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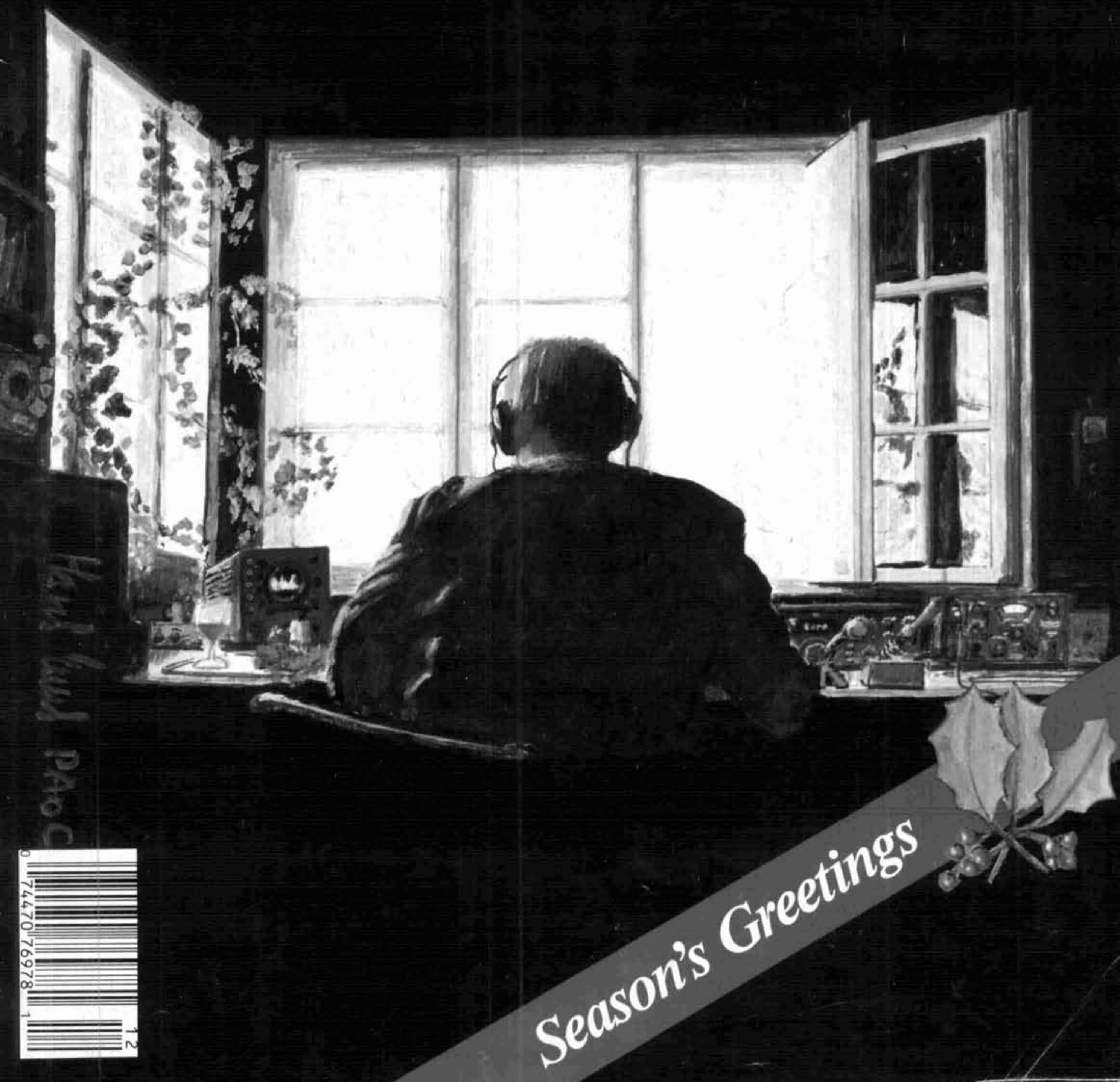

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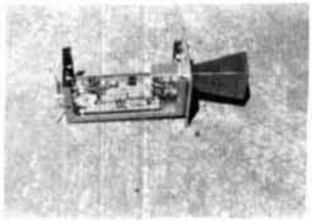
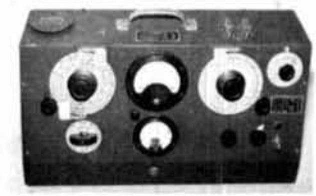


N6GN, page 9



W3QOM, page 49

DECEMBER 1989
Volume 22, Number 12

FEATURES

DEPARTMENTS

HAM RADIO Magazine (ISSN 0148-5989) is published monthly by Communications Technology, Inc. Main Street, Greenville, New Hampshire 03048-0498 Telephone: 603-878-1441 FAX: 603-878-1951. **Subscription Rates:** United States: one year, $22.95; two years, $38.95; three years, $49.95; Canada and Mexico: one year, $31.00; two years, $55.00; three years, $74.00. *All other countries:* one year, $35.00 via surface mail only. All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank. **International Subscription Agents:** page 94.

Microfilm copies are available from Buckmaster Publishing Mineral, Virginia 23117. Cassette tapes of selected articles from **HAM RADIO** are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107.

Second-class postage paid at Greenville, New Hampshire 03048-0498 and at additional mailing offices. *Send change of address to HAM RADIO, Greenville, New Hampshire 03048-0498.*

One of *Ham Radio's* Unsung Heroes

Most readers think of the staff at *Ham Radio* as editors, publishers, or staff members they may have met at Dayton or some other show. But it takes many more important people to complete the team that puts the magazine in your hands each month.

One of our "unsung heroes" is planning to retire at the end of this month, after 17 years in our circulation department giving outstanding assistance to both the magazine and its readers. Therese Bourgault is second in length of service only to myself.

Sue Shorrock, our circulation manager, has written a piece that not only pays tribute to "T", but also demonstrates the dedication that all of us at *Ham Radio* try to exhibit in bringing you the finest magazine that we can.

W1NLB

It seems like only yesterday that I started working with Therese Bourgault in the circulation department. Except that yesterday was in 1977.

My first day, 12 years ago, was memorable. After introductions all around I remember thinking, "They aren't really going to leave me alone in the same room with this female storm trooper, are they?"

But they did. Everyone else went back to work, and we were on our own. Because self-preservation is at the core of most human beings, I became an attentive student and a quick learner.

The first lesson was that there is only one way of doing things — T's way. I also learned that her way was the right way. Some more rules: As our subscriber you are number one. You are all to be treated equally and fairly. Your orders are to be processed quickly and carefully. If there is a problem we find out what happened, why it happened, and then correct the matter to your satisfaction.

Regardless of how busy or how frustrating things were, she always continued to do her work tirelessly. With time, humor, and our combined efforts to keep *Ham Radio* the best Amateur Radio magazine around, we became a good team and friends to boot.

Therese has devoted nearly 17 years of her career to making sure that you get the best possible service. During these years there have been some significant changes. One thing that never changed was her dedication to do the job and do it well. She has always been on your side.

I'm really going to miss working with T; she's been a good friend. But then, she always said if we're ever in a pinch....

Sue Shorrock

Comments

Author update

Dear HR

This letter is to clarify some points in my article, "A Simple DC Amplifier for Your Meter," *Ham Radio*, June 1989, page 10.

Figure 3 carries the note "Ground all unused pins of U1." The intent is to prevent feedback due to stray coupling with unused op amp units. In a letter I received from Robert A. Pease of the National Semiconductor Corporation, he agrees with grounding the unused input terminals, but recommends leaving the unused output terminals (numbers 7, 8 and 14) unconnected to save needless battery drain. I find that by disconnecting these terminals I save about 10 mA per terminal.

The type of pilot light used in **Figures 3** and **4** was not identified. I used light emitting diodes, and the series resistors RL are needed to limit the currents. Both should be 2.2 k. Resistor RL is shown incorrectly shorted out in **Figure 4**.

Yardley Beers, WØJF,
Boulder, Colorado

Fair share

Dear HR

I'm writing in regards to your editorial "Amateur Radio Licensing Fees — The 'Non-Tax' Tax," (October 1989). I think you are too pessimistic in one respect, but not pessimistic enough in another.

You are right — any "user fees" collected by the FCC have to, by law, go into the General Fund and do not accrue to the FCC itself. But any statute passed by Congress can be amended by Congress. In seeking such an amendment, ham radio operators would have important allies. The National Park Service, for example, would very much like to have user fees collected at park entrances to be used to support and maintain the parks.

On the other hand, even if user fees collected by the FCC from Amateur Radio operators went directly into the FCC's budget, there is no assurance that the fees would be used for the benefit of Amateur Radio. The Commission has many other responsibilities and many other ways to spend money.

I think you are right in saying that "Amateur Radio will derive little or no benefit if the monies simply go into the General Fund." But you're wrong in thinking that Amateur Radio would necessarily derive any benefit if the fees were paid to the FCC directly.

Hugh Aitken, W1PN,
Amherst, Massachusetts

A "Taxing" decision

Dear HR

Your "Backscatter" in the October issue will probably cause severe "Reflections" — and it should!

I was deeply upset after learning of the House Energy and Commerce Committee vote to levy fees for Amateur Radio licenses and several commercial ventures.

This is to reduce the federal deficit?

It's amazing that the esteemed committee would resort to "taxing" a group of voluntary hobbyists that have been, ever since the beginnings of Amateur (experimental) Radio, a national resource of self-trained and skilled individuals.

We have always been available, providing a public service without any compensation, in times of emergency — whether it be local, national, or international. In addition, we provide our government with a source of trained individuals, should the need arise, for the defense of our country. This has been proven a few times in this century.

The lack of growth (and even a decline) in Amateur numbers that occurred in the sixties was not due to the fees imposed at that time, but because of a general *deterioration of values* that swayed a generation of youth.

One has only to look back to a time when our country was in, and recovering from, an economic depression to see that the Amateur population was growing — although slowly at first. In those days of hardships, with more problems for our government than one could comprehend, an effective Commission was affordable and functioning well for its task — without Amateur Radio fees.

I can well understand the justification for fees on commercial interests in view of the fact that the profits obtained offset the costs.

In closing, I must express my disappointment in your willingness to accept this "tax" as stated in the article — even with your proposals.

Alex Hellman, W2OEQ,
Woodhaven, New York

Where's the missing band?

Dear HR

Just received my October *Ham Radio* and read with interest the review of the Kenwood TS-950S. I feel that they would do better if they included the 20-meter band (Oops!) in the engineering specs on page 29.

Thanks for the article in any case!

Robert A. Du Brul, WB0RJR,
Everton, Missouri

Whoops, our error! The 20-meter band is 14.0 to 14.35 MHz. Ed.

Do you have something you'd like to say? Address your comments to Dear HR, Ham Radio Magazine, Main Street, Greenville, NH 03055. Ed.

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INEXPENSIVE MULTI-MEGABAUD MICROWAVE DATA LINK

By Glenn Elmore, N6GN, 550 Willowside Road, Santa Rosa, California 95401 and Kevin Rowett, N6RCE, 1134 Steeplechase Lane, Cupertino, California 95014

We'd like to tell you about some inexpensive antenna, radio, and computer interface hardware which allows communication of digital data at rates up to 2 megabaud (1 megabaud = 1 million bits per second) on an Amateur Radio band. In addition to the data link, an analog voice channel is provided. It requires only an external microphone and speaker for simultaneous full duplex audio communication. The link operates in the 10-GHz Amateur band and uses an inexpensive commercial parabolic antenna along with a Doppler radar transceiver module to provide medium range communications at low cost. We'll discuss modifications to surplus networking interface cards that let you use this high speed data in Amateur Radio service with IBM-style personal computers.

The Amateur accustomed to conventional AX.25 packet operation might wonder why anyone would want to go to the trouble of building a digital radio approximately 1000 times as fast as the 1200-baud systems prevalent on the VHF bands. Although many metropolitan areas are experiencing severe congestion on some of the packet channels, it's also true that many keyboard-to-keyboard QSOs are taking place. A great deal of traffic is also being handled on the worldwide bulletin board systems using today's equipment. The success of AX.25 packet radio has suggested the need for faster systems to improve current performance and has spawned some fundamentally new ideas for Amateur Radio.

A whole spectrum of new user applications and the possibility of a nationwide or even worldwide digital Amateur network are two major areas made possible by faster hardware.

New applications

Packet has been regarded as a way for two stations' computers to communicate, allowing keyboard-to-keyboard QSOs, but the potential for far greater applications exists Almost any information which can be transmitted by analog means can also be transmitted digitally, making digital audio, facsimile, graphics, and even digital TV feasible on the Amateur bands once sufficient data speed is available. The concept of repeaters for a variety of modes is conceivable, when combined with the ability of each Amateur station to serve as a relay of data to and from other stations. Amateurs will also be able to share resources. A station with an interesting database will be able to make it available to others. On-line call directories, QSL information, and technical data — not to mention computer programs and even the computers themselves — can be shared. It's possible for one Amateur to actually run programs and applications on someone else's computer as though it were located in his own shack. Remote control of equipment and remote sensing are other possibilities. Remote digital control of repeaters or even complete stations, including audio or video uplinks and downlinks, can be supported. Conventional voice repeaters (analog) may be replaced by digital hardware for completely digital round tables. Since this data can be transmitted anywhere the network permits, there can be multistate, national, or even worldwide voice nets. If the data rate permits, all of these different applications could conceivably be going on at the same time!

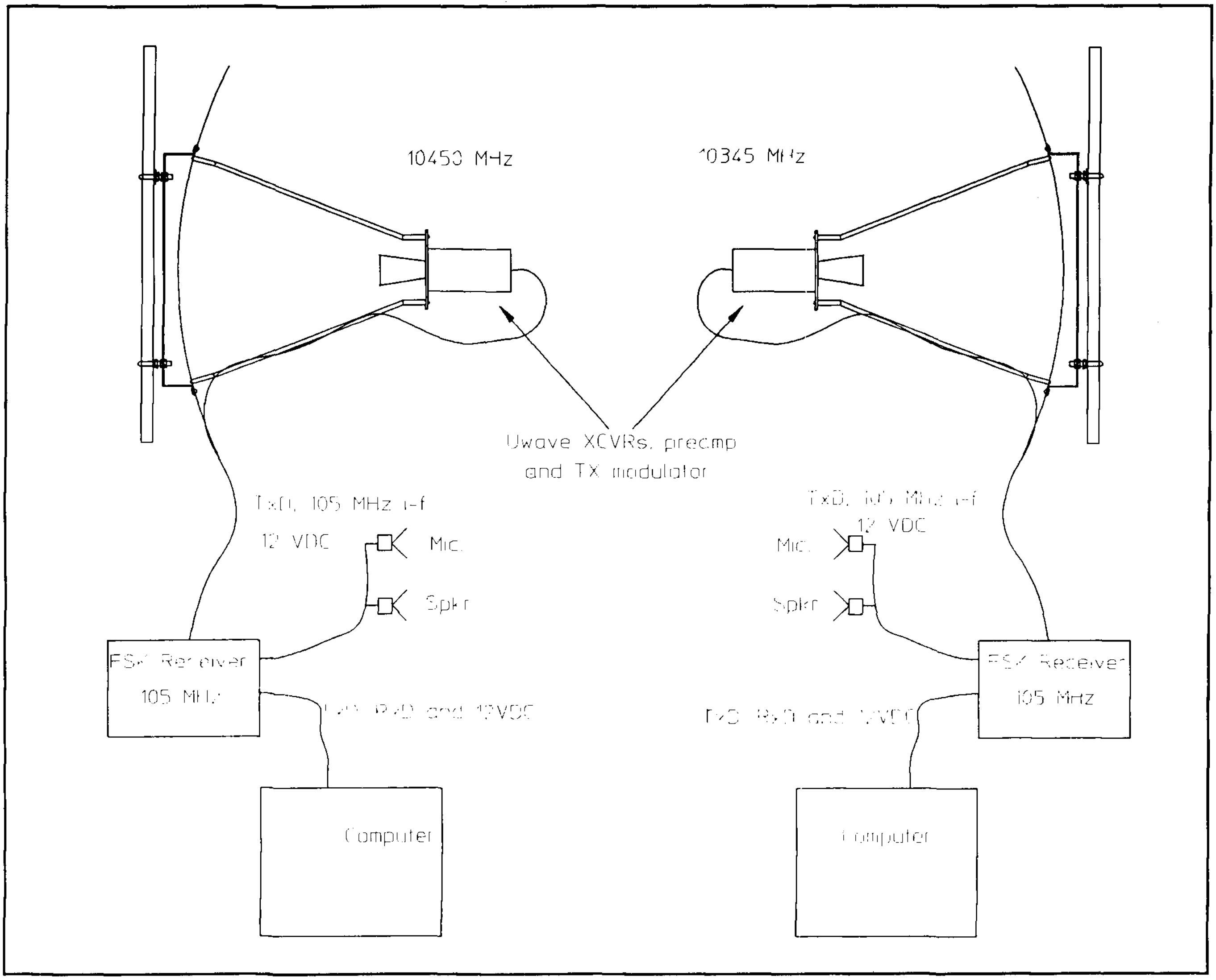
An Amateur Radio network

The possibility of an Amateur network is just as exciting as the variety of applications that high data rates can support. To date, groups of Amateurs have used limited networks for traffic handling and sharing information among members. A high speed digital network can provide these same services, as well as new applications, over very broad geographical areas on a full-time basis. A nationwide network capable of transmitting data quickly and with little delay could be beneficial to Amateur Radio public service and emergency operations. Data and resource sharing on a nationwide or worldwide network offers great potential in ushering the information age into Amateur Radio. The diversity of Amateur interests — DX, ragchewing, technical, and public service — could all be greatly enhanced by such a network. A network might also entice a great many potential and computer literate candidates into getting their tickets.

Goals

The link we'll describe was designed to help further the applications and networking made possible by high speed data exchange. It was built as an initial step in providing a moderate speed digital Amateur network in northern California to be used with a fledgling TCP/IP radio network.

FIGURE 1



System block diagram of the microwave high speed data link.

This was necessary to support some of the applications previously described. It was also built to help advance Amateur use of the microwave spectrum.

Fortunately, microwaves and high speed commmunication fit together very well. In fact, if the data rate is increased significantly it is absolutely necessary that wider and wider bands be used. As frequency is increased, antennas of reasonable physical size are better able to focus the transmitted beam without wasting signal in different directions. The Amateur microwave bands, through 24 GHz, offer the best available performance and cost for such communication. In order to be widely useful our link needed several attributes:

- To be inexpensive — competitive with present TNC/radio combinations
- Moderate speed — significantly faster than current alternatives of 1200 to 56,000 baud
- Medium range — at least 20 miles to be effective
- To use readily available parts
- To be simple to build and maintain
- To be reliable — a variety of applications may depend upon it

Problems

In addition to the problem of building radio hardware which the average Amateur could feel comfortable installing and maintaining, there are problems with the digital interface hardware portion of such a link.

At these speeds the data is too fast for normal serial ports on most computers, for the internal bus operations of many computers, and for TNCs. Similarly, the software to process data at these speeds can no longer operate on a character-by-character basis. Any solution we developed for these problems also needed to work with commonly available hardware, most notably the IBM PC and its clones.

Microwave hardware, propagation, and high speed data are new ground for many Amateurs. This means that any high speed link hardware needs to be relatively easy to work with.

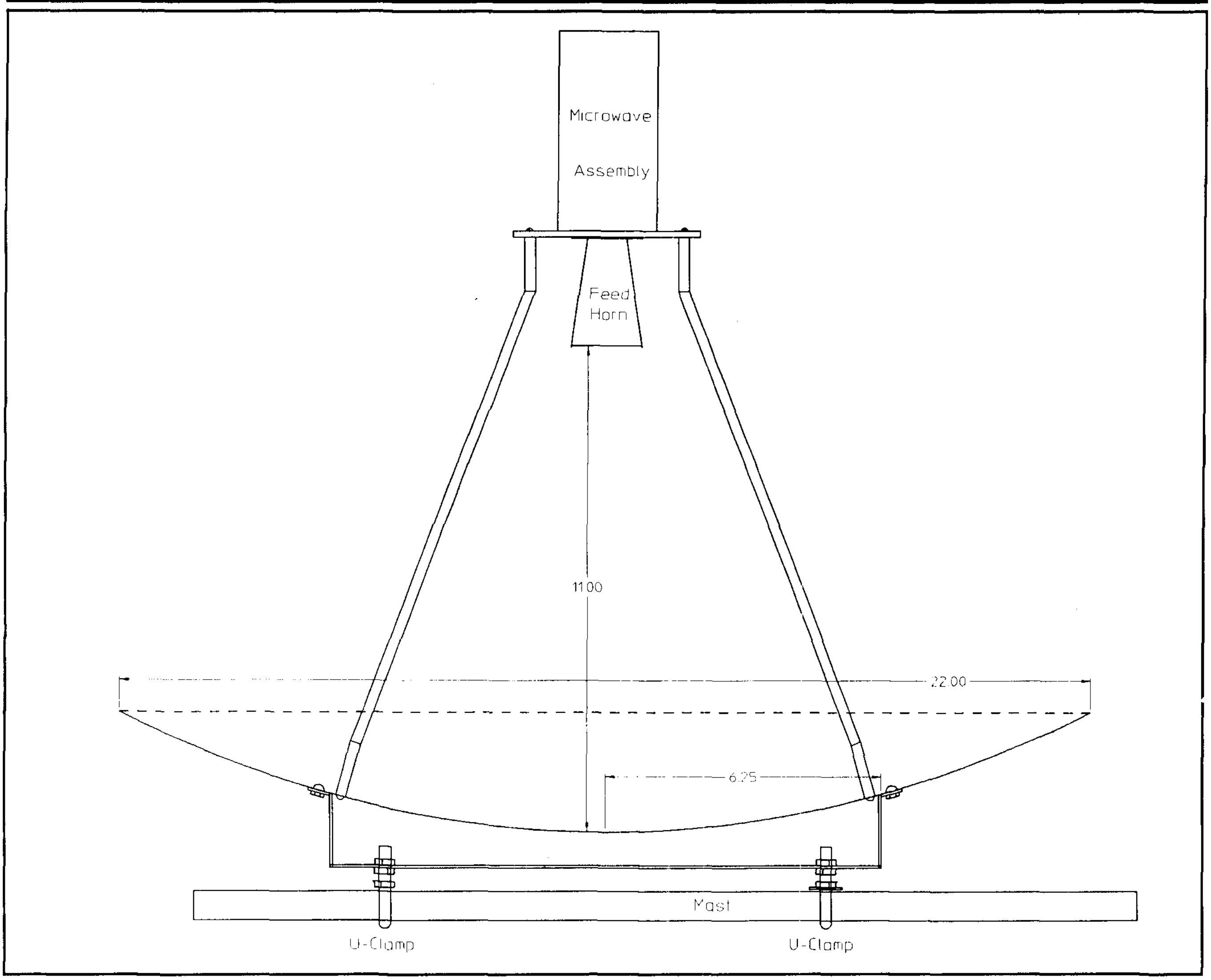
What we built

Previous successes using 10-GHz Gunn diode oscillators as local oscillators and transceivers for narrowband weak signal work, brought to mind the possibility of using these inexpensive units for higher speed digital data transmission. In addition to being inexpensive, these units — which are commonly used for motion detection (door openers and burglar alarms), speed measurement (police radar guns), and microwave receivers (radar detectors) — have all of the microwave circuitry self-contained. This is important because it makes the equipment more attractive to non-microwave users. The system block diagram in **Figure 1** shows the operating principles.

The two ends of a link operate "split." One transceiver oscillator typically operates on 10,450 MHz while the other end is 105 MHz lower, on 10,345 MHz. The difference between the two transmitter frequencies corresponds to the receiver first IF frequency. The receiver first IF on each end is generated when the remotely transmitted signal (frequency modulated by the data to be transmitted) is mixed with the local transmitter. Each end uses its own transmitter as a receiver local oscillator, and each unit transmits continuously. Therefore, each receiver sees the same IF. This is the same full duplex arrangement used for many years by Amateur microwave enthusiasts. The transmitters run 5 to 10 mW of output power. The transmitter is frequency modulated as its bias supply is varied and the frequency-voltage dependency of the transceivers is used for tuning. This same technique was used previously to phase lock such oscillators.[1] The 2-foot dish shown here has a gain of about 33 dB, or 2000 times at 10.5 GHz. When driven by the microwave transceiver, the effective radiated power (ERP) is about the same as that of a 10-watt 2-meter radio driving a quarter-wave whip. We selected 105 MHz for the receiver first IF, with provision for tuning ± 10 MHz to accommodate differential frequency drift with time or temperature of the free-running microwave transceivers. Using an IF in this range also lets you do some simple troubleshooting and testing with commonly available commercial FM broadcast receivers. No correction is necessary if both ends drift in the same direction because the IF doesn't change. Automatic Frequency Control (AFC), implemented by tuning the second LO nominally at 150 MHz, is provided to keep the receiver tuned correctly. This conversion produces the second IF at the point where detection takes place at 45 MHz in a Motorola MC13055 FSK receiver chip. This chip is specified to operate at data rates up to 2 megabytes per second (Mbps), but has actually been used as high as 10 Mbps.

Automatic frequency control circuits keep each receiver correctly tuned, even when the first IF deviates from 105 MHz. A search oscillator is also provided to allow the receiver to "find" the incoming signal when the link is first powered up, or if you lose signals temporarily. The searching is controlled by the Data Carrier Detect (DCD) circuitry. Once the signal is found, the oscillator is shut off and the AFC tunes the receiver correctly. Because the data is digital, an appropriate offset is introduced to the tuning depending on whether the data is a "0" or a "1." We added the audio channel as an afterthought. It provides for human communication, particularly while debugging the link and operating it with digital data the first time. An electret microphone produces the transmit audio signal. This is amplified and limited by high and low pass filters before modulating the transmitter. Levels were selected to provide only small deviation compared with that of the digital channel. This allows the audio channel to operate without significantly interfer-

FIGURE 2A



Mechanical layout of the 10-GHz dish feed and mounting system.

ing or degrading the digital data. A volume control and speaker amplifier sufficient for driving headphones or a small speaker are provided on receive.

An analog meter displays strength as carrier-to-noise (C/N) ratio or discriminator output to aid when manual frequency control (MFC) is used. The MC13055 FSK receiver chip has a built-in logarithmic amplifier which can give a pretty accurate measure of C/N. A switch lets you select manual or automatic frequency control.

The microwave transceiver, modulator, and receive preamplifier are mounted together in a box located at the prime focus of the parabolic antenna. A horn antenna was designed to illuminate the dish antenna efficiently so that near maximum gain could be obtained. The rest of the receiver, as well as circuits for the audio channel, are located in a separate enclosure. This lets you place the antenna and microwave hardware a considerable distance from the receiver for tower or mast mounting.

We used Emitter Coupled Logic (ECL) for incoming and outgoing data. These are differential lines and can be used even when there is considerable line length — for example, when the microwave portion is high on a tower or the receiver is located some distance from the host computer. A standard 15-pin connector is used as the interface to the radio hardware. Those familiar with Local Area Networks (LANs) may recognize this connector and pinout as identical to that of a Media Access Unit (MAU), the device used to link a computer to a coaxial cable connecting a building or area wide network. You need just 12 volts DC at approximately 350-mA data input and data output to operate all the radio link hardware.

Antenna

The antenna is mounted to a mast with a rear mounting bracket. This plate is cut from sheet aluminum and folded to produce four "feet" which attach to the dish. Mount the plate to the mast with U clamps. For minor elevation steering of the antenna, add two extra sets of nuts to the clamps.

(continued on page 17)

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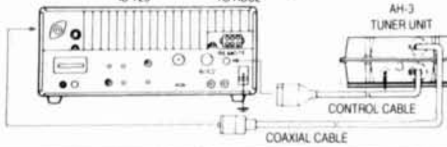

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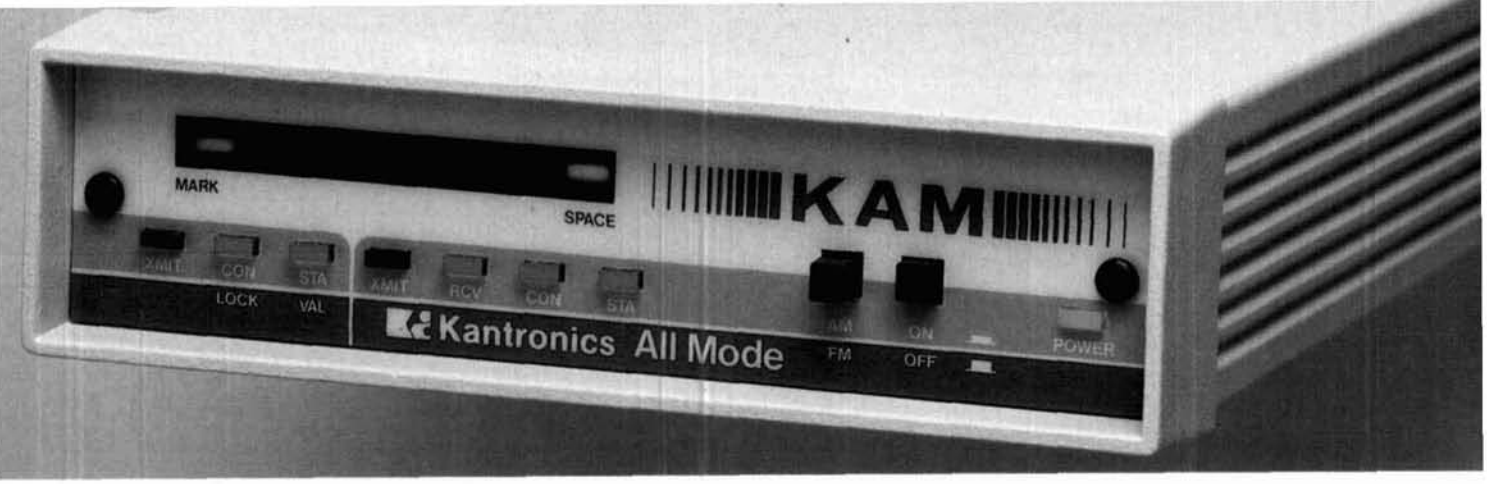

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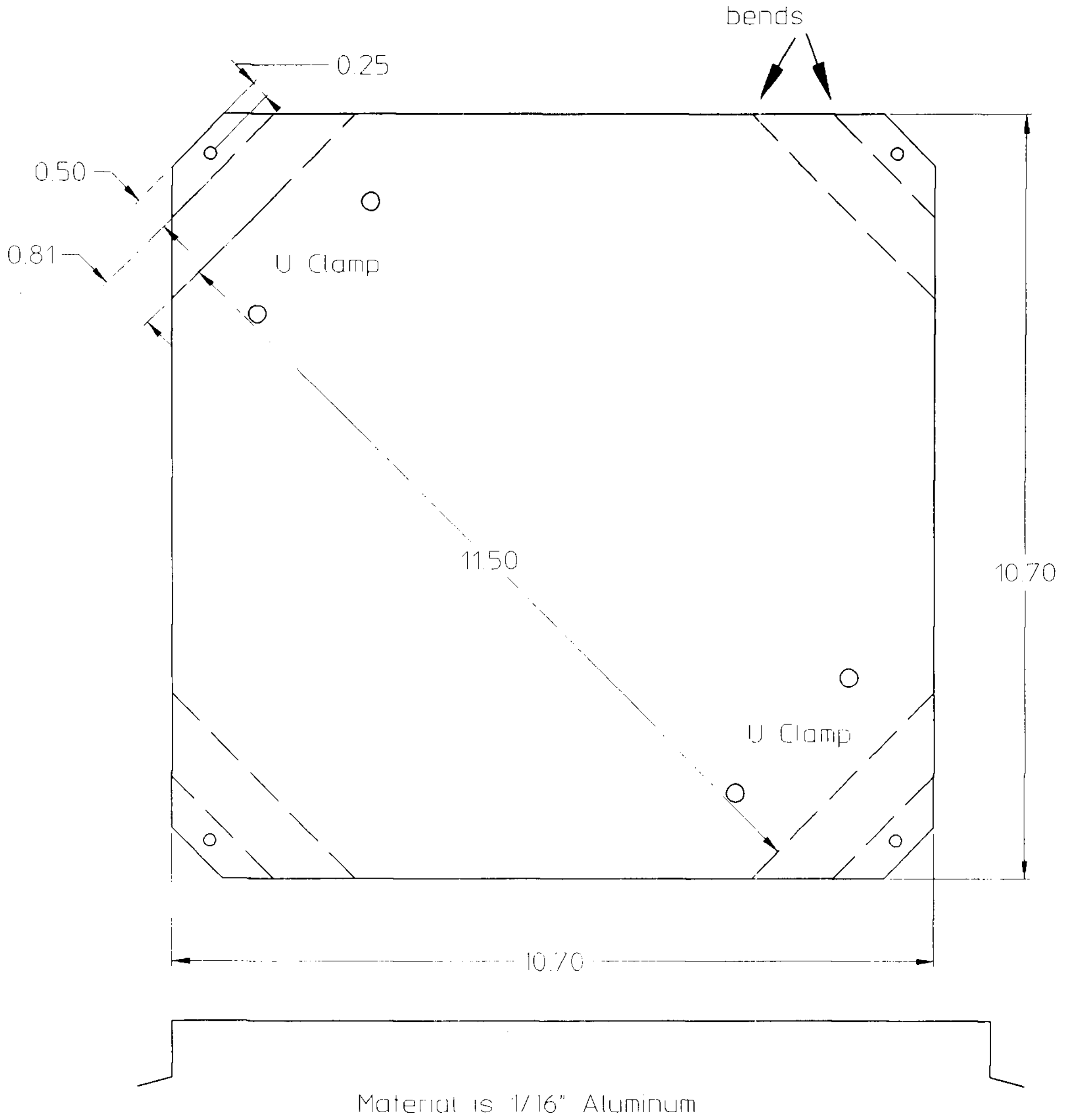
✓ 136

(continued from page 12)

FIGURE 2B



Dimensions of the feed support struts.

This lets you adjust the spacing between the mast and plate. Less spacing on the top than on the bottom clamp points the dish upward; more spacing points it downward. Because the antenna has less than a 4-degree half-power beamwidth, you may need to make this adjustment — particularly when the two ends of the link are at different elevations and not very far apart.

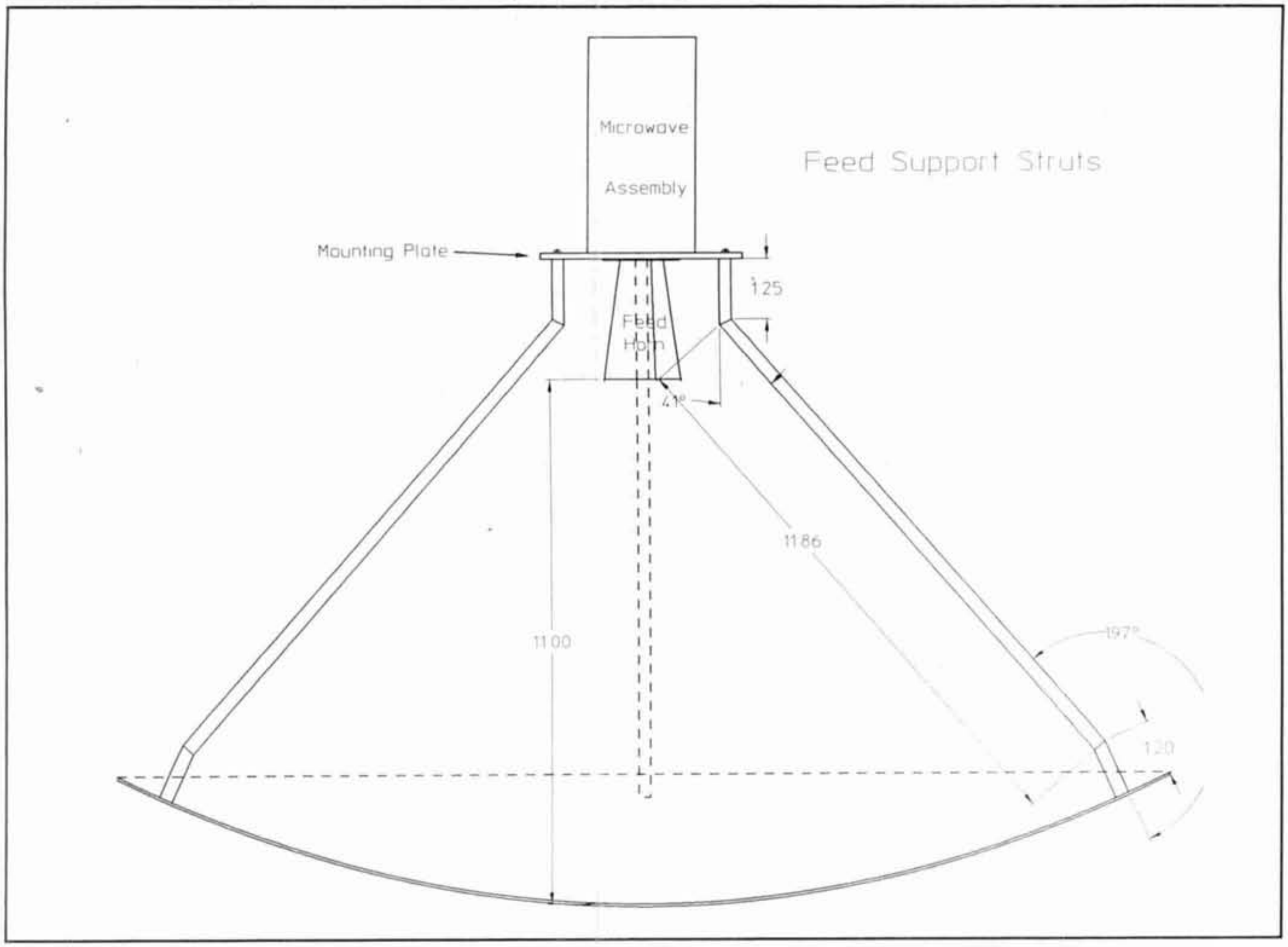
The horn feed and microwave assembly attach to a plate and are held at the dish focal point by four 1/4-inch diameter struts made from soft aluminum rod. We found this material at a local home supply store. First cut the aluminum rod to length; then drill and tap it at each end. Use a tubing bender to shape the rod properly. **Figures 2A, 2B** and **3** show the mounting bracket and feed support struts, respectively.

Feedhorn

To construct the feedhorn, first cut the sides and flange from copper or brass shim stock as shown in **Figure 4**. Because the material is so thin, you may want to begin by tacking the whole assembly together using a medium sized soldering iron and complete your soldering after everything is in place.

The feed/microwave assembly is shown in **Photo A**. The mounting plate has a short section of waveguide at its center. The feedhorn and transceiver mount on opposite sides and a small Bud box encloses the electronics. Make the waveguide section by milling (or drilling) and filing a 0.40 by 0.90-inch rectangle in the plate. Great precision of construction for either the feed or the mounting plate isn't

FIGURE 3



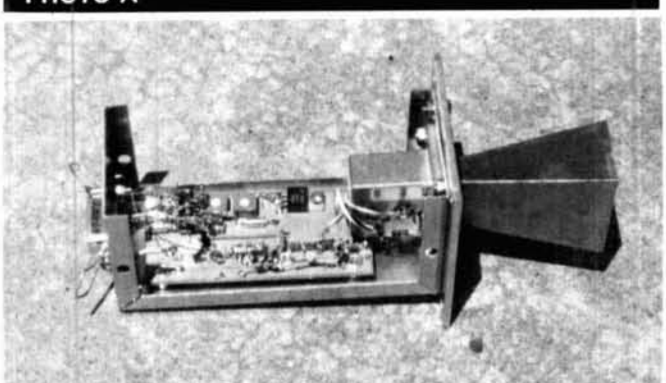
Dimensions of the feed support struts.

necessary to obtain good performance. **Figure 5** shows the feed mounting plate.

Microwave assembly

Because the microwave transceiver is self-contained, the RF electronics aren't particularly critical or difficult to assemble. The receive preamplifier is probably the only sensitive circuitry, and because this uses MMICs, short lead length and good grounding are the only prerequisites. If you use pc board material, you can make the entire board using a file and small hobby knife. Fifty-ohm transmission line is used to connect to and from the MMICs. Try making this line by filing 0.005 to 0.010-inch slots 0.1 inch apart. The line can then be cut into short sections and the components soldered directly to it. Holes drilled in the board allow the MMIC packages to sit flush with the lines. Holes are also drilled for all component ground leads, and the leads are soldered on the top and bottom of the board. The regulator and modulator circuits aren't critical and the ECL IC may be "dead bug" mounted on top of the board. You can mount the board to the aluminum box with short spacers. Use a twisted pair made from hookup wire to connect to the mixer diode on the transceiver. **Figure 6** shows an approximate board layout. (See **Figure 7** for enclosure dimensions.)

PHOTO A

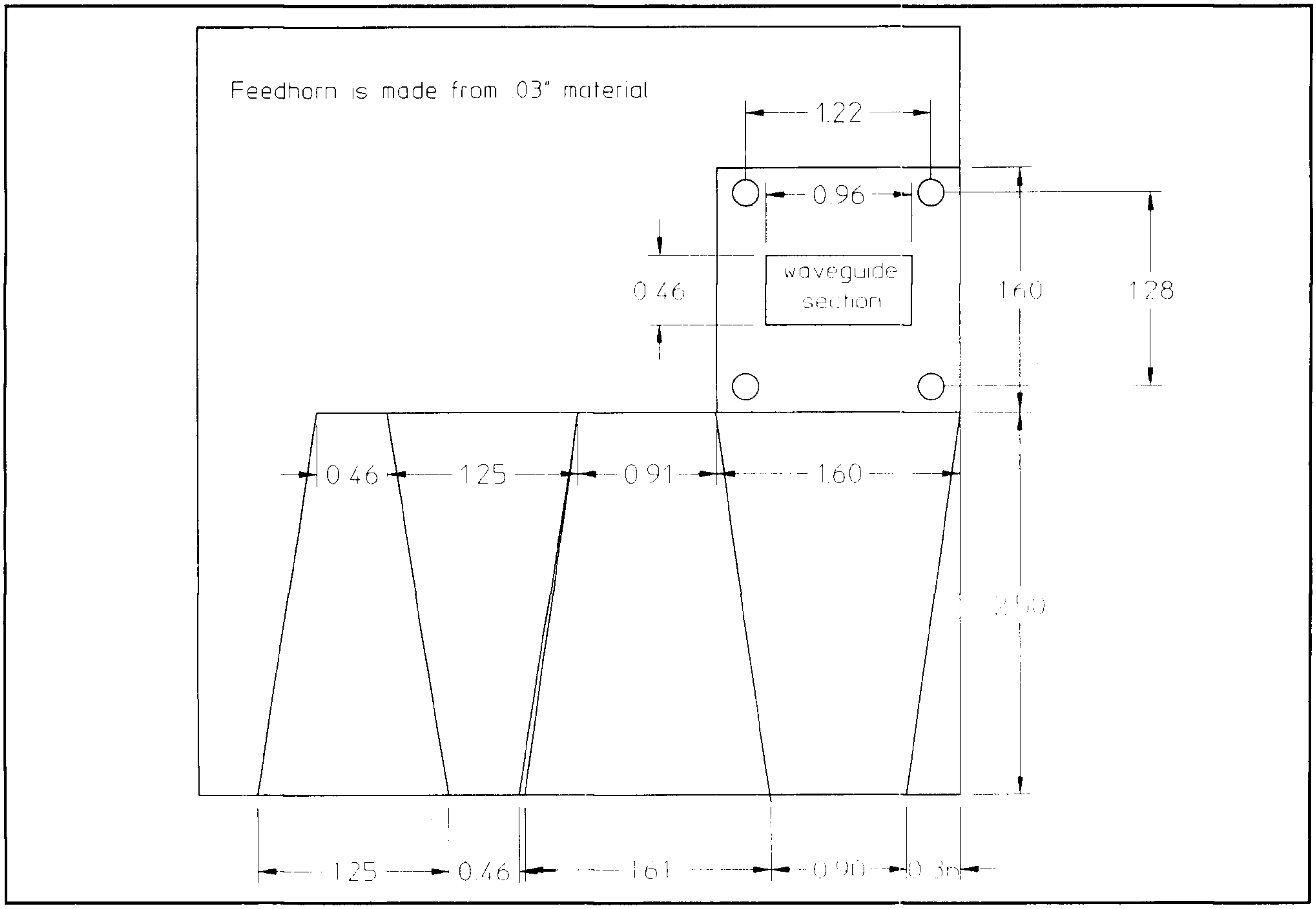


Feed/microwave assembly.

Receiver assembly

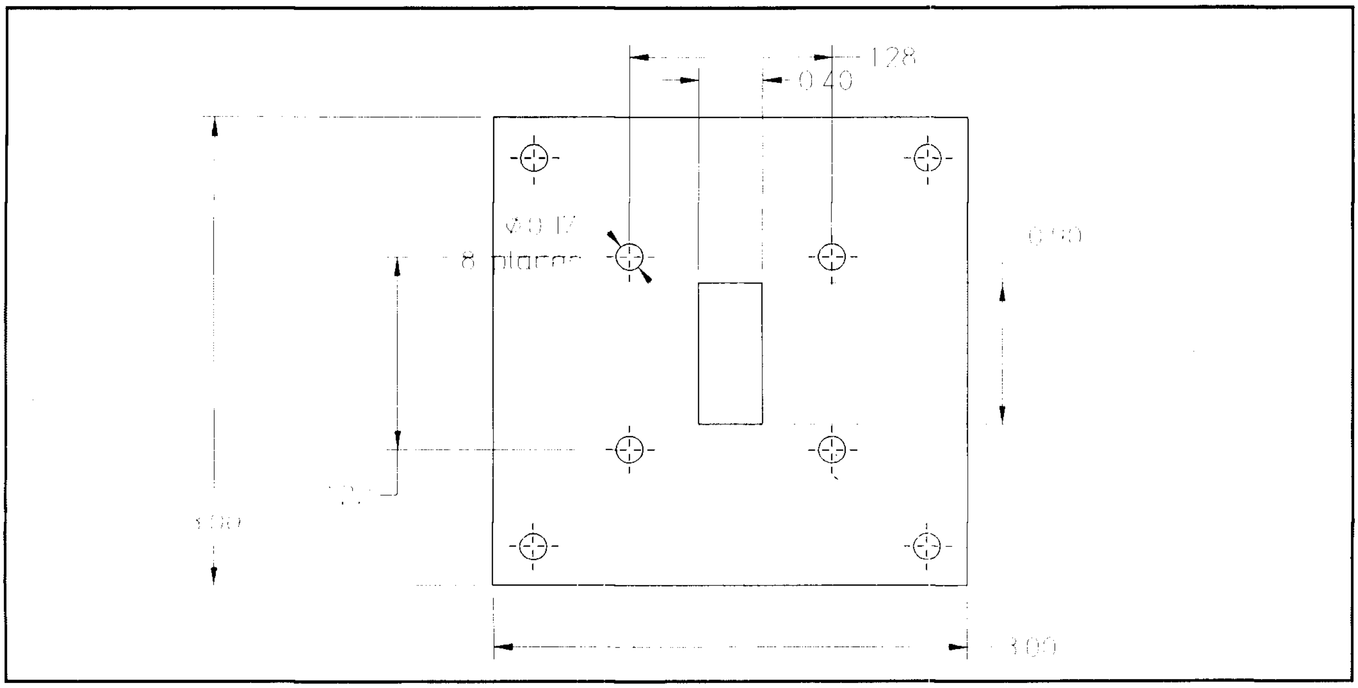
Receiver assembly construction also isn't critical. See **Figures 8A** through **8C** for details. Use ground plane as much as possible on the component side of the board and keep traces to the 45-MHz filter and discriminator reasonably short. Otherwise, no special precautions need be

FIGURE 4



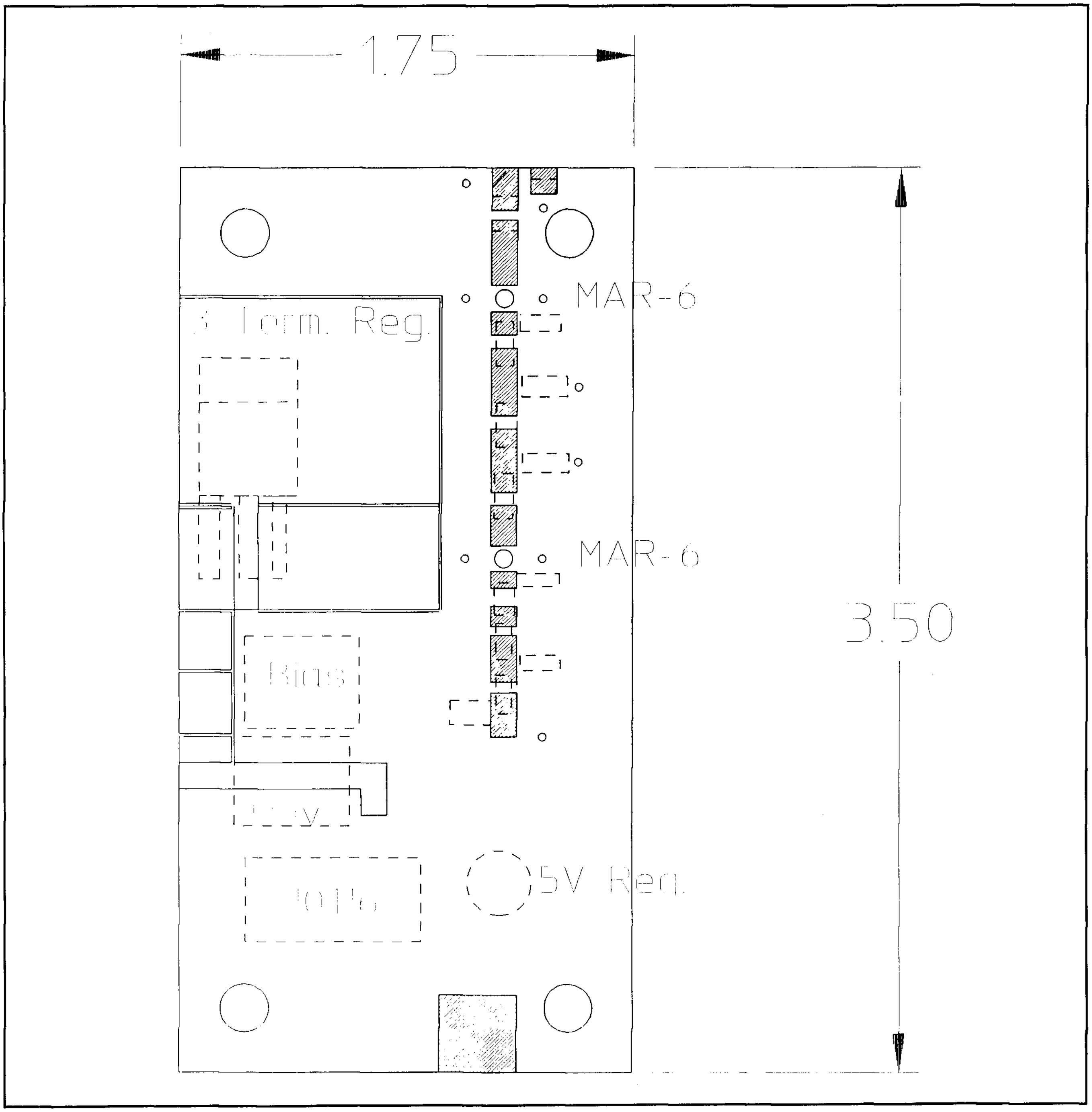
Dimensions for feedhorn construction.

FIGURE 5



Microwave assembly/feed mounting plate.

FIGURE 6



Preamplifier/Tx modulator board component layout.

taken. All ICs may be socketed for convenience. (PC layout or circuit boards may be available by press time. Contact the authors for further information. Ed.)

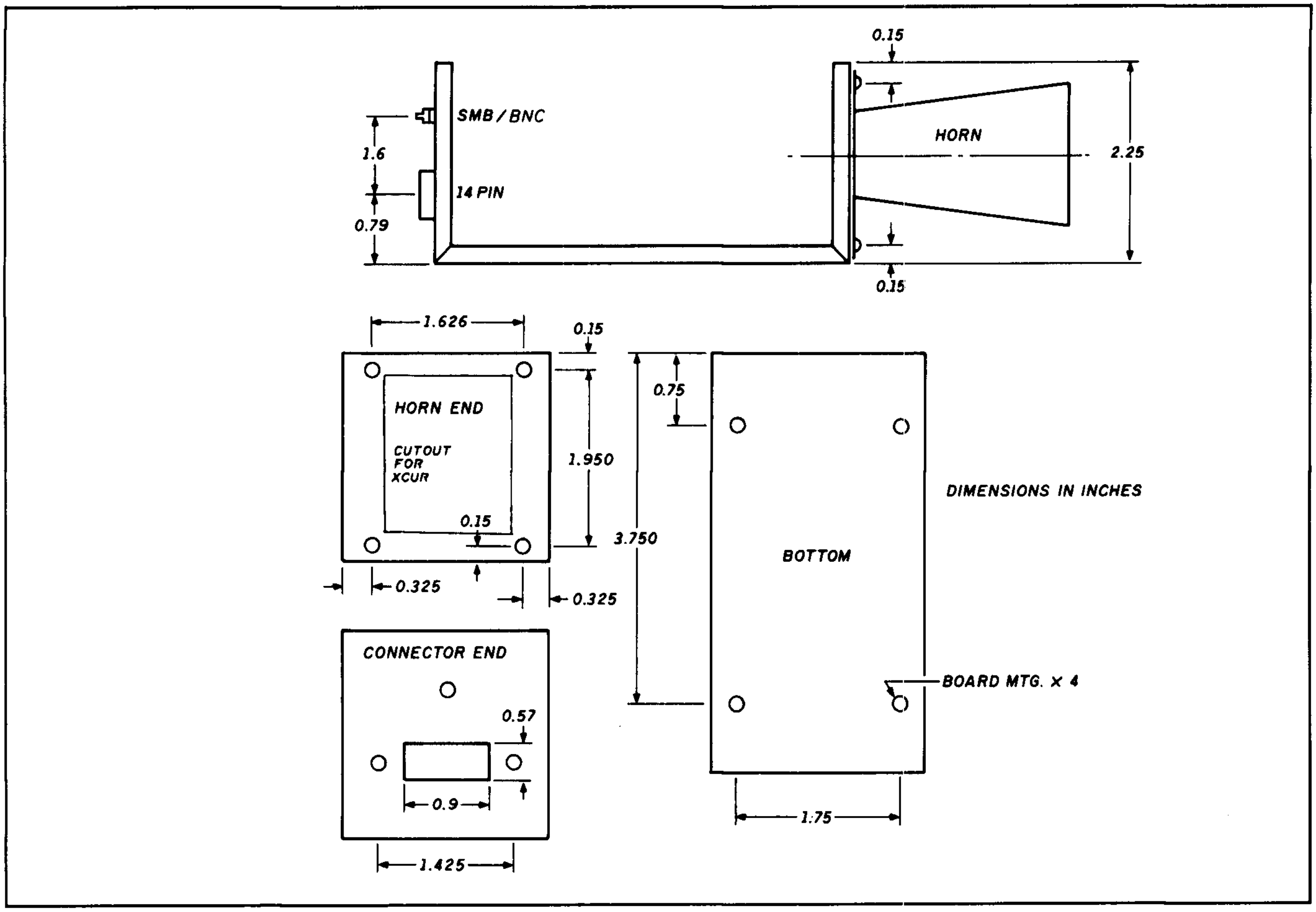
Computer interface

We chose the IBM PC as the initial platform for developing and testing faster packet hardware. The IBM PC is generally available and affordable, with sufficient capability and adaptability. The IBM PC is the defacto standard for people pursuing higher speed packet. The bus architecture is well known, and there are a large number of experts to consult should you encounter problems.

The original system design called for standard off-the-shelf Ethernet™ adapter cards. Normally Ethernet lets a number of computers intercommunicate within a local area at a data rate of 10 Mbps. N3EUA suggested we use the same widely available cards and the associated IEEE 802.3 protocol with the adapter card clocks slowed to 1 Mbps. Using a standard Ethernet adapter gives you access to an existing range of networking software, including NetBios/PC Network and TCP/IP implementations. It's an interface familiar to the general ham community, one that the advanced packeteer probably already knows and works with.

Stock Ethernet cards can't be slowed from 10 to 1 Mbps

FIGURE 7



Dimensions of the box to house the microwave circuitry.

without extensive reworking. The serial data interface portion of the cards must produce a clock rate within 0.001 percent of 10 Mbps to conform to the IEEE 802.3 specification. By the time we discovered this we had working "RF bit pumps," but found ourselves without a suitable digital interface.

Several years ago IBM produced a digital communications adapter known as the PCLANA or SYTEK 6120. This adapter was designed to communicate using FSK signals transmitted on a coaxial cable at a 1-Mbps rate. The card implemented Ethernet framing with a NetBios interface directly on the card. The card consists of a local μP (80186), an Ethernet chip (82586), custom 802.3 serial data interface, RAM, ROM, PC bus interface, and an RF modem. While the RF modem is interesting, it was unnecessary for this project and was disconnected.

We discovered that this card had all the right pieces: 1-Mbps Ethernet frames, defined PC interface, and because 10-Mbps Ethernet was displacing these cards, good availability on the surplus market — sometimes just for the asking.

To use the PCLANA card, we needed to gain access to the TTL signals directly (before modulating the RF modem), build an adapter card onto the PCLANA for converting TTL to differential ECL, generate DCD, and route Transmit Data (TxD) and Receive Data (RxD). You'll need a software driver if you want something other than a NetBios interface. A schematic of the card is shown in the *IBM PC Technical Reference Manual*, "Options and Adapters" section.

How the adapter card works

A "daughter" adapter (**Figure 9**) is fitted to the PCLANA to take the TTL TxD, RxD, DCD, and RTS. It produces a valid interface to the microwave RF modem, including power and differential ECL interface.

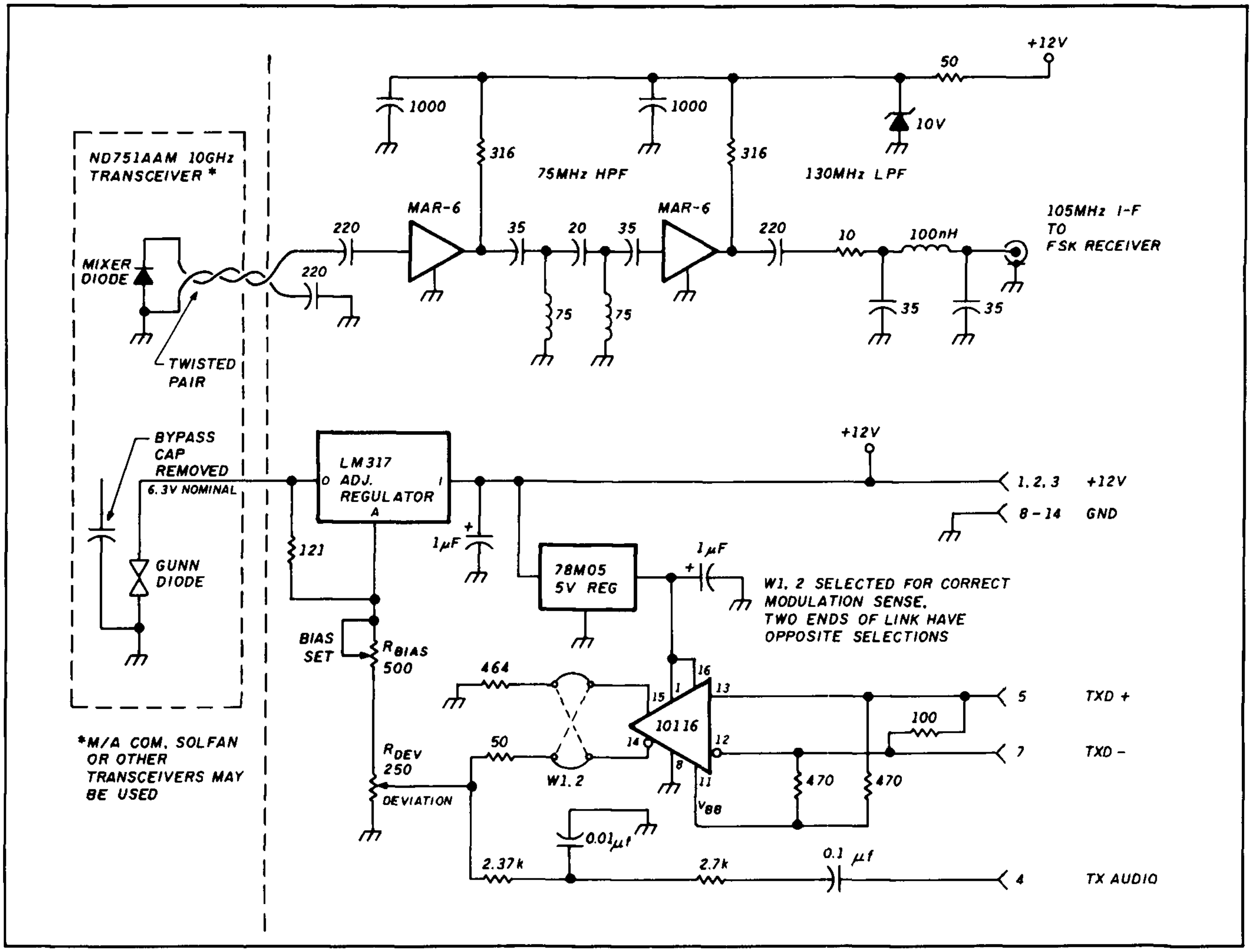
The microwave modem interface closely matches the IEEE 802.3 MAU which normally connects the digital interface to a coaxial cable. A MAU is also known as an Ethernet transceiver (XCVR). We chose this interface because it allows long (120 foot) cable runs, good common mode noise immunity (0.6 volts), and a standard interface.

TxD is converted to differential ECL levels with an open collector (OC) NAND gate and a resistor totem pole. This produces the right voltage level for one end of an MC10116 differential line driver input. The other differential input is tied to the MC10116 Vbb. The output of the MC10116 is differential ECL. Because the ECL drivers are open ended, each line is pulled to ground with a 470-ohm resistor. The polarity of ECL lines to the pins of the DB15 connector is important. Switching these lines will result in a bit sense inversion.

RxD is converted from differential ECL to TTL using the differential drive from an MC10116 biasing the base emitter junction of a 2N3906 PNP transistor. This drives a standard TTL NAND input.

TxD is qualified by Ready to Send (RTS) from the

FIGURE 8A



The schematic for preamplifier bias and modulation.

PCLANA (U1b). This is necessary because the SYTEK SIC doesn't clamp the TxD line to logical zero when RTS goes false.

The SYTEK SIC interface chip is designed to work on a cable with multiple stations. It monitors the DCD line, and if it finds that it has been true too long, the SIC declares the cable jammed. Because the microwave RF modem provides continuous DCD with or without data, we used a retriggerable one shot (U2a) connected to the incoming RxD signal to generate an appropriate noncontinuous DCD. On the first low-to-high transition, DCD will be asserted and the one shot will start timing. Each low-to-high transition in the incoming data will retrigger the one shot and keep it from expiring. When data stops and the RxD line clamps to a low, the DCD will fall to a zero when the one shot expires. Because each end of the link expects to hear itself, the DCD is ORed with the local RTS (U1a).

Building the interface adapter and PCLAN adapter modification

Adapter card construction is straightforward and can be completed quickly with IC sockets, perfboard, and point-to-point wiring. The entire circuit runs at baseband speed, so layout isn't important. (Contact the authors if you want a pc board layout.)

The PCLANA modification can be simple or time consuming, depending upon how elegant you want the finished project to be. The adapter daughter board must be mounted on the PCLANA. The best place to do this is over the long metal cover housing the actual RF modem. Decide on a place and prepare your mount.

You might consider removing enough of the RF modem components to make room for the daughter adapter board. If you do, be aware that the RF modem reports to the onboard μP (80188) as to the validity of the −12 volt DC power line (for historical reasons). If you remove the RF modem without connecting this signal, the μP will report an error whenever you attempt any operation. Locate Q20 and R121 on the left side of the pc board next to the lower left corner of the RF modem cover (if it's still installed). The left end of R121 is tied to the base of Q20. Cut the trace to the right end (or unsolder R121) and reconnect it directly to −12 volts DC on the board (bus pin B7).

You need four signal lines to connect the daughter card to the PCLANA. They are: TxD, RxD, DCD, and RTS. You also need three power lines: +5 volts, +12 volts, and GND.

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2K CLASSIC X	Domestic Console	**5K CLASSIC**	Export Console
2K CLASSIC X	Export Console	**5K CLASSIC RF**	RF Deck only
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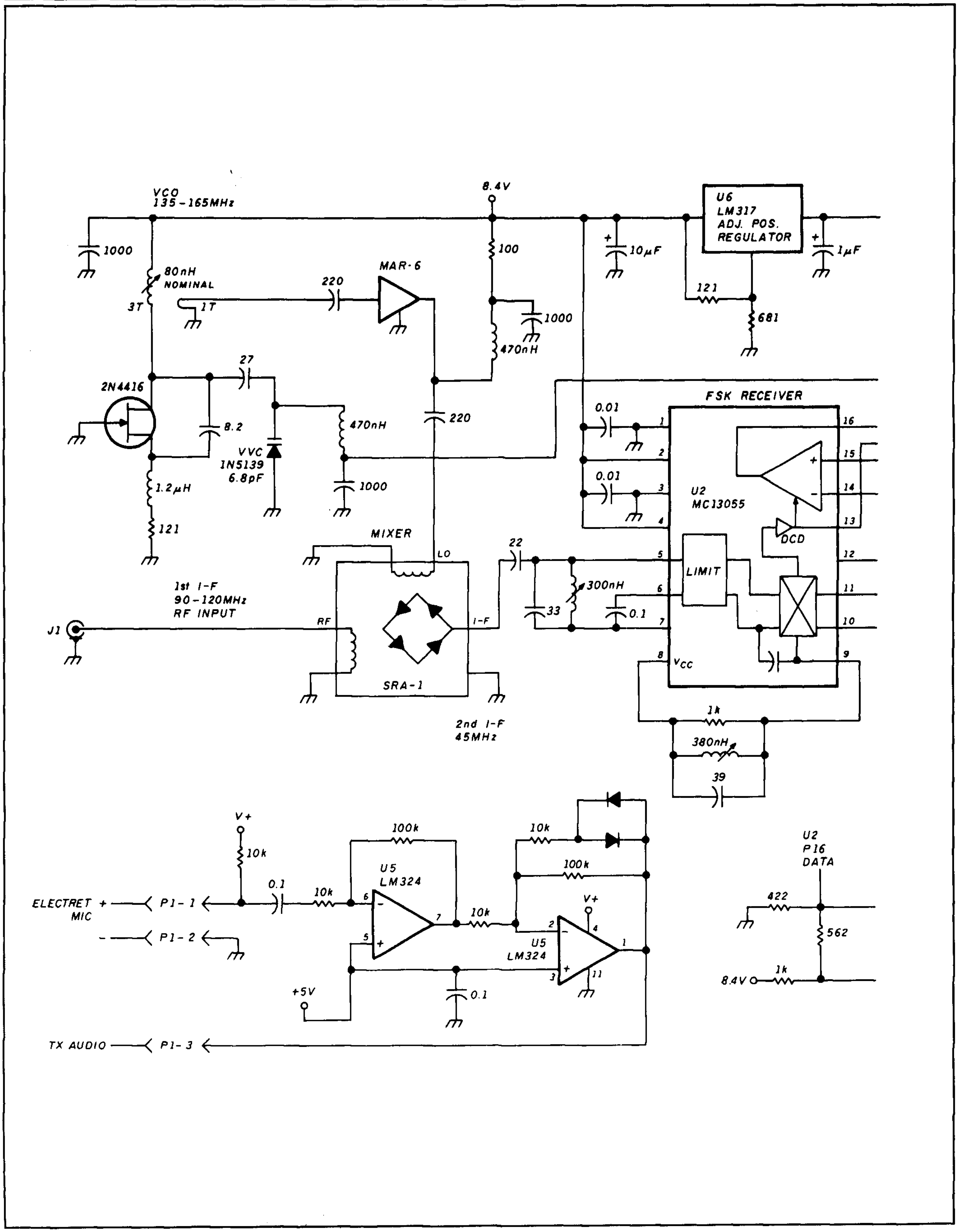
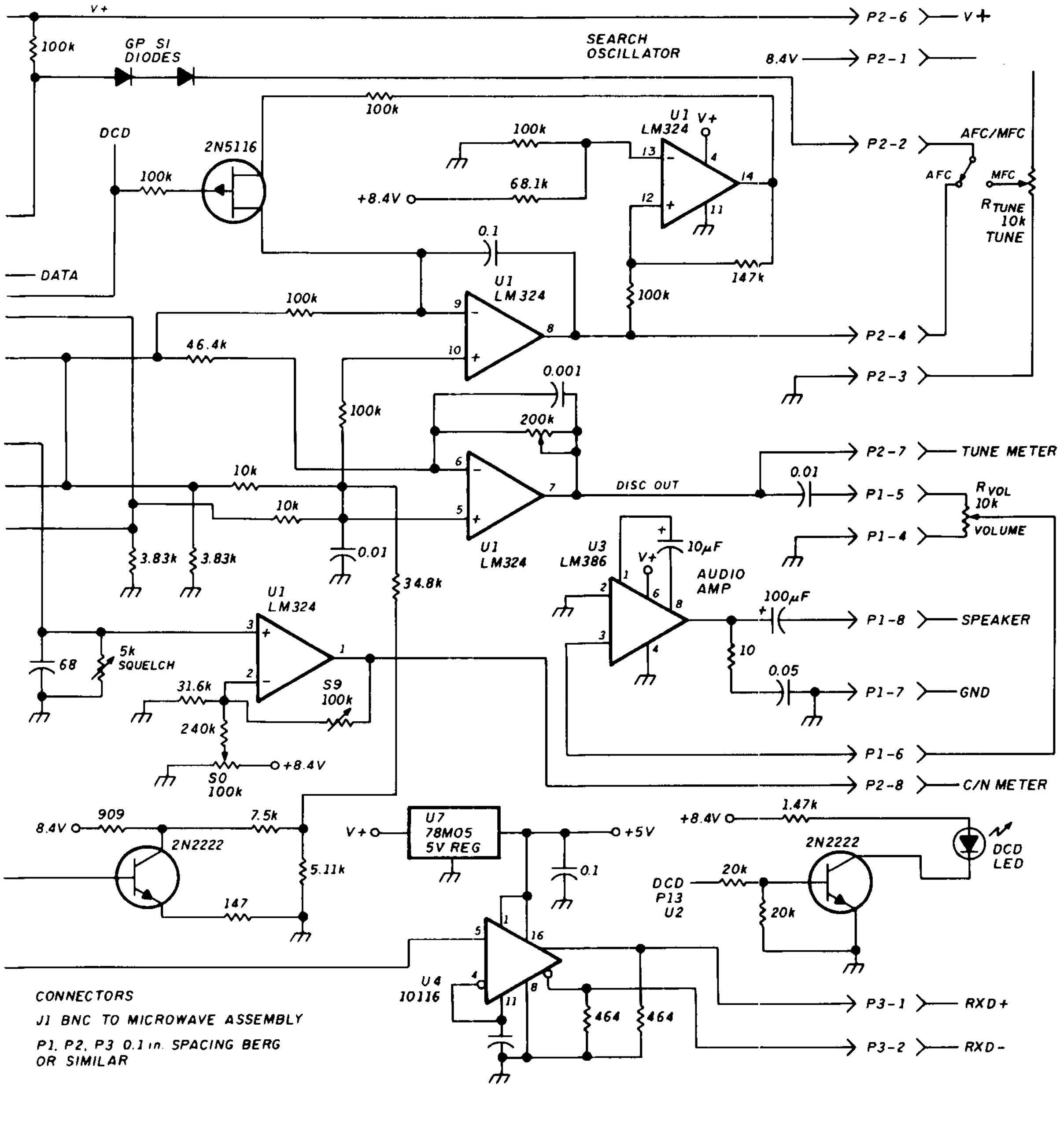
✓ 193

FIGURE 8B



The receiver portion of the transceiver.

FIGURE 8B


V+
100k
GP SI DIODES
SEARCH OSCILLATOR
8.4V
P2-6
V+
P2-1
100k
DCD
2N5116
100k
U1 LM324
V+
+8.4V
68.1k
P2-2
AFC/MFC
AFC
MFC
R TUNE 10k TUNE
0.1
DATA
147k
100k
U1 LM324
46.4k
P2-4
P2-3
0.001
200k
100k
P2-7
TUNE METER
10k
DISC OUT
0.01
P1-5
R VOL 10k
VOLUME
10k
P1-4
U1 LM324
U3 LM386
10μF
3.83k
3.83k
0.01
AUDIO AMP
34.8k
100μF
P1-8
SPEAKER
U1 LM324
5k SQUELCH
68
S9 100k
10
0.05
P1-7
GND
31.6k
240k
P1-6
S0 100k
+8.4V
P2-8
C/N METER
909
7.5k
8.4V
2N2222
U7 78M05 5V REG
+5V
+8.4V
1.47k
2N2222
DCD LED
5.11k
0.1
DCD P13 U2
20k
20k
147
U4 10116
464
464
P3-1
RXD+
P3-2
RXD-
CONNECTORS
J1 BNC TO MICROWAVE ASSEMBLY
P1, P2, P3 0.1 in. SPACING BERG OR SIMILAR

You'll find the connection to ground underneath the screw holding the mounting bracket to the rear of the card. Postive 5 volts DC is taken from a trace leading to edge connector A1 (component side of the card, on the right). Positive 12 volts DC is also taken from a trace leading from B9 (solder side of the card, on the left). This trace also "comes through" to the component side of the card and is easier to solder to. The current demand is low, so you can make contact by cleaning a portion of a *wide* trace, tinning it, and soldering to it.

Make signal connections to the SYTEK SIC chip by bending pins up out of the socket and soldering to them. Find IC U16 in the upper left of the board. It's designated SIC and is a wide 28-pin device. Pin 1 should have a red dot and be on the lower left. Remove the device carefully; you probably won't be able to find a replacement easily. Bend pins 12, 13, 17, and 18 up so they won't make contact with the socket when the IC is reinserted, and so you can solder to them. Reinsert the IC. Connect the daughter board signal leads directly to the exposed leads. Pin 12 is RxD, 13 is DCD, 17 is RTS, and 18 is TxD. It's a good idea to use shrink tubing on each lead. Be careful not to heat the device unnecessarily while soldering.

With the daughter card mounted on the PCLANA and all seven interface lines hooked up, measure the resistance from the +5 and +12 lines to GND. Find the cause of any reading less than 700 ohms before installing the card in the PC.

If everything checks out, install the board in a PC bus slot and power up the computer. If the microwave hardware isn't attached to the 15-pin daughter board connector, the PC will delay for about 15 to 45 seconds during the boot cycle. It may display an error 3015.

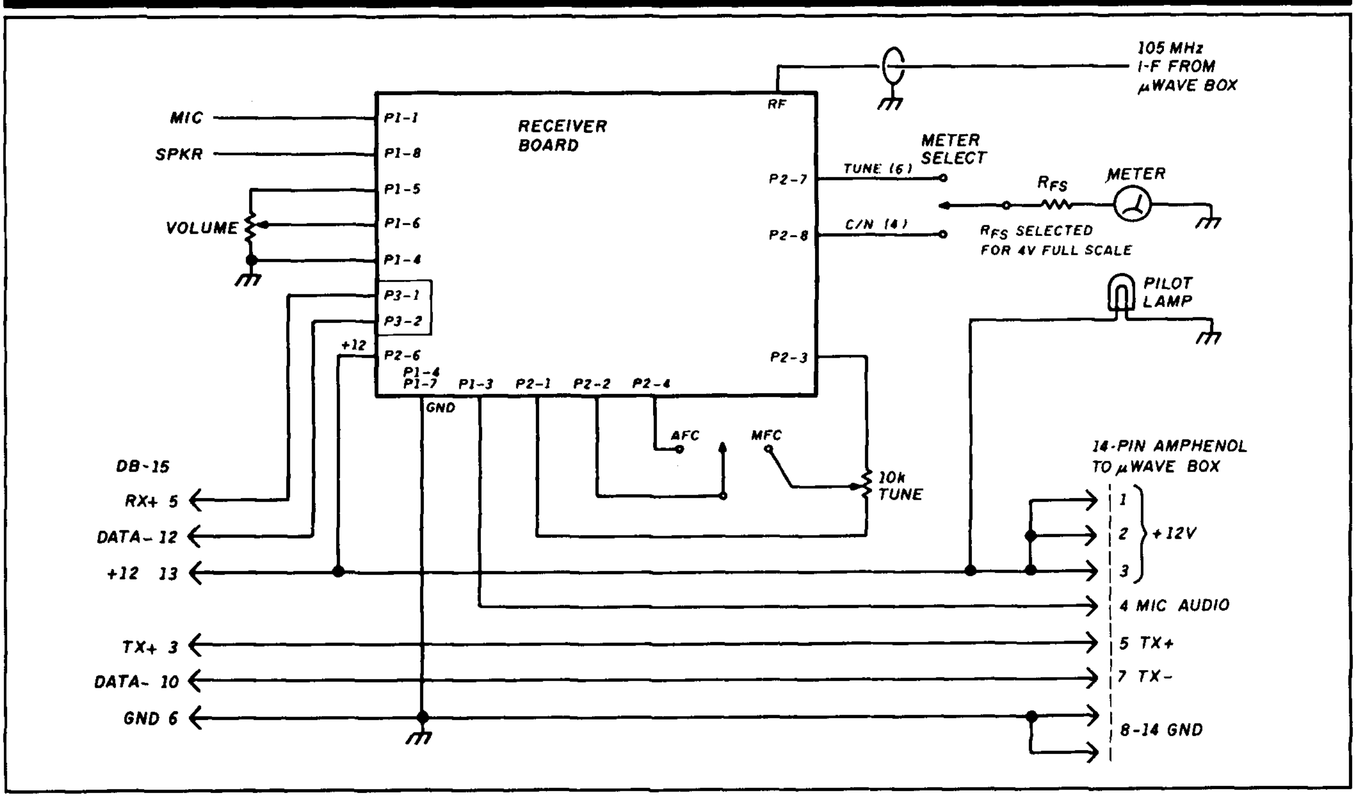
To complete testing, install a similarly modified card in another PC, connect the microwave hardware, power up both computers, and check to see that both FSK receivers show DCD. It may be necessary to reboot the PC by selecting ctl-alt-del after DCD has been established. When the PC is booted, the PCLANA runs through a series of diagnostics which include frame loopback. The loopback will fail if the microwave hardware doesn't have DCD. Depending on the PC, the PCLANA card will declare itself inoperative until you run diagnostics again.

If you have a copy of the IBM PC network program, you can now start it on both machines and share disks. Playing with the network can provide lots of creative fun. With the link running to a fellow ham, you can access each other's hard disks. Suppose you just finished some nice graphics and you want to show them off. Instead of reaching for your ATV camera, bit dump the screen image to disk and do a DOS copy file from your disk to your friend's. Your friend will be able to see your work in seconds. A driver is also available to provide packet interface support for Phil Karn's (KA9Q) TCP/IP package for the PC. (Contact the authors for further information.)

Tune-up and testing

Unless you have a 10-GHz microwave signal generator available, you should build these units as a pair — although two dishes aren't necessary for short range use or testing. You should build the microwave assembly and set the bias voltage from the three-terminal regulator to approximately

FIGURE 8C



The transceiver interconnect layout.

6.3 volts before connecting to the transceiver. Verify that the deviation control can be set to give 0.25 to 0.5-volt variation when the ECL line receiver is toggled between states. Once the biases are correct, hook up the transceiver. Most transceivers as shipped will be close to 10,525 MHz. With two transceiver/horn assemblies pointed at each other and separated a few feet, hook a frequency counter or general coverage receiver to the preamplifier output. Leaving one unit's tuning unchanged, tune the second unit while monitoring the IF frequency with a counter or listening for it in a general coverage receiver. Turning the mechanical tuning screw further into the cavity will reduce frequency. As the unit is tuned 70 MHz (or more) lower, you should be able to read the difference in frequency with a counter. You should be able to "walk" the two units lower in frequency into the hamband using this technique and space them 105 MHz apart. If you get "lost" and don't know the absolute frequency, try using a local supermarket door opener as an approximate 10525-MHz reference. If a microwave frequency indicator is available, adjustment is trivial.

Once the two ends are operating 105 MHz apart, you can align the receivers. Select MFC and midrange control setting, and use a counter or 2-meter receiver to monitor the VCO frequency. Set it to 148 to 150 MHz at midrange. You should be able to tune several MHz on either side of this center with the manual tuning control. You can use AFC to tune it even further once the other circuits are operating. Tune the VCO to 45 MHz above the previously measured frequency of the microwave IF and adjust the 45-MHz bandpass coil for maximum C/N reading. It may be necessary to separate the units or use conductive foam material to keep the signal strength reading on scale. Once the receiver is peaked on a 45-MHz IF, tune the discriminator coil to center the detector output voltage on pin 10 or 11 of the MC13055. With the squelch control set to maximum resistance of 5 k, a 0.35-volt change on pin 12 corresponds to 10-dB change in signal strength. Keeping the receiver tuned to center with MFC, adjust the position and absorbers to produce about 10 dB of C/N. Then adjust the squelch control so the DCD light just extinguishes. Measure the squelch control resistance again and calibrate your C/N reading by calculating sensitivity:

$$V(p12) = 0.070 * Rsquelch \qquad \textbf{(1)}$$

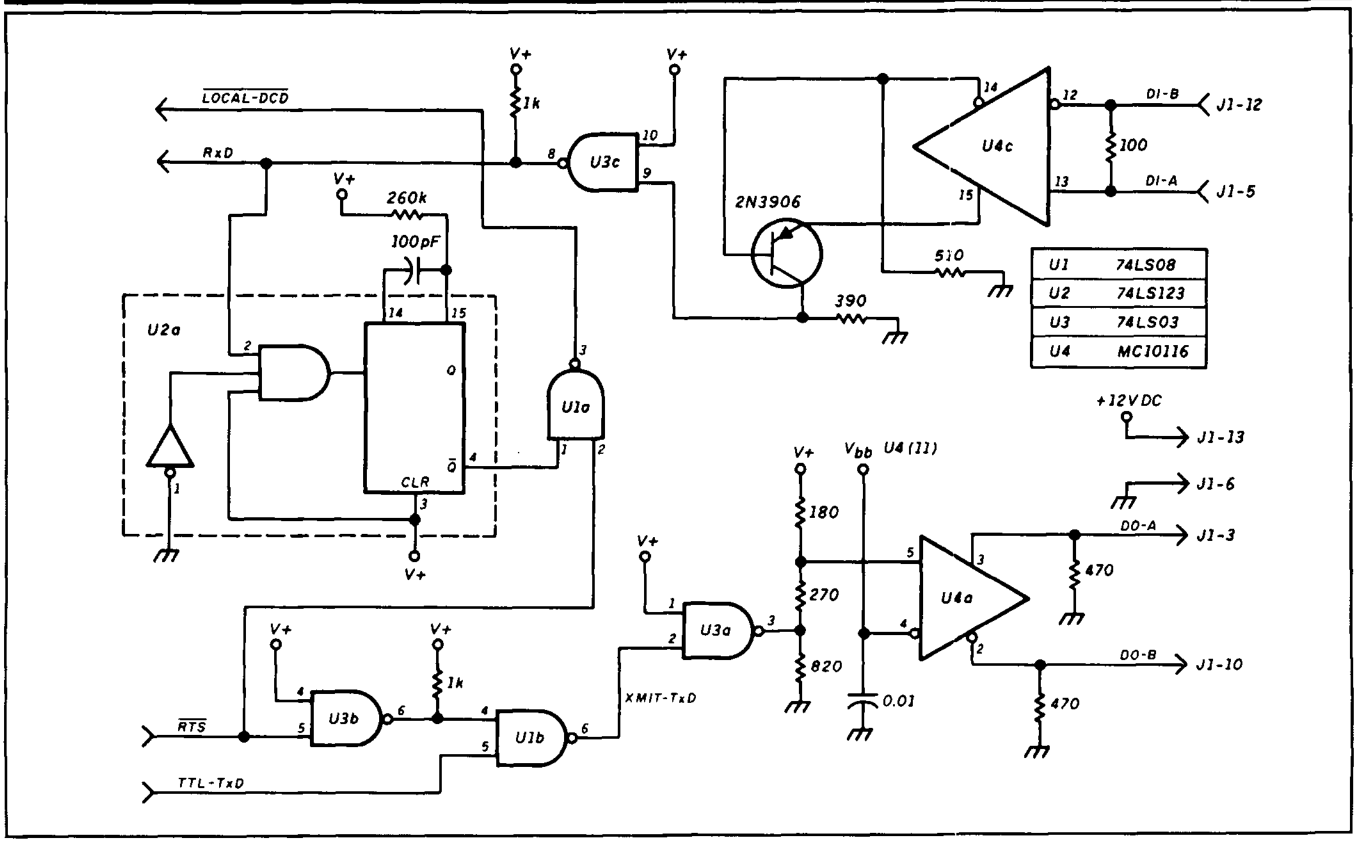
Rsquelch = squelch resistance in kilohms.
V(p12) = voltage change at MC13055 pin 12 in volts for 10-dB change in signal.

Adjust the discriminator output sensitivity to give full scale on your meter as you use the MFC to tune across the incoming signal. Finally, verify that the search oscillator runs when you select AFC and that there's no incoming 105-MHz IF signal. This should appear as a sawtooth oscillation on the VCO tuning line.

The audio channel should work without further adjustment. Some background noise may be audible even when signal strength is high due to the phase noise of the microwave oscillators, but the level shouldn't be objectionable.

Use an oscilloscope to verify data throughput and correct transmitter deviation setting. Monitor the discriminator out-

FIGURE 9



Adapter board for the PCLANA card.

put with the scope and set the scope sensitivity to give full screen display as you use the MFC to tune through a signal. When you reach this stage, the transmitter may be modulated with data and the deviation adjustment may be used to set the discriminator output to slightly less than full screen. It may be necessary to iterate with the bias setting to keep the transceiver bias centered on 6.25 volts.

At this point, both the transmitter and receiver should be functioning properly and may be used for audio or digital communications. When units are separated by a great distance, or signals are otherwise weak, it may be beneficial to monitor the audio channel as an aid to link adjustment. Audio communication will be possible even when noise is causing excessive errors on a data channel.

Performance, results, and remaining problems

Getting data to flow on the bench led to a couple of surprises. While debugging the software drivers, we learned new elements of timing relationships. Since this is point to point, and the only start-up delay is software latency (no hardware TXDELAY), data frame ACKs arrived from the other end before we'd finished processing the send request. Pieces of software that were just fine at lower speeds had to be rethought and streamlined to achieve throughput.

Aligning the microwave dishes requires some skill. If you haven't done this before, allow plenty of time for alignment, have solid mounts, and don't expect it to be like 2-meter work. Use the audio channel to listen for receiver quieting and get a feel for the narrow beamwidth. Don't try to hand hold the antennas at both ends; both must be pointed correctly before either end hears anything. It may be useful to use manual frequency control at first. If you can put one end of the link at a high elevation temporarily, you can power the other end from 12 volts DC in your car and drive around to see what microwave communication feels like. The experience you gain doing this will help to make you a good judge of final locations for the digital link. Because these are low budget systems, line-of-sight transmission is probably necessary for anything other than fairly short links. An exception would be if a good planar reflector were located close to one end and used as an efficient mirror. You can try this technique to keep the hardware at ground level using a mast or tower-mounted "billboard" reflector. This has environmental advantages for the hardware, too.

Measurements indicate that the unit passes data with a low bit error rate (BER) down to signal strengths below 15-dB C/N. It's important to use direct paths; severe distortion can occur when multiple paths exist between the ends of the link. Such multipath conditions can cause link failure, even with very large C/N. This sensitivity should provide low error data transmission on a line-of-sight path of more than 40 miles with well-stirred air. In many locales, marine air layers and other causes of fading and ducting may require shortening the path to guarantee high linkup time.

With the link installed at two locations 13.5 miles apart in northern California, C/N measurements show that there is at least 10 to 15 dB more signal strength than the minimum necessary. This indicates that more than 40 miles should be possible with this hardware as shown. However, because longer paths are more likely to experience propagation anomalies and heavy rain could decrease signal strength temporarily, it's desirable to use slightly larger dishes for longer paths. The audio link has proved useful in system troubleshooting too.

As with any ham project, there's certainly room for improvement. Because the original RF design was for a 2-Mbaud link, you should be able to improve DX by optimizing the receiver detector bandwidth. If you operate with a mast, the equipment needs to be waterproofed for all-weather use. As an alternative, you could mount a coax waveguide adapter to the feedhorn and locate the microwave circuitry remotely in a more protected environment. Use low loss semi-rigid coax cable for connecting to the antenna if you do so. A suitable coax waveguide adapter was described in an earlier article.[2]

If you want to use them, almost any of the surplus radar detector, motion detector, or burglar alarm Gunn transceivers should work well. M/A-COM Gunnplexers™, although somewhat more expensive, will work too. They have built-in electronic tuning that permits modulating at higher rates for full 10-Mbaud data links or ATV uses. It should be possible to frequency modulate them by driving the electronic tuning input from the ECL output, properly scaled and offset with a resistor network.

The first prototype of this link was built using 24-GHz radar transceivers and metal lamp reflectors for antennas. This arrangement works very well. Because of the modular system design, you may substitue these microwave assemblies for the 10-GHz ones described here without making any other adjustments. The higher gain available for a given dish antenna size at 24 GHz can actually provide better performance over some paths.

You can use a larger antenna for greater DX or more difficult paths. If you use something other than a 0.5 F/D reflector, you'll need to design a new feedhorn to produce maximum performance. Other diameters are available from the indicated supplier.

Where to go from here

Ham radio has often made use of surplus and obsolete gear. Many have designed and built their own equipment. This project is no exception. By the time you read this, there will be a PC card (designed primarily by K3MC) capable of two-channel, full-duplex 2.5-Mbps operation. You'll be able to split the channels into four half duplex if you wish. The card will have a V40 μP, RAM, and Zilog 85C30 SCC devices, plus the usual glue logic. Bit rate will be software selectable. The card will have enough capacity to run as an IP router, allowing the PC to perform other functions while continuing to provide network access.

We are also working to build inexpensive 250 to 500-Kbaud 900 and 1200-MHz radios to give the individual user access to other hams and to a "backbone," using this higher speed microwave hardware. We hope to have a fledgling moderate speed network in place in northern California and Colorado by the time this article goes to press. As the hardware is put into place, the platform for some really exciting applications and a whole new era of Amateur Radio becomes a reality.

The authors would like to thank WN6I, N3EUA, K3MC, and N6TTO for their encouragement and perseverance during testing. We'd also like to thank our XYLs, Sharon and Lynn.

Suppliers

Most of the components for this project should be available from:

Digi-Key Corporation
701 Brooks Avenue South
Thief River Falls, Minnesota 56701, 0677

The antennas are available from:

The Antenna Center
505 Oak Street
Calumet, Michigan 49913 (906)337-5062

The microwave transceivers shown are NEC ND751AAM, which may be available from:

California Eastern Labs
3260 Jay Street
Santa Clara, California 95054
(408)980-3500

You should be able to substitute many other transceivers, like those made by M/A-COM or Solfan and various types available at flea markets.

REFERENCES

1. Glenn Elmore, N6GN, "Designing A Station For The Microwave Bands, Parts 1-3," *Ham Radio Magazine*, February, June, and October 1988.
2. Glen Elmore, N6GN, "Designing A Station For The Microwave Bands, Part 2," *Ham Radio*, June 1988, page 35-37.

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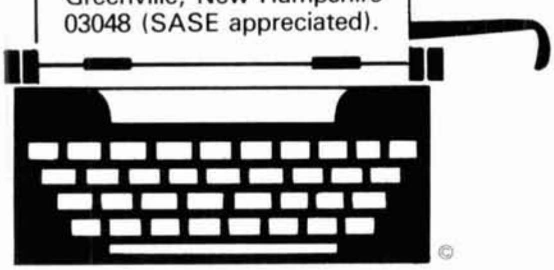

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ULTRA LOW POWER FOUR-DIGIT SEQUENCE TOUCH TONE DECODER

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

For some time now Radio Shack has been selling a very useful Touch Tone™ decoder IC for about $12. The all-CMOS IC incorporates the following: on-chip preamp, bandpass filters, voltage regulators, clock generators, and output decoders. All you need to decode a Touch Tone signal is a quartz crystal, a resistor and one capacitor, and 5 volts DC. The performance and reliability of this chip are amazing. By adding a few inexpensive shift registers and comparators, you can build a four-digit sequence decoder for less than $20. **Figure 1** shows the pc board; **Figure 2** is the schematic diagram.

I've built several of these units and used them for applications like repeater autopatch and control link decoders. The response time of the decoder is very fast (specs. = 40 ms), much faster than you can move your finger from one button to another. The power consumption is an unbelievable 6 mA at 5 volts DC.

Hardware description

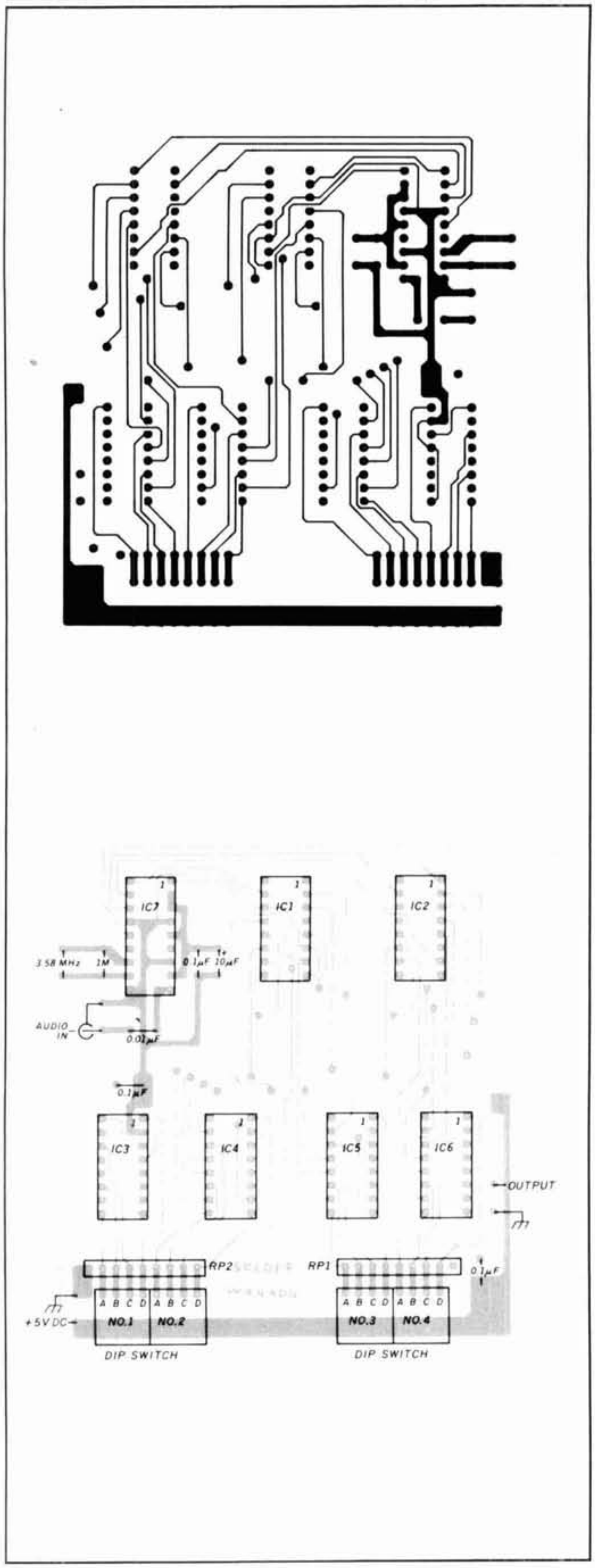
AC-coupled audio enters the decoder on pin 9. To prevent falsing, this level shouldn't exceed 1 volt p-p. Pins 11 and 12 are connected to a "color-burst" 3.58 MHz crystal, also available from Radio Shack. In this circuit, the decoder is configured to detect all 16 standard Touch Tone digits and produce a hexadecimal output corresponding to the digit decoded. Pin 14 is the "valid digit" flag and goes high each time a digit is decoded. The rising edge of each valid digit flag pulse is used to clock the hex data from the decoder into a pair of CD4015 dual four-bit shift registers. The shift registers store the hex data for the last four digits detected. IC1 stores binary bits A and B of the hex code while IC2 stores bits C and D. The corresponding two bits of each shift register position go together to form four, four-bit hex digits. The DCBA data for each digit is sent to a CD4063 magnitude comparator chip. Each CD4063 compares the binary number from the shift register to a binary

TABLE 1

Binary coding chart.

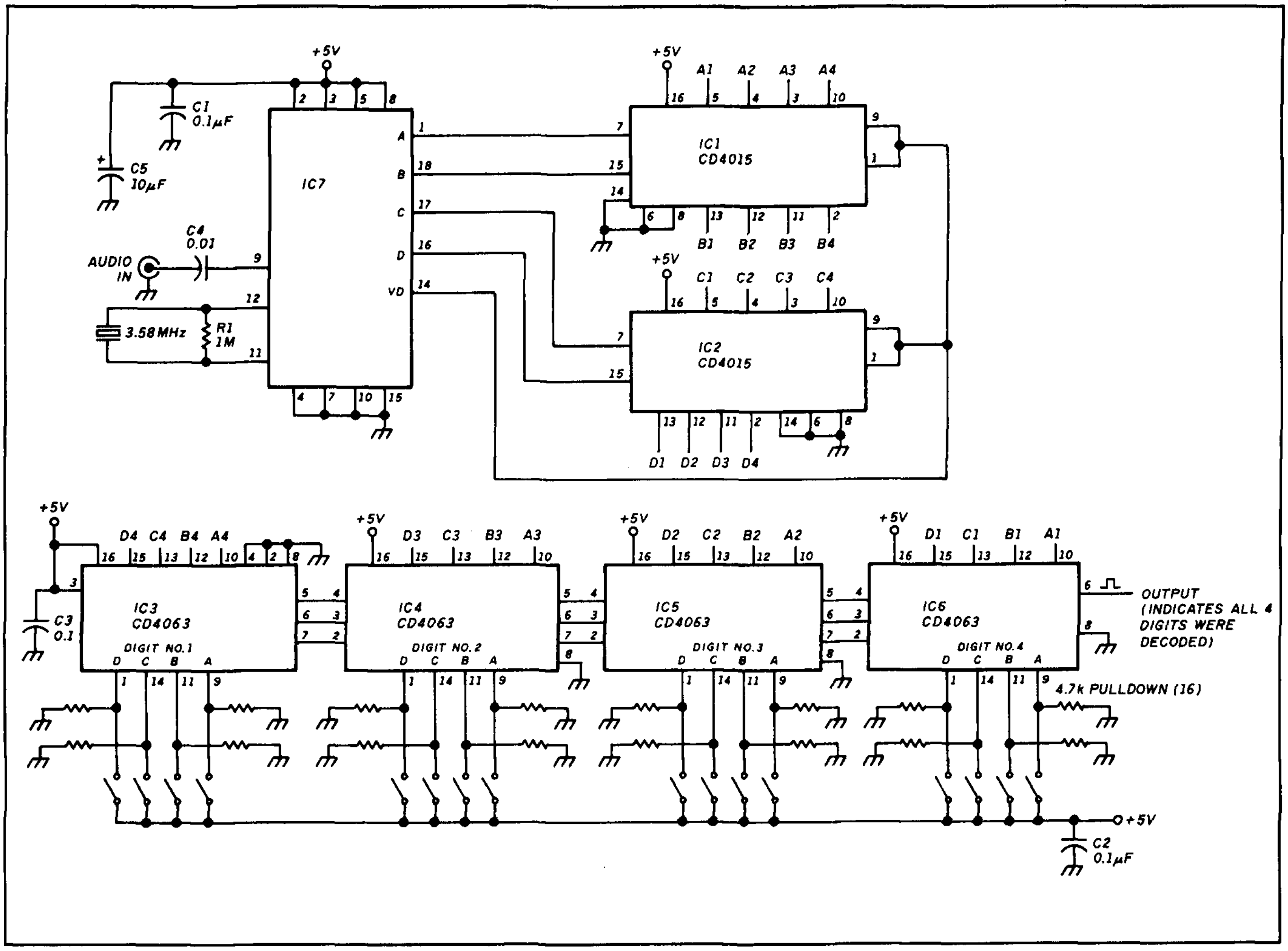
Digit	D (8)	C (4)	B (2)	A (1)
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	1	0	1	0
*	1	0	1	1
#	1	1	0	0
A	1	1	0	1
B	1	1	1	0
C	1	1	1	1
D	0	0	0	0

FIGURE 1



Foil and component sides of pc board.

FIGURE 2



Low power Touch Tone decoder.

PARTS LIST

C1,2,3	0.1µF	ceramic or monolithic bypass
C4	0.01µF	ceramic
C5	10 µF	16-volt electrolitic
IC1,2	CD4015	dual four-bit shift register
IC3,4,5,6	CD4063	or 74HC85 magnitude comparator
IC7	276-1303	Touch Tone™ decoder (Radio Shack)
R1	1 meg	1/4 watt
Crystal	272-1310	color burst 3.58 MHz (Radio Shack)
RP1,2	8 x 47 k	pull-down resistors
SW1,2	275-1301	eight-position dip switch (Radio Shack)

number programmed by a dip switch for each corresponding digit position. When the two numbers are equal the CD4063 generates an "=" flag. As each successive CD4063 receives its correct digit from the shift register matching the programmed digit from the switches, the "=" flag is propagated to the next stage. When all four stages are equal, a high is generated on pin 6 of IC6. This is the final decoded output, and will remain high until another digit is detected and entered into the shift registers. The output can latch an external flip-flop or be connected to whatever logic you desire.

The dip switches I chose contain eight switches per package. This provides two digit positions per package. The DCBA pattern of the switches is equivalent to the more commonly used method of presenting binary data as 8421. Regardless of how you consider the four-bit data, if a dip switch is closed, then that bit is equal to a binary 1, or high. If a switch is open, that bit is a 0, or low. The Touch Tone decoder has a slightly different hexadecimal output than is expected, but you can simply refer to the chart in **Table 1** for the bit pattern of each digit.

After choosing the four-digit sequence you wish to decode, enter the hex data from the chart for the appropriate digit position.

To save space, I used two single in-line 47-k resistor packs for the pull-down resistors on the dip switches. These packs each contain eight 47-k resistors all tied to a common pin. You can replace these packs with individual resistors if you wish. The 47-k value of the pull-down resistors is not critical; however, a lower value for these resistors will result in a higher current draw from the 5-volt supply. hr

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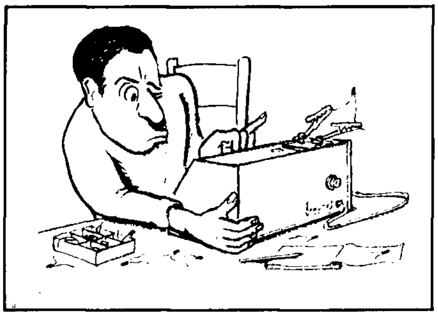


Joseph J. Carr, K4IPV

GETTING TO KNOW THE LOGIC FAMILIES, PART 1: TTL

Of all the IC digital logic families that have been on the market over the past 20 years or so, the *transistor transistor logic* (TTL, or T²L) is probably the most successful. TTL devices require more current than CMOS, but also operate at much faster speeds. Although most TTL devices operate in the 18 to 25-MHz region, special types are available to speeds of 80 MHz. TTL devices are designated by type numbers in the 74xx and 74xxx series (54xx and 54xxx devices are military grade TTL devices). For example, a 7402 is a quad two-input NOR gate and a 5402 is its MIL-SPEC cousin. The principal difference between the 54 series and 74 series is the temperature range. The 74 series is commercial grade and is designed to operate over the range 0 to +70 degrees Celcius; the 54 series operates over −55 to +125 degrees Celcius.

Figure 1 shows the operating regions for logic levels and operating potentials for TTL. The DC power supply must be +4.7 to +5.2 volts, and must be regulated. Although these "official" limits are well publicized, it isn't recommended that you try to operate close to the edges of the range. For example, at +5.2 volts DC the reliability of the devices may be compromised. At the other end of the range, +4.7 volts, some complex function devices may become flaky in their operation — especially in noisy environments. As a result, it's probably best to keep the DC power supply in the +4.9 to +5.1 volts range all of the time. The standard TTL DC power supply is voltage regulated.

The logic levels for TTL are as follows:

HIGH (logical-1): +2.4 volts to +5 volts

LOW (logical-0): 0 to +0.8 volts

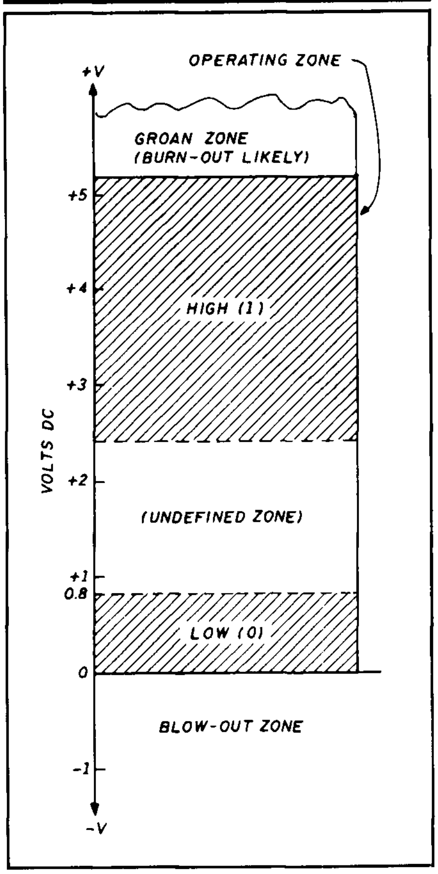
TTL output circuits

The output circuit for a TTL device forms a current sink. That is, the output will accept a current from a TTL input (a current source) and route it to ground. **Figure 2** shows two popular forms of TTL output. In **Figure 2A**, a TTL inverter, you see a regular TTL output circuit consisting of Q3 and Q4. This is the approximate circuit in almost all TTL devices. Transistors Q3 and Q4 are an identical pair, and form a "totem pole" circuit; Q4 is a current regulator and Q3 is the output switch. The series diode CR2 prevents current flow in the wrong direction. When the output is HIGH, transistor Q3 is turned off, so the current from the next stage isn't able to find a path to ground. But when the output is LOW, the transistor is biased hard on (it is in saturation), so the output terminal is grounded.

Figure 2B is an "open collector" TTL output. There's no current regulator in this circuit. That function is taken over by an external *pull-up* resistor (R1). Depending upon the type of open collector TTL device, the V+ voltage can be either +5 volts, or anything up to either +15 or +30 volts. Open collector inverters can be used for interfacing to other logic families, other digital devices, or nondigital output devices (relays, LEDs, lamps). Most open collector devices are hex inverters.

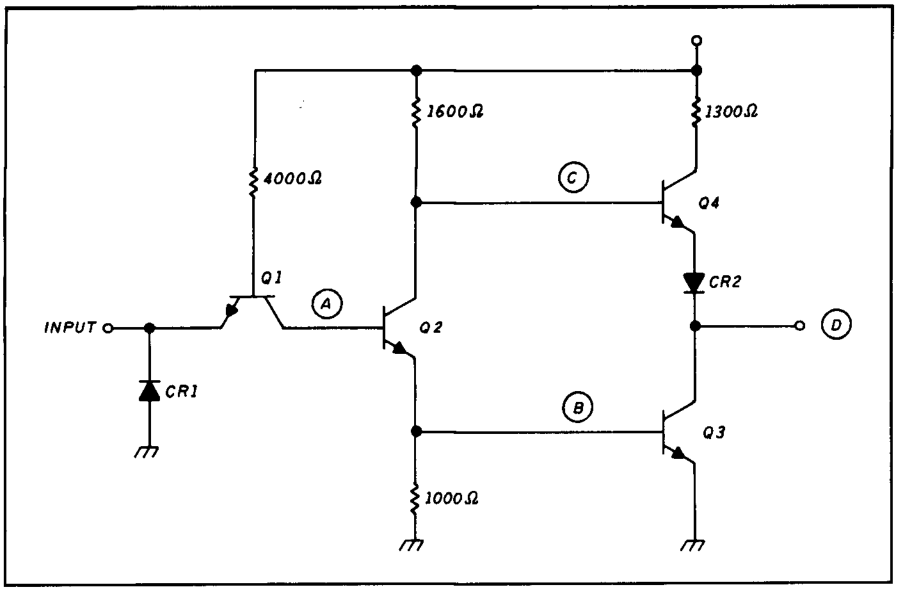
The TTL output is rated according to the number of standard (1.8 mA) TTL inputs it will drive. This number is called the *fan-out* of the device. Thus, a fan-out of ten (the usual number for standard devices) means that it will drive

FIGURE 1



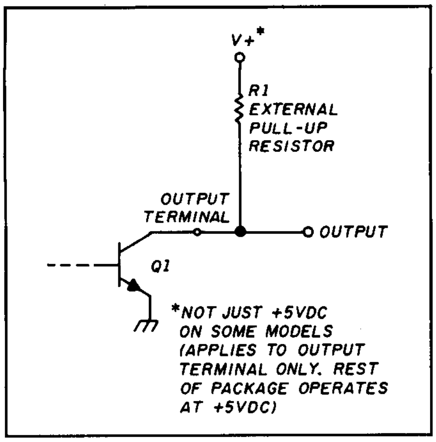
Voltage ranges for a *valid* "logical 0" or a *valid* "logical 1".

FIGURE 2A



A regular TTL output circuit consisting of Q3 and Q4. In this "totem-pole" circuit, Q3 is the output switch and Q4 is the current regulator.

FIGURE 2B



An "open collector" TTL output is shown here. Current regulation is provided by an external pull-up resistor.

up to ten standard TTL inputs. The standard TTL input represents a load, or *fan-in*, of one.

Figure 3 shows the relationship between the TTL input and the related TTL output circuit of the previous stage. The input may be a single emitter, as in the case of an inverter, or a multiple emitter. The inputs shown are dual inputs as might be found on a 7400 two-input NAND gate or 7402 two-input NOR gate. *The TTL input is a current source and the TTL output is a current sink.* It's important to keep these distinctions in mind when attempting to interface TTL with non-TTL digital and other circuits.

TTL subfamilies

The overall class of devices called TTL is divided into several subfamilies that are tailored to specified types of applications by differences in operating power, speed, and propagation delay. The ordinary TTL device is called regular TTL. It's typified by power consumptions of about 10 mW per gate and operates to speeds in the 25 to 35-MHz region. Propagation delay is on the order of 10 ns. The other TTL subfamilies include: low power TTL, high power TTL, Schottky TTL, and low power Schottky TTL. The type numbers for these devices are modified as follows:

Series	Typical Type Numbers
Regular TTL	74xx/74xxx
Low power TTL	74Lxx/74Lxxx
High power TTL	74Hxx/74Hxxx
Schottky TTL	74Sxx/74Sxxx
Low power Schottky TTL	74LSxx/74LSxxx

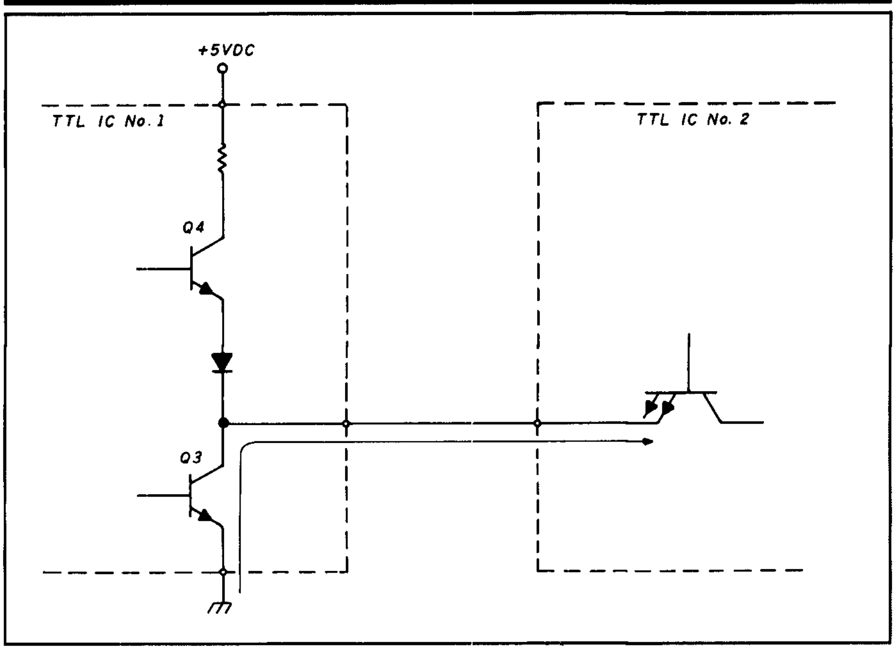
The operating speeds of the various subfamilies are radically different from each other. Typically, the 74xx device operates to 25 to 35 MHz (with some older samples being limited to 18 MHz); 74Lxx operates to 3 MHz; 74Hxx operates to 50 MHz; 74Sxx operates to 125 MHz; and the 74LSxx device operates to 45 MHz.

The fan-out and fan-in requirements also differ between the families:

Series	Output sinks (mA)	Input sources (mA)
74xx	16	1.6
74Lxx	3.6	0.18
74Hxx	20	2.0
74Sxx	20	2.0
74LSxx	8	0.4

Table 1 is a chart showing how many of which kind of inputs each subfamily drives.

FIGURE 3



The relationship between TTL input and related TTL output circuitry is shown here.

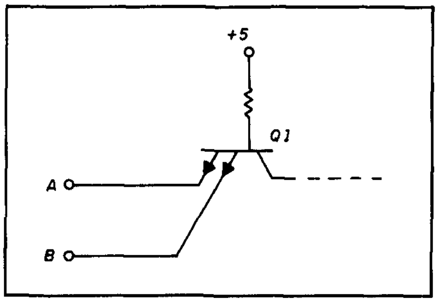
TABLE 1

This chart shows different input and output requirements in the TTL device families.

This output	Will drive this many inputs 74xx	74Lxx	74LSxx	74Hxx	74Sxx
74xx	10	40	20	6	6
74Lxx	2	10	10	1	1
74LS	5	20	10	4	4
74H	12	40	40	10	10
74Sxx	12	40	40	10	10

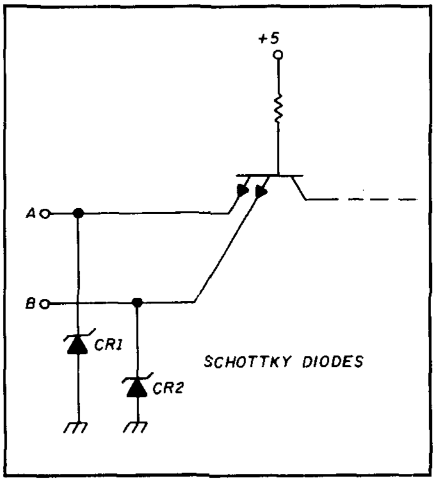
The principal differences between certain of these families can be seen in **Figure 4**. In all three cases a two-input circuit is assumed. The standard "regular" TTL input is shown in **Figure 4A**. The regular input consists of an NPN transistor with two emitter terminals. The Schottky TTL device is similar, except that a pair of Schottky diodes are shunted across the inputs (see **Figure 4B**). Finally, in the LS series TTL a set of four Schottky diodes are used (see **Figure 4C**). In each input, one is in series with the input line and the other is shunted to ground.

FIGURE 4A



A standard TTL input.

FIGURE 4B

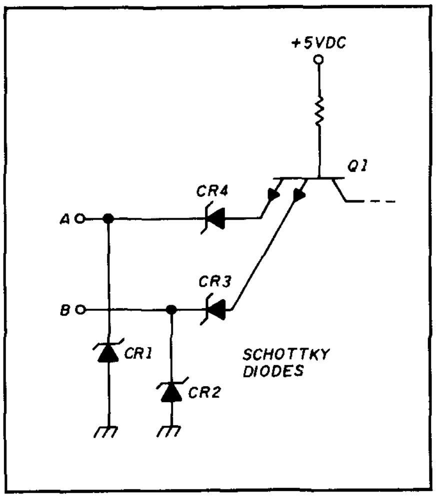


A Schottky TTL device input.

Tri-state logic

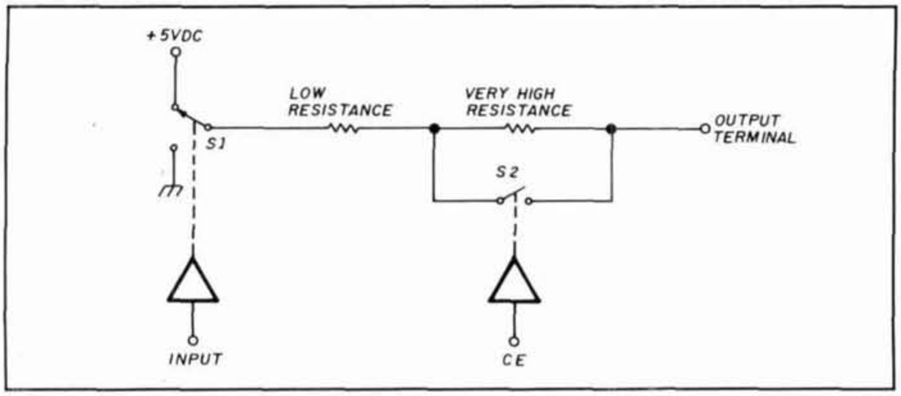
Many TTL and CMOS digital devices are called "tri-state" logic devices. Normal digital devices are two-state types. That is, they are *binary* in nature. This designation means that an output can be only HIGH or LOW — there's no in-between state. But a *tri-state* logic device has a third state in which the output terminal is effectively disconnected from the output circuits. **Figure 5** shows an equivalent circuit for the tri-state device. Switch S1 represents the normal binary operation of any TTL device (in this case an "inverter"). When the input is LOW, the output is HIGH, so switch S1 is connected to the +5 volt source. Alternatively, when the input is HIGH, the output is LOW, so S1 is connected to ground. The tri-state condition is provided by switch S2. When the *chip select* (CS) line is LOW, then switch S2 is closed so the output is connected directly to the inverter output (the S1 pole). But when CS is HIGH, switch S2 is open, so the output terminal is connected to the output

FIGURE 4C



A low power Schottky TTL input with both series and shunt Schottky diodes.

FIGURE 5



Equivalent circuit for a tri-state TTL device.

of the inverter through a very high resistance. This action has the effect of disconnecting the internal circuitry of the device from the output terminal. Tri-state logic devices are mainly used in computer and other digital applications where several devices must share a common bus or line.

Power supply decoupling

There are several general rules for placing power supply bypassing capacitors in TTL circuits. One of two protocols are generally used:

- a single 0.001-μF capacitor at each TTL package, or
- a single 0.01 to 0.1-μF capacitor every second or third device, or every 3 inches — whichever is spaced closest.

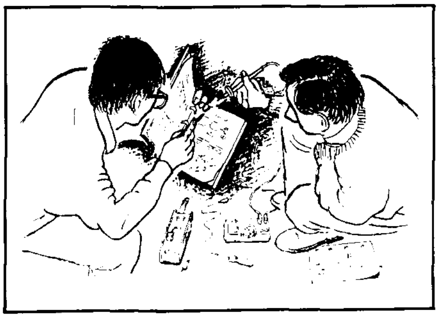
These capacitors are connected between the +5 volts DC terminal of the device and ground. The capacitors should be located close to the device.

On large projects it's advisable to place a 50 to 200-μF capacitor at the power supply connection for the printed wiring board, and 4.7 μF every 10 to 12 inches along the +5 volt bus.

If you build a really large project, one that draws 4 to 10 A from the +5 volt line, you might want to consider one of two power supply schemes. In the first, you use a voltage regulator with a *sense* line. That type of DC power supply has a reference voltage sensing line connected at the point where you want the voltage to be +5 volts. The DC resistance of the power supply bus causes a voltage drop that can hurt the operation of the circuits. The second uses distributed regulation. In this scheme, the main DC power bus is +8 volts. Each printed wiring board, or several sections of the same board, has its own three-terminal IC voltage regulator. The S-100 microcomputer (the original microcomputer) used this system. Each S-100 plug-in card had one to five 7805, LM-340T-05, LM-340K-05, or LM-309 voltage regulators.

Conclusion

Transistor transistor logic devices are inexpensive and are, for the most part, well behaved in practical circuits. You should be able to use them easily in both published construction projects or custom-designed projects of your own. hr



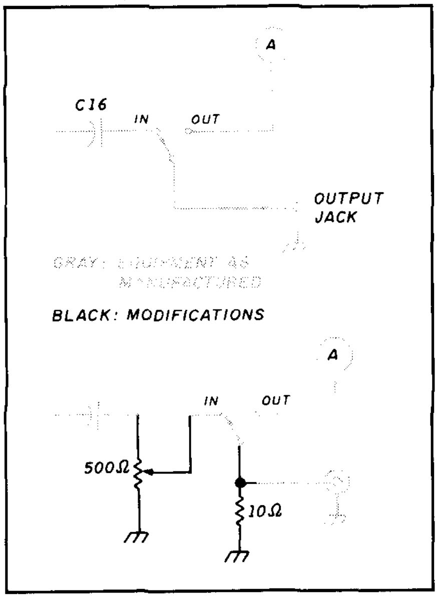
Optimizing The QF-1A Audio Filter

These small additions to the Autek QF-1A audio filter won't take an entire weekend, but you may find you want to spend some time playing with the settings (of the new controls and the existing ones) afterwards.

Setting up the rig

With the unmodified QF-1A filter in circuit but switched to OFF (BYPASS), experiment with the RF gain control of your rig while listening to a weak (just above the noise) SSB signal. Concentrate on finding the setting that gives you the best signal-to-noise ratio and intelligibility. This will *not* be the setting

FIGURE 1



Change to output.

that gives the *loudest* signal. You may be surprised to find how far back you have to turn the RF gain — especially if you're an old-timer brought up on the "full RF gain for fone, retarded for CW" rule popular in the old days of AM and diode detectors. The rule for SSB and product detectors is, "If you can hear the background noise in the absence of a signal, a receivable signal will be audible above it." This applies especially if you have a lot of local manmade noise.

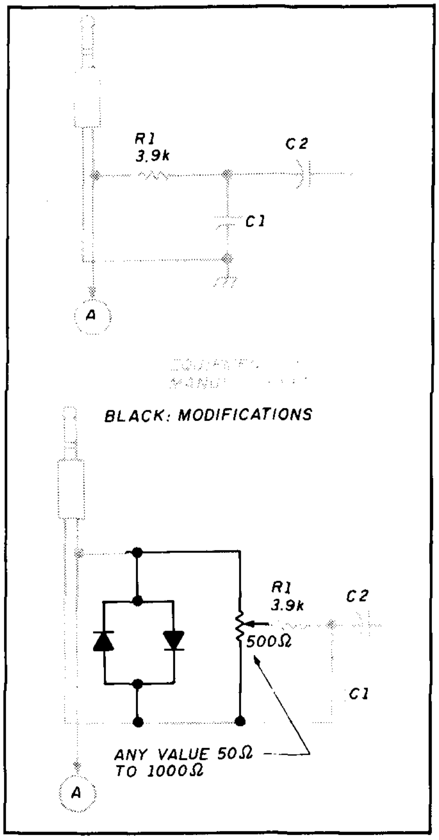
After you've found the best place for the RF gain, adjust the AF gain to a comfortable listening level. (If you're using headphones, and the comfortable audio level is near minimum AF control setting, you might consider putting a series resistor in the headset plug.)

Now switch on the QF-1A with the function switch on LOWPASS and all the other controls fully counterclockwise. If the audio is louder than it was before, you need the modification shown in **Figure 1**. (If it's not, you may still need it when you increase the filter gain by turning the selectivity control up.)

The next test is done more easily on CW. With the filter switched OFF find a CW signal, or (preferably) a constant audio tone from a calibrator or WWV, and select a comfortable audio level. Switch on the filter, put the QF-1A function switch at PEAK, the selectivity control at half scale or more, and swing the frequency control above and below the peak frequency. Note the approximate width of the peak. There's no need to be precise; just get the feel of it.

Reduce the setting of the AF gain on the rig and swing the frequency control again. If it's sharper than it was before, the output from the rig was overloading the filter and you need the modification shown in **Figure 2**. The back-to-back silicon diodes in **Figure 2** are included mainly to protect your ears from the sudden arrival of a huge signal or the Woodpecker.

FIGURE 2



Change to input

The modifications

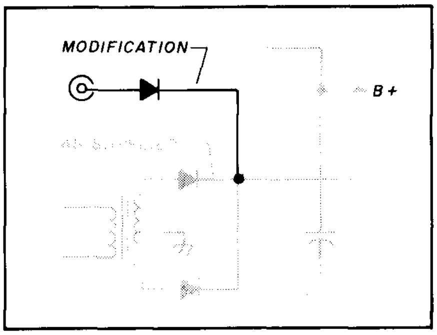
It's convenient to run the QF-1A from one of the 12-volt accessory sockets of the rig if the supply line is 12 volts positive (it only takes a fraction of a watt). **Figure 3** shows a suitable point to make the connection. A silicon diode in series protects the filter if it's plugged into a 12-volt negative line accidentally. There's plenty of room on the back wall of the filter enclosure for the two new potentiometers and an RCA-type socket. Physically, the pots can be as small as you like and the value isn't critical — somewhere between 50 and 500 ohms is ideal.

The 10-ohm resistor in **Figure 1** presents a reasonably low impedance load to the filter, even if you use high impedance headphones.

Adjusting the pots

After you've completed the modifications, turn both pots to maximum. The output should sound just as it did before. Make the CW test again. But after switching the filter on, reduce the input pot until the signal no longer saturates the filter. Then adjust the output pot until the audio level is about the same, whether the filter is ON or OFF.

FIGURE 3



+12 volts dc from rig. Diode is to protect QF1-A against accidental connection to −12 volt supply.

Adjusting the filter

You may prefer to make adjustments based on your own methods. For what it's worth, this is what I do on SSB. (I find the rig itself copes pretty well most of the time on CW.)

I set the function switch on LOW-PASS and the selectivity and frequency controls fully counterclockwise. Then, with a signal that has some noise on it I turn the frequency control until the high frequency components of the voice just begin to be attenuated. This usually results in a vast reduction of the noise. I leave the controls at this setting most of the time. I may, however, turn the frequency control a bit to the right on CW, "roofing" the noise somewhere just above the CW tone.

It often helps to adjust the AUX NOTCH control to about 10 o'clock on a particularly noisy SSB signal, leaving the selectivity control at minimum to give a broad notch. That's about it. The QF-1A is an excellent filter just the way it is, but adding these two controls lets you customize it to give optimum performance on your rig.

Bob Eldridge, VE7BS

Using The ICOM IC-32AT As A Crossband "Mini-Repeater"

Here's a simple modification that lets you use your IC-32AT as a crossband repeater. All you need to do as far as the hardware is concerned is clip diode D912 on the logic unit. Once you've done this and reassembled the radio, use the keypad to place the radio into crossband repeat mode:

- Push and hold the FUNCTION switch on the side of the radio.
- Push the [C] key.
- Push the [6] key.
- Push the [D] key.
- Release the FUNCTION switch.

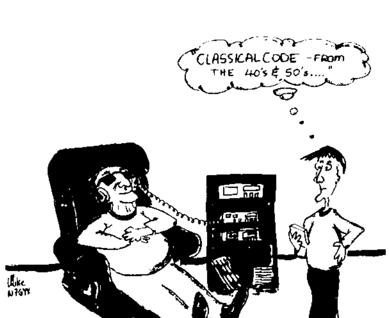
To cancel the repeater function, enter the following on the keypad:

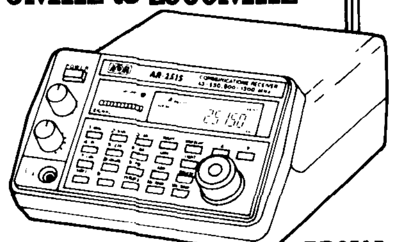
- Push and hold the FUNCTION switch on the side of the radio.
- Push the [D] key.
- Push the [C] key.
- Release the FUNCTION switch.

When the radio is in repeater mode, you'll note that it scans between the VHF and UHF frequencies last programmed into the VFOs. The radio will continue to scan between these two frequencies until a signal breaks the squelch or you stop the scan manually. When the scanning has stopped, the transmit frequency will be displayed until the incoming signal terminates. If the incoming signal was in the VHF/VFO, it will be retransmitted automatically on the UHF/VFO, and vice versa.

I think you'll find this feature useful if you're ever in an emergency situation, or communicating with someone who has VHF or UHF capabilities only.

Russell Dudley, KW5O





THE FIVE-BAND JUNKBOX TRANSMITTER

Short on cash but long on spare parts? This is the radio for you!

By Charlie Tiemeyer, W3RMD, RD 2, Box 427-C, Chestertown, Maryland 21620

Many Amateurs wonder how they can pursue their hobby inexpensively. Some are fortunate enough to have a sizable junkbox or an Elmer who's happy to contribute parts. Of course, there are probably plenty of old TV or radio sets around which contain the parts we need.

Transmitter

Figure 1 shows the schematic of my junkbox rig. The oscillator is a 6AQ5 tube and the final amplifier a 6DQ6. I chose these tubes because I have quite a few on hand. Any tube that renders reasonable output will work. I suggest that you select a final amplifier tube that can handle the output voltage of the power transformer you intend to use. My transformer is a 730-volt center-tapped unit I built about 35 years ago for a homebrew AM modulator. You may have one that delivers higher voltage which will let you use a 6146 or 807 in the final, allowing more power output.

Construction

All components were mounted and installed on an aluminum chassis, 13″ × 7″ × 2″. I suggest you mount the components logically and keep all leads as short as possible when soldering. I salvaged my tunable oscillator coil and the input and output variable capacitors of the pi-network final from a defunct Globe Chief transmitter. The tank coil was resurrected from a cannibalized Drake 2-NT transmitter, but any final coil from an old Globe Chief, DX-40, or DX-60 will suffice. If you can't find these particular parts, refer to **Tables 1** and **2** for coil data for both the tunable oscillator and the final tank circuit.

I prefer to operate 80 and 40 meters. If you want other bands, you'll need a switching arrangement to short circuit the unnecessary parts of the coils. I have used the 40-meter taps successfully to work 30 meters with 5-MHz crystals. Both oscillator and final tank coils are wound on 1″ diameter forms (see **Tables 1** and **2**).

Although I didn't try it, I think you could use 12 meters with either the 15 or 10-meter band coil positions and the appropriate crystals. You'll need to experiment. I also think it's possible to use *one* wire size instead of the three indicated. Because I've listed a maximum of 35 turns of wire, you can use one longer 1″ diameter coil form with taps at the appropriate bands. You'll need all 35 turns for 80 meters. For 40 meters, the tap would be up twelve turns. Twenty meters would be up from this tap at thirteen turns, 15 meters at four turns, 10 meters up at one turn, and 15 and 10 meters would be space wound.

The same arrangement used with the oscilator coil(s) applies for 12 meters on the final tank coil(s). Use a 1″ coil form with 30 turns for 80 meters. For 40 meters, the tap would be up 13 turns. Twenty meters would be up from this tap at 11 turns, 15 meters up 2 turns, and 10 meters up 1 turn and space wound.

Because I operate this rig on 80 and 40 meters only, I use copper alligator clips to short wanted turns on both the

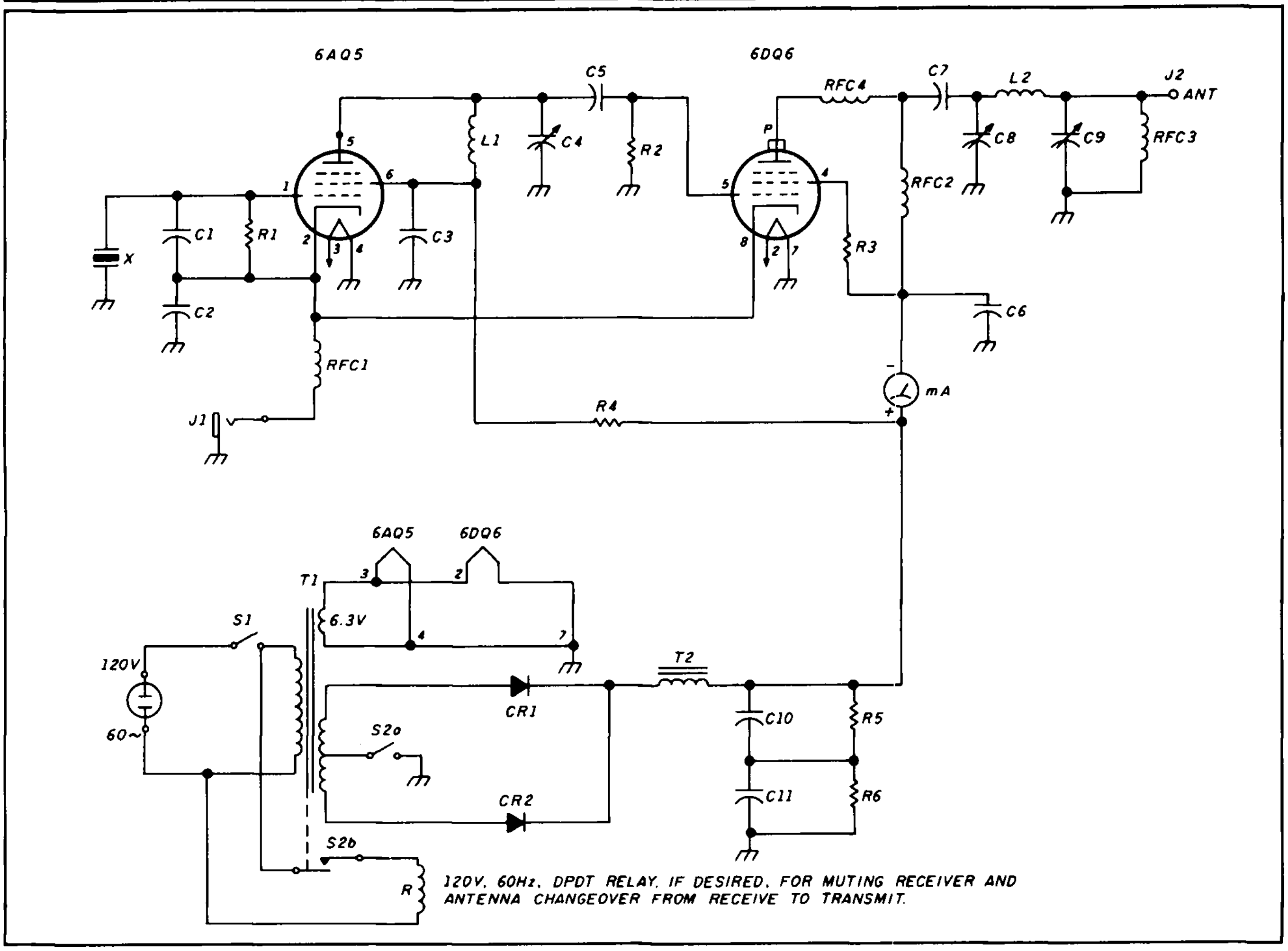
TABLE 1

Oscillator coil(s).
80 meters, 35 turns no. 22 enamel wire close wound
40 meters, 23 turns no. 22 enamel wire close wound
20 meters, 10 turns no. 22 enamel wire close wound
15 meters, 6 turns no. 18 enamel wire space wound by wire diameter
10 meters, 5 turns no. 16 enamel wire space wound by wire diameter

TABLE 2

Final (tank) coil(s).
80 meters, 30 turns no. 14, 16, or 18 enamel wire close wound
40 meters, 17 turns no. 14, 16, or 18 enamel wire close wound
20 meters, 6 turns no. 14, 16, or 18 enamel wire space wound by wire diameter
15 meters, 4 turns no. 14, 16, or 18 enamel wire double spaced by wire diameter
10 meters, 3 turns no. 14, 16, or 18 enamel wire double spaced by wire diameter

FIGURE 1



Schematic of the five-band junkbox transmitter.

PARTS LIST

C1	22-pF or 0 to 30-pF trimmer capacitor
C2,C5	100-pF disc ceramic capacitors or mica
C3	0.01-μF 1 kV± disc ceramic or mica capacitors
C4	100-pF variable capacitor, broadcast type okay
C6,C7	0.001 to 0.005-μF 1 kV± disc ceramic or mica capacitors
C8	350 to 450-pF variable tuning capacitor, broadcast type okay
C9	1200-pF variable tuning capacitor (usually 3 gang ±400 pF, each gang in parallel)
C10,C11	80 or 100-μF 450-volt electrolytic capacitors in series
R1	47-k, 1/2 or 1-watt carbon resistor
R2	27-k, 1/2 or 1-watt carbon resistor
R3	4-k, 10-watt wire-wound resistor
R4	1.5-k, 10-watt wire-wound resistor (may not need if 300 volts not exceeded)
R5,R6	330-k, 1-watt carbon equalizing resistors (470 k okay)
X	Any 80 or 40-meter crystal
RFC1,RFC2, RFC3	2.5-mH (1 mH okay) 125 to 150-mA RF chokes
RFC4	7 turns no. 20 wire space wound on 47-ohm, 1-watt carbon resistor
T1	See text (any voltage from about 350 to 450 each side of center)
T2	Any choke from 5 to 10 H, 100 to 200 mA
CR1,CR2	1000-PIV, 400-mA or more silicon diodes
S1	SPST toggle switch
S2	DPDT toggle switch (if relay is used, otherwise same as S1)
J1	Open or closed-circuit phone jack for key
J2	Coaxial receptacle, no. SO-239
MA	0 to 200-mA milliammeter for loading PA
R	Relay for muting receiver and antenna changeover (optional)

oscillator and final tank coils. If you can obtain these coils from old discarded transmitters, you'll find that the proper tap points for each band are indented on the forms or may still have leads extending from them. If they aren't available, you'll need to follow the steps for winding your own.

Recommended voltages and currents

My rig has voltages and currents based on the power transformer I'm using. These are shown in **Table 3**. I don't know the transformer s current rating, but I think that any reasonable unit capable of at least 150 mA (preferably around 200 mA) would be adequate. If you have a transformer capable of 400 or 500-volts output, you might need to use a different power amplifier tube. You'll also need appropriate screen-dropping resistors for the final tube and for the plate and screen of the oscillator tube to avoid overload.

This rig uses choke input for better regulation, but you can use capacitor input and get more output voltage. My transformer is rated around 365-0-365 volts at choke input and resolves to 365 volts × 0.90, or approximately 328 volts. For capacitor input, 365 volts × 1.2 = 438 volts output; for no load, 365 volts × 1.4 = 511 volts. However, I *assume* my transformer is 365-0-365 volts; hence I arrived at the data in **Table 3** taken on both 40 and 80 meters.

Tuneup

Tuning up is simple. Put all three variable capacitors at maximum capacitance (plates fully meshed). Don't forget to use a dummy load to tune up before attaching an antenna. While listening to your receiver around your crystal frequency, close switch S2, depress the key, and quickly tune C4 for the loudest signal. Then tune C8 for minimum

TABLE 3

No load voltages, 470 volts choke input.
305 volts at 100 mA = 32 watts input, 235 volts to 6AQ5, 200 volts to 6DQ6 screen
300 volts at 125 mA = 38 watts input, 230 volts to 6AQ5, 210 volts to 6DQ6 screen
295 volts at 150 mA = 44 watts input, 220 volts to 6AQ5, 230 volts to 6DQ6 screen

dip in plate current; this should be less than 100 mA. Increase C9 a little at a time, redipping C8 until you've loaded between 100 and 150 mA after each try. Actually, 125 mA is best. Now you're ready to operate.

Some closing thoughts

There you have it. I'm still having fun with this little rig and getting excellent results and reports. I haven't tried my old Heathkit VF-1 VFO with it yet, but feel it would give me more versatility — assuming it works okay in place of my crystals. I have a "rock pile" accumulated through many years in Amateur radio; however, I prefer crystal control for the obvious stability.

I think you'll not only enjoy building and experimenting with this rig, but will have many enjoyable hours on the air. hr

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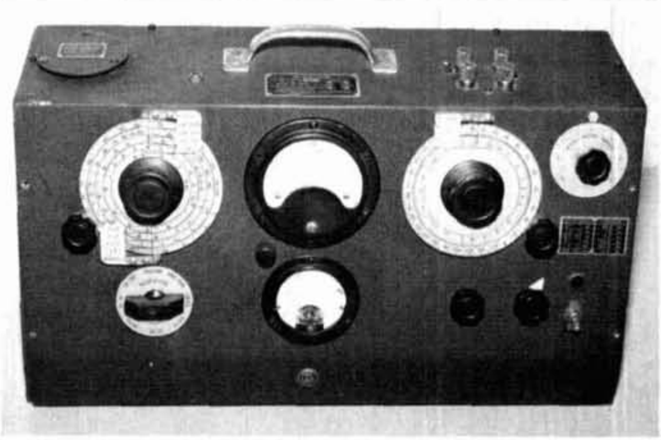
Q METERS

By Keats A. Pullen, Jr., W3QOM,
2807 Jerusalem Road, Kingsville, Maryland 21087

Keep your eyes open at the next hamfest you attend. You may see a Q meter at a good price (under $50). Once you know how to use it, you'll find it's one of the most useful test instruments to own.

However, there's a problem with Q meters today. Units like the Boonton type 160-A model 1 are full of antiquated tubes. The 160-A uses tubes with 2.5-volt filaments (types 45 and 2A6, a dual diode triode with a grid lead on the top). The unit I picked up didn't respond to Q measurements, so I decided to replace these tubes with more modern 6-volt types — like the 6Y6GT or 6AR6 in place of the 45, or a 6J6 in place of the 2A6. Get spares, and test them to be sure they work!

PHOTO A



Front panel view of a Q meter.

How does it work?

Q is measured using a fundamental characteristic of series LC circuits. At resonance, the magnitude of the voltage appearing across either reactance is equal to the voltage induced in the circuit, multiplied by the "circuit" Q. Through careful test instrument design, the circuit Q is essentially the same as the Q of the component under test.

A brief description of the type 160-A Q meter is in order. The meter consists of two sections, an oscillator and a voltmeter. The oscillator uses a type 45 triode to provide the required RF current to the exciting circuit, which consists of a resistive ribbon with a value of 40 milliohms. The coil to be measured is connected from the ungrounded end of this resistance to the stator terminal of a built-in variable capacitor to provide the series test circuit. This resistance must have enough current running through it to give about a 10-mV drop at the test frequency. The amount of RF current in the exciting resistor must be of sufficient magnitude that the resonant current due to the Q multiplication won't make a significant change in the resistor current.

I selected the 6J6 tube, a dual diode triode unit, for its extremely high "mu" or amplification factor. A 12BZ7 triode has similar properties and adequate gm, but the 6J6 can be made to work. Whatever tube you choose, it's used in a circuit called an "infinite impedance" detector circuit; it's biased nearly at cutoff, and the positive swing of the signal causes the tube to draw current. The voltage change across the cathode resistance is measured by a simple DC voltmeter.

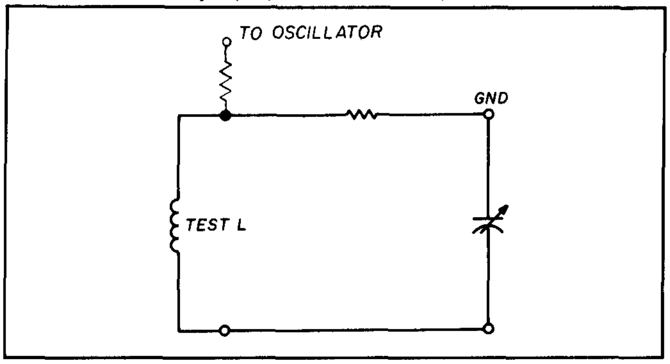
Because of this, there's a frequency-range changing switch and a tuning circuit on the left side of the instrument which selects the desired operating frequency (see Photo A). The amplitude of the applied current to the test circuit is set by the smaller meter and the two knobs to its right. The left knob is the coarse adjustment; the right is the fine.

The meter that indicates the value of Q measures the voltage generated across the cathode resistor of the infinite impedance detector. The detector senses the RF voltage across the tuned circuit, consisting of the coil and the variable capacitor which is calibrated from 30 to 450 pF. This capacitor is just to the right of the Q measuring meter. The small knob below the meter is used for adjusting the zero setting of the meter. This setting may be somewhat sensitive to the level of current in the tuned circuit, as the knobs that control the RF current act by varying the output supply voltage to the oscillator tube. The zero set should be done after the signal amplitude has been set in the current meter.

The layout for the coil connections is indicated by the binding posts on the top of the instrument (see Figure 1). There's one terminal for ground, one for the injection resistance, and two for the ungrounded end of the capacitor — which also connects to the grid of the detector tube. I'll describe the various ways to use these connections later.

The 45/6Y6GT/6AR6 tube operates as a power oscillator and provides up to 1 A of RF current to the measurement circuit. This current level must be much higher than the circulating current that flows in the test circuit at the highest possible Q factor. This current flows through a thermocouple, and perhaps some additional resistance, in addition to the injection resistance that excites the tuned circuit under test. The thermocouple provides metering current to a panel meter that indicates the magnitude of current flow, thereby giving a multiplicative factor for the Q reading. It's very

FIGURE 1



Binding post placement on the instrument.

important that the thermocouple current be limited to a maximum indicated value of 1 on the multiplier meter; too much current can easily burn out the thermocouple. The thermocouple is very delicate and can't tolerate any overshoot.

The metering circuit uses only the triode section of the 2A6. The diodes would load the circuit and keep it from operating properly. There's a small resistance in series with the filament in this arrangement to minimize the zero-bias grid current and make the unit work more effectively. Using the infinite impedance detector configuration further reduces the loading. In addition, the relation between the plate current and the bias is very nonlinear. This lets it suppress the negative half cycle of the applied signal, and gives an output current that rises rapidly with the increase in applied signal.

Don't be surprised if you haven't heard of the infinite impedance detector. I learned of its existance before World War II, and haven't seen any use of this unique circuit since — except for this Q meter application. The advantage of this detector is that it doesn't load a circuit that it's coupled to, and lets you measure the output voltage of the tuned circuit without degrading it, as would a diode. The "output" obtained with this detector is taken across a cathode resistor, and the circuit behaves like a cathode or an emitter follower. I'll give more information about the process for setting the bias current level on this tube later.

There are several different definitions of Q, but as long as the measured Q exceeds 10, the definitions are, for practical purposes, more or less equivalent. A good discussion of Q appears on page 110 of the September 1988 issue of *Ham Radio*.[1] It's usually defined as the ratio of the reactance of the capacitor, divided by the effective internal resistance of the overall tuned circuit. (This is usually greater than the DC resistance.) The best definition involves the ratio of the stored energy in the coil or the capacitor per cycle, divided by the dissipated energy per cycle. This may occur at a slightly different frequency, but gives essentially the same value of Q.

Possibly useful changes

If the unit is working reliably with the existing tubes (or tubes you bought at a hamfest) don't change anything, but do acquire tubes that you can use to modernize your meter at a later date. If the Q voltmeter doesn't seem to function reliably on RF (mine didn't), you may find my changes useful. Incidentally, the "AC hum" technique used to make a rough test of the detector circuit may not be a valid test for the unit's high frequency operation. The detector requires a 5-volt signal for full-scale deflection, but its operation at 60 Hz indicates only that the circuit should be okay. Check to be sure that the lower "calibration" meter deflects upscale as the left knob to the right of the meter is turned slowly clockwise. When testing, **always** be sure to turn these knobs counterclockwise before turning the instrument on. Protect that thermocouple!

A need to change to 6-volt tubes may be indicated if either tube is inoperative and you can't find spares. (You may not be able to test the original tubes with present-day tube testers.) If the lower meter fails to deflect on one or two ranges only, the problem is certainly an oscillator tube. If it doesn't deflect on any range, it could be either the tube or the thermocouple. Be careful: the thermocouple is inside the oscillator box, and is hard to get to. You may be able to get a hint of what's causing the problem by disconnecting the leads on the lower meter and measuring the resistance through the leads. (That will indicate continuity in the thermocouple itself.) If the thermocouple is burned out, there's a good possibility that the metering circuit to the meter is also open.

I used a 6-volt, 2-A transformer like the one sold by Radio Shack for my new filament transformer. A center tap isn't necessary. One end of the filament winding connects to ground and the other goes in place of the ungrounded end of the 2.5-volt winding which is, of course, disconnected. These are on the tie-point strip near the variable capacitor.

You must take apart the oscillator assembly to change the tube socket from four pin to octal — preferably a low loss socket. Move the heater leads from the larger pins on the four-prong socket to pins 2 and 7 on the octal socket (6Y6GT only). Ground the cathode, pin 8. Attach the grid connection to pin 5, the plate to pin 3.

Pin 4 is now the screen grid lead. It must be bypassed to cathode at the socket, and brought out of the oscillator shield. (To minimize leakage, mount a small resistance just inside the shield at the point of exit. About 100 ohms should work.) Bypass the lead at the point of exit to keep RF from leaking out. A 0.01-μF ceramic should be fine. You can back it up with a larger capacitor if you wish. This lead shouldn't be connected directly to the plate supply, but should have a resistor in series to the supply. I brought it out to a dropping resistance that connects to the center terminal of the large, high wattage potentiometer found just to the right of the lower meter. Start with a resistance of about 25,000 ohms and decrease it until the multiplier meter reads unity, with the potentiometers set near maximum clockwise setting. Adjust both the plate and screen voltages by these resistances.

I replaced the 2A6 tube with a 6J6 tube. My old (1973) ARRL handbook lists the 2A6 and gives the basing connections, but it doesn't indicate the characteristics otherwise. My (older) RCA tube handbook implies that the tube is essentially similar to the 6SQ7 (or 6Q7), and that it requires very little negative bias between cathode and grid to stop current flow. The 6J6 requires significantly more bias, and gave me some problems initially. Two zener diodes and a few spare resistors straightened things out. A 6T8A is an another possibility.

I put my 6J6 tube on a small metal "outrigger" that I could attach to the frame of the main variable capacitor.

A 100-meg resistor runs across the stator of the capacitor to its frame. I left it in the circuit connected to the grid. I put a capacitor from the stator to the 6J6 grids. This blocks the detector's 60-Hz sensitivity. I also put a small (51 ohm) resistor between the two grids to minimize the possibility of parasitics in the 6J6.

To limit the plate voltage on the 6J6 to 100 volts, I added a gaseous voltage regulator (OA2). This improved the stability of the detector significantly when I corrected other problems. Stabilizing the plate voltage on the 6J6 stabilizes its operating point, because of the cathode degeneration in the infinite impedance detector.

I had to bias the cathode of the 6J6 to a point that would place it in the nonlinear operating region. This required about 5 volts of forward bias on the cathode. The best way to get this was by using a zener diode. The bias point varies from tube to tube, so check the bias point of the tube you choose. I made a little voltage divider (see **Figure 2**) to vary the cathode potential, and adjusted the forward bias until there was only about 1/10-volt bias across the cathode resistor — about 10,000 ohms. Then I found a zener diode with that forward drop at about 5 to 10 mA current, and inserted a resistance to the 100 volts from the OA2 to draw that much current (see **Figure 3**).

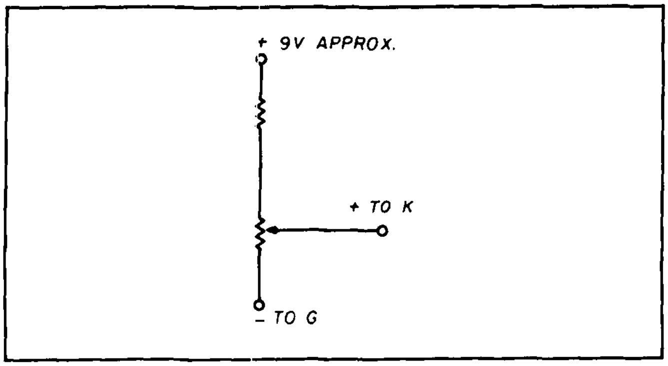
There are a number of high wattage power resistors (at least 5 watts) behind the rectifier tube on the lower subchassis. The lower ends of some of these resistors are connected together, and are also connected to ground. The smallest of these is the cathode resistor for the 2A6. I disconnected the cathode resistor's lower connection from its neighbor and installed the zener diode between the two, so the cathode resistor had its return end about 5 volts above ground. As I mentioned before, I attached a resistance from the bottom lead of the cathode resistor to the stabilized 100 volts. To assure proper operation, the zener diode current should be about 10 mA, and the quiescent voltage across the cathode return resistor shouldn't exceed 0.1 volts.

I returned the cathode lead on the 6J6 to the cathode lead on the bottom of the 2A6 socket, pin 5. There are several bypasses on this point and also continuity to the top of the smaller of the power resistors. I bypassed this lead to ground on the 6J6 socket, and bypassed the plates to ground. (The plates return to the 100 volts from the regulator; refer to **Figure 3**).

I installed a 2-ohm power resistor in series with the ungrounded end of the 6J6's heater lead to reduce the heater voltage and the emission energy of the electrons leaving the cathode. This helps keep the input impedance of the grid circuit very high. Boonton had such a resistance in the 2A6 filament lead.

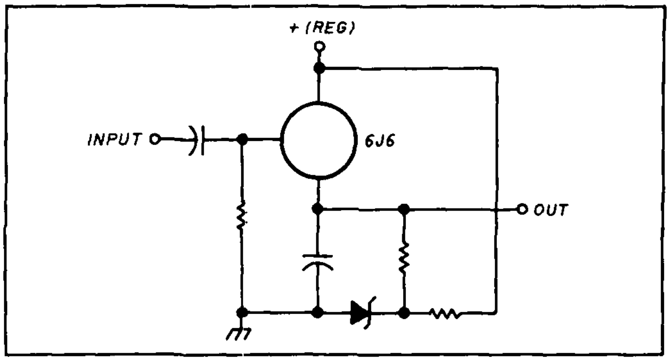
At this point, everything was working well, but the zero point on the Q measuring meter was changing with the power setting. It turned out that the voltage regulation of the high voltage supply was changing with oscillator loading. Once again, I solved my problem with a zener diode. For best all-around operation, two zener diodes here may be better than one. One diode connects from ground to the fourth tie-point from the filament ground. (The resistance between the two points should be taken out.) The second diode (perhaps about 7 volts) goes from ground to the "high" end of the Q meter adjustment potentiometer. With both ends stabilized, the reading is no longer a function

FIGURE 2



Simple bias divider.

FIGURE 3



Bias setup for the 6J6.

of power level in the oscillator. The problem was one of DC shift all along!

Now, test your unit with a coil from your junkbox. It should work with no problems.

Using the Q meter

The overall scope of these instruments is really quite remarkable. I'll touch on the more common applications. Q meters can be used to measure the inductance of a coil, what its Q may be at a desired operating frequency, and what capacitance it should be used with. For instance, I may want to know if I can use a certain coil, or I may want to make a coil for operation at a selected frequency. I place the coil between the low and high terminals and start searching — first in the neighborhood of the desired operating frequency. Then I set the selected frequency with the range and tuning controls on the left side of the instrument, and tune the right-hand capacitor over its full range. I may get a peak. If so, I read the capacitance and see if it's close to what I want. If I don't get a peak, I have to start searching. If I think the inductance may be too small, I move the range switch to a higher frequency range and repeat the process, readjusting the power setting as necessary to protect the thermocouple. Once I get a peak, I can calculate the inductance and read the Q at that frequency.

Perhaps I want to know the operating frequency of a coil with a given capacitance. The connections are the same; I set the capacitance and vary the frequency of the oscillator until I find it. Then I can go to a desired frequency and measure its Q.

There are reasons why I may not wish to measure a coil at its chosen operating frequency. One of the most important ones is that the minimum capacitance on the tuning capacitor is only about 30 pF and the maximum is approximately 450 pF. My design may tell me I need over 1000 pF, or less than 10, for example. I then measure at a frequency that fits the range of the instrument.

A Q meter can also be used to measure inductance. Simply find some set frequencies at which to make the measurements and make a calibration for the capacitor dial to read inductances. The calibration is based on an assumption of an inductance that is a multiple of 10 when the capacitor is set at 450 pF. Set the frequency at one frequency first and then move to another, until you find a resonance on the meter. Read the capacitance and select the correct inductance.

You aren't limited to a top capacitance of 500 pF. You can parallel a silver-mica capacitor across the internal capacitor and continue as before. The equations you need are:

$$L = 1/((2\times\pi\times f)\times C) = 1/(39.5\times C\times f^2) \quad \textbf{(1)}$$

where (f^2) is f squared and C is the total capacitance,
f is frequency in cycles per second,
L is inductance in henries,
C is capacitance in farads.
Note that if L is in microhenries and C in microfarads, then f is in megacycles (MHz).

$$XL = 6.3\times f\times L \quad \textbf{(2)}$$

$$Reff = 6.3\times f\times L/Q = XL/Q \quad \textbf{(3)}$$

$$Ztuned = 6.3\times f\times L\times Q = Q\times XL \quad \textbf{(4)}$$

These numbers are all important, but you can learn more.

Suppose you want to test a circuit using an untuned coupling link to drive the tuned circuit. In this case, you'd connect the untuned link from the low terminal to ground, and the tuned coil from the high terminal to ground. You can use this combination to test the combination circuit; it will give a test of effective Q (here the product of coupling and Q). Test a double-tuned circuit in a similar fashion. Use a fixed capacitor from the "high" end of the injection tuned circuit, and place the second coil from ground to high on the tuning capacitor. Adjust the tuning so both coils peak, vary your coupling as needed, and observe the behavior of the coupled circuit as the frequency changes.

Why do you need the value of a tuned impedance? Amplifier stability is a function of voltage gain, not current gain. Beta and triode mu can't be used to find the voltage gain — only transconductance can. The gain Kv is:

$$Kv = gm\times RL \quad \textbf{(5)}$$

where RL is the tuned impedance.

Voltage gain *must* be limited to assure stable operation; values under 10 are usually desirable.

You say you don't normally know gm or transconductance for solid-state devices? That's not a problem. It's approximately 39xIc with a bipolar transistor, where Ic is the collector current. (q/kT has a value of 39!) The transconductance has similar form with FETs and electron tubes, but needs an efficiency factor which I call kappa, that must be multiplied by 39 and the output current. This is particularly important with transmitters, where large blocks of power must be handled.

Note that:
q (charge on an electron) = 1.6×10^{-19} coulombs
k (Boltzman constant) = 1.38×10^{-23} joules/Kelvin
T (absolute temperature) = 296°

You can measure kappa easily for any operating conditions you desire. Select an output current that is 2/3 of the desired operating current, and one that is 4/3 of the present operating current. Read the change in input voltage required to switch the output current from one value to the other with a voltmeter, and divide that voltage change into 0.018, which is kT/q times the natural logarithm of 2. The resulting value of kappa varies slowly, so you're in business! Multiply this quotient by the value of output current in amperes and by 39 to get the device transconductance at that value of current. The product of this number and the load impedance gives the voltage gain. Incidentally, if you multiply the reciprocal of kappa by 3 you'll have a measure of the maximum output supply voltage that can be applied to the device in question. There are other ramifications of this, too detailed to examine here.

Once you get your Q meter running, you can have all kinds of fun building RF circuits, amplifiers, and filters. Have a good time!

REFERENCES

1. Tom McMullen, W1SL, "Elmer's Notebook," *Ham Radio*, September 1988, page 110.

Introducing the only compact HT designed for you—Heath's new 2-meter and 450 MHz Micro-Deluxe handheld transceivers.

Built with a receiver sensitivity of 0.158 μV for 12 dB SINAD, the micro-sized HW2P or HW4P measures an unbelievable 4-3/8"H x 2-1/16"W x 1-1/4"D. Battery-packs hinge onto the back of the unit so the HT retains the same basic form, even with the largest capacity batteries. Slip it into your pocket or hook it on your belt - no more hassles with bent clips or tangles with car seatbelts. Heath's new micro-HTs will go anywhere you do.

The art of Easy Operation. Enter frequencies directly from the full-function keyboard or QSY from the displayed frequency via the rotary frequency selector. Scan between two frequencies, Scan 1 Mhz or scan all except between two frequencies. Scan favorite memory channels (useful for temporarily locking out a busy channel), scan first ten memory channels, last ten or all twenty. All scanning modes support either Pause Scan (stop on active channel then resume) or Busy Scan (stop on active channel and hold). One button Call channel is a quick way to get to your favorite repeater or simplex frequency.

HW2P shown actual size.

The art of Low Power Consumption. With only 46 mA required for RX squelched, and 1200 mA for full 5 watts TX output, these new handhelds are the most efficient designs available. A nine-step battery saver defaults to 22 mA in receive, but life can be further extended, approaching only 10 mA average RX current squelched.

The art of small talk

The art of 5 Watts Power. With the optional 12V, 600 mA/h battery-pack, the HW2P and HW4P offer full 5 watts out in High, 3.5 watts in Medium and 300 mW in Low. The 7.2 V battery-packs (400 mA/h, 700 mA/h, 1200 mA/h) offer 2 watts in High, 1 watt in Medium, and 300 mW in Low. The 7.2 V, 700 mA/h battery is included standard with the HTs.

Full Line of HT's. Also new are the Heath 2-meter and 450 MHz Mini-Deluxe handheld transceivers. Only slightly larger than the Micro-Deluxe HTs, with all the same exciting features.

Discover the art of small talk, call your authorized Heath dealer about the complete line of Heath HT's and Heathkit station accessories today.

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The Ham Station,
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For your free Heathkit catalog, call 1-800-44-HEATH.

Best to start with.
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DDS Direct Digital Synthesis

Performance. Yours and your radio's. They go hand in hand. To be a truly world-class competitor, you've got to have a truly world-class rig. And it's here, now. The versatile new FT-1000 from Yaesu.

Designed for the elite global contest and DX operators. With state-of-the-art design including **direct digital synthesis (DDS)** for low noise and fast lock-up time. The FT-1000 will blow away your competition with a spectacular combination of power and operating flexibility. This HF transceiver boasts a list of

Performance.

The Best of the Best

features and options that other manufacturers still have on their drawing boards: Like **200 watts RF power output; Built-in TCXO,** for superior frequency stability; **Independent filter selection; Dual receive with balance control** and **two tuning knobs** for simultaneous reception in tough pile-up situations. Using **BPF-1** allows cross-band dual receive.

And the FT-1000 options such as **digital voice-recording system (DVS-2)** for storing and playback "CQ Contest" messages. On RX the DVS-2 has a 16-second running memory for playing back garbled calls. There's also a **CW spot control,** so you can align your frequency to that of an incoming signal without having to transmit; Plus **direct keyboard frequency entry; Front panel RX antenna selector; Built-in cascaded filters;**

Dual-mode noise blanker. And the receiver front-end uses a **four JFET up-conversion mixer,** for high dynamic range.

This HF rig is the product of three years of intensive research and design. These efforts show in Yaesu's scrupulous attention to detail with features and options ergonomically designed to allow you to achieve a position of competitive dominance. To hear and be heard… Like never before.

See the exciting new FT-1000 at your Yaesu dealer today. It's the best of the best.

YAESU

Performance without compromise.

Ham Radio Techniques

Bill Orr, W6SAI

ANTENNAS, GFI, CAPACITORS, AND FUNDAMENTALS

It was a so-so year for DX. The high MUF provided DX openings on 10 meters (sometimes), but the irregular outbursts of the sun wiped out the HF bands for days at a time. The 6-meter DXers were happy because when the HF bands pooped out, often as not the 6-meter band was open for long-haul DX. It was truly a mixed bag of propagation for 1989. Let's hope Old Sol settles down and provides some good stable HF/DX conditions in the coming year!

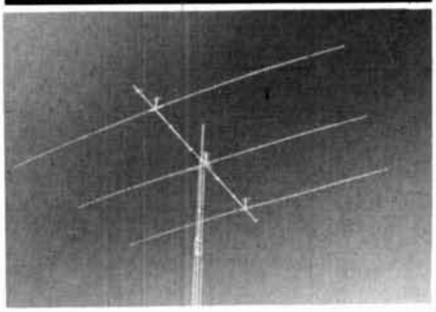
KØBIT's 40-meter "Death Ray"

Pete, KØBIT, decided he would build a 40-meter Yagi the "right" way (see **Photo A**). The three-element monster is constructed on a 48-foot boom consisting of two 24-foot sections of 3-inch OD by 0.125-inch wall aluminum tubing. A 12-foot long sleeve connects them together and provides additional strength at the center of the boom. The spacing between elements is 18 feet, and the extra 6 feet on each end of the boom are used for side guys on the elements.

The elements are made of 1.5-inch tubing telescoping to 1 inch, providing a mild taper ratio. Each element is guyed overhead to one 30-inch vertical post centered on the boom and is also guyed in the horizontal plane back to the boom on each side. This provides a sagless element. The guys are made of Phillystran Kevlar™ rope and are electrically transparent. Element dimensions are taken from the *Radio Handbook*.[1]

Pete says, "This beam is not something you can whip up in your garage, since a great deal of custom machine work and heli-arc welding has to be done for the special fittings. The effort was worth it. Forty meters is a whole new band with this beam. I can work Europe consistently and can break through the East Coast on difficult contacts!"

PHOTO A



KØBIT's 40-meter beam is built on a 48-foot boom. No element sag here!

WØSVM's 17-meter "Rabbit Ears"

No big beam for you? Well then, how about the "Rabbit Ears" antenna built by Jack, WØSVM. The design of the center-loaded V dipole is shown in **Figure 1**. Jack cuts a half-wave copper (or aluminum) tubing dipole in half and mounts it as shown. This particular model is cut for the 17-meter band. A framework of 1 by 2-inch lumber holds the tubing in position. A tapped coil connects the dipole halves and a small link coil is adjusted to frequency with a dip oscillator. The final step is to apply power to the antenna and adjust the coil coupling and antenna tap for lowest SWR on the line. Jack adjusted his antenna at 18.120 kHz; it covers the narrow band nicely.

GFI interference

A while back I reported cases of Ground Fault Interrupter (GFI) interference and queried readers about this problem. Here are some of the replies I've received:

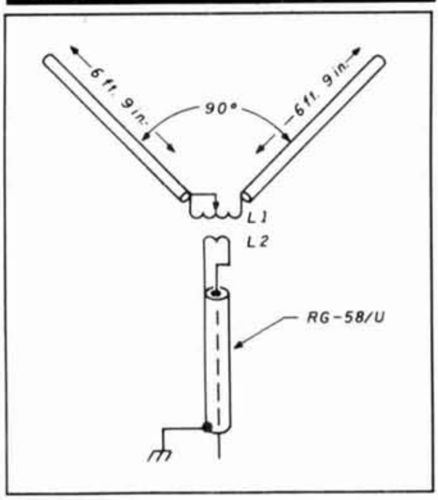
Ralph Dieter, K1RD, "I solved the GFI problem in my house by placing a ferrite tube (the equivalent of about 15 cores) on the neutral line to the GFI device. This appears to place enough impedance in the line to stop rectified signals from unbalancing the neutral circuit."

Bob Paine, W7RX, "The GFI indicator operates on an imbalance of about 5 mA between positive and neutral, and is very sensitive to RF. My cure was to place 0.003 μF, 1.6-kV (AC rated) ceramic capacitors from positive and neutral to ground. The capacitors are mounted in a two-wire plug inserted into the GFI unit."

Mike Schultz, KSØT, "The GFI unit is very susceptible to RF in the power line. I use a center-fed dipole antenna, 51 feet on a leg, fed with ladder line. When I use it as a dipole, I don't encounter any trouble. But when I short the feedline together and use the antenna as an end-fed wire on 160 meters, the GFI pops as soon as I press the key."

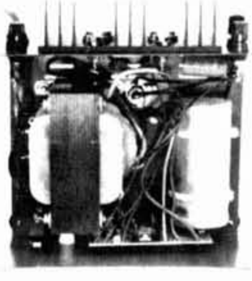
Mike's solutions include using a

FIGURE 1



WØSVM's "Rabbit Ears" antenna. Dimensions are for the 17-meter band. L1: 20 turns no. 12, 2-1/2" diameter, 6 turns per inch. Alligator clip adjusts coil to resonance. L2: 5 turns of hookup wire over the center of L1.

ASTRON CORPORATION
9 Autry
Irvine, CA 92718
(714) 458-7277



INSIDE VIEW — RS-12A

ASTRON POWER SUPPLIES

• HEAVY DUTY • HIGH QUALITY • RUGGED • RELIABLE •

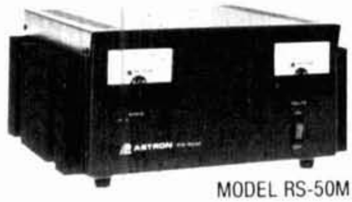
SPECIAL FEATURES

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

PERFORMANCE SPECIFICATIONS

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

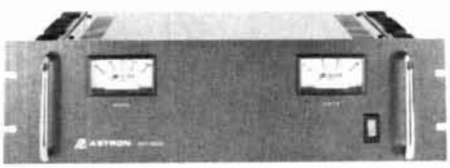
MODEL RS-50A



MODEL RS-50M

MODEL VS-50M

RM SERIES



MODEL RM-35M

19" × 5¼ RACK MOUNT POWER SUPPLIES

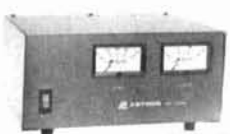
MODEL	Continuous Duty (Amps)	ICS* (Amps)	Size (IN) H × W × D	Shipping Wt. (lbs.)
RM-12A	9	12	5¼ × 19 × 8¼	16
RM-35A	25	35	5¼ × 19 × 12½	38
RM-50A	37	50	5¼ × 19 × 12½	50
• Separate Volt and Amp Meters				
RM-12M	9	12	5¼ × 19 × 8¼	16
RM-35M	25	35	5¼ × 19 × 12½	38
RM-50M	37	50	5¼ × 19 × 12½	50

RS-A SERIES

MODEL RS-7A

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

RS-M SERIES



MODEL RS-35M

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

VS-M AND VRM-M SERIES

MODEL VS-35M

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

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

RS-S SERIES

MODEL RS-12S

- Built in speaker

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

*ICS—Intermittent Communication Service (50% Duty Cycle 5min. on 5 min. off) balanced antenna, using ground radials or counterpoise wires plus a good electrical ground connection for an end-fed antenna (or vertical), and avoiding expensive GFI breakers built into the panel. He recommends GFI receptacles with minimum wiring on their load side instead.

Mike notes that those who live in trailer parks or marinas should experiment with different types of RF grounds or counterpoises. He also suggests you avoid a resonant length of extension cord to feed AC power to your vehicle or craft.

The 1-farad capacitor

It's not hard to buy a 120,000-μF capacitor. (See any large distributor's catalog.) But how about a 1-F capacitor (1,000,000 μF)? There is one made by Nippon Electric that costs just a few dollars. My friend Joe, W8IIP, dropped one in the mail for me. This super capacitor can store enough charge to enable it to serve as a backup power source for memory and processor circuits in computers.

The construction of the super capacitor is unusual, but quite simple. The charge is stored in layers of activated charcoal with a very large surface area. The layers are separated by a porous plastic film. The electrolyte is sulfuric acid. A single capacitor has a maximum breakdown voltage of about 1.2, so units are stacked in series to provide higher working potentials. The capacitor isn't polarized.

I don't know what to do with my 1-F capacitor, so I keep it on the operating desk to overawe the humble.

All about electricity

The no-code license scheme, which includes a beefed-up technical quiz, is on the horizon. It looks as if we should pay attention to electrical fundamentals. Gadgets like 1-F capacitors seem to indicate that life is getting complicated. Attention to fundamentals — that's the secret path to knowledge!

Joe, K1REC, pays plenty of attention. Here are his remarks, condensed from the May issue of *World Radio* magazine. Joe and I will be pleased if the following technical information helps some would-be Novice achieve his license.

Joe says, "I've been fiddling with electricity for 50 years! I'd like to pass along some of my vast knowledge about this stuff.

"Electricity is manufactured in power plants where it is fed into wires wrapped around large drums. Some electricity, like that used for lightning does not need to go through wires. This kind of electricity isn't manufactured, but just hangs around loose in the air.

"Electricity makes a low humming noise. This noise may be pitched differently for doorbells, telephones, etc.

"Electricity must be grounded before it can function — except in airplanes, which have their own arrangements.

"Although electricity doesn't leak out of an empty socket, you can stick your finger in it and tell that it's there. Electricity is made out of two ingredients, positive and negative. One travels along a wire covered with white plastic, the other along a wire covered with black plastic. The wires connect to a device called a plug, in which the ingredients are mixed to form electricity.

"The electric switch contains a vise grip that squeezes the wire very hard so the electricity can't get through. Opening the switch releases the grip and lets the electricity flow.

"Electricity goes into a light bulb where we can actually see it! It is enlarged many times by the curvature of the bulb, which acts as a magnifying glass.

"Finally, electricity may be stored in boxes called batteries. In big batteries the electricity is shoveled in, while in small batteries it is packed in flat."

This concludes Joe's "Lessons on Electricity," part 1; I'm sure we're all looking forward to part 2.

All about vacuum tube logic

No kidding. Folks are building high class stereo amplifiers with *tubes*! Amplifiers ranging from 45 to 500 watts are available. The itty-bitty amplifiers use 6CA7s or 6550s. Bigger jobs use 6L6GCs or 807s. The number one amplifier uses a pair of class A carbon plate 845s. Wow! Music lovers seem to be the major buyers. The manufacturer is: Vacuum Tube Logic, 4709 Brooks Street, Montclair, California 91763. Too bad the days of amplitude modulation are past — it sounds as if the 845 amplifier would make a good modulator for a pair of 203As!

The Measurements Corporation dip meter

The Measurements Corporation HF

dip meter is a rare find at swap meets or flea markets. The device has an indicating meter and a compact power supply in a metal cabinet, plus a remote dip meter head. Seven plug-in coils cover the range from 2.5 to 420 MHz. The advantage of this unit over the conventional Millen dip meter is its compact remote head, which will fit into areas too small to permit the use of the Millen device. You're lucky indeed if you can pick up the Measurements Corporation unit (as I did a year or so ago).

One unfortunate aspect of the remote head is that the cable connecting it to the power supply is "hot," and moving the cable (or even the power supply) can affect the frequency of the tiny oscillator. The cure is to wrap the cable from the supply to the head through a ferrite core. I used one of the snap-apart cores, with six turns of the cable wound through it. That decoupled the RF head from the power supply, and provided more accurate readings that were less affected by the position of the user and the supply relative to the circuit being examined.

It's possible to remove the knob, the front of the housing, and the dial in order to reach the variable capacitor. If your unit is like mine, the rear capacitor bearing is caked with dried lubricant. Remove this with a small screwdriver or pin; then coat the bearing liberally with Lubriplate® or some other electrical grease. This will improve the stability of the oscillator.

Intermittent operation

On occasion you'll find that the dip oscillator stops operating. That is, the meter reading gradually drops to zero, or even goes negative. Tapping the oscillator head usually starts things going again. In my case, this annoying symptom was caused by poor connections in the plug-in coil. The coil wires are attached to the plugs by means of rivets, and electrical continuity is achieved through the riveted connection. Clean the soldering lug inside the form and the plug arm on the outside and solder a very short jumper between them, making an electrical short across the rivet.

After you've done these simple maintenance chores, your oscillator will be as good as new.

The Dead Band contests

Answers have been trickling in to the various little quizzes given in this column. Here are more "winners" who are heads up in quiz solving:

The five-resistor black box: WD6DUD, WØHJI, KØAS, W5ECB, W2LYH, K3TX, N3GDE, WBØTCZ, W8MQW, W8FBH, WA6JTD, N9DEO, KA2ZGW, K3GCM, N2JHS, W3LOY, K3GCM.

The jar of transistors (419 transistors in the jar):
W3DZH, WØHJI, K3TX, N3GDE, W8MQW, WA6JTD, N9DEO, K3GCM.

The bridge of multiple resistors (1.579 ohms): WD9FAQ, WB8WTS, W2TT, AA5AN, KB2WN, K4SE, W4EHU.

The coax cable puzzle: W6SIV, W2TT.

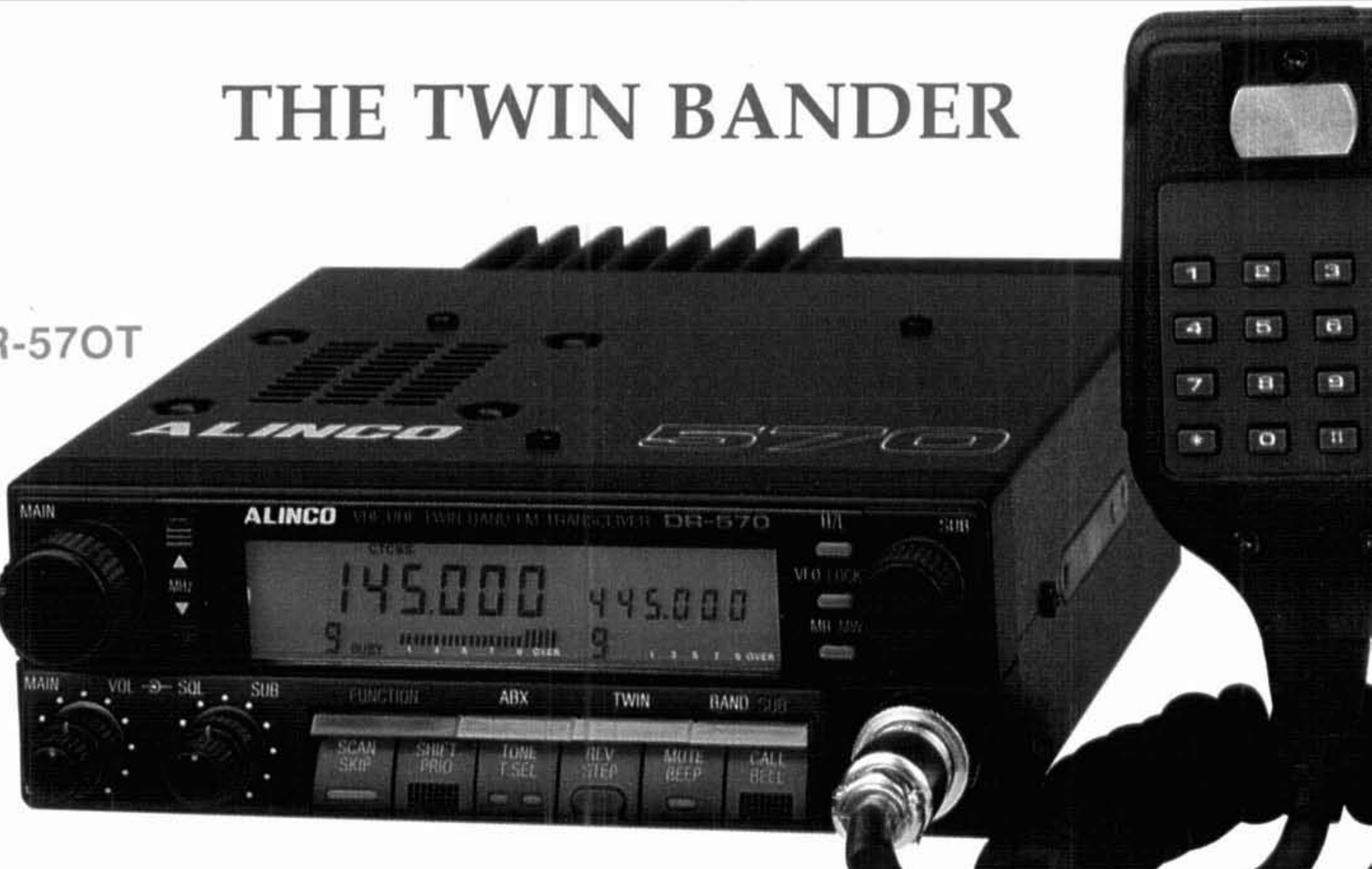
Congratulations, people!

REFERENCES

1. Bill Orr, W6SAI, *Radio Handbook*, 23rd edition, 1986, pages 24-27. Available from the **HAM RADIO** Bookstore for $26.95, plus $3.75 shipping and handling.

THE TWIN BANDER

DR-57OT



The ALINCO Model DR-57OT is a dual band transceiver offering big value in a small package. The independent main band and sub-band operation permits full duplex operation. The front panel is easy to read and understand. The LCD display lets the operator know at a glance which functions are in operation. The built-in duplexer has a single antenna output for a dual band antenna. ALINCO has listened to the consumer and in response has created the versatile DR-57OT which is truly user-friendly with minimal effort.

- *ULTRA-COMPACT BODY*
  5 7/8" (W) x 2" (H) x 8 1/2" (D)
- *HIGH POWER*
  45 watts on 2M and 35 watts on 70 cm. Approximately 5 watts low power.
- *EXTENDED RECEIVER RANGE*
  (130-169.995 MHz) on 2M, 144-147.995 MHz transmit. 440-449.995 MHz on 70 cm. (transmit and receive)
  (Specifications guaranteed on amateur bands only. Modifiable for MARS/CAP permits required)
- *SIMULTANEOUS*
  Receiving on both bands at the same time
  Scanning: intermix scan modes on both bands at the same time
- *INDEPENDENT*
  The volume, squelch and control dial are independently adjustable on both bands. You can store the following information on both bands at the same time. Priority function, choice of 37 encoding/decoding sub-tone frequencies,call channel, scan function (program, memory channel, VFO or unique open channel scan), memory skip, bell function, + or - repeater shift.

FULL FEATURES

- *FULL DUPLEX CROSS BAND OPERATION*
  Transmit on one band while receiving on the other band -- telephone style.
- *AUTOMATIC BAND EXCHANGE (A.B.X.)*
  When in the ABX function is active, an incoming signal on the sub-band will activate an automatic exchange between the main band and the sub-band.
- *PRIORITY*
  The VFO frequency is monitored for 5 seconds and then shifts for one second to the selected priority channel (In both bands at the same time).
- *DUAL SPLIT SHIFT OPERATION*
  Operates odd offset operation
- *BELL FUNCTION*
- *REPEATER REVERSE FUNCTION*
- *CALL CHANNEL FUNCTION*
- *BEEP FUNCTION*
- *20 MEMORIES (10 FOR EACH BAND)*
  Each memory channel can store frequency, repeater offset, encode/decode frequency.
- *4 SCANNING MODES*
  Program scan, memory scan, band scan and unique open channel scan (opposite to normal busy scan). Scan stops on a busy (or open channel) channel andthen resumes approximately 5 seconds after stopping even if the signal is still present.
- *REPEATER OPERATION*
  The DR-57OT can be used as a cross band repeater.

EASY TO OPERATE FUNCTION

- *LARGE AMBER MULTI-FUNCTION LCD DISPLAY*
  Visible in all conditions, it indicates main and sub-band frequencies, frequency step, "on air", "call", "CTCSS", "PRI", "REV", "-", "+", "•", "T" (tone), tone frequency, "MUTE", "LOCK", "ABX", "♪", "BUSY", "F", "S/RF meter", "REV"
- *MHz FUNCTION FOR BOTH BANDS*
  One MHz is increased or decreased per touch
- *SELECTABLE DUAL AND SINGLE BAND OPERATIONS*
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AN AUDIO PATCH PANEL

FOR THE MULTIMODE STATION

By Lewis F. McIntyre, KB6IC, 3711 Gayle Avene, Omaha, Nebraska 68123

I began operating teletype six years ago and discovered quickly that switching from RTTY back to SSB could be a real nuisance. My mic connectors weren't really made to stand up to frequent changes and the speaker connections on the back of my rig were inaccessible. These problems became worse as I added VHF packet capability.

A number of solutions have been proposed. However, most address only the RTTY/packet problem and limit their solutions to a choice of two transceivers.[1]

My solution was a simple, but extremely useful, addition to my shack called an audio patch panel. This unit lets you connect any audio source to any audio load in the shack. It controls the HF and VHF keylines so the HF and VHF transceivers can be keyed by any of the available microphones, CW key, toggle switches, or computer PTT lines — depending on your operating mode. I also gained some new capabilities along the way.

How it works

The patch panel design is very basic. It's a simple switch matrix made up of eight 12-pole rotary switches. You can find all the parts at Radio Shack; the total cost is about $30. The circuit diagram for the switch matrix is shown in **Figure 1**. For simplicity, I've shown only four of the eight switches. Audio loads (mic jacks of the HF and VHF sets, speakers, inputs to modems and patches) are connected to the arms of the switches; audio sources (output of the HF and VHF sets, microphones, outputs of modems and patches) are connected to the contacts of the rotary switches. With this arrangement, only a single source can ever be connected to any load — although all eight loads can be connected to any source. This is important because most sources don't like to be connected in parallel with others.

All audio connections run through two 2×4 phono jack panels on the back of the unit. My unit is wired with the sources on the top row and the loads on the bottom row. To accommodate standard connectors and reduce the number of wires in the shack, I've added five microphone four-pin jacks. The three mic jacks on the back accommodate the HF and VHF mic lines, and the AEA PakRatt audio output; the two on the front accommodate both mics. These are connected internally in parallel with their corresponding phono jacks on the back.

The speaker lines go through a normally closed stereo headphone jack, in series with the line to the phono jack. I used the right and left-most load jacks for the speakers. This way, I can use headphones without interrupting other accessories — like the PakRatt.

Besides the audio switch matrix, two more rotaries (S9 and S10) control the keylines (see **Figure 2**). Because my HF transceiver keys differently from the VHF transceiver, I use a double pole six-position rotary for keyline switches. One pole is connected to mic PTT and the other to the CW key jack. Two positions on S9 and S10 connect to either side of an SPDT toggle, S11. This switch is useful for handling VHF to HF relay operations. (More on that mode later.)

Two diodes, CR1 and CR2, prevent the HF and VHF rigs from interacting when they are connected to the same keyline. Depending on your rig, it may be necessary to reverse their polarity or eliminate them entirely.

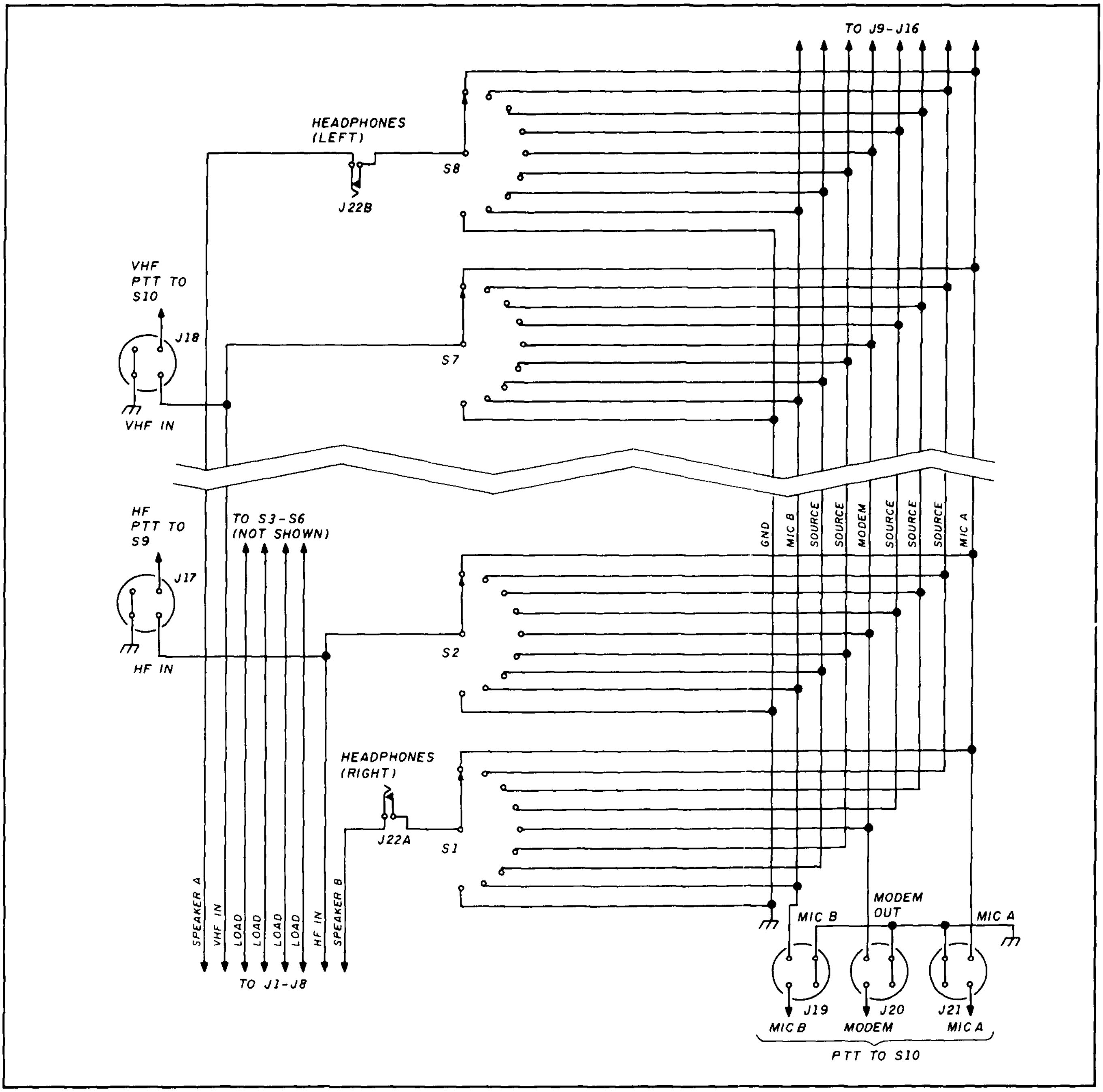
You may wish to review your station setup to see if you want to add or alter some of these "customizing" features. I tried to keep the order of connections to the back panel as general as possible so I could add or change equipment without having to rewire.

Assembly

This audio patch panel was built into a Radio Shack 3″ × 8″ × 6″ project box. The audio bundles run down both sides of the cabinet, left-side jacks to left-side switches and right-side jacks to right-side switches.

Wiring the audio switch array is the most tedious part of the construction. Use short lengths of single conductor wire to connect each switch contact to its corresponding contact on all the other switches. You need to connect only nine contacts — eight loads and ground. When this is done,

FIGURE 1



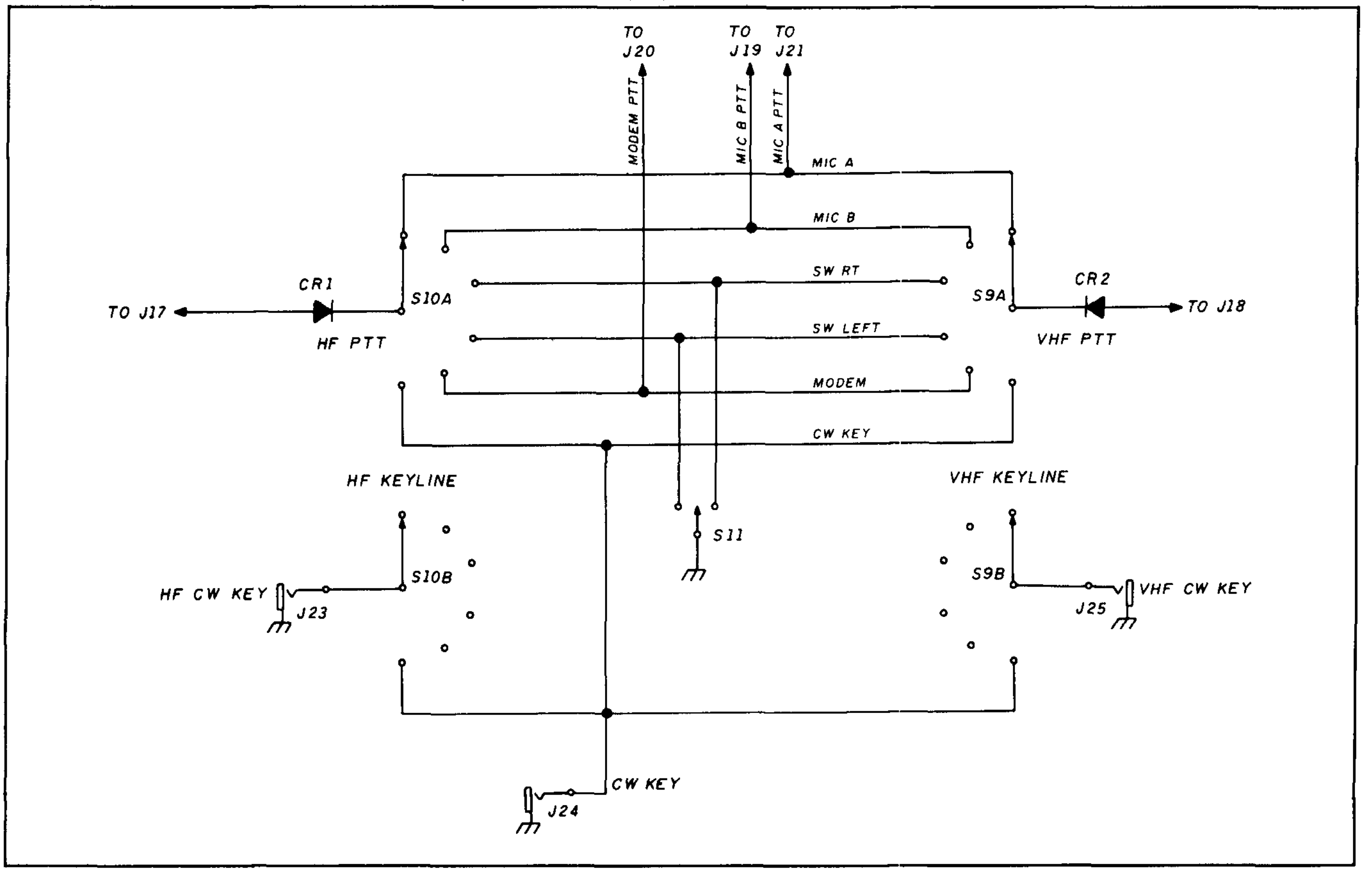
Schematic of the audio switch matrix.

check all connections for shorts and opens. Then, using two-conductor shielded audio cable, connect one conductor to the left-hand audio source on the upper row of phono jacks on the rear chassis and the other conductor to the audio load jack directly below. Route this cable to the switch where the source will be connected. Solder the source line to switch position no. 1 and the load to the normally closed contact to the stereo headset jack. Route a short length of single conductor cable from the jack to the switch contact.

PARTS LIST

Cabinet	3x8x6-inch aluminum	(Radio Shack 270-274A)
J1-J8	2x4 phono jacks	(Radio Shack 274-370)
J9-J14	four-pin mic jacks	(Radio Shack 274-002)
J15-J17	one-conductor NO jack	(Radio Shack 274-255A)
J18	two-conductor NC jack	(Radio Shack 274-250)
S1-S8	one-pole 12-pos rotary	(Radio Shack 275-1385)
S9-S10	two-pole six-pos rotary	(Radio Shack 275-1386)
S11	SPDT toggle	(Radio Shack 275-620)

FIGURE 2



Schematic of the HF/VHF keyline control.

Do likewise on the other side of the box for the right-hand jacks. This completes the special speaker wiring.

For the remaining pairs of source and load plugs, connect the two conductor cables from the plug pair to the switch rotor and contact points. Ground the shield at the phono plug block and at the ninth (ground) switch contact. Because all switch contacts are connected together, this accomplishes all the wiring for this source/load pair. The result is a single cable connected to each switch. When you've finished, check carefully for shorts and continuity, and then bundle the cable runs together with cable ties. Add the special connections to the modem, HF, VHF, and mic jacks.

Wire the keylines when the audio wiring is complete. You can do this with single conductor cable; the process is fairly self-explanatory. After you've completed this step, check again for shorts and continuity.

Wiring the station

I tied the following items together: HF transceiver, VHF transceiver, Heath SB-634 phone patch, AEA PK-232 digital data converter, and three speakers. I used to have a stereo tape recorder on the patch so I could record two channels. Because I added a third HF receiver and speaker, one channel (record and play) had to go. You also might want to add audio CW filters and VU meters.

Use a good grade of audio cable to tie everything together. I purchased new cable in 6-foot lengths. It was surprisingly inexpensive, considering that it came with installed connectors. This cable is available with either double-ended phono, or phono to miniature phone plug connectors. I ran the cables together in bundles behind the station console. Avoid bundling them with antenna coaxial cable or power lines, however; that's asking for hum and RF problems!

I used a small stereo amplifier (Radio Shack SA-10) between the speaker terminals on the patch and the speakers. This lets me keep volume at a comfortable level, independent of what level the various loads might want.

The keylines require PTT connections to each transceiver. This is handled through the special mic connectors on the rear panel for HF and VHF transceivers. You may require connections to each rig's CW key. Some transceivers key CW separately from the mic PTT (mine did) and need this connection. Others key in parallel with mic PTT and won't need it. Check your rig to make sure.

Using the patch panel

Each transceiver requires three switch selections:

- Connect an audio source to the transceiver's input. Do this by locating the switch corresponding to the transceiver input and rotate it to one of eight sources. For my configuration that can be mic A or B, phone patch output, modem output, HF or VHF output. With this configuration it's impossible to connect two sources to the same load.
- Connect the transceiver's audio output to one or more loads. Do this by selecting a switch corresponding to

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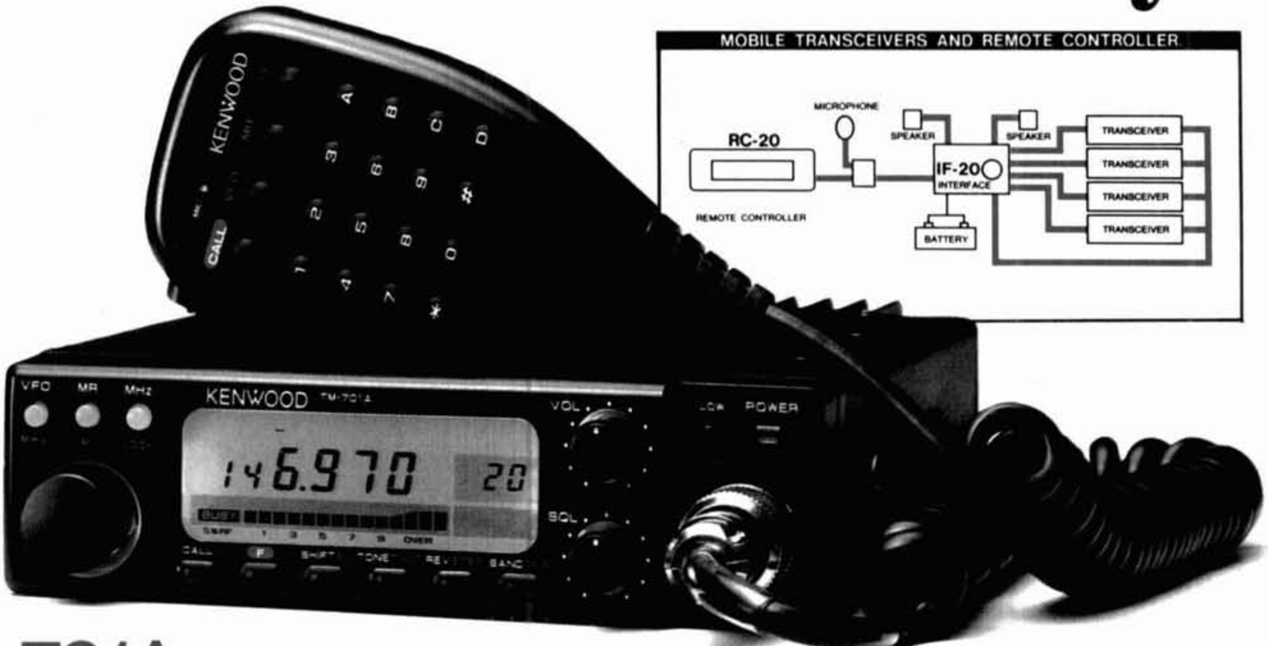

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- **25W on 2m and 70cm.**
- **Selectable full duplex-cross band (Telephone style) operation.**
- **Easy-to-operate front panel layout.**
- **Multi-function DTMF mic. supplied.** Controls are provided on the microphone for CALL (Call Channel), VFO, MR (Memory Call or to change the memory channel) and a programmable function key. The programmable key can be used to control one of the following functions on the radio: MHz, T. ALT, TONE, REV, BAND, or LOW power.
- **Easy-to-operate illuminated keys.** A functionally designed control panel with individually backlit keys increases the convenience and ease of operation during night-time use.
- **Optional full-function remote controller (RC-20).** A full-function remote controller using the Kenwood bus line may be easily connected to the TM-701A and mounted in any convenient location. The new controller is capable of operating all front panel functions.
- **Built-in dual digital VFO's.**
  - **a) Frequency step selection (5, 10, 15, 20, 12.5, 25kHz)**
  - **b) Programmable VFO**
    The user friendly programmable VFOs allow the operator to select and program variable tuning ranges in 1 MHz band increments.
- **Programmable call channel function.** The call channel key allows instant recall of your most commonly used frequency data.
- **Programmable tone encoder built-in.**
- **Tone alert system—for true quiet monitoring.** When activated this function will cause a distinct beeper tone to be emitted from the transceiver for approximately 10 seconds to signal the presence of an incoming signal.
- **Easy-to-operate multi-mode scanning.**
  - **a) VFO scan**
    Band scan, Programmable band scan.
  - **b) Memory scan plus programmable memory channel lock-out**
  - **c) Dual scan**
    Dual call channel scan
    Dual memory scan
    Dual VFO scan
  - **d) Scan stop modes**
    Time operated scan (TO)
    Carrier operated scan (CO)
  - **e) Scan direction**
  - **f) Alert**
    When the AL switch is depressed memory channel 1 is scanned for activity at approximately 5 second intervals.
- **MHz switch.**
- **Lock function.**
- **Repeater reverse switch.**

Optional Accessories

• **RC-20** Full-function remote controller • **RC-10** Multi-function remote controller • **IF-20** Interface unit handset • **MC-44** Multi-function hand mic. • **MC-44DM** Multi-function hand mic. with auto-patch • **MC-48B** 16-key DTMF hand mic. • **MC-55** 8-pin mobile mic. • **MC-60A/80/85** Desk-top mics. • **MA-700** Dual band (2m/70cm) mobile antenna (mount not supplied) • **SP-41** Compact mobile speaker • **SP-50B** Mobile speaker • **PS-430** Power supply • **PS-50** Heavy-duty power supply • **MB-201** Mobile mount • **PG-2N** Power cable • **PG-3B** DC line noise filter • **PG-4H** Interface connecting cable • **PG-4J** Extension cable kit • **TSU-6** CTCSS unit

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the load you wish to connect (speaker A or B, HF or VHF input, phone patch, or modem input). You may connect as many loads as you need, usually the speaker plus one more.

- Connect the transceiver's keyline to a keying source. This can be mic A or B PTT, SW11 left, SW11 right, modem PTT, or CW key.

Results

I expected numerous headaches with this arrangement — like crosstalk between the different lines, RF pickup, and 60-Hz hum. To my amazement, I had only some minor RF pickup by the SA-10 amp while operating on 40 meters. You should have the same results if you use a good grade of audio cable to tie it all together and have a good ground at both ends of the audio cables inside the box.

I have used this unit for:

- HF/VHF relay. In this mode VHF out is connected to HF in, VHF in to HF out, HF keyline to the left side of the toggle S11, and VHF keyline to the right side of S11. When S11 is placed in the left-most position, all signals received on VHF are relayed onto HF; when it's in the right-most position, HF is relayed to VHF. This lets you use your station as an HF/VHF repeater under manual control. While this isn't as sophisticated as some systems described in other articles,[2] it does provide a powerful capability to link local VHF stations into long-haul HF circuits.
- VHF phone patch. Phone patches, like the Heathkit SB-634 that I use, are easy to place on line with HF equipment. However, I found that VHF patches are extremely useful as well. When the "Connie" operated off San Diego, I could easily raise my home QTH via simplex frequencies or wide area repeaters in San Diego which didn't have autopatch. The audio quality is vastly superior to HF.
- RTTY and packet. My preferred mode is RTTY. I also do a lot of RTTY and FAX SWLing using a vintage Hammarlund HQ-180. That unit lives on position 5 on my patch panel, and I can switch easily to that receiver when I need more frequencies than my ham-bands-only TS-830S can provide. Switching between two HF receivers and the VHF rig is a breeze with this patch panel.

Future growth

I have considered expanding this unit beyond the eight switches, adding some internal VU meters, and moving the speaker amplifier into the unit. A bank of 1-of-10 (*not* BCD!) thumbwheel switches might make for a more compact panel. But this unit has worked so well as is, that I haven't made the move to transfer these thoughts off the drawing board.

Summary

This audio patch panel has added to the flexibility of my multimode station enormously and has eliminated the rat's nest of different connectors to get all the equipment to work together. Why not make one of your own? It's inexpensive and easy to build. hr

REFERENCES

1. William Schreiber, NH6N, "Going Digital," *Ham Radio*, January 1989, pages 20-23.
2. David P. Allen, W1VKZ, "Breakthrough in Boston, The Birth of Crosslinking," *73*, January 1984, pages 10-14.

A NEW ADDITION FOR YOUR TNC

By Joel Eschmann, K9MLD, 6964 Meadowdale Drive, Hartford, Wisconsin 53027

Over the last few years I've become very active on packet. I have a number of TNCs and use them at home, at my summer place, and in my camper. I use a number of terminals and computers available to me and I find the big sore spot with many of them is the "connect bell."

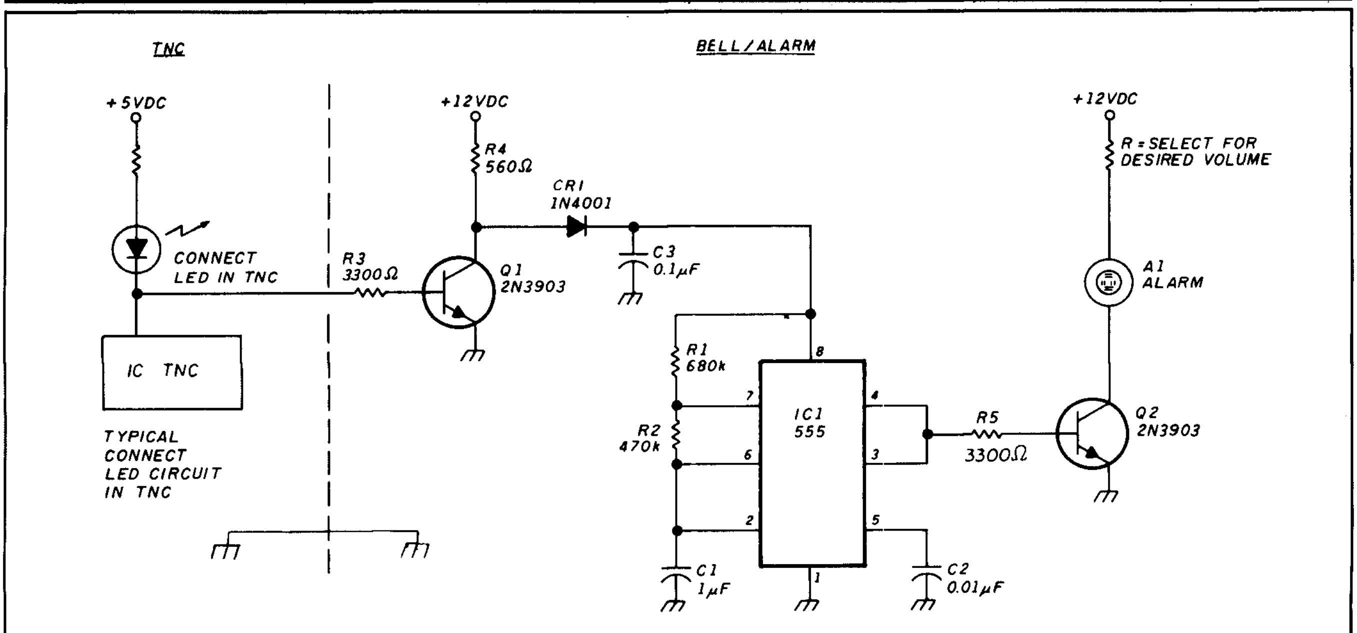
The bell is either too quiet or doesn't exist. When the packet equipment takes over after a connect, I want it to let me know someone is there so I can respond. I hope those of you with similar problems will find this article of interest.

Most current TNCs have a connect light or indicator. To make use of this element of the TNC and the existing cir-

PARTS LIST

IC1	NE555 Radio Shack 276-1723
R1	680-k 1/8 watt resistor
R2	470-k 1/8 watt resistor
R3,R5	3300-ohm 1/8 watt resistor
R4	560-ohm 1/8 watt resistor
C1	1-μF capacitor 15 volt minimum
C2	0.01-μF capacitor 15 volt minimum
C3	0.1-μF capacitor 15 volt minimum
A1	Alarm Radio Shack 273-066
RY1	Relay 12-volt Radio Shack 275-248
CR1	Diode 1N4004 Radio Shack 276-1103
Q1,Q2	NPN 2N3053 Radio Shack 276-2030

FIGURE 1



Schematic of the connect buzzer circuit.

cuits, I've developed a very simple device which adds an accessory the TNC manufacturers forgot. The circuit is very basic and uses the popular 555 timer available from Radio Shack (which also carries a choice of bells, alarms, and breadboard items).

As **Figure 1** shows, the circuit can fit into the TNC. The bell, because of its size, is best mounted on the outside of the cabinet or in a separate box. You may want to provide a switch to select different bells at other locations. Exercise a little caution if you use bells not compatible with the one mentioned here; the current drain may be in excess of the capabilities of the 555 and could damage it.

Circuit description

Q1 is a DC switch which controls the 555 timer (IC1). When voltage is present at the base of Q1, the transistor conducts and the voltage at the collector goes to zero. At the time of the connect, the internal circuits of the TNC cause current to flow in the CONNECT LED. The voltage at the base of Q1 goes to zero and the transistor turns off. This causes the collector voltage to rise to the supply voltage. The supply voltage then applied to the 555 timer causes it to start, and also sounds the bell. After a time determined by R1, R2, and C1, the 555 timer times out and the bell stops. The 555 timer allows for a timed alert that's long enough to attract your attention. If you wish to change the timing, alter the values of R1, R2, and C1. Note that this circuit won't function if R2 is greater than one-half R1. The circuit has an automatic reset that triggers when the TNC disconnects and returns the circuit to an off state.

I've used the basic internal connect circuit from my AEA PK-88 for this illustration. This circuit may vary from manufacturer to manufacturer, but understanding the operation of this optional circuit will enable you to install it in your TNC.

I have found this circuit very useful and I hope you will too. *Note: Making modifications to your TNC may void your warranty. Check with the TNC manufacturer. Ed.* hr

IDENTIFYING KERCHUNKERS
AND OTHER INTERFERENCE

Finding the fingerprints of unknown signal sources

By Richard R. Regent, K9GDF, 5003 South 26th Street, Milwaukee, Wisconsin 53221

A *kerchunker* is a person who turns on a repeater's transmitter briefly without identifying himself. He will sometimes do this to see if he can reach a repeater from various locations, or at random times to ensure that the repeater and his transceiver are working. However, transmitting a signal without identifying is illegal.

Kerchunkers are difficult to pin down because their transmissions are short. A method for identifying momentary signals should make it easy to determine the origin of longer duration signals, ranging from accidental keyups to blatant jamming.

Warren Schall, K9IZV, told the Milwaukee Repeater Club about a technological tool that can identify kerchunkers on 2-meter repeaters. The detective equipment consists of a Micro Control Specialties receiver (Model MR4), a Heathkit® Model 4850 digital memory oscilloscope, and an IBM PC compatible computer.

Receiver selection for this setup isn't critical. Most repeater receivers have test connections for the points that have the two signals you need to track down kerchunkers — the discriminator and signal strength alignment. Some receivers have convenient external outputs with two BNC coaxial cable connections.

The digital memory oscilloscope (DMO) turns your PC into a powerful dual trace 50-MHz digital storage oscilloscope. Scope settings are controlled from the DMO front panel and identified by LED indicators. Once you've fed the proper signals from the receiver into the DMO, and connected it to the computer via its RS-232 port, the signal-handling magic takes place.

The computer monitor gives a visual display of the signals, taking the place of the old familiar bench scope display screen. You can display two channels on graphic 8 × 10 division graticules to obtain readouts of voltage, time, and frequency automatically at any point on a waveform. Your computer should have at least 128K of RAM and a graphics card. This configuration of equipment can measure signals with timebases ranging from 20 seconds to 10 milliseconds per division; 50 milliseconds per division works well for studying kerchunkers.

The DMO, set for one-shot triggering on a rising signal, is ready to capture and store data to memory. It stores an entire waveform as digital numbers, using 256 amplitude and time coordinates. A transmission a fraction of a second long gives you enough time to get a complete file on a kerchunker.

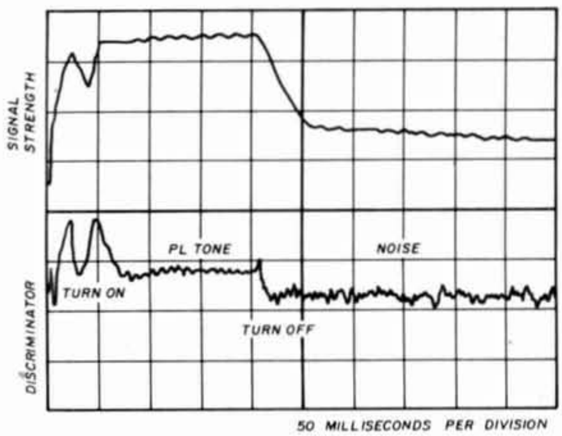
A freeze display of the signal on the monitor shows the unidentified transmitter's fingerprint (see **Figure 1**). The system can eventually be programmed to match the signal from a kerchunker, or other unidentified source, with records in a database of characteristic waveforms of transmitters in the area. Warren explains, "Each transmitter has a characteristic set of parameters, sometimes called a signature."

There are a few key factors to look for when analyzing waveform signatures:

- **Initial transient waveforms**. The momentary frequency changes a transmitter undergoes as it stabilizes after being turned on produce a unique blip on the monitor screen. The phase lock loop time constants used in most modern FM transmitters generate fairly similar signatures from a given unit each time it's keyed.
- **Frequency calibration accuracy**. The difference between the transceiver-transmit and the repeater-receive frequencies, in cycles per second, as indicated by the receiver discriminator output DC level.
- **Frequency and amplitude of a Private Line (PL), subaudible tone, or an extraneous hum**. The frequency of the subaudible tone can be found easily by expanding the waveform on the computer screen. Count the cycles in a given time period, or find the time period for a number of full cycles, and then take its reciprocal to get the frequency of the tone. The tone may match one of several used in the area, but could be off frequency enough or have such an unusual amplitude that it provides positive identification.
- **Audio deviation level**. This level is normally around 4.0 to 5.5 kHz.
- **Absolute strength of the signal.**

These are the five main factors of identification, but there are also a few special considerations. By monitoring the signal strength on the second limiter output of the receiver, it's sometimes possible to determine if the transmitter is mobile or fixed. This shows up as a wavering strength indication. Even certain transmitters designed with turn-on

FIGURE 1



An example of a freeze display of a signal on the monitor showing an unidentified transmitter's fingerprint.

Y1: DC (normal)
500 mV/div
Offset: +2.38 volts

Y2: DC (normal)
1.0 volts/div
Offset: +3.24 volts

Timebase: <->
50 ms/div
Trig source: Y1
Trig slope: (+)
Trig level: +0.34 volt
Trig mode: single manual trigger
2lim = 500 mV; 50 ms
disc = 1.0 volt; 50 ms
F5:Memory F6:Average F7:Exit to system F8:Next menu

delays that may mask part of the initial transient use different time delays which give clues for identification. Again, time and waveform shapes reveal interesting particulars.

Various units of the same model transmitter may have similar waveforms; however, they can usually be distinguished from one another by analysis of their signatures. The detective work takes time, but once a signal is captured it can be documented by unique waveforms which are stored on floppy disk and printed out for later analysis or comparison. With more refinement, you could apply this digital technology to the HF bands to track down jamming and intentional interference. For the time being, however, the research continues on VHF repeater frequencies.

The signals for our club meeting demonstration traveled from the digital scope to the computer with RS-232 cable, but signals could be transmitted over packet radio to distant monitoring control operators. Control commands could then arm or disarm the scope system and request waveform data. hr

Note: This technology has the potential to identify many types of interference. Future units of this sort may be mobile and used to track down CATV, power line, and other types of interference. Ed.

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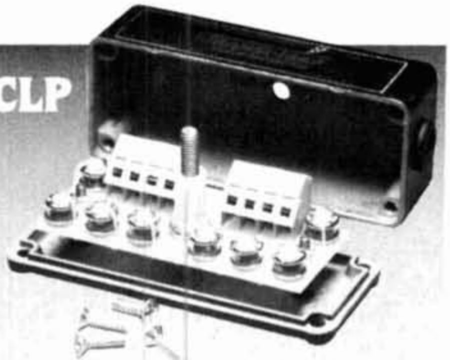

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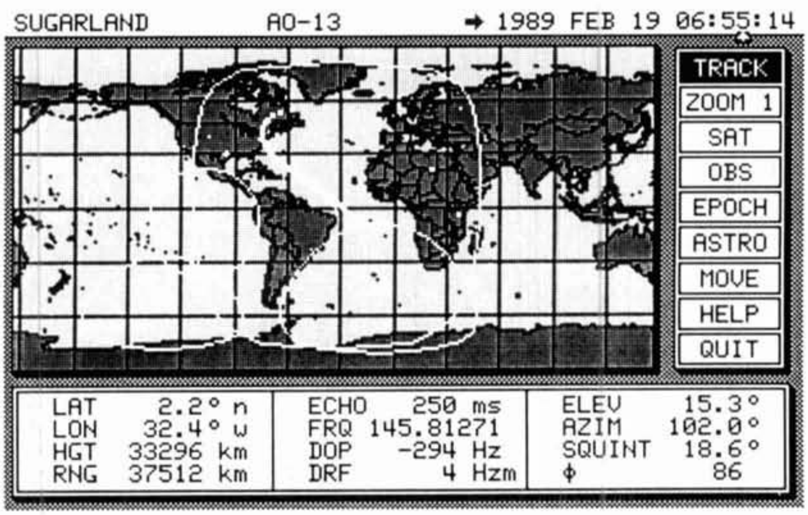

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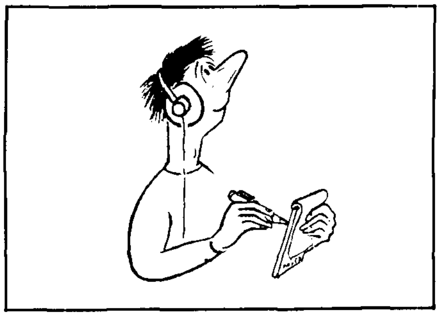

Garth Stonehocker, KØRYW

DXING FROM WINTER ANOMALIES

Winter is the enhanced DX season because it usually has higher signal strengths and lower thunderstorm noise than the summer. This is particularly true on the lower bands. The anomally of this ordinarily improved wintertime signal is the five to six day period of 20 to 40-dB weaker signals (more like summertime) through the mid-to-high latitude paths which provide our communication links to European, Asian, and Japanese Amateurs. I've discussed the reasons for this anomally in previous December columns; it affects those latitudes in 90-degree increments of longitude. The longitudes directly opposite (180 degrees) each other have higher than normal winter signals. Those longitudes in between (90 degrees), but again across from each other, have lower than normal winter signals. During the five to six days (or longer) of the anomalous absorption event, the areas rotate in unison 30 degrees (two time zones) per day. At the same time, they decrease from 65 at day zero to 30 degrees latitude (ending) in the five days of rotation of 7 degrees latitude per day.

To take advantage of the decreased absorption providing the strong DX signals on east, west, and transpolar paths, check WWV at 18 minutes after the hour, WWVH at 45 minutes after the hour, or the bulletin board to keep track of the daily geomagnetic A value during the winter (mainly January). When you hear an A value of 15 or higher, continue to listen daily until a STRATWARM and its location is given. Next, consult your maps to find the 90-degree position between the location given for the STRATWARM and its 180-degree companion. Coordinate your beam bearings and the DX path control points (1200 miles from the QTHs "on" the great circle) with the areas of lower absorption on both, or at least one, end of the path. If that area isn't right for your DX at this time, you can forecast — at shifts of 30 degrees of longitude to the west and 7 degrees lower latitude per day — when better conditions will prevail.

The occurrence of higher wintertime maximum usable frequencies (MUFs) is another geophysical winter effect that seems like an anomaly. While the D, E, and lower F regions have larger electron densities in summer, the daily maximum density of the F-region (which usually sets the day's MUF) peaks during the winter. This peak isn't as broad (measured by hours of the day) as it is in the summer, but it's narrower and higher. You have to be right there when the band opens (on 10 meters, for example) to catch these few hours. This same effect makes the one long hop transequatorial propagation (TE) possible in the evenings. But again, you must be watching and jump on fast. Remember, a raised geomagnetic A level increases the probability of TE openings.

Last-minute forecast

The first, second, and last weeks of December should have excellent higher frequency (10 to 30 meter) DX band openings. Look for both long skip and extra DX transequatorial openings from high MUF build-up during the day and evenings. Some short skip sporadic E openings might even help your DX. The lower bands should be best the second and third weeks of the month.

The Geminids meteor shower, which peaks on December 13th and 14th, will provide rates of 60 to 70 per hour. Optical observations may be difficult or impossible to make during periods of poor December weather, so determine the actual numbers by radio reception. A smaller version of the shower will occur on December 22nd. The full moon appears on the 12th, lunar perigee is on the 10th. Winter solstice is on December 21st at 2100 UTC.

Band-by-band summary

Ten, 12, 15, and 17 meters will be open from morning until early evening most days to most areas of the world. The higher band openings will be shorter and occur closer to local noon. Transequatorial propagation on the higher bands will probably occur toward evening, during times of high solar flux and disturbed geomagnetic field conditions.

You may find 20, 30, and 40 meters useful almost 24 hours a day. Skip distances and signal strengths may decrease during midday on days coinciding with these higher solar flux values. Expect good nighttime DX, except after days of high MUF conditions and during geomagnetic disturbances. Look for DX from unusual locations on eastern, northern, and western paths during this time. The usable distance on the lower bands should be somewhat less than 20 in the daytime and greater than on 80 at night.

Eighty and 160 meters will exhibit short skip propagation during daylight hours and lengthen for DX at dusk. These bands follow the darkness regions opening to the east just before your sunset, swinging more to the south around midnight, and ending up in the Pacific areas an hour or so before dawn.

DECEMBER

WESTERN USA

	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	GMT
	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	PST
ASIA FAR EAST	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	20	17*	15	17	N
EUROPE	30	30	30	30	20	17	15	15	15	15	20	30	30	30	30	30	30	30	30	30	30	30	30	30	NE
S. AFRICA	12	12	10	10	10	10	10	10	10	10	10	17	20	20	20	20	17	17	17	17	17	15	15	12	E
S. AMERICA	10	10	10	10	10	10	10	10	10	10	10	20	17	17	17	17	17	17	15	15	15	12	12	10	SE
ANTARCTICA	10	10	10	10	10	10	10	10	10	12	15	17	20	17	17	17	15	15	12	12	10	10	10	10	S
NEW ZEALAND	10	10	10	10	10	12	12	15	17	20	17	17	17	17	17	17	15	15	15	12	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	10	12	12	15	20	15	15	20	17	17	17	17	17	17	15	15	15	10	10	10	10	W
JAPAN	12	12	12	15	30	30	30	30	30	30	30	30	30	30	30	30	30	30	20	20	17*	12	12	12	NW

MID USA

	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	GMT
	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	MST
ASIA FAR EAST	30	30	30	30	30	30	30	20	17	20	30	30	30	30	30	30	30	30	30	30	20	15	15	17	N
EUROPE	30	30	30	30	20	17	15	15	15	15	15	17	20	30	30	30	30	30	30	30	30	30	30	30	NE
S. AFRICA	12	12	10	10	10	10	10	10	10	10	10	10	17	20	20	20	20	17	17	17	15	15	12	12	E
S. AMERICA	10	10	10	10	10	10	10	10	10	10	12	15	20	17	17	17	17	17	17	15	15	15	12	12	SE
ANTARCTICA	10	10	10	10	10	10	10	10	10	10	12	15	17	20	17	17	17	15	15	15	12	12	10	10	S
NEW ZEALAND	10	10	10	10	10	10	12	12	15	17	20	17	17	17	17	17	17	15	15	12	12	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	10	12	12	12	12	15	17	20	20	20	20	20	20	20	17	17	15	15	15	10	10	W
JAPAN	15	15	15	15	30	30	30	30	30	30	30	30	30	30	30	30	30	30	20	20	17	15	15	15	NW
	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	CST

EASTERN USA

	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	EST
ASIA FAR EAST	30	30	30	30	30	30	30	30	30	30	20	17	17	30	30	30	30	30	30	30	30	30	30	30	N
EUROPE	30	30	30	30	20	17*	15	15	15	15	15	15	15	17	30	30	30	30	30	30	30	30	30	30	NE
S. AFRICA	15	15	10	10	10	10	10	10	10	10	10	10	10	10	20	20	20	20	17	17	17	17	17	17	E
CARIBBEAN S. AMERICA	10	10	10	10	10	10	10	10	10	10	10	10	12	17	17	17	17	17	17	15	15	15	12	12	SE
ANTARCTICA	10	10	10	10	10	10	10	10	10	10	12	15	20	17	17	17	17	17	15	15	15	12	12	12	S
NEW ZEALAND	10	10	10	10	10	10	12	15	17	15	15	15	20	20	20	17	17	17	17	17*	15	15	15	10	SW
OCEANIA AUSTRALIA	10	10	10	10	12	15	17*	15	15	12	12	17	20	20	20	20	20	17	17	17	17	15	15	10	W
JAPAN	17*	15	15	17	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	20	20	NW

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INTRODUCTION TO WAVEFORM GENERATORS PART 2

Astable (free running) multivibrator circuits

By Joseph J. Carr, K4IPV, P.O.B. 1099, Falls Church, Virginia 22041-0099

The circuits discussed in part 1 of this three-part series were aperiodic, meaning that an output pulse occurs just once in response to an input stimulus or trigger. Such circuits are said to be monostable because they possess only one stable state. An astable multivibrator (AMV) is free running. The output of the AMV is a periodic pulse or wave train. In a periodic signal, the wave repeats itself indefinitely until the circuit is either turned off or otherwise inhibited.

Astable multivibrators are oscillators. Waveforms available from the AMV include square, triangle, and sawtooth waves. Sine waves are also available from oscillator circuits. But because those circuits operate differently from the others, I won't discuss them here.

The nonsinusoidal AMV circuits will produce square, triangle, or sawtooth waves. When they are used as a clock to drive a very short duration monostable multivibrator (MMV), a pulse generator results. I'll begin my discussion of AMV circuits with square waves because the square wave generator is the most basic form of AMV.

Square wave generators

Figure 1A shows a square wave. Each time interval of the wave is quasi-stable, so you may conclude that the square wave generator has no stable states (is astable). The waveform snaps back and forth between –V and +V, dwelling on each level a duration of time (ta or tb). The period, T, is:

$$T = ta + tb \qquad \textbf{(1)}$$

Where:

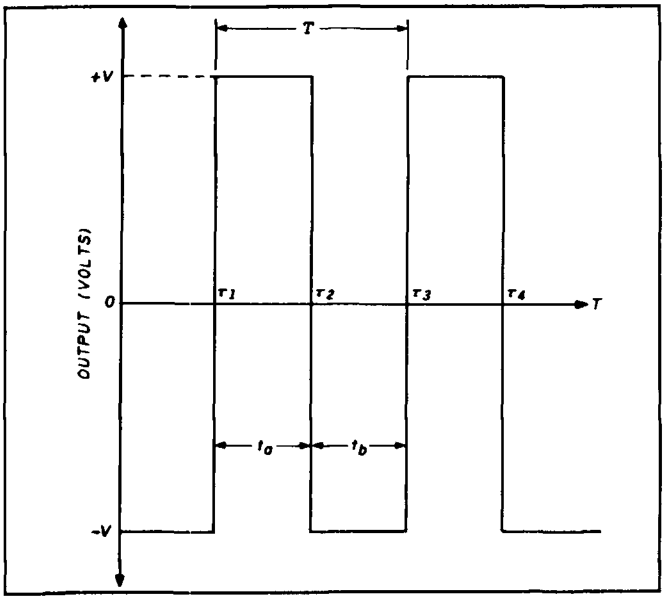
T is the period of the square wave (t1 to t3)
ta is the interval t1 to t2
tb is the interval t2 to t3

The frequency of oscillation (F) is the reciprocal of T:

$$F = \frac{1}{t} \qquad \textbf{(2)}$$

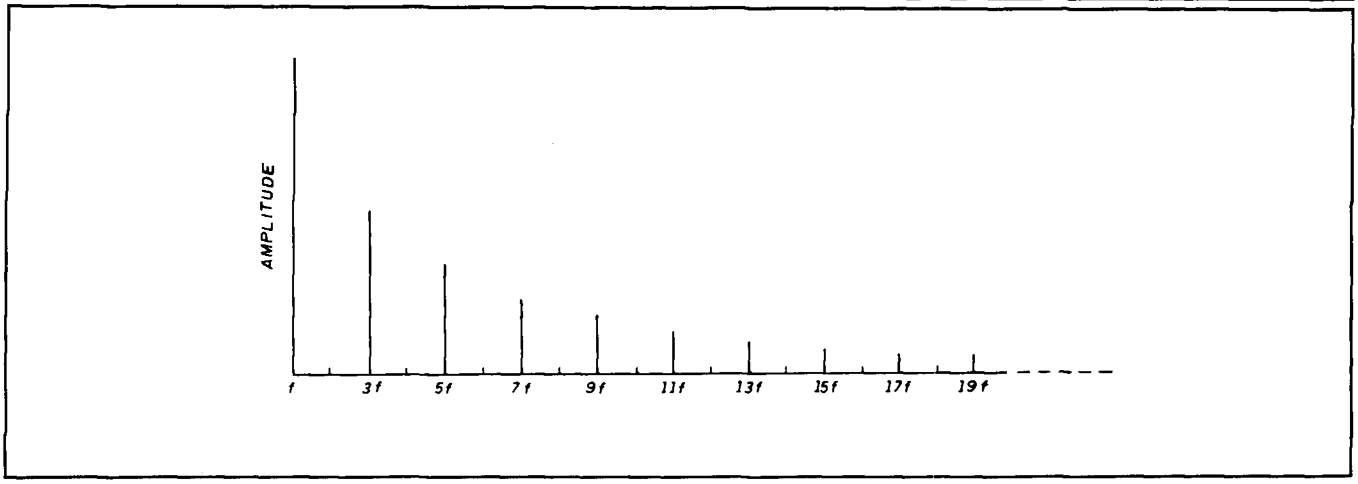
The ideal square wave is both base line and time line symmetrical. That means that $|+V| = |-V|$ and ta = tb. Under time line symmetry ta = tb = t, so T = 2t and f = 1/2t.

FIGURE 1A



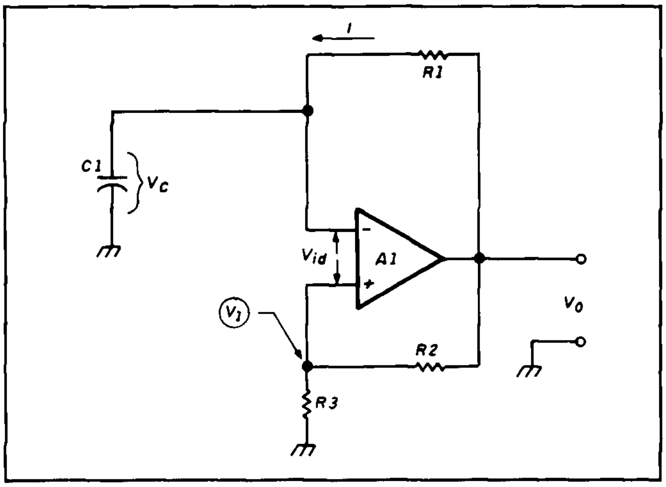
Representation of a typical square wave.

FIGURE 1B



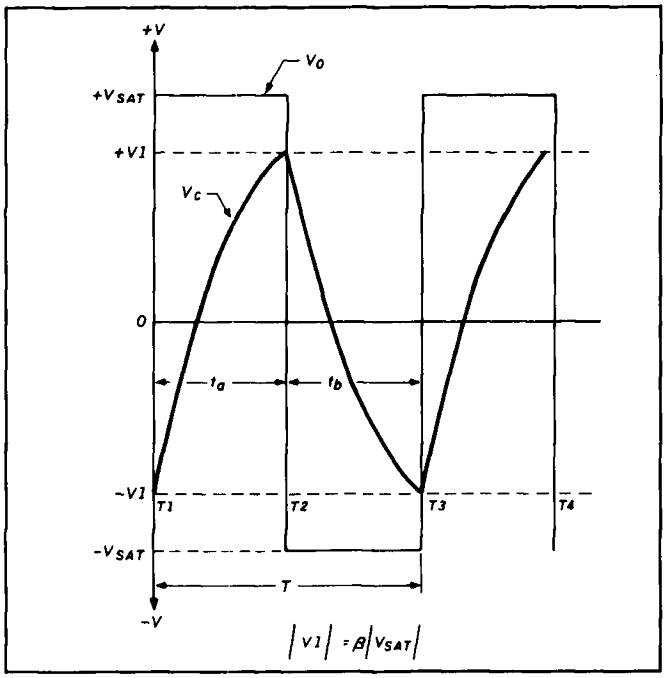
Bar graph depicting the Fourier series spectrum of a true square wave.

FIGURE 2A



A simple square wave generator circuit using an op amp.

FIGURE 2B



Timing chart for the circuit in *Figure 2A*.

All continous mathematical functions (including voltage functions of time) can be constructed from a fundamental frequency sine wave (f) added to a series of sine and cosine harmonics (2f, 3f, 4f, ... , nf). The mathematical expression of which harmonics are present, and their respective amplitudes and phase relationships, is called the *Fourier series* or *Fourier spectrum* of the waveform. The Fourier series is usually depicted as a bar graph spectrum as shown in **Figure 1B**.

In the ideal symmetrical square wave, the Fourier spectrum (**Figure 1B**) consists of the fundamental frequency (f) plus the *odd order* harmonics (3f, 5f, 7f, and so on). Furthermore, the harmonics are in phase with the fundamental. Theoretically, an infinite number of odd number harmonics are present in the ideal square wave. However, in practical square waves, the "ideal" is considered satisfied with harmonics to about 999f. That ideal is almost never reached due to the normal bandwidth limitations of the circuit. The rise time of the square waves is an indicator of harmonic content. The faster the rise time, the higher the number of harmonics.

The circuit for an operational amplifier square wave generator is shown in **Figure 2A**. The basic circuit is similar to the simple voltage comparator and the MMV. Like the MMV, AMV operation depends upon the relationship between V(– in) and V(+ in). In the circuit of **Figure 2A** the voltage applied to the noninverting input (V(+ in)) is determined by a resistor voltage divider, R2 and R3. This voltage is called V1 in **Figure 2A** and is:

$$V1 = \frac{Vo\ R3}{R2 + R3} \qquad \textbf{(3)}$$

or when Vo is saturated:

$$V1 = \frac{Vsat\ R3}{R2 + R3} \tag{4}$$

Because R3/(R2+R3) is always a fraction, V1 < Vsat, and V1 is of the same polarity as Vsat.

The voltage applied to the inverting input V(−in) is the voltage across capacitor C1; i.e., V(C1). This voltage is created when C1 charges under the influence of current I, which is a function of Vo and the time constant of R1C1. **Figure 2B** shows the timing operation of the circuit.

At turn-on, VC1 = 0 volts and Vo = +Vsat, so V1 = +V1 = B(+Vsat). Because VC1 < V1, the op amp sees a negative differential input voltage, so the output remains at +Vsat. During this time, however, VC1 is charging towards +Vsat at a rate of:

$$V(C1) = Vsat \left[1\text{-}e\ \frac{(-t\ /\ R1C1)}{a} \right] \tag{5}$$

When VC1 reaches +V1, the op amp sees VC1 = V1, so Vid = 0. The output now snaps from +Vsat to −Vsat (time t2 in **Figure 2B**). The capacitor now begins to discharge from +V1 towards zero, and then recharges towards −Vsat. When it reaches −V1, the inputs are zero once again, so the output snaps to +Vsat. The output snaps back and forth continuously between −Vsat and +Vsat, producing a square wave output signal.

Using **Equation 4** from part 1, the time constant required to charge from an initial voltage VC1 to an end voltage VC2 in time t is defined by:

$$RC = \frac{-T}{Ln\left[\dfrac{V - V(C2)}{V - V(C1)}\right]} \tag{6}$$

In **Figure 6A** the RC time constant is R1C1. From **Figure 6B** it's apparent that VC1 = −BVsat, VC2 = +BVsat, and V = Vsat for interval ta. To calculate the period T:

$$2\ R1C1 = \frac{-T}{Ln\left[\dfrac{Vsat - BVsat}{Vsat - (-BVsat)}\right]} \tag{7}$$

or rearranging **Equation 7**:

$$-T = 2R1C1\ Ln\left[\frac{Vsat - BVsat}{Vsat - (-Bsat)}\right] \tag{8}$$

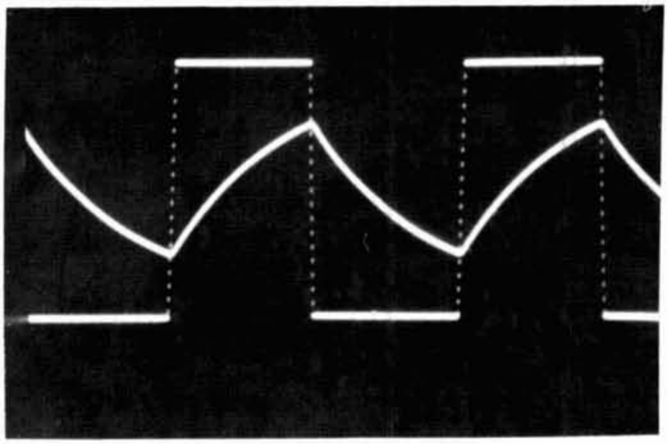
$$-T = 2R1C1\ Ln\left[\frac{1 - B}{1 + B}\right] \tag{9}$$

$$T = 2R1C1\ Ln\left[\frac{1 + B}{1 - B}\right] \tag{10}$$

Because B =R3/(R2+R3):

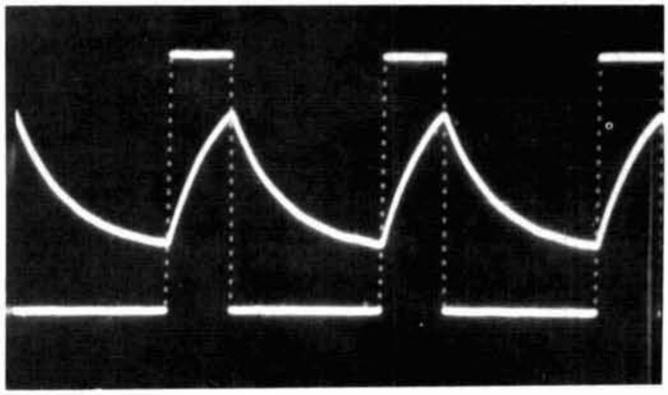
$$T = 2R1C1\ Ln\left[\frac{1 + (R3/(R2 + R3))}{1 - (R3/(R2 + R3))}\right] \tag{11}$$

PHOTO A



V_{out} of a 741 op amp square wave generator superimposed on V_c.

PHOTO B



V_a = +V.

which reduces to:

$$T = 2R1C1\ Ln\left[\frac{2\ R2}{R3}\right] \tag{12}$$

Equation 12 defines the frequency of oscillation for any combination of R1, R2, R3, and C1. In the special case R2 = R3, B = 0.5 so:

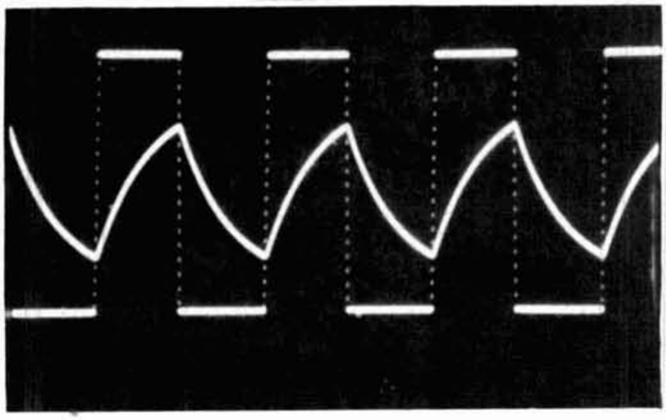
$$T = 2R1C1\ Ln\left[\frac{1 + 0.5}{1 - 0.5}\right] \tag{13}$$

$$T = 2R1C1\ Ln\left[\frac{1.5}{0.5}\right] \tag{14}$$

$$T = 2R1C1\ Ln\ [1.09] = 2.2R1C1 \tag{15}$$

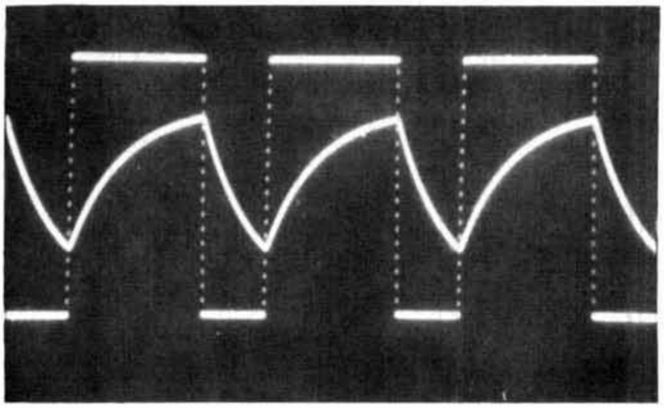
The circuit in **Figure 2A** produces time line symmetrical square waves (ta = tb). **Photo A** shows the output square wave superimposed on Vc for a 741 op amp square wave generator. If time line asymmetrical square waves are required, then you'll need a circuit like **Figure 3** or **4**. The circuit in **Figure 3** uses a potentiometer (R4) and a fixed resistor (R5) to establish a variable duty cycle asymmetry. The circuit is similar to **Figure 2A**, but an offset circuit (R4/R5) has been added. The assumptions are that R5 = R1, and R4 << R1. If Va is the potentiometer output volt-

PHOTO C



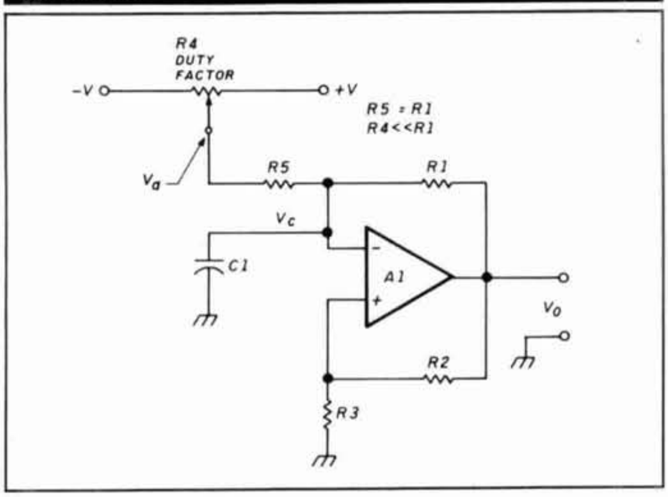
V_a = 0 volts.

PHOTO D



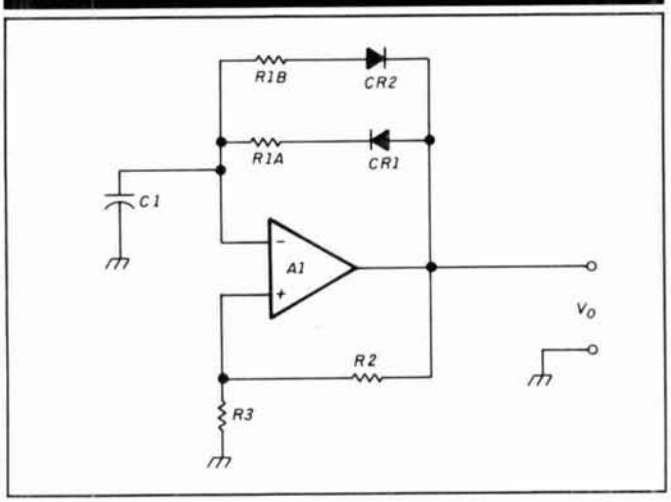
V_a = –V.

FIGURE 3



A circuit for generating asymmetrical square waves with a variable duty cycle.

FIGURE 4



Another asymmetrical wave producer with a fixed duty cycle.

age, C1 charges at a rate of (R1/2)C1 towards a potential of Va + Vsat. However, after output transition the capacitor discharges at the same (R1/2)C1 rate towards Va – Vsat. The two interval times are therefore different; ta and tb are no longer equal. **Photos B, C,** and **D** show three extremes of Va. They are: Va = +V (**Photo B**), Va = 0 (**Photo C**), and Va = –V (**Photo D**). These traces represent very long, equal, and very short duty cycles, respectively.

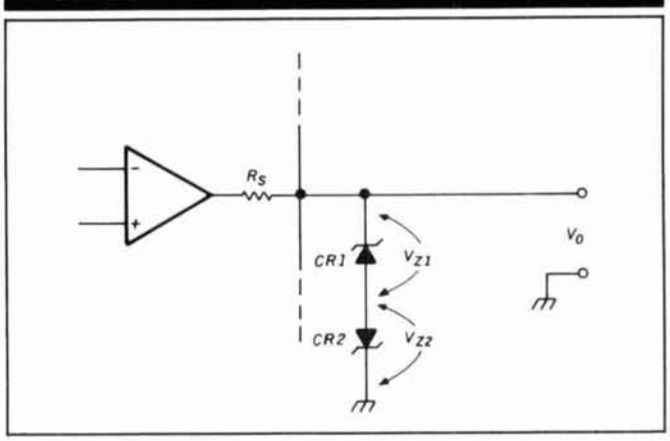
The circuit of **Figure 4** also produces asymmetrical square waves, but the duty cycle is fixed instead of variable. Once again, the basic circuit is like **Figure 2A**, but with added components. In **Figure 4** the RC timing network is altered so the resistors are different on each swing of the output signal. During ta, Va = +Vsat, so diode CR1 is forward biased and CR2 is reverse biased. For this interval:

$$ta = (R1A)\ (C1)\ Ln\left[1 + \frac{2\ R2}{R3}\right] \qquad \textbf{(16)}$$

During the alternate half cycle (tb), the output voltage Vo is at –Vsat, so CR1 is reverse biased and CR2 is forward biased. During this interval R1B is the timing resistor, while R1A is effectively out of the circuit. The timing equation is:

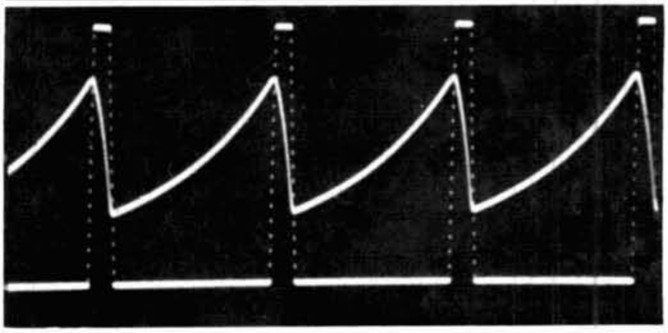
$$tb = (R1B)\ (C1)\ Ln\left[1 + \frac{2\ R2}{R3}\right] \qquad \textbf{(17)}$$

FIGURE 5



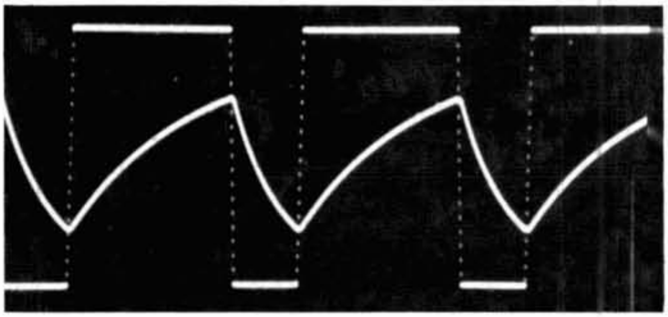
Using back-to-back zener diodes to clean up the square wave generator output.

PHOTO E



R1A/R1B = 10:1.

PHOTO F



R1A/R1B = 2.6:1.

the total period, T, is ta + tb, so:

$$T = (R1A)\ (C1)\ Ln\left[1 + \frac{2\ R2}{R3}\right] + (R1B)\ (C1)\ Ln\left[1 + \frac{2\ R2}{R3}\right] \quad (18)$$

Collecting terms:

$$T = (R1A + R1B)\ (C1)\ Ln\left[1 + \frac{2\ R2}{R3}\right] \quad (19)$$

Equation 19 defines the oscillation frequency of the circuit in **Figure 4**. **Photos E** and **F** show the effects of two values of the R1A/R1B ratio. In **Photo E** the ratio R1A/R1B = 10:1; in **Photo F** R1A/R1B = 2.6:1.

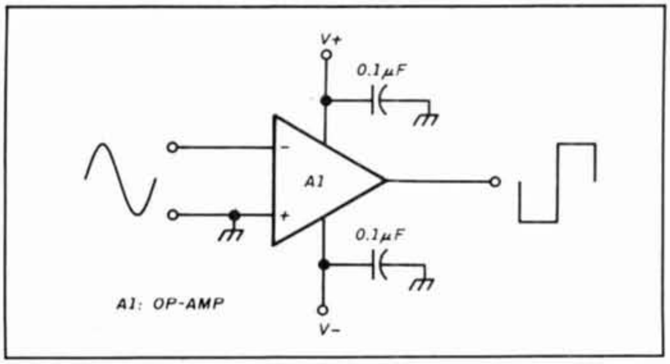
Output voltage limiting

The standard op amp MMV or AMV circuit sometimes produces a relatively sloppy square output wave. You can clean up the signal by adding a pair of back-to-back zener diodes (**Figure 5**) across the output. For each polarity the output signal sees one forward biased and one reverse biased zener diode. On the positive swing, the output voltage is clamped at [VZ1 + 0.7] volts. The 0.7-volts factor represents the normal junction potential across the forward biased diode CR2. The situation reverses on negative swings of the output signal. The output signal is clamped to [−(VZ2 + 0.7)] volts.

Square waves from sine waves

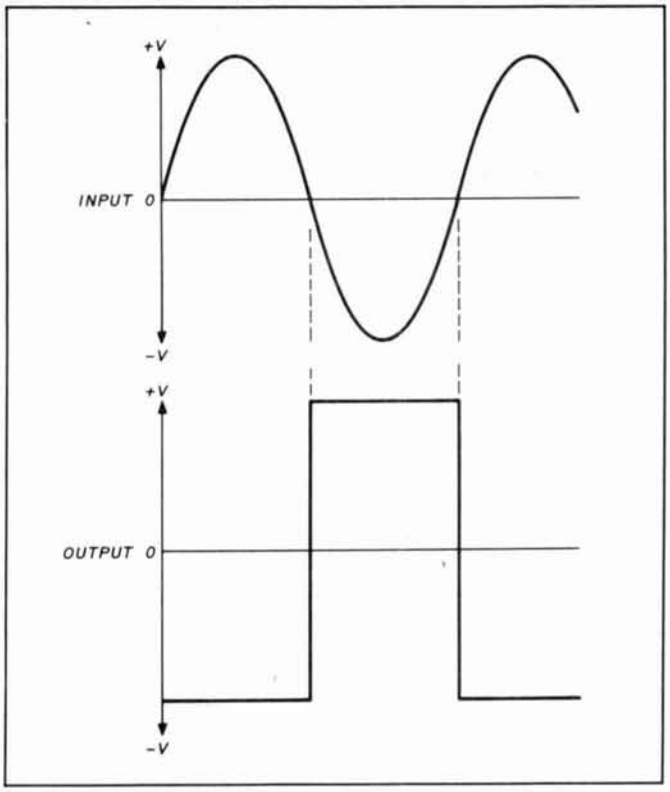
Figure 6 shows a method for converting sine waves to square waves. The circuit is shown in **Figure 6A**, while the

FIGURE 6A



Sine to square wave circuit.

FIGURE 6B



Graphical representation of the waveforms.

waveforms are shown in **Figure 6B**. The circuit is an operational amplifier connected as a comparator. Because the op amp has no negative feedback path, the gain is very high (Avol). In typical op amps, gains of 20,000 to 2,000,000 are found. Thus, a voltage difference across the input terminals of only a few millivolts will saturate the output. From this behavior you can understand the operation of the circuit, and the waveform in **Figure 6B**.

The input waveform is a sine wave. Because the noninverting input is grounded (**Figure 6A**), the output of the op amp is zero only when the input signal voltage is also zero. When the sine wave is positive, the output signal will be at −Vo; when the sine wave is negative, the output signal will be at +Vo. The output signal will be a square wave at the sine wave frequency, with a peak-to-peak amplitude of [(+Vo)−(−Vo)] . hr

HAM RADIO cumulative index

1985-1989

ANTENNAS AND TRANSMISSION LINES

general

hf antennas

vhf antennas

matching and tuning

towers and rotators

transmission lines

AUDIO

COMMERCIAL EQUIPMENT

COMPUTER-AIDED DESIGN

CONSTRUCTION TECHNIQUES

DIGITAL TECHNIQUES

FEATURES AND FICTION

FILTERS

FM AND REPEATERS

HAZARDS

INTEGRATED CIRCUITS

KEYING AND CONTROL

MEASUREMENTS AND TEST EQUIPMENT

MISCELLANEOUS TECHNICAL

NOVICE READING

OPERATING

OSCILLATORS

PACKET

POWER SUPPLIES

PROPAGATION

RECEIVERS AND CONVERTERS

general

hf

vhf

RTTY

SATELLITES

SEMI-CONDUCTORS

SINGLE SIDEBAND

SOFTWARE

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general

hf

(continued on page 97)

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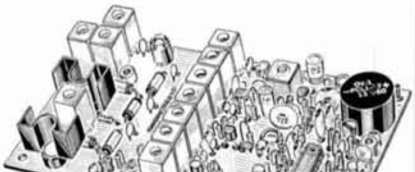

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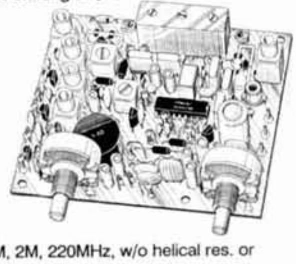

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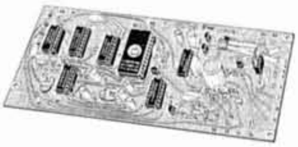

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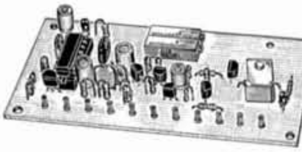

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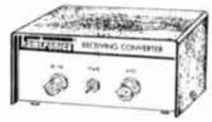

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146

145

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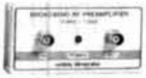

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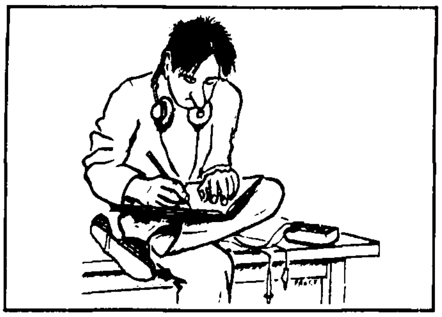


Tom McMullen, W1SL

EXPLORING MAGNETISM

In last month's column I mentioned an experiment using bell wire, a compass, and a battery in connection with magnetic fields. It occurred to me later that perhaps some of you had never performed this experiment, or had never heard of it. It's sometimes good to go back to basics and look at the principles that make our world of electronics possible.

The equipment

The equipment list for this experiment isn't very long, and the cost involved is small. If you're a good scrounger or pack rat, you may not need to spend a cent.

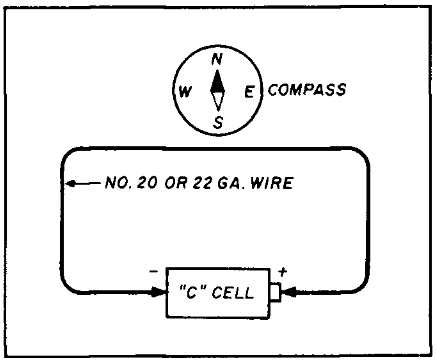
You'll need some wire — about 5 or 6 feet of bell wire will do. (Bell wire is sometimes used to wire up door bells, hence its name.) If you buy it, you'll probably have to purchase a roll of 25 or 30 feet. You might have better luck in a hardware or electrical store than at an electronics shop. Bell wire is solid copper covered with insulation. If you can't find bell wire, use solid copper wire of approximately 20 or 22 gauge, with either an enamel coating or plastic insulation. (Twenty-gauge wire is approximately the same diameter as the lead in a common mechanical pencil.)

Next, you'll need a power source. A C-size flashlight cell will do nicely. Be sure it's fresh — this experiment soaks up current quickly. You can use an alkaline, carbon zinc, or mercury cell.

CAUTION: *Do not use NiCd cells or any storage battery! The high current capacity of these batteries will cause the wire to overheat quickly and may cause burns.*

The last item on the list is a compass. Any simple, inexpensive compass, like those used by Scouts or sold by camping outfitters, should work.

FIGURE 1



The basic experiment requires a C cell, a piece of wire, and a compass. Tape the wire in place to hold it still, and place a small compass on top of the wire or beside it. Be sure the wire is placed North and South as shown.

After you've collected all the parts, clear a space on a wood (not metal) work surface and try some experiments.

Cut off about 2 feet of wire, and bare the ends for approximately half an inch. If you have enamel insulated wire, you'll need a bit of sandpaper to clean the insulation off.

Place the wire on the table in an oval or rectangle, as shown in **Figure 1**. Place the compass either under or over the wire along the side away from the battery. This stiff wire sometimes tends to flop around a bit, so use a couple of pieces of tape to hold it down.

If you have a battery holder that the C cell will slip into, use it. Otherwise, you'll have to hold a wire on one end of the cell. Touch the other end of the wire to the positive cap of the cell while you watch the compass. It should swing quickly to a right angle from the wire. Don't hold the wire on the cell any longer than necessary to see what the compass does.

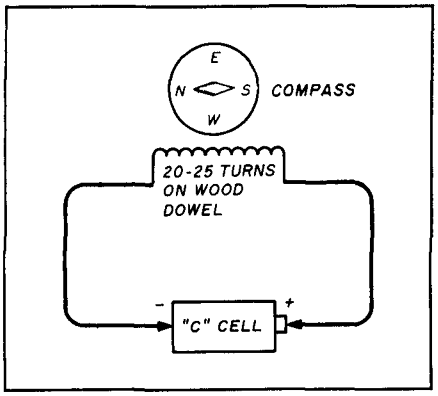
What did that?

When you completed the circuit from one end of the cell to the other, a heavy current started flowing through the wire. Current flow (electron movement) creates a magnetic field and the lines of magnetic force go around the wire. The compass needle aligns with them, just as it does with the earth's magnetic field.

Try it again; but this time reverse the battery. Which way did the compass point? This demonstrates another rule. If you reverse the direction of electron flow, the magnetic field also reverses. Move the compass away from the wire a little bit at a time, and note how far away it is before the field doesn't affect it. Make a note of the distance; I'll refer to it later on.

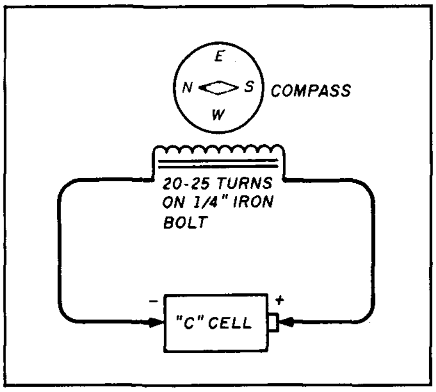
Now let's see what happens when the wire is coiled up, with several turns next to each other. Use a 1/4-inch wooden dowel or stick as a form. Wind 20 or so turns of wire on the dowel, making the turns close to each other. Place this coil on the table, and tape the wires down as before. Put the compass right next to the coil, perhaps on top of it, (see **Figure 2**). Touch the wires to the cells and watch the compass. Which way did it point? It seems to point along the coil, right? Look closely at the coil. If the compass is pointing along the coil, then it's also pointing at right angles to each individual wire in the coil. Perhaps it moved more quickly

FIGURE 2



Wind the wire into a coil around a wooden dowel and place the compass beside it or on top of it. Note the position of the N and S markings and the coil for this experiment.

FIGURE 3



Replace the wooden dowel with an iron bolt and note how much stronger the field is. You may have to move the compass more than a foot away before the field no longer affects it.

this time than it did with the single wire you started with. This tells you that the magnetic field is stronger. How can this be? The current capability of the C cell is still the same, so the answer must be that the lines of force are more concentrated by the wires being so close together.

Next, put some metal in the field and see what it will do. Replace the wooden dowel with a 1/4-inch bolt, (see **Figure 3**). A plain, hardware store soft iron bolt will do (don't use hardened steel). Tape the wires in place, with the compass beside the coil, and touch the wires to the battery. That compass snapped around smartly, didn't it? Move the compass near one end of the bolt and try again. The compass is telling you that the bolt is a magnet. (Even a soft iron bolt will stay magnetized to some extent after the current stops flowing in the coil, so the compass will still point toward the bolt.)

Move the compass away again, and see how far the field makes it move. Compare this with the results of the first experiment. Not only is the field more intense near the coil, but it affects the compass from farther away. Iron or steel concentrates and intensifies the magnetic field. This is one principle that makes electric motors, loudspeakers, power transformers, and hundreds of other devices work.

Another experiment comes to mind, but we'll have to cheat a bit on the equipment list. The compass isn't fast enough to show what will happen. I'll explain why in a moment.

Instead of using the compass as an indicator, get an LED. A plain LED without any resistor in the base will do the trick. Wind a layer of wire on top of the previous winding. If you had 20 turns on the first winding, make this second one twice as large — 40 turns. Remove the insulation from the ends of the wire and connect the LED to the bare ends. Clip lead connections are fine; there's no need to solder them on.

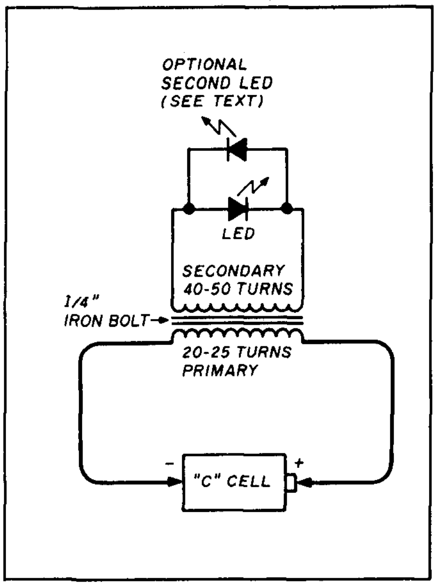
Tape the wires down to hold things steady, and touch the wires to the battery. Watch the LED closely; note whether it flashes when you *touch* the wire, or when you *remove* the wire from the battery. Reverse the connections to the LED and try again. What happened this time? Which flash was brighter? Why didn't the LED stay on? Here's what's going on. This is a very crude transformer (see **Figure 4**). The original winding is the primary; the extra winding you added is the secondary. The bolt serves as the core of the transformer to concentrate the magnetic field.

Current flows when you touch the wires to the battery, generating a magnetic field. This magnetic field cuts across the secondary wires, causing a current flow in that circuit.

The LED is a diode which conducts in only one direction. Depending on the way it was connected in the circuit, it may have flashed when you touched the wire to the battery, or when you removed the wire. When you reverse the diode connections, the effect is the opposite of the first try. If you have two LEDs, you can connect them both in the circuit in parallel, but with opposite polarity. One will flash when you touch the wires, the other when you remove the wires.

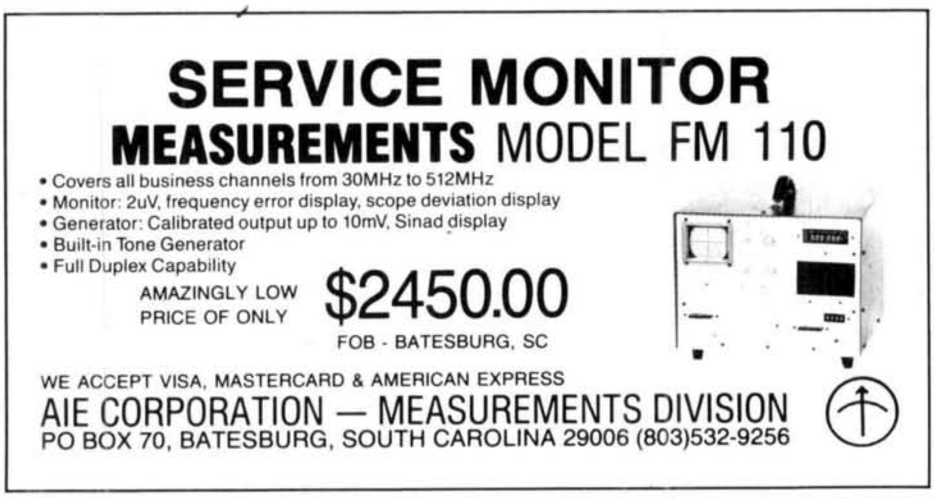
A magnetic field induces current flow in wires only when it's moving across the wire (or when the wire is moving through the field). Because the power source is DC, the field builds up and then stabilizes, so you'll see the LED flash while the field is building up. There's no current flow in the secondary after the field stabilizes, so the LED isn't on. When you remove the wire from the battery, the field collapses because there's no electron flow to sustain it. As it collapses, it cuts across the secondary wires again. This creates current flow, and the diode will flash (if its polarity is right). By using two LEDs, you can demonstrate that the current flows in one direction as the field builds up and the other direction when the field collapses. The rule that's confirmed here is that the direction of current flow depends upon the direction of movement of the magnetic field relative to the wire.

FIGURE 4



A simple transformer is made by placing another winding on top of the first one. The second winding has more turns than the first one. You can use one or two LEDs, as explained in the text.

Now, why is the flash brighter when the wire is removed from the battery? It's a matter of stored energy. The current flow is sustaining the magnetic field as long as the wire is connected to the battery. This is energy being used to keep the field in place, so you can say that some energy is stored in the magnetic field. It's a bit like pressing against a strong spring. As long as you're pushing against the spring,



140

you're using energy to hold it in place. When you stop pushing, the spring rebounds, and the energy you "stored" there while pushing against it is released by the spring when it returns to the original position.

The stored energy in the magnetic field induces a greater current flow in the secondary winding of the transformer, causing the LED to flash brighter. This is what makes automotive ignition systems work — the stored energy in the coil's magnetic field creates a very large spark when the points open. This is why you'll see a diode connected across the winding of relays used in transistorized equipment. The pulse generated by the relay coil when the circuit is turned off can ruin a sensitive transistor in a microsecond. The diode absorbs most of the energy and saves the transistor.

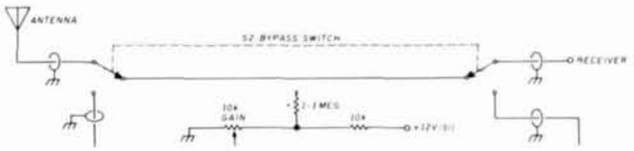
As I mentioned earlier, the compass isn't useful as an indicator in this experiment. The pulse that lights the LED is so brief that the compass needle doesn't have time to move before the pulse dies out. I had you wind more turns for the secondary of the transformer so the voltage across the winding would be increased. Because the primary winding gets its power from a 1.5-volt cell, and there are always losses in a transformer, a secondary winding of the same number of turns produces much less than 1.5 volts in the pulse. If you have an oscilloscope or can borrow one, you can measure it. But with the inefficient iron bolt transformer core, I'd expect less than 1/2-volt output from a 1:1 winding ratio. By making the secondary winding twice as big, you increase the voltage enough that the LEDs will flash easily — perhaps somewhere near 1 volt peak.

We've just looked at some basic magnetic field principles, using a DC power source. Things work much the same way with AC magnetic fields, but the fields keep changing direction with the frequency of the power source. This is the basis for Amateur Radio communications. The end result of all the circuitry in your transmitter is that an alternating current (radio frequency) in your antenna creates a magnetic field that intercepts another antenna and generates a minute current flow in it. The receiver circuitry attached to that antenna lets the other person hear what you say. It's almost like magic, isn't it?

short circuit

Art Correction

In the October issue the DPDT switches at the top of **Figure 1** on page 47 of KD9SV's article "Variable Gain 160-Meter Preamp" were shown incorrectly. They should have appeared as shown in the corrected drawing below.



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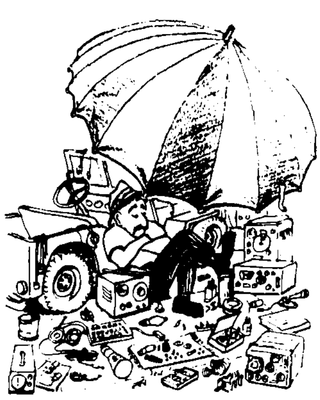

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RATES Noncommercial ads 10¢ per word; commercial ads 60¢ per word **both payable in advance**. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing) on a space available basis only. Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (**not** all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

BEGINNER'S RADIO CLEARINGHOUSE. On a space available basis, we are going to offer you, OUR SUBSCRIBER, free of charge, a chance to find a home for your used equipment with a new Ham. Please send us a short description of what you want to sell along with price, name, address and phone number. We'll run it once in a special section of the classified ads under the heading of BEGINNER'S RADIO CLEARINGHOUSE. Please limit your ad to 20 words or less.

NYE-VIKING straight key w/base $10. 1990 North American Callbooks $24.75 postpaid. D. Heise, AA6EE, 16832 Whirlwind, Ramona, CA 92065. (619) 789-3674 eves.

WAVETEK TECHNICIAN NEEDED. If you have experience with the 3001 Signal Generator, I need help repairing mine. Dan Marshall, K5UTV, 8240 Mpack Expy, #395, Austin, TX 78759. (512) 343-6262.

10 Mtr FM Hy-Gain CB Board with instructions $9.95. FM DET Kit $7.00. 40 channel switch $5.00. Crystal $5.00. SQ/VOL pots $2.00/pair. All for $24.95 plus $2.00 s/h. MORNING DISTRIBUTORS, PO Box 717, Hialeah, FL 33011. (305) 884-8686.

HAM SOFTWARE IBM/Compatibles 10 disks $26.95. MC/VISA/Discover. N5ABV EAPCO/H, Keller, TX 76248-0014. (817) 498-4242. 1-800-869-7208.

WANTED: Old, unique and foreign bugs. Smiley White, PO Box 5150, Fredericksburg, VA 22403. (703) 373-0996.

FOR SALE: Due to health must sell Amateur and Broadcast radios, books, magazines, tubes and miscellaneous parts. Teletype machines and more. Appreciate a long 45-cent SASE. K4UJZ, Russ Olmsted, 608 W. Thompson Lane, Murfreesboro, TN 37129.

WANTED: Schematic, Regency HR-212. Will pay for copying. KB4LBK, 3247 Lynmouth St, Memphis, TN 38118.

HT-CLONE BATTERIES: ICOM: BPS $42.95, BP-3S (2xBP3 Wall Chg) $42.95, YAESU: FNB2 $21.95, FNB10S/FNB12 $45.50, SANTEC 142/442/1200 $22.95. "REBUILDING: SEND-UR-PACK" ICOM BP3 $20, BP5 $28, BP7/8 $34, BP70 $35. YAESU: FNB9 $19 FNB10 $24 FNB4/4A $37, Kenwood PB21 $18, PB25/HK/26 $25 "U-DO-IT REPAIR INSERTS" ICOM: BP3 $16.95, BP5 $2.95, BP7/8 $28.95, Kenwood: PB21 $12.95, PB24/25/26 $19.95, Tempo: S1-15/series $22.95, YAESU: FNB9 $14.95, FNB10 $18.95, FNB4/4A $32.95, Azden: 300 $19.95. PORTA-PAC w/chgr 12V5AHr $49.95, 1400LT Pack (25-3520/No-Plug) $54.95 "TELEPHONE/PAGER & COMMERCIAL PACKS" "FREE CATALOG" $3 shipping/order. PA +6%. VISA/MC +$2. (814) 623-7000. CUNARD ASSOCIATES, Dept H, RD 6, Box 104, Bedford, PA 15522.

FOR SALE: ICOM at 500 automatic antenna tuner. Used once. Price $350 Don Turner, 3764 Nightingale Dr, Cincinnati, OH 45227.

POLICE/FIREFIGHTER HAMS. Please send your call, name, address, rank, department name for inclusion in special roster, available early 1990. Capt. Bob Blakeslee, N2IHQ, 1-1/2 Macomber Avenue, Binghamton, NY 13901.

KD9KW QSLs. Globe, Eagle, Tower, and State Outline designs. $9/100, $15/300, $33/1000. Shipping included. Guaranteed correct! Free samples. Shell Printing, Box 50B, Rockton, IL 61072.

HALLICRAFTERS RECEIVERS 1947-1956 models $25-$75. Have lots of test equipment for trade or sale. Need Yaesu FT2700RH mobile, Motorola Molon 70 base station, CE-3 test set. K6KZT. (805)528-3181.

NEW UNIDEN SCANNER. 100 channels 25-512 MHz. Mobile unit w/all extras. Also handheld unit. M.K. 201-991-9280.

FOR SALE: Ten-Tec Paragon line, complete with mike, power supply, antenna tuner and voice synthesizer. KL7BT, A.C. Perry, Box 871643, Wasilla, Alaska 99687. Phone (907) 376-4854.

RTTY JOURNAL published 10 times per year for those interested in digital communications. Read about RTTY, AMTOR, MOS'S, PACKET, RTTY DX and Contesting. Plus technical articles concerning the digital modes. $12.50 per year *(foreign higher)*. RTTY JOURNAL, 9085 La Casita Ave, Fountain Valley, CA 92708.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., 7960 SW Manitou Trail, Glen Arbor, MI 49636. (616) 334-4385.

IBM-PC RTTY/CW. New CompRtty II is the complete RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in screen editor! Adjustable split screen display. Instand mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS-232C TU. $65. Send call letters (including MARS) with order. David A. Rice, KC2HO, 144 N. Putt Corners Rd, New Paltz, NY 12561.

WANTED: MX-2995 dual trace plug-in preamplifier for OS-117 oscilloscope. Must be in good working condition. C.A. Carhoun. Call collect (508) 486-8454 weekends.

LET THE GOVERNMENT FINANCE your small business. Grants/loans to $500,000. Free recorded message: 707-448-0270. (KH5).

ICOM, KENWOOD & YAESU OWNERS: Informative separate Newsletters. 10th year. USA bulk ($10.50) F.C. ($12.50) Canada ($13.00). Elsewhere ($14.00 & $18.00). Free catalog. Send 45-cent SASE. International Radio Computers, Inc., 751 South Macedo Blvd, Port St. Lucie, FL 34983. Tel (407) 879-6868.

MORSE TERMINAL for Radio Shack Color Computers with interface cables $42.95. Free Catalog. Dynamic Electronics, POB 896, Hartselle, AL 35640. (205) 773-2758.

WIRE ANTENNAS and accessories. Antennas from $10. Coffee cups, callsign plaques. SASE for list. W8EV Products, 205 W. First St, Arcanum, Ohio 45304.

BEAT THE COLD! Melbourne, FL QTH: 4:2:2 (3100 sq/ft) house, 1.6+ acres, 220V wired shack with coax races built in, RHON/25 pad, workshop, pool, sprinkler system, in the country no restrictions, many tall pines and oaks, easy commute to Cape Canaveral, close to fishing/beaches/shopping, SAE for details and photos, $209,000. N0DH/4.

DIGITAL AUTOMATIC DISPLAYS. Any Radio. Be specific. Large 45 cent SASE. GRAND SYSTEMS, POB 2171, Blaine, WA 98230.

SLEP SPECIALS: Military USM-207 frequency counter, solid state, range 0-500 MHz, eight digit readout, high stability crystal oven oscillator, lab quality $185.00, HP606A signal generator 50 kHz to 65 MHz, calibrated output, ideal for Amateur repair $295.00, military HP USM-281A oscilloscope (180A) solid state 50 MHz, dual channel, with 1801A, 1821A, plugins, portable $295.00, military TS-510A signal generator 10 MHz thru 420 MHz, calibrated output, MIL/version HP608D $195.00, HP616A microwave signal generator 1.8 GHz thru 4.2 GHz $275.00, military ME-26D/U VTVM with probes, frequency response 20CPS to 700 MHz $65.00, have quantity, all lab calibrated/guaranteed, VISA/MC or check, add shipping, write/phone Bill Slep, 704-524-7519, SLEP ELECTRONICS COMPANY, Highway 441, Otto, NC 28763.

AVANTEK ATF10135, $12.00, MMIC's, P.C. board, SASE: WA3IAC, 7148 Montague St, Philadelphia, PA 19135.

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

FREE Ham Gospel Tracts, SASE, Steve Forst, N3FTT, 5133 Gramercy, Clifton Heights, PA 19018.

WANTED: Ham equipment and other property. The Radio Club of Junior High School 22 NYC, Inc. is a nonprofit organization, granted 501(C) (3) status by the IRS, incorporated with the goal of using the theme of Ham Radio to further and enhance the education of young people nationwide. Your property donation or financial support would be greatly appreciated and acknowledged with a receipt for your tax deductible contribution. All of the "22 Crew" want to wish our friends and supporters worldwide the very best Holiday Season ever. "Education thru Communication" celebrates its tenth anniversary thanks to you. Please write us at: PO Box 1052, New York, NY 10002. Round the clock hotline: (516) 674-4072.

450 MHz SPECTRUM ANALYZER. Adapted from Nov 85 QST article by Al Helfrick, K2BLA. Features: Three digit LED center frequency digital readout. 12 position calibrated Scan Width, 1 kHz to 50 MHz, switchable bandwidth; Wide 5 300 kHz, Narrow 5 10 kHz. Use your low frequency scope for the display portion. Switchable 10 kHz video filter. Variable IF attenuator, LOG output calibrated in 10 db steps. For complete kit, order #450-KIT $459.95 plus $4.50 s/h. For assembled and tested unit, order 450-AST, $799.95 plus $6.50 s/h. *Calif residents add 6% sales tax.* Foreign orders add 15% for shipping. A & A Engineering, 2521 W. LaPalma, #K, Anaheim, CA 92801. (714) 952-2114.

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

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

FOR SALE: One Kenwood Transceiver (brand new) model TS-440S equipped with auto tuner and voice synthesizer. Paid over $1600.00. Will take best offer. Have other interest. Ed Summerill, W9HVZ.

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

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

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

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

COMING EVENTS

Activities — "Places to go . . ."

INDIANA: December 31. South Bend. Hamfest Swap & Shop, December 31, last day of 1989 BEFORE New Year's Day at CENTURY CENTER downtown on U.S. 33 ONEWAY North between Trustcorp Bank Building and river. Four lane highways to door from all directions. Tables: $5/5 ft. Round; $15/8x2.5 rectangular; $20/8 ft. Wall locations; Over half acre on carpeted floor. Electric NO charge— Bring long cord. Talk in 52, 39, 09, 94, 145.29. Call 219-233-5307, write Wayne Werts, K9IXU, 1889 Riverside Drive, South Bend, IN 46616.

WISCONSIN: January 13. The 18th annual Midwinter Swapfest, sponsored by the West Allis Radio Amateur Club, Waukesha County Expo Center Forum. 8 AM to 3 PM. Admission $2/advance; $3/door. Amateur exams. Great food. For tickets or information SASE to WARAC Swapfest, PO Box 1072, Milwaukee, WI 53201.

OPERATING EVENTS

"Things to do . . ."

December 20: The Providence, Rhode Island, Radio Association, W1OP, will operate from 0000-0500Z on 1.825 mcw to celebrate its 70th anniversary. A 400 cycle AC note will simulate the spark signal from the PRA in 1919. For a commemorative certificate SASE to PRA, W1OP, 1 Ludlow Street, Johnston, RI 02919.

December 30-January 1: The Relay Repeater ARC will operate KE6PE 1600Z—0400Z each day, to commemorate the 101th anniversary of the Tournament of Roses, 101 years of the Rose Parade and 76 years of the Rose Bowl Game. Sugg Freq: 14.260, 21.335 and 28.450 Novice/Tech. For certificate send QSL and 9x12 SASE to Relay Repeater Club, PO Box 81, Arcadia, CA 91006-5019.

YOUTH LINK NET. Open to all Hams under age 18. Saturdays at 2000 UTC, 28.425 MHz. For more information contact Net Control, George Manning, WB5NMH, 602 Glendale St, Burkburnett, TX 76354.

FREE 1989-90 Florida two meter repeater directories are currently being distributed by the Hernando County Amateur Radio Assn. of Brooksville, FL. Ask for one at any official Florida Welcome Center or SASE to Repeater Directory, Hernando County ARA, POB 1721, Brooksville, FL 34605-1721.

LICENSE EXAMS: Middlesex Amateur Radio Society (MARS) has scheduled the following exams: December 12- United Methodist Church, 381 Main Street, Portland, CT. 6:45 to 9 PM. To pre-register call Ed Kerns, KN9Y (203) 342-3400. Walkins allowed. The Middlesex ARS meets every Tuesday evening at 7 PM at the United Methodist Church. All are welcome.

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

NORTH COAST ARC 1989 LICENSE EXAMS. 12:30 PM, Saturdays December 9. N. Olmsted Community Cabin, S of Lorain on W. Park. Novice thru Extra. Walkins allowed. Talk in 145.29 repeater. For information Dan Sarama, KB8A, 15591 Rademaker Blvd, Brookpark, Ohio 44142. 267-5083 or Pauline Wells, KA8FOE, Rick Wells, K8SCI, 777-9480/779-8999.

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

THE MIT UHF REPEATER ASSOCIATION and the MIT Radio Society offer monthly HAM EXAMS. All classes Novice to Extra. Wednesday, DECEMBER 20, 7 PM, MIT Room 1-150, 77 Mass Avenue, Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann at (617) 484-2098. Exam fee $4.50. Bring a copy of your current license (if any), two forms of picture ID, and a completed form 610 availab' from the FCC in Quincy, MA (617) 770-4023.

ADVERTISER'S INDEX AND READER SERVICE NUMBERS

Listed below are the page and reader service number for each advertiser in this issue. For more information on their products, select the appropriate reader service number make a check mark in the space provided. Mail this form to *ham radio* Reader Service, I.C.A., P.O. Box 2558, Woburn, MA 01801.

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Orders to U.S. and Canada add 5% to total ($2 min, $10 max). Florida residents, add 6% sales tax. COD fee $3. Foreign orders add 15%. MasterCard and VISA accepted.

Compare...Ours & Theirs

Choosing the radio that's right for you can be pretty confusing. That's why we decided to make it as simple as possible for you to see how these Yaesu hand-helds stack up against the competition. No boasts, no sales pitches, just a factual side-by-side comparison of "ours" versus "theirs." Because Yaesu quality speaks for itself.

2 METER HANDHELD SPECIFICATIONS	YAESU FT-411/811	ICOM IC-2SAT/IC-4SAT	KENWOOD TH-215/TH-415
Memory Channels	49	48	10
VFOs	2	1	1
Memory Channels Store Any Offset	49	10	10
Wide Receiver Frequency Range (MHz)—VHF	140-173	138-174	141-163
Wide Receiver Frequency Range (MHz)—UHF	430-450	440-450	438-450
Built-in CTCSS Encode/Decode	Included	Option	Encode Only
Memory DTMF Autodialer	10	None	None
CTCSS Paging	✓	Option	—
Programmable Battery Saver	✓	✓	✓
Backlit LCD Display	✓	✓	✓
Backlit DTMF Keypad	✓	—	—
APO, Automatic Power Off	✓	✓	—
1 MHz Up/Down Stepping	✓	✓	✓
Vinyl Case	✓	Option	Option
Scan For CTCSS Tone	✓	—	—
Built In VOX	✓	—	—
Clock	—	✓	—
Odd Split, Any Tx Or Rx Frequency In Any Memory Channel	49	10	1
Suggested Retail Price	$406.00*	$439.95*	$349.95*

DUAL-BAND HANDHELD SPECIFICATIONS	YAESU FT-470	ICOM IC-32AT	KENWOOD TH-75A
Memory Channels	42	20	20
VFOs Per Band	2	1	1
Wide Receiver Frequency Range (MHz)—VHF	130-180	138-174	140-164
Wide Receiver Frequency Range (MHz)—UHF	430-450	440-450	438-450
Built-in CTCSS Encode/Decode	Included	Option	Encode Only
Memory DTMF Autodialer	10	None	None
Dual Receive With Balance Control	✓	—	✓
CTCSS Paging	✓	—	✓
Cross Band Full Duplex	✓	✓	✓
Programmable Battery Saver	✓	✓	✓
Backlit LCD Display	✓	✓	✓
Backlit DTMF Keypad	✓	—	—
Alternating Band Scan	✓	✓	✓
Cross Band Repeater	✓	—	—
Power Output on 2 Meter and 440	2.3W	5.0W	1.5W
APO, Automatic Power Off	✓	—	✓
1 MHz Up/Down Stepping	✓	✓	✓
Memory Channels Store Any Offset	42	20	20
Vinyl Case	✓	Option	Option
Odd Split, Tx Or Rx, Any Frequency In Any Memory Channel	42	20	2
Suggested Retail Price	$576.00	$629.00	$549.00

YAESU

17210 Edwards Road Cerritos, CA 90701 (800) 999-2070

Data and prices obtained from latest available manufacturers' brochures & printed material. October, 1989.

*VHF Radios only.

KENWOOD

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TM-231A/ 331A/431A/531A

FM Mobile Transceiver

Looking for a compact transceiver for your mobile VHF and UHF operations? KENWOOD has a compact rig for each of the most popular VHF/UHF bands.

- **20 multi-function memory channels.**
- **High performance — high power! 50W (TM-231A), 35W (TM-431A) with a 3 position power switch.**
- **Optional full-function remote controller (RC-20).** A full-function remote controller can be mounted in any convenient location. Using the IF-20 interface the RC-20 may be connected to four mobile transceivers. (TM-231A/431A/531A or the TM-701A).
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- **Auto repeater offset on 144 and 220 MHz.**
- **Built-in digital VFO allows selection of the frequency step.** (5, 10, 15, 20, 12.5, 25kHz; TM-531A: 10, 20, 12.5, 25kHz.)
- **Selectable CTCSS tone built-in.**
- **Tone alert system — for true "quiet monitoring"!** When enabled this function will activate a tone when squelch opens.
- **DRS (Digital recording system).** The optional DRU-1 can store received and transmitted messages for up to 32 seconds, allowing the operator to check or return any call using the tone alert system.
- **Automatic lock tuning function (TM-531A).**
- **Repeater reverse switch.**

TM-231A
136–174 MHz receive,
TX on Amateur bands only.
Modifiable for MARS/CAP.
Permit required.

Optional Accessories:
• **RC-20** Full-function remote controller • **RC-10** Handset • **IF-20** Interface unit handset • **DRU-1** Digital recording unit • **MC-44** Multi-function hand mic. • **MC-44DM** Multi-function hand mic. with auto-patch • **MC-48B** 16-key DTMF hand mic. • **MC-55** 8-pin mobile mic. • **MC-60A/80/85** Desk-top mics. • **MA-700** Dual band (2m/70cm) mobile antenna (mount not supplied) • **SP-41** Compact mobile speaker • **SP-50B** Mobile speaker • **PS-430** Power supply • **MB-201** Mobile mount • **PG-2N** Power cable • **PG-3B** DC line noise filter • **PG-4H** Interface connecting cable • **PG-4J** Extension cable kit • **TSU-6** CTCSS unit

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