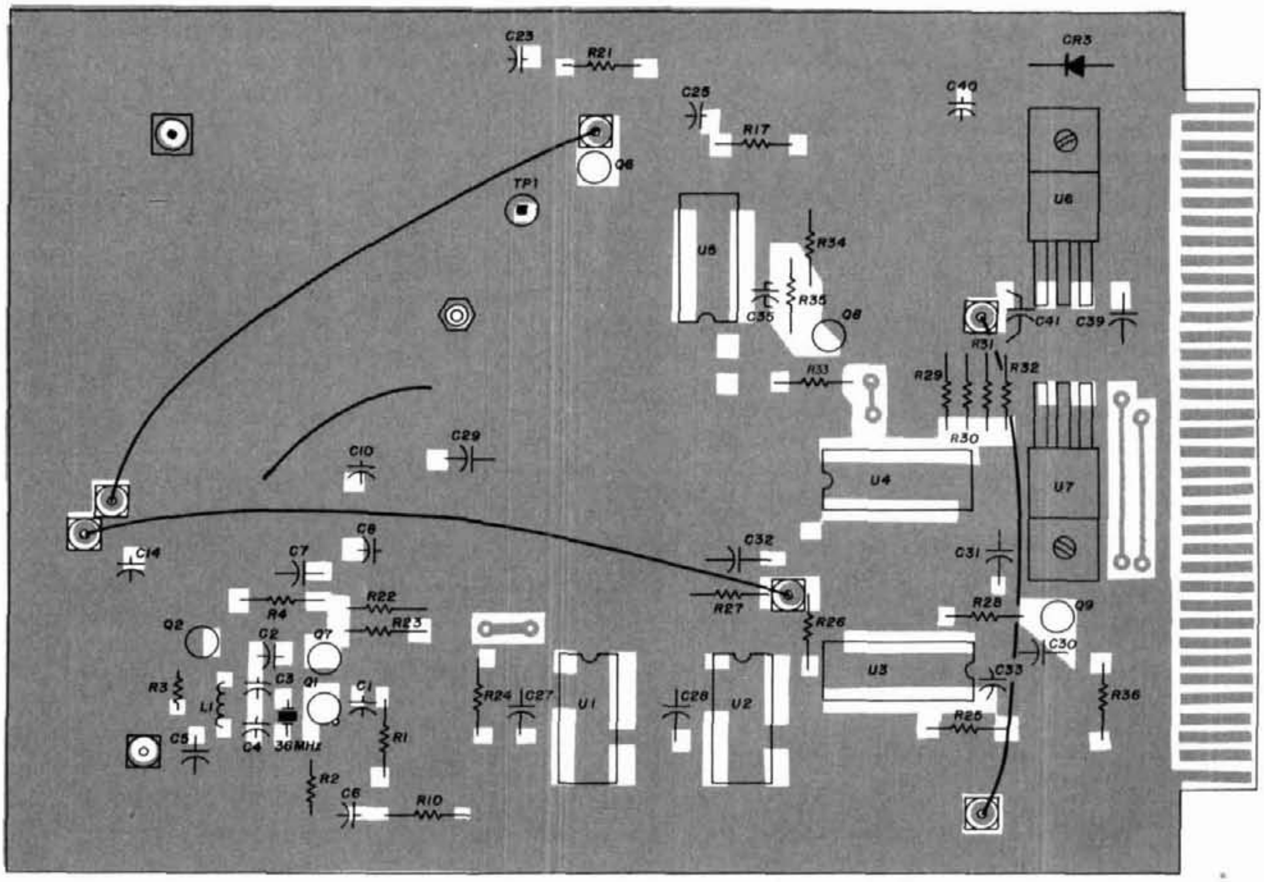

fig. 10(A). Component layout superimposed on groundplane artwork.

reach 4 volts, but as little as 2 volts are needed to drive U1.

• Connect a DVM or 50,000 ohm/volt meter to TP1. Tune the piston trimmer and note the meter response, which should be similar to the discriminator curve shown in **fig. 6**. The oscillator will be phase-locked if the voltage at TP1 falls on the sloping part of the curve. If the oscillator isn't operating, TP1 will be less than 2.0 volts, and possibly almost zero. If the voltage on TP1 is greater than about 7 VDC, the AFC (U3) is inoperative.

• Pins 3 and 14 of U3 should show square waves at the same frequency; the leading edges should be approximately in phase if the oscillator is phase-locked. You can check this with a dual-trace scope with a common time base. The square waves should have periods of 1.777 μsec.

• Adjust the piston trimmer until the square waves are exactly in phase. The voltage on TP1 now corresponds to the optimum operating point where phase noise should be at its lowest. On the prototype PC board, the optimum value was 4.0 volts DC.

an interesting experiment

To illustrate the increase in phase noise caused by large values of N, you can perform this experiment if you have access to a spectrum analyzer. Carefully solder a short piece of wire across the phase detector from the loop, leaving the CD4046 to perform both AFC and phase detection. Lockup will occur as before, and voltage levels at TP1 will be unchanged. However, the level of phase noise as seen on the spectrum analyzer will have increased by about 60 dB in and around the carrier and out to several MHz. Except for the fact that the carrier is stable, the spectrum appears only slightly cleaner than when the oscillator is free-running. This agrees fairly well with the phase-locked N2048 curve of **fig. 3** of part 1. **Figure 7** is an oscillogram of the VCO spectrum under these conditions, while **fig. 8.** shows the phase-locked spectrum.

I've chosen to call the PLL described here a "low noise" system. The title, of course, is relative, so further explanation is needed.

The experts all agree that measuring phase noise accurately is difficult at best and strewn with potential pitfalls depending on the technique used. Basically, phase noise level is defined as:

$$\frac{E_{sb}}{E_c} = 20 \log \left[\frac{\Delta f_{rms}}{\sqrt{2}\, f_m} \right] dB \quad (1)$$

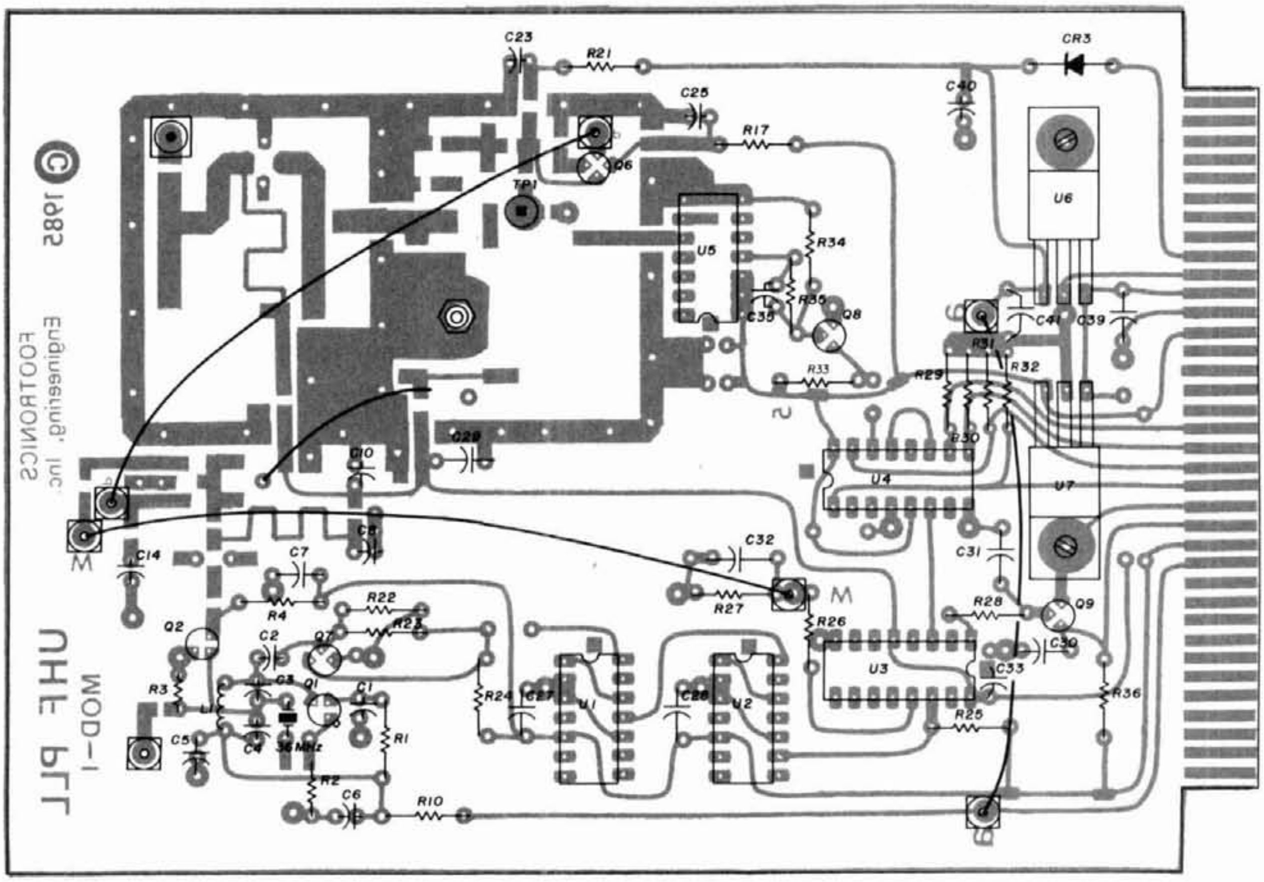

fig. 10(B). Component layout superimposed on trace side artwork.

where E_{sb} and E_c are respectively sideband and carrier voltages. Here, Δf_{rms} is the RMS value of peak frequency deviation at a distance f_m from the carrier. But how does one measure Δf? In high-purity sources, $20 \log (\Delta f / f_m$ is an extremely small number, typically more than 60 dB below the carrier. At an offset of 10 kHz, phase deviation of a phase-locked source may well be much less than ± 0.001 degree.

In the absence of sophisticated test equipment, which is well beyond the reach of most Amateurs, what can an inexpensive analyzer such as the HP-8551 show us? One sees the RMS sum of all the power passing through the 1-kHz bandwidth. This can be extrapolated to a 1-Hz band by use of so-called stochastic or random theory:

$$\frac{W_{3000}}{W_1} \pm 10 \log \frac{B_{1000}}{B_1} \pm 30 \text{ dB}$$

In other words, the ultimate sensitivity of the 8551 is $-(70+30)$ or -100 dBc/Hz. Based on this estimate, it should be easy to see the noise of free-running UHF oscillators. Judging from the spectrum response shown in **fig. 8**, the phase noise of the UHF VCO described here is less than -100 dBc/Hz close-in — considerably better than the calculated level of -85

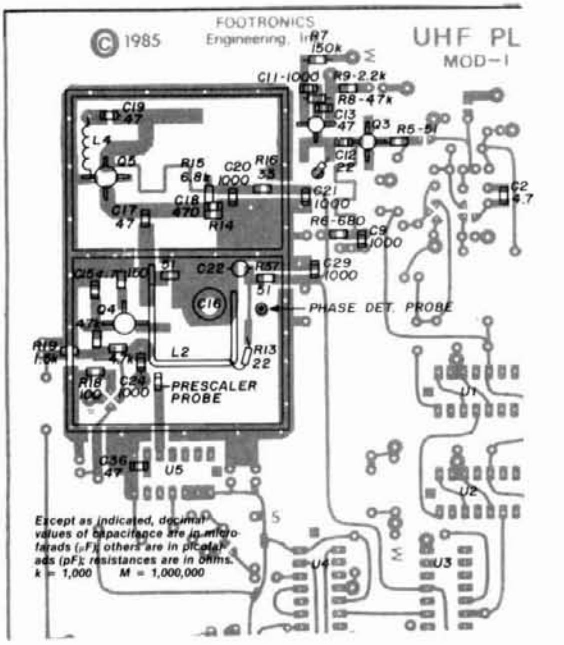

fig. 11. Detail of trace side of PCB showing locations of chip capacitors and resistors as well as other VCO buffer and loop amplifier components.

dBc/Hz. At offsets beyond 10 kHz, the noise is below the resolving power of the spectrum analyzer.

conclusion

In this article, I've described a phase-locked UHF VCO for Amateurs and experimenters who need a very clean signal source. The performance of this VCO has been compared with an earlier type of signal source using a crystal oscillator multiplier scheme. Both models are shown to have excellent phase-noise characteristics, based on measurements made on a spectrum analyzer. The UHF VCO's level of coherent sidebands is over 60 dB below the carrier, a considerable improvement over the 1969 model. This characteristic is particularly important when the VCO is used to drive a multiplier for microwave applications. The VCO and associated circuits are mounted on a standard plug-in PC card. This assembly is typically dedicated to provide approximately +10 dBm of clean local oscillator power for UHF up- or down-converters. The VCO is also well suited for block down-conversion use.

The plated-through nature of the PC board is essential to good UHF performance. The complete VHF/PLL, double-sided printed circuit board artwork is illustrated in **fig. 9A** (ground plane side) and **fig. 9B** (trace side). The ground plane-mounted component layout includes two views in **fig. 10** — with the ground plane side **fig. 10A** and the trace side of the PC board **fig. 10B** provided in the background. Finally, a section of the trace side of the PCB shows the chip capacitors' and resistors' component layout superimposed on it in **fig. 11**. If you need help in obtaining this board or other components such as shield boxes, coils, diodes, transistors, and the like, send a business-sized SASE to me at the address shown at the beginning of the article.

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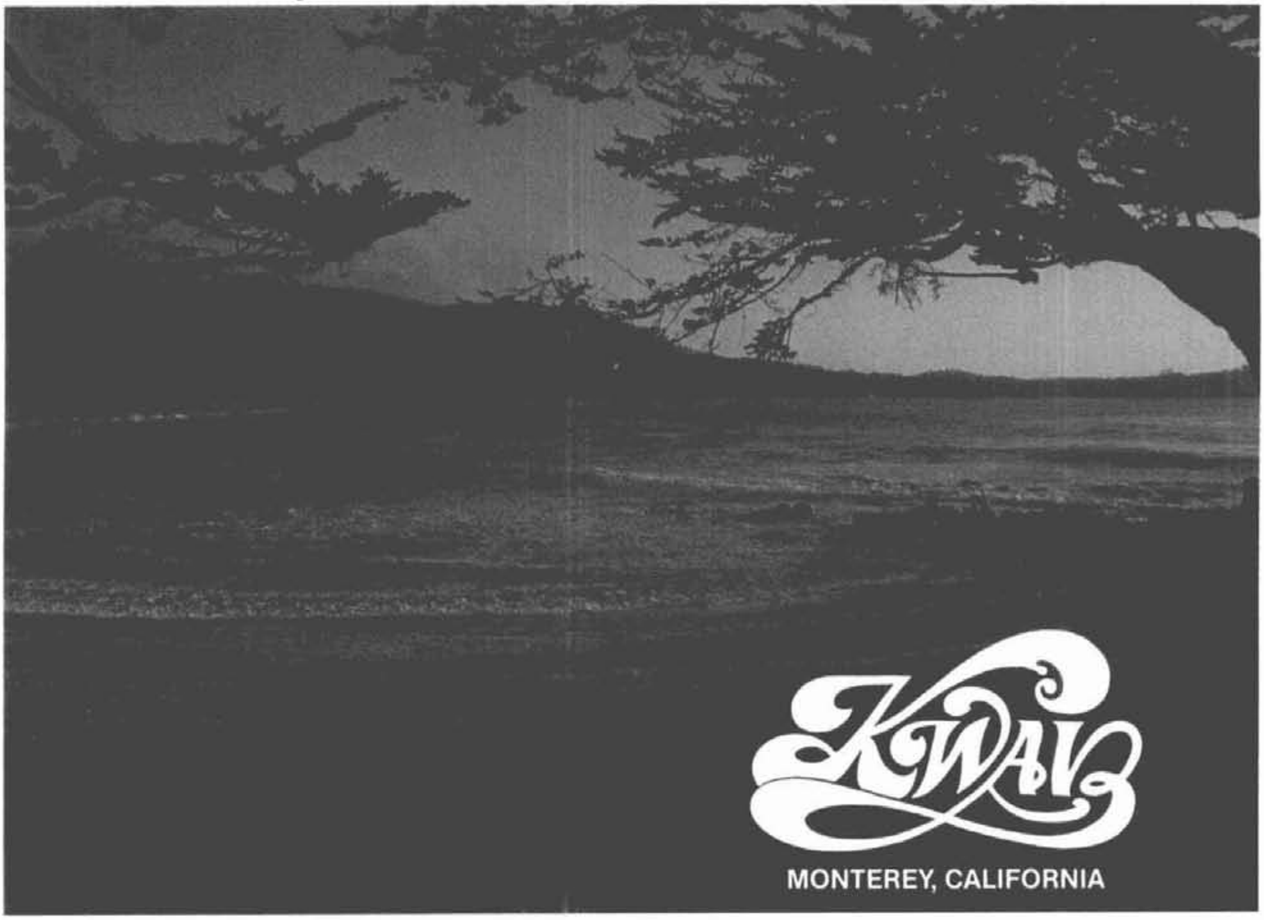

Ken Warren, Chief Engineer at KWAV reports that their 10 kW FM transmitter went on the air in November, 1972, equipped with EIMAC power tubes. The original tubes are still in operation after over 13 years of continuous duty!

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ham radio TECHNIQUES

Bill Orr, W6SAI

50th anniversary of the tube that changed everything

1936 was a very good year. The country seemed to be coming out of the Great Depression. More people were at work and the lines in front of the soup kitchens seemed to be getting shorter . . . and great things were stirring in the young field of electronics.

For years circuit designers and radio manufacturers had struggled with low-gain, low-performance receiving tubes that consumed a lot of power and produced only mediocre results. The battery-operated receiver was dead; the AC receiver was here to stay. The time was ripe for the introduction of a new family of tubes that would transform radio from a curiosity into a piece of household furniture.

In 1935 the General Electric Company developed the idea of a metal receiving tube that wouldn't require an external shield and could be made in large quantity at low cost. Experimental tubes were made and the Radio Corporation of America was licensed to produce such tubes for the home entertainment market.

At the same time, Otto Schade, Sr., and his associates at RCA were at work on a revolutionary tube design that would offer high gain, high power output, and low signal distortion. It seemed a good idea to incorporate this concept in the newly developed metal envelope. The new tetrode tube made use of aligned grid and screen elements and beam-confining plates. This resulted in an electronic suppressor within the tube structure that increased overall efficiency and removed some of the "kinks" in the tube characteristics that had plagued older, less sophisticated designs.

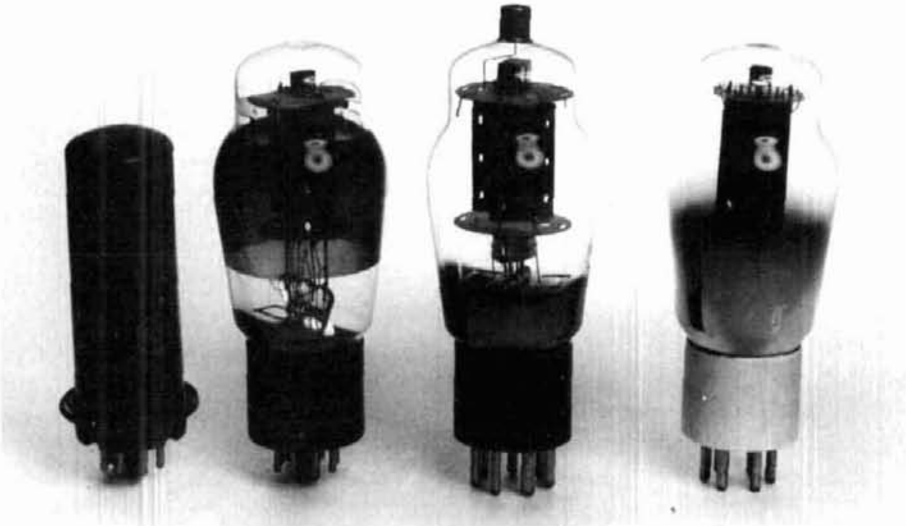

fig. 1. The famous 6L6 passed through several designs in its long lifespan. At left is the original metal 6L6. Next to it is the glass 6L6G version. Second from right is the transmitting version, the 807 (6.3 volts) or 1625 (12.6 volts). The 807 had two getters in the base of the tube, shield plates around the tube stem and extra insulation between the metal anode and the mica supports. The plate lead was brought out the top of the envelope. At right is the T-21, a transmitting version of the 6L6G. It employed a 6-pin ceramic base of low loss, but eliminated the anode insulating supports. The T-21 performed well at 500 volts but often flashed over when run at higher voltages. Even so, it was a bargain for less than two dollars.

The happy results of this pioneering work were announced in the early spring of 1936 with the introduction of the 6L6 "Beam Power Tube" (**fig. 1**).

too good to be true?

The characteristics of the new tube seemed too much to believe. A pair of 6L6s working with 400 volts on the plate could produce over 25 watts of audio power! And even more interesting, the 6L6 could grind out over 35 watts as a crystal oscillator!

Now the big question — how would the 6L6 act as an RF amplifier? The tube was tried out; results were mixed. What to do with the metal envelope? Ground it? Let it float? There was much argument about this. *QST* wasn't sure what to do, so they left the shield floating in a simple amplifier design and remarked that — unfortunately — the tube had to be neutralized to operate stably.

The problem resolved itself later that year, when RCA and others announced a glass version of the 6L6 known as the 6L6G. This repackaging job was presumably done to reduce manufacturing costs and speed up production; it's thought that the metal tube manufacturing technique was not proving cost-effective. At the same time, the 6L6G was rearranged to bring the plate connection out of the top of the envelope. Thus was the 807 born.

In order to make the 807 a true transmitting tube, additional internal insulation was added to boost the maximum voltage rating to 600 volts and small shields were added around the base of the tube stem to reduce internal feedback paths. In reviewing the tube, *QST* said, "It may have a tendency to self-oscillate in high-gain circuits above 14 Megacycles, or in designs where input and output circuits [are] not carefully isolated."

life and death of the 807

The 807 was a blockbuster. It was the first high-gain, low-drive, inexpensive transmitting tube for the Radio Amateur. A pair of 807s — at $3 each — could comfortably run at 120 to 150 watts input on CW all day long!

Unfortunately, everybody got into the act. Clones of the 807 were made by many manufacturers, and cheaper versions of the 6L6G were sold with low-loss bases for RF service. Old-timers remember the Taylor T-21, which sold for $1.95 and seemed to work as well as the 807.

But the 807 was to come upon rocky

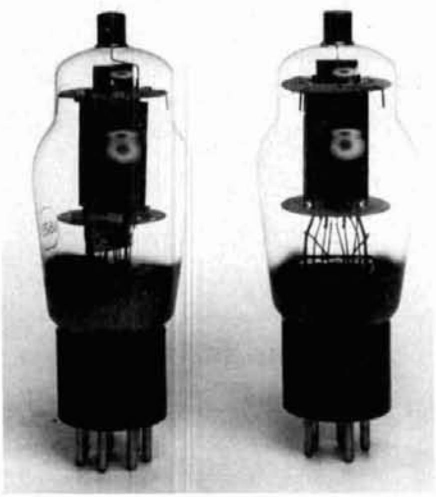

fig. 2. The pre-war 807 (1625). Note the base shield and the ceramic insulators between anode and mica supporting structure. At right is post-war 807. The base shield is missing and the ceramic anode supports have been removed. The changed electrical characteristics of the tube, plus the fact that many manufacturers were making the tube to slightly different specifications, tended to give the tube a reputation for instability and poor performance

days. When it went into large-scale production during World War II, the special insulators, as well as the base stem shields within the tube, were eliminated to cut costs. The 807 began to look more and more like a simple version of the 6L6G (**fig. 2**).

The problem was that circuits designed for the "good" 807 couldn't perform properly with the cheaper version. The 807 rapidly earned a reputation as an unstable tube, mainly because so many different versions were available. In those days, manufacturers didn't know — or simply ignored the fact — that changing the internal support structure and moving the connecting leads to the elements about to fit a particular manufacturing process would drastically alter the operation of the tube, particularly at higher frequencies.

While the 807 faded into obscurity and was replaced by the newer 6146, the 6L6G flourished in the brand-new field of television. It was revived for hi-fi audio as the 6L6GC/6L6GB and various improved models saw duty as sweep tubes, with the final versions of the venerable design being the 6LQ6 and the 6MJ6. Some of these tubes saw duty as linear amplifiers in Amateur service (**fig. 3**).

All in all, the original 6L6 concept endured for 50 years in one form or another, and the principle of electron beam direction has been carried into the modern transmitting tubes. The 8877, 4CX5000A, and many other modern tubes are descendents of the original design worked out by Schade and his colleagues over 50 years ago. Hats off to these pioneers!

the horizontal square loop antenna

A letter arrived from Bob Morrison, AG9C, which may be of general interest:

The November, 1985, ***QST*** *contained an article on a horizontal square loop antenna. Such strong claims were made that I decided to compare a full-wave horizontal square loop with a half-wave dipole using the numerical electromagnetics code computer program, NEC-2.*

A perfectly conducting ground plane is assumed. Far-field radiation patterns in either horizontal or vertical planes show little difference between the antennas.

This is not surprising since both antennas consist of elemental horizontal dipoles. However, nulls in the zenith lobe occur at different antenna heights. Also, the loop is resonant at all harmonics, while the dipole is resonant only at odd harmonics.

This is not to say the horizontal loop is not a good antenna—it is. Just don't expect miracles.

the K4EF antenna and tuner

The "All-band" wire antenna and tuner designed by Ev Brown, K4EF, perform well on all bands between 160 and 10 meters (**fig. 4**). The antenna consists of a 200-foot wire, with 50 feet in the vertical plane and the remainder run horizontally to a nearby tiepoint. The antenna works against

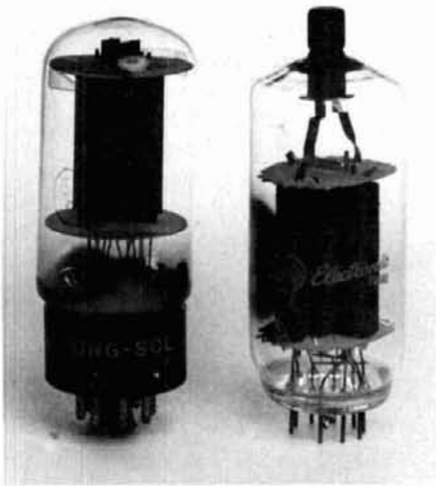

fig. 3. The ultimate 6L6. At left is the 6L6-GB with high plate dissipation rating (30 watts) and improved base structure. A single tube would deliver 11 watts of audio at 350 volts plate potential. At right is the sweep-tube version of the 6L6—the 6LQ6. Note the heavy anode leads. Tubes of this type were popular in Amateur linear amplifiers for a number of years.

ground in Marconi fashion. Ev originally used a single ground rod, but later laid out a ground screen beneath the antenna consisting of 1000 feet of No. 14 wire forming a mat about 20 feet wide and parallel to the horizontal portion of the overhead wire. After all this effort, he could detect no change in performance!

One reason efficiency is high is that the feedpoint resistance of the antenna is about 100 ohms at 3.5 MHz and nearly 4000 ohms at 1.8 MHz.

The feedpoint is very "hot" on the 160- and 80-meter bands and a high voltage, transmitting-type capacitor is required to prevent flashover. Toroidal coils, wound on several stacked Amidon T-200 forms, were tried but proved unsatisfactory because of heating and inductance drift. The solution was air-wound inductors.

Generally speaking, the tuner will tune any length of wire over 40 feet long at 7 MHz or higher, provided the wire is not a quarter wavelength long. The antenna feedpoint resistance must be higher than 50 ohms in order to allow the tuner to do its job.

If the antenna is used exclusively on 160 meters, the antenna length can be chosen to match available components. For example, if the tuner capacitor is only 200 pF, antenna length should be increased to about 210 feet. The coil inductance must be increased to about 80 turns (40μH). Conversely, if a 1000-pF capacitor is available and you want to reduce the length of the antenna, a length of 175 feet is appropriate.

Ev says this antenna is outstanding on 160, 80, and 40 meters because the current loop is quite high in the air. On the higher bands he's able to compete with the "big boys" and frequently raises DX stations on the first or second call.

Ev likes the antenna so well he never got around to erecting his "Christmas tree" stack of Yagi beams on his 50-foot tower!

K1LPS on radials

One of the top DXers on 160 meters is K1LPS. Larry advises against being fooled by claims stating that a good ground (radial) system isn't required on 160 meters. "While a station using a vertical without radials will work stuff," he says, "a station using the same vertical with a good radial system will consistently outperform the equivalent antenna without radials on a given path."

K1LPS started out with an "L" antenna about 45 feet high with the end 90 feet running horizontally — quite a typical 160-meter antenna for the lean purse. He began with a single ground rod, plus four radials, none of which were more than 60 feet long, but found that results improved markedly as he improved his ground system. "The antenna was certainly not a pileup-beater by any means, but I eventually got there," he comments.

Encouraged by these results, Larry put up a better antenna. It was an L-shape, with 66 feet vertical and the remainder horizontal. He made careful measurements as he laid in a ground system, bit by bit. Starting out with a ground rod and four quarter-wave radi-

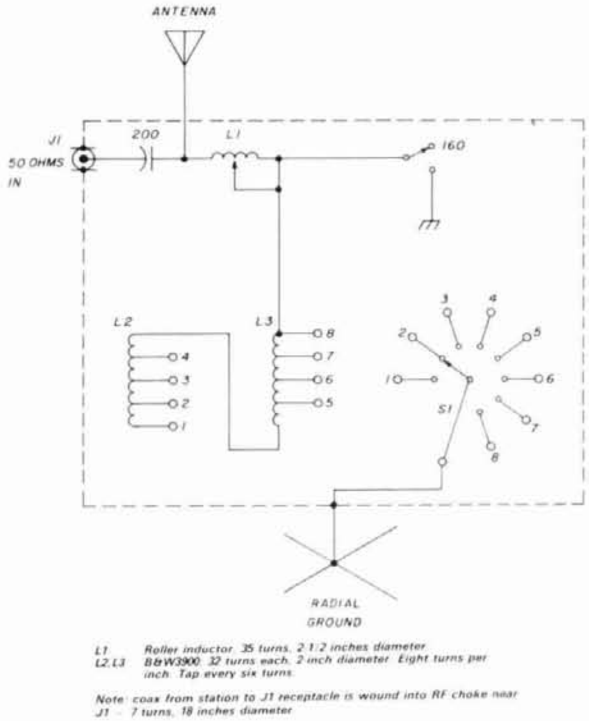

fig. 4. The K4EF wire tuner.

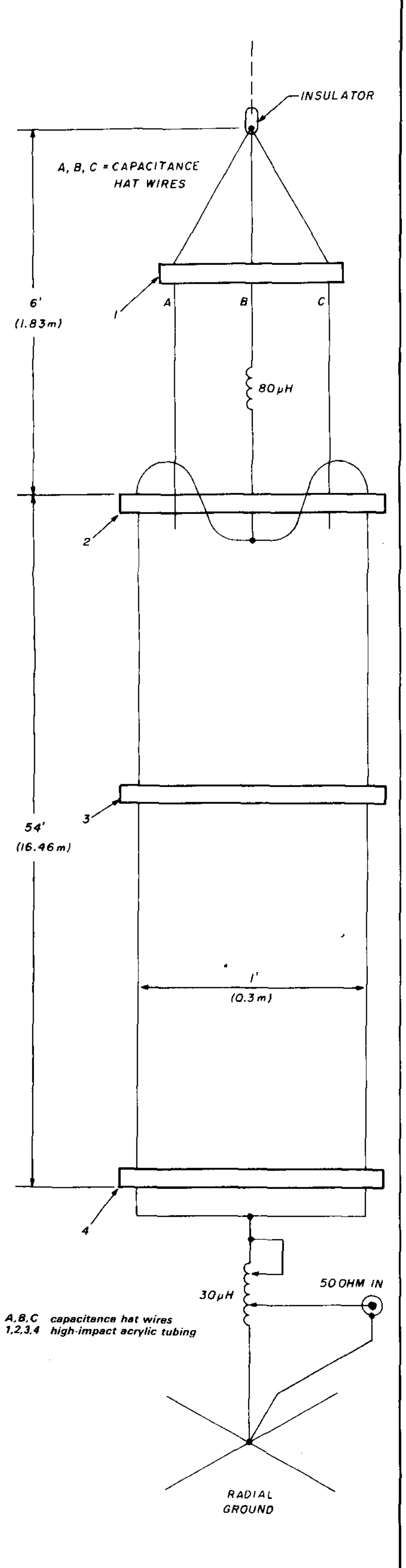

fig. 5. The W1FB 160 meter monopole antenna.

als, he measured his feedpoint resistance as 45 ohms. Bandwidth between the 1.5-to-1 SWR points was about 70 kHz.

He next added 18 additional quarter-wave radials. The feedpoint resistance dropped to 38 ohms and the 1.5-to-1 passband disappeared, because the minimum value of SWR at antenna resonance was 1.6-to-1! Before he built a matching network, he added ten more radials, bringing the feedpoint resistance down to about 22 ohms. Using a fixed matching network, K1LPS achieved a match of unity at 1820 kHz, but the antenna bandwidth between the 1.5-to-1 SWR points had dropped to 40 kHz.

These various changes took place over an extended period of time. Signal reports were solicited from many stations at various distances each night after additions to the ground system. A good many hams kept track of Larry's progress and there was a noticeable improvement as radials were added. It was finally concluded, however, that additional radials over 44 didn't seem to make much difference. And — finally — K1LPS made that elusive Japanese contact!

K1LPS says, "Yes, you can get by without radials. But if you want to work long-haul DX, find a way to get a good ground system installed. That's the difference between a passable signal and a pile-up breaker!"

In closing, Larry remarks, "A poor ground system has one thing going for it — a nice, broad SWR curve across a relatively wide frequency range. But then, so does a dummy load!"

the W1FB 160-meter monopole

Because it's difficult to be loud on 160 meters when you live on a city lot, I've long envied those lucky hams who live on country estates, with acres of land at their disposal. My good friend Doug, W1FB, has pondered the problem and finally come up with a compact monopole antenna design that solves this problem for Amateurs who can find 60 feet of space, either straight up, or at an angle (**fig. 5**).

Basically, the antenna is a "fat" monopole, top-loaded with an inductor and a capacitance hat. An arrangement such as this could end up being a rat's nest, but Doug has engineered the design through several models and arrived at a clean, compact, rugged package that's easy to install and adjust. Eighteen radials, each 130 feet long, are laid out beneath the antenna. The spacers are made of high-impact acrylic tubing and the array is made of No. 14 wire. Slung up in the clear, the measured SWR of the antenna between the 2-to-1 SWR points is 165 kHz. That's not too shabby for such a compact antenna!

More information on this nifty antenna? Write Oak Hills Research, 4061 North Douglas Road, Luther, Michigan 49656. Doug says the only problem now is that he doesn't have time to get on the air and work DX anymore!

ham radio

PRACTICALLY SPEAKING ... Joe Carr K4IPV

solid-state rectifiers

Because the lowly rectifier diode isn't exactly a high-tech electronic part, it's sometimes overlooked by those accustomed to more sophisticated electronics — microprocessors, packet radio TNCs, and HF SSB transceivers, for example. Nonetheless, the rectifier diode is extremely important.

Consider this: about 20 years ago there was a popular SSB rig on the market that suffered a terrible reputation for poor reliability. These rigs were on the blink more often than not (or so it seemed to those of us who owned them). The main — and for the most part *only* — problem was with the rectifier diodes. The manufacturer used a 1000-volt PIV rectifier in a 750-volt DC power supply. So what's wrong with using a 1000-volt diode in a 750-volt circuit? Read on, and you'll find out.

what are rectifiers?

The word "rectify" means "to make right or remove impurities." The purpose of a rectifier in a DC power supply circuit is to remove the impurities of the AC line current and make it right for DC-craving electronic circuits. AC is incompatible with most electronic circuits, so it must be changed to DC by a rectifier. From the above discussion you can probably guess that the main requirement for a rectifier is to convert bidirectional AC into a unidirectional form of current. Although ham equipment once used vacuum and mercury vapor rectifier tubes to accomplish this task, all modern equipment now relies on solid-state PN junction rectifiers.

Figure 1 shows the standard circuit symbol for the solid-state rectifer diode (**fig. 1A**), along with some common shapes of actual diodes. The "input" side, where AC is applied, is the anode, while the "DC" output is at the cathode. The diodes shown in **figs. 1B through 1G** are positioned so that the respective anodes and cathodes are aligned with those of the circuit symbol in **fig. 1A**. Rectifiers in **figs. 1B** through **1E** are epoxy or "plastic" package devices, the type we usually see. The cathode end will be marked with either a rounded end **fig. 1B**, a line (**fig. 1C**), a diode arrow (**fig. 1D**) or a plus sign (**fig. 1E**).

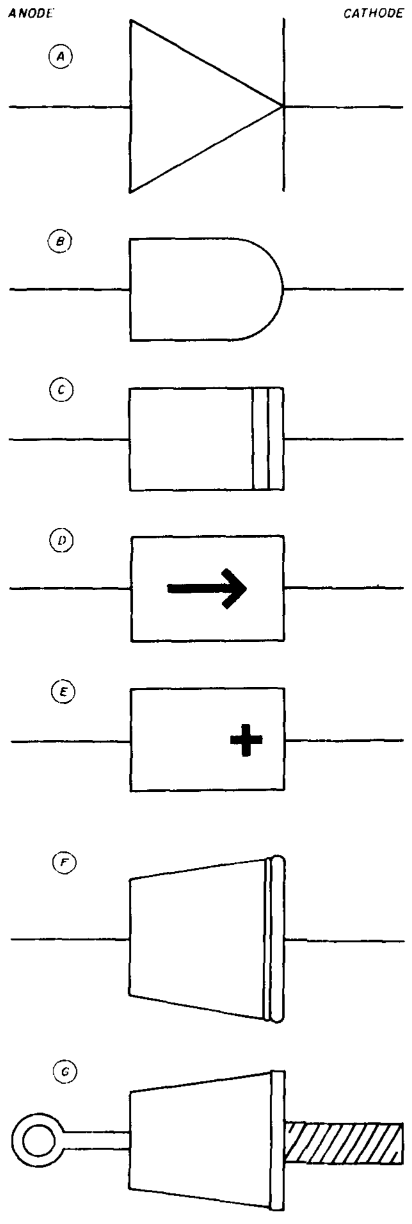

fig. 1. Solid state rectifier diodes: (A) standard circuit symbol; (B) through (E) common shape of epoxy or "plastic" package devices; (F) "Top-hat" type and (G) stud mounted.

The diode shown in **fig. 1F** is the old-fashioned — and now obsolete — "top-hat" type. Unless otherwise specified, the top-hat type can safely pass a current of 400 milliamperes, while those in **figs. 1B through 1E** generally pass 1 ampere (or more, for larger packages).

The stud-mounted type shown in **fig. 1G** is a high-current model. These diodes are rated at currents from 6 amperes or more; 50- and 100-ampere models are easily obtained. They are mounted using a threaded screw at one end, which also forms one electrical connection. The other electrical connection is the solder terminal at the other end. Unless otherwise specified, the solder terminal is the anode, while the stud-mount is the cathode terminal. Exceptions to the polarity rule are sometimes seen. The reverse polarity diodes will have either an arrow symbol pointing in the opposite direction (the arrow always points to the cathode), or an "R" suffix on the type number — for example, 1NxxxxR.

rectifier specifications

The use and abuse of solid-state rectifiers involve key specifications: for-

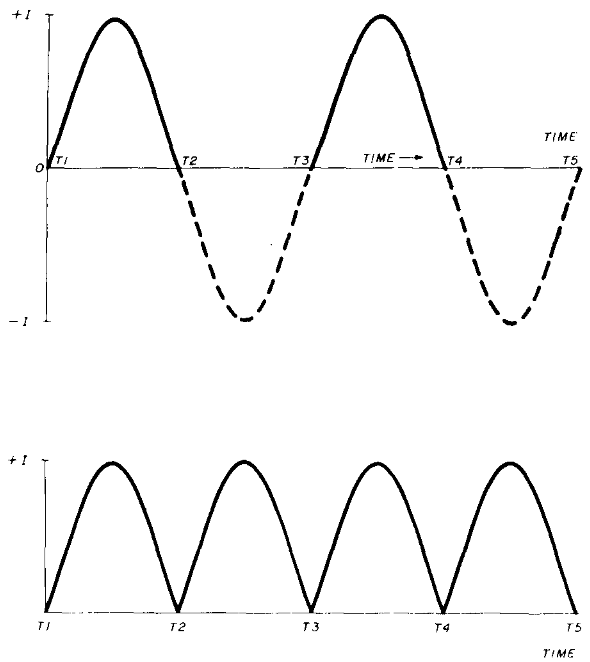

fig. 2. Rectifier output: (A) Solid line, half-wave rectified; (B) Full-wave rectified.

ward current, leakage current, surge current, junction temperature, and peak inverse voltage (PIV) — also called peak reverse voltage (PRV).

The forward current is the maximum constant current that the diode can pass without damage. For the popular 1N400x series of rectifiers the forward current rating is 1 ampere. The leakage current is the maximum current that will flow through a reverse biased junction. In an ideal diode, the leakage current is zero; in practical diodes of reasonable quality it is very low.

The maximum surge current is a rating that can get you into trouble. The surge current is typically very much larger than the forward current, so it's sometimes erroneously taken to be the operating current of the diode. It's defined as the maximum short-duration current that will not damage the diode. "Short duration" typically means 1/60 of a second! So don't use the surge current as if it were the forward current (a common but disastrous mistake).

The junction temperature is merely the maximum allowable temperature of the PN junction. The actual junction temperature depends on the forward current and how well the package (and environment) rids the diode of internal heat. Although typical maximum junction temperatures range from +125 to +150 degrees C, good design requires as low a temperature as possible. One reliability guide mentions that the junction temperature should be limited to a maximum of +110 degrees C.

The peak inverse voltage (PIV) is the maximum allowable reverse bias voltage that won't damage the diode. This rating is usually the limiting rating in certain power supply designs, and the least often heeded. Later in this article, we'll learn how to select the PIV rating for practical power supplies.

The output from the rectifier is not pure DC, but rather pulsating DC. For halfwave rectifiers we see a waveform such as **fig. 2A**, and for fullwave rectifiers we see the waveform of **fig. 2B**. The pulsating DC waveform is almost as useless for electronic circuits as the AC input. However, we can filter the pulsating DC output to form nearly pure DC. Although the subject of filtering is beyond the scope of this article, we must consider at least the simplest form of a power supply filter in order to correctly select a rectifier for any given application. **Figure 3A** shows a simple power supply with a brute-force filter capacitor, C, shunting the load to filter the pulsating DC into nearly pure DC. This capacitor will charge to a potential equal to the peak voltage, i.e. 1.414 times the applied RMS voltage.

selecting rectifier diodes

The two parameters that you'll most often use to specify practical power supply diodes are the forward current and peak inverse voltage. Get these right and in almost all cases the rectifier will work long and hard for you.

The forward current rating of the diodes must be at least equal to the maximum current load the power supply must deliver. That's common sense. But in the real world there's also the necessity for a safety margin to account for tolerances in the diodes and variations of the real load (as opposed to the calculated load). It's also true that making the rating of the diode larger than the load curent will greatly improve reliability. A good rule of thumb is to select a diode with a forward current rating of 1.5 to 2 times the calculated (or design goal) load current — or more if you can get it. Although selecting a diode with a very much larger forward current (e.g., 100 amperes for a 1-ampere circuit) is both wasteful and likely to make the diode not work like a diode, it's generally the rule to make the rating as high as feasible. The 1.5 to 2 times rule, however, should result in a reasonable margin of safety.

The peak inverse voltage (PIV) rating can be a little more complicated. In unfiltered, purely resistive circuits the PIV rating needs only to be greater than the maximum peak applied AC voltage (1.414 times RMS). If a 20-percent safety margin is desired, then make it 1.7 times RMS voltage.

Most rectifiers are used in filtered circuits (e.g. **fig. 3A**), and that makes the problem different. **Figure 3B** shows the simple capacitor filtered circuit redrawn to better illustrate the circuit action. Keep in mind that capacitor C is charged to the peak voltage with the polarity shown. The voltage across the transformer secondary (V) is in series with the capacitor voltage. When voltage V is positive, the transformer voltage and capacitor voltage cancel out, making the diode reverse voltage nearly zero. But when the transformer voltage (V) is negative, the two negative voltages (V and Vc) add up to twice the peak voltage, or approximately 2.83 times the RMS voltage. Therefore, the absolute minimum value of PIV rating for the diode is 2.83 times the applied RMS. If you prefer a 20-percent safety margin (a good idea), then make the diode PIV rating 3.4 times RMS (or more).

The problem with the HF SSB rig referred to at the beginning of this column was that the PIV rating of the diodes was too low. The applied RMS voltage from the secondary of the power transformer in that unit was about 540 volts, with the peak voltage being approximately 750 volts. Thus, the maximum reverse voltage seen by those diodes was on the order of 1500 volts — which is death for a 1000-volt PIV diode! The cure, which many Amateurs opted to use, was to replace each diode in the power supply with two diodes connected in series (see below).

using rectifier diodes

In most cases, especially in low-voltage DC power supplies used by many electronic circuits, we can get away with simply using the diodes as shown in the circuits above. In **fig. 4**, however, we see the so-called "proper" way to use the solid-state diode rectifier. The resistor in series with diode CR1 (i.e. R_S) is used to limit the forward current. Many circuits, especially those with capacitor-input filter circuits, exhibit a surge current at initial turn-on. This current can sometimes pop the diode, so R_S is used to limit the possible damage. The value of resistance used for R_S is typically 5 to 20 ohms, with a power rating of 2 watts. In most cases, however, we can eliminate R_S by using a diode with a rating larger than the load current (for example, the two-times rule).

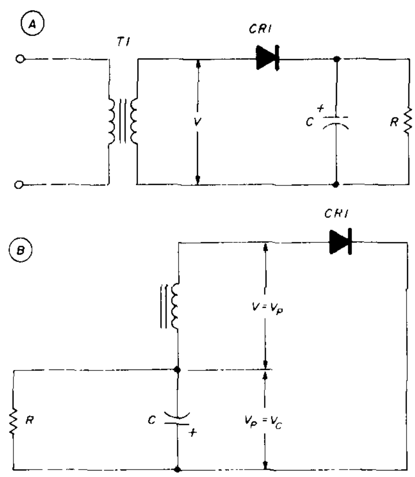

fig. 3. Simple half-wave rectification power supply; (A) Common circuit diagram; (B) Diagram redrawn to illustrate voltages present across each terminal.

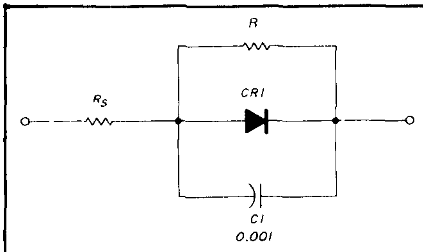

fig. 4. Proper way to use solid state rectifier. R_s limits the surge current experienced by the diode.

Capacitor C1 in **fig. 4** is used to bypass high voltage transient spikes around the diode. These spikes could possibly blow the diode PN junction. In fact, high voltage line spikes make diodes pop with regularity. Placing the capacitor in parallel with the diode will eliminate much of that problem. The working voltage (WVDC) of the capacitor should be equal to or greater than the PIV rating of the diode.

By using 1000-volt PIV diodes even in low-voltage circuits we can eliminate much of the damage caused by transients. We therefore would not need the capacitors. We can also eliminate the capacitors if a Metal Oxide Varistor (MOV) spike suppressor is used across the AC supply voltage.

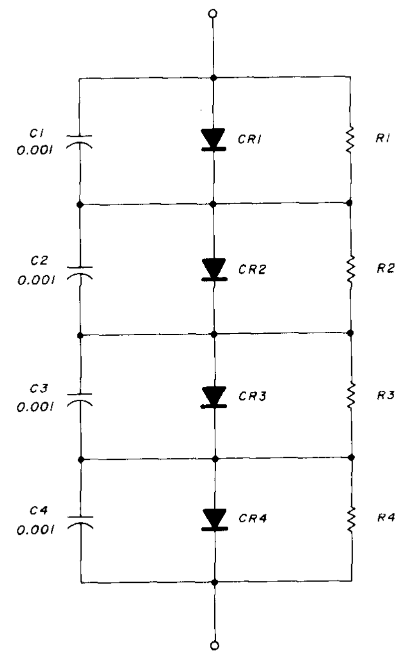

fig. 5. Method for using several diodes in series to increase the overall PIV rating.

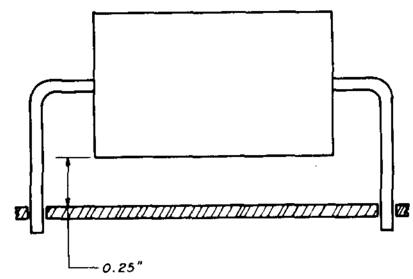

fig. 6. Preferred method of mounting an axial lead rectifier diode above a PCB to dissipate heat and prevent damage.

Figure 5 shows a method for using several diodes in series to increase the PIV rating. Assuming that the PIV ratings of the diodes are equal, then the overall rating is four times the rating of one diode. In general, if 1000-volt PIV diodes are used the PIV rating in the circuit is now 4000 volts. In the HF SSB transceiver we replaced the single diode with a pair of diodes connected exactly as shown in **fig. 5**.

The capacitors used in **fig. 5** are used for exactly the same purpose as those in **fig. 4**. The resistors, however, are needed for a different purpose. They equalize the forward voltage drop across each diode. A 470-kilohm, 1-watt resistor is typically used for 1000-volt PIV diodes. The wattage rating is required not because of the power dissipation of the resistors, but for the voltage rating — yes, resistors *do* have voltage ratings.

Figure 6 shows the proper method for mounting an axial lead rectifier on a perf or printed circuit board. This method is used anyplace where no excessive vibration is expected; this includes most sedentary projects or equipment. The space beneath the diode body allows air to circulate (keeping the diode cooler) and prevents diode heat from damaging the board.

conclusion

Although solid-state rectifiers are among the most common electronic components used by Amateurs, they are also among the most common causes of failure in homebrew projects, repaired equipment, and equipment that was poorly designed from the beginning. By following the rules given above, you'll be able to successfully select the correct rectifier — and prevent reliability problems that take you off the air.

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VISA

Simple modification allows HF and VHF packet operation with one TNC

using an RTTY terminal unit with the Heathkit HD 4040 TNC

When I first started running packet radio my primary mode was 2-meter FM. The TNC (terminal node controller) was already set up with the proper tone pair for 2-meter operation. I had the appropriate radio equipment, and there was a fair amount of operating activity in the area. Operating was also very easy: I just dialed in the correct frequency on the HT, set the volume, and was on the air.

But soon I began to long for the excitement, challenge, and advantages of operating the HF Amateur bands. Packet was permitted on HF Amateur bands, but at a reduced baud rate and with a different tone pair than used on the 2-meter FM. It quickly became clear that to run both 2-meter and HF packet with the same TNC would require a bit of ingenuity.

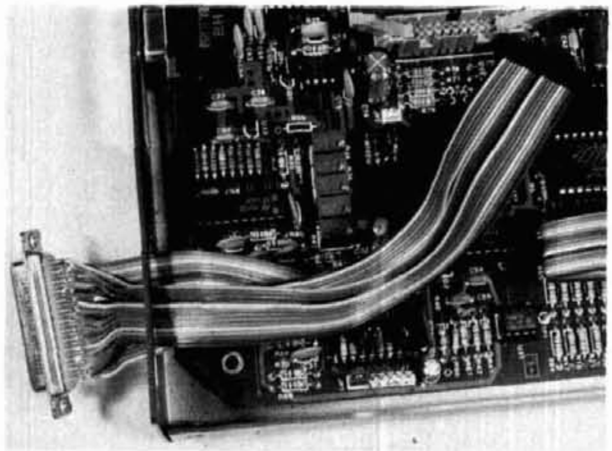
the problem

When you first build the Heath TNC* it's set up for the tone pair used on VHF packet — 1200 Hz and 2200 Hz. The wide (1 kHz) shift allows for higher baud rates and lower error rates than are possible with a narrower shift. However, spectrum requirements on the HF Amateur bands require the use of a narrower shift, 200 Hz. The tones currently being used are 1600 Hz and 1800 Hz.

Though the on-board modem is very flexible, the difference in the tone pairs for the VHF and HF frequencies is too great for the modem to accommodate without changing the DIP headers and recalibrating the modem. (The DIP headers are the little cards with the resistors and capacitors on them that are plugged into the IC sockets.)

These changes, though easy to perform, do present a problem: every time you want to go from VHF to HF and vice-versa, you have to open the cabinet, change the headers, and recalibrate the modem. Although this isn't difficult, it's sufficiently troublesome to keep one from readily changing bands. In addition, the on-board modem lacks the type of filtering needed for reliable performance in the HF Amateur bands.

* The TAPR-1, AEA, and other clones are very similar to the Heath TNC. The modifications listed here should apply to them as well.



The wires have been soldered to the DB25 connector on one end and attached to a 20-pin header plug on the other. The header plug has been threaded through the hole in the back panel. The DB25 is ready to be mounted on the back panel and the header inserted into J5.

the solution

The designers of the Heath TNC included an onboard connector (J5) to allow you to use an

By Gregory P. Latta, AA8V, 438 Eastland Avenue, Akron, Ohio 44305

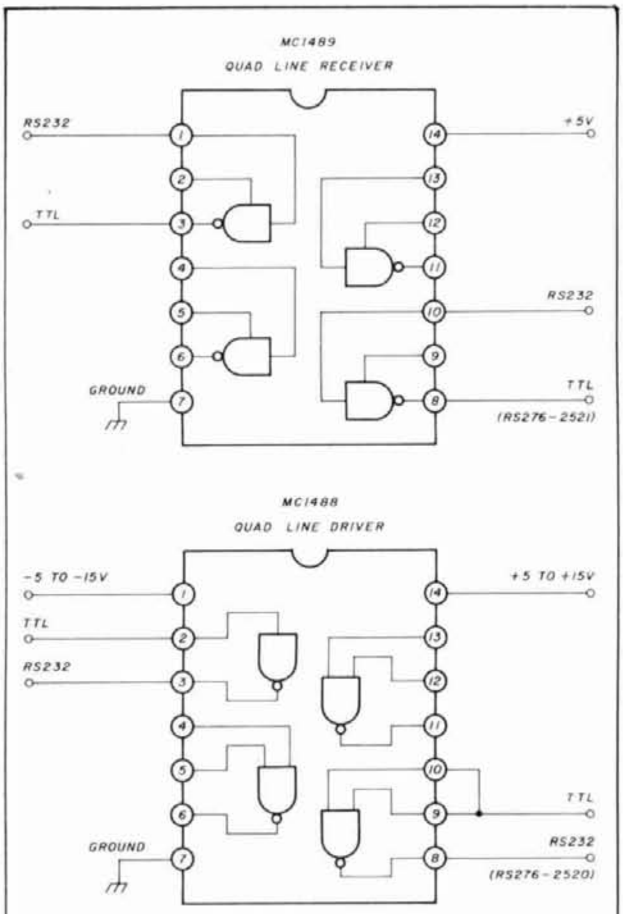


fig. 1. RS-232/TTL and TTL/RS-232 level converters use readily available ICs (Radio Shack). Top view of the chips is shown. Note that the voltages applied to pins 1 and 14 of the MC1488 need not be of equal magnitude. Example: − 12 volts on pin 1 and + 5 volts on pin 14 would work just fine. (Photo courtesy of Radio Shack.)

EXTERNAL modem (or TU) and bypass the on-board modem. (Thank you, Heathkit!) If the TNC were interfaced to an external terminal unit (TU), one would have the needed filtering, and changing bands would be reduced to switching a plug.

TU requirements

Certain minimum requirements that a modem (RTTY computer interface, terminal unit, etc.) must meet for operation with packet radio on the HF bands are detailed below:

•The TU must be able to operate at 200 or 170 Hz shift. (The difference between 200 Hz and 170 Hz is small enough that proper operation is not impaired.) *Note that the actual frequencies used are unimportant!* As long as the difference in frequencies (the shift) is 200 or 170 Hz, you can use the TU for packet radio. Just about all RTTY modems meet the 170 Hz requirement.

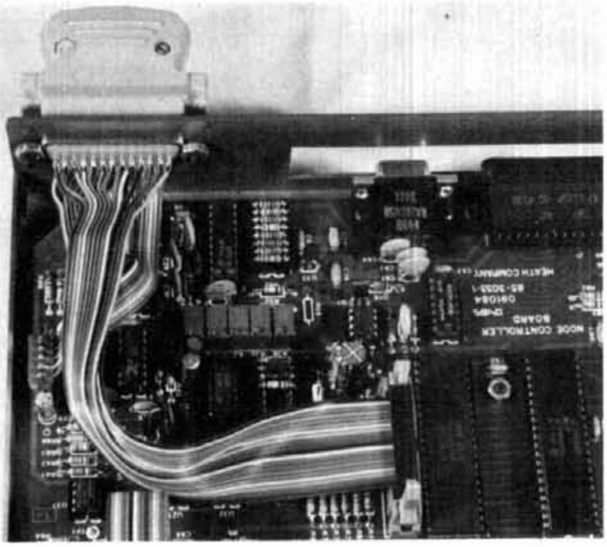
•The TU must be able to operate at 300 baud, the rate commonly used for HF packet operation. Some modems will not operate at 300 baud without modifications. Check the specifications of your TU to see if it meets this requirement.

•The TU *must* have some type of reliable tuning indicator. (If it doesn't you can devise your own.) A scope tuning indicator is fine. Because of the nature of packet radio, you cannot "tune until you get the print." You must be able to tune in the signal "blind" without looking for a print-out. If you can tune in the signal with your printer off, then flip on the printer and get good copy on RTTY, your tuning indicator is probably OK.

•The TU must have an output that indicates when the frequency is busy (i.e., when a Mark or Space is present). Packet radio is computer controlled and it is necessary for the TNC to be able to tell whether someone is using the frequency.

Some TUs have an RDA (Receive Data Available) output. This is ideal. If your TU lacks such an output, don't despair. Some have an autostart circuit that may be modified to provide the needed output. If your TU has no autostart circuit or RDA output, you'll have to devise your own carrier detect circuit. (See below.)

•The TU inputs and outputs *must be TTL compatible. RS-232 inputs and outputs will not work and may damage the TNC!* If in doubt, measure the voltages on the TU output pins under both on-off or mark-space conditions. If you ever obtain a negative voltage or a positive voltage greater than 5 volts, chances



Completed modifications to the TNC. The DB25 has been mounted on the back panel, and the 20-pin header plug has been plugged into J5. The jumper for VHF operation (as shown in *fig. 3*, but now with hood installed) has been plugged into the DB25 connector and can be seen at the top of the photo.

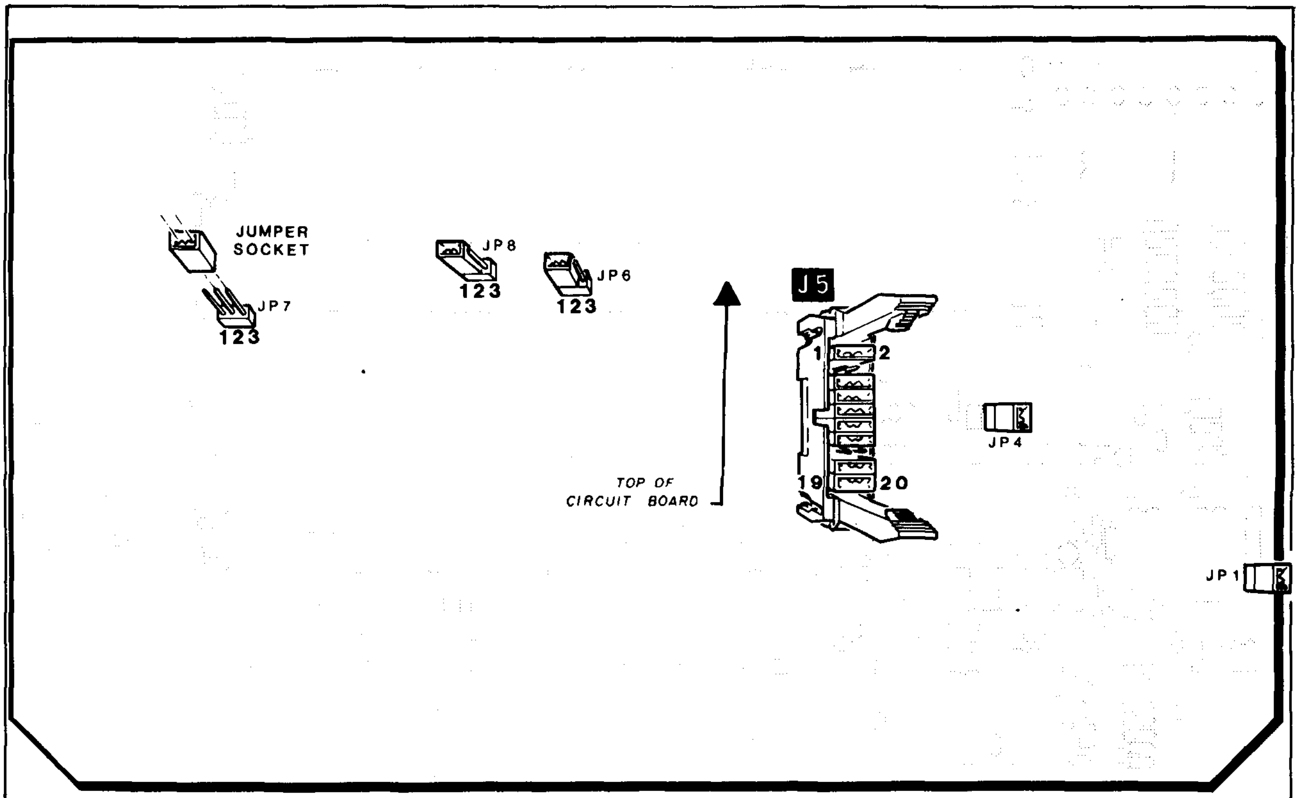


fig. 2. Diagram from the Heathkit manual shows the header plug J5 pinouts. The WD 1935 HDLC chip is to the left of J5, but is not shown in the figure (see *photo 5* as well). Pins 1-20 are connected to pins 1-20 respectively on the back panel mounted DB25 connector. (Photo courtesy of Heathkit.)

are that the output is RS-232 and should not be used. *Some of the better units have both TTL and RS-232* inputs and outputs. Be sure to use those designated TTL.

If you have only RS-232 inputs and outputs you can build a simple circuit to convert them to TTL (see **fig. 1**).

TU candidate

I had been using the Heath HD-3030 RTTY Computer Interface on both VHF and HF RTTY for some time. This unit had a wonderful tuning indicator built in and the TU had proven its reliability under noisy conditions. It could also operate at 300 baud, the rate used for HF packet. In addition, the HD-3030 TU had an RDA (Receive Data Available) output that could be used as a "channel busy" indication. TTY inputs and outputs were also available. It met all the requirements mentioned above, and thus was an *ideal* choice for use as an external modem.

modifying the TNC

Before modifying the TNC, it is strongly recommended that you first get it working on 2-meter FM or some other VHF frequency. This way you can be sure that the TNC is operating properly. If you don't have a VHF radio, find a ham who's running packet radio and let him or her hook your TNC into his or her system. This will also allow you to gain some familiarity with the operation of the TNC. After you're sure that the TNC is working properly, you can start the modification.

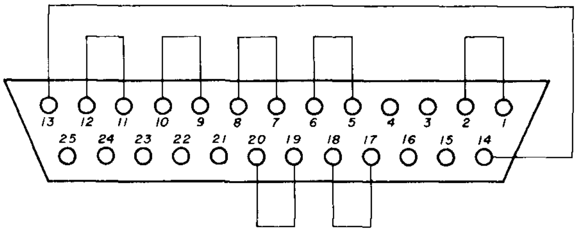


fig. 3. Wiring of the jumper plug used for VHF operation. *Photo 2* shows this jumper plugged into the newly installed DB25 connector.

You'll need the parts shown in **table 1**.

The first step is to make the hole for mounting the female DB25 connector on the back panel of the TNC in the area marked "caution." (Be sure to remove the board while making the hole for the connector.) Because it's much easier to solder the ribbon cable

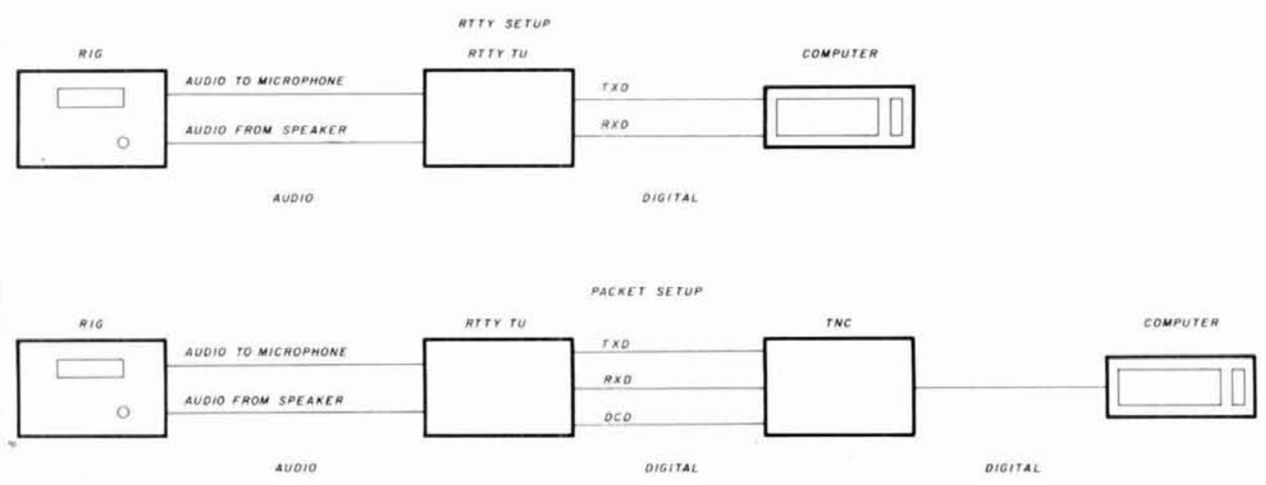
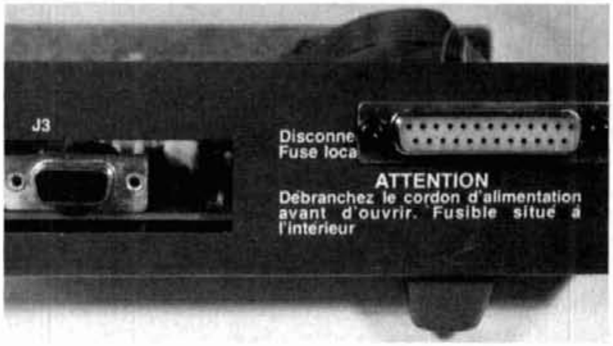
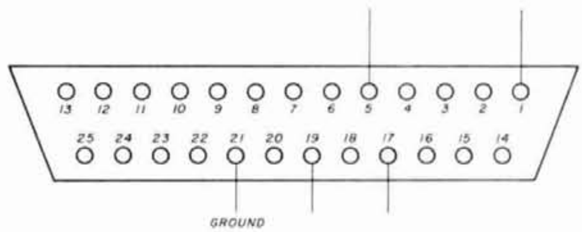


fig. 4. Comparison of RTTY and packet setups when an external modem is used for packet operation. Clarifies which signals are audio and which are digital. Note that the PTT lines have been omitted for clarity.



Rear view of the TNC after modifications have been completed. J3 is the transmitter jack. (See also *fig. 5.*)



MSCOP(PTT) — AN OUTPUT FROM THE TNC. THE PUSH-TO-TALK LINE TO THE TRANSMITTER. LOW MEANS TRANSMIT; HIGH MEANS RECEIVE.

CARRIER DETECT IN (DCD) — AN INPUT TO THE TNC. LOW INDICATES THAT THE CHANNEL IS BUSY.

TRANSMIT DATA (TXD) — AN OUTPUT FROM THE TNC. DATA TO BE MODULATED BY THE TERMINAL UNIT.

RECEIVE DATA (RXD) — AN INPUT TO THE TNC — DEMODULATED DATA FROM THE MODEM OR TERMINAL UNIT.

fig. 5. Diagram and explanation of the important pins on the newly mounted connector as viewed from the back panel. (See also *photo 3.*)

to the connector before it has been mounted, make the hole but don't mount the connector yet. After you've cut the appropriate mounting holes, re-install the board in the cabinet.

Next, connect the 20-pin header plug to one end of the ribbon cable. Be very careful to keep track of which pin is pin 1 and which is pin 20 (see **fig. 2**). Now solder the other end of the ribbon cable to the DB25 connector. The wire from pin 1 of the header plug should go to pin 1 of the DB25. The wire from pin 2 of the header plug should go to pin 2 of the DB25, and so on up to pin 20. *Be very careful not to get any of the wires crossed.* Check the cable with an ohmmeter when you're done. Finally, connect the solder lug to one end of a 3 inch (7.62 cm) wire. Connect the other end of the wire to pin 21 of the DB25 connector.

Feed the header plug, ribbon cable, and wire with solder lug through the mounting hole from the back and mount the DB25 connector (**photo 1**). Connect the solder lug to the closest available ground. (A circuit board mounting nut is perfect.) Plug the header plug into the header at J5, put on the cover, and you're all done! (See **photo 2**.)

So far, what we've done is to move the modem connector from the circuit board to the back panel. For

table 1. Parts needed for modification of the TNC.

25-pin female DB25 connector
25-pin male DB25 connector and hood
No. 6 solder lug
20-pin connector to fit header J5
about 9 inches (23 cm) of 20-conductor ribbon cable

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normal operation, it will be necessary to make a jumper plug to replace the jumpers that were originally at J5. To make a jumper plug, take the male DB25 and solder jumper wires between the following pins: 1-2, 5-6, 7-8, 9-10, 11-12, 13-14, 17-18, 19-20 (see **fig. 3**). Put the hood on the connector and plug it into the previously installed DB25 connector.

That's it! At this point, you should verify that the TNC functions normally on VHF. If it does not, then there's a wiring error somewhere and it must be fixed.

between the TU and TNC

Even the most experienced ham is likely to be intimidated by the external modem section of the TNC manual, in which each pin ofJ5, the modem connector, is described in great detail. Fortunately, however, we need concern ourselves with only four of the 20 pins: two of these pins are used for input, and two are used for output from the HDLC chip. Before proceeding with the details, a description of these inputs and outputs is in order.

TNC digital inputs and outputs

When the TNC is operated with an external modem, it's important to realize that the inputs and outputs are not audio signals, but digital signals. It is the purpose of the external modem (MODulator-DEModulator) to convert the digital signals into an audio form that can be used by the radio link, and vice-versa. The only difference in using your TU for packet instead of RTTY is that instead of hooking it directly to your computer, you hook it to the TNC, and it's the TNC that communicates directly with your computer (see **fig. 4**).

There are four lines, besides ground (GND), that connect the TU to the TNC. Two go from the TNC to the TU, and two go from the TU to the TNC. The pin designations are for the DB25 connector installed earlier (see **fig. 5**). Recall that there's a 1:1 correspondence between pins 1-20 of J5 and pins 1-20 of our newly installed connector.

The two output lines that run from the TNC to the TU are labeled "MSCOT" and "TXD."

MSCOT (PTT) (Pin 5) is an output from the TNC to the modem. The name is, unfortunately, a real misnomer: MSCOT stands for "Miscellaneous Output," but this is nothing more than the TNC's PTT (Push-To-Talk) line. When the TNC drives this line low, the transmitter should be keyed or the TU should go into SEND mode. This should be connected to the TU's SEND or PTT input. *Do not use this pin to directly key your transmitter.* Doing so could damage the TNC.

TXD (Pin 19) stands for "Transmitted Data." The data output of the TNC, will normally be connected to the TU's "AFSK INPUT." (AFSK stands for "Audio Frequency Shift Keying.")

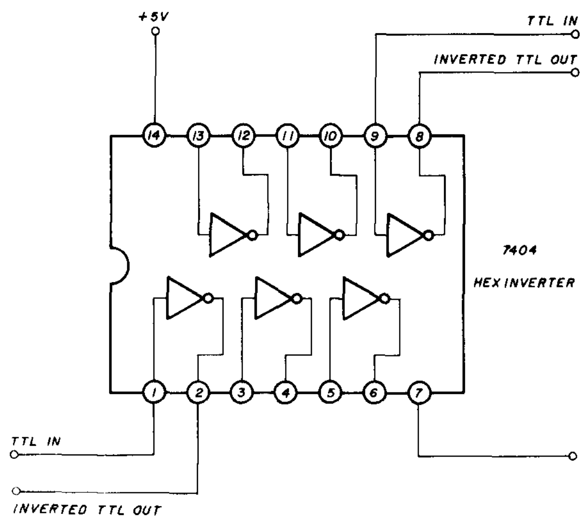

fig. 6. Circuit used for inverting TTL signals, necessary when a TTL signal on a non-Heath TU is inverted (i.e., when RDA is high when it should be low, etc.). The 7404 is available at Radio Shack (part No. 276-1802). Top view of the chip. (This circuit, reproduced with permission, originally appeared in Don Lancaster's *TTL Cookbook*, published by Howard Sams & Co., Inc., 1978.)

table 2. Connections for the HD-3030 RTTY TU.

TNC pin number			Heath TU pin number	
1	(DCD)	to	1	(RDA)
5	(PTT)	to	9	(SEND-N)
17	(RXD)	to	3	(DMOUT-TTL)
19	(TXD)	to	5	(AFSKIN-TTL)
21	(Ground)	to	21	(Ground)

The two input lines running from the TU to the TNC are labeled "Carrier Detect In" and "RXD."

CARRIER DETECT IN (Pin 1) — or "DCD" for "Data Carrier Detect" — is an input to the TNC that tells the TNC when the channel is busy. A low on this line indicates that a carrier (mark or space) is present and that the TNC should not transmit. This is usually connected to the TU's "RDA" (Receive Data Available) output. Note that a low indicates that the channel is busy. If your TU's RDA output is high when the channel is busy, you'll have to use an inverter circuit (see **fig. 6**).

If you don't have an RDA output on your TU, you may be able to make use of its "autostart circuit" if it has one. What you need is a TTL output that's low (0 volts) when mark or space is present, and high (3-5 volts) when mark or space is NOT present. Autostart circuits vary greatly, so you're on your own here.

RXD (Pin 17) is the "Received Data" input to the

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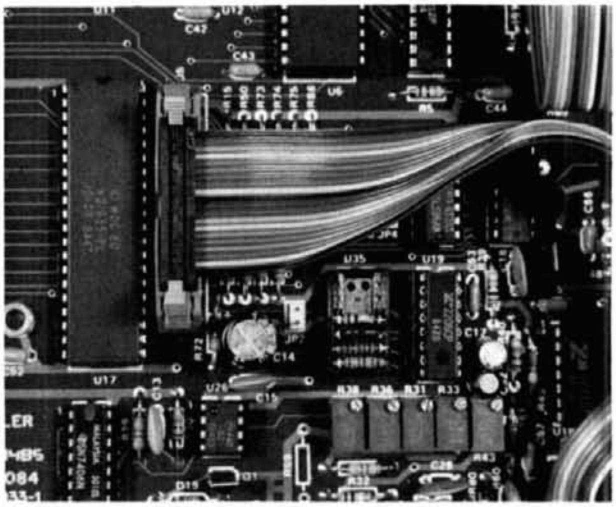
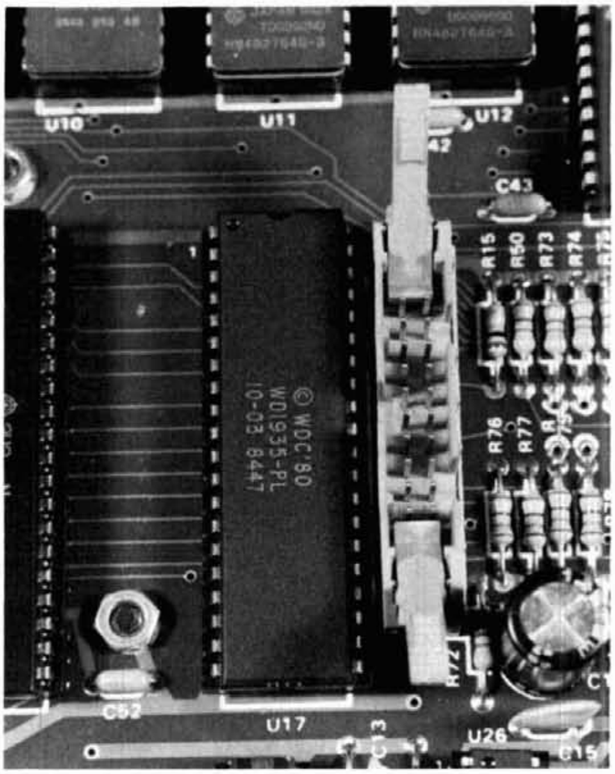


Closeup of J5 with 20-pin header plug installed. (See also *fig. 2*).



Closeup of J5. The WD-1935 HDLC clip is seen to the left of J5. (See also *fig. 2*.)

TNC. After your TU has decoded the audio tones and converted them back into a digital signal, that signal is applied to this input. This normally goes to your TU's "DMOUT" (DeModulator OUTput) pin.

These four lines, in addition to a ground lead, are all that's needed to connect the TNC to your TU!

By the way, don't worry if the data lines "TXD" and "RXD" might be inverted or "upside down." It's the TRANSISTIONS from mark to space that count in packet radio. The result is that the data can be "right side up" or "upside down." It will work either way!

HD-3030

The connections given below are for the HD-3030 RTTY TU. If you plan on using a different TU, you'll have to work out the connections based on the information given above.

You'll need two 25-pin DB25 male connectors and hoods and a length of 4-conductor (plus ground) cable long enough to run from the TU to the TNC. Keep it as short as possible. Shielded cable is preferred. Make the connections shown in **table 2**.

It will also be necessary to solder jumpers between the following pins on the TNC connector: 7-8, 9-10, 11-12, 13-14. Note: these jumpers should be installed no matter what TU you use (see **fig. 7**).

That's all there is to it, (although you must, of course, also make the appropriate connections to the transmitter and receiver as you did for RTTY operation). Use a label maker to label the connectors so you can keep track of which goes to the TNC and which to the TU.

modifications to the TU

The modifications to the Heath TU are minimal. The time constant of the RDA circuit is much too long for packet operation. To reduce the time constant to a value suitable for both RTTY and packet, replace capacitor C29 (a 4.7 μF electrolytic) with a 0.047 μF capacitor. If you don't plan to use the TU with RTTY, then a value of 0.01 μF is more suitable. Some readjustment of the RDA threshold may also be necessary, as explained below.

making it work

If you're still with me and have performed all the necessary modifications (there really aren't that many), you should be ready to start operating. Unplug the jumper from the back of the TNC and connect the previously prepared cable from the TU to the TNC. Make the appropriate connections between the TU and your radio, and between your computer and the TNC.

The various settings of the TNC can make or break the performance of your packet system. I recommend the following settings as a starting point:

PACLEN	60
HBAUD	300
AXD	6
DWAIT	0
TXD	1
FRACK	6
MAXFRAME	1

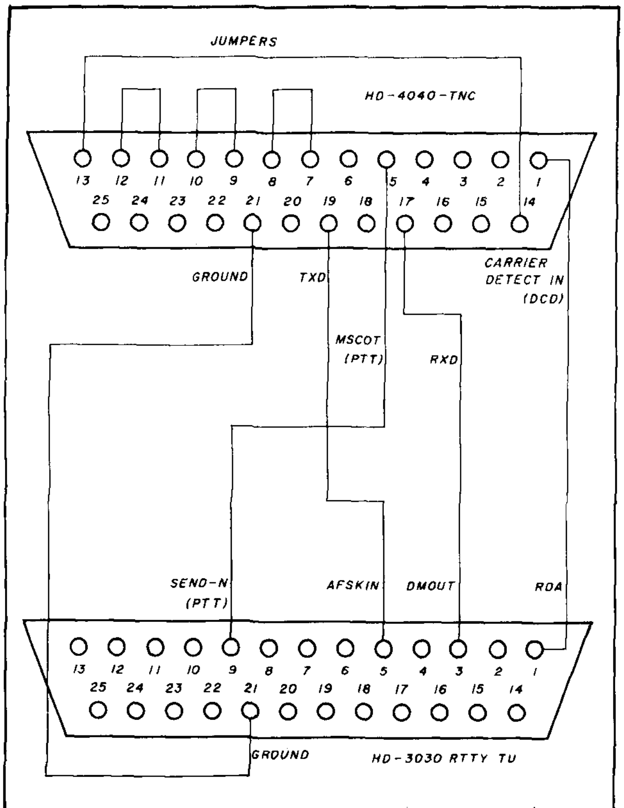


fig. 7. Connections between the Heath HD-4040 TNC and the Heath HD-3030 RTTY TU. Both connectors are shown as viewed from the back of the corresponding unit.

The time settings AXD, DWAIT, and TXD will give adequate key-up delay while minimizing the delay in transmitting once the channel clears. The parameters PACLEN, FRACK, and MAXFRAME are set to minimize the lengths of packets and transmitter "on" time. This results in fewer retries and increased throughput on the frequency. You can, of course, experiment with all of the settings except HBAUD, which must be set to 300.

NOTE: There's a bug in the resident TNC software (Version 3.2). The TNC won't properly receive packets at 300 baud until it has sent a packet or done a CW identification. Also, on powerup, you may get an "HDLC Can't Init" error. Don't worry. This is also easily solved by making the TNC identify. Therefore, after setting HBAUD to 300, or after powerup, enter ID <RETURN>. This will cause the TNC to identify and initialize the HDLC chip so that you can receive packets.

It's best to gain some listening experience before jumping into your first QSO. Tuning is critical, and there's no point trying to transmit packets unless you can receive them.

Make sure that you've enabled all of the TNC monitor functions: (M ON, MALL ON, MCON ON, MFROM ALL, MTO ALL, MAX FRAME 1). Next, set your receiver bandwidth to approximately 1 kHz. (After receiving packets you may be able to use a narrower bandpass, but in some receivers 400 Hz to 500 Hz is too narrow for proper operation.) Tune your receiver to one of the HF packet frequencies currently in use: 7.097, 14.103, 14.105, or 14.107 MHz. The latter is a good choice to start with because it's usually active at all times of the day, and signals are usually fairly strong.

Packet signals make a very distinctive whirring noise. But you must tune quickly, because individual packets don't last long. Tune as if you were tuning in an RTTY station, but note that the packet will not be displayed until all of it has been received. (This is why you must be able to tune "blind.") Also, if there are any errors in the packet, it won't be displayed. After a little practice you'll get the hang of it, and packets will be flying across your screen!

Transmitting is no problem, although you may find that the TNC waits a long time before transmitting the packet. These long waits (sometimes almost forever) are caused by the TNC's "thinking" that the channel is busy when it really isn't. This usually indicates that the signal on the "Carrier Detect" or DCD input is hanging on too long. With the Heath TU, this means that the RDA (Receive Data Available) indicator is hanging on too long. To keep this from happening, reduce the receive audio to the minimum needed to trip the RDA circuit. Also adjust the RDA threshold so that the circuit trips at the highest allowed audio level. These settings will cause the RDA light to go off as quickly as possible once the frequency is clear.

Other TUs may also exhibit the same problem. The cure is to simply find a way to reduce the time constant of the circuit driving the "Carrier Detect" or "DCD" input of the TNC to a suitably low value. If the time constant is too long, the TNC will think the frequency is always busy and never initiate a transmission.

conclusion

This TNC-RTTY TU combination has been in use for almost a year with good results. Switching between HF and VHF operation is very easy, since all one need do is remove the jumper on the back of the TNC and plug in the TU.

I hope that the information given here will enable many people to get in on the fun of HF packet radio. The interfacing information under "Digital Inputs and Outputs" should also be useful to those VHF operators who want to try using very high speed modems or some of the exotic modulation techniques that are permitted on the VHF bands.

ham radio

VHF/UHF WORLD

Joe Reisert W1JR

microwave and millimeter wave propagation: part 2

Last month's column, an introduction to microwave and millimeter-wave propagation, provided tables of frequency allocations and DX records established on these frequencies.[1] It stressed that at present, the primary mode of propagation on these frequencies is line-of-sight (LOS).

It was further noted that the apparent attenuation of an RF signal between two stations is more of a *physical* phenomenon than an *electrical* parameter. This is because of the decrease in the wavelength or size of a dipole antenna and hence its capture area. Therefore, if transmitter power, receiver sensitivity, and the size of the antenna are kept constant, the signal-to-noise ratio will actually *increase* as you go higher in frequency! This apparent "path loss" can be calculated using the equations and graph found in reference 1.

Ironically, the same propagation modes that serve as media for DX are the bane of commercial microwave users because they can induce path disruptions, outages, or interference. These modes — which microwave users often call "non-standard" or "anomalous" propagation — are the very ones that Amateurs are interested in exploiting for DX purposes.

tropospheric propagation

LOS propagation assumes that both stations can "see" each other. But this would be true only if you were operating in a complete vacuum, where the speed of light is constant. In the Earth's atmosphere, the presence of atmospheric gases and water molecules causes radio waves to travel more slowly.

In a standard atmosphere, the barometric pressure, temperature, and water vapor content all decrease linearly as altitude increases. Atmospheric density — the combination of these properties — also decreases with altitude. When microwave or millimeter-wave signals pass from dense air to thinner air, they undergo a change in direction proportional to the difference in density; this happens because the portion of the wavefront that enters the thinner air layer first begins to travel faster than the portion still in the dense air.

The result is a bending or refraction towards the denser air, which causes the signals to follow the contour of the Earth. Hence under normal weather conditions you can usually work about 25 to 50 percent further than the LOS path. If there's an extreme drop in atmospheric pressure with increasing altitude, anomalous or possibly extended propagation may occur; Amateurs often refer to this phenomenon as a "tropo" opening.

The amount of bending, known as the *refractive index gradient*, is more frequently referred to as the Earth's radius factor, or K. During standard atmospheric conditions, K will be 1.2 for dry elevated areas and 1.33 for inland areas. What this means is that under normal conditions, the typical path distance is 1.2 to 1.33 times the LOS distance.

However, K may reach 2 or 3 in humid coastal areas, which explains why coastal stations often enjoy improved propagation, especially over water. If an abnormal weather condition is present, the K index may go below 1 or even negative. If this happens, the path may become trapped or completely blocked, greatly attenuating the signals on a given path.

tropo bending and super-refraction

One of the most widely used DX propagation modes employed on the microwave and millimeter-wave frequencies is tropo bending. This often happens when the refractive index, K, goes positive beyond a value of 2.

If K gets very large, super-refraction takes place and microwave and millimeter-wave signals travel relatively unattenuated. They follow the curvature of the Earth for considerable distances until they reach a point where the K index drops back to normal. Methods of calculating the refractive index are discussed in references 2 and 3.

A rise in the K index results from changes in the atmosphere that result from abnormal weather conditions. For example, cool air passes over a warm body of water, causing evaporation of the water and a subsequent temperature inversion. Or a cold front may pass over an area of warm, stable weather, causing a marked decrease in total moisture content as altitude increases.

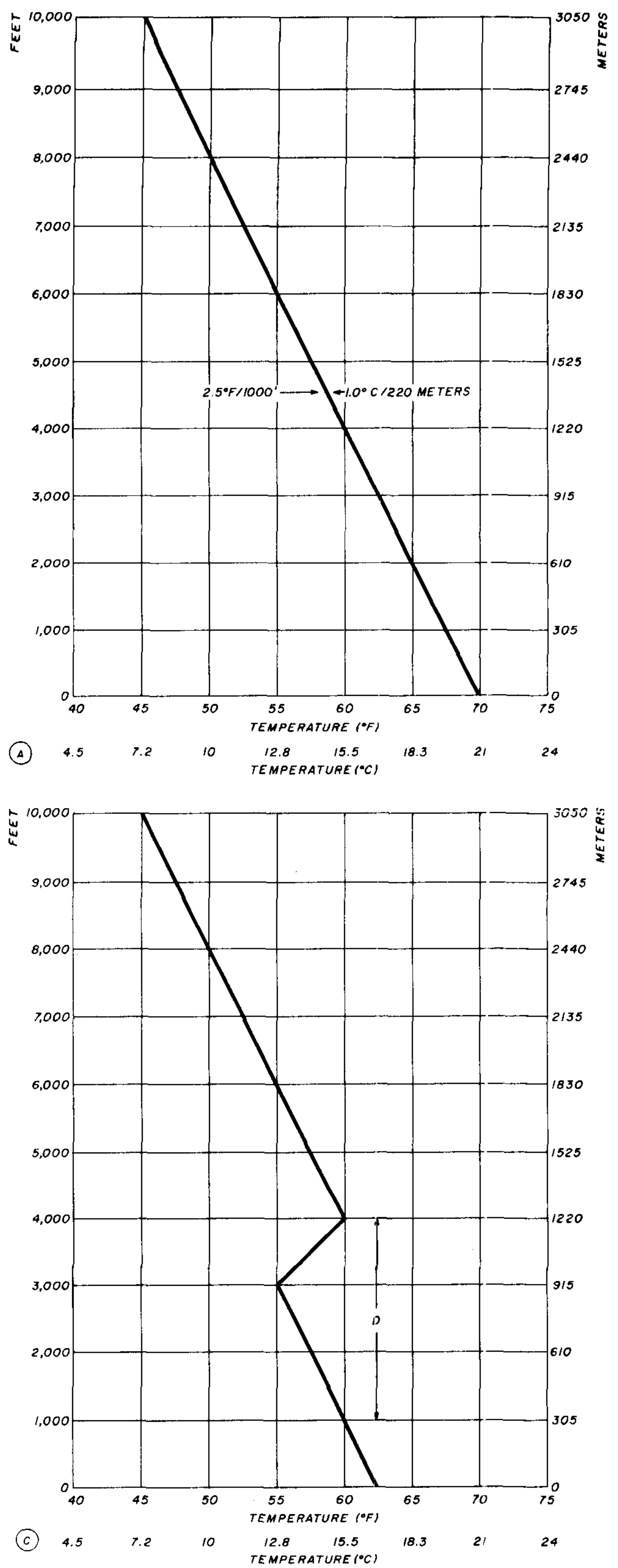


fig. 1. These graphs are examples of the standard atmosphere and typical ducts. (A) Temperature versus altitude graph of the "Standard Atmosphere." Temperature decreases approximately 2.5 degrees F per 1000 feet (1.0 degree C per 220 meters). (B) Typical evaporation duct that often happens over warm bodies of water is caused by a temperature inversion near the surface. "D" is the duct height. (C) Elevated duct. (D) Elevated duct that has its lower limits right at the surface.

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These conditions typically occur between late spring and fall, but can happen at any time of the year. Openings also tend to be more pronounced in the evenings and around sunrise. They occur less frequently around noon, when the sun tends to warm the layers more uniformly.

In the southern portions of the continental United States, especially near the Gulf of Mexico, tropo openings begin in the late winter and continue through the spring. Optimum DX conditions across the Pacific between the west coast of the continental United States and Hawaii tend to peak in the summer. In the regions north and east of the Mississippi River, the longest overland DX via tropo bending tends to peak in the late summer and early fall.

At colder temperatures, the contribution of water vapor to refractivity is small because the saturated vapor pressure is low. However, at higher temperatures, humidity plays an increasingly important role in refraction. Therefore, refraction changes are least expected at northern latitudes but can be severe in hot, moist climates, especially in the equatorial regions.

The best DX conditions occur when the weather has been warm with high barometric pressure typically above 30.3 inches, and especially when a high pressure region is stalled or moving slowly across an area.[4,5] Then, if a weather front approaches, the high will move away, the barometric pressure will fall, and an opening may occur even if the barometer drops lower than 30 inches. I've noticed, by the way, that the best contacts take place between stations that have similar barometric pressure.

ducting

When the K index gets very high, a duct may form near the surface of the earth. These ducts act like a waveguide and propagate signals with extremely low attenuation. The height of the duct determines the range of frequencies that will propagate best within the duct.

Figure 1A shows the so-called "standard atmosphere." Note that temperature decreases at a uniform rate with increasing altitude. For comparison, temperature typically drops about 2.5 degrees F per 1000 feet.

Figure 1B shows the typical atmosphere when a temperature inversion is present. If the bend is sharp enough, a duct will form. This condition typically occurs over warm bodies of water and is caused by temperature inversion near the surface of the water. Signals present below the duct will be slightly attenuated. However, if you're above the duct, as you might be during hilltop or mountaintop operation, your signal will undergo severe attenuation towards the duct and you may find communications to be impossible — although others *in* the duct may be experiencing good conditions.

Figure 1C shows a typical profile for an elevated duct. In this case, elevated or mountaintop stations at the proper elevation will experience little or no signal attenuation. Those above or below the duct will experience severe attenuation. This profile is very typical of the ducting that occurs between California and Hawaii at the Hawaiian end. It was carefully measured in the late 1950s by U.S. Navy planes flying at various altitudes near the Hawaiian Islands while monitoring beacons from the California coast.

In the mid-1970s several Amateurs observed this characteristic by driving up and down the side of Mauna Loa on the island of Hawaii. This is one of the reasons that propagation beacons are now located just over 8000 feet above sea level on the side of Mauna Loa. An elevated duct could drop over the path and actually touch the surface as shown on **fig. 1D**. This is probably the typical situation at the California end of the trans-Pacific tropo records.

During the ARRL VHF contest in September, 1984, there was strong evidence to suggest that an elevated duct was the cause of the long distance covered. Jim Stewart, WA4MVI, decided to test the theory by flying a private aircraft at various altitudes on the southern end of the openings (in western South Carolina, in grid square EM-84). He monitored the 432.1-MHz signal of W2SZ/1, located on Mount Greylock in western Massachusetts at about 3500 feet above sea level.

The elevated temperature data he took, shown in **fig. 2**, is unmistakably that of elevated ducting. Signals were strongest between 6000 and 8500 feet above sea level. Signals were very weak above 9500 feet and barely readable above 10,000 feet. Signals decreased slowly below 4000 feet. Ironically, the wind speed in the duct was 40 to 45 knots from the east, but 30 knots from the west above the duct! Hurricane Diana was located just off the northeast coast of Florida at the time.

Unlike a metal waveguide, a duct doesn't have a sharp cutoff frequency. It has a rather slow transition from good trapping (low leakage) to poor trapping (high leakage). The cutoff frequency of a duct is the lowest frequency that will support propagation.

Generally speaking, the duct improves as the frequency is increased until the walls of the duct become too irregular for propagation. Furthermore, the cutoff frequency of a surface duct is lower than that of an elevated duct.[6]

Duct heights of 150 to 1500 feet are most common and seem to be optimum for frequencies of 50 MHz through 1500 MHz[3,4]. Thinner ducts that favor the microwave frequencies are present but are harder to use because of their narrow height. The Europeans have been exploiting these narrower ducts for years by operating on beaches and near large bodies of water during the times of the year when these conditions are most likely to occur. By moving your station and antenna height around, an optimum location can be found — if ducts are present.

scattering

Many types of scatter propagation are especially useful on the microwave frequencies but often overlooked by Amateurs. These include, but are not limited to, aurora, tropospheric scatter, aircraft scatter, rain scatter, light-

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107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311	323	335	347
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
109	121	133	145	157	169	181	193	205	217	229	241	253	265	277	289	301	313	325	337	349
110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314	326	338	350
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315	327	339	
112	124	136	148	160	172	184	196	208	220	232	244	256	268	280	292	304	316	328	340	

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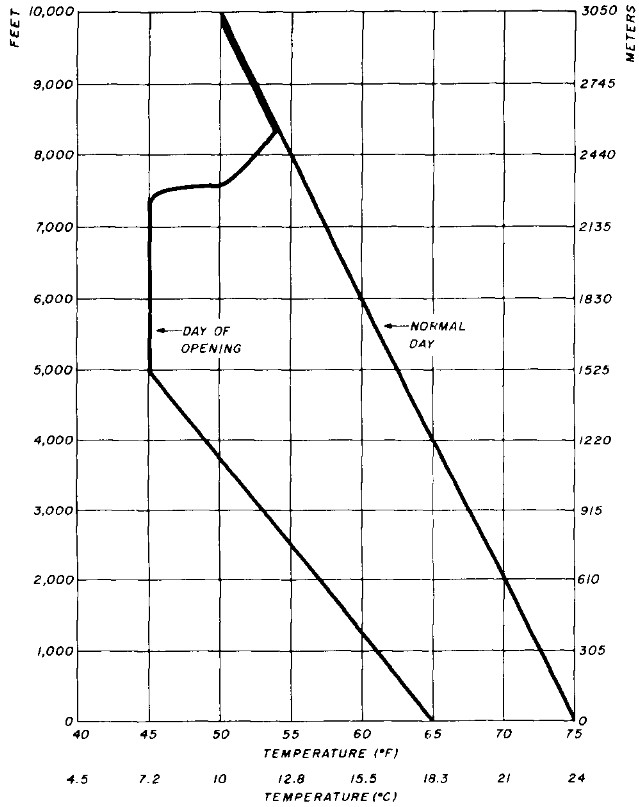

fig. 2. Temperature versus altitude for a typical day as well as data taken at 1400 UTC on September 9, 1984, in the western portion of South Carolina. WA4MVI measured the temperature from an aircraft. Note the breaks at 5000 and 7400 feet (1525 and 2255 meters). See text for further information.

ning scatter, knife-edge diffraction or obstacle gain, and scatter from tall or large objects.

Generally speaking, scatter modes are much more lossy than tropospheric propagation but provide a means to communicate when the normal modes of propagation aren't available. Thus they can provide moderate to long DX more regularly when properly understood and exploited. Because they're more lossy, use better equipment such as higher power and greater antenna gain (more on this later).

Aurora. This mode of scatter propagation has been widely exploited on the frequencies below 450 MHz.[4,5] **Table 4** in reference 5 lists recent records, although all of them were exceeded in the February 8, 1986 aurora. Professional studies have shown that auroral scatter is usable up through the 13-cm (2450-MHz) band, but I've never heard of any successful Amateur aurora QSOs above 450 MHz.

One of the problems with auroral propagation is frequency spread. As you go higher in frequency, signals are spread out over a wider bandwidth, so wide bandwidth (2 kHz minimum) receivers are desired. Aurora signals on the UHF bands usually sound as if the background noise level is being keyed to a higher level. Therefore, the received SNR is reduced.

Although this can be offset by using higher gain antennas, doing so also has its drawbacks. The higher the frequency, the narrower the "hot spot." Hence it will be more difficult to locate the optimum reflection point. Add this to the difference in geometry with the station to be worked and you have some fairly tight windows to match.

One of the parameters most overlooked by Amateurs operating auroral scatter is doppler shift. During the auroral opening on February 8, 1986, doppler shifts of up to 4 kHz were observed at 432 MHz. This is clearly out of the tuning range of the RIT on many modern transceivers! Needless to say, there was much QRM and many incomplete QSOs.

To work aurora on the microwave bands, look for a high MUF. This usually happens in the early portion of the opening, especially when radio station WWV is broadcasting a K index of 5 or higher. Other operating tips for detecting aurora are described in detail in references 4 and 5.

Because of the difficulty of properly aiming your antenna, time-sequenced schedules with stations on or within a few degrees of your latitude are recommended. The higher the power, the better — up to the legal limit — with a moderate (20 dBi maximum) antenna gain to maximize the chances of hitting the hot spot. Keep your transmitter frequency fixed and listen up to ±20 kHz! Let me know if you complete a QSO above 450 MHz so we can get you into the record book.

Tropospheric scatter. This mode of propagation, widely used in the commercial and government sectors, is often referred to as *troposcatter*. Huge billboard-type antennas are often used with high power for very high reliability communications over reasonable distances (120 to 620 miles) in the 400 to 5000-MHz frequency range. Even wideband systems such as multiplexed telephone links are used.

The principle of troposcatter is quite straightforward. There are numerous dust particles, clouds, and refractive index changes in the troposphere (1000 to 5000 feet above sea level) that can reflect or scatter microwave signals. If two stations want to communicate, all they have to do is to aim their antennas at a common volume or scattering spot as shown in **fig. 3.** Amateur troposcatter communications on frequencies even as high as 3 cm (10 GHz) have been successful, even with moderate (10 watts) power levels!

For best results the beamwidth of the antenna should be moderate (at least a few degrees) because too narrow a beamwidth will miss some of the returns from the scattering volume. Ideally, both stations should use approximately the same beamwidth. Antenna elevation angles should be higher for shorter distances and lower (1 to 2 degrees) for longer distances. For best results there should be a clear horizon because any obstructions will severely attenuate the signals.

Troposcatter can be quite reliable and yield good DX, especially on the microwave bands, but is seldom mentioned by Amateurs. The path loss is roughly equivalent to EME operation for the longer distances just mentioned. New low-noise GaAs FETs and recent developments in higher solid-state power amplifiers make antenna-mounted gear useful in decreasing feedline losses. Further information on troposcatter communications can be found in reference 7.

Aircraft scatter. References 4 and 5 mentioned the tremendous possibilities for QSOs using aircraft scatter out to 500 miles. As the frequency increases, so does the effectiveness of the scattering medium — i.e., the aircraft. Hence there are many possibilities for moderate microwave DX, especially if you live on a path where there are frequent flights, especially at higher altitudes such as in the midwest.

Communicating via aircraft scatter does require timing and patience. Because most aircraft travel at sufficiently high speeds, there will also usually be doppler shift. I have seen shifts approaching 1 kHz at 2304 MHz.

One other caution: aircraft are still quite usable even after they move off the direct path, but *only* if you and the station being worked both follow the aircraft by moving your antenna positions accordingly. I've observed azimuth changes up to 5 degrees at 13 cm; these can be catastrophic if high gain antennas are used. This microwave propagation mode represents an exciting possibililty for year-round communications.

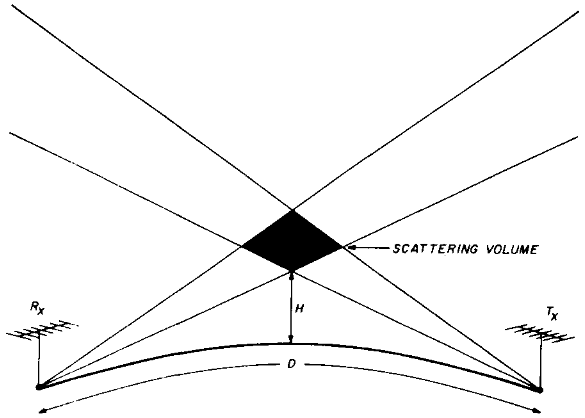

fig. 3. Geometry involved for conducting troposcatter communications, "H" is the height of the scattering medium and "D" is the Great Circle distance between the stations.

Lightning scatter. The possibilities of lightning scatter QSOs were described in reference 4. To my knowledge, this mode has been exploited only through 450 MHz, but should be usable through the microwave frequencies.

As described in reference 4, both stations should aim at the storm center. In this respect, communication will be sort of a cross between aurora and meteor burst because it will occur in bursts that coincide with the lightning itself. Hence communications may be erratic and doppler shift will be quite evident.

Although this mode of propagation has received very little attention, it should yield exciting opportunities for stations located in regions where lightning is quite prevalent, such as in the Gulf states and in the Rocky Mountains.

Rain scatter. This mode of propagation was only recently discovered in the UK.[4] Amateurs aiming their antennas in the direction of a severe rain storm noticed scatter communications over paths where normal communications were not possible.

Best results have been on 3 cm. In some cases one of the two stations involved was aiming straight up as a storm cell passed overhead. This mode should be possible at 5.6 GHz, but tests are inconclusive.

Millimeter propagation via rain scatter will probably not be possible, for reasons to be explained shortly. While this isn't a propagation mode for those using Gunnplexers, it should be quite exciting for well-equipped stations using narrowband communications gear. Stations with obstructed paths — and especially stations not situated at high locations — are particularly favored, especially if they can elevate their antennas.

obstacle gain

We often think that obstacles such as hills or mountain tops are impossible barriers to microwave and millimeter-wave signals, but this isn't true. Experiments have shown that if the peak on a mountain or hill is reasonably sharp, it can reradiate signals in a propagation mode called "knife edge diffraction"[4].

Commercial microwave communications stations have used this mode for many years. The sharper the peak and the closer it is to one end of the path, the more efficient it will be for diffraction. This is an ideal setup for stations located in valleys or those having obstacles that would limit LOS propagation.

Tall buildings, structures, hills, and mountains can also be used to scatter microwave and millimeter-wave signals. If no LOS path is available, but a tall structure or hill is present, both stations should aim at the structure or hill and scatter their signals that way. 23 cm and up seem to be ideal for this mode.

EME communications

This is another form of scatter communications. The path loss is typically 275 dB at 1296 MHz and proportionally higher as you go up in frequency. The background or sky noise temperature above 900 MHz is very low. A good low-noise parabolic dish, 12 to 15 feet in diameter, with a low-noise GaAs FET preamplifier and 100 watts, is more than sufficient to produce echoes at 1296 MHz and above. Furthermore, if the antenna size is kept constant, the signal strength will actually increase as you go higher in frequency!

The highest reported Amateur QSO via EME is at 2320 MHz. There are no reports yet in the new 33-cm band. The possibilities of EME are endless because there are typically 8 to 11 hours of moon-time every day of the year.

EME communications also yields a platform for testing new antennas, preamplifiers, and transmitters; you're able to listen to your improvements 2.5 seconds later! No more wondering if your gear is functional or if the band is open but no one's there. You *know* that path is open! EME offers a great challenge and is within Amateur capabilities at least through 3 cm!

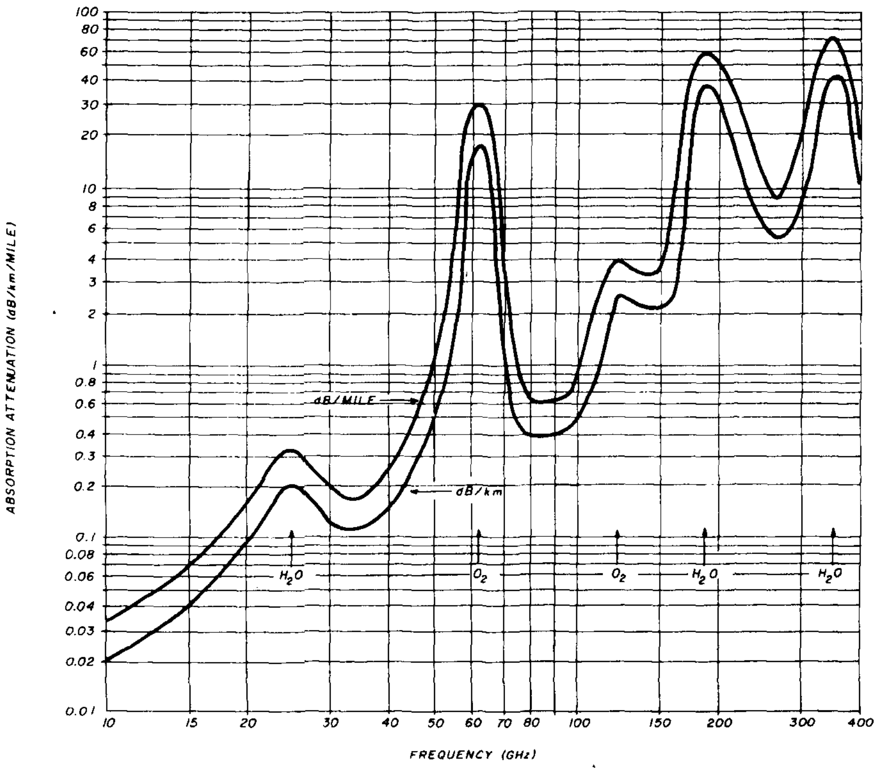

fig. 4. Additional attenuation that is experienced due to the resonance frequencies of water and oxygen. The upper data is for attenuation in miles and the lower data is for kilometers. ***Note that the attenuation is a function of frequency as well as distance. See text for further explanation.***

millimeter-wave propagation

So far, most of the propagation modes mentioned apply mainly to microwaves. Millimeter-wave — or the world above 3 cm — is definitely more challenging than the microwave frequencies. Tropospheric and some of the scatter modes of propagation are available but more difficult to explore fully. With the millimeter-wave gear presently available, most operation depends upon LOS propagation.

But it won't always be easy. Why? Because as you go above 20 GHz, you approach the resonance frequencies of water and oxygen. As a result, there may be unexpected attenuation due to absorption, especially on certain frequencies, *some of which are in or near our Amateur bands.*

Furthermore, fog and rain have a pronounced effect on millimeter-wave band performance. Two things must be remembered for improving millimeter-wave operation: first, for greatest distances, operate on a day when the humidity is low. This probably means the late fall or even winter — definitely not the time of year during which you'd normally expect to set DX records. Second, as you go higher in altitude, absorption attenuation and humidity usually drop, so mountaintopping is highly recommended.

Figure 4 is useful for determining the additional path loss due to water and oxygen absorption. Note that the additional path loss is not only a function of frequency but also of path length. Therefore, in order to determine the nominal loss on a millimeter-wave path, you have to first determine the normal LOS path loss using **eqns 1** and **2** or **fig. 1** in reference 1 and then add this to the loss attributable to oxygen and water absorption.

For example, let's assume that you're calculating the LOS path loss for a 20-mile link on 24 GHz. Using reference 1, the nominal path loss is approximately 151 dB. **Figure 4** shows that the additional loss due to absorption is approximately 0.32 dB per mile because of the proximity of water resonance (frequency). So the additional attenuation is 6.4 dB for a total LOS path loss of approximately 157.4 dB. As a rule of thumb, the absorption attenuation will be about one-tenth the sea level value shown in **fig. 4** at 30,000 feet elevation. Anyone for trying Mount Everest?

The absorption losses at 48 GHz are

about the same as at 24 GHz, although the LOS path loss is 6 dB higher. However, on our new 4-mm (76 GHz) band the absorption losses would be about 5 times higher! This is true because the latter band is close to the resonance frequency of oxygen.

The 75 GHz band, then, is a real challenge to Amateurs. Late-breaking news is that the first known Amateur QSO on 75 GHz took place on December 30, 1985, between HB9AGE and HB9MIN at a distance of 0.3 miles. Congratulations!

passive reflectors

Special reflectors can be used to great advantage on the upper microwave and millimeter-wave bands. They can scatter signals in a manner similar to that of obstacle gain just discussed.

However, while mountains can't be easily moved, passive reflectors can be optimized because the direction can usually be controlled. One type of reflector, often called a "billboard," is commonly used in the commercial community in situations in which mountains or hills must be spanned but the equipment can't be mounted high enough. As with knife-edge diffraction, the optimum solution is to mount the reflector closer to one station rather than at or near the middle of the path.

A special variation of the passive reflector popular among European Amateurs is the "flyswatter" or "periscope" antenna.[8,9,10] Often used on 3 cm and above, its active equipment is mounted near the ground. Its power is radiated from a horn or small parabolic dish antenna aimed directly at a large reflecting surface placed at a 45-degree angle between 50 and 100 feet above this radiator. The reflective surface reradiates most of the RF inthe desired direction. This antenna configuration is particularly recommended for stations that would normally require long runs of transmission line.

repeaters

Although this particular column addresses weak-signal work, I would be remiss if I didn't at least mention active repeaters. Let's face it: FM repeaters are everywhere. For technical reasons, it's often desirable to separate the receiver and transmitter by a good distance, so there's the need for a link between the two sites.

Low-power links are usually all that's required to connect the repeater receiver and transmitter. Microwave links, even those as simple as Gunnplexers, are ideal for this type of communications. So when you access a 2-meter FM repeater, you may be using the microwave bands without even knowing it!

major obstacles to communications

So far I've been stressing the positive possibilities of microwave and millimeter-wave propagation. But to be honest, communication on the microwave and millimeter-wave frequencies has its shortcomings — but these are usually a challenge to the enterprising Amateur.

Ice, rain, and fog surely present problems, especially on the millimeter-wave bands as just discussed. Try to work around them by choosing clear, dry weather or by operating from a high location when attempting new DX records.

Foliage attenuation — even that caused by evergreens — can totally disrupt a microwave path. In fact, the additional attenuation from deciduous and evergreen foliage can even be noticed at as low as 2 meters! On 23 cm and above, pine needles act like reradiating dipoles that significantly increase the attenuation on a particular path. Operation in the winter is no real cure-all, either, since most of the good tropo types of propagation aren't prevalent at this time of year. Recently there's been a lot of interest in foliage attenuation, especially in mobile communications and on the microwave bands. In fact, some typical data is just beginning to be correlated. It's been suggested that between 200 MHz and 95 GHz, attenuation can be calculated — if the depth of a grove of trees to be penetrated is less than 1200' feet — using the following equation:

$$L = 0.187 \bullet f^{0.284} \bullet D^{0.588} \quad (1)$$

where L is loss in dB, f is frequency in MHz, and D is depth of the grove expressed in meters. The CCIR Study Group recommends a more simplified equation:

$$L = 0.2 \bullet f^{0.3} \bullet D^{0.6} \quad (2)$$

For example, using a scientific calculator, the attenuation through a 10-meter grove of trees at 1 GHz would be about 5.15 dB using **eqn 1** and 6.32 dB using **eqn 2**. Although there are differences, this may be the first time that Amateurs may be able to quantitatively determine the destructive effects of foliage attenuation.

Before leaving the subject of obstacles to propagation, it may be appropriate to again review the subject of antenna height. I've pointed out many times that the maximum height for Amateur antennas on VHF and above should be 2 to 3 wavelengths, or just above any local obstructions, whichever is higher.

This factor is particularly true as frequency increases. A taller tower requires a longer transmission line that can often increase attenuation at a faster rate than the increased gain attributable to greater antenna height. The overall loss of transmitter power is important, but the loss in the received signal is often more important, since the noise levels are usually so low above 1 GHz.

summary

This two-part series was prepared to give an overall view of microwave and millimeter-wave radio propagation and how to best exploit DXing on those bands. Many of the typical propagation modes — and some of the lesser known ones — were discussed. Light waves were not discussed because they're a subject in themselves.

Because the majority of radio propagation conditions that facilitate DX operation are called "anomalous" or "disruptive" by commercial and government users, most research has been done from a negative point of view. It is up to Amateurs to see the positive side of this data.

Many of the references used in preparation of this column weren't detailed because they are cited in the references listed, particularly in references 4 and 5.

acknowledgements

I'd like to thank Jim Stewart, WA4MVI, for sharing his meteorolgical data on the now-famous east-coast tropo duct of September, 1984.

See you soon on the microwave and millimeter-wave bands!

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important VHF/UHF events:

August 2-3	*ARRL UHF Contest*
August 12	*Predicted peak of the Perseids meteor shower at 0700 UTC.*
August 16	*EME perigee*
August 28-31	*"Microwave Update 1986 Conference," Estes Park, Colorado (contact W0PW).*
September 6-7	*International Region 1 VHF Contest.*
September 12	*EME perigee*
September 13-14	*ARRL VHF QSO Party.*
September 26-27	*First ARRL 10 GHz Cumulative Contest.*

ham radio

how to plot great circles on your favorite map

Bearings at a glance for the Amateur DXer

Many active hams can recall the tremendous activity of the FCC in the years just before and during World War II. At the time, the authors were engineers engaged in developing a system for intercepting unauthorized, possibly subversive, radio transmissions and attempting to determine their source. These activities were part of the wartime mission of the FCC's Radio Intelligence Division (RID), under the direction of George E. Sterling, W1AE, and the late Charles A. Ellert, W3LO. Even before the United States entered the war, RID had developed a nationwide system of monitoring and direction finding for these purposes.

Shortly after the bombing of Pearl Harbor, the military requested that the FCC assume responsibility for radio security of the Territory of Hawaii. It also asked that a direction-finding system be established to provide navigational information for lost military aircraft flying over the Pacific Ocean, generally from the west coast to Hawaii. Six Adcock DF stations were located at strategic sites on Oahu, Kauai, Maui, Molokai, and the "big island," Hawaii. These stations maintained two-way radio communication with the Radio Security Center in Honolulu, where bearings on lost aircraft transmissions were plotted and evaluated, with the results then transmitted to Hickam Air Force Base.

At the Radio Security Center, bearings were plotted on a Gnomonic Projection map of the central Pacific area. Individual "compass roses" for each Adcock station were computed, using the meridian intercept system developed by Charles Ellert. It is a tribute to Sterling and Ellert that the Hawaiian system, with its DF bearings, safely brought in 272 lost bombers, hospital aircraft, and passenger planes during its two years of operation.

Computation of the compass roses for the DF stations was a laborious process. The hand calculator and computer had not yet been developed, and slide-rule calculations weren't sufficiently accurate, so logarithm tables had to be used. This article describes W3LO's system for computing great circle tracks using the meridian intercept method. All computation can be done with either a calculator or a computer; both methods are fully described.

making the map

Referring to a computer readout of bearings to each country can be slow and cumbersome when you're eager to snag a new one. It's much quicker and easier to refer to a map that shows great circle bearings from your location to all others throughout the world.

spherical geometry and maps

The earth is an oblate spheroid — a slightly flattened sphere. Maps are, of course, intended to represent all or a portion of the earth's surface; but the greater the area of the earth included, the greater the difficulty in achieving a realistic portrayal of the earth. (Try cutting a hollow rubber ball in half and flattening it . . . you'll get a good idea of the problem. Considerable distortion and deformation obviously result).

Latitude and longitude lines, the imaginary reference marks used to locate points on a map, correspond to equivalent points on the earth's surface. It is these lines that define a map's projection. But most maps are not truly projections in the geometric sense.

Several kinds of maps are commonly found in the radio room. Cartographers have developed special-purpose maps such as the Gnomonic, Lambert Conformal Conic, Polyconic, Albers Equal-Area, Azimuthal, and the familiar projection developed in 1538 by Gerhard Kramer, better known by his Latin sur-

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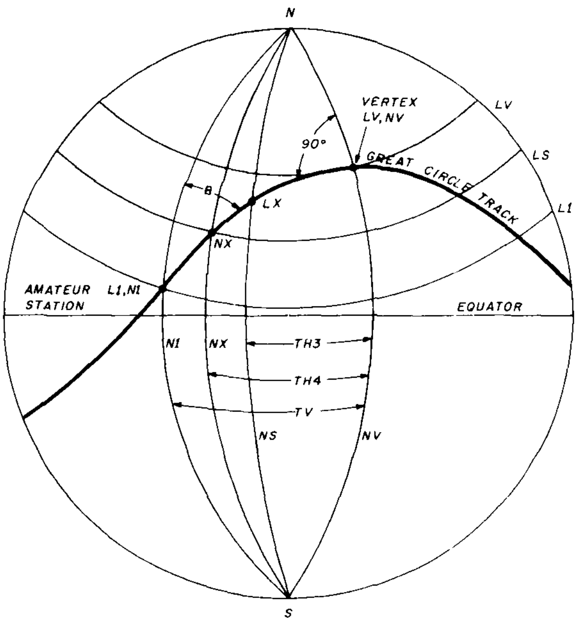

B	Bearing angle from Amateur station measured clockwise from True North
L1,N1	Latitude and longitude of Amateur station
LV,NV	Latitude and longitude of the Vertex
LS,NS	Selected latitude and longitude lines on which bearing intercepts are computed
LX	Latitude of Bearing B intercept on NS
NX	Longitude of Bearing B intercept on LS
TV	Longitude difference between the Vertex and Amateur station
TH3	Longitude difference between NV and NS
TH4	Longitude difference between NV and NX

fig. 1. Geometric Portrayal of pertinent latitude, longitude lines and great circle track intercepts for computation of Great Circle Tracks using the Meridian Intercept Method.

name, Mercator. An equal-area projection, the Mercator projection is simple to construct. It uses straight lines at right angles to each other for latitude and longitude. Its scale increases with latitude.

The Gnomonic Projection is the only map on which great circle tracks appear as straight lines. The more common azimuthal maps used by Amateurs are special cases of the Gnomonic. For radio bearings (i.e., azimuths) over considerable distances, this map has no equal. Even so, there are distortions (remember the rubber ball?), and individual "compass roses" must be computed for each station's location, except at the point of tangency. The Gnomonic is a perspective projection of the earth on a tangent plane, with the point from which the projecting lines are drawn being situated at the center of the earth.

Regardless of the map used, the path of a great circle track around the world will inevitably intercept latitude and longitude lines as it passes from the origin (station location) to the antipode. The object of this "meridian intercept" system is to determine where the great circle paths intercept selected parallels and meridians of latitude and longitude so that they can be plotted on a map.

the meridian intercept system

The diagram shown in **fig. 1** is the basis for the computations of intercepts using a hand calculator for solving the equations. The corresponding computer program is shown in **fig. 2**. Studying **fig. 1** and referring to a globe will help in visualizing the process more easily.

Although they may appear to be slightly different, the equations for the calculator* are identical to those used in the computer program. Although somewhat tedious, they do provide accurate results. The station location need be specified only to the nearest degree of latitude and longitude; this helps simplify calculation. Map distortion, plotting accuracy, and horizontal beamwidths of Amateur directional antennas make extreme accuracy unnecessary.

intercept calculations using a calculator

In **fig. 1**, coordinates of the Amateur station are L1, N1. The bearing, B, is represented by a heavy black line. Its great circle track reaches a maximum latitude at a point called the vertex, with coordinates LV, NV. For each great circle track there are two vertices, one east and one west of the Amateur station. If intercepts are computed for bearings from 0 to 180 degrees, reciprocals of those intercepts may be used for bearings 180-360 degrees. It's necessary to compute the latitude and longitudes of the vertex so that values for TV, TH3, TH4, LX, and NX may be obtained. Take time to understand the definitions in **fig. 1** — they're important.

Finding LV: latitude of the vertex

Example: let B = 60 degrees from W4BW

L1 = 30.4N (latitude of W4BW)

N1 = 84.2W (longitude of W4BW)

$$COS(LV) = SIN((PI/2) - L1) \cdot SIN(B) \qquad \textbf{(eqn 1)}$$

solving:

$$COS(LV) = 0.86251 \cdot 0.86603$$

$$COS(LV) = 0.74696,\ LV = 41.7\ degrees$$

Finding NV: longitude of the vertex (using definitions value of TV and N1)

$$COT(TV) = COS((PI/2)\text{-}L1) \cdot TAN(B) \qquad \textbf{(eqn 2)}$$

using value from above example:

---

*The original "Ellert equations" are given below. In all cases they give identical results to those used herein. When using a hand calculator, these original equations may be more convenient. With these equations (or the others) it is nesessary to carefully ensure that the answers obtained have the correct signs and fall in the correct quadrants on the map of your choice. Roughly plotting your intercepts will verify the correct quadrant. It is useful to have your map available when making the calculations.

$$COS(LV) = SIN(B) \cdot COS(L1) \quad \textbf{(eqn 1)}$$
$$COS(TV) = SIN(L1) \cdot TAN(B) \quad \textbf{(eqn 2)}$$
$$TAN(LX) = COS(TH3) \cdot TAN(LV) \quad \textbf{(eqn 3)}$$
$$COS(TH4) = TAN(LS) \cdot COT(LV) \quad \textbf{(eqn 4)}$$

$$COT(TV) = 0.50603 \cdot 1.73205$$

COT (TV) = 0.87647,
TV = 48.8 degrees

TV, by definition, is the longitude difference between the station and the nearest vertex: consequently $NV = N1 - TV$

or $NV = 84.2 - 48.8 = 35.4W$ *longitude of the vertex (NV).*

Before proceeding, note the definition of TH3. Select suitable (NS) meridians that a bearing of 60 degrees (B) will intercept. A different value of LX will result for each selected meridian. In the following example, values of NS used are 30W and 60E.

$$TAN(LX) = COS(TH3) \cdot TAN(LV) \qquad \textbf{(eqn 3)}$$

Example:

NS	=	30W	60E
TH3	=	5.4	95.4
COS(TH3)	=	0.99556	−0.09411
TAN(LV)	=	0.89097	0.89097 (LV from Eqn. 1)
TAN(LX)	=	0.88701	−0.08385 (reverse latitude)
LX	=	41.5N	4.8S

In many cases, use of **eqn 4** may not be necessary. In other words, the latitude intercepts on longitude meridians will generally locate the great circle points with sufficient clarity to enable them to be joined with a smooth curve. In some circumstances, such as when the great circle track approaches the antipode, accurate location of the points may require solving **eqn 5** to obtain longitude intercepts NX, on several selected latitudes NS. Note again the definitions from **fig. 1** before setting up your table for **eqn 4**. In the following example, azimuths B of 10, 20, 30, and 40 degrees are used to compute the longitude intercepts NX on a latitude LS of 60 degrees.

$$COS(TH4) = COT((PI/2) - LS) \cdot TAN((PI/2) - LV) \qquad \textbf{(eqn 4)}$$

B	10	20	30	40
LS	60N	60N	60N	60N
LV	81.4N	72.8N	64.5N	56.3N
TAN((PI/2) − LV)	0.15124	0.30955	0.47698	0.66692
COT((PI/2)-LS)	1.73205	1.73205	1.73205	1.73205
COS(TH4)	0.26196	0.53616	0.82615	(1.15519)*
TH4	74.8	57.6	34.1	....
NV	−0.7	4.6	10.5	17.2
NX	74.1	62.2	44.6	no intercept

max value of cosine is 1 or −1

Thus we have computed longitude intercepts on a 60-degree north latitude for bearings of 10, 20, and 30 degrees. Reference to your map will verify that there is no intercept for a bearing of 40 degrees on

```
5 LPRINT "A. Prose Walker, W4BW and Jack W. Herbstreit, WØDW";LPRINT ;LPRINT
10 LPRINT "                    VERTEX"; 'LPRINT TAB(66) DATE$
20 LPRINT "PROGRAM TO COMPUTE CROSSINGS OF GREAT CIRCLE PATHS ON MERIDIANS"
30 LPRINT "OF LATITUDES AND LONGITUDES FROM A POINT ON THE EARTHS SURFACE"
40 LPRINT "AT SELECTED BEARINGS, B,FROM THE POINT OF ORIGIN."
50 '
60 PI=3.141593
70 DEF FNR(X1)=X1*PI/180
80 DEF FND(X2)=X2*180/PI
90 INPUT "LATITUDE OF POINT OF ORIGIN IN DEGREES NORTH OF THE EQUATOR ";L1
100 INPUT "LONGITUDE OF POINT OF ORIGIN IN DEGREES WEST OF GRNWCH. ";N1
110 LPRINT "GIVEN THE LATITUDE";L1;"DEGREES AND LONGITUDE ";N1;"DEGREES OF THE"
120 L1=FNR(L1)
130 N1=FNR(N1)
140 LPRINT "POINT OF ORIGIN (DEGREES WEST OF GREENWICH). NORTH LATITUDES ARE"
150 LPRINT "GIVEN AS POSITIVE AND SOUTH LATITUDES ARE NEGATIVE. WEST"
160 LPRINT "LONGITUDES ARE GIVEN AS POSITIVE AND EAST LONGITUDES ARE NEGATIVE."
170 LPRINT "B IS SELECTED BEARING FROM POINT ON EARTHS SURFACE IN DEGREES "
180 LPRINT: LPRINT
190 LPRINT "LATITUDE OF VERTEX (HIGHEST LATITUDE THAT BEARING CROSSES) = LV"
200 LPRINT "LONGITUDE OF VERTEX EAST OF ORIGIN = NVE"
210 LPRINT "LONGITUDE OF VERTEX WEST OF ORIGIN = NVW"
220 LPRINT "LONGITUDE DIFFERENCE BETWEEN ORIGIN AND NEAREST VERTEX = TV"
230 LPRINT
240 'LS=FNR(LS) SELECTED LATITUDES ON WHICH BEARING CROSSES ARE COMPUTED
250 'NS=FNR(NS) SELECTED MERIDIANS ON WHICH BEARING CROSSES ARE COMPUTED
260 'LX=FNR(LX) LATITUDES OF CROSSINGS ON NS
270 'NX=FNR(NX) LONGITUDES OF CROSSINGS ON LX
280 'TV=(N1-NV) LONGITUDE DIFFERENCE BETWEEN NEAREST VERTEX AND POINT OF ORIGI
290 DIM A(19,39)
300 FOR I = 0 TO 18
310     C = I * 10
320 A(I,1)=C
330 C = FNR(C)
340 CLV=SIN((PI/2)-L1)*SIN(C)
350 CLV=ATN(CLV/SQR(1-CLV*CLV)) 'LATITUDE OF VERTEX
360 LV=(PI/2)-CLV
370 A(I,2)=LV
380 IF TAN(C)=0 THEN TV=PI/2:GOTO 410
390 TTV=1/((COS((PI/2)-L1))*TAN(C))
400 TV=ATN(TTV)
410 A(I,4)=TV
420 NVE=N1-TV 'LONGITUDE OF VERTEX EAST OF ORIGIN
430 A(I,3)=NVE
440 NVW=N1+TV 'LONGITUDE OF VERTEX WEST OF ORIGIN
450 A(I,4)=NVW
460 A(I,5)=TV
470 FOR J = -6 TO 5
480     NS = J * 30
490 NS = FNR(NS)  ' SELECTED LONGITUDES
500 TH3E=NVE-NS 'LONGITUDE DIFFERENCE BETWEEN NVE (EASTERN VERTEX) AND NS
510 TH3W=NVW-NS 'LONGITUDE DIFFERENCE BETWEEN NVW (WESTERN VERTEX) AND NS
520 LXE=COS(TH3E)*TAN(LV)
530 LXW=COS(TH3W)*TAN(LV)
540 LXE=ATN(LXE) 'LATITUDE OF CROSSING EAST OF VERTEX ON SELECTED LONGITUDE, NS
550 LXW=ATN(LXW)  LATITUDE OF CROSSING WEST OF VERTEX ON SELECTED LONGITUDE, NS
560 A(I,J+12)=LXE
570 NEXT J
580 '
590 FOR J = -5 TO 5
600         LS = J * 15
610 LS = FNR(LS)
620 TH4=TAN((PI/2)-LV)/TAN((PI/2)-LS)
630 IF ABS(TH4)<1 THEN GOTO 670
640 NXEW=0
650 NXWE=0
660 GOTO 790
670 TH4=(-ATN(TH4/SQR(1-TH4*TH4)))+PI/2
680 'TH4=LONGITUDE DIFFERENCE BETWEEN NV AND NX
690 NXEE=NVE-TH4 'LONGITUDE OF CROSSING EAST OF EASTERN VERTEX
700 NXEW=NVE+TH4 'LONGITUDE OF CROSSING WEST OF EASTERN VERTEX
710 NXWE=NVW-TH4 'LONGITUDE OF CROSSING EAST OF WESTERN VERTEX
720 NXWW=NVW+TH4 'LONGITUDE OF CROSSING WEST OF WESTERN VERTEX
730 IF NXEW>PI THEN NXEW = NXEW - 2*PI: GOTO 750
740 IF NXEW<-PI THEN NXEW = NXEW + 2*PI
750 A(I,J+23)=NXEW
760 IF NXWE>PI THEN NXWE = NXWE - 2*PI: GOTO 790
770 IF NXWE<-PI THEN NXWE = NXWE + 2*PI
780 A(I,J+34)=NXWE
790 NEXT J
800 NEXT I
810 LPRINT TAB(8) "TABLE I": LPRINT
820 LPRINT TAB(2)"B"; TAB(7)"LV"; TAB(12) "NVE"; TAB(18) "NVW"; TAB(25)"TV"
830 FOR I= 0 TO 18
840 LPRINT USING "###";A(I,1);
850 LPRINT USING "####.#";FND(A(I,2));
860 LPRINT USING "####.#";FND(A(I,3));
870 LPRINT USING "####.#";FND(A(I,4));
880 LPRINT USING "####.#";FND(A(I,5))
890 NEXT I
895 LPRINT CHR$(12)
896 LPRINT "A. Prose Walker, W4BW and Jack W. Herbstreit, WØDW":LPRINT :LPRINT
900 LPRINT :LPRINT TAB(30) "TABLE II":LPRINT
910 LPRINT"LATITUDE  OF CROSSING FOR DESIGNATED LONGITUDE BETWEEN 180 AND 150W"
920 LPRINT"B/LO";"  180";" E150";" E120";" E90  ";" E60";"  E30";"    0";
930 LPRINT "  30W";"  60W";"  90W";" 120W";" 150W"
940 FOR I = 0 TO 18
950 LPRINT USING "###";A(I,1);
960 FOR J = 1 TO 11
970 LPRINT USING "####.#";FND(A(I,J+5));
980 NEXT J
990 LPRINT USING "####.#";FND(A(I,17))
1000 NEXT I
1010 LPRINT :LPRINT  TAB(30) "TABLE III": LPRINT
1020 LPRINT "LONGITUDE AT CROSSING FOR DESIGNATED LATITUDES BETWEEN -75 AND 75"
1030 LPRINT"B/LA";"  S75";"  S60";"  S45";"  S30";"  S15";"    0";"  15N";
1040 LPRINT "  30N";"  45N";"  60N";"  75N"
1050 FOR I = 0 TO 18
1060 LPRINT USING "###";A(I,1);
1070 FOR J = 1 TO 10
1080 LPRINT USING "####.#";FND(A(I,J+17));
1090 NEXT J
1100 LPRINT USING "####.#";FND(A(I,28))
1110 NEXT I
1115 LPRINT CHR$(12)
1116 LPRINT "A. Prose Walker, W4BW and Jack W. Herbstreit, WØDW":LPRINT :LPRINT
1120 LPRINT :LPRINT  TAB(30) "TABLE IV":LPRINT
1130 LPRINT "LONGITUDE AT CROSSING FOR DESIGNATED LATITUDES BETWEEN -75 AND 75"
1140 LPRINT"B/LA";"  S75";"  S60";"  S45";"  S30";"  S15";"    0";"  15N";
1150 LPRINT "  30N";"  45N";"  60N";"  75N"
1160 FOR I = 0 TO 18
1170 LPRINT USING "###";A(I,1);
1180 FOR J = 1 TO 10
1190 LPRINT USING "####.#";FND(A(I,J+28));
1200 NEXT J
1210 LPRINT USING "####.#";FND(A(I,39))
1220 NEXT I
1225 LPRINT CHR$(12)
1230 END
```

fig. 2. Program listing to determine great circle paths from your location. (Send SASE for large-print copy of program.)

the 60th parallel because the great circle track passes south of that latitude.

The principles and notations for determining intercepts with a calculator are the same as will be later explained for the computer program (see **fig. 2**). LS and NS values are selected as computations progress, taking into account the easily identified *parallels* and *meridians* as shown on a Mercator map ("Standard Time Zone Chart of the World," HO 5192, published by the United States Naval Oceanographic Office). Because of the time zones, some of them were not even values. In the computer program, bearings (B) every 10 degrees are used; selected longitude lines (NS) are every 30 degrees, and selected latitudes (LS,) every 15 degrees from 75S to 75N. The photo of the W4BW map, **fig. 3**, shows the great circle paths throughout the world from Tallahassee, Florida.

table 1. Latitudes and longitudes of the vertices for W4BW.

B	LV	NVE	NVW	TV
0	90.0	−5.8	174.2	90.0
10	81.4	−0.7	169.1	84.9
20	72.8	4.6	163.8	79.6
30	64.5	10.5	157.9	73.7
40	56.3	17.2	151.2	67.0
50	48.6	25.3	143.1	58.9
60	41.7	35.4	133.0	48.8
70	35.9	48.5	119.9	35.7
80	31.9	65.0	103.4	19.2
90	30.4	84.2	84.2	−0.0
100	31.9	103.4	65.0	−19.2
110	35.9	119.9	48.5	−35.7
120	41.7	133.0	35.4	−48.8
130	48.6	143.1	25.3	−58.9
140	56.3	151.2	17.2	−67.0
150	64.5	157.9	10.5	−73.7
160	72.8	163.8	4.6	−79.6
170	81.4	169.1	−0.7	−84.9
180	90.0	−5.8	174.2	90.0

Program to compute crossings of great circle paths on meridians of latitudes and longitudes from a point on the earth's surface at selected bearings, B, from the point of origin. Given *the latitude 30.4 degrees and longitude 84.2 degrees of the point of origin* (degrees west of Greenwich). North latitudes are given as positive and south latitudes are negative. West longitudes are given as positive and east longitudes are negative. B is selected bearing from point on earths surface in degrees.
Latitude of vertex (highest latitude that bearing crosses) = LV
Longitude of vertex east of origin = NVE
Longitude of vertex west of origin = NVW
Longitude difference between origin and nearest vertex = TV

program vertex

The computer program uses simple right-angle spherical trigonometric relationships and computes the crossings of great circle tracks from any origin (for example, your location at latitude L1 and longitude N1) on parallels of latitude and meridians of longitude on your map. As with the calculator, select suitable latitude and longitude lines around the world wherever you want the bearing to be plotted (on any type of map of the world, such as a

table 2. Latitudes of crossings for designated longitudes between 80 and 150 w.

B/LO	180	E150	E120	E90	E60	E30	0	30W	60W	90W	120W	150W
0	90.0	90.0	90.0	−90.0	−90.0	−90.0	−90.0	−90.0	−90.0	90.0	90.0	90.0
10	−81.4	−80.0	−72.8	4.6	73.5	80.1	81.4	80.0	72.8	−4.6	−73.5	−80.1
20	−72.8	−71.1	−61.5	−14.7	54.2	69.4	72.8	71.1	61.5	14.7	−54.2	−69.4
30	−64.1	−63.1	−53.6	−20.8	34.9	57.9	64.1	63.1	53.6	20.8	−34.9	−57.9
40	−55.1	−55.7	−47.8	−23.9	18.4	45.6	55.1	55.7	47.8	23.9	−18.4	−45.6
50	−45.8	−48.5	−43.0	−25.9	5.3	32.9	45.8	48.5	43.0	25.9	−5.3	−32.9
60	−36.0	−41.5	−39.0	−27.3	−4.8	20.3	36.0	41.5	39.0	27.3	4.8	−20.3
70	−25.6	−34.4	−35.3	−28.4	−12.9	8.2	25.6	34.4	35.3	28.4	12.9	−8.2
80	−14.7	−27.0	−31.8	−29.4	−19.6	−3.1	14.7	27.0	31.8	29.4	19.6	3.1
90	−3.4	−18.9	−28.2	−30.3	−25.4	−13.5	3.4	18.9	28.2	30.3	25.4	13.5
100	8.2	−10.1	−24.3	−31.1	−30.8	−23.1	−8.2	10.1	24.3	31.1	30.8	23.1
110	19.8	−0.1	−19.9	−32.1	−35.9	−32.0	−19.8	0.1	19.9	32.1	35.9	32.0
120	31.2	11.3	−14.6	−33.1	−40.9	−40.4	−31.2	−11.3	14.6	33.1	40.9	40.4
130	42.3	24.0	−7.8	−34.3	−46.3	−48.4	−42.3	−24.0	7.8	34.3	46.3	48.4
140	52.8	37.9	1.8	−35.9	−52.1	−56.3	−52.8	−37.9	−1.8	35.9	52.1	56.3
150	62.7	52.1	16.1	−38.2	−58.8	−64.2	−62.7	−52.1	−16.1	38.2	58.8	64.2
160	72.2	65.9	37.6	−42.2	−66.9	−72.4	−72.2	−65.9	−37.6	42.2	66.9	72.4
170	81.2	78.7	65.2	−51.3	−77.0	−80.9	−81.2	−78.7	−65.2	51.3	77.0	80.9
180	90.0	90.0	90.0	−90.0	−90.0	−90.0	−90.0	−90.0	−90.0	90.0	90.0	90.0

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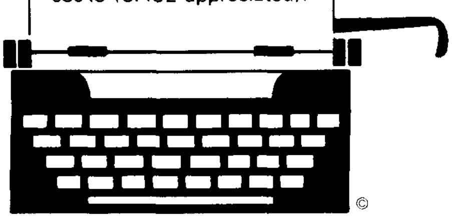

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table 3. Longitudes of great circle track crossings at specific latitudes, using longitude of the eastern vertex.

B/LA	S75	S60	S45	S30	S15	0	15N	30N	45N	60N	75N
0	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2
10	123.7	104.5	98.0	94.3	91.6	89.3	87.0	84.3	80.6	74.1	54.9
20	0.0	127.0	112.6	104.9	99.4	94.6	89.9	84.4	76.7	62.3	0.0
30	0.0	156.4	129.0	116.5	107.8	100.5	93.1	84.5	71.9	44.6	0.0
40	0.0	0.0	149.0	129.8	117.5	107.2	96.9	84.6	65.4	0.0	0.0
50	0.0	0.0	177.0	145.8	128.9	115.3	101.7	84.7	53.6	0.0	0.0
60	0.0	0.0	0.0	165.9	143.0	125.4	107.9	85.0	0.0	0.0	0.0
70	0.0	0.0	0.0	−168.5	160.2	138.5	116.7	85.5	0.0	0.0	0.0
80	0.0	0.0	0.0	−136.7	−179.5	155.0	129.4	86.7	0.0	0.0	0.0
90	0.0	0.0	0.0	−106.0	−158.6	174.2	147.0	94.4	0.0	0.0	0.0
100	0.0	0.0	0.0	−98.3	−141.0	−166.6	167.9	125.1	0.0	0.0	0.0
110	0.0	0.0	0.0	−97.1	−128.3	−150.1	−171.8	156.9	0.0	0.0	0.0
120	0.0	0.0	0.0	−96.6	−119.5	−137.0	−154.6	−177.5	0.0	0.0	0.0
130	0.0	0.0	−65.2	−96.3	−113.3	−126.9	−140.5	−157.4	171.4	0.0	0.0
140	0.0	0.0	−77.0	−96.2	−108.5	−118.8	−129.1	−141.4	−160.6	0.0	0.0
150	0.0	−56.2	−83.5	−96.1	−104.7	−112.1	−119.4	−128.1	−140.6	−168.0	0.0
160	0.0	−73.9	−88.3	−96.0	−101.5	−106.2	−111.0	−116.5	−124.2	−138.6	0.0
170	−66.5	−85.7	−92.2	−95.9	−98.6	−100.9	−103.2	−105.9	−109.6	−116.1	−135.0
180	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2

table 4. Longitudes of great circle track crossings at specific latitudes, using longitudes of the western vertex.

B/LA	S75	S60	S45	S30	S15	0	15N	30N	45N	60N	75N
0	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2
10	44.7	63.9	70.4	74.1	76.8	79.1	81.4	84.1	87.8	94.3	113.5
20	0.0	41.4	55.8	63.5	69.0	73.8	78.5	84.0	91.7	106.1	0.0
30	0.0	12.0	39.4	51.9	60.6	67.9	75.3	83.9	96.5	123.8	0.0
40	0.0	0.0	19.4	38.6	50.9	61.2	71.5	83.8	103.0	0.0	0.0
50	0.0	0.0	−8.6	22.6	39.5	53.1	66.7	83.7	114.8	0.0	0.0
60	0.0	0.0	0.0	2.5	25.4	43.0	60.5	83.4	0.0	0.0	0.0
70	0.0	0.0	0.0	−23.1	8.2	29.9	51.7	82.9	0.0	0.0	0.0
80	0.0	0.0	0.0	−54.9	−12.1	13.4	39.0	81.7	0.0	0.0	0.0
90	0.0	0.0	0.0	−85.6	−33.0	−5.8	21.4	74.0	0.0	0.0	0.0
100	0.0	0.0	0.0	−93.3	−50.6	−25.0	0.5	43.3	0.0	0.0	0.0
110	0.0	0.0	0.0	−94.5	−63.3	−41.5	−19.8	11.5	0.0	0.0	0.0
120	0.0	0.0	0.0	−95.0	−72.1	−54.6	−37.0	−14.1	0.0	0.0	0.0
130	0.0	0.0	−126.4	−95.3	−78.3	−64.7	−51.1	−34.2	−3.0	0.0	0.0
140	0.0	0.0	−114.6	−95.4	−83.1	−72.8	−62.5	−50.2	−31.0	0.0	0.0
150	0.0	−135.4	−108.1	−95.5	−86.9	−79.5	−72.2	−63.5	−51.0	−23.6	0.0
160	0.0	−117.7	−103.3	−95.6	−90.1	−85.4	−80.6	−75.1	−67.4	−53.0	0.0
170	−125.1	−105.9	−99.4	−95.7	−93.0	−90.7	−88.4	−85.7	−82.0	−75.5	−56.3
180	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2

Mercator) and compute where the bearing tracks cross these selected latitude and longitude lines. In this program, northern latitudes and western longitudes are taken as positive. Southern latitudes and eastern longitudes are negative.

The program begins by asking you to provide the geographical coordinates of the origin (i.e., your location) in program **lines 90 and 100.** Then for a selected number of bearings, B, from this origin, it computes the maximum latitude, LV, which each bearing track reaches (the vertex) as well as the longitudes, NV, of these vertices. Great circle tracks for bearings, B, every 10 degrees from zero to 180 (**line 310**) were selected for computation. This gives complete

fig. 3. W4BW map, HO 5129, showing great circles from Tallahassee, Florida. This map was produced using the meridian intercept method of calculation.

360-degree coverage when you consider the great circle paths going in the reciprocal direction through the origin.

On the diagram, the great circle having a bearing, B, reaches the maximum latitude LV when angle C = 90 degrees. First we compute the co-latitude of the vertex CLV = (PI/2-LV) using the right spherical trigonometric identity (C = B in the program):

$SIN(CLV) = SIN((PI/2)\text{-}L1) \cdot SIN(B)$ (**line 340**)
and then: $LV = (PI/2) - ARCSIN(CLV)$(**line 360**)
where $PI = 3.141593$ (**line 60**)

The longitude of the vertex NV is then computed by first obtaining TV as defined on the diagram (the difference between the longitude of the origin, N1, and the longitude of the vertex NV) from the equation:

$TAN(TTV) = 1/((COS((PI/2)\text{-}L1)) \cdot TAN(B)$ (**line 390**)

from which: $TV = ARCTAN(TTV)$ (**line 400**)

The longitude of the Vertex NV is obtained from the definition of TV. Notice that there is a vertex both east (NVE) and west (NVW) of the origin:

$NVE = N1 - TV$ (**line 420**)
$NVW = N1 + TV$ (**line 440**)

The results of the computations for each selected bearing are stored in Array A(19,39) (**line 290**) for subsequent print-out after all computations are made.

Next select the longitudes NS on which to determine the latitudes LX of the crossings of the (azimuthal) bearing tracks. In the program, NS was selected for every 30 degrees of longitude between −180 and 150 degrees (**line 480**). Then compute LX for each bearing track at each of the selected longitudes NS as follows:

By definition $TH3 = NV - NS$ (**line 500**)

then $TAN(LX) = COS(TH3) \cdot TAN(LV)$ (**line 520**)
and $LX = ARCTAN(LX)$ (**line 540**)

The longitudes of the bearing tracks NX at selected latitudes LS are found by using the following:

$COS(TH4) = TAN((PI/2)-LV)/TAN((PI/2\text{-}LS)$ (**line 620**)
$TH4 = ARCCOS(TH4)$ (**line 670**)
by definition $NX = NV + TH4$ (**line 700**)

The selected latitudes LS in the program are every 15 degrees from −75 to 75 degrees (**line 600**). A second table of bearing track crossings, NX, are also computed using the other vertex.

Program **lines 810** through **1220** are the part of the program that prints out the answers. As an example, the results are given of computations made for the origin at the QTH of W4BW (latitude = 30.4N, longitude = 84.2W). **Table 1** is a list of latitudes and longitudes of the vertices for the W4BW location as well as TV (the degrees of longitude between the origin and the vertex) for the bearing angles selected. **Table 2** gives the latitudes of the great circle track crossings at the specified longitudes. **Tables 3** and **4** give the longitudes of the great circle track crossings on the specified latitudes. **Table 3** uses the longitude of the vertex east of the eastern vertex and **table 4** uses the longitudes of the western vertex. When these tables have been computed for your location as origin, the crossing points for each bearing given in the tables can be plotted on your map. When they are connected, the lines show the desired great circle paths emanating from your location.

conclusion

For those of you who use a calculator, remember that each bearing has two vertices, one east and one west of the origin. For azimuths from 0 to 90 degrees, the nearest vertex will lie east of the station, and for azimuths 90-180 degrees, the nearest vertex will lie west of the station. This applies to stations in the northern hemisphere. For stations in the southern hemisphere, the conditions will be reversed. When computing the nearest vertex for bearings of 90 and 270 degrees, note that it coincides with the station location.

Any map can be used as long as you can identify latitude and longitude lines in order to plot the intercepts. First connect the intercept points free-hand, using a soft pencil. Make the final lines with a water-base marking pen in any color you wish. Black is probably best.

Label the azimuths either by hand or with dry transfer lettering. For neatness, position the values vertically on the Greenwich and 180th longitude meridians, for 0-180 and 180-360 degrees, respectively.

Readers who are too busy to do their own calculations can obtain an intercept computer readout for their locations from WØDW, for a nominal fee of $10.00, which covers the cost of paper and use of the computer. All you need to provide is the latitude and longitude of your location as accurately as possible.

For you avid DXers, nothing is easier or faster than glancing up at a map and instantly seeing the azimuth from your station to any location in the world. It's interesting to observe where your signal may travel with the beam heading on various azimuths. It also helps you understand some of the anomolies encountered with stations in the far corners of the earth when turning your beam makes little or no difference in signal strength. Lateral deviation of the signal path accounts for some of it, but in many cases it's the result of your signal reaching the area of the antipode regardless of the direction in which you point your beam.

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440	$730	$980

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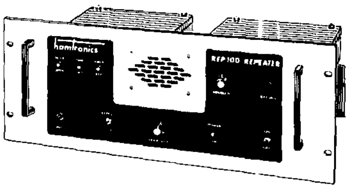

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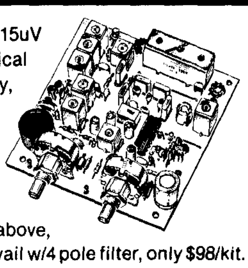

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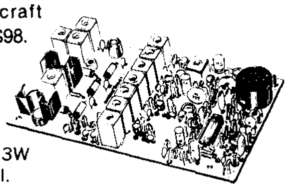

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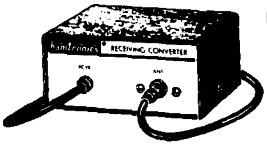

VHF MODELS

Kit with Case	**$49**
Less Case	**$39**
Wired	**$69**

Antenna Input Range	Receiver Output
28-32	144-148
50-52	28-30
50-54	144-148
144-146	28-30
145-147	28-30
144-144.4	27-27.4
146-148	28-30
220-222	28-30
220-224	144-148
222-226	144-148
220-224	50-54
222-224	28-30
902-928	422-448

UHF MODELS

Kit with Case	**$59**
Less Case	**$49**
Wired	**$75**

Antenna Input Range	Receiver Output
432-434	28-30
435-437	28-30
432-436	144-148
432-436	50-54
439.25	61.25

SCANNER CONVERTERS Copy 806 MHz band on any scanner. Wired/tested ONLY $88.

TRANSMIT CONVERTERS

For SSB, CW, ATV, FM, etc. Why pay big bucks for a multi mode rig for each band? Can be linked with receive converters for transceive. 2 Watts output vhf, 1 Watt uhf.

For VHF, Model XV2 Kit $79 Wired $149 (Specify band)

Exciter Input Range	Antenna Output
28-30	144-146
28-29	145-146
28-30	50-52
27-27.4	144-144.4
28-30	220-222*
50-54	220-224
144-146	50-52
144-146	28-30

For UHF, Model XV4 Kit $79 Wired $139

Exciter Input Range	Antenna Output
28-30	432-434
28-30	435-437
61.25	439.25
144-148	432-436*

*Add $20 for 2M input

VHF & UHF LINEAR AMPLIFIERS. Use with above. Power levels from 10 to 45 Watts. Several models, kits from $78.

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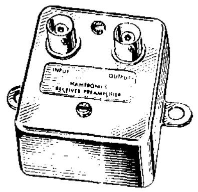

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- High Gain: 13 to 20dB, Depending on Freq.
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MODEL	TUNES RANGE	PRICE
LNG-28	26-30 MHz	$49
LNG-50	46-56 MHz	$49
LNG-144	137-150 MHz	$49
LNG-160	150-172 MHz	$49
LNG-220	210-230 MHz	$49
LNG-432	400-470 MHz	$49
LNG-800	800-960 MHz	$49

HELICAL RESONATOR PREAMPS

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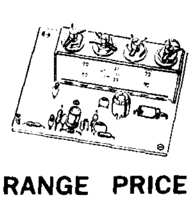
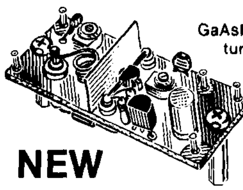


MODEL	TUNING RANGE	PRICE
HRA–144	143–150 MHz	$49
HRA–(*)	150–174 MHz	$49
HRA–220	213–233 MHz	$49
HRA–432	420–450 MHz	$64
HRA–(*)	450–470 MHz	$64

**Specify Center frequency desired*

MINIATURE PREAMPS



GaAsFET Preamps with features similar to LNG, except designed for LOW COST and SMALL SIZE: only 5/8"W x 1-5/8L x 3/4H. Easily mounts inside many radios.

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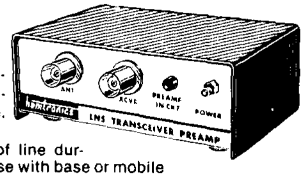
*Specify band

IN-LINE PREAMPS

NEW



GaAsFET Preamp with features like LNG. Automatically switches out of line during transmit. Use with base or mobile transceivers up to 25W. Tower mtg hdwr incl.

MODEL	TUNES RANGE	KIT	WIRED
LNS–144	120–175 MHz	$59	$79
LNS–220	200–240 MHz	$59	$79
LNS–432	400–500 MHz	$59	$79

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DX FORECASTER

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summer propagation

Summertime QRN is this month's topic. The predominating noise source over omnipresent local noise is atmospherics, the cumulative propagated noise from some distance away. It isn't associated with weather storm fronts passing your QHT, but rather with air mass thunderstorms. These large high-pressure air masses cover several states and can linger for several days — even a week or more.

Some regions of the country have a greater number and variety of thunderstorms than others; in these areas, thunderstorm activity is measured by the number of "thunderstorm-days," or days in which at least one thunderstorm occurs. Areas with 100 thunderstorm-days or more are found in Florida and in the Rocky Mountains; the southern parts of Louisiana, Alabama, and Georgia endure 80 days. A band stretching across Nebraska to Ohio and then bending southward into South Carolina, and another reaching across New Mexico to Northern Texas, have 60 days, with the rest of the Mid-west experiencing 50 thunderstorm-days. Notice that most of the high numbers of thunderstorm-days occur in the southeast.

Because frontal weather activity is limited in these areas, the high numbers can be attributed mostly to air-mass thunderstorms. Moist air from the Gulf of Mexico moving northeast along the land serves as a prime thunderstorm generator.

Thunderstorm activity depends on how much moisture the air contains. If the air is dry, perhaps no thunderstorms will form at all. If the relative humidity is 50 percent or more, they may develop by noontime.

The process works as follows. First the sun heats the ground. As the heat from the ground rises, it warms the air above it and causes it to rise. As this heated air meets the colder air above, its moisture condenses, forming clouds. The clouds — some of which may be seized by the winds and carried into the jet stream to form the characteristic anvil-shaped top of a thunderstorm at 30 to 40,000 feet — continue to rise until their condensed moisture forms heavy drops heavy enough to fall as rain; some drops are taken further upward and freeze into hail. This fast up-and-down motion generates static electricity strong enough to cause the air to break down between a cloud and the earth or between one cloud and another. As the lightning stroke releases this energy, both sound and electromagnetic pulses are produced. Our receivers pick up the HF radio frequency pulse and we call it "noise."

After several days the air dries out or slowly moves on. However, during these days QRN may limit the usefulness of the low-frequency HF bands, enabling only local ragchewing and ruling out weak-signal DX reception.

How can you communicate with DX stations on these bands? Directional antennas may help if the thunderstorm activity is in the opposite direction from the DX stations. If you're using phased verticals you may be able to form a null in the right direction, or rotate one of the big beams to a noise null and then hear the DX. Receivers with effective noise blankers also spare your ears when the static crashes occur. When the going is really rough, most operators switch operating hours, giving up evening hours in favor of the pre-dawn hours. By this time the thunderstorms have lost their heat and dissipated to the east, locally, and are weakening on DX paths to the west as the sun moves across Asia and the Middle East. In addition, the sun in the morning hasn't yet warmed the air enough for the day's thunderstorms to occur. This is a cool, comfortable time of the day to be up and around.

last-minute forecast

The higher-frequency HF bands, 10 through 30 meters, are expected to be best for long-skip the first week and the last few days of August. Expect sporadic-E short-skip to be the best of the summer season on 6 meters and lower in frequency a good many hours of many days of the month. The lower bands aren't expected to be very good in the evenings because of the air-mass thunderstorm build-up. These bands can provide some good DX contacts across the continent or into Europe for a short period in very early morning on those days during the third week, when the solar flux is at its lowest. Geomagnetic disturbances will occur less frequently, with the greatest possibility during the third week.

For the VHF/UHF enthusiast the moon's perigee will occur on the 16th, with full moon on the 27th. The Perseids meteor shower will occur from the 10th to 14th, with a maximum rate of better than 50 meteors per hour expected on the 11th and 12th. This is an excellent shower to work with.

band-by-band summary

Six-meter sporadic E short-skip conditions will occur for a half hour to several hours around local noon on some days for this last good month of this summer's E_S season. Expect about 1000 miles per hop.

Ten, twelve, and fifteen meters will have a quite few short-skip E_S openings and some long-skip openings to southern areas of the world during daylight hours. Fifteen meters will be best for only an hour or two as the maximum usable frequency decreases during the late afternoon.

Twenty, thirty, and forty meters will be useful for distance communications to most eastern, western, and northern areas of the world during daytime and into the evening almost every day,

AUGUST

WESTERN USA

GMT	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	
PDT	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	
ASIA FAR EAST	20	20	20	40*	30	30*	30	30	20	20	20	20	40*	30	30	30	30	20	20	20	20	20	20	20	N
EUROPE	20	20	20	20	20	20*	15	15	20*	20	20	20	20	30	30	30	20	20	20	20	20	30	30	20	NE
S. AFRICA	20	20	15	12	12	10	10	10	10	12	12	15	20	20	20	20	20	20	20	30*	20	20	20	20	E
S. AMERICA	10	10	10	10	10	10	12	12	12	15	20	20	20	30*	20	20	20	20	20	20	15	12	12	10	SE
ANTARCTICA	15	15	15	15	15	20	20	30	40	40	40	40	40	40	30	30	30	30	30	20	20	20*	15	15	S
NEW ZEALAND	10	10	12	12	15	20*	20	20	20	20	20	20	20	20	20	15	12	12	10	10	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	12	12	20	30	30	30	20	20	20	20	20	20	20	15	12	12	10	10	10	10	10	10	W
JAPAN	15	20	20	20	20	20	30	30	30	30	30	30	30	30	30	20	20	20	20	20	15	15	15	15	NW

MID USA

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

EASTERN USA

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

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next **higher** band for possible openings.

either long-skip to 2000 miles per hop or short-skip E_s with 1000-mile hops. The period of daylight is still relatively long, but will be noticeably shorter by the end of the month.

Thirty, forty, eighty, and one-sixty meters are all good for nighttime DX even though the background noise is severe in the evenings. The direction of the openings will rotate around from the east, to the south, and then westward toward the morning. Sporadic E layer propagation may be of help in the early evening toward the east and south to override thunderstorm noise. Try those early morning hours for communication paths to the west and monitor WWV or WWVH on 2.5 and 5 MHz.

ham radio

✓ 115

✓ 116

general purpose line transformers

HF, VHF or UHF performance without ferrite cores

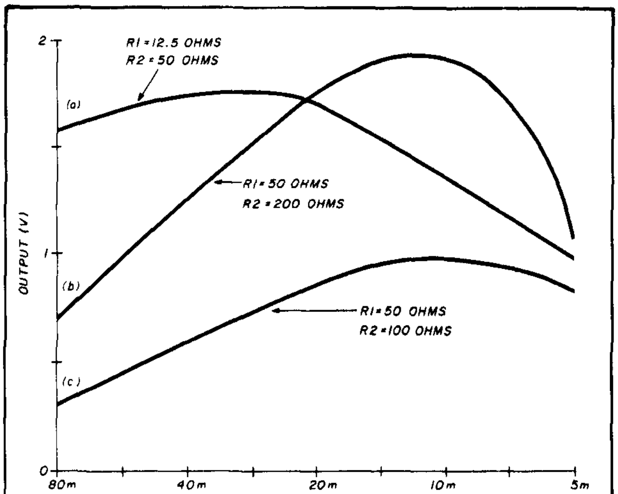


fig. 1A. Isolated winding line transformer response curves: (a) unbalanced configuration, lower impedance level; (b) unbalanced configuration, higher impedance level; (c) balanced configuration.

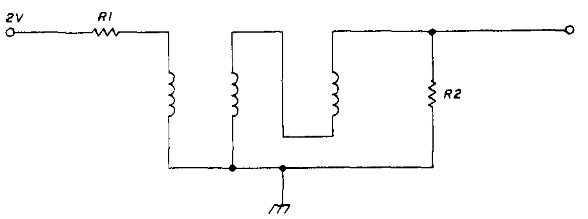


fig. 1B. Isolated winding line transformer, unbalanced configuration.

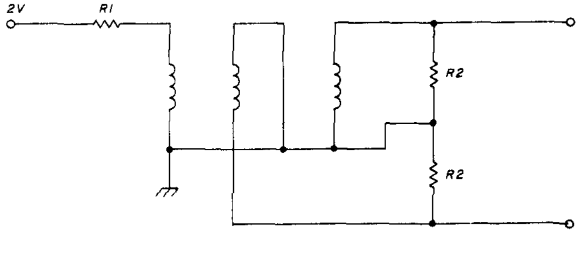


fig. 1C. Isolated winding line transformer, balanced configuration.

Line transformers are usually associated with antenna matching or VHF/UHF stripline applications. This article, however, describes general-purpose transformers made from wire. They're simple to make and can serve in many applications normally reserved for ferrite core transformers. All the examples considered use tightly twisted trifilar enamel or Formvar-coated No. 22 wire, with approximately 1/8 inch between twists. Because each wire is comparable to one winding on a conventional trifilar transformer, these transformers can be operated in all the normal trifilar configurations. Relatively broadband, their center frequency response is determined by the wire length — several inches for UHF operation and several feet for the lower HF frequencies. Although the trifilar twisted wire could be wound on a small diameter form, little difference in performance would be noticed between it and an uncoiled version.

Measurements have been made on a 17-inch long trifilar wire transformer coiled on a 5/16-inch diameter, 3/4-inch long form. Test results and configurations are shown in **figs. 1, 2** and **3**. Resonance is influenced by both the configuration and loading. The balanced configuration with the inductors in parallel **(fig. 1)** has the highest frequency response, while the 3:1 balun with the windings in series **(fig. 2)** has the lowest frequency response. Inherently a low-impedance device, its lower termination resistance minimizes reflections and results in a wider bandpass. This is illustrated in

By John C. Reed, W6IOJ, 770 La Buena Tierra, Santa Barbara, California 93111

the 2:1 balun (**fig. 3**), where the 200-ohm termination shows a dominant resonant condition as compared to that of the 50-ohm termination. This 17-inch transformer is used in a test equipment balanced modulator application using the circuit shown in **fig. 4**. It provides 100 milliwatts at 21 MHz, with the balanced transformer isolating the modulated output from the input excitation by over 40dB.

My primary application for the transformers has been in double-balanced mixers; an example is shown in **fig. 5**. The UHF transformer, with only a 3-inch trifilar wire, isn't coiled, but instead mounted in a convenient loop arrangement forming an interface with the circuit. The mixer loss is −6 to −8 dB, and the poorest port-to-port isolation, between the local oscillator and output, is over 20 dB.

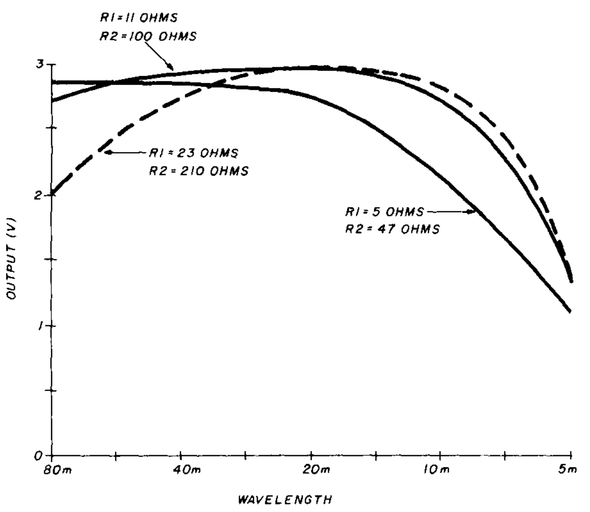


fig. 2A. 3:1 (voltage ratio) balun: frequency response.

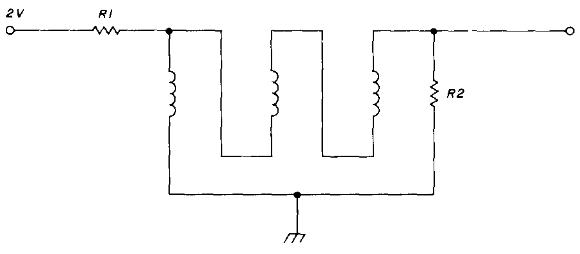


fig. 2B. 3:1 (voltage ratio) balun: circuit configuration.

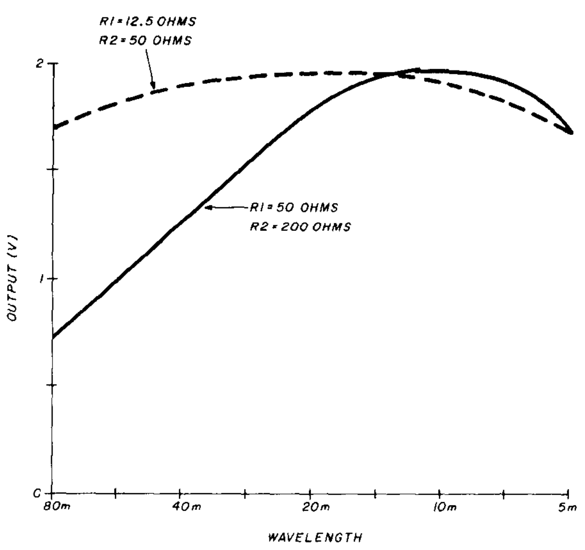


fig. 3A. (voltage ratio) balun response with two different set of termination conditions.

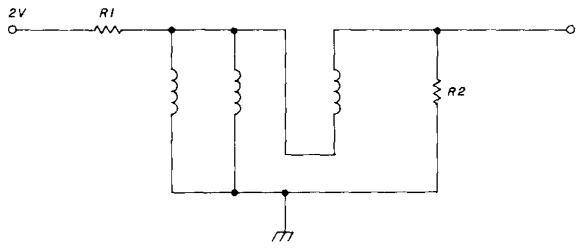


fig. 3B. 2:1 (voltage ratio) balun: circuit configuration.

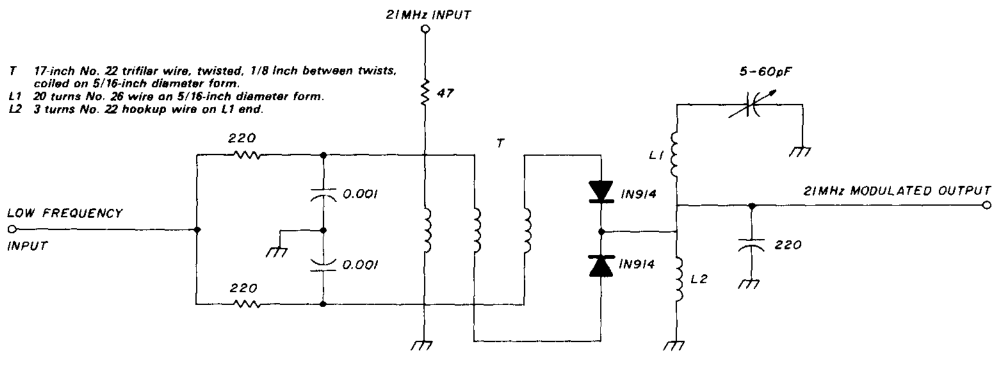


fig. 4. Balanced modulator circuit using trifilar wound line transformer.

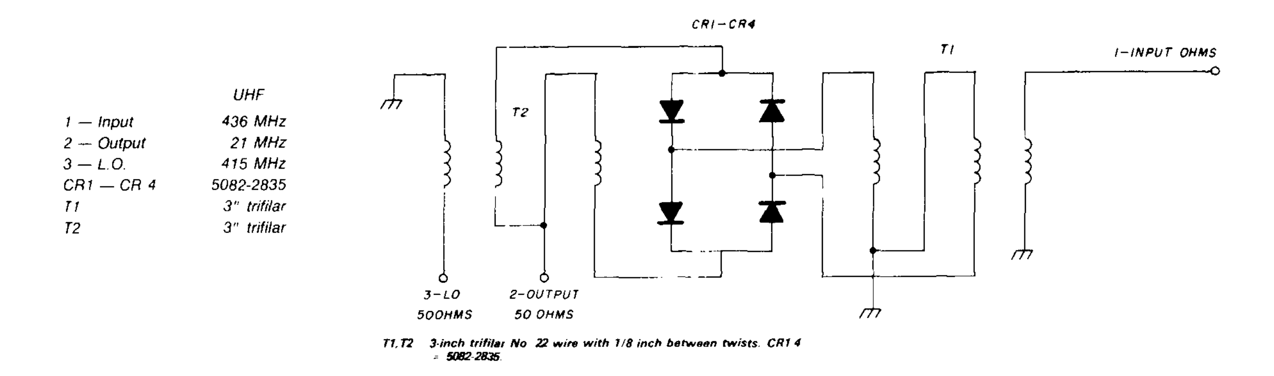


fig. 5. Double balanced mixer.

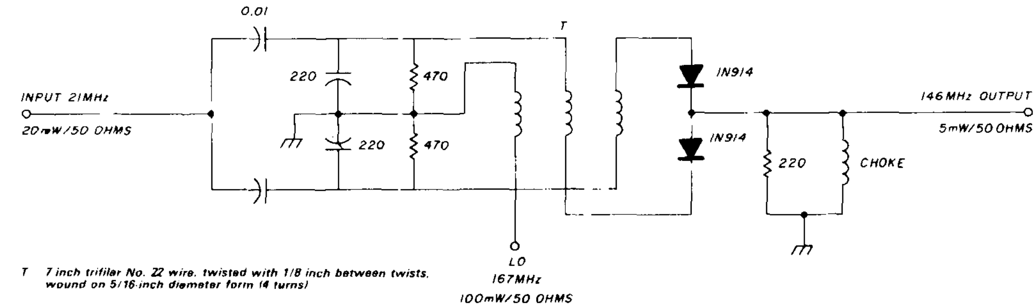


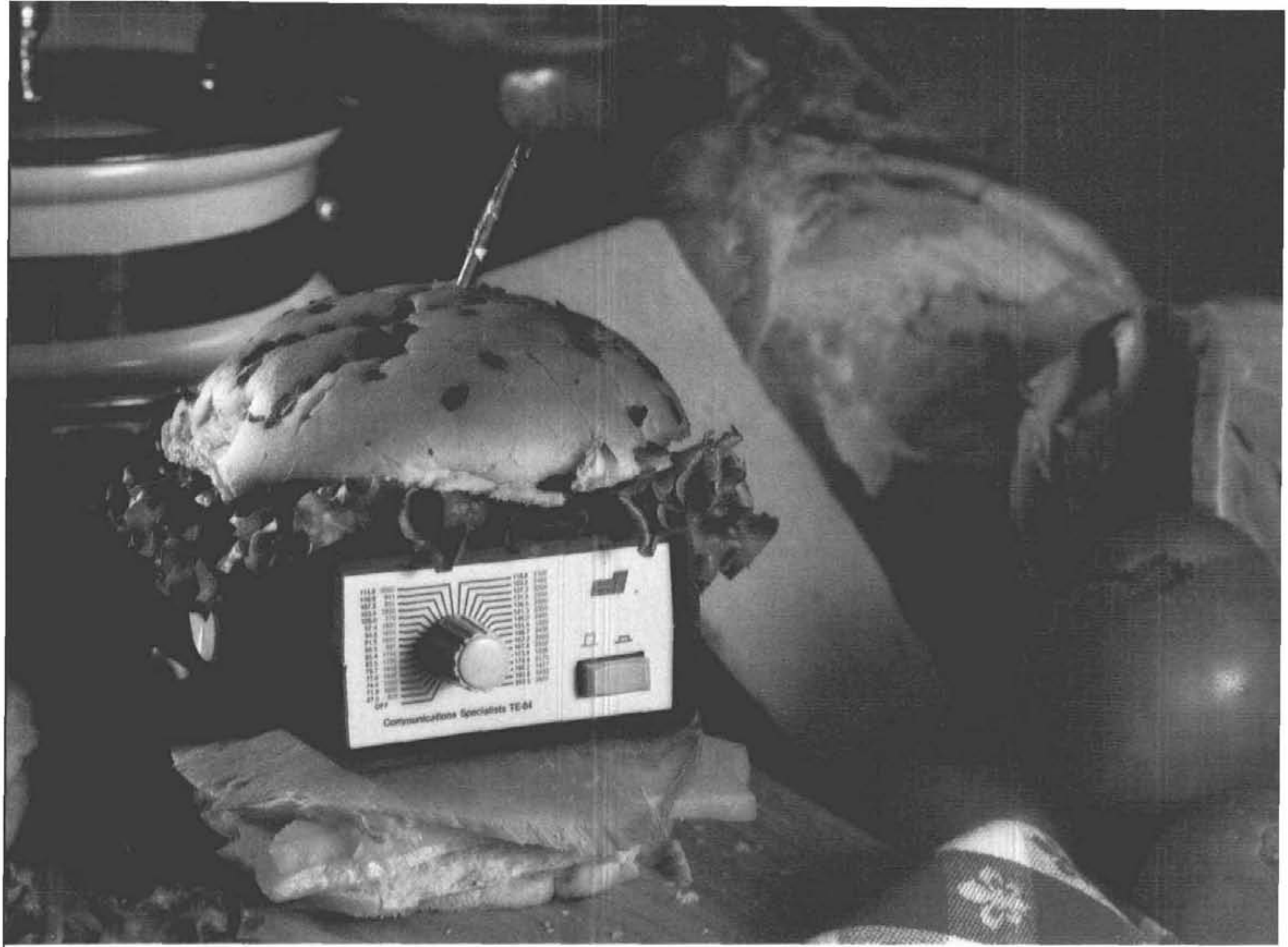
fig. 6. Single balanced mixer provides 2-meter output with 21 MHz input and 167 MHz LO.

I have also used the trifilar wire transformer in a 2-meter single balanced mixer (**fig. 6**).

This experimental effort was initiated after questionable results were obtained from homebrew UHF trifilar ferrite core transformers. The wire transformers solved my problems with consistent and satisfactory results.

The technique is simple enough to try out in a few minutes. Using easily obtainable wire (I used Radio Shack No. 276-1345), stretch the three wires between a solid tie point and a variable-speed drill, turning the drill for the desired 1/8-inch twist spacing. I quickly check the resonant frequency of a particular wire-length/configuration by simply coupling the input to a grid-dip meter, detecting the transformer output with a 1N34A diode peak detector.

ham radio



SAY YOU SAW IT IN ham radio!

More Details? CHECK—OFF Page 110

✓ 119

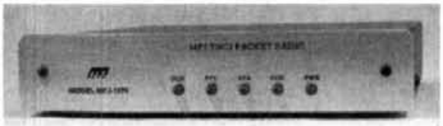
NEW products

new TNC from MFJ breaks price barrier

MFJ Enterprises, Inc. of Starkville, Mississippi, has released its new affordable packet radio controller.

At $129.95 (plus $6 shipping), the MFJ-1270 breaks a price barrier to make packet radio more affordable by bringing together efficient manufacturing techniques and TAPR'S Tucson Amateur Packet Radio) leading-edge technology.

The MFJ-1270 is a nearly identical clone of the widely acclaimed TAPR TNC 2, with identical software and hardware. Neatly packaged in a new cabinet, the unit includes a TTL serial port for extra versatility.



All that's needed to operate packet radio is a rig and any home computer with an RS-232 serial port and a terminal program.

For Commodore 64, 128, or VIC 20 users there's an optional Starter Pack for $19.95; this puts them on the air immediately and includes interfacing cable, terminal software on tape or disk, and complete instructions — everything the users need to get on packet radio. The MFJ-1282 is the disk version and the MFJ-1283 is the tape version. Both are priced at $19.95 each.

Unlike machine-specific TNCs, the general-purpose MFJ-1270 won't become obsolete because the user changes computer or because packet radio standards change. The MFJ-1270 can be used with *any* computer that has an RS-232 serial port and an appropriate terminal program. If packet radio standards change, software updates will be made available as TAPR releases them.

Speeds in excess of 56 Kilobauds are possible with a suitable external modem. These faster speeds would be very difficult, if not impossible, with any machine-specific TNC or a TNC without hardware HDLC. The MFJ-1270 can be used as an inexpensive digipeater.

The MFJ TNC uses the latest AX.25 Version 2.0 software. As few as three commands can be used to make contacts; 82 software commands are featured. The "MHEARD" command lists stations and the time heard. Up to four station roundtables are possible.

Hardware features include HDLC for full duplex, Z80A CPU, and a 16K EPROM, expandable to 32K. 16K RAM (with battery backup) and true data carrier detect are included. Terminals up to 9600 baud may be used. A tuning indicator port for HF and satellite operation is featured, and LEDs indicate connection, packet tone received, packet acknowledgement, power on, and activation of transmitter.

The MFJ-1270 Packet Radio TNC 2 and MFJ-1282/MFJ-1283 Starter Packs come with a double guarantee. They can be ordered from MFJ for a 30-day trial period. If they don't satisfy your needs, return them for a full refund, less shipping. MFJ's full one-year unconditional guarantee covers all products.

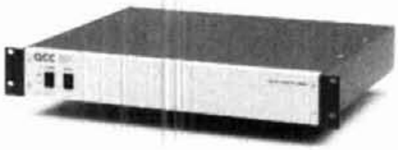
To order or request additional information, contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762.

Circle #301 on Reader Service Card.

digital voice recorder

Advanced Computer Controls, Inc., has announced its new Digital Voice Recorder, which provides remote audio record and playback capability for voice repeaters. The DVR allows the repeater owner to remotely record any of the repeater's programmable messages — IDs, tail messages, emergency autodial responses, alarms, courtesy tones, etc. In addition, its touchtone-activated voice mailbox lets users leave recorded messages for others.

The DVR's direct digital recording technique offers a high-quality audio mode as well as two additional quality level modes designed to conserve memory and extend recording time.



The DVR uses up to 32 inexpensive 64K or 256K dynamic RAM chips and is available with one, two, or three independent record/playback channels, which means that one DVR can service up to three repeaters at one site, or two repeaters and the phone line.

The DVR is available from $849 (manual alone, $5 postpaid). For additional information, contact Advanced Computer Controls, Inc., 10816 Northridge Square, Cupertino, California 95014.

Circle #302 on Reader Service Card.

Butterworth design program for IBM PC and compatibles

Etron RF Enterprises has released the third in their series of PC-DOS programs for designing RF circuitry. RF Notes Number 3, Volume 1 covers low-pass, high-pass, bandpass and band-reject Butterworth filters. Each of the four programs outputs both graphical response curves and schematic diagrams.

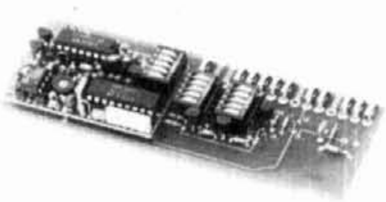
Written in BASIC A, the programs are available in both monochrome and color versions for the IBM PC, PC XT, PCjr and most compatibles. Each requires 128K of memory and the appropriate graphics display card.

Further information is available from Etron RF Enterprises, P.O. Box 4042, Diamond Bar, California 91765. (Also available from Ham Radio's Bookstore, Greenville, NH 03048, for $84.95 plus $3.50 shipping and handling.)

Circle #303 on Reader Service Card.

plug-in encoder-decoder for RCA/TACTEC TAC-200

Communications Specialists, Inc. of Orange, California has just introduced a direct plug-in encoder-decoder for the RCA/TACTEC TAC-200 and VEETAC mobiles. The TS-32TAC, based on the proven TS-32, is available in two versions; the TS-32TAC-1 will encode and decode one tone only, while the TS-32TAC-2 will either encode and decode two tones, or encode one tone and decode a different tone.



Both versions of the TS-32TAC plug directly into the host radio without any modifications to the tone board or the radio, to allow for economical installation and removal.

The TS-32TAC is available for immediate shipment and comes complete with a one-year warranty. Prices are $78.26 for the TS-32TAC-1 single tone unit and $82.92 for the TS-32TAC-2 two-tone board.

A catalog is available on request. For information, contact Communications Specialists, Inc., 426 West Taft Avenue, Orange, California 92665.

Circle #304 on Reader Service Card.

ham upgrade cassettes and books

Gordon West's Radio School has produced a four-cassette stereo theory course entitled "Tapes'N Books Theory Course." Each course contains four long-play, stereo theory tapes plus a fully illustrated textbook and the ARRL's *FCC Rule Book*. Theory cassette courses are available for all grades of amateur radio licensing.

The course contains the questions and answers to be found on any Amateur Radio examination, as well as the "sounds" of Amateur Radio. You can actually hear the difference between a properly adjusted speech processor and the effects of overmodulation, for example. You can hear the difference between AMTOR, ASCII, and BAUDOT. You'll tune into actual ham radio transmissions, and actually hear the

NEW products

difference between long-path and short-path communications.

Included with the theory cassettes are code test preparation sample QSO's. These sample CW QSO's will assist you in preparation for any code test that may be part of your upgrade. Also included with this course is the FCC test questions syllabus, with updates; a copy of the new Form 610; a sample VEC-type theory examination; and all necessary FCC and VEC forms.

All courses are $19.95 plus $5.00 for first class, same-day, postage, handling, and mailing.

For more information, contact Gordon West Radio School, 2414 College Drive, Costa Mesa, California 92626.

Circle #305 on Reader Service Card.

repair or build antennas — with ease

At last there's a brazing rod for aluminum with a low melting point of only 732 degrees. All that's needed for easy antenna construction or repair is a hand-held propane torch, a good wire brush, and a supply of M.S.S. Wonder Rods. Only three simple steps are necessary: (1) clean the area to be welded with wire brush; (2) heat the area to be welded until the rod flows, scrubbing with the wire brush; and (3) heat the area again until the rod flows, fill it in, and let it cool.

In building or repairing antennas, you can eliminate high-resistance joints and the need for clamps by welding. Antenna elements damaged by wind or sleet can be straightened; kinks or cracks can simply be filled in.

Other uses for M.S.S. Wonder Rods include welding copper to aluminum (as in a matching network), repairing or plugging holes in aluminum panels, repairing holes in aluminum boats, or repairing most of the parts of your alternator. Other metals you can weld with Wonder Rods include copper, brass, galvanized steel, and white metal.

A kit containing Wonder Rods and a stainless steel brush is available for $19.95, which includes tax and postage. For details, contact M.S.S. Wonder Rods, N3401 Castle Road, Medford, Wisconsin 54451.

Circle #306 on Reader Service Card.

"clamp-on" RF choke suppresses interference

EMC Datacare's D910 series of clip-on chokes are said to greatly reduce interference when they're clamped onto interconnecting cables of various types of electronic systems. For example, installing them between the various parts — external drives, monitors, and printers — of a computer system provides significant reduction of any computer-caused RFI problems.

The chokes clamp onto cables up to 0.4 inch in diameter. A professional kit (D918), designed to protect up to eight cables, is available.

For details, contact EMC Datacare Ltd., Powe Court, Luton, Bedfordshire, LU1 3JJ, England

Circle #307 on Reader Service Card.

packet switch allows instant change from 1200 to 300 baud operation

Amateur Packet Alaska has announced th availability of its TNC VHF/HF Switch Kit. It all-CMOS logic assembly quickly changes criti cal filter and timing components in the TAPR AEA, MFJ, Heath and Pac-com TNCs to op timize the on-board modem for HF or VHF use

The easy-to-build kit installs easily inside th TNC's case. Complete step-by-step instruction are included; construction should be complet in just one hour.

The APA VHF/HF Switch is available for $30 which includes airmail postage. As an all volunteer organization, APA is unable to accep telephone or credit card orders. Bu you can write to them for more information — or to place an order — at AX.25 Communica tions Trail, Ester, Alaska 99725.

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heat-powered "battery"

A unique electrical generator has been deve oped and is being marketed by Ovonic Thermoe lectric Company, a division of Energy Conve sion Devices, Inc. This compact, lightweigh silent, solid-state generator obtains its energ from any convenient source of heat an produces up to 6 watts of DC power at 9 volt and up to 5 watts at 6 or 12 volts. Accordin to Ovonic, it can be thought of as a hea powered battery that never needs recharging

Designated CSG (Compact Silent Generator it can serve either as a primary source of powe or as a backup or emergency power source, an can power portable televisions, radios, lamps fans, pumps or other light electrical loads. It ca also be used with an accessory to recharge ba teries.

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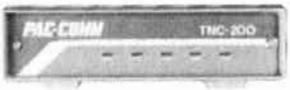

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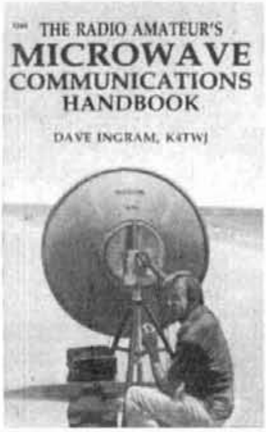

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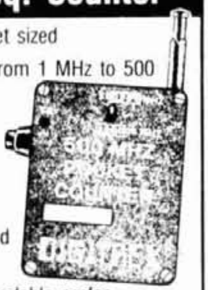

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equipped with wood stoves, the CSG can be placed directly on the stove to produce electricity. In homes it can also provide emergency power from a gas stove or can of Sterno™.

For information, contact Energy Conversion Devices, 1864 Northwood, Troy, Michigan 48084.

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Monitoring Times merges with *International Radio*

Bob Grove, Editor of *Monitoring Times*, and Larry Miller, Editor of *International Radio* (formerly *Shortwave Guide*), have announced plans to combine their publications into a single operation.

Monitoring Times, now in its fifth year of publication, has grown steadily, earning a worldwide reputation for accuracy, timely reporting, and journalistic integrity. *International Radio* has similarly earned a reputation for in-depth interviews of broadcasting personalities, up-to-the-minute time and frequency schedules, and program details.

The expanded 60-page tabloid will be the largest periodical in the monitoring industry, featuring authoritative content and improved printing from a new laser printer on heavier paper.

A year's subscription to the new *Monitoring Times* will be only $14. Discounts are available for two- and three-year subscriptions, quantity orders for resale, and educational institutions.

For more information on domestic or foreign subscriptions, contact *Monitoring Times* at 140 Dog Branch Road, P.O. Box 98, Brasstown, North Carolina 28902.

Circle #310 on Reader Service Card.

160-meter vertical

Oak Hills Research has announced its new DX-60V 160-meter vertical antenna, a folded design that measures 160 feet overall, with 120 feet of wire. The DX-60V can be installed in a tree, on a tower, in either a slanted or vertical position. It will be handle the full legal limit and has a typical bandwidth of 110 kHz between 2:1 SWR points. High-impact polystrene coil frames and spreaders are used to prevent breakage in high winds and cold weather. Tapping the loading coil at two points and switching between them will give band coverage. In order to achieve maximum performance, Oak Hills warns that it's imperative to have a ground system. Several suggestions are provided in the maufacturer's literature.

For more details, contact Oak Hills Research, 4961 North Douglas Road, Luther, Michigan 49656.

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NYE Antenna Tuner MB-IV. Near perfect cond. $250. FOB W1CPI. 789-1817.

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THE GOOD SAM HAMS invite RV operators to check in the Good Sam Ham net 14.240 *Sundays 1900Z also 3.880 Tuesdays at 2359Z. Net control N5BDN, Clarksville, IN*

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EIMAC 4CX1000A/8168 tube, brand new. $275. SASE for list of electronic components and computer gear. David Roscoe, *W1DWZ, 49 Cedar, East Bridgewater, MA 02333 (617) 378-3619.*

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COMING EVENTS

Activities — "Places to go . . ."

THANK YOU! TCRA (Tri-County Radio Association) thanks all our customers and vendors who made our May 4, Stirling, NJ, Hamfest a big success. We look forward to seeing you next year.

ALABAMA: The Huntsville Hamfest, Alabama's largest, Saturday *and Sunday, August 16 and 17, Von Braun Civic Center,* Huntsville. No admission charge. Exhibits, forums, ARRL booth. Also non-ham activities. Air-conditioned indoor flea market. Reserved tables $8/day. Walk in CAVEC exams given at the Huntsville HS cafeteria beginning 9 AM Saturday. Tours of the Alabama Space & Rocket Center available. A limited number of camp sites with hookups available at the VBCC. Talk in on 34/94. For more information: Huntsville Hamfest, 2804 S. Memorial Parkway, Huntsville, AL 35801.

OHIO: The Lancaster and Fairfield County Amateur Radio Club's annual Hamfest, Sunday, August 10, Fairfield County Fairgrounds, Lancaster. 8 AM to 4PM. Admission $3.00 advance or $4.00 at the door. Limited tables at $4.00 each advance; $5.00 at door or bring your own. Table space $3.00 advance or $4.00 at door. Plenty of parking. Refreshments available all day. For more information write Box 3, Lancaster, Ohio 43130.

ILLINOIS: The Hamfesters Radio Club is sponsoring their 52nd Hamfest, Sunday, August 10, Santa Fe Park, 91st and Wolf Road, Willow Springs (near Chicago). Gates open 6 AM. Free parking. Vendors, ARRL and FCC tables. Refreshments available at reasonable prices. Tickets $3.00 donation advance. $4.00 donation at gate. For advance tickets send check and SASE to Hamfesters Radio Club, *PO Box 42792, Chicago, IL 60642. For general* information call (312) 598-4802.

OHIO: The 12th annual Hall of Fame Hamfest, August 10, presented by the Tusco ARC, W8ZX and the Canton ARC, W8AL. Nimishillen Grange, 6461 Easton Street, Louisville. Registration $2.50 advance; $3.00 at the gate. Reserved tables available $5.00 each. Deadline 8/1/86. Large flea market, forums and plenty of *good food. Mobile check in on 146.52/52 and 147.72/12. For in-*formation: Tusco ARC, PO Box 725, New Philadelphia, OH 44663.

NEW YORK: Electronics Extravaganza sponsored by the Putnam Emergency Amateur Repeater League, Saturday, August 16, J.F. Kennedy Elementary School, Brewster. 9 AM to 4 PM. Admission $3.00. Children under 12 free with adult. Food and refreshments available. Indoor tables, with one admission, $10.00. Tailgating *$5.00. FCC exams. Limited walkins. Talk in on 144.535/145.135.* For table reservations or information: R. Dillon, N2EFA, RFD 7, Noel Court, Brewster, NY 10509.

WYOMING: ARRL Rocky Mountain Division Convention and 5th annual WIMU Hamfest, August 1, 2 and 3, Virginian Motel, Jackson Hole. Offering the scenic beauty of Yellowstone and Teton National Parks. Great fishing, horseback riding, raft rides on the Snake *River. Fun for the entire family! For more information:* George Siegel, 130 E. 17th Street, Idaho Falls, ID 83401. Telephone (208) 523-7433.

PENNSYLVANIA: W3PIE, the Uniontown Amateur Radio Club's 37th annual Gabfest, Saturday, September 6, Club Grounds, Old Pittsburgh Road, Uniontown, 50 miles south of Pittsburgh. Free parking, free coffee, free Swap & Shop setup with registration at $3.00 each or 2/$5.00. Talk in on 147.645-.045 and 144.57-.17. For further information: UARC Gabfest Committee c/o John T. Cermak, WB3DOD, PO Box 43, Republic, PA 15475. (412) 246-2870.

PENNSYLVANIA: The Central PA Repeater Association's annual Electronic Exhibit/Ham/Computerfest, August 24, Penn Harris Inn and Convention Center Rts 11 and 15, Camp Hill. Gates open 8 AM. Admission $4.00. XYL's and children 12 and under free. Indoor air-conditioned exhibit area. Large outdoor tailgating area. Various seminars. Amateur license exams starting 9 AM. Food and refreshments available. Talk in on 145.47 and 146.52 simplex. For information and reservations: Paul McDonnell, N3BKI, 1207 Apple Drive, Mechanicsburg, PA 17055. (717) 697-1880 (12 noon to 8 PM)

INDIANA: The 9th annual Bloomington Hamfest, Sunday, August 31, 2335 Vernal Pike, the 147.78/.18 repeater site. 8 AM to 2 PM. Admission $2.00. Food concession. No charge for setups but bring own tables. FCC VE exams contact K9PS for details. For Hamfest information please SASE to Bob Myers, K9KTH, 306 S. Fairview St., Bloomington, IN 47401 or call (812) 332-1105.

MAINE: ARRL sanctioned Windsor Hamfest, sponsored by the Augusta Emergency Amateur Radio Unit, September 6, Windsor Fairgrounds. Flea market, programs, speakers, commercial distributors and the traditional Saturday bean and casserole supper. Gate donation $1.00. Camping $3.00 per night or $5.00 for two nights. Talk in on 146.22/82 repeater. For more information: Dot, W1TGY and Phil, W1JTH, Young, 47 Longwood Avenue, Augusta, ME 04330. (207) 622-1385.

INDIANA: The Porter County Amateur Radio Club's Hamfest, August 3, 49'er Drive-In Theater, State Road 49, Valparaiso. Gates open 8 AM. Admission $3.00 at gate. Talk in on 147.96/.36 and .52 simplex. For more information: PCARC, PO Box 1782, Valparaiso, IN 46382.

NEW JERSEY: The Ramapo Mountain Amateur Radio Club's 10th annual Flea Market, August 23, Oakland American Legion Hall, 65 Oak Street, Oakland. 20 miles from GW bridge. Indoor tables $6.50. Tailgating $3.00. Admission $1.00. Non-ham family members free. Talk in on 147.49/146.49 and 52. For information: Tom Risseeuw, N2AAZ, 63 Page Drive, Oakland, NJ 07436. Tel. 337-8389 after 6 PM.

INDIANA: The 7th annual Grant County Amateur Radio Club Hamfest, Sunday, August 10, 4-H Fairgrounds, Marion. Doors open 8 AM. Refreshments, free parking license exams. Donation $2.00 advance; $3.00 gate. For information/tickets SASE to: WB9EAP, *Brooks Clark, 2202 South Boots Street, Marion, IN 46953.*

MISSOURI: The St. Charles ARC will sponsor Hamfest '86, Sunday, August 24, Blanchette Park (New Site), St. Charles. 7 AM to 2:30 PM. Free admission and parking. Forums and FCC license exams at 10 AM. $2.00 donation for tailgate flea market. Dealers welcome. Talk in on 146.07/67 repeater and 146.52 simplex. Contact: Eric Koch, NF0Q, 2805 Westminister, St. Charles, MO 63301. (314) 946-0948.

MINNESOTA: The St. Cloud Amateur Radio Club Hamfest, August 10, Lake George, St. Cloud. Displays, demonstrations and trades. Ticket donation $3.00. Extra ticket $2.00. Snack counter. Talk in 34/94 primary, 615/015 secondary. Contact: SCARC, Box 141, St. Cloud, MN 56302.

TENNESSEE: The Lebanon Hamfest sponsored by the Short Mountain Repeater Club, August 31, Cedars of Lebanon State Park, US 231, Lebanon. Outdoor facilities only. Exhibitors bring your own tables. Food and drinks available. Talk in on 146.31-146.91. For more information: Mary Alice Fanning, KA4GSB, 4936 Danby Drive, Nashville, TN 37211.

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

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

VIRGINIA/WEST VIRGINIA: The Bluefield Hamfest, sponsored by the East River ARC, Sunday, Augusta 24, Brushford Armory, 1 mile north of Bluefield, WV, US 52. Admission $4.00. Children under 12 free. Large indoor flea market. Amateur radio, computer, satellite TV and other specialty dealers. Walk-in Amateur Radio exams 9 AM only. $4.00 fee for all exams except Novice. Talk in on 144.89/145.49 and 146.52. Paved parking, food on site, other activities. For information: Jim Perdue, KC8NG, Rt. 5, Box 457, Bluefield, WV 24701.

MICHIGAN: The Five County annual Swap-N-Shop, August 24, Saginaw Civic Center. Doors open 8 AM, 6 AM for dealers. Advance tickets $2.00. $3.00 at the door. Tables $7.50/8' tables. Covered trunk sales area $3.00 per car. Talk in on 147.84/24 and 146.52. For information call Don (517) 893-3475. For advance tickets and table reservations: Five County Swap-n-Shop, PO Box 1783, Saginaw, MI 48605-1783.

OHIO: The Union County Amateur Radio Club's 10th annual Marysville Hamfest and Auction, Sunday, August 24, Marysville Fairground. Gates open 6 PM Saturday evening for free overnight camping, free entertainment Saturday night. Auction Sunday afternoon. Large flea market area. $1.00/10' space. Power $2.00 extra. Advance tickets $3.00. At the gate $4.00. For information please SASE to: Gene Kirby, W8BJN, 13613 US 36, Marysville, OH 43040. (513) 644-0468.

PENNSYLVANIA: The Mid-Atlantic Amateur Radio Club's annual Hamfest, Sunday, August 10, Bucks County Drive-in Theater, Rt. 611, Warrington. 8 AM to 3 PM. Rain or shine. Admission $3.00 plus $2.00 for each tailgate space. Bring your own tables. Talk in on WB3JOE/R, 147.66/.06 or 146.52. For information: MARC*PO Box 352, Villanova, PA 19085 or call Bob Josuweit, WA3PZO (215) 449-9727.

INDIANA: The WA9SNT Amateur Radio Club will hold its annual Swapfest, August 9, ITT Technical Institute, 9511 Angola Court, Indianapolis. 8 AM to 4 PM. General admission $2.00. Students $1.00. Flea market space $1.00 additional. Setup time 6 AM. Auction, large flea market, refreshments avialable. ITT Technical Institute will hold an open house during the Swapfest. All interested are invited to tour the facilities. For additional information: Dave Johnston, K9HDQ, c/o ITT Technical Institute, 9511 Angola Court, Indianapolis, IN 46368. (317) 875-8640.

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

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

MASSACHUSETTS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday, August 20, 7 PM, MIT Room 1-134, 77 Mass Avenue, Cambridge MA. Reservations requested 2 days in advance. Contact Ron Hoffmann (617) 253-0160/646-1641 or Craige Rodgers (617) 494-1986. Exam fee $4.25. Bring copy of current license (if any), two forms of picture ID and completed form 610 available from FCC in Boston (223-6609)

OPERATING EVENTS

"Things to do . . ."

OHIO STATE FAIR Special Event, August 1-17. Listen for W8TO, 80-10 meters. Exchange QTH and RST. All correspondence and requests for awards to ARS W8TO, att: State Fair event coordinator, 280 East Broad St., Columbus, Ohio 43215.

The Penn-Jersey ARC will operate W2SJT, from 1600 UTC, August 9 to 1600 UTC August 10, to honor the Oxford Furnace, an historic landmark. 2m, 450 and all HF bands. For certificate send QSL and 3 stamps to Ron Semonche, WB2TOJ, 263 W. Carlton Avenue, Washington, NJ 07882.

SCHAUMBURG SEPTEMBERFEST The Schaumburg ARC will operate club station WB9TXO from the grounds of the Schaumburg Septemberfest, August 31, 1600Z-2100Z. For certificate send QSL to SARC, PO Box 94251, Schaumburg, IL 60194.

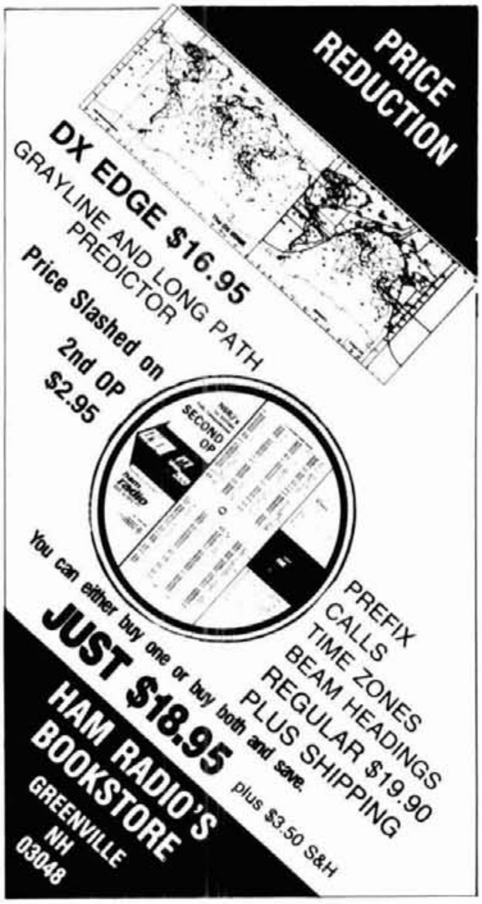
IBM RADIO CLUB will operate special event station WD0GNK, August 16, to celebrate the 30th anniversary of the IBM Corp in Rochester, Minnesota. Certificate for QSL and SASE via WD0GNK-IBM Radio Club, IBM Corp, Dept. 868, Hwy 52 North, Rochester, MN 55901.

The NORTH OTTAWA ARC will operate KA8USK aboard the US Coast Guard cutter Mackinaw as part of the Grand Haven Coast Guard Festival July 30-August 3. For commemorative certificate send QSL and 9x12 SASE via NOARC, Box 44, Ferrysburg, MI 49404.

NEW JERSEY QSO PARTY All Amateurs worldwide are invited to participate. 2000 UTC August 16 to 0700 UTC August 17, 1300 UTC August 17 to 02000 UTC August 18. Phone/CW same contest. Contact a station once each band. Phone/CW separate bands. Call "CQ New Jersey" or "CQ NJ". New Jersey stations sign "DE NJ". Exchange QSO number, RST and QTH. NJ stations send county. Send logs and comments to Englewood ARA, PO Box 528, Englewood, NJ 07631-0528 with -10 SASE for results.

THE WILD BUNCH 160 meter SSB Contest, 0000 GMT August 2 to 2400 GMT August 3. Deadline for logs 9/7/86 postmark. Send to Rob Koziomkowski, KA1SR, 5 Watson Drive, Portsmouth, RI 02871.

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



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READER SERVICE # — PAGE #

PRODUCT REVIEW/NEW PRODUCTS

*Please contact this advertiser directly.

Limit 15 inquiries per request.

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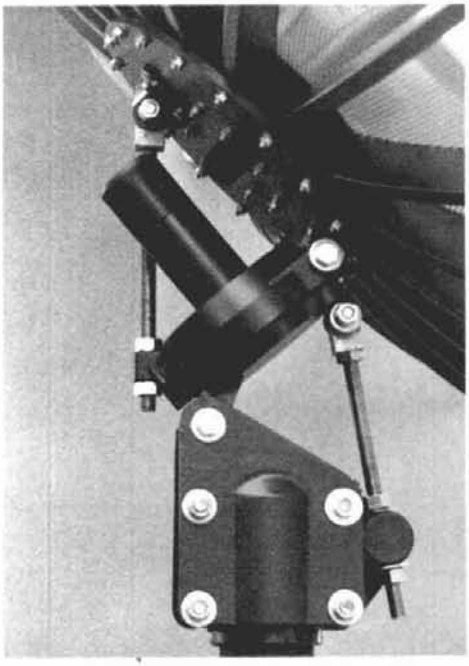

1000 ft/lbs Torque. Well, that's the design that's got the TVRO Industry so excited. The engineers at Raydx found that existing Geo-stationary satellite tracking systems just couldn't meet the company's exacting standards for superior performance, dependability and consumer appeal. So they suggested that Raydx, the Leader In Dish sales manufacture their own. And that's just what they did.

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