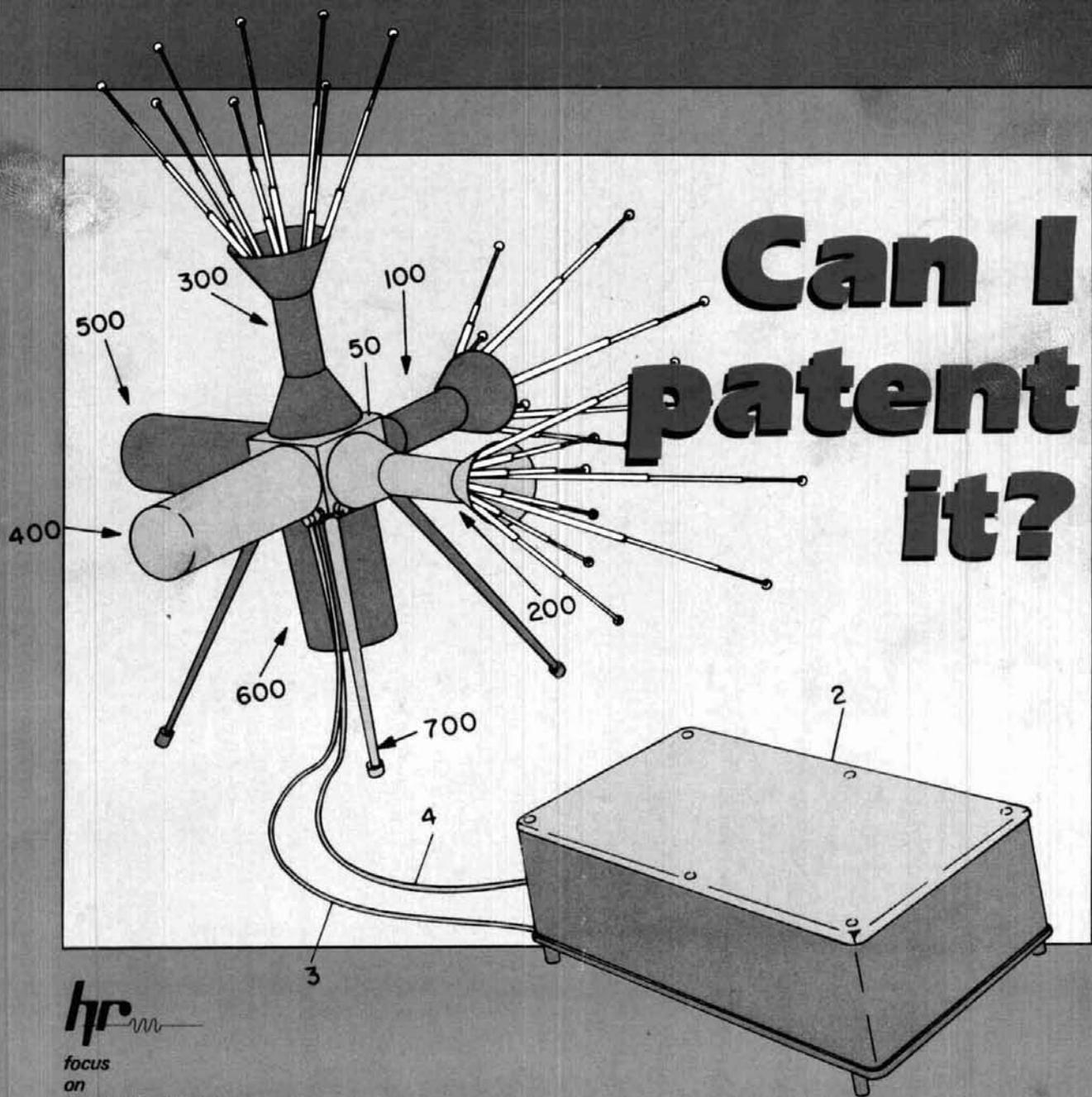
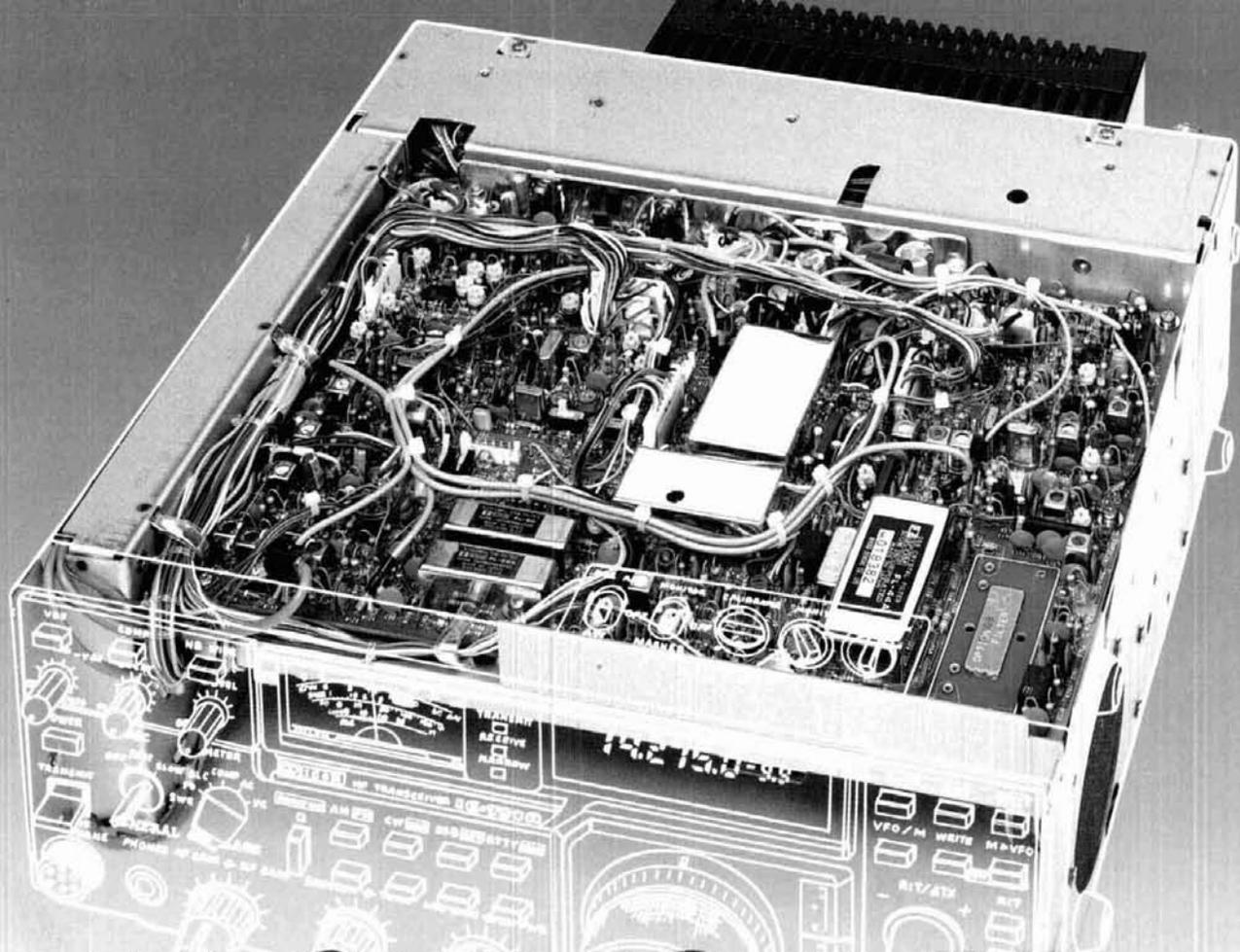


ham radio

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Can I patent it?





ICOM IC-751A

"IT'S WHAT'S INSIDE THAT COUNTS!"

- All HF Band Transceiver / General Coverage Receiver
- Advanced Circuit Designs
- All Modes Built-in USB, LSB, FM, AM, CW, RTTY
- Superb Frequency Stability
- Continuous Duty Operation
- Crystal Clear Signal Quality

Midsize Masterpiece! The deluxe IC-751A includes more high performance features and professional circuitry per cubic inch than any other HF transceiver. Its smooth-as-silk operation and long-term reliability produce the ideal contesting, DX'ing, mobiling and portable rig. Owning an IC-751A truly means "Going First Class!"

Unsurpassed Quality and Reliability. Quality and Reliability is important to you and it's important to ICOM. ICOM now covers you and your investment with its exclusive



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First in Communications

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Kantronics All Mode

KAM gives you CW, RTTY, ASCII, AMTOR, HF and VHF PACKET all together in one unit.

We combined the features of our UTU-XT and KPC-2 to give you the true all mode unit you've been asking for, the Kantronics All Mode (KAM™).

KAM features bargraph tuning and user programmable MARK and SPACE tones for RTTY and HF packet, as well as limiter/limiterless operation on HF for weak signal operation.

KAM's CW demodulator is also programmable for both center frequency and bandwidth.

KAM's RS-232/TTL terminal interfacing provides universal compatibility to all computers, including Commodores and PC compatibles.

If you're looking for increased sensitivity and the greatest amount of flexibility in an all mode unit, look to Kantronics. We've got it all together in the Kantronics All Mode.

Suggested Retail \$319.00

KAM's FEATURES

- Transmit and receive CW 6-99, RTTY/ASCII 45-300 baud, ARQ, FEC, SELFEC, Listen ARQ, VHF and HF Packet.
- HF and VHF radio ports.
- Command driven by your computer with over 100 software commands.
- User programmable baud rates for RTTY/ASCII—selectable in one-baud increments.
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- Selective RTTY Autostart operation.
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- Separate CW keying relay for positive or negative keying.
- 12-pole programmable switched capacitance input filtering.
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- RS-232 or TTL level operation by jumper selection.
- 16K RAM (expandable to 32K), 256K EPROM, EEPROM for parameter storage.
- Compatible with any computer having an asynchronous serial I/O port.
- FCC Part 15 compliant. ✓ 106

NEW
PROGRAM

EXTRA SPECIAL FEATURES

- ★ Simultaneous HF and VHF Packet connects & digipeating.
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All New Compact HF!

“DX-citing!”

TS-440S Compact high performance HF transceiver with general coverage receiver

Kenwood's advanced digital know-how brings Amateurs world-wide "big-rig" performance in a compact package. We call it "Digital DX-citement"—that special feeling you get every time you turn the power on!

• **Covers All Amateur bands**

General coverage receiver tunes from 100 kHz—30 MHz. Easily modified for HF MARS operation.

• **Direct keyboard entry of frequency**

• **All modes built-in**
USB, LSB, CW, AM, FM, and AFSK. Mode selection is verified in Morse Code.

• **Built-in automatic antenna tuner (optional)**

Covers 80-10 meters.

• **VS-1 voice synthesizer (optional)**

• **Superior receiver dynamic range**

Kenwood DynaMix™ high sensitivity direct mixing system ensures true 102 dB receiver dynamic range. (500Hz bandwidth on 20m)

• **100% duty cycle transmitter**

Super efficient cooling permits continuous key-down for periods exceeding one hour. RF input power is rated at 200 W PEP on SSB, 200 W DC on CW, AFSK, FM, and 110 W DC AM. (The PS-50 power supply is needed for continuous duty.)

• **Adjustable dial torque**

• **100 memory channels**

Frequency and mode may be stored in 10 groups of 10 channels each. Split frequencies may be stored in 10 channels for repeater operation.

• **TU-8 CTCSS unit (optional)**

Subtone is memorized when TU-8 is installed.

• **Superb interference reduction**

IF shift, tuneable notch filter, noise blanker, all-mode squelch, RF attenuator, RIT/XIT, and optional filters fight QRM.

• **MC-43S UP/DOWN mic. included**

• **Computer interface port**

• **5 IF filter functions**

• **Dual SSB IF filtering**

A built-in SSB filter is standard. When an optional SSB filter (YK-88S or YK-88SN) is installed, **dual** filtering is provided.

• **VOX, full or semi break-in CW**

• **AMTOR compatible**



Optional accessories:

- AT-440 internal auto. antenna tuner (80 m—10 m)
- AT-250 external auto. tuner (160 m—10 m)
- AT-130 compact mobile antenna tuner (160 m—10 m)
- IF-232C/IC-10 level translator and modem IC kit
- PS-50 heavy duty power supply
- PS-430/PS-30 DC power supply
- SP-430 external speaker
- MB-430 mobile mounting bracket
- YK-88C/88CN 500 Hz/270 Hz CW filters
- YK-88S/88SN 2.4 kHz/1.8 kHz SSB filters
- MC-60A/80/85 desk microphones
- MC-55 (8P) mobile microphone
- HS-5/6/7 headphones
- SP-40/50B mobile speakers
- MA-5/VP-1 HF 5 band mobile helical antenna and bumper mount
- TL-922A 2 kw PEP linear amplifier
- SM-220 station monitor
- VS-1 voice synthesizer
- SW-100A/200A/2000 SWR/power meters
- TU-8 CTCSS tone unit
- PG-2S extra DC cable.

Kenwood takes you from HF to OSCAR!



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Compton, California 90220

This month's cover:

Can I patent it?

... No, *you* can't patent the multi-octave, omnidirectional antenna pictured on the cover, because it's already been patented -- by Harold A. Wheeler, a well-known inventor and holder of many patents in electronics and communications, some dating back to the late 1920's. U.S. Patent No. 4,633,266 was issued to Wheeler, with rights assigned to the Hazeltine Corporation of Commack, NY, on December 30, 1986.

Thanks to Harold Wheeler, the Hazeltine Corporation, and Leo Zucker, K2LZ (see "Can I Patent It?") for making these illustrations available.

Ed.

FCC ANNOUNCES NEW NOVICE PRIVILEGES — SEE PAGE 6

ham radio

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REFLECTIONS REFLECTIONS

manned vs. unmanned space flight

Having recently celebrated the 25th anniversary of the launch of OSCAR I, the world's first non-government orbiting satellite, Amateur Radio has a proud history to look back upon, and an exciting future to anticipate. Our nearly two dozen experimental communications satellites and three manned Ham-In-Space missions have made it possible for thousands worldwide to participate, both personally and vicariously, in space exploration and research. They have also afforded us an unprecedented opportunity to compare the relative value and merits of manned vs. unmanned space missions.

Are the complexity, expense, and risk of manned space exploration justified, and if so, on what grounds? These questions are voiced by the lay public from time to time, either in the wake of a disaster or when appropriations are under consideration. The great strides in space exploration attributable to unmanned space probes raise some valid questions. Couldn't shuttle-type missions be accomplished by unmanned, computerized, robotically controlled machinery? Wouldn't this be cheaper, safer, and easier than providing life support systems? Isn't man, in the final analysis, just so much excess baggage?

A more general question might be: Does the future of the space program lie in manned or unmanned missions? The unmanned craft now in space, and those planned for the foreseeable future, are singular enough in purpose to be controlled by telecommand. Their missions are of long duration and generally one-way; hence volunteer crew members are scarce. The rationale behind unmanned space probes is obvious; that behind manned exploration less so.

The common justifications for a human presence in space fall into three categories: philosophical, political, and technical. "Earth is the cradle of mankind," wrote early rocketry theorist Konstantin Tsiolkovsky (1857-1935), "but man cannot live in the cradle forever." We go into space for the same reason we climb mountains, explore caves, and sail the Queen's ships toward the edge of the earth and certain doom; because it is there, and we are who we are. We still rise to a challenge, just as we did in Columbus' day, and the challenges are much the same: propulsion, guidance, and environment. Within the past generation we have met these challenges, to the extent that space travel is now not only possible, but almost routine. But is it advisable?

The politician will consider the military aspects of a manned space presence, and conclude that further progress is inevitable; the only question is whether to lead or to follow. A generation ago President Kennedy said, "The exploration of space will go ahead whether we join it or not. It is one of the great adventures of our time and no nation that expects to be the leader of other nations can stay behind in the race for space."

The United States and the Soviet Union may dominate, but no longer monopolize the quest for space. Japan and the European Space Agency are making great strides not only in their well proven launch capabilities, but in space manufacturing. If the United States is to remain competitive we must continue to send manned laboratories into space. The financial and scientific rewards are just around the corner.

The technological imperative for manned space missions becomes obvious when we consider the experiments which have been carried aloft in the cargo bay of the space shuttle, just in the past three years. We have witnessed breakthroughs in space manufacturing and materials processing, as well as astronomy, space plasma physics, life sciences, crystal growing, antenna testing, remote sensing, radar experiments, and of course, Amateur Radio! The launching, retrieving and on-orbit repair of unmanned spacecraft require mission specialists, as well as pilot astronauts to deliver hardware and personnel to the lofty job site.

All that is present technology. In January of 1984 our President directed NASA to begin developing plans toward launching a permanent space station by the end of the decade. Current schedules suggest that fabrication can begin this year, leading to an operational space station between 1992 and 1994. Even allowing for further scheduling delays associated with returning the space shuttle to service, it is clear that the question is not one of *if*, but rather *when*. Already Europe, Canada, and Japan have indicated an intention to participate in a truly international, permanent manned space presence.

There are still those who say manned space missions are too costly, in human life as well as dollars and cents. But by the National Transportation Safety Board's uniform measure of safety — fatalities per hundred thousand miles — space travel shines as the safest transportation mode yet devised! As for financial costs, how can one put a price on progress? The medical breakthroughs alone justify the expense of the whole program. Through electrophoresis, the separating of cells by electricity in microgravity, pharmaceuticals have been manufactured in earth orbit at 700 times the yield and five times the purity of similar processes on earth. Dramatic advances in the treatment of anemia, cancer, diabetes, emphysema, dwarfism, thrombosis, and viral infection are but a few of the tangible results.

We who have been privileged to participate in the Amateur space program, through our OSCARs, RSs, ISKRAs, and now JAS-1 — as well as through the efforts and accomplishments of W5LFL, W0ORE, and DP0SL — are in a unique position to appreciate the roles which both manned and unmanned missions will play in a well balanced space program. To whatever extent we can influence national space policy, it behooves us to press for an aggressive space future which avails itself of the relative strengths of both men and machines. It is not only prudent to pursue both avenues of exploration, but essential to the advancement of civilization, and worthy of our financial and patriotic support.

Tedd E. Hankins, AMSAT 19192 and H. Paul Shuch, N6TX, AMSAT LM167

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NEW!
Computer Interface!

Complete Control...

IF-232C Level translator

IF-10A Computer interface for TS-711A/TS-811A

IF-10B Computer interface for TS-940S

IC-10 IC kit for TS-440S computer control

Attention "computing" hams! The Kenwood IF-Series computer interface units will enable you to connect your TS-711A, TS-811A, TS-940S, or TS-440S transceivers to your home computer. RS-232C standard is used, so the interface units are compatible with many computers!

The IF-10A and IF-10B computer interface boards and IC-10 kit are designed to be installed inside the transceivers. Control is performed via the computer RS-232C port and



Simulated CRT display

Short Wave Listener's map and directory—simply select the QTH you'd like to listen to, and the pre-programmed frequency is "dialed up."

Display frequency, band, and mode data. Control your rig via keyboard!

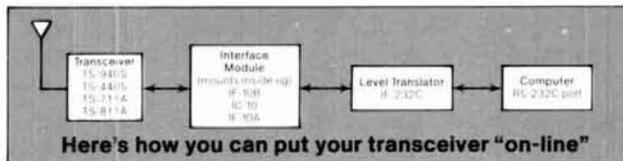


through the IF-232C level translator. The level translator performs two functions: (1) converts voltage levels from the RS-232C port to the TTL levels in the transceiver, (2) and acts as a noise suppressor. A complete interface "kit" would include the appropriate computer interface units (IF-10A, IF-10B, or IC-10) and the IF-232C level translator.

The applications of automated station control are almost endless! Just imagine...work DX from your hand-held...operate OSCAR "automatically"...remote operation of your station...or put together the "ultimate" contest station....

CRT display shown is a simulation

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



- **Interchangeable commands**
This means that one program may be used with several rigs, to minimize program changes.
- **Simultaneous operation of the computer and transceiver is possible**
- **Powerful, easy-to-understand instruction set**
- **AC-10 AC power adapter (optional)**
- **Wide variety of commands**
Memory input and recall, frequency selection, frequency step, sub-tone frequency, offset, antenna tuner, DCS, scan, and many, many more functions are accessible with the Kenwood computer interface unit!

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NOVICES GET 220, 1270 MHz — PLUS SSB AND DIGITAL ON 10 METERS

Novices will soon be eligible for *full privileges* in all emission modes (though with a 25-watt power limit) on as yet unspecified subbands of 220 and 1270, as well as expanded privileges on 10 meters, which will be divided evenly between CW/digital (including packet, RTTY, ASCII, etc.) and SSB/CW. While complete details were not available at presstime — in early February — more information is expected shortly, with the release of the Commission's official report and order. Informed sources predict that the new privileges will take effect in late March or early April, perhaps even before you read this.

In awarding privileges on 220, the FCC reportedly took the Amateur community somewhat by surprise, since it had indicated earlier that 220 would not be a part of the enhanced Novice package because of unresolved conflicts over that band. A strong showing of support for granting 220 privileges to Novices, however, was credited for convincing the FCC of the importance of reserving portions of that band for Novice Amateur use. Though not specified in the FCC's January 30 release, repeater operation is expected to be included among the enhanced privileges.

According to the FCC release, Part 97 will not only be modified to include expanded Novice privileges, but will also provide for the separation of Element 3 of the Amateur Radio examination into Elements 3(A) and 3(B), providing different theory tests for Technicians and Generals. All Technicians licensed before the effective date of the new regulations will be "grandfathered," however, and will not be required to pass the new General theory exam before upgrading.

All existing Novices will likewise be "grandfathered" and will be allowed to operate on the new bands without passing the new, more demanding Novice exam, which will be expanded to include questions pertaining to operation on the newly-awarded bands. While current Novice examinations may be supervised by only one licensed Amateur, Novice exams occurring after the effective date of the new privileges will be supervised by two examiners. The FCC has specifically recommended that current Novice operators, who were authorized the new privileges without additional qualifications, become knowledgeable in the new requirements before using their new privileges.

According to the FCC release, the expansion of Novice privileges will be implemented in order to attract more Novice operators to the Amateur service without diminishing their incentive to upgrade to higher license classes. FCC Private Radio Bureau Chief Mike Fitch was quoted as saying, "I am delighted with the Commission's actions. I believe the new operating privileges on the 0.23, 1.25, and 10-meter bands will attract new people to Amateur Radio and keep their interest in the hobby by encouraging upgrades. We've provided these new growth tools to Amateur Radio. It's now up to the Amateur community to put the tools to work."

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NEW!

This HT Has it All!

TH-215A/415A

Full-featured Hand-held Transceivers

Kenwood brings you the greatest hand-held transceiver ever! More than just "big rig performance," the new TH-215A for 2 m and TH-415A for 70 cm pack the most features and the best performance in a handy size. And our full line of accessories will let you go from ham shack to portable to mobile with the greatest of ease!



- Wide receiver frequency range. Receives from 141-163 MHz. Includes the weather channels! Transmit from 144-148 MHz. Modifiable to cover 141-151 MHz (MARS or CAP permit required).
- TH-415A covers 440-449.995 MHz.
- 5, 2.5, or 1.5 W output, depending on the power source. Supplied battery pack (PB-2) provides 2.5 W output. Optional NiCd packs for extended operation or higher RF output available.
- CTCSS encoder built-in. TSU-4 CTCSS decoder optional.
- 10 memory channels store any offset, in 100-kHz steps. Each memory channel can store frequency, frequency step, offset, reverse switch position, and CTCSS frequency.
- Nine types of scanning! Including new "seek scan" and priority alert.
- Intelligent 2-way battery saver circuit extends battery life. Two battery-saver modes to choose, with power save ratio selection.
- Easy memory recall. Simply press the channel number!
- 12 VDC input terminal for direct mobile or base station supply operation. When 12 volts is applied, RF output is 5 W!
- New Twist-Lok Positive-Connect locking battery case.
- Frequency entry by keyboard or UP/DWN keys.
- Priority alert function.
- Monitor switch to defeat squelch. Used to check the frequency when CTCSS encode/decode is used or when squelch is on.

- Large, easy-to-read multi-function LCD display with night light.
- Audible beeper to confirm keypad operation. The beeper has a unique tone for each key. DTMF monitor also included.
- Supplied accessories: Belt hook, rubber flex antenna, PB-2 standard NiCd battery pack (for 2.5 W operation), wall charger, dust caps.



Optional Accessories:

- PB-1: 12 V, 800 mAh NiCd pack for 5 W output
- PB-2: 8.4 V, 500 mAh NiCd pack (2.5 W output)
- PB-3: 7.2 V, 800 mAh NiCd pack (1.5 W output)
- PB-4: 7.2 V, 1600 mAh NiCd pack (1.5 W output)
- BT-5 AA cell manganese/alkaline battery case
- BC-7 rapid charger for PB-1, 2, 3, or 4
- BC-8 Compact battery charger
- SMC-30 speaker microphone
- SC-12, 13 soft cases
- RA-3, 5 telescoping antennas
- RA-8B StubbyDuk antenna
- TSU-4 CTCSS decode unit
- VB-2530: 2m, 25 W amplifier
- LH-4, 5 leather cases
- MB-4 mobile bracket
- BH-5 swivel mount
- PG-2V DC cable
- PG-3C cigarette lighter cord with filter



TH-215A shown

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can I patent it?

Some patent law basics for the industrious Amateur

Although Amateurs often express interest in obtaining patent protection for some circuit, antenna, or other device which they've conceived, they may not have sufficient understanding of the patent process to protect their inventions adequately.

In this article, we'll discuss what makes an invention patentable. We'll examine a typical patent application, timing limitations, and employee agreements covering inventions created on the job.

what is a patent?

Article I, Section 8 of the United States Constitution authorizes Congress to "promote the Progress of Science . . . by securing for limited Times to . . . Inventors exclusive Right to their . . . Discoveries" — in short, to grant patents. While the constitutional directive would appear to offer virtually unlimited protection, it's important to note that the owner of a patent has the right only to exclude others from making, using, or selling the patented invention in the United States without license by the owner. The patent grant does not confer an absolute right to produce or market the invention free of infringement claims by another who holds a so-called "dominant" or broader patent (more on this later).

The bulk of legislation dealing with patents comes under Title 35 of the United States Code (35 U.S.C.), as enacted in 1952 and amended to date. The federal agency authorized to examine applications and issue patents is the Patent and Trademark Office (PTO) of

the United States Department of Commerce.* The PTO's *Rules of Practice*¹ deal with specific requirements for patent applications, procedures to be followed while applications are pending, and payment of maintenance fees for issued patents.

The PTO issues utility patents, patents for new varieties of asexually reproduceable plants, and patents for ornamental designs of articles of manufacture. Utility patents are of potentially greatest interest to Amateurs because they're granted to those who invent or discover "...any new and useful process, machine, manufacture or composition of matter, or any new and useful improvement thereof."² These patents are granted for 17 years from date of issue, but may lapse after 4, 8, or 12 years if maintenance fees are not paid in a timely manner.

In electronics, utility patents were granted last year for items ranging in sophistication from, for example, an electric cord holder to nuclear magnetic resonance (NMR) methods and apparatus. While it isn't necessary to furnish a model or prototype of the invention with a patent application, the PTO does reserve the right to require one. So if you've conceived of a device that consumes less energy than it produces — i.e., a "perpetual motion" machine — be sure to have a working model on hand. The patent examiner will certainly want to see it.

To be worthy of a patent, the subject of a utility patent application must be more than just new and useful. It must also have been "non-obvious" to one of ordinary skill in the pertinent art when the invention

*Address: Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Leo Zucker, K2LZ, 34 South Broadway, White Plains, New York 10601

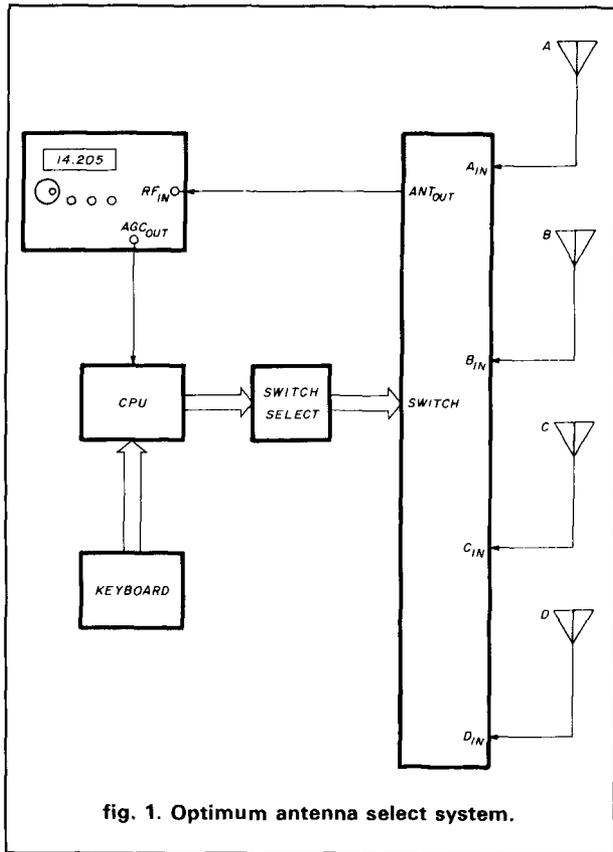


fig. 1. Optimum antenna select system.

was made.³ The "non-obviousness" criterion is determined initially during PTO proceedings on an application, usually by an evaluation of two or more prior patents or publications which together show all the elements of the claimed invention. If, in the examiner's judgment, it would have been obvious to a skilled worker to combine the disclosures of the references so as to give rise to the invention, your claims will be rejected.

A word of caution: if you're making or selling an article for which a patent is pending, you may use terms such as "patent pending" on the article or in advertising to dissuade others from risking an infringement suit should a patent ultimately be issued. The false use of "patent pending" or similar phrases, however, subjects the perpetrator to a maximum \$500 fine for each offense.

what to do before applying

Let's say you're trying to develop a system that will automatically select from four different antennas the one antenna that will provide optimum signal strength while a signal is tuned on your receiver. You've searched the available literature and found nothing. You sit down and sketch out a system as shown in fig. 1.

Even before trying out the system, *sign and date*

your sketch and have a witness who understands it countersign the sketch. Properly signed and dated sketches — preferably on sequentially numbered pages of a hardbound notebook — can be used as valuable evidence of the date of your invention.

You may then try to assemble all necessary parts for your system and determine operating parameters such as the following: the antenna sampling time and protocol; the necessary increase in receiver AGC level a sampled antenna must provide over a previously switched-in antenna, for the sampled antenna to be switched on line; and the time period over which a switched-in antenna will be held on line prior to initiating the next sampling routine. You may allow the operating parameters to be set in a microprocessor CPU by an input device such as a keyboard and create a program for enabling the CPU to carry out all operating functions.

When your system performs exactly as you planned, make sure you properly record the successful test in your notebook, with all components correctly identified. By doing this, you've established a so-called "reduction to practice" of your invention, evidence of which may also be valuable at a later time.

It isn't necessary to have actually reduced your invention to practice before applying for a patent, however. Once you've conceived your system (for example, as shown in fig. 1), and determined what you believe to be all other details a skilled worker would need to make and use your system in the best way you know, you may consider filing a patent application.

At this point it's wise to consider obtaining guidance from a patent attorney or agent. A roster of attorneys and agents registered to practice before the PTO is available from the Superintendent of Documents, Washington, D.C. 20402. You should, of course, feel satisfied that a particular individual has the technical background and experience to portray your invention adequately in a formal application if you decide to have him or her represent you before the PTO.

the search

Your attorney will probably advise that a search be conducted before formal papers are filed with the PTO. The cost of a search is often many times less than the total cost — including drawings and filing fee — of preparing formal application papers. It typically takes about two weeks to conduct a search and obtain the results.

The search should be directed to cover all important aspects of your invention. Frequently, an invention disclosure may encompass more than one patentable invention, and a professional search will uncover references pertinent to every aspect of your invention that might qualify for a patent. Two or more

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distortion, not sharp-skirted filters with high phase distortion. All signal processing is done at the input tone frequency; heterodyning is NOT used. This avoids distortion due to frequency conversion or introduced by abnormally high or low filter Q's. Bandwidths of the input, Mark/Space channels, and post-detection filters are all computed and set for the baud rate you select, from 10 to 1200 baud. Other standard features of the ST-8000 include:

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- Split or Transceive TX/RX
- CRT Tuning Indicator
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- 8, 600, or 10K Audio Input
- Signal Regeneration
- Variable Threshold Diversity
- RS-232 Remote Control I/O
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patents sometimes stem from a single "parent" application.

Even if the results are discouraging, you'll get a good idea of how your invention stacks up against the state of the art. If you later conceive of certain additions or improvements to your invention which are not suggested or "obvious" over the references found in the search, you may then give serious thought to obtaining patent protection for the later version.

A patent search can be beneficial in other ways. Remember that even if your invention is eventually patented, it could still infringe upon an enforceable patent of broader scope. Such dominant patents often turn up in the search, and you will at least be forewarned of their existence at an early stage.

the application

If all systems are "go," you'll want to have a formal application prepared and filed with diligence at the PTO. Although the process of examining an application and issuing a patent, if warranted, takes time, there's now a definite trend toward shortening the traditional wait between filing and final disposition. Furthermore, both the applicant and his or her attorney now must inform the PTO of all information they know "which is material to the examination of the application or else face strict sanctions."⁴ Such information includes those patents found during prior searches, and thus can be of great help and save time for the examiner who conducts the search at the PTO.

A complete patent application includes a written description of the invention sufficient to enable one skilled in the pertinent art to make and use it; one or more claims delineating the scope of the invention described; a drawing of one or more figures if necessary; an oath or declaration by the applicant stating, *inter alia*, that he or she believes himself or herself to be the original and first inventor of the claimed subject matter; and the required filing fee.

Using the automatic antenna select system proposed in **fig. 1** as an example, your notebook entries will provide a good basis for the written description. If you've arrived at one or more variations of the original configuration you think would enhance the system construction or performance, these alternative "embodiments" must be specified as well. The description must be adequate to enable a skilled worker to make and use the invention you're claiming.

The claim(s) of invention must particularly point out and distinctly claim those aspects of the system you regard as your invention. Depending on what your search uncovered, you may feel you're entitled to relatively broad, intermediate, or only narrow protection. Each claim generally must read as a single sentence. In cases where the invention itself is believed quite narrow, just one claim having very specific terminology

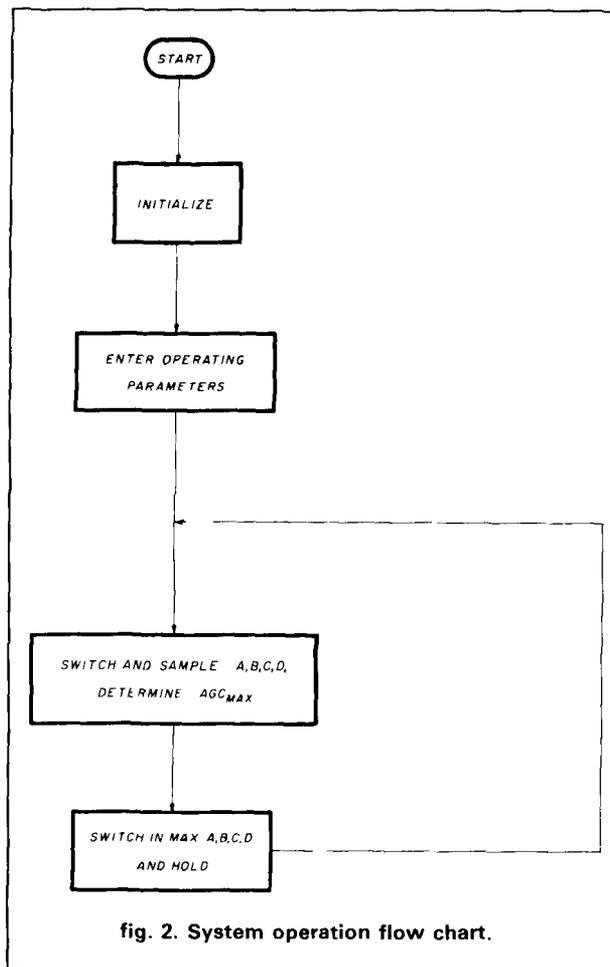


fig. 2. System operation flow chart.

may occupy two or more pages of the application papers.

A drawing showing at least the overall system as shown in **fig. 1** would facilitate the drafting of the written description, which can make frequent reference to the illustrated system components while explaining their structure and operation.

Once completed, your application should be filed promptly with the PTO along with the prescribed oath and filing fee. If all formal requirements are met, it will be accorded an official filing date and serial number, and then routed to a patent examiner for further action.

Don't forget to disclose to the PTO all material references of which you're aware. You can do this by filing a separate statement with your application papers or shortly thereafter.

what about software?

You may have taken considerable time and effort to create working system software and wonder if it alone can be protected by a patent. Insofar as software is only a list of instructions addressed to and performed by a computer to bring about a certain result, a patent is generally not available for software, per se.

You may, however, apply to register your software with the Copyright Office at the Library of Congress, Washington, D.C. 20559. For further information, call or write the Copyright Office and ask for Circular No. R61, "Copyright Registration for Computer Programs."

Since your software enables your system (**fig. 1**) to operate as you intended, a flow chart such as shown in **fig. 2**, depicting the system operation when properly programmed, is a worthwhile, possibly even essential addition to your original application disclosure. A full listing of your program need not be included with your written description, as long as a skilled programmer could arrive at a working program without undue difficulty by referring to your written description and drawings.

some important time limits

As mentioned, it's important to move swiftly once you decide you've conceived of a patentable invention. Suspension of pre-filing development work for a long time without good cause can amount to an "abandonment" on your part. The result — if another person conceives the same invention and acts without delay to file an application, he or she may be the one entitled to any patent which may be issued.

If your invention was patented or described in a printed publication anywhere in the world more than a year before your application filing date in the United States, you'll be barred from obtaining a patent here. You'll also be barred if the invention was in public use or on sale in the United States more than one year prior to your filing date.⁵ For example, if an article describing all essential details of your automatic antenna selection system appears in a magazine published in Japan on January 1, 1987 — and you believe you're the original inventor — you have only until January 1, 1988, to apply for a patent in the United States.

Another example: suppose your antenna selection system works so well you decide to manufacture a large quantity and offer it for sale through an advertisement in the January 1, 1987, issue of *ham radio*. Your deadline for filing a United States application (assuming no prior disclosures) is January 1, 1988.

Although you may disclose your invention publicly up to one year before filing an application in the United States, it's sometimes necessary to file before publicly announcing or commercially exploiting your invention. One example is when you wish to file corresponding applications in certain other countries where "absolute novelty" requirements exist for patent applications. That is, the patent laws of some countries do not allow public disclosure of an invention anywhere in the world prior to filing an application with their governments. Because other time bars

may exist, in your case, consult your patent attorney or agent prior to filing.

employment agreements

Amateurs who work in technical capacities for others may be required, as a condition of employment, to execute a written agreement to assign all inventions they develop while on the job to their employer. Without such a written agreement, the employer could not claim title to any patents obtained by the employee independently. The employer would derive only a "shop right" or royalty-free license to use the patented invention.

Because the employee agreements are generally upheld if contested in court, employees who are subject to them should review them carefully before applying for patents on their own. Sometimes an employer will release an invention after an employee discloses the invention and the employer decides not to pursue a patent. Upon obtaining such a release, the employee is then free to apply for a patent — at his or her own expense.

conclusion

The patent system is an integral part of our nation's commercial activity and growth. To foster and reward inventiveness, the framers of our Constitution empowered the owner of a patent with the right to exclude others, for a limited time, from making, using, or selling the claimed invention in the United States. Before obtaining this right, however, the patent applicant must describe the invention in a manner sufficient to enable others skilled in the relevant art to make and use it.

Individual inventors and small businesses play a prominent role in advancing the state of the art in many high technology fields. To encourage this initiative, the PTO reduces by 50 percent its patent filing, processing, and maintenance fees for applications filed only in the interests of individual inventors and small businesses (*i.e.*, those with 500 or fewer employees).

The next time you conceive a new circuit, system, antenna, or any other useful device or process — and feel you can exploit it on your own — consider conducting a professional search. You just might have the makings of a patentable invention.

references

1. Title 37, Code of Federal Regulations (37 C.F.R.).
2. 35 U.S.C. Sec. 101.
3. 35 U.S.C. Sec. 103.
4. 37 C.F.R. Sec. 1.56.
5. 35 U.S.C. Sec. 102.

Leo Zucker, a patent attorney, welcomes inquiries from readers and suggestions for future articles.

ham radio

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This may be the world's most popular 3 KW roller inductor tuner because it's small, compact, reliable, matches virtually everything and gives you SWR/Wattmeter, antenna switch, dummy load and balun — all at a great price!

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Matches everything from 1.8 to 30 MHz! dipoles, inverted vee, random wires, verticals, mobile whips, beams, balanced and coax lines.

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Lighted Cross-needle Meter reads SWR, forward and reflected power in one glance. Has 300 and 3,000 watt ranges. 6 position antenna switch handles 2 coax lines, wire and balanced lines. 4:1 balun. 250 pf, 6 kv variable capacitors. 12 position ceramic inductor switch. New smaller size matches new rigs: 10 3/4" x 4 1/2" x 14 7/8" inches. Flip stand for easy viewing. Requires 12V for light.

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

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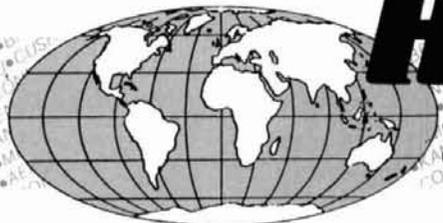
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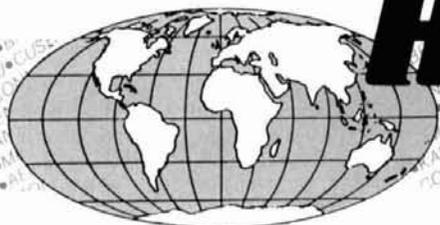
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JET	ICH*	25-50	1.5 MW	20 seconds
JT-60	ICH*	110-130	750 kW	10 seconds
JFT-2M	ICH*	10-40	1.5 MW	300 milliseconds
KFA-Textor	ICH*	29-59	1.5 MW	3 seconds

*ICH = Ion cyclotron heating



modular transmit and receive converters for 902 MHz

MMICs make inexpensive building blocks for new band circuits

This article describes a set of up- and downconverters for the 902-MHz band. When used together with the local oscillator chain described previously,¹ the result is a set of building blocks which can form the core

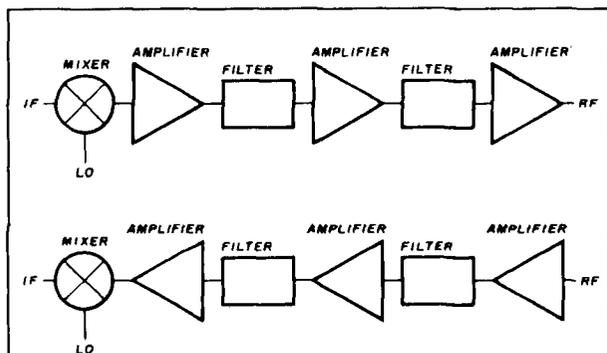


fig. 1. Block diagrams of the converters. The upconverter (top) and the downconverter (bottom) differ only in the direction of the signal flow.

of a complete 902-MHz transverter. The converters have a common board design for simplicity; MMIC amplifiers are used throughout, and the filtering is designed for ease in tuning.

The block diagrams of the up- and downconverter are shown in fig. 1. The similarity between the two is immediately apparent. The mixer and the two bandpass filters are identical in each converter, and only the direction of signal flow is changed by reversing the MMIC amplifiers. The two bandpass filters in each are used to provide selectivity, for the amplifier stages are inherently broadband.

With these converters, a 902-MHz transverter is easily assembled. A power amplifier hybrid, such as those discussed by Reisert² and Hilliard,³ can be driven directly from the upconverter module. A low-noise amplifier, such as the one described by Hilliard⁴ can be used ahead of the downconverter for critical small-signal work; the converter board alone will provide sufficient sensitivity for local QSOs.

design goals

These converters were designed to achieve several goals which were not met in some of my earlier designs. First, the converter printed circuit board (PCB)

Jerry Hinshaw, N6JH, 142 Kensington Place, Frederick, Maryland 21701

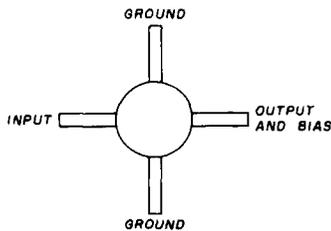


fig. 2. MMIC device typical outline. The various MMIC amplifiers all have the same pin configuration, though the package dimensions vary somewhat.

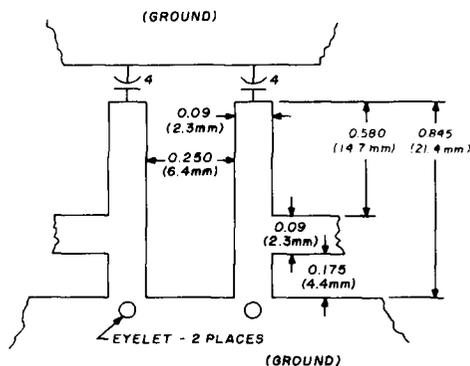


fig. 3. Details of the 903 MHz filter. The dimensions shown are for 1/16 inch G-10 board with a ground plane on the far side.

is common to both the up- and downconverter to simplify fabrication. The physical size of each PCB is small, and a standardized outline was planned from the start to simplify packaging. The converters were designed to be non-critical so that tuning with simple equipment is possible. All circuitry operates from a single 13.6-volt dc supply. Finally, no very costly components are used. There are two configurations of a single circuit card: one is for the receiving downconverter and the second for the transmitting upconverter. For receiving, the main considerations are noise figure and intermodulation distortion, while the transmitting converter should have good spectral purity and sufficient output to drive a final amplifier. These different requirements dictate the selection of different amplifiers, but the same filtering is used for both converters. Before we leap into the "how-to" construction hints, however, a brief review of the amplifiers, filters, and the PCB itself should be helpful.

MMICs

Both converters use silicon microwave monolithic

integrated circuits (MMICs) extensively. These devices have been described recently in Amateur publications.^{5,6} Each MMIC device is a completely matched broadband rf circuit, so only blocking capacitors and a bias network are needed to make a 50-ohm amplifier. These "building block" amplifiers are a great aid in the design of UHF equipment; at last it can truly be said that gain is cheap.

Among the MMIC amplifier devices suitable for use in this converter are the Avantek MSA series, the CGY-40 device from Siemens, and the newly announced MMIC from Mini-Circuits Labs, the MAR-1.⁷ Each of these devices is somewhat different, but they are all similar enough mechanically so that any one of them can be installed on the circuit board for this converter. Only the bias resistor value needs to be changed to adapt to a different MMIC. Table 1 lists some MMICs, their principle characteristics, and the value of the bias resistor for 13.6-volt operation.

Most of the MMIC amplifiers are available in small, four-lead plastic pill-type packages, while the CGY-40 is available only in a ceramic package. In all cases, two of the leads are grounds and the other two are input and output. Bias is applied through the output lead. Their typical outline is shown in fig. 3. Since the package is symmetrical, the device can be simply reversed (and the bias connection moved to the output) to "turn around" the signal flow in a circuit. This idea is central to the re-use of circuitry in this transverter.

filters

The filters used in both the up- and downconverters are identical, although the filtering requirements in the two converters are not exactly the same. In the downconverter, filtering is used to screen the mixer from noise at the image frequency and to help prevent intermodulation distortion by attenuating out-of-band signals. The filtering also helps to prevent the mixer local oscillator (LO) signal from reradiating (out the antenna port), although the reverse isolation of the preamplifiers may well be sufficient to block it. In the upconverter, however, the filters must prevent the LO signal from reaching the antenna through the forward path of the amplifiers. The LO signal must not be permitted to saturate the amplifier chain. In general, these different requirements would result in different filter designs, but it is possible, if not optimal, to use one design.

The filters used here are of edge-coupled design, and are similar to combline filters. Filters of this type have been built on microstrip circuitry before and used with good results by Amateurs.^{8,9} Their chief advantage lies in their ease of reproduction and stability; because the inductors are printed onto the board they

need no adjustment. Here, the main variations on this old theme are that the filter layout was optimized using computer-aided design (CAD) software, and that

the filtering is distributed. The use of CAD helps to design a good filter, one which comes close to its specifications the first time. By distributing the filter-

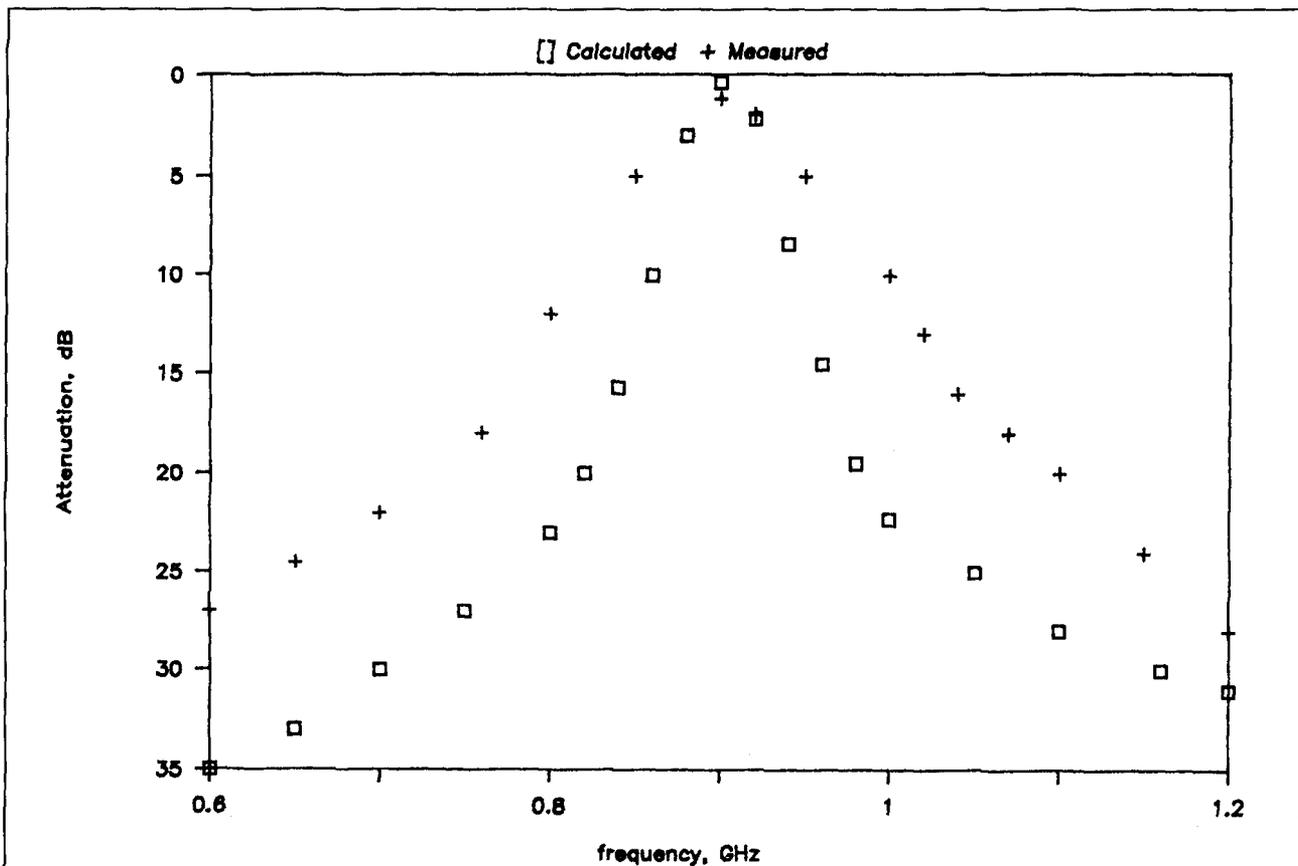


fig. 4. Frequency response of the 903-MHz filter. Both the calculated response (squares) and the measured response (crosses) of a prototype are shown.

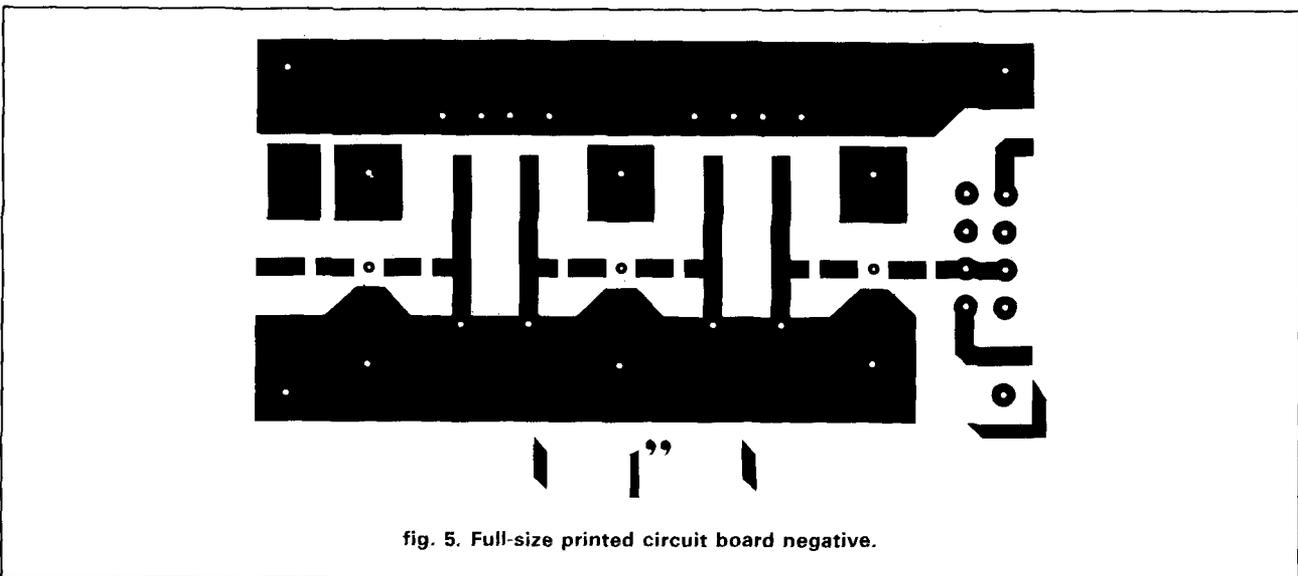


fig. 5. Full-size printed circuit board negative.

ing, the required rejection of out-of-band products is achieved not in one filter, but in two or more. There is a simple reason for this: it is easier to tune two in-

dependent filters with few elements than it is to tune one filter which has many resonators. This is especially true when simple test equipment (i.e., no spectrum

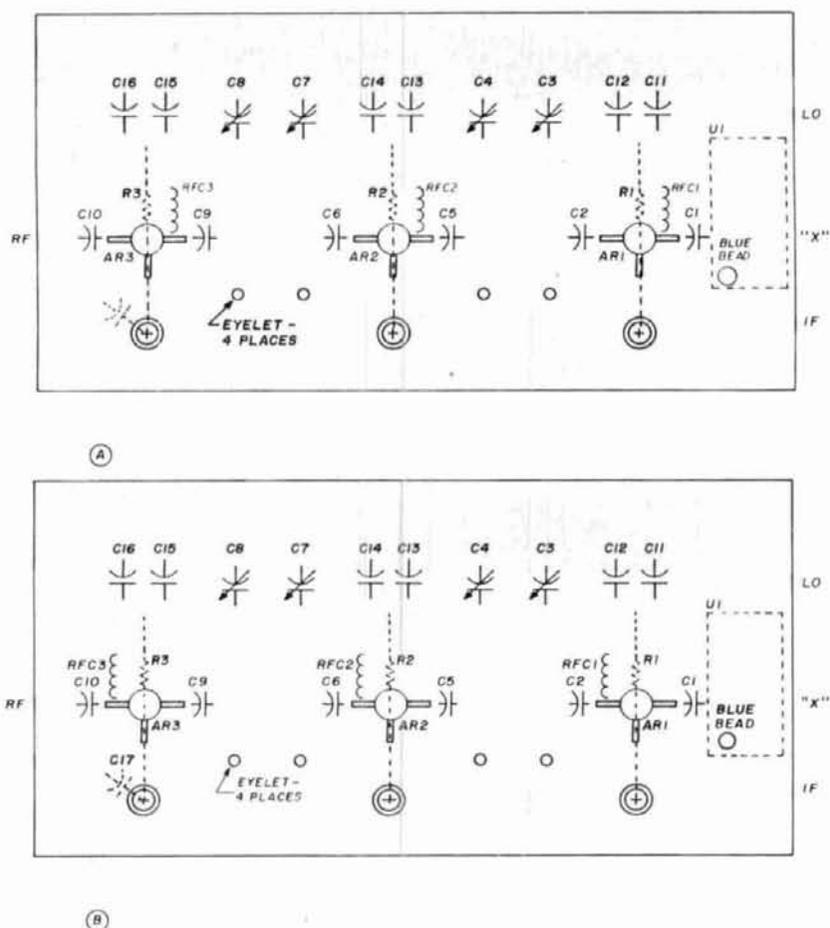


fig. 6. Parts placement: (A) downconverter, (B) upconverter. Parts shown in dotted lines are installed on the other side of the board. Eyelets are used in four places to ensure good grounding for the filters.

Table 1. Typical 900 MHz performance of three different manufacturers' MMIC's.

Device	Typical gain, dB	Typical Noise figure dB	Typical P1dB dBm	Bias volts/mA	Bias Resistor 13.6 volts	Package & Lead Identification
Avantek:						
MSA0104	17	5	+1	4.5/17	560	Plastic package; moulded "bump" near output lead.
MSA0204	13	6	+3	5/25	510	
MSA0304	12	6	+8	5/35	270	
MSA0404	8	6	+11	5.5/50	160	
Siemens:						
CGY-40	9	3	+17	4.5/65	130	Ceramic package. Output lead slashed.
Mini-Circuits:						
MAR-1	14	5	+1	7/20	330	Plastic package. Input lead slashed.

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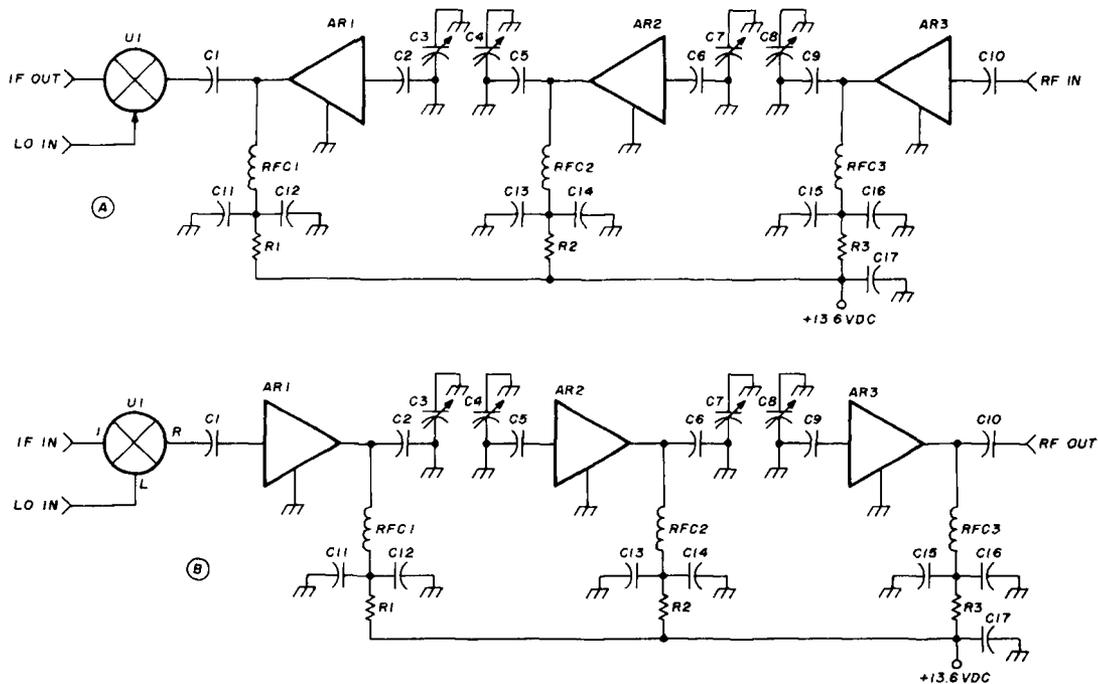


fig. 7. Schematic diagrams: (A) downconverter, (B) upconverter.

analyzer) is used.

Therefore, a pair of two-section filters is used in each converter. The two filters are separated by an amplifier stage which prevents interaction and consequently improves out-of-band rejection.

Each filter consists of a pair of broadside coupled microstrip transmission lines. Each line is shorted to ground at one end and capacitively loaded at the open-circuited end. A top view of this structure is shown in fig. 4. Signals are coupled in and out of the filters by transmission lines which "tap" the resonators at a point whose location helps determine the filter's passband impedance match. The variables in the filter design include the width, length, and spacing of the lines, the loading capacitance, and the location of the tap points. The CAD program juggled these variables to produce a good compromise between insertion loss, rejection, and in-band VSWR. The circuit model presumed typical losses in G-10 type PCB material. Note that the coupling between the filters is, according to the model, entirely between the lines. The tuning capacitors at the ends of the lines are presumed by the software model to be dimensionless. In practice, however, the capacitors tend to increase the coupling between the two resonator sections, increasing the bandwidth and reducing the out-of-band rejection relative to the model. No attempt was made to model the capacitors' non-ideal behavior because there are so many different types of capacitors, and

each would require its own analysis.

Figure 5 shows the filter frequency response with a dual plot. The points are the predicted performance of a single filter, while the crosses show actual results from a hand-cut prototype. This prototype used small tubular trimmer capacitors similar to those used in the downconverter. Note that the calculated response is considerably sharper than the actual results, which show the expected overcoupled behavior. This deviation from theoretical performance is often seen in handmade prototypes, where the fabrication accuracy is poor. The performance could probably be improved by using capacitors which are physically smaller, and which therefore produce less stray coupling. Further refinement would be made by carefully etching a precision filter design onto good microwave substrate material. However, this is an amateur design, and it is just this sort of expected inaccuracy which led to the design approach of using non-critical filters. *Non-critical filters tuned to the center frequency are better than sharp filters on the wrong frequency.* The rejection of the converter depends on the cascade of two filters. With two of these filters cascaded, as on the PCB, the out-of-band rejection is approximately twice that of a single filter.

printed circuit board

The board is common fiberglass epoxy G-10 material, 0.06 inch thick. The top traces are shown in the

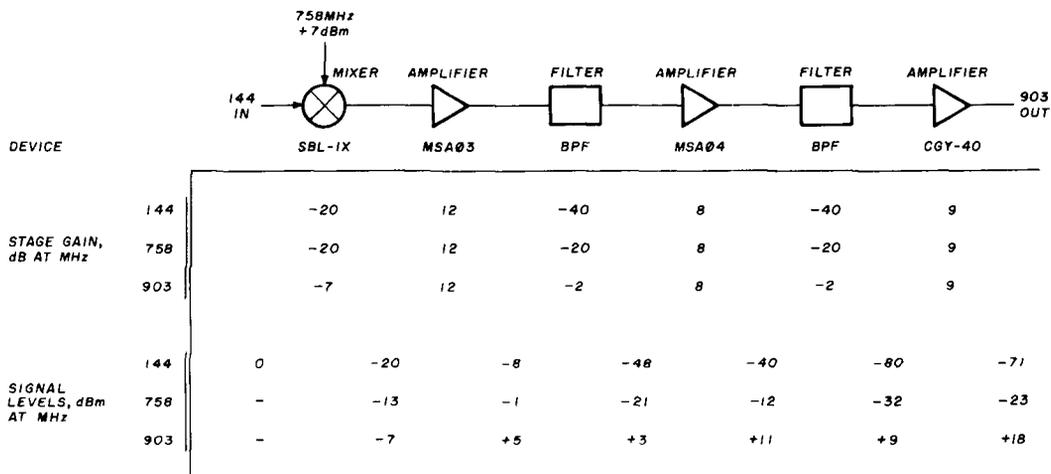


fig. 8. Signal level diagram for the upconverter. The three main frequencies of interest are tracked through the chain to ensure that each is at a manageable level at each stage.

Parts list, fig. 8

Parts common to both versions

- C1,2,5,6,9,10. 30 to 100 pF chip capacitor
- 11,13,15
- C3,4,7,8 2-10 pF variable cap
- C12,14,16 0.01 to 1 μF ceramic disk capacitor, 25 volts
- C17 5-100 μF electrolytic or tantalum
- RFC 1,2,3 Approximately 10 turns No. 30 AWG solid Kynar insulated wire (wire-wrap wire), close-wound on 0.06-inch diameter form (removed after winding)
- U1 SBL-1X mixer, Mini Circuits Labs

Parts specific to upconverter:

- AR1 Avantek MSA0304 MMIC amplifier
- AR2 Avantek MSA0404 MMIC amplifier
- AR3 Siemens CGY 40 MMIC amplifier
- R1 270 ohms, 1/2-Watt
- R2 160 ohms, 1/2-Watt
- R3 130 ohms, 1 Watt

Parts specific to downconverter:

- AR1,2 Avantek MSA0304 MMIC amplifier
- AR3 Siemens CGY 40 MMIC amplifier
- R1,2 270 ohms, 1/2-Watt
- R3 130 ohms, 1 Watt

full-size negative (fig. 6). The bottom side, visible in the photograph, is unbroken copper that serves as a ground plane for the microstriplines. Components are mounted mainly on the top of the board, and soldered to the top traces. Where good grounds are essential, such as at the bases of the filter stubs, eyelets are used to connect top and bottom grounds. The edge of the board was wrapped with copper foil and soldered on both sides to further decrease ground impedances.

A few components — including the mixer, whose can is soldered to the ground plane, and the bias resistors — are mounted on the bottom side. Remember to clear away the copper where non-grounded leads pass through the board. There are four pins on the mixer which must be isolated above ground, and each end of the bias resistors also must be so isolated. There

is no artwork for the ground plane side of the board, so the clearance holes are made by hand with a small drill or pad cutter. A pad cutter can also be used to make a pad for the bias resistor on the microstrip side of the board, if desired.

The MMICs are mounted in a hole drilled through the board. One of the two ground leads on each package is soldered to the top ground. The second ground lead is bent at a right angle to the package, inserted through the hole, and soldered to the bottom ground plane. The clearance hole size depends on the device used, because the MMICs listed in fig. 2 range in diameter from 0.07 to 0.19 inches.

There are two component layout drawings, one for the upconverter and the second for the downconverter. These are both shown in fig. 7. Note that the bias inductor is routed to the output end of the MMIC, so the locations of the three coils are somewhat different for the two versions. The MMIC orientations are of course opposite in the two versions. Otherwise, the parts locations are identical.

the downconverter

The schematic diagram of the receiving version is shown in fig. 8. The downconverter should have good noise performance, moderate gain, and good selectivity. Recall that the intent of this converter is not to produce the lowest possible noise figure. If a very low noise figure system is needed, a preamplifier should be used.

The input signal from a low-noise amplifier, or directly from an antenna, is fed to the first amplifier in the chain. There are a number of possible choices for this first amplifier stage. Any of the listed devices

could be used, but in general an amplifier with a low noise figure is used at the front end. The CGY-40 is a good choice here because it combines relatively low noise figure with good power handling ability, so that the overall dynamic range is excellent. The main drawback of this MMIC is that it is more expensive than some of the others. (A discrete bipolar or FET transistor stage could also be installed as the first amplifier in the chain.) The board layout includes a rectangular pad near the input for use of base or gate biasing circuitry, if needed.

The first filter stage follows the first MMIC. After filtering, the next amplifier is used mainly as a buffer between the two filters and adds a bit of gain. Lower-cost silicon MMICs are a good choice here; I used the Avantek MSA0304. At first glance it may seem strange that the input stage should have a higher intercept point than the following stage, but the reasoning is this: the second stage has the benefit of filtering to screen strong out-of-band signals, while the broadband input stage must face the world of large signals "naked," as it were. This reasoning is not theoretically rigorous, but in practice it seems to be correct — even a moderately selective filter in front of a preamplifier works wonders in reducing intermodulation spurious responses.

A second filter and a third amplifier follow. The final amplifier provides a good broadband termination for the mixer, which helps to preserve the mixer's low intermodulation distortion. If there is too much gain in the system, such as might be the case when a high-gain preamplifier is used with this converter, the middle stage could be replaced with a resistive π attenuator pad to isolate the two filters somewhat.

The PCB is laid out for a specific mixer, the Mini-Circuits SBL-1X. This low-cost mixer, which provides good performance up to 1000 MHz, can be used with any i-f of 5 to 500 MHz. The local oscillator drive level is 5 milliwatts (+7 dBm). Other mixers can physically be plugged into the same eight-pin layout, but take care; the SBL-1X has an unusual pin assignment.

When the downconverter is configured as shown in the schematic, it will have a noise figure of 3 to 4 dB at room temperature. It will have good selectivity; the gain at 700 MHz, for example, will be more than 20 dB, down from its gain at 903 MHz (which is +17 dB). The image response at 613 MHz (the 758 MHz LO minus the 144 MHz i-f) measured more than 50 dB below the desired 903-MHz response.** The selectivity of this cascade of two broad filters is sufficient to keep most fm broadcast, TV, and other signals below UHF from causing any problems with 903-MHz reception.

**Measured with the rf drive level set to -35 dBm and with +10 dBm drive at 758 at the LO port.

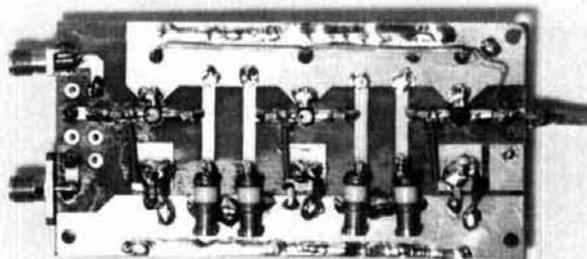


fig. 9. Photograph of the circuit side of the converter, which in this case is a downconverter version.

the upconverter

The upconverter has a somewhat different task than the downconverter. Here, noise figure is not of great importance, but the output level should be high enough to drive an amplifier. In this case, I wanted 30 to 40 milliwatts output so that a hybrid amplifier would be fully driven to its 7-watt output. This requirement dictated a different choice of amplifier MMICs than did the receiver converter. **Figure 9** is a matrix of the required signal levels. This matrix was put together to ensure that the various signals which exit the mixer do not saturate the amplifier chain, and that the undesired signals are ultimately well attenuated at the converter's output. Thus, the three main signals of note are tracked through the chain. As an example, the 758-MHz LO drive leaks through the mixer somewhat, and appears at the output of the mixer as an undesired spurious at about -13 dBm maximum. This spurious must be attenuated before it reaches the output. The chart shows that the undesired signals remain within manageable range throughout the upconverter chain, and that the expected signal levels are within the linear power limits of each MMIC.

This chart also shows that the desired drive level at 144 MHz is about 1 milliwatt (0 dBm). The drive from the i-f source must not be much greater than 10 milliwatts, and should never be greater than 100 milliwatts or the mixer may be damaged. To adjust the output power of the upconverter, change the input drive level.

The schematic of the upconverter is given in **fig. 8**. The desired 903-MHz signal, mixed from 144 and 758, continues to be amplified throughout the chain, and by the time it reaches the output it is considerably stronger than the next larger signal at 758 MHz. At the output, a power level of +16 dBm is achieved, easily enough to drive a hybrid amplifier to its full output.

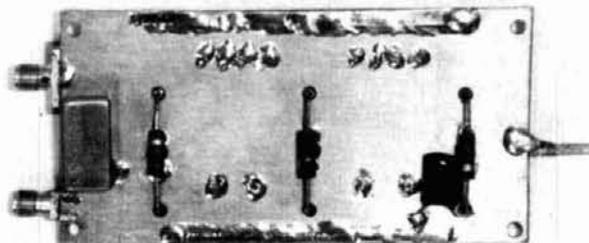


fig. 10. Photograph of the groundplane side of the converter. The mixer and the three MMIC bias resistors are visible.

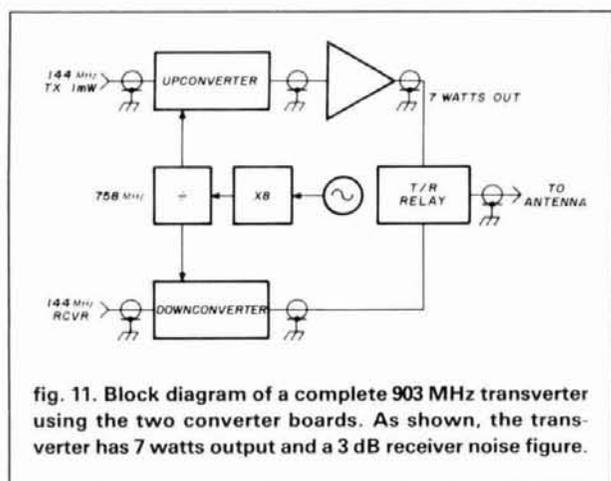


fig. 11. Block diagram of a complete 903 MHz transverter using the two converter boards. As shown, the transverter has 7 watts output and a 3 dB receiver noise figure.

tuning

Once a converter is assembled, it is necessary to tune the filters. No other part of the circuitry requires tuning, fortunately. The filters must be peaked for minimum loss at the center frequency. Once peaked at 903 MHz, for instance, the converter should work well enough over the entire 902 to 928 MHz band. The 3-dB bandwidth of the converter is about 50 MHz. I found that there was only one peak reading obtainable, so that there is no problem with tuning to the wrong harmonic as long as you are measuring the correct frequency. The board can be tested at 903 MHz with all of the components except the mixer installed. A test connector is temporarily installed at the point marked "x" on the layout drawing (fig. 7). The other end of the converter board is connected normally as either the drive input (downconverter version) or the output (upconverter).

After tuning and testing at 903, install the mixer. Test the entire converter by applying a low-level signal to the input, the LO to the L port of the mixer,

and verify that the output signal is no more than about 10 dB lower than the straight-through gain was before the mixer loss was added. The alignment is then complete.

A number of these converter boards have been built, and none has shown any tuning difficulties. See figs. 10 and 11. The filters tune with a single peak, and there have been no instabilities with the MMIC amplifiers. They thus appear to be simple, well-behaved conversion blocks, useful in many applications. The filters' center frequency can in fact be tuned (simply by adjusting the end loading capacitors) over a fairly wide bandwidth, so that these boards could probably be operated anywhere between about 750 and 1000 MHz with only slightly degraded selectivity. Clearly, if the filters' coupled microstrip line lengths were scaled, this range could be further extended. The mixer's operating range is guaranteed only up to 1 GHz, but one was tried at 1300 MHz and showed good conversion loss and isolation.

A complete block diagram of a 903 transverter is shown in fig. 12. This transverter uses the two converter boards described here. One converter drives a hybrid amplifier module to 7 watts output in Class C operation, and the receiving converter is used alone with a low-noise MMIC to give a system noise figure of about 3 dB. The entire transverter operates from a single 13.6-volt supply.

sources of parts

The parts should be available from a number of sources. Small capacitors and connectors are listed in a few companies' advertisements in the Amateur press. Although manufacturers are sometimes unwilling to sell single devices, MMICs are available from manufacturers and their distributors in moderate quantities. MMICs will probably be stocked by Amateur vendors soon, too. As a courtesy to Amateur builders, I can supply the pc boards and a few of the other parts for this project. Send an SASE to me for a list of available items.

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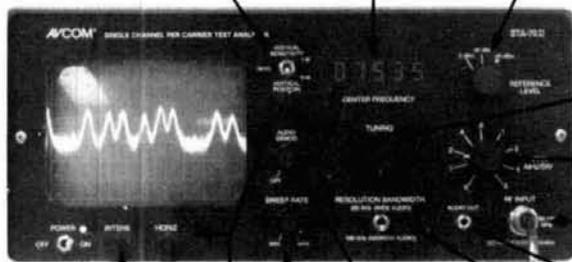
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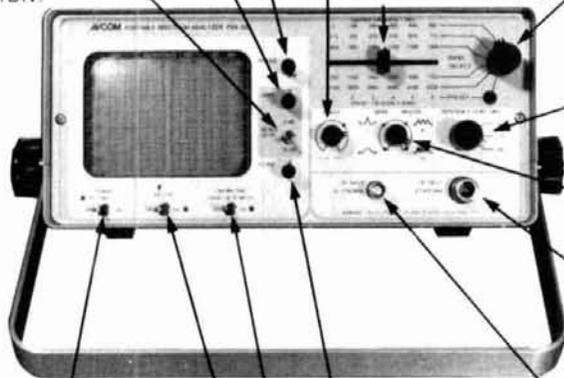
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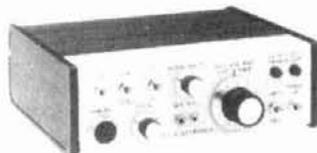
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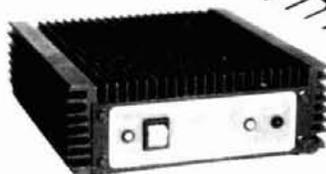


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the TEXNET packet-switching network

part 1: system definition and design

Four-node
digipeater system
reduces congestion,
speeds packet delivery

In response to the phenomenal growth of packet radio over the past three years, many packet repeater ("digipeater") networks have been developed, allowing packet communications to be extended over many hundreds, even thousands, of miles. The operation of these digipeater systems has not been without some significant problems, however; most notably, congestion and difficulty in maintaining connections through more than about four or five individual repeaters, with excessive time delays between endpoints.

In an effort to resolve these problems, we decided to establish a rapid, reliable network that would allow Texas packet radio operators to communicate effectively over distances of several hundred miles *in real time*. We now have TEXNET, a four-node network with some of the communication trunks between nodes operating at 9600 bits per second.

In developing TEXNET, our goal was to minimize the cost of building a network node, yet provide very small transmission delay time between users. After the system was in place, we added additional services to the network without degrading the quick response time.

digipeaters — pro and con

A digipeater repeats what is transmitted to it; it can't remember anything about what it is repeating.

A good analogy to a "string" of individual digipeaters is a bucket-brigade line at a fire, in which *each person* is handed a bucket, which he or she in turn hands down the line to the next person. Eventually, each bucket makes it to the last person in the line, who throws the water onto the fire. With digipeaters, the

system works like this: the first person in the line fills up a bucket and hands it to the second person. The second person hands it to the third, and so on until it reaches the end of the line (the receiver). Utilizing digipeaters, the sender must wait until the bucket is delivered to the receiver, emptied, and then sent backwards up the line back to the sender, who fills it up again. In other words, *there's only one bucket!*

Just as water can leak or spill from the bucket each time it's passed in the bucket brigade, data packets can be lost at each digipeater. Thus, it's not at all certain that all of the packets will arrive at their appointed destination.

On packet radio we use a layer 2 protocol called AX.25 to assure that all the packets get to the destination in the right order, without any getting lost along the way. This protocol is no more than a set of rules upon which the sender and receiver have agreed; one of the rules is that the receiver will "acknowledge" packets when they're received. The receiver sends these acknowledgments ("ACK," for short) backwards up the bucket-brigade line (i.e., the string of digipeaters) to the sender. If the sender doesn't see an acknowledgment within a few seconds, it assumes that the packet was lost somewhere and retransmits the packet. When the ACK is received, the sender transmits the next packet. However, only one bucket can be put into the line at a time; the ACK must come back from the receiver before the next packet can be started. Notice that none of the digipeaters really get involved in what's going on; they merely repeat the packets. This method of acknowledgment is known as *end-to-end acknowledgment* — that is, the acknowledgment travels all the way through the string of digipeaters from the packet receiver back to the packet sender. (AX.25 is really a little more complicated than this, but it's a good approximation of what's happening.)

Thomas H. Aschenbrenner, WB5PUC, and
Thomas C. McDermott, N5EG, Texas Packet
Radio Society, 265 Daniel Drive, Plano, Texas
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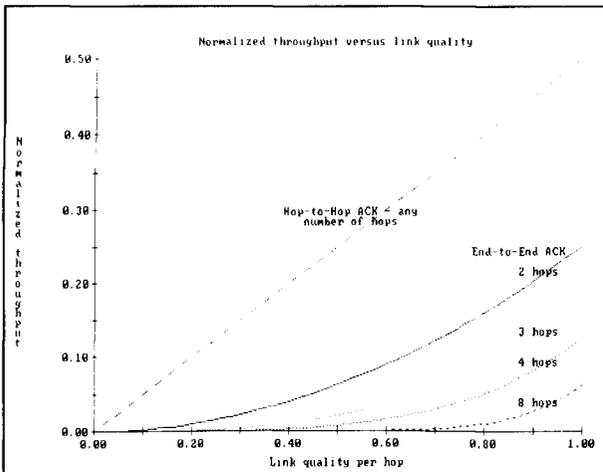


fig. 1. Throughput vs. rf link quality end-to-end and hop-to-hop methods. This graph shows the relative throughput for several packet repeating strategies. The throughput for hop-to-hop acknowledgments is independent of the number of hops, while the throughput for end-to-end acknowledgments degrades with an increasing number of hops. Both strategies degrade (i.e., the throughput is reduced) as the quality of the packet links becomes worse and causes more retries.

As anyone who's used a string of digipeaters to communicate with another station can attest, AX.25 works. But because we have only one bucket, the throughput (the amount of water that can be delivered to the fire) is very limited, and the greater the number of digipeaters in the path, the worse the problem becomes. In fact, it gets *much* worse *very* fast. Since the loss of a packet or of an acknowledgment at any point in the path will cause the retransmission of a packet, the probability of both the packet and the acknowledgment making the round trip successfully quickly becomes very small. This means that communicating a single packet will require many retransmissions, so throughput is reduced significantly.

A better method of relaying the information along a network would be to have each repeater along the way check the validity of the information before passing it on to the next repeater. That is, each repeater would ask for a "fill" of the message before sending it down the line. When the sender is assured that the first repeater received the packet, it could immediately send the next packet into the bucket-brigade line. Thus, we would have a bucket-brigade line with many buckets. Once the first bucket is delivered to the first repeater, another bucket would be filled and delivered to the first repeater by the sender. Thus the throughput (amount of water delivered) would be increased greatly. If we were to employ this strategy in relaying a message, the chance of losing packets grows only slightly larger as the number of digipeaters is in-

creased. This method is called *hop-to-hop acknowledgment*, as each packet is acknowledged between adjacent repeaters before being sent along the network. As the probability of losing a packet grows, the necessity of retransmitting it increases — that is, fewer packets per unit of time can be transmitted. **Figure 1** compares the throughput for hop-to-hop and end-to-end ACK methods to the rf path quality between each repeater.

Response time — the amount of time it takes for a message to be delivered from the sender to the receiver, and for the sender to receive the ACK — is an additional consideration. **Figure 2** compares the round-trip response time for hop-to-hop and end-to-end ACK methods to the rf link quality between each repeater. As can be seen, if the repeaters operate virtually error-free, then the end-to-end acknowledgment strategy works very well. However, if the quality is degraded even slightly, it can be seen that the end-to-end strategy behaves poorly, whereas the hop-to-hop acknowledgment degrades linearly only with path quality. It should be noted that 2-meter packet users consider a path with 75 percent reliability extremely good!

A second problem with any string of digipeaters lies in determining just where a problem exists. If one of the repeaters in the string isn't receiving packets at all, then the sender and receiver know only that the path is "blocked" and are unable to tell where the packets aren't being relayed.

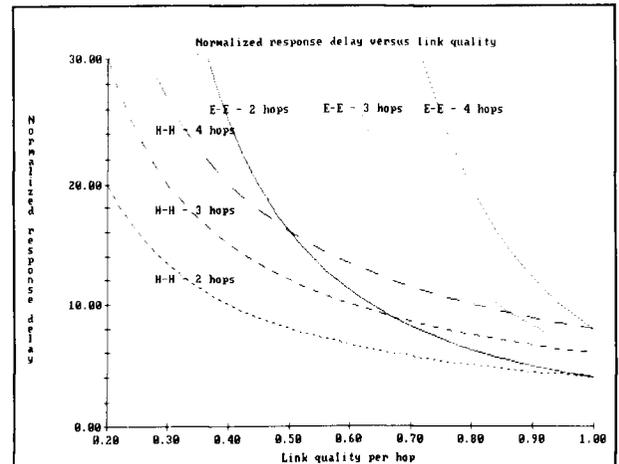
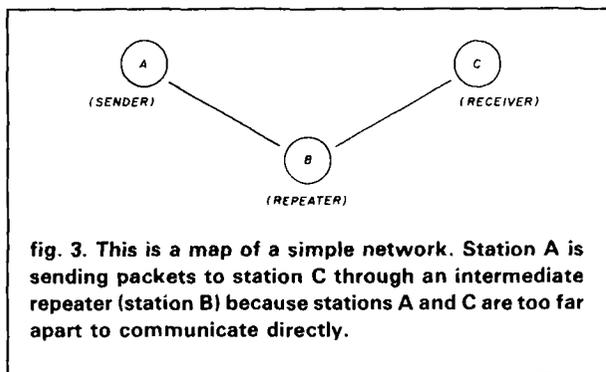


fig. 2. Response time vs. rf link quality end-to-end and hop-to-hop methods. This graph shows the relative response delay for several packet repeating strategies. The response delay for hop-to-hop acknowledgments is shorter (faster response) than for end-to-end acknowledgments unless the rf links are perfect (quality = 1.0), when the two have equal performance. Both strategies degrade (i.e., the response slows down) as the quality of the packet links degrades and causes more retries.

a network solution

To try and solve some of these problems, we wanted to build a packet network that would acknowledge packets at each step on the path, operate with minimal time delay, and provide us with information about the network: specifically, a measurement of the path quality at each point in the network and clear indication of where the break in the path has occurred, should one of the paths be out or one of the nodes be broken. It could also provide other features, such as conference bridges between any three or more users, or bulletin board service to several users simultaneously.

Earlier we stated that AX.25 would provide only end-to-end acknowledgments. This is because X.25 (from which AX.25 was derived) was designed basically as a point-to-point protocol. As a result, it works very well when Station A wants to communicate reliably with Station B. Our network, however, must use some additional strategies (protocols) for managing things



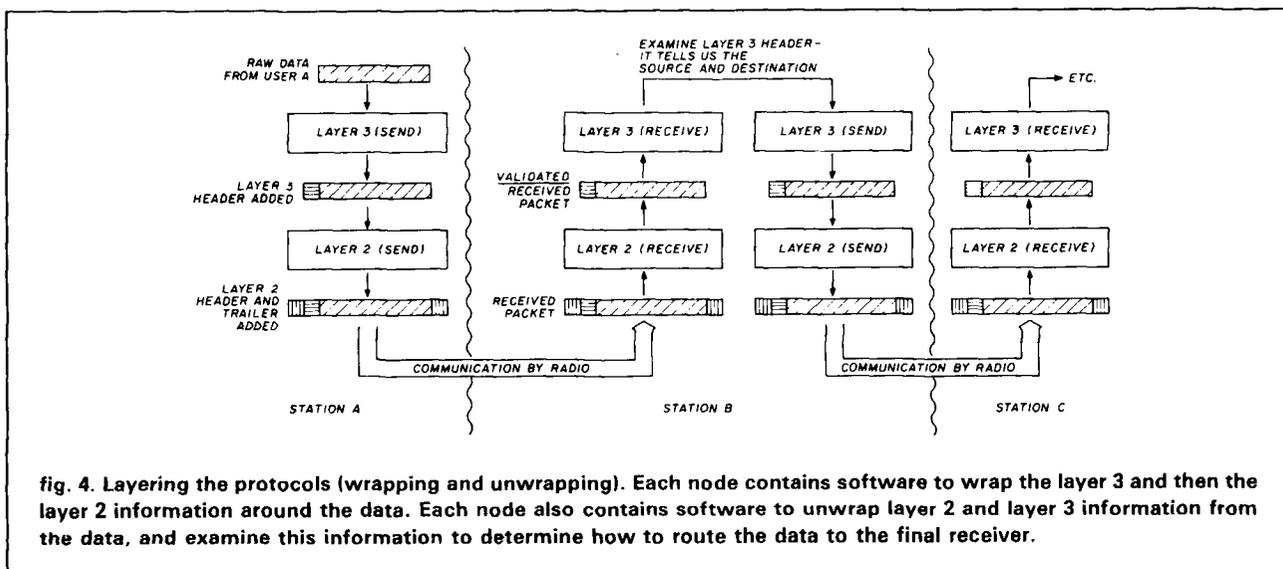
like supervision (altering routing tables, reinitializing nodes), error recovery (to indicate where network has failed), and hop-to-hop acknowledgments.

It's at this point that we'll break up the problem of communicating between two stations into several "pieces," each of which will have the responsibility of solving only a part of the total problem. If we're smart about how to divide up the problem, each piece will be a fairly straightforward design problem, and each piece will know what to expect of the other pieces. That is, each of the pieces will cooperate with the others in order to solve the entire communication problem. This approach is called "layering" a problem.

layered protocols

Let's look at the problem of communicating a message along a network. Station A is the sender, Station B is the repeater, and Station C is the receiver (see fig. 3). The sender, Station A, needs a way to send information along the route A-B-C.

The first problem is to make sure that the information gets from A to B accurately. Let us assign this problem to layer 2 (ignoring layer 1 for now). That is, layer 2 must get information from A to B in the correct sequence, without duplicating any packets and without losing any packets. AX.25 works just fine for this job. Getting data from A to B is a point-to-point problem; A sends the packets and B acknowledges them. Now that some packets have traversed from A to B, how does B know what to do with them? This is a job for the next layer of the protocol, layer 3. Layer 3 tells each node where the information is going; if B is unable to send the information to C (or a path that leads to C), then it informs A that something is



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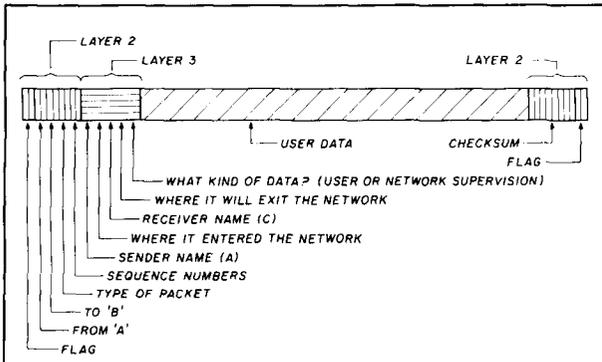


fig. 5. Contents of the packet. The layer 3 envelope is wrapped around the data first. It tells each node where the data came from, and where it is going, and the network entry and exit points. The layer 2 envelope is wrapped around the layer 3 envelope, and tells two adjacent nodes how to exchange the information reliably between themselves.

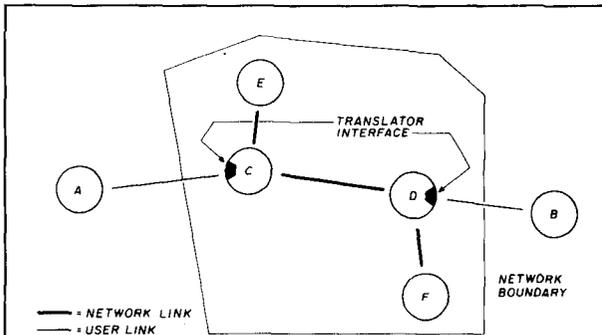


fig. 6. Drawing the network boundaries—which nodes translate from AX.25 to TEXNET-IP. In order for network users not to have to understand the internal network protocol, each network node has a user entry point, which supplies an English-language interface between the user and the network. The user may ask the network for services via this interface.

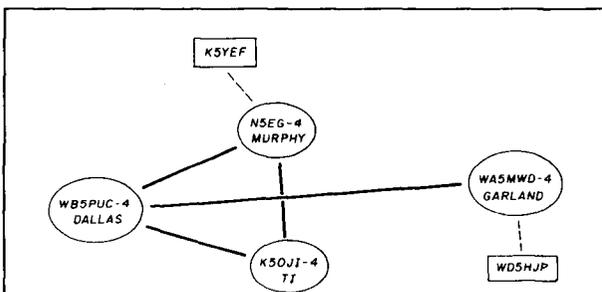


fig. 7. This is a map of the TEXNET test bed and two user stations (operators, TNCs, and 2-meter radios) of the network. Network trunks exist between Murphy, Dallas, and TI, but Garland can only communicate with Dallas.

wrong with the network. So Station A has to add a little additional information at the front of each packet that tells the intermediate stations where the information came from and where it's going.

Let's examine the sequence of events that occurs here. In fig. 4, Station A generates some data and sends it to its own layer 3 box. This box adds some information to the data packet (who the sender and receiver are, for example). Then the layer 3 box gives this slightly larger packet to the layer 2 box, which in turn adds a little information to it (things like a checksum for detecting errors, and the callsigns of Stations A and B). Layer 2 at Station A then assures that this packet is reliably delivered to the layer 2 box at Station B. The layer 2 box at Station B, happy with this packet, "unwraps" the layer 2 information and delivers what's left to the layer 3 box at Station B. The layer 3 box at Station B now looks at the information that the layer 3 box at Station A added to the packet and decides what to do with the packet. Probably Station B will determine the best way to get to Station C, and will tell its own layer 2 to send this packet to Station C; Station B will not alter the layer 3 information that station A put on the packet. Then the layer 2 box at Station B will add information (like a checksum, and the callsigns of Stations B and C) to the packet, and reliably deliver it to Station C. The "unwrapping" (examination of the layer 3 header, and the "rewrapping" of the layer 2 data) will continue at each node until the packet arrives at C. At Station C, the layer 2 box will "unwrap" the layer 2 data and then present the remainder to the layer 3 process, which will notice that this packet is destined for this station. Then the layer 3 box at Station C will remove the layer 3 information and present the raw data to the receiver at Station C. The contents of this individual packet is shown in fig. 5.

Thus raw data has traversed the network from A to B, through intervening users. At each step of the way it was error-checked and reliably exchanged by adjacent nodes, and each node decided how to route the information along to the final destination. Thus we have built a method that offers hop-to-hop acknowledgment, routing information reliably between two points. It also returns error messages to the sender, since it knows who the sender and receiver are.

There are two important points to consider: a standard protocol (AX.25) has been used at layer 2, and some of the more distressing problems with digipeaters have been solved. Unfortunately, we've added the requirement that the sender and receiver, Stations A and B, understand and implement an additional protocol, the layer 3 box. Rather than require this, we can instead build a "translation" function into Stations C,

D, E, and F. These would converse with A and with B in an English language-like manner, and would make all the decisions about to and from whom packets should be delivered. Thus if Stations A and B can wrap and unwrap the layer 2 information from each packet, and if the human operators at Stations A and B understand the English language commands that C through F need in order to translate and add layer 3 information to each packet, then the users at A and B need only to possess a TNC that has a layer 2 function that is compatible with AX.25 (see fig. 6). Fortunately, all TNCs are capable of this.

the TEXNET implementation

This is how TEXNET operates. A user connects to TEXNET just as anyone with a TNC would connect to any station. For example, let's look at the sequence K5YEF (in Plano) would follow to utilize the network to talk to a station in Garland (see fig. 7).

In this case, K5YEF is located near the Murphy node, and WD5HJP is located near the Garland node. Notice that the network node stations are not normal TNCs, but are TEXNET network nodes instead.

What K5YEF types is shown underlined; all other text appears on his CRT.

```

CMD>C N5EG-4
CMD>***CONNECTED TO N5EG-4

N5EG-4 VIRTUAL CONNECTION 03 AT 17:04:57 ON 11/26/86

*** WELCOME TO TEXNET V0706-WB5PUC ***

COMMAND ? Circuit WD5HJP @ GARLAND
YOUR CONNECTION IS ESTABLISHED
  
```

From this point on, the communication proceeds normally.

What does the station WD5HJP see? Let's take a look at WD5HJP's CRT.

```

CMD>***CONNECTED TO WA5MWD-4
INCOMING TEXNET CONNECTION FROM K5YEF-0 AT MURPHY
  
```

At this point, whatever K5YEF has typed appears on the screen.

The users of TEXNET connect to it on 145.05 MHz, at 1200 Baud using their standard TNCs. The network communicates between its own nodes using AX.25 as the layer 2 protocol and TEXNET-IP as the layer 3 protocol. The network nodes run their inter-nodal trunks at 9600 Baud on either 220 or 450 MHz, or can run them at 1200 Baud on 2 meters.

It would be best if the users of this network (Stations A and B, for example) had a way to communicate with the network that didn't require the use of human operators and English language commands. Then computers (at A and B) could control setting-up and tearing-down connections through the network. Unfortunately, this type of layer 3 protocol —

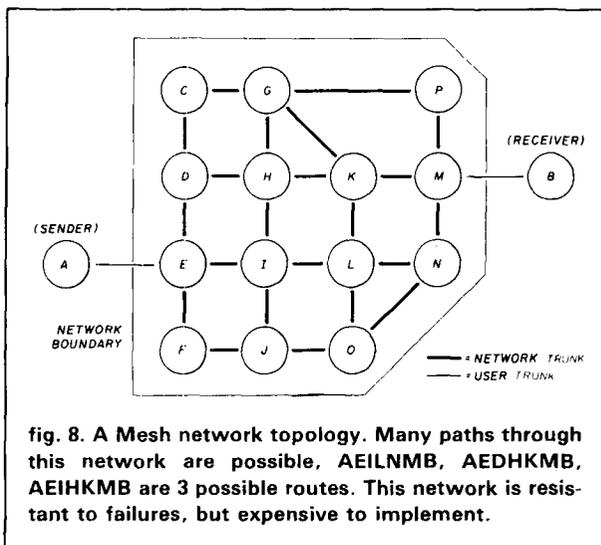


fig. 8. A Mesh network topology. Many paths through this network are possible, AEILNMB, AEDHKMB, AEIHKMB are 3 possible routes. This network is resistant to failures, but expensive to implement.

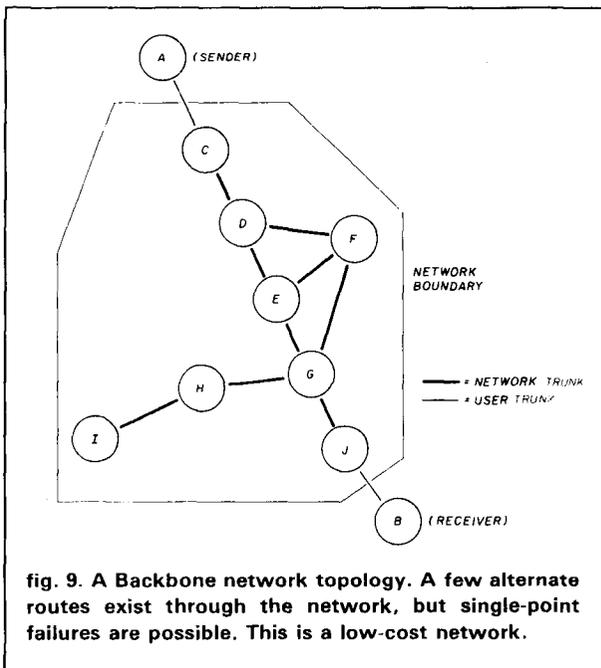
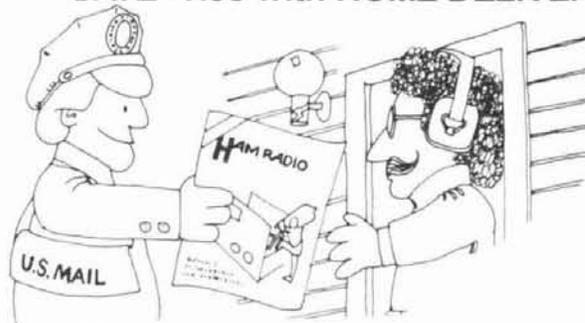


fig. 9. A Backbone network topology. A few alternate routes exist through the network, but single-point failures are possible. This is a low-cost network.

outside the network — requires that all TNCs be standardized for a layer 3 communication process, and no standards now exist in the Amateur community for this function.

The TEXNET-IP layer 3 protocol is "hidden" from all the users because the entry and exit nodes of the network translate the instructions from the users from English to TEXNET-IP and back again. The TEXNET-IP is utilized only within the network, and it is of a family of network protocols known as "datagram" (that is, each packet carries all of the information needed by

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the network). The TEXNET-IP protocol adds 5 bytes of overhead to the front of every packet inside the network, but is not suited for use as a user layer 3 protocol.

network topologies

How should all of these network nodes be physically located? How should the communication paths between nodes be set up? The topology of a network is a map of the network—that is, where the nodes of the network are located, and which nodes are within rf range of other nodes. The topology defines which nodes can be connected to each other, and gives a name to the different types of network configurations that could be made.

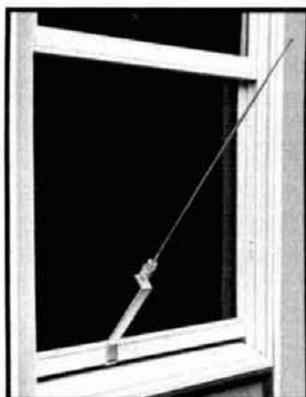
There are many topologies available for setting up a network, but we'll look at two common ones here. One way to set up a network—a "mesh" network—is shown in **fig. 8**. Mesh networks have many nodes, and many possible ways to route information between two users. Meshes also have a lot of "resiliency." They can suffer outages of nodes and/or paths, yet still have a way to route information between any two points.

Because the Texas Packet Radio Society doesn't have enough money to build and install switching nodes everywhere, we've chosen a topology that minimizes cost, but unfortunately degrades the survivability of the network. In our network, we've installed a "backbone" arrangement as shown in **fig. 9**. In this topology, nodes are installed along a "skinny" route between the major population centers—those users with the largest amount of traffic to send a long distance. Alternate routes to some of the paths are included. Each of the nodes contains a "table" in memory which is a map of the system, so that it knows to which node packets should be forwarded, depending upon which node will receive the packet and deliver it to the final user. These tables contain alternate routes in case the primary route is unavailable. In addition, each node contains an area in the memory where the routing table can be "patched" to accommodate recent changes to the map. These recent changes can be loaded into the network nodes by the network control operator. This type of routing is known as *static* or *directory* routing.

Further articles in this series will focus on specific issues addressed in implementing the TEXNET network. One section will be devoted to the hardware that was designed, and one section will be devoted to the software that was designed (protocol layers). The software section will also describe additional features provided by the network.

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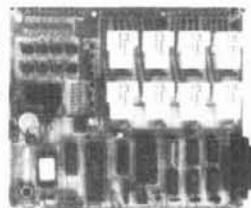


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simple ICOM IC-735 to C-64 interface

Software routine controls frequency, mode, memory channel, and VFO selection

This simple hardware and software interface can be used to control an IC-735 transceiver by means of a Commodore 64 using a serial data bus. With an understanding of the control codes listed in table 1, a routine can be written to perform many complex, useful operations with the IC-735 and, ultimately, to automate an entire station. Because future ICOM equipment will have the same data protocol, the program shown in fig. 1 should be easily adaptable to those as well.

Figure 2 is a schematic diagram of the hardware

Table 1. Control code designations and descriptions.

Control Code	Description
3	Requests transceiver to return its current operating frequency.
4	Requests transceiver to return its current operating mode.
5	Selects operating frequency.
6	Selects operating mode.
7	Selects VFO A or B
8	Sets parameters of selected memory channel.
9	Stores current configuration into displayed memory channel.
A	Stores current configuration into last displayed VFO memory.

NOTE: Codes 0 through 2, below, are not used in this program.

0	Code used by transceiver when returning frequency after main dial or mode switch has been activated.
1	Same as 0 except data is for mode.
2	Request to return valid operating range.

used to interface the IC-735 to the C-64. Notice that the only component needed is a 4.8 k pull-up resistor. A more sophisticated design involving transistors and inverters for buffering is possible but not necessary because the C-64 user port is TTL-level compatible with the IC-735. The pull-up resistor is used to provide sufficient current to drive the input and output pins of Commodore's user port. Since this is a bidirectional data bus, both input and output pins in the C-64 user port are connected together. The flag interrupt is also connected to the bus for data detection and timing. As can be seen from the schematic, pins B, C, and M on the user port are pulled up to +5 volts through the resistor by a connection at pin 2 in the user port. The center connector of the REMOTE output of the IC-735 is then connected via a two-conductor cable to these data pins. The outside connector of the IC-735 REMOTE is connected through the same cable to pin N (GND) on the user port, thus completing the hardware interface.

code description

A line-by-line description of the entire listing is not necessary because of the functional similarity of the functional control blocks. (See fig. 3.) The details presented in the first block are useful for understanding the balance of the program.

housekeeping

Lines 10 through 599 contain a brief introduction, a definition of variables used, and a subroutine map. Line 600 begins the functional part of the program by initializing the system. It opens the user port on the C-64, sets the screen color, clears the screen, and provides the data for the function keys. Lines 750 through 950 display the main menu and prompt the user for the desired function.

frequency selection

The block of code beginning at line 1000 is the first

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```

10 REM *****
20 REM * FILE NAME: CSMA/CD *
30 REM * THIS ROUTINE CONTROLS AN *
40 REM * ICOM 735 HF TRANSCEIVER *
50 REM * EQUIPPED WITH THE CI-V DATA *
60 REM * BUS AND CONTROLLED BY THE *
70 REM * COMMODORE 64. *
80 REM * REFER TO THE C-64 PROGRAMMERS *
90 REM * REFERENCE GUIDE PAGES 348 *
98 REM * THROUGH 357 FOR ASSISTANCE. *
99 REM *****
    
```

```

100 REM
110 REM BY: CHARLES F. BAHR
120 REM N7ICW
122 REM 5621 NO. 40TH
124 REM TACOMA, WN. 98407
140 REM
160 REM
    
```

```

170 REM ----- VARIABLE DEFINITION -----
180 REM FA = BAD DATA = 250
190 REM FB = GOOD DATA = 251
200 REM FC = JAMMER CODE = 252
210 REM FD = STOP BYTE = 253
220 REM FE = START BYTE = 254
230 REM SR = STATUS REGISTER
240 REM R = RECEIVER ADDRESS
260 REM C = CONTROLLER ADDRESS
265 REM F = INPUT FREQUENCY
280 REM
    
```

```

300 REM ----- SUBROUTINE MAP -----
    
```

```

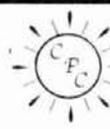
310 REM
320 REM 600 INITIALIZE
330 REM 750 MAIN MENU
340 REM 1000 SET FREQUENCY
350 REM 2000 SET MODE
360 REM 3000 SET VFO
370 REM 4000 SET MEMORY
380 REM 5000 PROGRAM MEMORY
390 REM 6000 MEMORY TO VFO
410 REM 8000 SOFT KEY SETUP
420 REM 8500 CLEAR SCREEN
425 REM 8600 RESULTS OF CHANGE
435 REM 8700 GET DATA
445 REM 8900 CONVERT TO HEXADECIMAL
450 REM 9500 ERROR PROCESSING
460 REM 9900 EXIT ROUTINE
470 REM
599 R=0
600 REM ----- INITIALIZE SYSTEM -----
601 OPEN 2,2,0,CHR$(8)+CHR$(17)
602 REM 1200 BAUD,PARITY DISABLED,XLINE
605 DIM K(20),Y(20),X(20),E$(20),V$(2),E(20),D$(20),D(20)
615 POKE 53280,0:POKE 53281,0:REM SCREEN AND BORDER
630 PRINT CHR$(30)
631 IF R>0 THEN GOTO 640
640 GOSUB 8500:REM CLEAR SCREEN
650 REM
680 DATA 1,SET FREQUENCY,2,SET MODE
690 DATA 3,SET VFO A OR B,4,MEMORY CHANNEL
700 DATA 5,STORE MEMORY,6,MEMORY TO VFO
705 REM
750 REM ----- MAIN MENU -----
755 REM
760 GOSUB 8500:REM CLEAR SCREEN
765 PRINT CHR$(30)
770 PRINT TAB(11)"MAIN MENU"
775 PRINT
780 PRINT
785 PRINT TAB(3)"CODE"TAB(10)"FUNCTION"
790 PRINT
795 RESTORE
800 FOR X=1 TO 6
    
```

fig. 1. ICOM-735 hf transceiver program.

```

805 READ D,B*
810 PRINT TAB(3)D TAB(10)B*
815 PRINT
820 NEXT X
825 PRINT
830 PRINT TAB(4) "ENTER CODE"
840 REM
850 GOSUB 8000:REM SOFT KEYS
860 GET A*
865 IF A*="" GOTO 860
870 A=ASC(A*+CHR$(0))
875 A=A-48
880 IF A*=CHR$(133) THEN GOTO 860:REM BLANK SOFT KEY
885 IF A*=CHR$(134) THEN GOTO 640:REM MAIN MENU
887 IF A*=CHR$(135) THEN GOSUB 7000:SYSTEM STATUS
888 IF A*=CHR$(135) THEN GOTO 631:REM REDISPLAY MENU
890 IF A*=CHR$(136) THEN GOTO 9900:REM EXIT PROGRAM
900 IF A<1 OR A>6 THEN GOTO 631
910 ON A GOTO 1000,2000,3000,4000,5000,6000
920 GOSUB 8500:REM CLEAR SCREEN
922 PRINT
924 PRINT
926 PRINT
928 PRINT
930 PRINT "      INVALID CHARACTER, TRY AGAIN."
940 FOR X=1 TO 2500: NEXT X
950 GOTO 760
1000 REM
1010 REM *****
1020 REM * SET FREQUENCY ROUTINE *
1030 REM * CONTROL CODE 05 *
1040 REM *****
1060 GOSUB 8500:REM CLEAR SCREEN
1061 CLOSE 2
1062 OPEN 2,2,0,CHR$(8)+CHR$(17)
1110 REM
1120 FOR X=1 TO 10
1130 PRINT
1140 NEXT X
1150 INPUT "  ENTER NEW FREQUENCY IN MHZ ";F
1170 IF F<=30 AND F>=.1 THEN GOTO 1290
1180 PRINT "  FREQUENCY SELECTED IS OUTSIDE "
1185 PRINT "  BOUNDS OF IC-735. TRY AGAIN."
1190 FOR X=1 TO 2500: NEXT X
1200 GOTO 1060
1290 GOSUB 8900:REM CONVERT TO HEX
1300 PRINT#2,CHR$(254)+CHR$(254)+CHR$(4)+CHR$(241);
1310 PRINT#2,CHR$(5)+CHR$(W)+CHR$(V)+CHR$(L)+CHR$(T)+CHR$(253)
1320 GOSUB 8700:REM VERIFY DATA
1330 CLOSE 2
1340 GOTO 600
2000 REM *****
2010 REM * SET MODE *
2020 REM * CONTROL CODE 06 *
2030 REM *****
2040 REM
2050 CLOSE 2
2060 OPEN 2,2,0,CHR$(8)+CHR$(17)
2080 GOSUB 8500:REM CLEAR SCREEN
2090 FOR X=1 TO 10
2100 PRINT
2110 NEXT X
2115 M=4
2130 PRINT TAB(3)"LSB";
2140 PRINT TAB(9)"USB";
2150 PRINT TAB(15)"AM";
2160 PRINT TAB(21)"CW";
2170 PRINT TAB(27)"FM"
2172 PRINT
2175 INPUT "  ENTER MODE: ";M*
2180 IF M*="LSB" THEN M=00
2190 IF M*="USB" THEN M=01
2200 IF M*="AM" THEN M=02
2210 IF M*="CW" THEN M=03

```

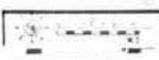


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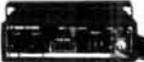
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```

2220 IF M$="FM" THEN M=05
2230 IF M=4 GOTO 2080
2240 PRINT#2,CHR$(254)+CHR$(254)+CHR$(4)+CHR$(242);
2250 PRINT#2,CHR$(06)+CHR$(M)+CHR$(253)
2260 GOSUB 8700:REM VERIFY DATA
2270 CLOSE 2
2280 GOTO 600
3000 REM *****
3010 REM * SET VFO *
3020 REM * CONTROL CODE 07 *
3030 REM *****
3040 REM
3050 CLOSE 2
3060 OPEN 2,2,0,CHR$(8)+CHR$(17)
3120 GOSUB 8500 :REM CLEAR SCREEN
3130 FOR X=1 TO 10
3140 PRINT
3150 NEXT X
3160 V=2
3170 INPUT " ENTER VFO A OR B";V$
3180 IF V$="B" THEN LET V=1
3190 IF V$="A" THEN LET V=0
3200 IF V=2 THEN GOTO 3000
3210 PRINT#2,CHR$(254)+CHR$(254)+CHR$(4)+CHR$(241);
3220 PRINT#2,CHR$(07)+CHR$(V)+CHR$(253)
3230 GOSUB 8700:REM VERIFY DATA
3240 CLOSE 2
3250 GOTO 600
4000 REM *****
4010 REM * DISPLAY MEMORY CHANNEL *
4020 REM * CONTROL CODE 08 *
4030 REM *****
4040 REM
4050 CLOSE 2
4060 OPEN 2,2,0,CHR$(8)+CHR$(17)
4080 GOSUB 8500 :REM CLEAR SCREEN
4090 FOR X=1 TO 10
4100 PRINT
4110 NEXT X
4130 INPUT " DISPLAY WHICH CHANNEL ";F
4150 IF F<=12 AND F>=1 THEN GOTO 4265
4160 PRINT " CHANNEL SELECTED IS NOT AVAILABLE"
4165 PRINT " ON IC-735. TRY AGAIN. "
4170 FOR X=1 TO 2500: NEXT X
4180 GOTO 4080
4265 GOSUB 8900:REM HEX CONVERSION
4270 PRINT#2,CHR$(254)+CHR$(254)+CHR$(4)+CHR$(241);
4280 PRINT#2,CHR$(08)+CHR$(T)+CHR$(253)
4290 PRINT#2,CHR$(254)+CHR$(254)+CHR$(4)+CHR$(241);
4300 PRINT#2,CHR$(08)+CHR$(253)
4310 GOSUB 8700:REM VERIFY DATA
4320 CLOSE 2
4330 GOTO 600
5000 REM *****
5010 REM * STORE TO MEMORY *
5020 REM * CONTROL CODE 09 *
5030 REM *****
5040 REM
5050 CLOSE 2
5060 OPEN 2,2,0,CHR$(8)+CHR$(17)
5120 GOSUB 8500 :REM CLEAR SCREEN
5170 PRINT#2,CHR$(254)+CHR$(254)+CHR$(4)+CHR$(241);
5180 PRINT#2,CHR$(09)+CHR$(253)
5185 FOR X=1 TO 10:PRINT:NEXT X
5190 GOSUB 8700:REM VERIFY DATA
5200 CLOSE 2
5210 GOTO 600
6000 REM *****
6010 REM * FROM MEMORY TO VFO *
6020 REM * CONTROL CODE 10 *
6030 REM *****
6040 REM
6050 CLOSE 2
6060 OPEN 2,2,0,CHR$(8)+CHR$(17)

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6150 GOSUB 8500 :REM CLEAR SCREEN
6170 PRINT#2,CHR$(254)+CHR$(254)+CHR$(4)+CHR$(241);
6175 PRINT#2,CHR$(10)+CHR$(253)
6180 FOR X=1 TO 10:PRINT:NEXT X
6190 GOSUB 8700:REM VERIFY DATA
6200 CLOSE 2
6210 GOTO 600
7000 REM *****
7010 REM * SYSTEM MONITOR *
7020 REM * CONTROLL CODES 03 AND 04 *
7030 REM *****
7040 REM
7061 CLOSE 2
7062 OPEN 2,2,0,CHR$(8)+CHR$(17)
7115 GOSUB 8500:REM CLEAR SCREEN
7120 FOR X=1 TO 10
7130 PRINT
7140 NEXT X
7240 M=3
7250 PRINT#2,CHR$(254)+CHR$(254)+CHR$(4)+CHR$(241);
7260 PRINT#2,CHR$(3)+CHR$(253)
7262 GOSUB 8700:REM GET DATA
7265 GOSUB 8600:REM RESULTS
7275 CLOSE 2
7280 OPEN 2,2,0,CHR$(8)+CHR$(17)
7284 M=4
7286 PRINT#2,CHR$(254)+CHR$(254)+CHR$(4)+CHR$(1)+CHR$(4)+CHR$(253)
7287 GOSUB 8700:REM GET DATA
7290 GOSUB 8626:REM RESULTS
7305 CLOSE 2
7310 RETURN
8000 REM ----- SOFT KEYS -----
8010 REM
8020 PRINT CHR$(18)
8030 PRINT CHR$(154)
8040 PRINT CHR$(19)
8045 PRINT
8046 PRINT
8047 PRINT
8060 REM PRINT TAB(33)"SYSTEM ";
8070 REM PRINT TAB(73)"MONITOR"
8100 PRINT
8110 PRINT TAB(33)" ";
8120 PRINT TAB(73)" ";
8130 PRINT TAB(30)"F3-MENU"
8140 PRINT
8150 PRINT
8155 PRINT
8160 PRINT
8170 PRINT TAB(30)"F5-SYSTEM";
8180 PRINT TAB(70)" STATUS "
8190 PRINT
8200 PRINT
8220 PRINT
8230 PRINT TAB(30)"F7-PROGRAM";
8240 PRINT TAB(71)" EXIT "
8250 PRINT CHR$(146):PRINT CHR$(30)
8260 RETURN
8270 REM
8500 REM ----- CLEAR SCREEN -----
8510 REM
8520 PRINT CHR$(19)
8530 PRINT CHR$(147)
8540 RETURN
8600 REM ----- RESULTS -----
8606 FOR X=1 TO 15
8608 IF K(X)=253 THEN GOTO 8610
8609 NEXT X
8610 PRINT "FREQUENCY:";
8614 FOR Y=X-1 TO 6 STEP -1
8616 F=K(Y)/16
8620 PRINT INT(F)TAB(0)(F-INT(F))*16;
8622 NEXT Y
8623 PRINT
8624 RETURN
8626 M$=""
8627 PRINT
    
```

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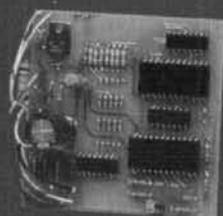
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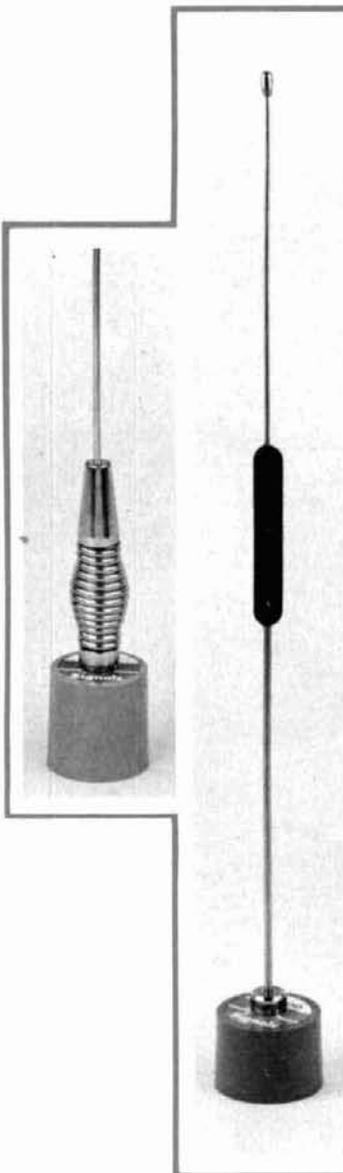
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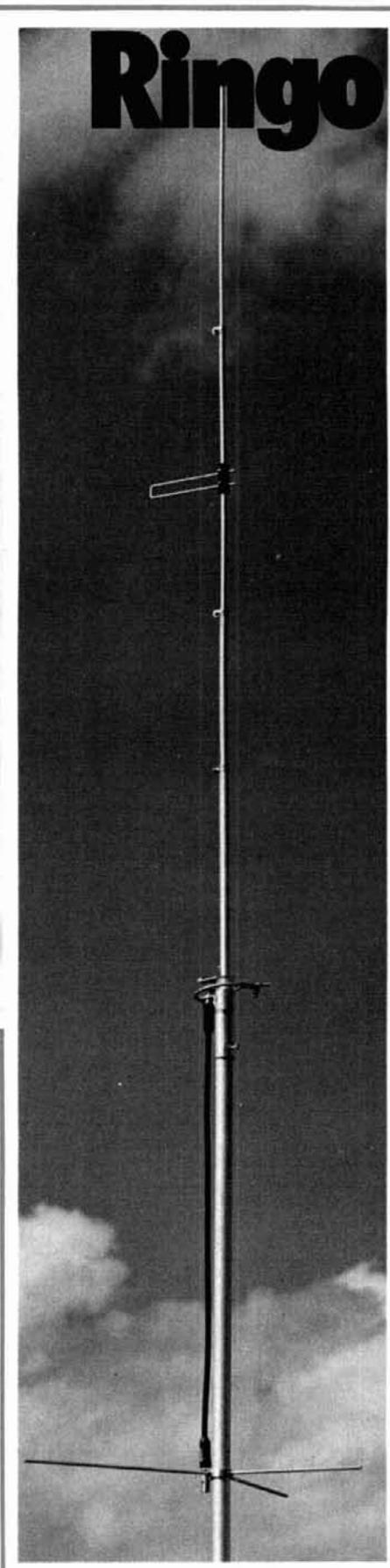
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ARX220B 220-225MHz
ARX450B 435-450MHz

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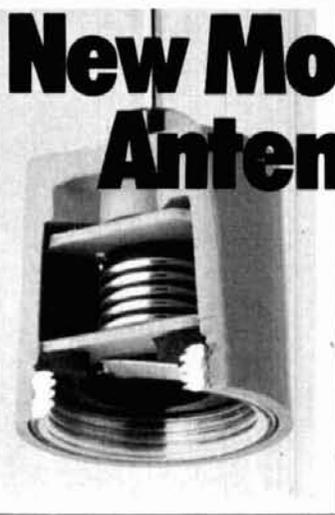
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```

8628 PRINT "MODE: ";
8630 IF K(5)=00 THEN M$="LOWER SIDE-BAND"
8632 IF K(5)=01 THEN M$="UPPER SIDE-BAND"
8634 IF K(5)=02 THEN M$="AM"
8636 IF K(5)=03 THEN M$="CW"
8638 IF K(5)=05 THEN M$="FM"
8640 IF M$="" THEN GOTO 9500:REM ERROR ROUTINE
8642 PRINT M$
8643 PRINT
8644 PRINT "PRESS RETURN TO CONTINUE"
8646 GET K$
8648 IF K$<>CHR$(13) THEN GOTO 8646
8650 CLOSE 2
8660 GOTO 600
8700 REM ----- VERIFY/GET DATA -----
8702 GET#2,D$
8704 IF D$="" GOTO 8702
8706 FOR D=1 TO 15
8710 GET#2,D$
8725 K(D)=ASC(D$+CHR$(0))
8727 LET E=K(D)
8730 SR=ST
8735 IF SR AND 247>0 GOTO 9500
8740 IF E=251 THEN PRINT " CHANGE ACCEPTED":REM VALID DATA
8745 IF E=253 THEN LET D=15:REM POST AMBLE
8750 IF E=250 THEN GOTO 9500:REM INVALID DATA
8755 IF E=252 THEN GOTO 9500:REM DATA COLLISION
8760 NEXT D
8770 FOR X=1 TO 2500:NEXT X
8785 RETURN
8790 REM
8900 REM ----- HEX CONVERSION -----
8902 REM F IS BROUGHT IN
8904 F=F+.000001
8906 T=INT(F)
8908 IF T>=10 THEN GOTO 8938
8910 F=(F-T)*10
8912 U=(INT(F))*16
8914 F=(F-INT(F))*10
8916 U=U+INT(F)
8918 F=(F-INT(F))*10
8920 V=(INT(F))*16
8922 F=(F-INT(F))*10
8924 V=V+INT(F)
8926 F=(F-T)*10
8928 W=(INT(F))*16
8930 F=(F-INT(F))*10
8932 W=W+F
8934 RETURN
8938 T=(T-(INT(T/10))*10)+(16*INT(T/10))
8940 F=(F-INT(F))*10
8950 GOTO 8912
9500 REM ----- ERROR PROCESS -----
9505 PRINT " STATUS ERROR "SR AND 255
9510 IF SR AND 2=2 THEN PRINT " FRAMING ERROR"
9515 IF SR AND 4=4 THEN PRINT " RECEIVER BUFFER OVERRUN"
9520 IF E=250 THEN PRINT " RADIO DETECTED BAD DATA"
9525 IF E=252 THEN PRINT " DATA COLLISION DETECTED."
9530 PRINT:PRINT
9535 PRINT " PRESS F1 TO RESTART"
9540 PRINT " PRESS F7 TO EXIT PROGRAM"
9545 GET A$
9550 IF A$="" THEN GOTO 9545
9555 IF A$<>CHR$(13) THEN GOTO 9910
9560 CLOSE 2
9565 GOTO 600
9900 REM ----- PROGRAM EXIT -----
9910 GOSUB 8500
9920 CLOSE 2
9930 END

```

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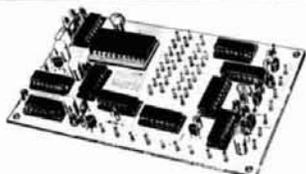
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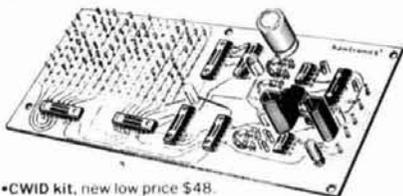
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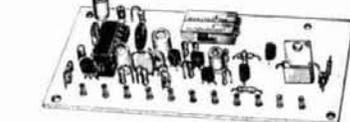
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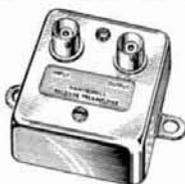


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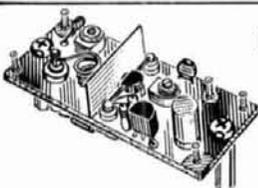
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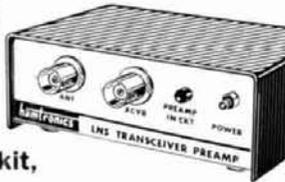
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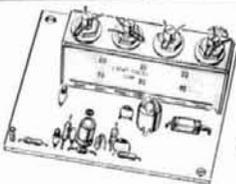
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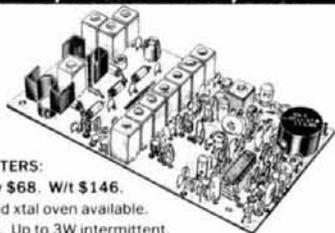
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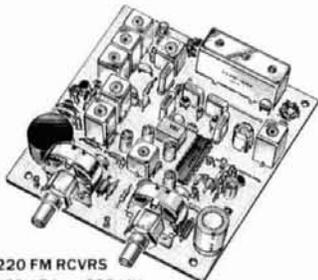
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	145-147	28-30
	146-148	27-27.4
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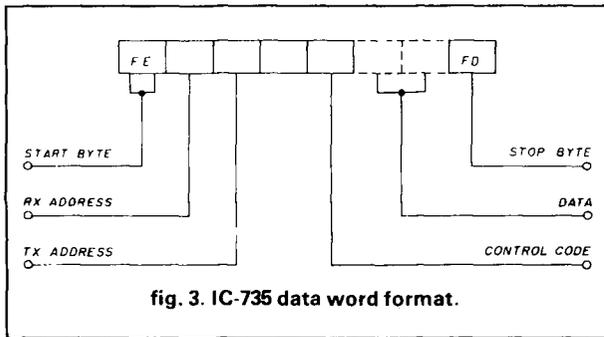
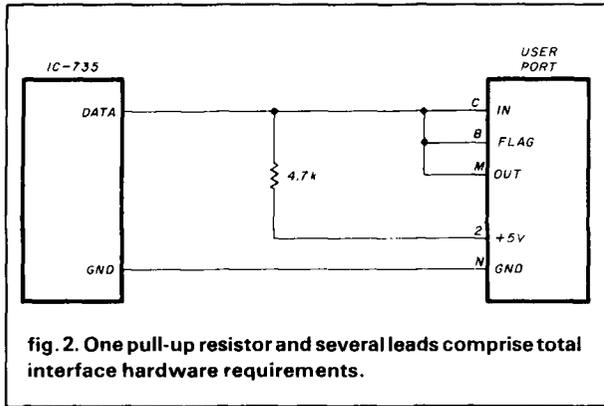
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functional control block encountered by the program. It, like those that follow, begins by closing and reopening the user port and clearing the screen. **Lines 1150 through 1200** prompt the user for a new frequency. **Line 1290** calls a subroutine beginning at **line 8900** that converts the user input value to a hexadecimal format as required by the IC-735. On return from the subroutine, the hexadecimal representation of the new frequency is stored in variables T, U, V, and W, with T having the most significant digit and W the least. **Figure 4** gives the basic format of the data word. The IC-735 recognizes a hex "FD" (253) as the final character in the data stream and responds by returning its own data stream with either a valid data character or an invalid data character embedded. To verify the acceptance of the sent data, the program calls a subroutine at **line 8700** which isolates the check character and validates the data. This subroutine tests for data collisions between rigs, incorrect data transmissions, C-64 buffer overflow, and framing errors. If the data is acceptable, the program returns from the subroutine. Otherwise, it branches to **line 9500**, which identifies the error and gives the operator the option of continuing or ending the program.

mode control

Port control, data conversion and error checking are performed here and in the following functions in the same manner as in the frequency selection function.

The block of code beginning at **line 2000** prompts the user for the desired operating mode and sets the transceiver accordingly. The acceptable modes are USB, LSB, a-m, fm, and CW.

VFO control

VFO control is performed by the block of code beginning at **line 3000**. The user is prompted to select the desired VFO, which is changed to a number, inserted into the character string, and printed to the Commodore's user port.

memory recall

Memory channel control is performed in the block beginning at **line 4000**. After the screen is cleared and the user port opened, the operator is prompted to select the desired memory channel. If the channel number selected is outside the bounds of the IC-735, the screen is cleared and the operator re-prompted for a correct channel number. The IC-735 is then programmed for memory mode and the character string to recall the selected channel sent after the channel number has been converted to its hexadecimal equivalent. It is important to remember that *any data sent to the serial bus must be in hexadecimal format.*

memory store

Storing the present transceiver frequency and mode into the displayed memory channel is performed in the code beginning at **line 5000**. This section requires no input from the operator because the current configuration of the rig is stored in the displayed memory channel automatically.

VFO programming

VFO programming is performed in the code beginning at **line 6000**. This section stores the transceiver's present mode and frequency into the last displayed VFO memory.

radio configuration

The transceiver's current frequency and mode is determined starting at **line 7000**. A character string with control codes 3 and 4 is sent to the rig. The transceiver responds by returning the current frequency and mode, which are decoded and printed to the monitor. Control is returned to the main menu after data has been verified.

subroutines

Housekeeping and support subroutines begin after **line 8000**. **Line 8000** begins a subroutine to provide visible "soft-keys" on the monitor screen. The legends on these "keys" correspond to the functions available on the Commodore "F" keys. **Line 8500** begins a "clear screen" subroutine. **Line 8600** starts a subrou-

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XF-9C	AM	3.75 kHz	8	77.40
XF-9D	AM	5.0 kHz	8	77.40
XF-9E	FM	12.0 kHz	8	77.40
XF-9M	CW	500 Hz	4	54.10
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tine that interprets data received from the transceiver in response to control codes 3 and 4. It calculates the frequency and mode from the data and prints the results. The subroutine at line 8700 checks the incoming variable length data stream for validity and sets error flags accordingly. The subroutine at line 8900 converts a decimal number to its hexadecimal equivalent. Error handling is performed by the subroutine at line 9500. Data failures for the IC-735 and Commodore are identified and the user is given the option of continuing or exiting the program.

summary

The hardware for this project is very simple: just an ordinary resistor. The software, though complex in appearance, is also quite simple. It provides the casual user the basic operational capability of an automated station. An experienced programmer can use the ideas presented here in more sophisticated applications or hang "bells and whistles" on the existing code. The possibilities are virtually unlimited. Automated control of Amateur equipment is the wave of the future. This little project is just one of the ripples.

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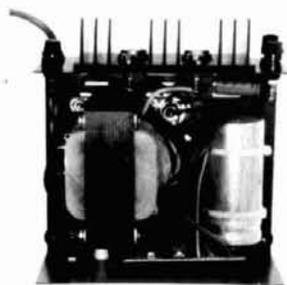
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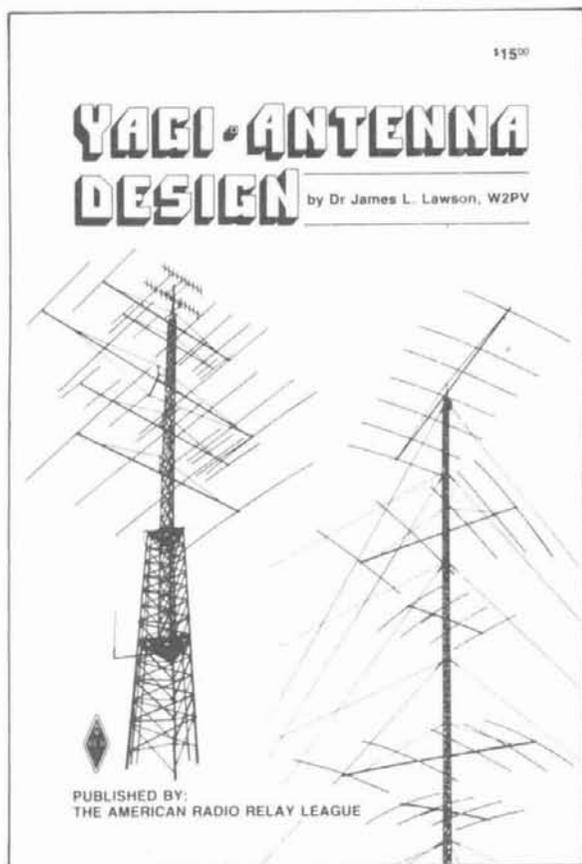
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the ubiquitous diode: part 2

Last month's column discussed the electrical and mechanical properties of solid-state diodes, with emphasis on the most important parameters.¹

This month we'll focus on specific applications using solid-state diodes, emphasizing circuitry and how to select the right diode for each particular application. Some of the applications we'll cover are rectifiers/detectors, regulators, mixers, switches, limiters, tuning elements, multipliers, oscillators, and optical devices.

simple diode applications

VHF/UHFers seldom give adequate notice to the use and abuse of low-frequency diodes. They forget that the diodes in a power supply or dc protection scheme are often just as important to system reliability and performance as the VHF/UHF diodes in rf circuits.

For instance, it makes little sense to use vacuum tube rectifiers, which generate rf noise and have a very short lifetime when compared with properly installed solid-state rectifiers. Furthermore, solid-state diodes are instantly ready to operate; no warm-up time is required. This is particularly important in bias supplies for high-power vacuum tube amplifiers where you need to have proper bias applied before ener-

gizing the high voltage.

While on the subject of high-voltage rectifiers, the economy and reliability of a single packaged unit is recommended.* Using strings of diodes, resistors, and capacitors for high-voltage rectifiers is an open invitation to failure and is really no longer cost-effective. I can attest to this because I once used such arrangements before complete packaged units were available.

Before leaving dc applications, don't forget the lowly "idiot diode." *If you leave it out you are an idiot.*² Idiot diodes are used to prevent connecting the dc power with reverse polarity to a solid-state circuit. Few solid-state devices will survive such an accident.

Some typical reverse protection circuits are shown in **fig. 1**. The circuit in **fig. 1A** is by far the most common,² but will induce an additional voltage drop of approximately 0.7 volts, which may be unacceptable, especially in power amplifier applications.³ The circuit illustrated in **fig. 1B** eliminates the voltage drop problem. However, using a small signal type diode in this circuit may still cause burnout if the circuit is improperly powered. *Forward current in this circuit is limited only by the supply and the diode resistance.* Therefore, its protection effectiveness decreases if the power supply current

capability is higher than the diode can handle.

The circuits illustrated in **figs. 1C** and **1D** are recommended to prevent idiot diode burnout. They can be used with small signal diodes if the voltage drop across the series resistor is acceptable. This is often acceptable, especially when using low-voltage devices such as GaAsFETs.⁴ Typically 50 to 100 ohms of series resistance is sufficient.

However, some diodes, especially high-speed types or those designed for use in computers, are fast enough to respond to hf signals. Any rf coupled into the power supply line, especially from a local hf transmitter, can be rectified by the idiot diode and increase the circuit voltage above that from the supply alone.^{5,6} Therefore a large (0.01 to 0.1 μ F typical) bypass capacitor at the power supply input terminals is recommended to bypass any rf before it reaches the idiot diode.

Low-frequency diodes are also used to bypass relay coils (**fig. 1E**). This diode, which Amateurs often leave out, is recommended because the transient induced by the de-energizing of a simple T/R relay can cause large voltage spikes to appear on power supply lines.

Therefore, never connect solid-state circuits, especially those used for low-

noise amplifiers, to a power supply that is also used to supply a relay. This is an open invitation to disaster because the voltage spikes generated by opening a relay coil can destroy other circuits connected to the same power supply.⁶

The zener is another diode popular with VHF/UHFers. Actually, this type of diode is working in a normally forbidden mode — in the reverse biased or avalanche region. By careful manufacturing control, the breakdown voltage of the zener is predetermined along with the series resistance of the diode. The heat dissipation in the junction must also be removed so that thermal runaway or junction burnout does not occur.

A zener diode makes a reasonable voltage regulator or limiter with a stable breakdown voltage within a speci-

fied current range. Zeners should be used with care, however, especially as voltage regulators for oscillators, because they generate broadband low-frequency noise in the avalanche mode.

If you use a zener in an oscillator circuit, be sure to provide adequate low-frequency bypassing such as a high-value (10 to 100 μ F) bypass capacitor (fig. 1G). Personally, I prefer to use the newer three-terminal voltage regulators rather than zeners because they are quieter and usually have a wider regulation range versus output current than most zeners.⁴

Finally, it has been shown that under certain operational conditions a three-terminal voltage regulator can be damaged. The addition of two extra diodes around the regulator is suggested (fig. 1F).⁴

rf detectors

One of the first major VHF-and-above applications of solid-state diodes was as rf detectors. This application, which dates back to the "good old a-m days," is still quite prevalent, especially as the detector in police radar! Rf detector diodes are also widely used today in VSWR and rf power meter applications.

Good rf detector diodes can be quite sensitive. The lowly point contact diode can detect rf below -60 dBm (200 microvolts rms in a 50-ohm system).¹ However, this will probably require some additional amplification at the output of the detector. At somewhat higher rf input levels (greater than -10 dBm or 70 millivolts), this same diode can directly drive a microammeter for power measurements.

Some typical rf detector circuits are shown in fig. 2. Figure 2A shows an optimized detector with an input matching network. Most detector diodes have a high input impedance. Therefore, the circuit in fig. 2A may exhibit narrow bandwidth.

If wide bandwidth is desired, the simple circuit in fig. 2B is usually used.⁷ It has lower sensitivity than a matched detector, but this is easily traded off for the wider bandwidth

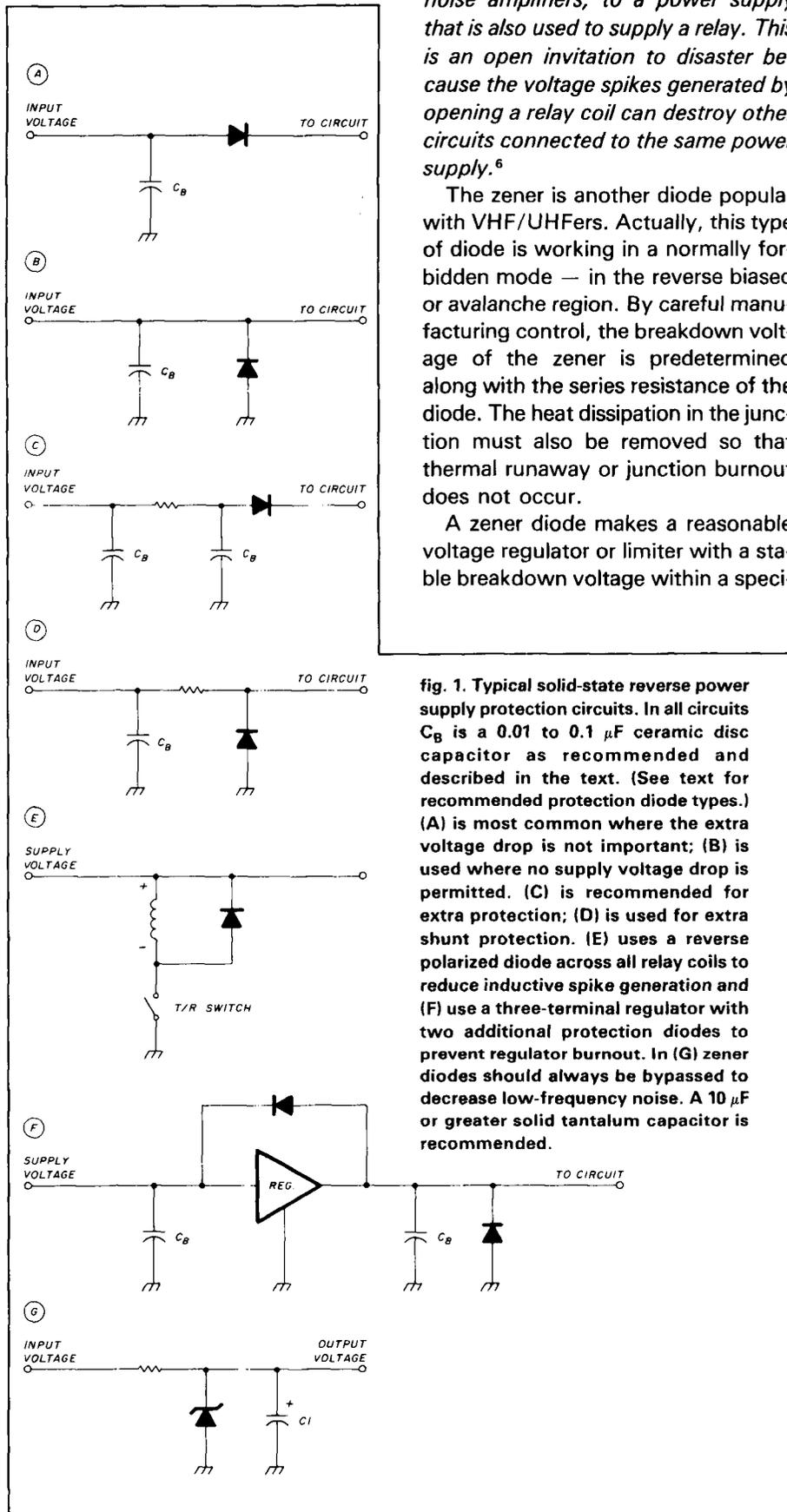


fig. 1. Typical solid-state reverse power supply protection circuits. In all circuits C_B is a 0.01 to 0.1 μ F ceramic disc capacitor as recommended and described in the text. (See text for recommended protection diode types.) (A) is most common where the extra voltage drop is not important; (B) is used where no supply voltage drop is permitted. (C) is recommended for extra protection; (D) is used for extra shunt protection. (E) uses a reverse polarized diode across all relay coils to reduce inductive spike generation and (F) use a three-terminal regulator with two additional protection diodes to prevent regulator burnout. In (G) zener diodes should always be bypassed to decrease low-frequency noise. A 10 μ F or greater solid tantalum capacitor is recommended.

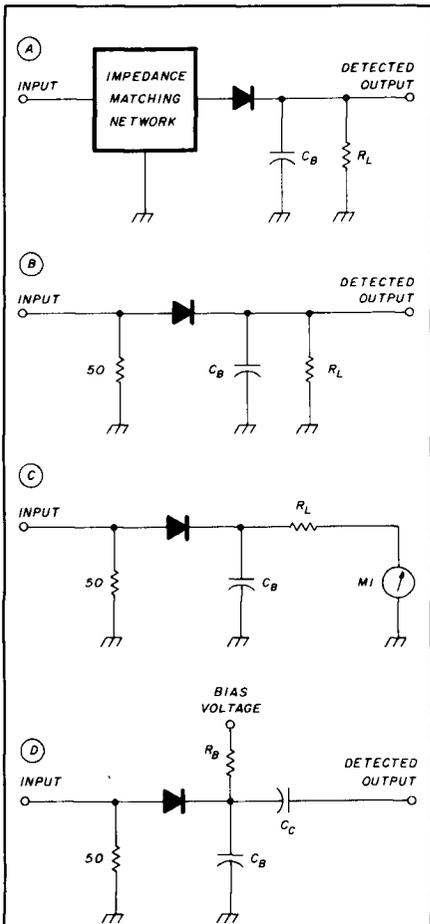


fig. 2. Typical diode detector circuits. (See text for recommended diode types.) In all cases C_B is an rf bypass capacitor. A feedthrough type $0.001 \mu\text{F}$ capacitor is recommended. R_L is the video load (10k ohms typical). (A) is recommended in narrowband applications where maximum detector sensitivity is desired. (B) shows a simple broadband detector. The 50-ohm resistor should have good rf characteristics. (C) illustrates a method for using the circuit shown in fig. 2B for power detection with a meter; (D) shows a method for increasing the sensitivity of an HCD by applying an external bias voltage. C_C is a dc blocking capacitor and R_B is the dc biasing current resistor as explained in the text.

capabilities. If a meter is added in series with the detector output load (fig. 2C), a detector can be used directly as a power meter over a wide frequency range.

Before designing a detector, it is important to compare the various types

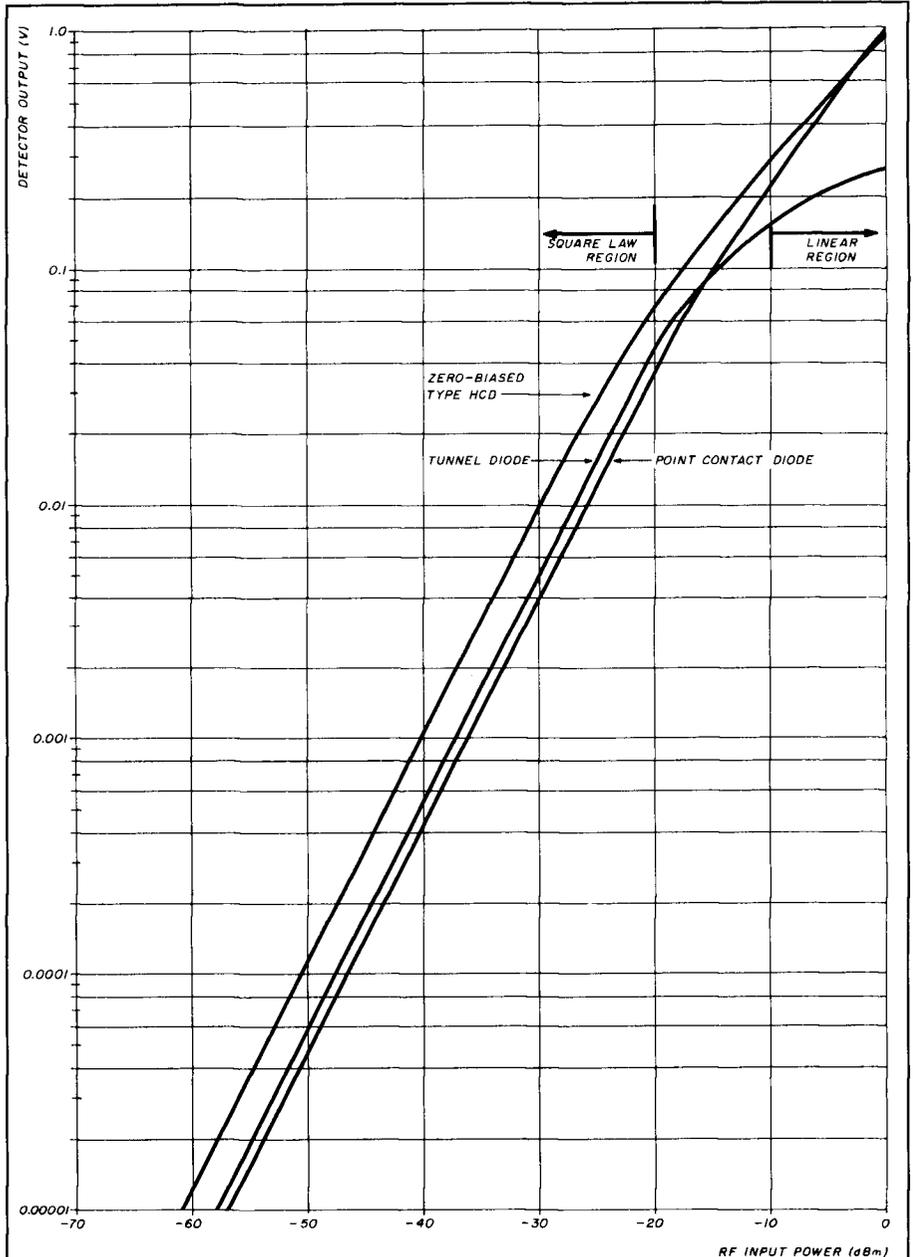


fig. 3. Typical output voltages for different types of detector diodes versus rf input power level into a 10-k load resistor using the circuit shown in fig. 2A.

of diodes that were mentioned in reference 1. The most common detector types are the point contact, the silicon junction, and the Schottky or hot carrier diode (HCD).

The point contact diode, the first sensitive solid-state detector diode, was followed by the much less sensitive junction diode in the late 1950s. First introduced in the 1960s, the HCD is 20 to 30 dB less sensitive than a typi-

cal point contact diode. However, the HCD is still more sensitive than the typical silicon junction diodes because it has a lower barrier voltage.¹

In the mid-1970s, the zero-bias HCD was developed. It has a very low barrier voltage, making it an ideal small signal detector. Typical input-versus-output voltages for the types of detector diodes just discussed are illustrated in fig. 3.

Note in **fig. 3** that below about -20 dBm (22 millivolts) most detector diodes have what is called a "square law" region where the output or detected voltage doubles each time the input power is doubled. However, above -10 dBm (70 millivolts) most detector diodes have a detected output

voltage that is a linear function of the input power level. In between these rf levels is a very nonlinear region where compression takes place.

Nowadays, the low- to medium-barrier voltage HCD is usually preferred for detector applications. However, to make it competitive in dynamic range and sensitivity with point contact diodes, the barrier voltage must be overcome. This can be accomplished easily with a small amount (5 to 20 microamperes) of forward bias current applied as shown in **fig. 2D**.

Properly biased, the HCD offers greater forward conductivity (more output voltage for a given input power level), almost zero recovery time, and low cost. Furthermore, HCDs usually have a better impedance match than other types of diodes. They have vastly lower microphonics than other types of detector diodes. HCDs also have less flicker or 1/f noise, a phenomenon in which the noise figure of a device increases with decreasing frequency, especially below 10 kHz. Point contact diodes are very noisy and therefore unsuitable for radar applications, in which the information returned is in the very low or subaudible frequency range.

Some precautions must be observed with HCDs. They normally have a low peak reverse breakdown voltage as discussed in reference 1. When a higher reverse breakdown voltage (15 to 75 volts) is required, a "guard ring" structure must be added internally to the diode chip by the manufacturer. However, this increases junction capacitance and thus decreases the upper frequency limits of operation.¹

tunnel diodes

One diode that I didn't mention previously, but is often used for rf detectors, is the tunnel diode, sometimes referred to as the Esaki diode after its inventor, Dr. Leo Esaki, who discovered the effect in 1959. It's also referred to as a "back" diode because its main current flow is in the back biased rather than the forward biased direction. It has high sensitivity at very low rf input levels, utilizing the quantum mechanical tunneling effect.

Tunnel diodes may be manufactured using different semiconductor materials such as germanium, silicon, or gallium arsenide, depending on the frequency range desired. The main drawbacks of tunnel diodes are difficulty of manufacture (because they require a highly doped alloy junction), a lower burnout level, and a narrow dynamic range, typically only 40 dB, as opposed to 60 or more dB for a good point contact or zero bias hot carrier type diode (**fig. 3**).

mixers

Frequency conversion or mixing is the process which converts a signal at a low power level from one frequency to another by combining it with a higher level signal such as the local oscillator (LO) in a nonlinear device such as a mixer diode. In theory, this mixer diode generates an infinite number of sum and difference frequencies called the i-f or intermediate frequency as well as harmonics of the input and local oscillator frequency.

In practice, only a small portion of the available rf signal power is converted to the i-f. This ratio of signal level to i-f power is referred to as *conver-*

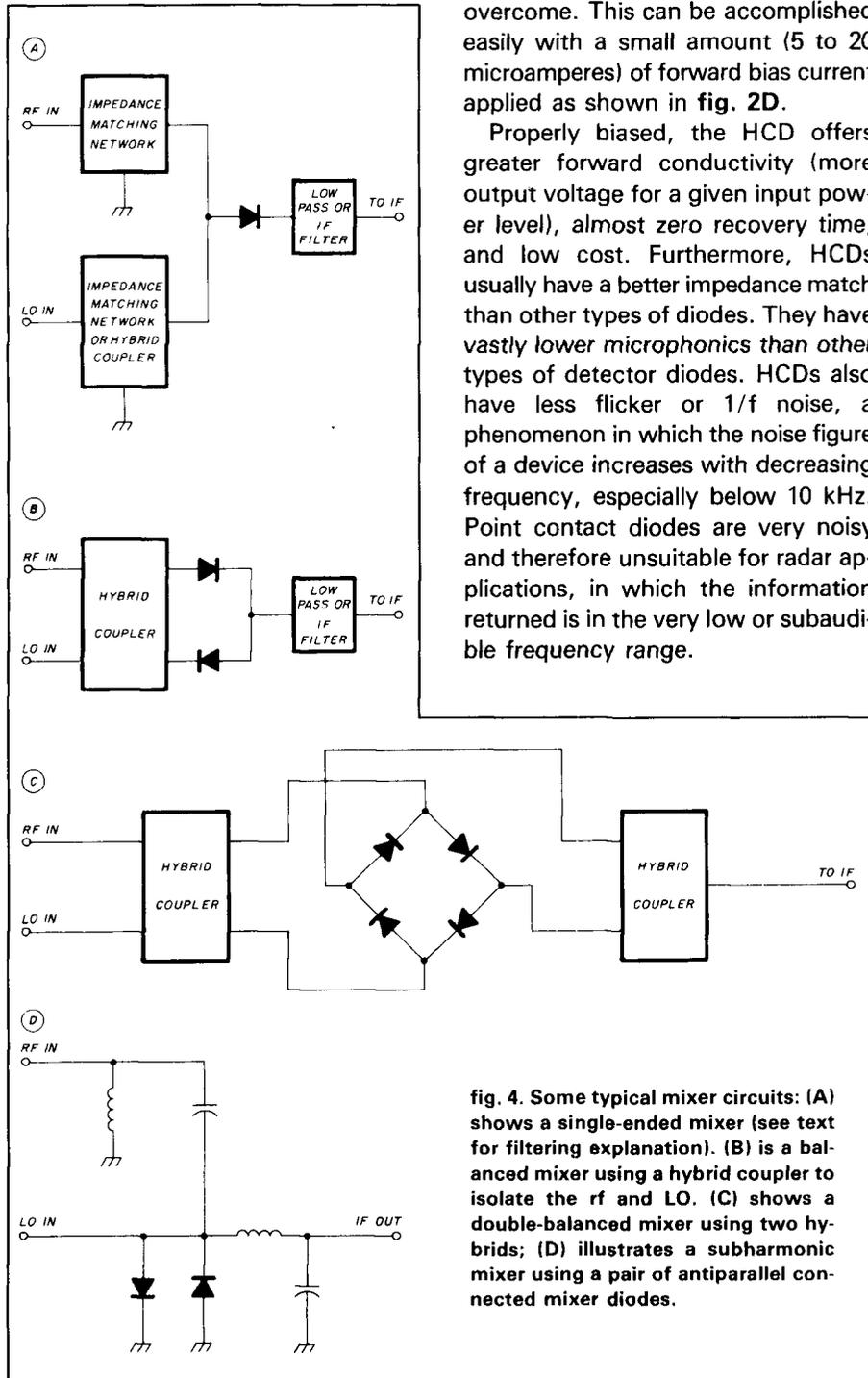


fig. 4. Some typical mixer circuits: (A) shows a single-ended mixer (see text for filtering explanation). (B) is a balanced mixer using a hybrid coupler to isolate the rf and LO. (C) shows a double-balanced mixer using two hybrids; (D) illustrates a subharmonic mixer using a pair of antiparallel connected mixer diodes.

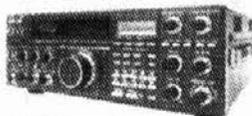
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sion loss. This loss is primarily a function of the local oscillator level (or rf bias), the diode junction, the diode's parasitics, and the mismatch at the rf and i-f frequencies. At higher frequencies, the junction capacitance becomes a primary limitation because it tends to bypass the junction resistance.¹

Figure 4A shows this mixing process schematically in a circuit which is usually referred to as a single-ended mixer. If the mixer is a downconverter, the typical receiver type, both the local oscillator and rf matching networks should be high-pass filters so that the i-f isn't shunted to the input. Conversely, the i-f port should be a low-pass filter type of matching network so that only the i-f is present at the output. For upconversion, the filters/matching networks are reversed accordingly.⁹

Most good detector diodes work well as mixers in a single-ended configuration. Point contact diodes were used for many years before the HCD

was available. The HCD is preferred since it has lower parasitics, lower series resistance, higher conversion efficiency, and low storage time and the ability to switch from the on to the off state in almost zero time.

The single-ended mixer has many disadvantages. The matching networks all have loss and restrict bandwidth. As the i-f, rf, and LO frequencies converge, filtering becomes more complicated and the conversion loss increases accordingly. It is also difficult to adequately filter out all the frequencies causing increased conversion loss.

Some of the impedance matching disadvantages of the single-ended mixer can be overcome by using a 90- or 180-degree hybrid coupler in a balanced mixer such as shown in **fig. 4B**. The hybrid transformer isolates the LO and rf from each other. However, the i-f matching/filtering is still a problem and twice as much LO power is required. The double-balanced mixer or DBM solves most of these problems

and is essentially two single-ended balanced mixers connected in parallel and 180 degrees out of phase (**fig. 4C**).

Actually, the DBM is really acting as a switch rather than a nonlinear junction. If the diodes are all similar (matched) and the transformers are well balanced, the rf, LO, and i-f ports will be well isolated from each other. Furthermore, there is suppression of the even-order harmonics, which significantly reduces intermodulation products. Finally, since the LO power is four times that required for a single-ended mixer, and less rf is across each diode, the intermodulation distortion is greatly improved.

Low series resistance and almost zero charge storage time make the HCD the ideal diode for a switching type of mixer. Furthermore, diode manufacturing technology now permits HCDs to be manufactured as either beam lead, monolithic pairs, or monolithic quads of diodes all closely matched on a single miniature sub-

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strate with a minimum of parasitics.

The DBM works well as a mixer and is very simple to implement in up- or downconverters. Further use and applications of the DBM are discussed in references 8 through 10.

A newer type of mixer is the subharmonic configuration,¹¹ which uses two diodes in antiparallel connection (fig. 4D). The chief advantage of this type of mixer is that the LO operates at half the normal frequency, so fewer LO multipliers are needed; this represents a significant breakthrough on millimeter-wave frequencies.

switches

Diodes can make excellent switches because they usually require only low forward current and can be remotely situated from the power supply. Therefore they can be located close to the circuitry to be switched.

Because of its high speed and fast recovery time, the HCD can be a good switch. However, its series resistance

may be too high if low insertion loss is important. The HCD is also a good rectifier, as discussed earlier. Therefore HCDs can introduce some loss and intermodulation distortion, especially if the rf level across the diode is sufficient.

The PIN (positive-intrinsic-negative), a three-layer diode, was invented accidentally in 1956 and is now the most widely used solid-state switch. A PIN diode is actually no more than a lousy rectifier. The longer its "lifetime" (the inability to rectify in the presence of rf), the less likely it will be to cause intermodulation. Diodes with at least a 1- to 2-microsecond lifetime can be used in the hf region. Shorter lifetimes are fine at VHF and above.

When reverse biased, the middle or intrinsic layer of a PIN diode has extremely high resistance, with a small shunt capacitance. When a PIN diode is forward biased, it takes a finite time to switch to the "on" state. When forward biased, it acts like a current-controlled resistor: the greater the for-

ward dc current, the lower the resistance.

PIN diodes are often used to switch rf because series resistances of less than 1.0 ohm are available. An example of a simple PIN diode switching circuit with low insertion loss is shown in fig. 5A. Low-capacitance PIN diodes will yield the highest isolation in the de-energized state, especially at the higher frequencies.

For very high isolation, two switch sections can be cascaded with a transmission line between the diodes (fig. 5B). For maximum isolation, the length of the interconnecting transmission line should be between 0.1 to 0.25 wavelengths, as explained in reference 5.

A typical two-pole PIN switch circuit is shown in fig. 5C. Commercially packaged two-pole, high-power switches suitable for switching over 100 watts through 1000 MHz (such as the M/A-Com MA8334 series) are now available. These high-power PIN diode pairs are available in a threaded stripline package for minimum VSWR



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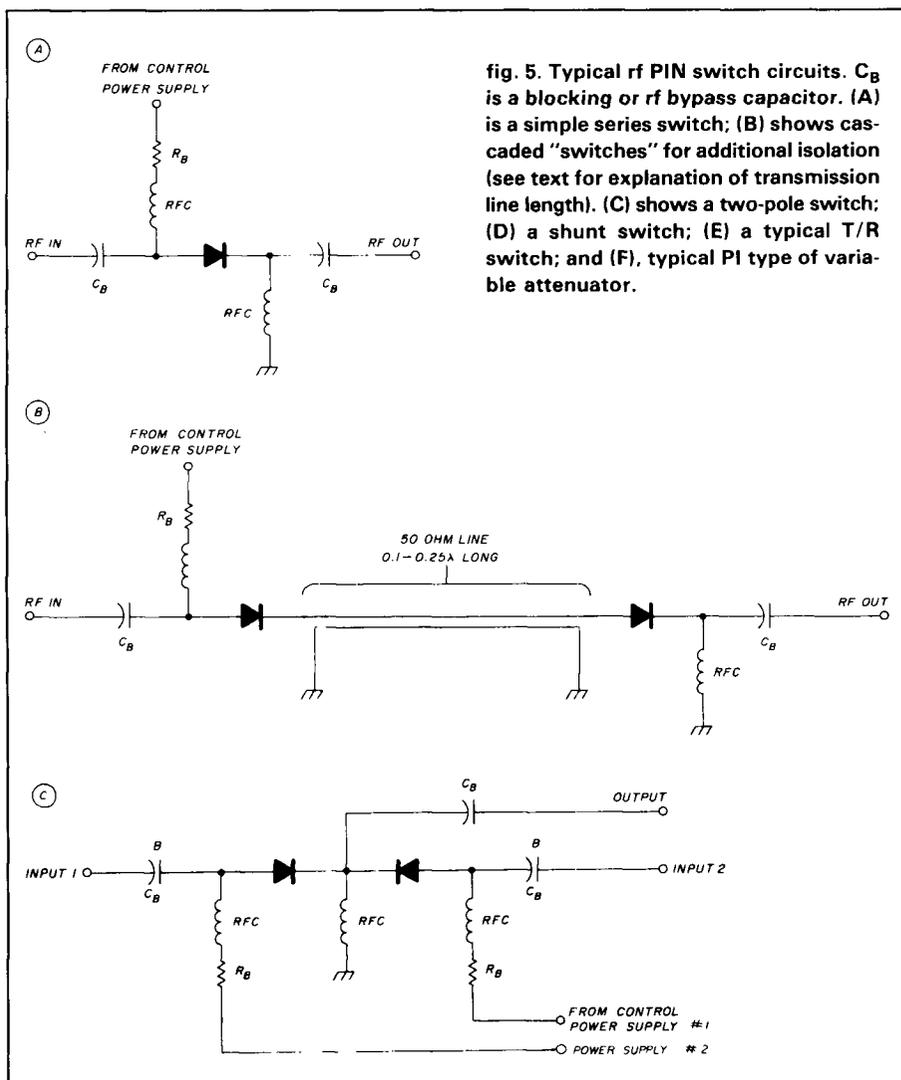


fig. 5. Typical rf PIN switch circuits. C_B is a blocking or rf bypass capacitor. (A) is a simple series switch; (B) shows cascaded "switches" for additional isolation (see text for explanation of transmission line length). (C) shows a two-pole switch; (D) a shunt switch; (E) a typical T/R switch; and (F), typical PI type of variable attenuator.

and maximum heat dissipation.

So far, the circuits illustrated use the series configuration. PIN diodes can also be used in shunt as illustrated in fig. 5D. An example of a shunt and series switch combination used as a T/R switch to provide extra receiver protection is shown in fig. 5E. Again, note the diode separation as described in reference 5.

Often used as variable attenuators, PIN diodes can have a very linear attenuation characteristic. The circuit shown in fig. 5A can be used as a variable attenuator by making R_1 and/or the power supply voltage adjustable. More complicated circuits such as "L," "T," and "PI" types with up to three PIN diodes are also in wide use. An ex-

ample of a typical "PI"-type variable attenuator circuit appears in fig. 5F.

Most PIN diodes specified for variable attenuator applications have a graded resistance versus control current, so you may need a wide range of current — 0.1 to 50 mA, typically, but this is a function of the type of PIN diode used. PIN diodes used for switching often require only a nominal fixed current. Remember that all PIN diodes used in the hf region must have longer charge carrier lifetimes to prevent intermodulation distortion.

tuning diodes

Varactors (sometimes called "varicaps" or tuning diodes) were first developed in 1958. Basically a voltage-

dependent capacitor, as described in reference 1, it is always operated with reverse bias across the diode.

Most varactor diodes are used to vary the frequency of a filter or oscillator. Varactors are especially common in places where only a small capacitance change is required, such as in a BFO or RIT control. A typical remotely tuneable filter using a varactor diode is shown in fig. 6A; fig. 6B shows a VFO circuit application. High- Q , low-capacitance varactors are still used in parametric amplifiers, where the diode is pumped with an external oscillator (usually called the pump) to act as a low-noise, high-gain amplifier. Note that the electronic symbol for a varactor diode is different from a standard diode with a sort of capacitor symbol tacked on to the cathode terminal.

In some applications there is sufficient rf voltage across a varactor diode to cause forward biasing, rectification, and distortion — a very undesirable situation. This phenomenon can be significantly improved or eliminated by using back-to-back varactors as illustrated in fig. 6C. However, the capacitance of each diode must then be doubled because they are now in series.

Because so many types of varactor diodes are available, many different capacitance-versus-voltage, or "CV" characteristics, may be obtained. Some examples of CV curves were provided in fig. 5 of reference 1, so they will not be repeated here. Examine the CV characteristics desired for your application to see whether abrupt or hyper-abrupt tuning characteristics are required.

Finally, when selecting a varactor diode, always check the supplier's data sheet carefully for the recommended frequency range, Q , nominal capacitance at -4 volts (the standard reference voltage), and the available tuning range. Always operate a varactor so that it doesn't become forward biased. If that is a problem, use a diode with twice the capacitance and the circuit recommended in fig. 6C as just described.

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multipliers

Diodes play a very important function as frequency multipliers. There are at least three types of diode multipliers in common use: varactor, resistive, and "step."

I'm sure that most readers have seen multiplier circuits where a diode is driven with a moderate amount of rf, typically 1 to 10 milliwatts, in order to generate harmonics. A typical circuit example is shown in **fig. 7A**.

In this particular application, the available harmonic power is primarily a function of the diode's nonlinear capacitance-versus-voltage characteristic and the stored charge in the diode, as mentioned earlier. In both regards, the point contact or typical

silicon junction diodes (even 1N914s have worked!) are preferred because they generally have a greater nonlinear capacitance change near zero bias and are more likely to take longer to "dump" the stored charge, which is a desired characteristic of a good multiplier.

The HCD would be a less efficient multiplier in the above configuration because it falls into the resistive multiplier class. It has very little capacitance-versus-voltage change (see **fig. 5** in reference 1) and is known for its quick switching response or ability to dump the stored charge almost instantly, as mentioned earlier.

However, if you operate an HCD in a balanced doubler configuration (analogous to a typical 60-Hz full wave power supply rectifier) similar to the frequency doubler circuit provided in reference 12, high efficiency can be obtained. Using HCDs in the circuit shown in **fig. 7B** yields good doubler efficiency results (only 6 to 12 dB conversion loss.) Furthermore, the fundamental and third harmonics are typically rejected by 20 to 30 dB. Hence less output filtering is required.

Although balanced HCD doublers have moderate conversion loss, they are very stable and have low noise. Sometimes they're easier to work with

than transistor doublers. With the availability of silicon MMICs (micro-wave monolithic integrated circuits), the conversion loss of a balanced HCD or the single-ended diode multiplier as described above can be inexpensively brought back to unity or greater gain as described in reference 12. I've been using this technique for many years with great success, and was doing so even before MMICs were available.

Moderate power (5 to 50 watt) varactors have been used for many years as doublers and triplers up through 23 cm (1296 MHz). Diodes such as the surplus Microwave Associates MA 4060 low-cost, threaded-package, high-power varactor are in widespread use.¹³ Even small signal varactors such as those discussed earlier for tuning oscillators and filters will work well at low input power levels (10 to 1000 milliwatts).

A typical varactor diode multiplier circuit (**fig. 7C**) consists of an input matching network, a varactor diode with its associated bias resistor, R_B and the output filter network. Although their efficiency decreases when varactors are used as triplers, it can be enhanced considerably by adding an idler circuit. This circuit consists of a high-Q series circuit tuned to the second harmonic of the input frequency (**fig. 7C**).

SRD multipliers

The SRD (step recovery or "snap" diode) is the "king" of multiplier diodes, especially when high efficiency and higher order multiplication (greater than 3 times) is required.¹⁴ SRDs have a structure very similar to that of a PIN diode.

The capacitance of an SRD can usually be assumed to be independent of minor voltage changes and has a CV characteristic similar to that of an HCD¹. When the rf input voltage goes positive, the diode turns on and stores a charge in the intrinsic region. When the applied voltage goes negative, it takes a finite time for the stored charge to decrease (the "snap" time), at which time the diode will abruptly turn off. During this transition period, the

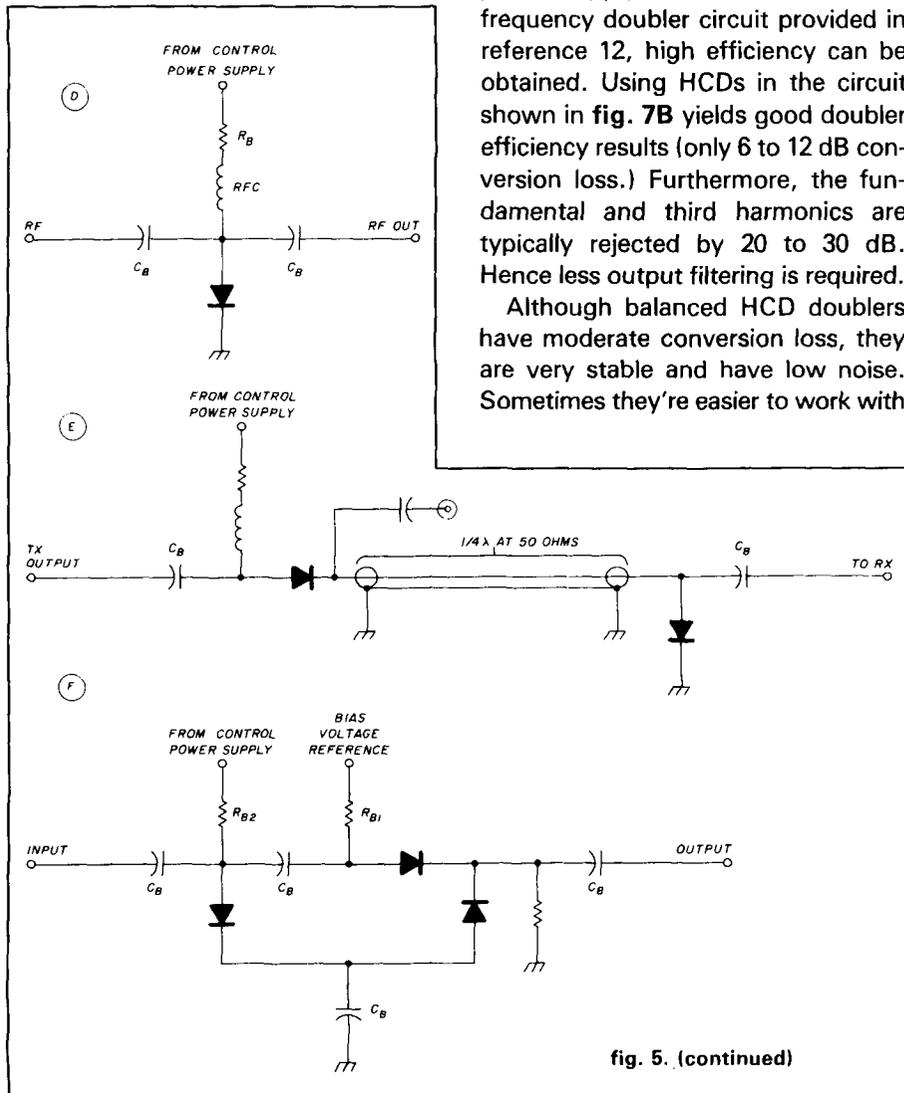


fig. 5. (continued)

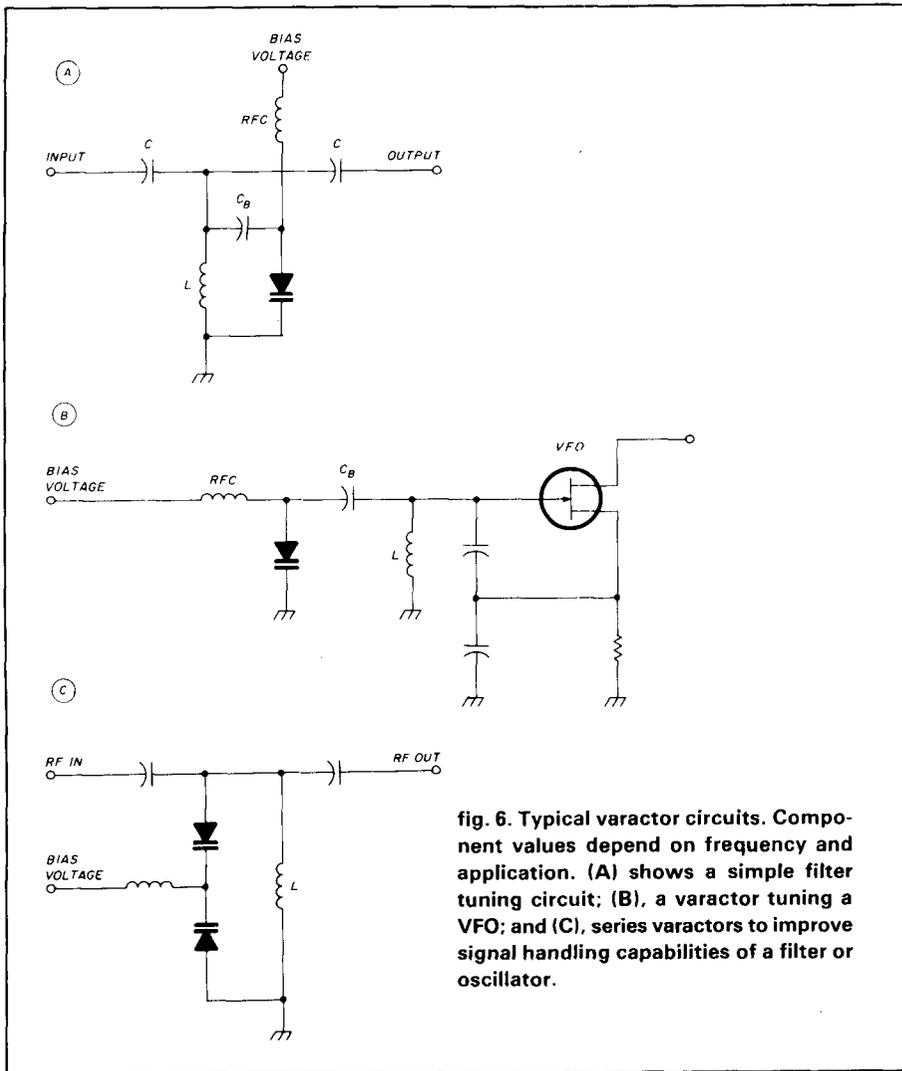


fig. 6. Typical varactor circuits. Component values depend on frequency and application. (A) shows a simple filter tuning circuit; (B), a varactor tuning a VFO; and (C), series varactors to improve signal handling capabilities of a filter or oscillator.

generators is beyond the scope of this month's column, but interested persons are encouraged to seek out copies of references 15 and 16.

limiters

It's often wise to place a circuit ahead of the input to your receiver to provide protection from stray rf, T/R relay leakage, or static.⁶ Such a circuit is often referred to as a limiter. The simplest limiter is a diode, typically an HCD, connected to ground across the input line to a receiver (fig. 8A) or from the base to emitter of a bipolar transistor (fig. 8B).²

This type of circuit is poor at best because it conducts only on one side of the input signal. Back-to-back diodes (fig. 8C) are better. However, neither configuration provides any protection from stray out-of-band rf. As a result, if moderate rf power is present on your transmission line, harmonics that will overload or degrade receiver performance may be generated by the limiter. Furthermore, HCDs can handle only low power (less than 1.0 watt); because they have a very low barrier voltage, 0.3 volts, they are easy to overload.¹

Placing a bandpass filter ahead of a limiter (fig. 8D) helps. (This was recommended in references 2 and 6.) A further limiter improvement would be to include the diode within the filter so that the capacitance of the diode could be tuned out. If the HCD barrier voltage is too low, diodes can be hooked in series until a suitable "turn-on" voltage is obtained. However, the HCD is a poor choice for a limiter diode because it's really a rectifier and doesn't have a very low impedance, even when turned on hard.

On the other hand, a PIN diode with a very thin I (intrinsic layer), typically 2-10 microns thick, makes an excellent rf limiter. PIN limiter diodes act like a power-dependent variable resistor with very low turn-on resistance through the mechanisms of charge injection and storage similar to rectification. Because of the long carrier lifetime of the PIN diode, only one di-

SRD conducts current for a very short period of time as if in a short circuit. This rf current is very rich in harmonics.

A typical SRD circuit is illustrated in fig. 7D. Note that the SRD has a different electronic symbol than other diodes. At first glance the circuit closely resembles that of the varactor multiplier (fig. 7C). However, there are a few subtleties. The input circuit has an extra section or "impulse" network, as illustrated. The bias circuit is slightly different. In the case of the SRD multiplier, a very low value bias resistor is used (typically 200 to 500 ohms, versus 50 to 100 kilohms for the varactor multiplier).

Another version of the SRD is the BIMODE™ or A mode™ diode, which

is enhanced for high power and high efficiency operation as a doubler or tripler. For best efficiency as a tripler, this type of diode requires an idler circuit similar to the one in a varactor multiplier (fig. 7C).

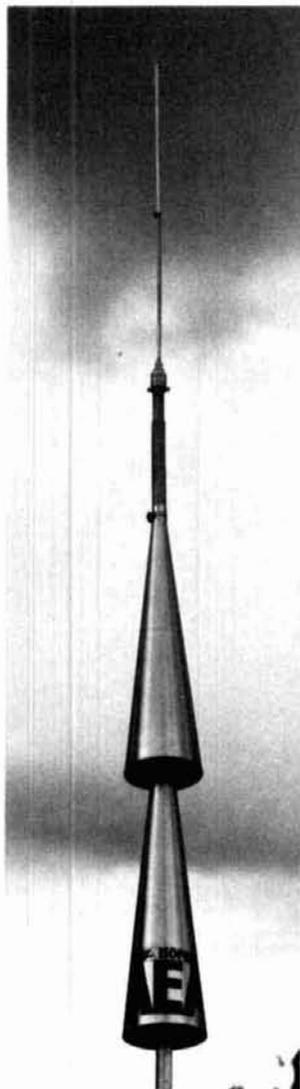
SRD multipliers can have conversion losses as low as a few dB — hence their popularity as multipliers. SRDs are usually capable of operation at up to 5 to 10 watts of power. If higher power (up to 50 watts) is required, SRDs are available in stacked or multichip packages.

SRDs are often used as impulse or "comb" spectrum generators for generating harmonics over a large frequency spectrum, as described in reference 14. Further information on designing SRD multipliers or comb

Put More Punch in Your Packet

Outstanding mechanical design makes the IsoPole the only logical choice for a VHF base station, especially for Packet operation. All IsoPole antennas yield the **maximum gain attainable** for their respective lengths and a maximum signal on the horizon. Exceptional decoupling from the feed line results in simple tuning and a significant reduction in TVI potential. The IsoPole antennas are all impedance matched in the factory so that no field tuning is required. The IsoPoles have the broadest frequency coverage of any comparable VHF base station antenna. This means no loss of power output from one end of the band to the other, when used with SWR protected solid state transceivers. **Typical SWR is 1.4 to 1 or better across the entire band.**

A standard 50 Ohm SO-239 connector is recessed within the base sleeve (fully weather protected). With the IsoPole you will not experience aggravating deviation in SWR with changes in weather. The impedance matching network is weather sealed and designed for maximum legal power. The aerodynamic cones are the only appreciable wind load and are attached directly to the support (a standard TV mast which is not supplied).



High Performance Hand-Held Antenna — The Hot Rod

The Hot Rod antenna can be expected to make the same improvement to hand-held communications that the IsoPole antennas have made to base station operation. **Achieve 1 or 2 db gain** over ANY 5/8 wave two meter telescopic antenna. The factory tuned HR-1 is 20% shorter, lighter and places far less stress on your hand-held connector and case. It will easily handle over 25 watts of power, making it an excellent emergency base or mobile antenna. In the collapsed position, the Hot Rod antenna will perform like a helical quarter wave. Three Hot Rods are available; HR-1 1/2 wave 2M Ant., HR-2 for 220 Mhz, and HR-4 for 440 Mhz. Amateur Net Price on all Hot Rods is \$19.95.

For either base station or hand-held operation AEA has the perfect VHF/UHF antenna. Put more punch in your Packet station with an AEA IsoPole or Hot Rod antenna. To order your new antenna contact your favorite Amateur Radio Distributor. For more information contact Advanced Electronic Applications, P.O. Box C-2160, Lynnwood, WA 98036, or call 206-775-7373.

IsoPole Specifications

Model	144	220	440
Freq. Coverage (Mhz)	135-160	210-230	415-465
2.1 VSWR bandwidth	>12Mhz @ 146Mhz	>15Mhz @ 220Mhz	>22Mhz @ 435Mhz
Power Rating	1 kw	1 kw	1 kw
Gain**	3 dbd	3 dbd	3 dbd
Radiating Element Length	125.5" (3.2m)	79.25" (2m)	46" (1.2m)
Amateur Net Price	\$49.95	\$49.95	\$69.95

** dbd — db gain over a dipole in free space

✓ 142

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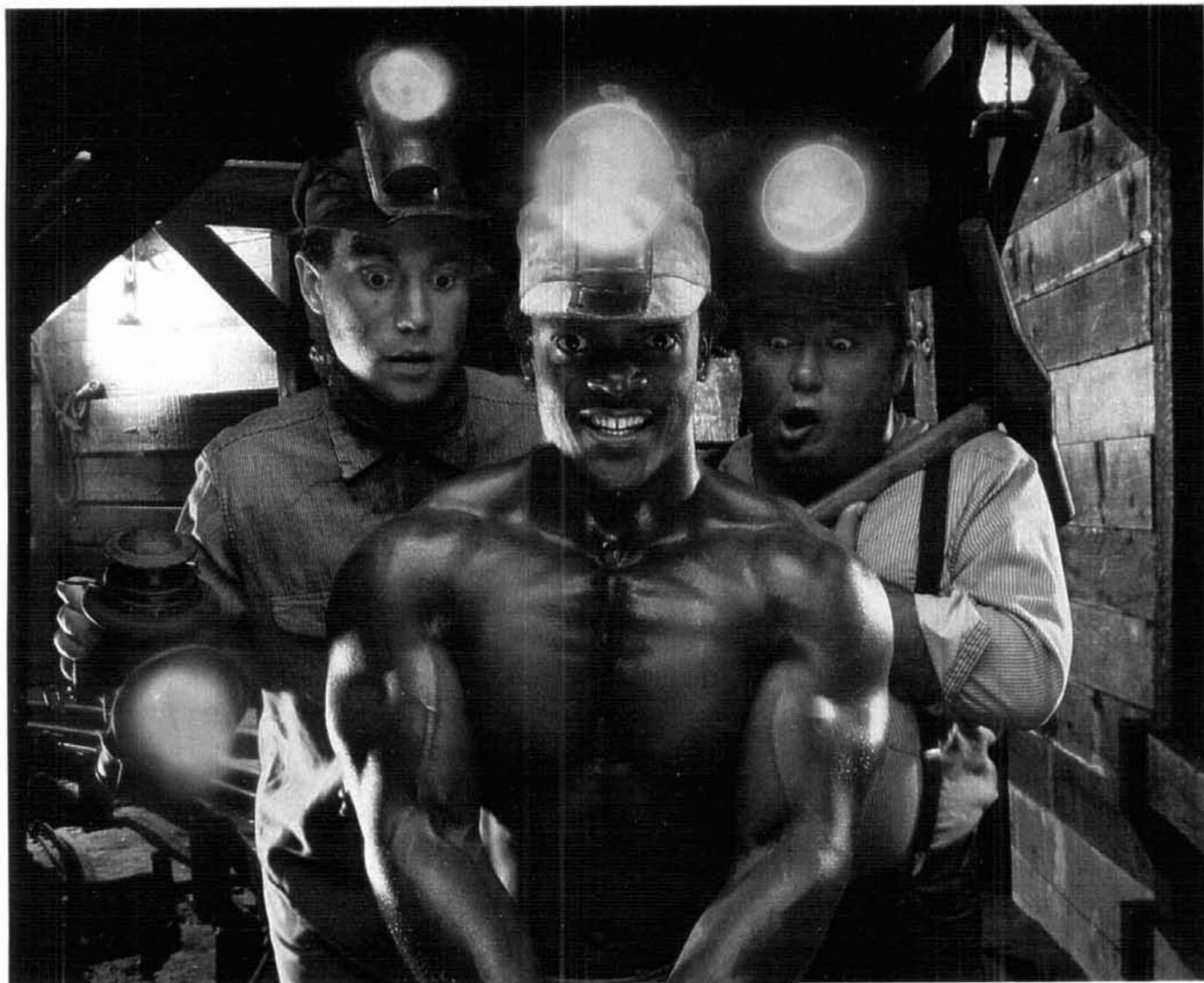
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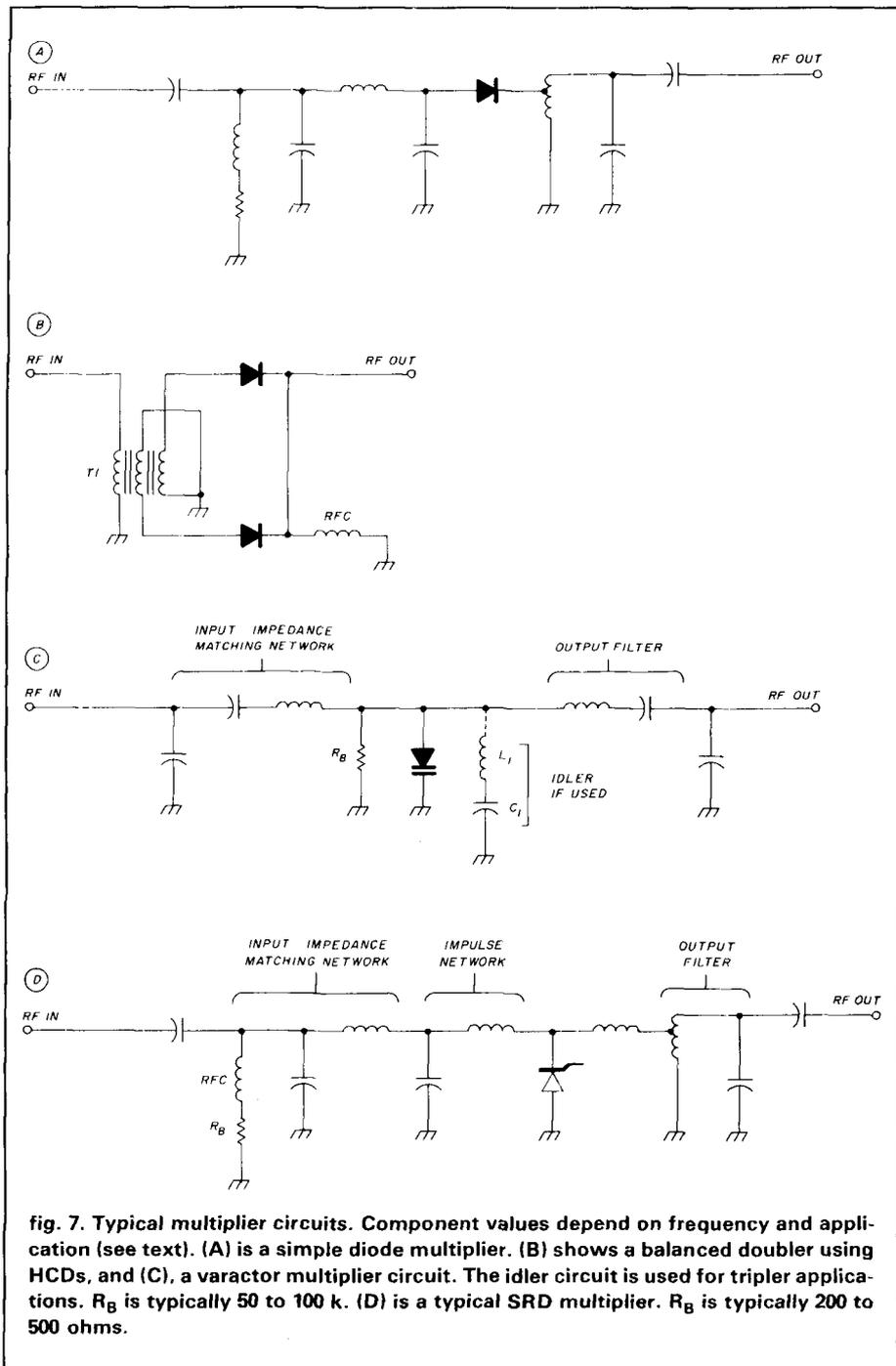


fig. 7. Typical multiplier circuits. Component values depend on frequency and application (see text). (A) is a simple diode multiplier. (B) shows a balanced doubler using HCDs, and (C), a varactor multiplier circuit. The idler circuit is used for tripler applications. R_B is typically 50 to 100 k. (D) is a typical SRD multiplier. R_B is typically 200 to 500 ohms.

ode is needed, since it stays on for a longer period than the rf cycle.

A single such PIN limiter diode can be substituted for an HCD (fig. 8E). If the I region is very thin, the diode can respond in nanoseconds. PIN limiter types of diodes have very low resistance and don't rectify the same as HCDs, as described earlier.

Thicker I region diodes with up to 50

nanosecond turn-on times are used for higher power operation. Power handling up to/in excess of 10 kilowatts for 1 microsecond duration is now possible! A thin and thick PIN limiter diode can be cascaded for additional protection (fig. 8F). Again, separate the diodes by 0.1 to 0.25 wavelengths, as discussed in reference 6. The inclusion of an HCD in the circuit shown in

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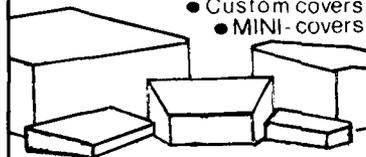
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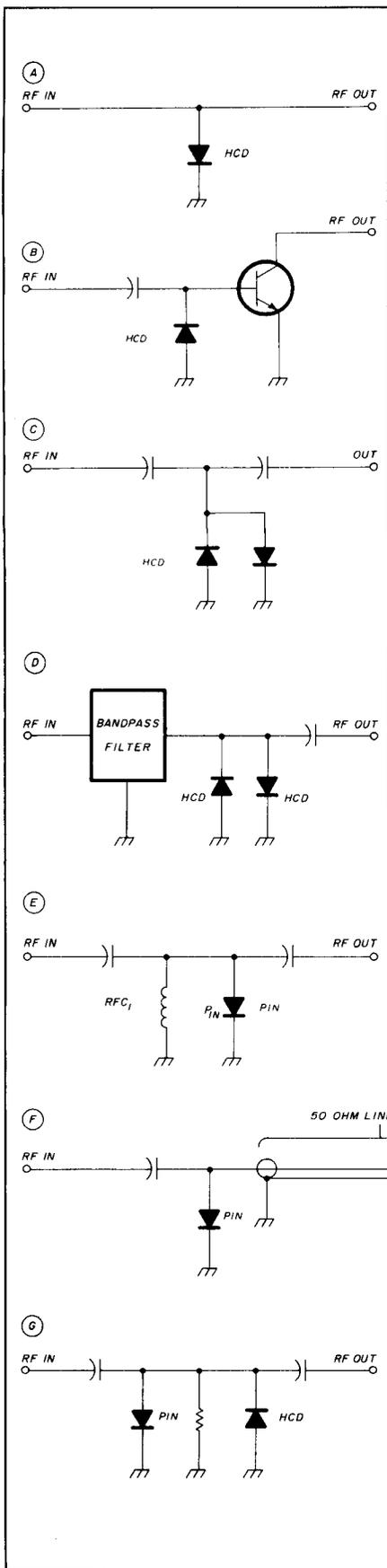


fig. 8G will help speed up turn-on time of a thick PIN limiter, especially at low power levels, for further low-power protection.

noise diodes

So far I haven't mentioned the noise diode, a special type that works in the avalanche mode similar to the operation of a zener diode. These diodes aren't always easy to construct and therefore are usually more expensive than conventional ones.

Noise diodes are particularly useful for testing receiver noise figures. Often Amateurs use point contact diodes (such as the old standby 1N21 type) in noise figure generators. Back biased transistor base to emitter junctions have also been used. Both of these diodes are tricky to use because they may have a low impedance and some reactive component when generating noise. Therefore, if you use them, place a large value (greater than 20 dB) attenuator pad between the diode

fig. 8. Typical limiter circuits: (A) shows a shunt diode; (B), bipolar transistor protection; and (C), a back-to-back limiter. (D) illustrates the preferred configuration for a limiter; (E) shows a typical single-ended PIN diode limiter; and (F) illustrates the use of two different PIN diode types for high power applications. (G) Adding a shunt HCD to a PIN diode limiter will improve turn-on speed and lower rf limit level.

noise generator and the device under test.

Good noise diodes generate "flat" or white noise over a wide frequency spectrum. Several microwave diode suppliers now supply noise diodes that are broadband and have excess noise ratios exceeding 35 dB. If you're interested in the subject, I'd suggest that you contact one of the suppliers, since this is a very specialized area.

oscillator diodes

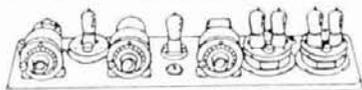
These diodes were very popular before the arrival of efficient multipliers and bipolar/GaAsFET rf sources. Probably one of the earliest microwave diode oscillators used the negative resistance characteristic of a tunnel diode. However, tunnel diodes didn't generate much rf power.

Great excitement followed the invention, in 1963, of the Gunn diode, named for its inventor, Dr. J. B. Gunn, of IBM Research. A bulk-effect device that uses GaAs as the semiconductor material, it is terribly inefficient (typically less than 5 percent) but will generate up to several hundred milliwatts of microwave power in the 4- to 100-GHz spectrum if properly biased and designed into a suitable tuning structure. Gunn diodes are the main component in GunnPlexers.⁹

The many other types of microwave and millimeter-wave oscillator diodes include but are not limited to the TEO (transferred electron oscillator), TRAPATT (trapped plasma avalanche triggered transit), BARITT, IMPATT (IMPact-ionization Avalanche Transit Time), and avalanche. The choice of an oscillator diode represents a tradeoff between frequency range, output power, power supply requirements, efficiency, and noise characteristics. No further discussion will be conducted at this time because there is probably only limited interest among Amateurs and stable sources followed by multipliers seem to be in current favor.

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short circuit rewinding with CAD

Two corrections should be made to "Rewinding Transformers with CAD" by Hugh Wells, W6WTU (December, 1986, page 83). One line should be added and another changed as follows:

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diodes because they're really operational in the upper or top of the millimeter-wave region, beyond 300 GHz! Most operate in the visible light region. Probably the most inexpensive

and well known is the LED or light emitting diode.

Another well-known type of optical diode is the LASER (Light Amplification by Stimulated Emission of Radiation). Amateur QSOs have been reported using lasers in the 474 THz region (474,000 GHz) region.¹⁷ In this instance, a photodiode is used as the detector. I'd highly recommend reference 17 for those interested in communications by light waves.

Finally, let's not forget the common photovoltaic (solar) cells, which can be used to provide power for operating Amateur gear, especially in remote areas where commercial power is either unreliable or not readily available. Typical solar cells will generate approximately 0.5 volts per cell, so several may be connected in series to power typical Amateur equipment.

summary

In this and last month's columns, I've tried to show that diodes are still very important to the VHF/UHF/microwave and millimeter-wave enthusiast. Time and space didn't allow all diode types to be described nor full applications of all types to be noted.

Diodes are too often taken for granted because they're so small and have only "two terminals!" Just because diodes appear so simple is no reason to treat them lightly. I hope that the information and circuits provided here will answer some questions that I often hear asked about diodes and encourage greater appreciation for their proper use in Amateur applications.

new DX records

Last month's column announced a new 9-cm (3456 MHz) microwave DX record. Since that time more details have become available. WB5LUA, operating portable with 10 watts and a 4-foot dish at 2680 feet ASL in Mena, Arkansas (EM24UQ) contacted WA5TNY, who was operating portable at 600 feet ASL with 1.5 watts and a 6-foot dish in Fairy, Texas (EM11AU). Using CW, the two established a new North American DX rec-

ord on this band of 288 miles (463.5 km) on October 19, 1986. Congratulations to Al and Rick as well as KD5RO, N5GEJ, N6CHA, and K5PS, who helped support this effort.

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| April 18 | EME perigee |
| April 21 | ARRL 220-MHz Spring Sprint Contest (Tuesday evening) |
| April 22 | Predicted peak of the Lyrids meteor shower at 1100 UTC |
| April 24-26 | Dayton Hamvention |
| April 29 | ARRL 432-MHz Spring Sprint Contest (Wednesday evening) |

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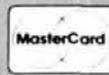
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160-meter equipment: problems and design hints

The 160-meter band occupies a very special place in the history of Amateur radio.

On the night of November 27, 1923, a striking event occurred. Using a special wavelength near the "top band," 1MO and 1XAM of the United States made a transatlantic contact with French 8AB. American and European Amateurs were in QSO for the first time! A mighty ocean had been spanned and, at the same time, millions of dollars worth of commercial long-wave communication equipment had been rendered obsolete. Short waves were the coming thing, and the rush to explore the very short waves — possibly as short as 20 meters — was on.

Over the years, Amateur interest in the 160-meter band has waxed and waned. It's now on the increase, and there's a lot going on in this historic portion of the radio spectrum. Most modern transceivers cover the 160-meter band, and more Amateurs are turning to the "gentleman's band" as a source of enjoyment.

special problems of 160 meters

The 160-meter band is a lot closer to the a-m broadcast band than it is to any other Amateur band, and some Amateurs find that everyday techniques they're comfortable with, say, on 80 meters, don't seem to work as well on 160. This can bring about problems that are unique to this band.

Many Amateurs have transceivers that use the popular 6146B tubes in the output stage. Some of them have

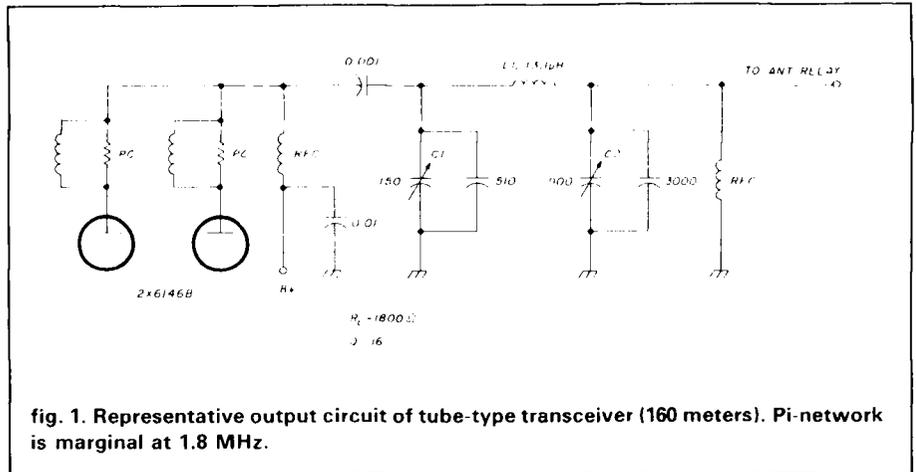


fig. 1. Representative output circuit of tube-type transceiver (160 meters). Pi-network is marginal at 1.8 MHz.

found, to their chagrin, that the transceiver won't load properly at 1.8 MHz, even though everything seems to work properly at 1.9 MHz or higher in the band. But at the low end, adjustments seem to "run off the end of the dial." In my case, my transceiver worked perfectly well down to about 1830 kHz, loading properly and providing a good 100-watts output into a 50-ohm dummy load. Alas, when I tuned up at 1800 kHz, the tuning control was fully counterclockwise, loading seemed sluggish, and the power output dropped to about 80 watts. Worst of all, the amplifier tubes ran very hot.

It didn't take much investigation to show that the amplifier plate circuit wouldn't tune that low in frequency — everything "fell apart" at about 1830 kHz. A phone call to the factory service center brought about the reluctant admission that operation was indeed "marginal" at the low-frequency end of the 160-meter band.

So — what to do? There was plenty of action around 1800 to 1810 kHz, and I thought it would be nice if the transceiver worked properly in this critical

range — so near to the "outer limit" of the transceiver's design.

To determine the possibilities, the plate circuit of the transceiver (fig. 1) was examined with a computerized pi-network program, using the circuit values shown in the schematic in the transceiver manual. Sure enough, reaching the low-frequency end of the 160-meter band was outside the tuning limit of the transceiver — by the merest margin — about 30 kHz in my case.

I didn't like the idea of tearing into the transceiver to modify the circuitry, so I looked for another answer via the pi-network program. Table 1 lists the component values needed for two different output impedances. Holding the plate impedance, circuit Q, and frequency constant, the output impedance was increased from 50 ohms to 75 ohms. The latter value was chosen because it's easy and inexpensive to obtain 75-ohm coax cable (RG-59/U and RG-11/U) and most transceivers are rated for a 75-ohm load. Note that while the value of the plate circuit inductance (L) remains fairly constant,

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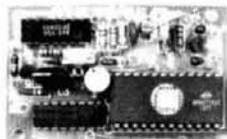
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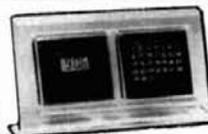
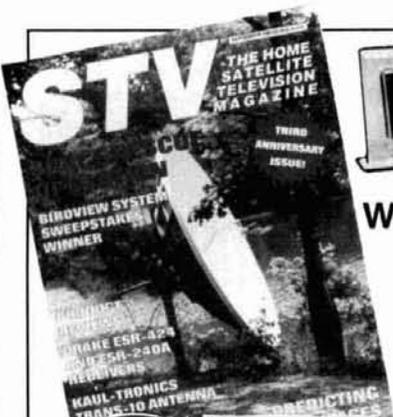
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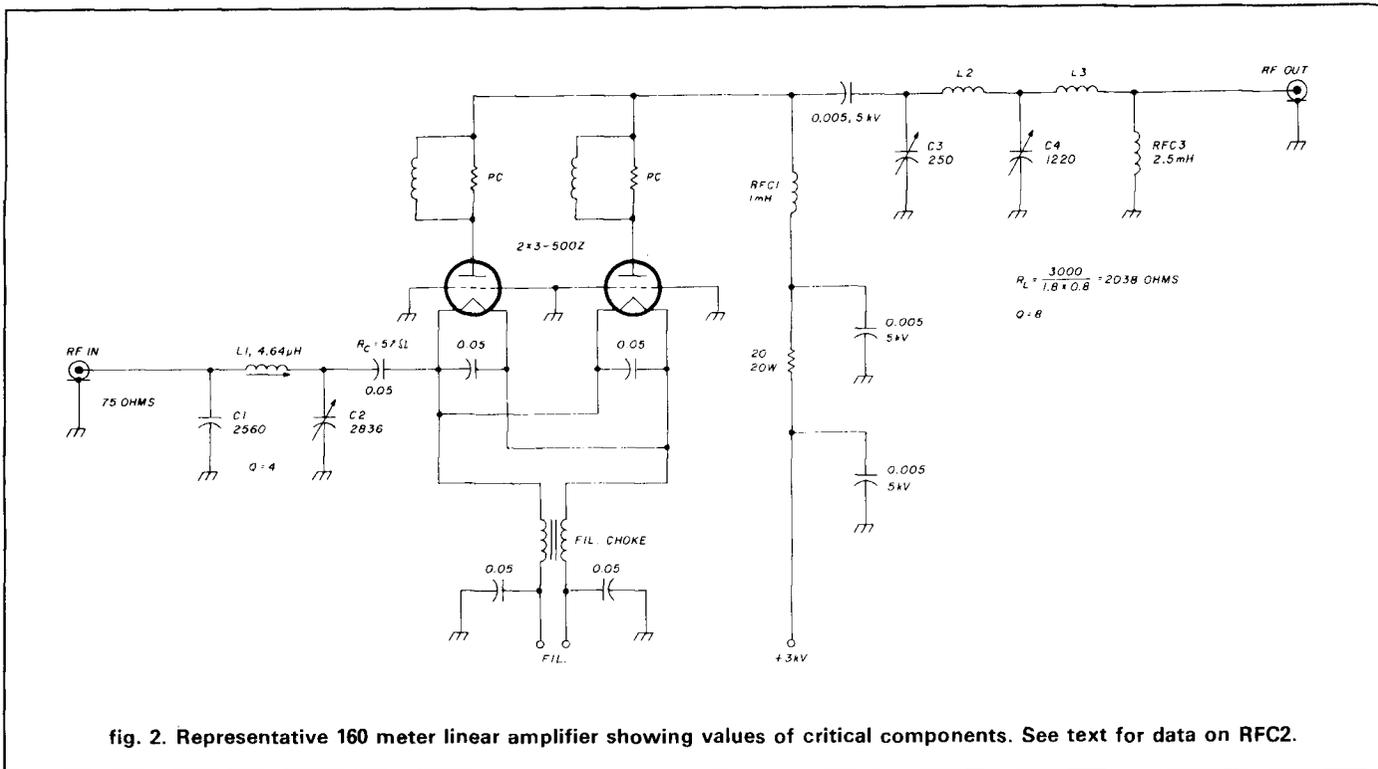


fig. 2. Representative 160 meter linear amplifier showing values of critical components. See text for data on RFC2.

both the tuning (C1) and loading (C2) capacitance values decrease by a noticeable amount. Switching to a 75-ohm feed system, therefore, can provide a greater tuning margin at 1.8 MHz for a given amplifier plate circuit network. Since the actual pi-network inductor wasn't changed, the tuning latitude gained isn't as much as predicted in this exercise, but it's still enough to permit an otherwise out-of-tune amplifier plate circuit to resonate properly at 1800 kHz. Accordingly, the transceiver was connected to a 75-ohm dummy load via RG-59/U coax and a 75-ohm model SWR meter. It was now possible to tune up properly at 1.8 MHz, with the amplifier tubes running much cooler.

Although switching to a 75-ohm feed system offered one solution, another equally satisfactory method

consisted of adjusting the 50-ohm feed system to reflect the proper reactance back into the final amplifier that would detune the pi-network circuit in the proper phase to allow sufficient tuning range on the tuning and loading controls. This can be done by changing the coax line length between the antenna and the transmitter. Accordingly, various lengths of 50-ohm coax were inserted into the original antenna feed system until a length was found that permitted proper tuning of the transceiver. It's difficult to specify the "magic" length because that depends upon the antenna installation and the equipment in use. By changing coax cable length from antenna to transceiver, the tuning settings of the amplifier stage could be varied to produce a reasonable tuning sequence for the transceiver.

Note that changing the length of the coax did not change the SWR on the antenna system — it merely moved the transceiver back and forth along the coax line so that the combination of SWR and phase shift along the line produced the wanted results, namely, the ability of the transceiver to tune and load properly.

160-meter amplifier construction hints

Building a linear amplifier for 160 meters? No big problem, provided you remember that this creation is operating at a frequency closer to the broadcast band than to any other ham band, and design accordingly. The amplifier shown in fig. 2 serves as an example. Only the rf circuitry is considered; the metering and control circuits aren't involved in this examination.

The first consideration is that all bypass capacitors have to be an order of magnitude larger than those values used on the higher frequency bands. For low-voltage, low-power circuits, a bypass or coupling capacitor of 0.05 μF is satisfactory. For high-voltage circuits, such as plate blocking and

Table 1. Pi network component values for different load impedances.

Q	Frequency	C1(Input C)	L(Induct.)	C2(Output C)	Load Z
16	1.8 MHz	682 pF	13.11 μH	3708 pF	50 ohms
16	1.8 MHz	660 pF	14.00 μH	3020 pF	75 ohms

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In low-voltage circuits, the Sprague "cera-mite" series of capacitors will do the job: the type 5HKP10 or 5GAP10 rated at 500 volts are satisfactory. For medium-high voltages, the Sprague 0.0047 μF , 6 kV (dc) capacitor, type 60GAD47 is suggested. Sangamo also makes a 500-volt dc-rated, 0.02 μF mica capacitor (FD203J03) that is satisfactory for low voltage circuits. Two of these units can be paralleled for 0.04 μF .

A larger-than-normal filament choke (RFC2) should be employed on 160 meters. If the choke is too small in inductance, it will tend to detune the pi-network input circuit because the choke is in parallel with capacitor C2 and introduces "negative capacitance" across C2, in addition to allowing rf power to pass down the choke and into the filament transformer. A suitable choke consists of 20 bifilar turns of No. 12 wire (Formvar) on a 0.5-inch diameter, 7-inch long ferrite rod ($\mu = 950$).

A pi-L plate circuit is recommended to provide additional harmonic attenuation over that of a pi-network. Using high power, it's possible for the second harmonic of a 160-meter transmitter to fully meet FCC specifications, yet provide enough power in the 80-meter band to seriously affect nearby Amateurs operating close to the harmonic frequency. In this case, the pi-L configuration provides an extra 15 dB of second-harmonic attenuation at very little additional cost to the amplifier.

The greater rejection of this circuit allows the designer to decrease the network Q to provide smaller component values. In this case, a Q of 8 was chosen. The required component values for resonance at 1.8 MHz are given in the drawing. A total of 300 pF, with at least 100 pF of it variable, will serve as the tuning capacitor, and a total value of 2000 pF, with 1000 pF of it variable, will do the job as the output loading capacitor.

Transmitting-type, zero-coefficient ceramic capacitors (such as the Cen-

tralab type 850S) may be used to pad capacitor C3. Large, mica transmitting-type capacitors (often found at flea markets) can be used for padding the loading capacitor, C4.

The plate rf choke (RFC 1) must have sufficient inductance so that it doesn't affect the pi-L network to any great extent. From an rf point of view, the choke is in parallel with tuning capacitor C3. If the choke is too small, the value of C3 must be increased to compensate for the inductance of the choke. A minimum inductance for RFC 1 for 160-meter operation is about 250 μH . An inductance value up to 1 mH is more acceptable.

Note that the plate blocking capacitor has a value of 0.005 μF . This is considerably larger than found in amplifiers designed for the higher frequency bands.

A 20-ohm, 20-watt wire-wound resistor is connected in series with the B-plus lead. This serves as a low- Q rf choke for VHF harmonic suppression as well as a safety device in case of an ion flashover in the amplifier power tubes. The plate bypass capacitors on each side of this choke are 0.005 μF , 5 kV-ceramic units.

When such large coils as L2 and L3 are used in the plate circuit, it's imperative that they not couple to the cabinet. If an all-metal cabinet is used, it can easily become a one-turn, shorted inductor closely coupled to the output tank. This fact was brought to light in a homemade amplifier built within a steel enclosure. The efficiency of the amplifier was mysteriously low and the cabinet ran very warm — warmer than one would think, since an efficient cooling system was used. It was found that the circulating rf currents in the enclosure accounted for nearly 200 watts of output power! No wonder the cabinet ran uncomfortably warm! Rearranging the amplifier coils cured the power loss problem.

design summary

Coupling and bypass capacitors for a 160-meter amplifier have to be an order of magnitude larger than those chosen for an amplifier whose lowest

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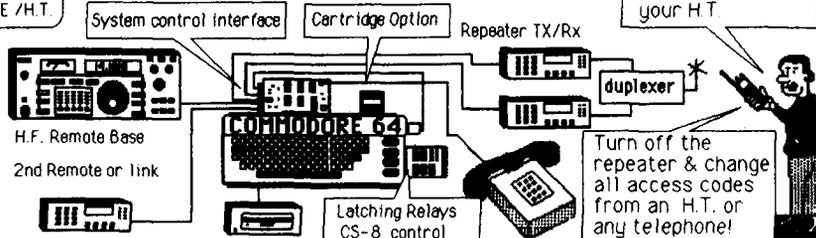
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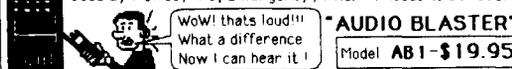
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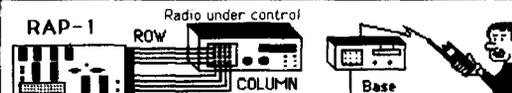
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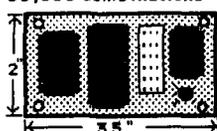


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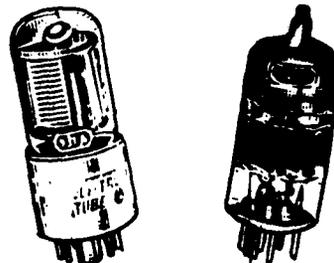
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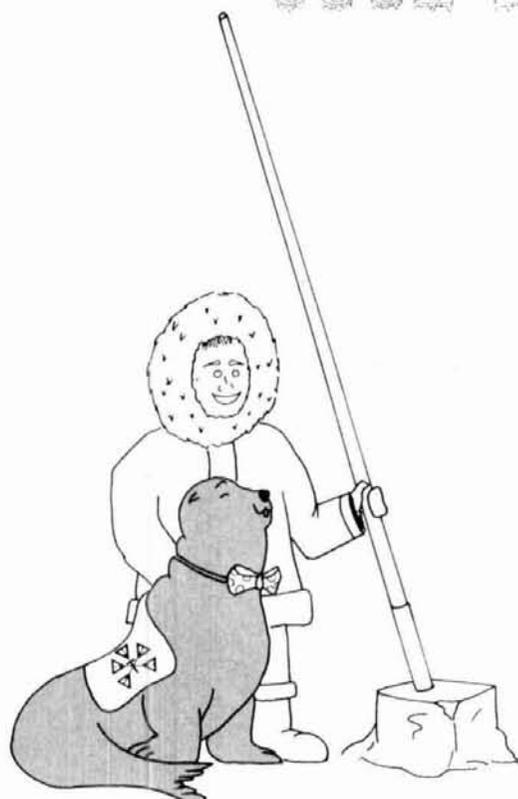
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C-64 and GLB PK-1 interface circuit

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Until just a few years ago, I thought that packet radio was an interesting part of our hobby, but one that was too difficult and too expensive to enter. I'd

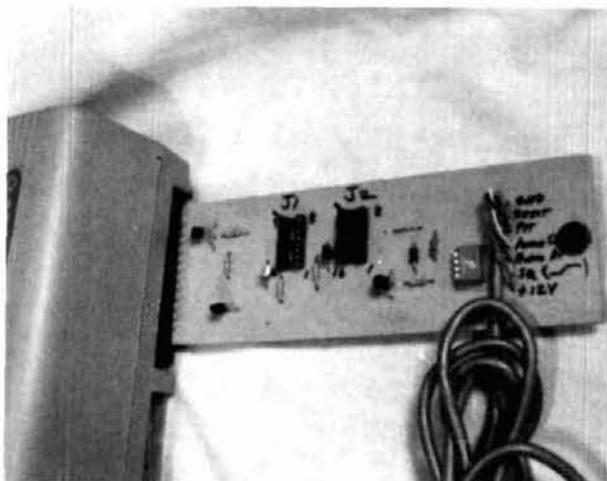


fig. 1. Interface card plugs into C-64 user port. On the author's version, the ribbon cables from J1 and J2 on the PK-1 are terminated in 16-pin DIP headers and plugged into IC sockets on the interface PC board. On later versions, the ribbon conductors were soldered to the PC board. The black dot at the end of the PC board is a rubber bumper which supports the free end of the board.

heard stories of people who spent months scrounging for parts and equipment.

All that changed when GLB introduced the PK-1 Terminal Node Controller. For those of us who already owned a Commodore 64 computer, the PK-1 was about the cheapest way to go. Intrigued, Neil Abitabile, WA2EZN, and I ordered two units from GLB.

We should have planned ahead. The PK-1s were only days from delivery when we realized that neither of us had the foggiest idea of how we were going to interface them with the C-64. One thing was clear; no one was offering an interface off the shelf.

Neil and I began making inquiries on the 145.135 repeater in Carmel, New York, where a large number of packeteers hang out. Eventually we got the information we needed to design a circuit that provides the necessary functions.

interface requirements

The DATA IN and DATA OUT lines between the PK-1 and the C-64 must be inverted. RTS and CTS lines from the PK-1 to the D and K pins on the user port must be linked without inverting polarity. A pc board serves as the common point for the three cables that link the various units.

Two ribbon cables connect J1 and J2 on the rear of the PK-1 to the solder pads on the pc board. A third cable (see fig 1) goes from the pc board to the transceiver for +12 volts, receive audio, transmit audio, push-to-talk, and squelch back-off (if used — see sidebar).

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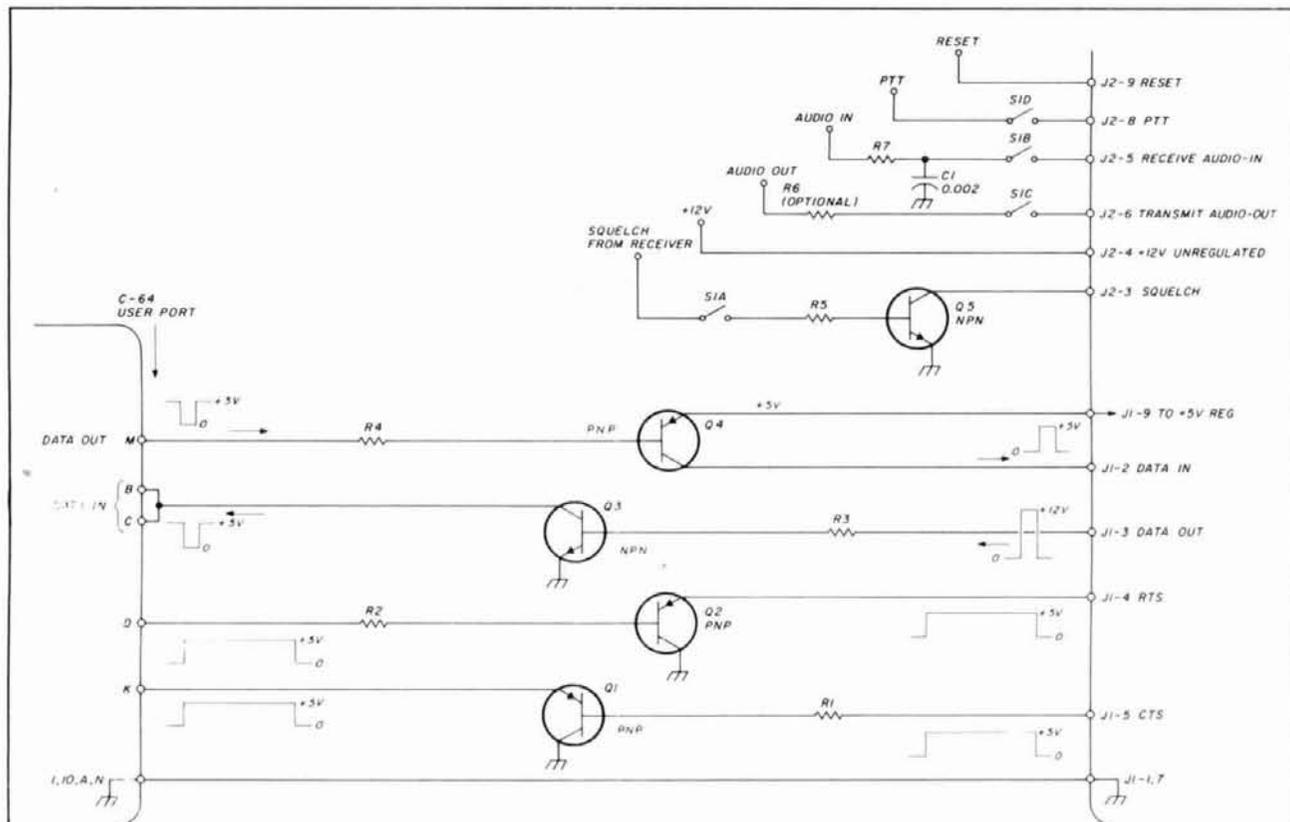


fig. 2. Interface card schematic.

C1	0.002 μ F
P1, P2	5/10 0.156 inch insulation displacement edge connector (available from GLB)
P3	12/24 0.156 inch edge connector (Texas Instrument PN H411121 12). Available from Digi-Key PN C1-12
Q1, Q2, Q4	PNP (2N3906 or equivalent)
Q3, Q5	NPN (2N3904, 2N2222 or equivalent)
R1, R5	10 k 1/4 Watt, 10 percent
R6	18 k optional (see text)
R7	6.2 k optional (see text)
S1	4PST DIP switch

construction

Flexibility was a key consideration in board layout. S1 is a 4PST DIP switch which permits the operator to positively disable SQUELCH, BACK-OFF, PTT, RECEIVE-AUDIO and TRANSMIT-AUDIO. Neil and I found that there were times when we needed to isolate the PK-1 and the transceiver from the outside world for checks or experimentation.

Refer to the schematic (fig. 2) while reading the next few paragraphs. Note that R6 is optional. If the PK-1 packet audio to the transmitter can't be sufficiently reduced by R30 on the PK-1 board, then R6 can be inserted. The value can be determined experimentally. More than likely, however, it won't be needed, so it can simply be jumpered out.

R7 is also optional. We obtain receive audio for the

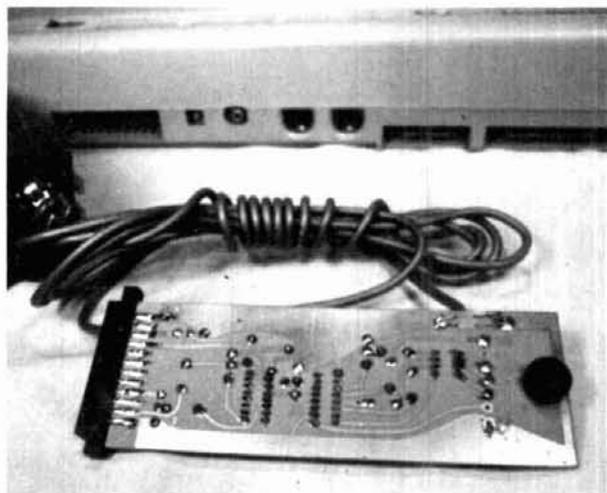


fig. 3. Bottom view of the interface PC board. The pins of the PC card edge connector are soldered to the contact fingers.

PK-1 directly from the discriminator. Initially, I was afraid that R29 (in the PK-1) might not provide adequate isolation to avoid overloading the discriminator. C1 is also an option. Some packeteers claim that oper-

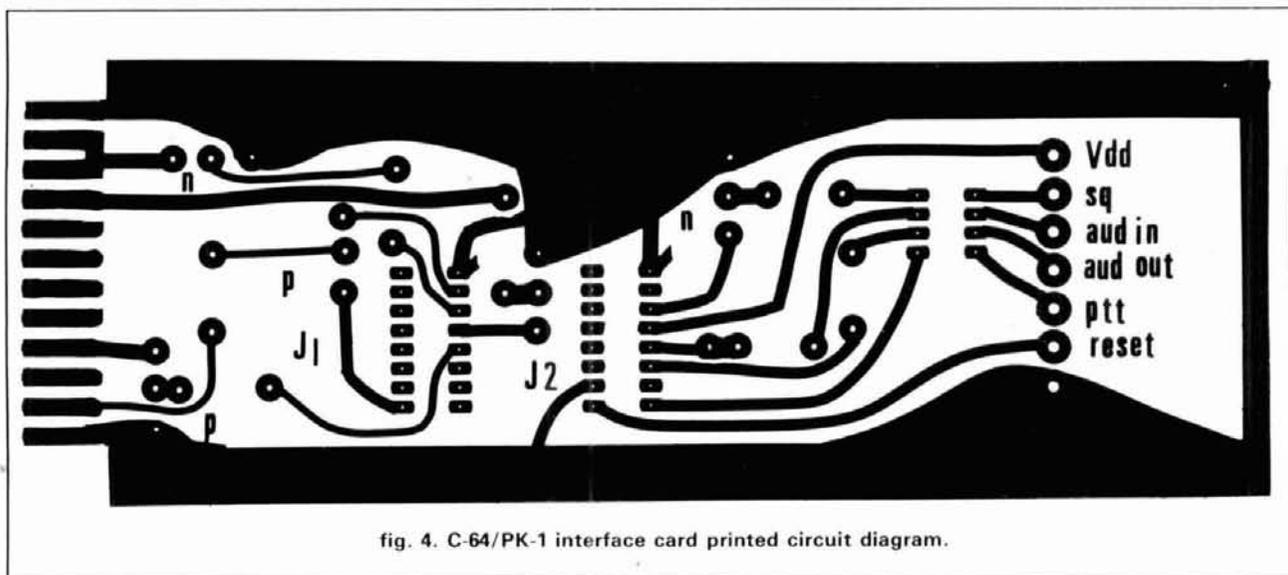


fig. 4. C-64/PK-1 interface card printed circuit diagram.

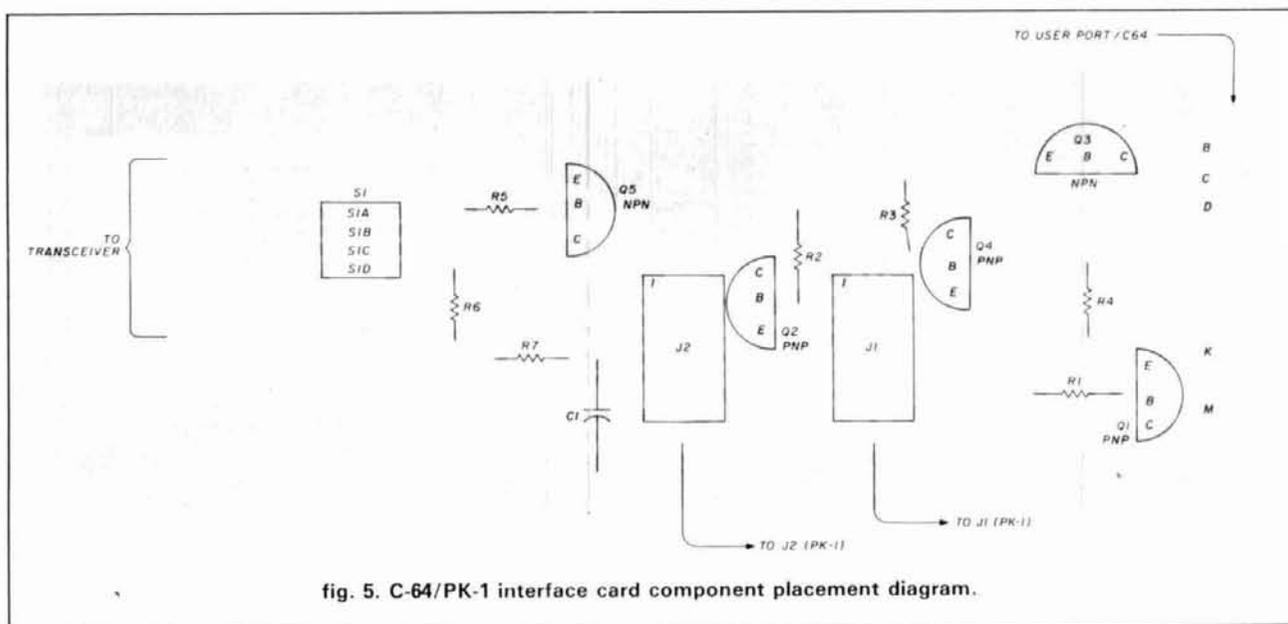


fig. 5. C-64/PK-1 interface card component placement diagram.

ation is more reliable if the high frequency components of the receive audio are rolled off. The values for base resistors R1-R4 are not critical. I used 10 k, but any value from 3.9 k to 15 k worked just as well.

At first we had a tough time finding a proper 12/24 pin, 0.156-inch pc edge connector to mate with the C-64 user port. The initial version of the interface board uses a connector that was cut to length with a handheld jigsaw. Later, Terry McGraw, WA2UDG, discovered that TI makes one that's an exact fit (see parts list).

connections

The PK-1 requires 12 volts at 200 milliamperes. The simplest source is the transceiver with which the PK-1

will be used. After etching and drilling the pc board (figs. 4 and 5), connect the ribbon cable to the "IDC" (Insulation Displacement Connector) cable plugs for J1 and J2 on the rear of the PK-1. (Neil and I bought the connectors and the cable from GLB when we ordered the PK-1s.) Strip the other end of the ribbon cable conductors; before soldering them through the pc board holes, however, *make sure that the appropriate conductor from the plug goes to the correct pc board hole*. Double-check against the pin-out illustration in the GLB PK-1 owner's manual. (On the original version, the ribbon cables from the PK-1 terminate in DIP headers and plug into IC sockets on the board.)

The umbilical to the transceiver is next. You'll have to decide how to access the +12 volt bus, PTT, audio-

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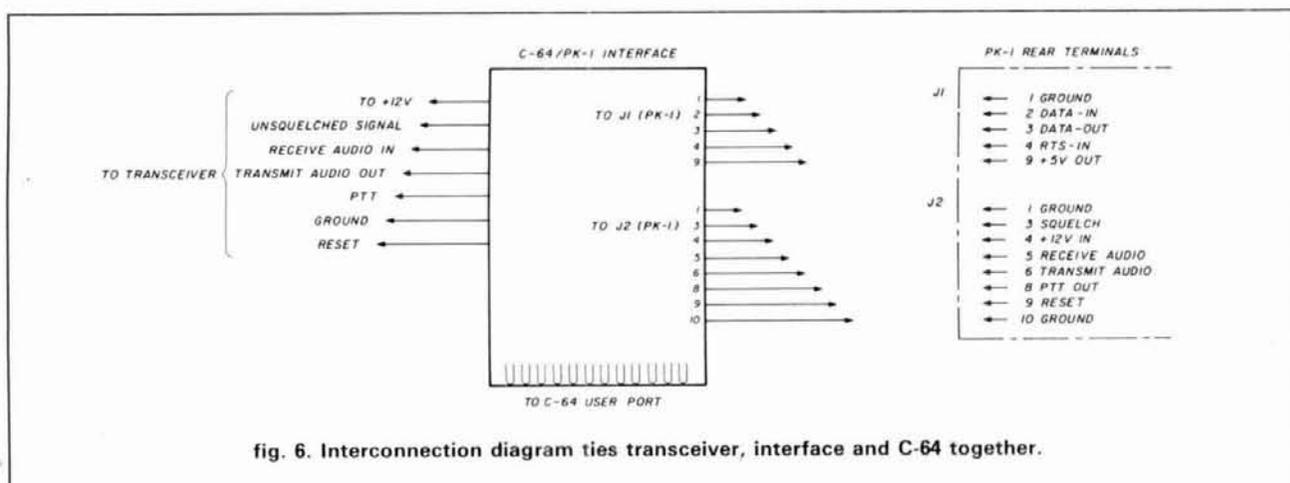
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in, and audio-out on your rig. Ben Spieker, WB2YSJ, kindly milled five fins from my Azden PCS-2000's heat sink and bored a 5/8-inch hole for a multipin connector. Note that there's a seventh conductor on the pc board labeled "Reset" (fig. 6). It's there if you want or need an external connection to the PK-1's reset line. Solder the lower (foil side) pins of the edge connector to each of the 12 "contact fingers" etched on the underside of the pc board. For mechanical strength, you could flow 5-minute epoxy or hot glue between the top pins and the component side of the pc board or use a couple of threaded spade lugs from the connector mounting holes to the pc board.

operation

Before applying power, check for any wiring errors. With power off, plug the interface cable into the transceiver. Turn on the transceiver, and with a voltmeter, check to see if +12 volts exists on pin 4 of J2. You should be able to key the rig by grounding the PTT line. A scope should indicate noise on the receive-audio line. (If you are picking off from the discriminator, 25 to 50 millivolts of noise will be present under no-signal conditions.) Turn power off and plug the cable connectors (J1 and J2) into the back of the PK-1. *Make absolutely sure the plugs go to the correct locations! Since they're identical and nonpolarized, it's a good idea to mark which is which to make sure they're not swapped or installed upside down!*

Make sure all four DIP switches on S1 are open, then turn on the power. The LED on the front of the PK-1 should light. (Note, so that you don't go crazy, when you input +12 volts via J2, the PK-1 front panel on-off switch is bypassed and has no effect.)

Remove power and plug the interface board (component side up) into the user port on the rear of the C-64. Turn on the computer, the transceiver, and the PK-1. Load whatever terminal program you wish to use for packet radio. (Neil and I have used a series of

programs including *SuperTerm*, *Vidtex 4.0*, and the Texas Packet Radio Society's *TNC64*.

Once the program is running and you have packet traffic coming through the receiver, close the DIP switch that interrupts incoming audio. Packet traffic passing by should begin showing up on the computer monitor screen. Make sure the PK-1 is not in any of the following modes: OO (*display only connected packets*); OA (*display only stations with specified call signs*) or OQ (*store the packets in the PK-1 RAM*). If you're in any of these modes, no passing traffic will appear on the screen.

To test transmit, close the audio-out and PTT DIP switches and connect with a friend or with yourself through a local digipeater.

As good as it is, the PK-1 has no output timer to prevent a mishap from locking the transmitter on the air. WA3EZN and I have designed one we call the "Packetimer"; it's described in the following article.

monitor squelch status with "Back-off"

"Back-off" (Pin J2-3) permits the PK-1 to monitor the squelch status of the receiver. If the "back-off" pin is pulled LOW by a signal other than one from a packet station, the PK-1 is inhibited from transmitting. Without "back-off," the PK-1 and other TNCs ignore the presence of other non-packet signals and will transmit right over them. The interface has a transistor inverter (Q5) because the unsquelched signal from my transceiver (an Azden PCS-2000) is a HIGH.

Back-off is especially helpful where packet and fm phone operators attempt to coexist. It isn't as important if the channel is exclusively packet because TNCs are always inhibited from transmitting if they "hear" another packet signal.

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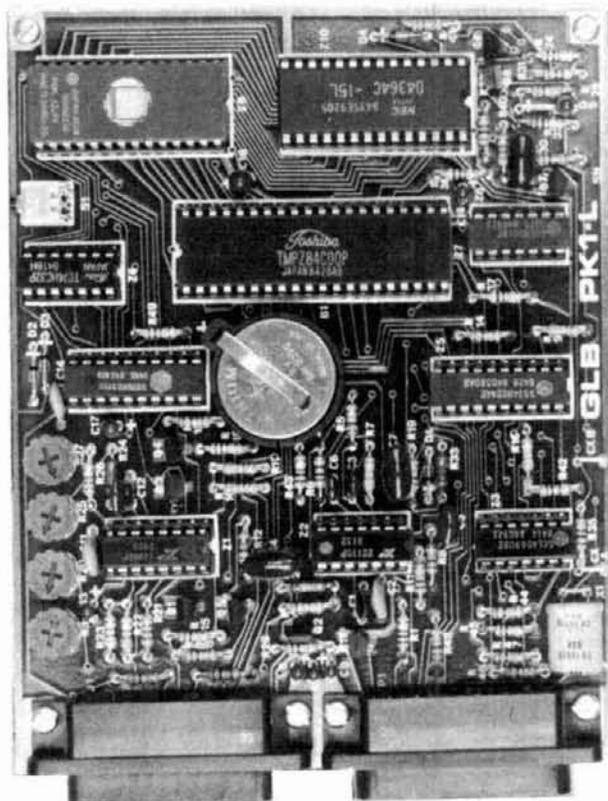
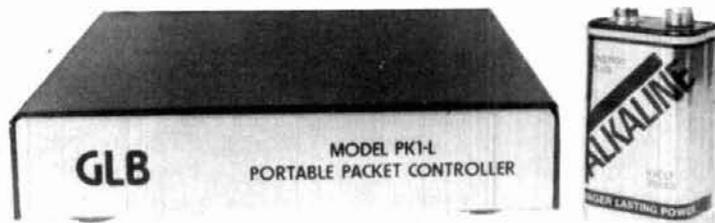
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“packetimer” for the PK-1

Handy circuit prevents lockup

In the previous article we described an interface circuit that allows the GLB PK-1 TNC to work with a Commodore 64. Soon after we put that combination into operation, one fact became obvious: the PK-1 has no fail-safe method of preventing accidental, long-term key-up. Amateurs not on packet may not realize the implications of this, but when it happens, your TNC “hears” the carrier of another packet station on the channel and automatically prevents the other transmitter from going on the air!

One evening, for reasons still unknown, my PK-1 locked up and sent 25 watts of rf through an 11-element beam for several hours. An unknown number of packet stations in the North Jersey/New York City area were suddenly struck dumb. No doubt their operators cussed out the dingbat whose carrier was blanketing 145.010. (If you were affected, my sincerest apologies!)

That’s why we devised the Packetimer (see fig. 1), which is designed to go into action if the transmitter is on the air continuously for a length of time that exceeds the time-out period. Using the suggested com-

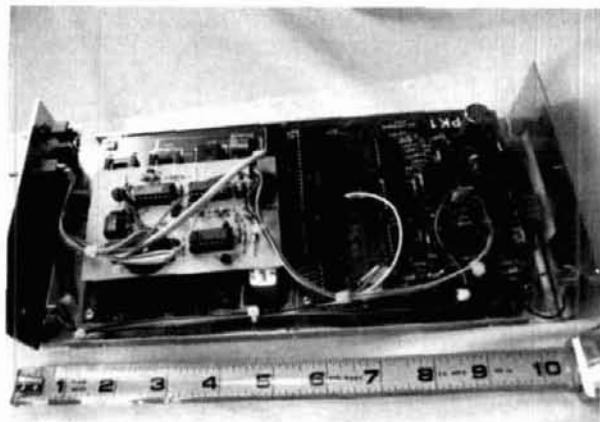


fig. 1. Side view of PK-1 with Packetimer installed. The wires from the PC board plug go to S1, CR6. +5v and the base and collector of PK-1 keying transistor, Q3.

ponent values, the device permits transmissions lasting up to about 30 seconds. Since 99 percent of the packet transmissions last well under 10 seconds, plenty of leeway is permitted, but a lockup (such as the one that occurred at this station) is no longer a threat.

operation

The Packetimer monitors the push-to-talk line from the PK-1 to the transmitter. Whenever the PK-1’s keying transistor, Q3, pulls the PTT line LOW, U1 (the 4060 oscillator/14-stage binary counter) is activated through CR1 (see fig. 2).

The suggested values for C1, R2, and R3 yield a clock frequency of approximately 15 Hz. Within U1, the clock pulses are sent through a series of 14 flip-flops. Each flip-flop divides the incoming pulse train by a factor of two. In normal operation, the counters in U1 remain at zero because RESET (pin 12) is held HIGH through pullup resistor R1. *Only when the PTT line goes LOW (transmit mode) can the flip-flops operate.* The counters in U1 are reset to zero at the end of every transmission when the PTT line goes HIGH again.

However, in the event of a lockup condition, the counters keep going until the Q output to which CR2 is connected goes HIGH. When that happens, latch U3 is SET and its Q output (pin 2) goes HIGH. The HIGH from pin 2 of U3 does two things: it turns on Q1, which puts a stranglehold on the base of the PK-1’s keying transistor, Q3. That takes the transmitter off the air and keeps it off. U3’s output also turns on CR6, the blinking LED, and U4 (555) so that a continuous tone warns the station operator of the lockup condition.

The Packetimer must be manually reset via S1 before the packet station can transmit again. With the recommended values for C1, R2, and R3, and with CR2 connected to pin 1 (Q12 output) of U1, the transmitter can remain on the air for about 30 seconds before the Packetimer goes into action. Coarse divider increments (doubling or halving the time) can be achieved by shifting the jumper wire from CR2 to the next higher or lower Q output on U1.

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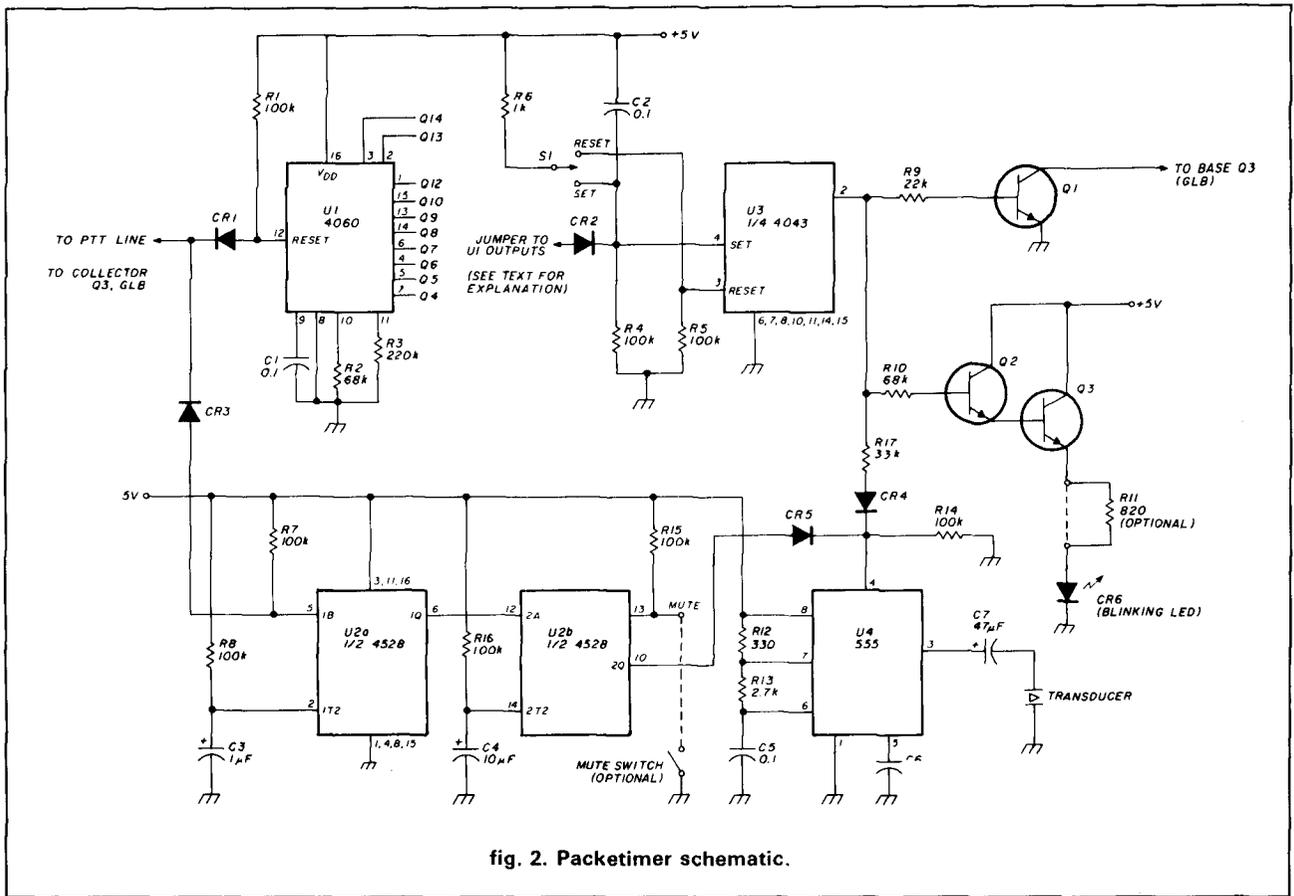


fig. 2. Packetimer schematic.

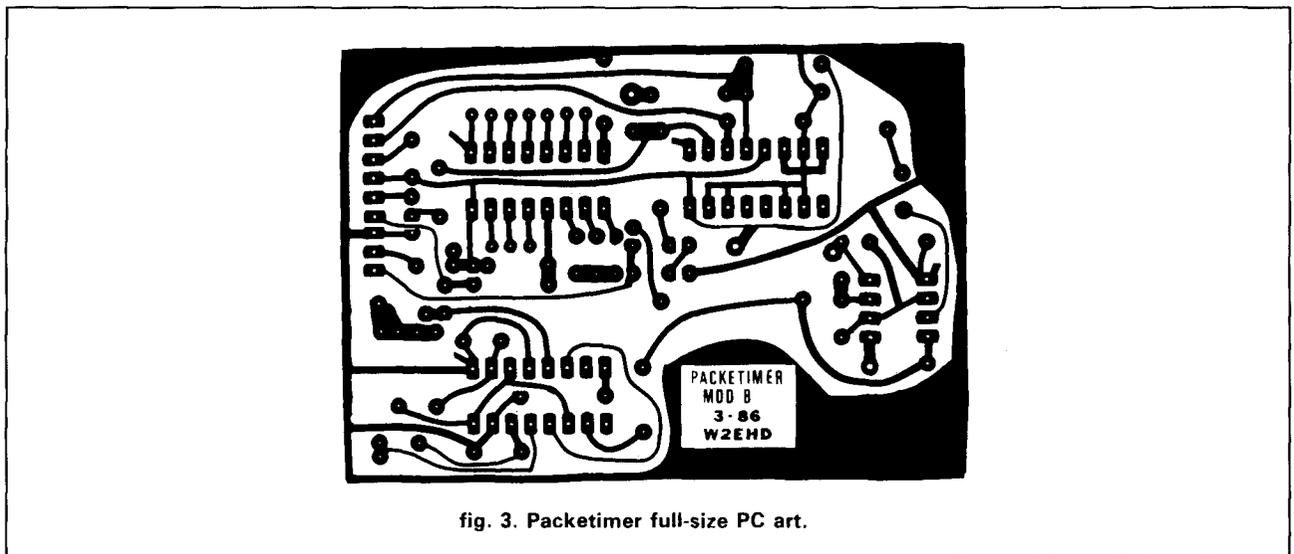


fig. 3. Packetimer full-size PC art.

The Packetimer beeps for about half a second whenever the PK-1 triggers the transmitter to send a packet. If the muted "tweet" from inside the PK-1 case gets on your nerves, simply ground pin 13 on U2 to shut it off. Don't worry; even if you decide to mute

the beep, if the Packetimer is triggered, the continuous alarm will sound.

The purpose of C2 (between the +5-volt bus and the SET pin on the U3 latch) is to ensure that the Packetimer is latched ON (timed-out mode) at power-up.

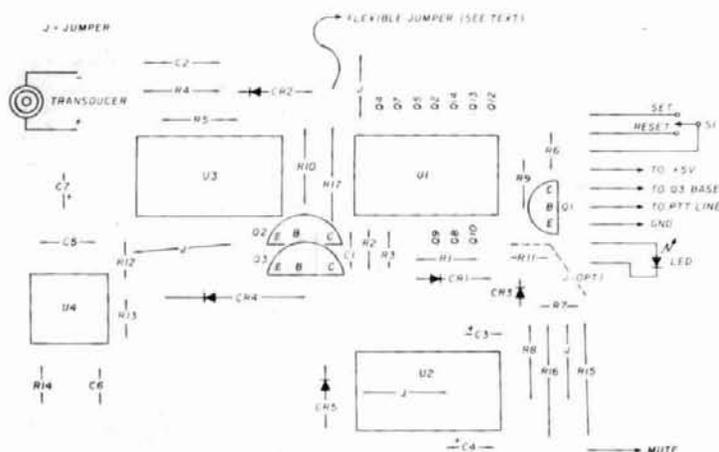


fig. 4. Packetimer PC board component placement diagram.

C1, C2, C5	0.1 μ F, disc ceramic
C3	1.0 μ F tantalum
C4	10.0 μ F tantalum
C6	0.01 μ F disc ceramic
C7	47.0 μ F tantalum
	(All capacitors 12 VDC or better)
CR1-5	Silicon (1N914 or equivalent)
CR6	Blinking LED RS No. 276-036; Marlin P. Jones No. OP-2364
Q1,2,3	NPN Silicon (2N3904 or equivalent)
R1, R4, R5, R7, R8, R14, R15, R16	100 k
R2, R10	68 k
R3	220 k
R6	1 k
R9	22 k
R11 (see text)	820 ohms
R12	330 ohms
R13	2.7 k
R17	33 k
	(All resistors 1/4 watt, 10 percent)
S1	SPDT center-off toggle switch
U1	4060 (CMOS oscillator/14 stage divider)
U2	4528 or 4098 (CMOS dual one-shot multivibrator)
U3	4043 (CMOS quad set/reset latch)
U4	555 timer
Transducer	RS 273-069 or Marlin P. Jones No. SU-2205

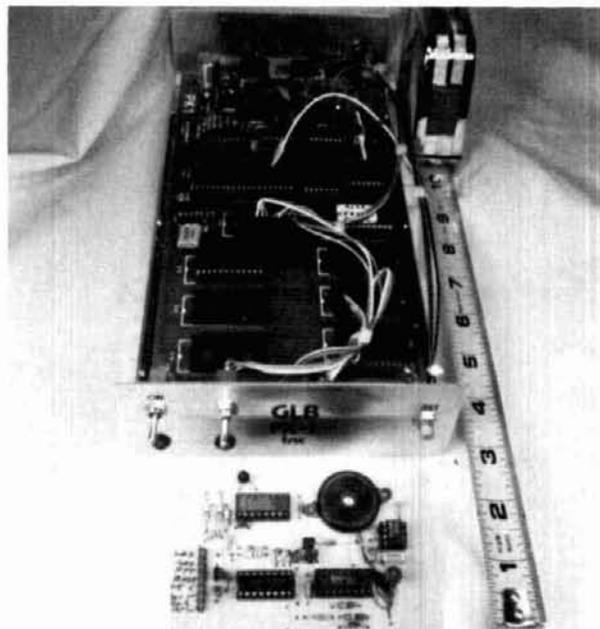


fig. 5. Front view of the PK-1 shows the added switch (S1) and LED (CR6). The packetimer is unplugged from the cable harness to show the Radio Shack transducer which is held to the PC board by a couple of dabs of hot glue. If the transducer from Marlin P. Jones is used, it can be soldered directly to the PC board.

This eliminates the possibility that a power glitch might wipe your terminal program from the computer and latch the transmitter on the air.

construction

The pc board (figs. 3 and 4) is straightforward. Note, however, that to avoid going to a double-foil board layout, three jumpers must be installed on the component side. Note, too, that R11 (820 ohms) is optional. If you use the Radio Shack blinking LED or the one from Marlin Jones, R11 is then replaced by a jumper. The devices contain their own current-limiting circuitry. If you install an ordinary LED, R11 must be installed to limit the LED current to a safe level. Both CR6 and S1 (the Packetimer manual set/reset switch) are added to the PK-1 front panel.

connections

Two connections must be made to the PK-1 keying transistor, Q3. The first goes to the collector of Q3. This is where the Packetimer monitors the PTT line. The second connection is to the base of Q3 from the Packetimer's key-inhibit transistor (Q1). The ground connection on the Packetimer goes to the ground foil on the PK-1. The LM7805 voltage regula-

tor (Z6) in the PK-1 is a convenient source for the +5 volts needed by the Packetimer. With the GLB board edge terminals facing away from you, the +5-volt output terminal is the one on the right-hand side. If there's any uncertainty, it's easy to double-check with a voltmeter while the GLB is powered up. You'll find +12 volts on one side, zero volts (ground) on the middle terminal, and +5 volts on the other side.

installation

There are a number of options for mounting the Packetimer in the PK-1. A small piece of double-sided foam tape works well to attach the pc board to the top of one of the 6116 RAM chips. The circuit pads for external connections to the Packetimer are on 0.1-inch centers to facilitate a plug and harness installation (see fig. 5). If the Packetimer is removed, there's no effect on the operation of the PK-1 other than loss of the time-out protection.

testing

You can check the completed Packetimer on the bench. Connect ground and +5 volts. LED CR6 should start to blink and a steady tone should come from the transducer. If you short the pin that goes from the arm of the reset switch (S1) to the reset pin, the flashing and the noise should stop. With power still applied to the Packetimer board, ground the pin that will be connected to the push-to-talk line. It should give you a brief beep. Next, hold the PTT pin low with a grounded alligator clip and see how much time it takes for the alarm to go off. If the anode of CR2 is wired to pin 1 on U1 (4060), the Packetimer should sound the alarm in roughly 30 seconds.

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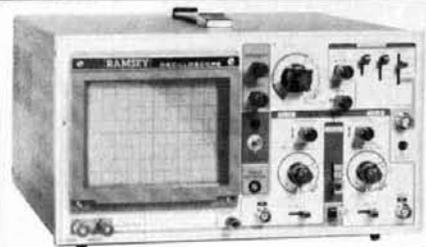
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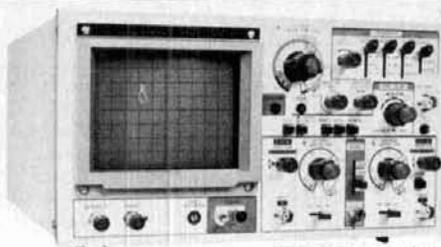
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building the "poor man's spectrum analyzer"

In September 1986 an exciting article on spectrum analyzers appeared in *ham radio* ("Low-Cost Spectrum Analyzer With Kilobuck Features," page 82). Having been in both communications servicing and engineering school, I'd used spectrum analyzers, but never owned one. (Most professionals can't afford them.) I once considered purchasing a plug-in spectrum analyzer to fit our existing biomedical electronics laboratory oscilloscope mainframe, but it cost over \$12,000! Then came W4UCH and his article on the very affordable WA2PZO/Science Workshop "Poor Man's Spectrum Analyzer."¹ I decided to build my own spectrum analyzer.

The WA2PZO concept is based on the fact that modern TV tuners, especially the "cable-ready" variety, are varactor-tuned. The familiar switched inductor tuner is replaced by a voltage-tuned varactor oscillator. Two types are available: one, which was used in the W4UCH article, has separate low-VHF, high-VHF, and UHF bands. A switch is used to select band coverage. The second is a wide-range "cable-ready" tuner that tunes from low VHF through UHF television bands in one 0-35 volt (some are 0-30 volt) range. Obviously, if you can modulate the tuning voltage with a sawtooth waveform (see "Practically Speaking," January, 1987, page 89), then you have a swept tuner. Demodulate its

amplified i-f output and display it on a 'scope, and you have a spectrum analyzer. Sheer genius! I bought both forms of tuner from Science Workshop; **fig. 1** shows the cable-ready, wide-range model.*

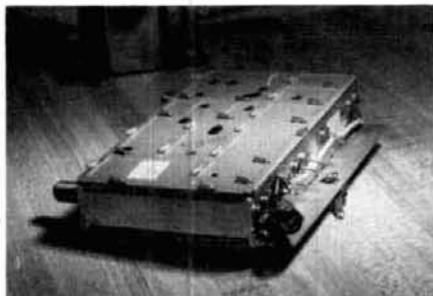


fig. 1. Wide range, L-VHF/H-VHF/UHF, voltage-tuned "cable ready" TV tuner used by the author.

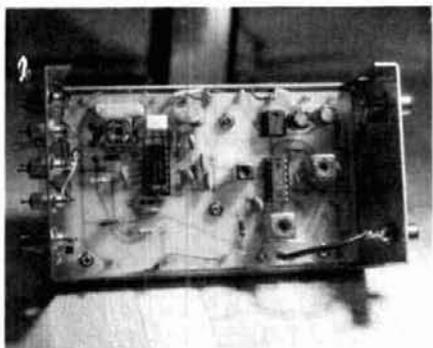


fig. 2. WA2PZO/Science Workshop i-f board built into shielded box.

*WA2PZO, *Science Workshop*, P.O. Box 393, Bethpage, New York 11714

The i-f board used in the W4UCH article and sold by Science Workshop is shown in **fig. 2**. The term "i-f" used here actually means a fixed frequency, single-conversion superheterodyne fm receiver tuned to 45.75 MHz (the tuner's i-f output frequency), and down-converted to the standard 10.7 MHz used for fm receiver i-f amplifiers. Because the i-f strip is actually a single-conversion receiver, the overall spectrum analyzer is a dual-conversion superhet. In fact, it can be used as a VHF receiver if the sweep is turned off (see *Sweep On/Off* in **fig. 3**).

The literature that came with the i-f board suggested that it be well shielded, and that feedthrough capacitors be used on all leads except the i-f input. The shielded enclosure is a standard chassis box with foldover flanges. Beware of many "shielded boxes" now on the market. The flanged type shown in **fig. 2** is minimally acceptable for shielded projects. The type of box that doesn't have overlapping flanges isn't acceptable at all. Some LMB boxes use little dimples on each edge for support, so they won't provide adequate shielding for most rf projects. While they're fine for audio and DC projects, they leave a great deal to be desired at rf.

Being an "older guy" in radio, I still called the feedthrough capacitors by that name and had a difficult time finding them locally; it seems that they're now called "EMI filters." Luckily, a local number for Newark Electronics was listed in the Yellow Pages, so I was

able to buy them directly from the source called for in the article.

In retrospect, "next time" I might try using a single connector for all leads other than the i-f, and 0.002- μ F disk ceramic capacitors on each lead at the connector. A good chassis-mounted connector costs about \$5 (or less), and high quality disk capacitors cost only about 80 cents each and even less per unit in bargain packs. The EMI filters called for in the article are about \$4 each; about 12 are required.

adding a sweep circuit

A significant problem with the W4UCH article for many readers is the lack of a sawtooth circuit. W4UCH used the sawtooth output of his Heath

OL-1 oscilloscope to sweep the tuner. That approach works if your oscilloscope provides this waveform. But modern oscilloscopes rarely have the sawtooth available on the front or rear panels. Also, many don't have a horizontal input. Look at your own oscilloscope's front panel. Some two-channel oscilloscopes have an "X-Y" mode on the vertical selector. If yours does, then one of the vertical channels can be re-configured as a horizontal channel at the flick of a switch.

If you don't have a horizontal input, or X-Y capability, you can still build the "Poor Man's Spectrum Analyzer" if you have either an "EXTERNAL TRIGGER" input (most 'scopes do) or a "TRIGGER GATE" output. The form-

er allows an external signal, such as the falling edge of an external sawtooth, to trigger the sweep. The latter outputs a narrow pulse every time the oscilloscope triggers. By allowing the 'scope to self-trigger, you get a string of pulses that can be used to trigger certain types of sawtooth generators.

Science Workshop makes a board available (fig. 3) that can be used for generating and controlling an external sawtooth. Although it suffices at this point, I'm not totally happy with the design. As I see it, there are two problems (see fig. 4): first, the sawtooth isn't very linear (see fig. 4A), and its fall time is too long. Second, the sawtooth clips at various settings of the center frequency and sweep rate controls. Perhaps in the future I'll find time to re-design these circuits, but for now the sawtooth board is satisfactory.

dc power supply

The Poor Man's Spectrum Analyzer requires a two-voltage, single-polarity dc power supply: +12 VDC and +24 VDC. The schematic diagram of a power supply that meets these requirements is shown in fig. 5.

I used a pair of small 12.6-VAC transformers (T1 and T2), with the primaries connected in parallel and the secondaries connected in series, to obtain the required voltage. I used available components — a pair of brand-new *Radio Shack* pc-mount transformers. You can use instead either a 25.6-VAC transformer or a dual-secondary transformer stocked by Digi-Key,* Dick

*Digi-Key Corporation, P.O. Box 677, Thief River Falls, Minnesota 56701.

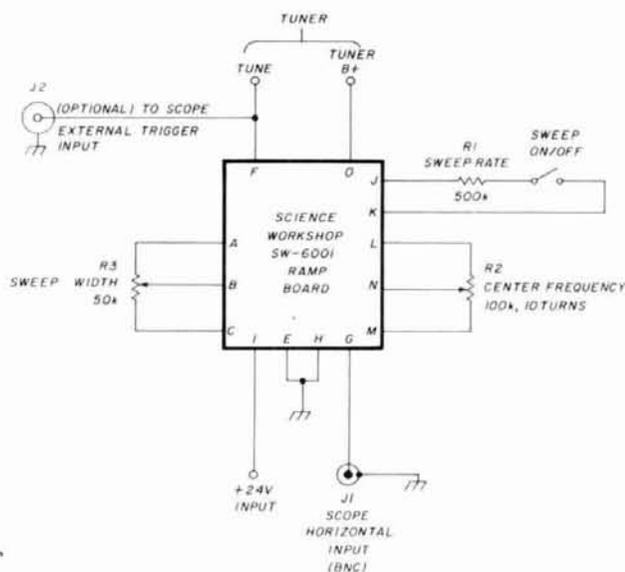


fig. 3. Sweep board SW-6001 connections (available from Science Workshop).

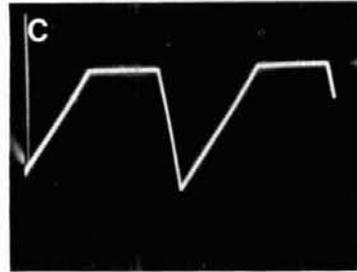
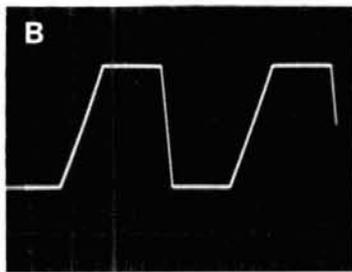


fig. 4. Waveforms from SW-6001: (A) Mid-range sawtooth, (B) and (C) are sawtooths taken at extremes of CENTER FREQUENCY and SWEEP RATE controls.

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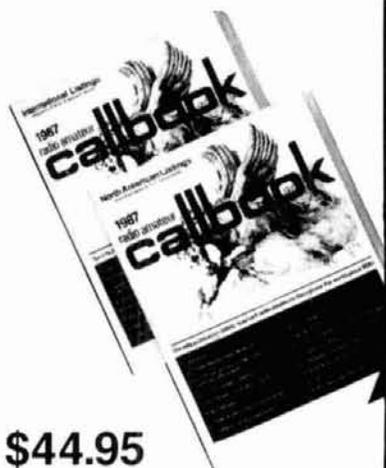
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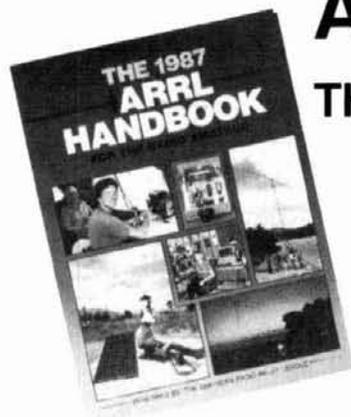
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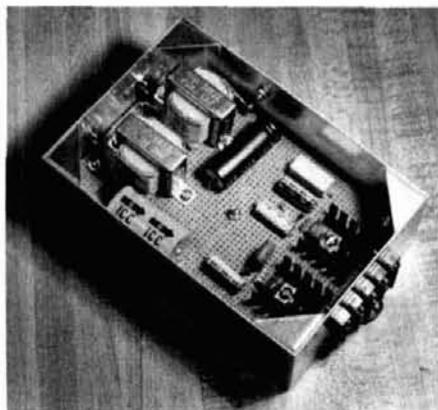


fig. 5A. DC power supply: top view of perforated assembly.

Smith Electronics,** and other distributors. The current requirements for this project aren't critical, so almost any transformer with a rating of 300 mA or more is acceptable.

Two three-terminal IC regulators are used in this project. The 7824 (also usable: LM-340T-24) provides the needed +24 VDC, while a 7812 (or LM-340T-12) provides the +12 VDC. Both regulators are standard, but I found that the 7824 was a little hard to find locally. The NTR line of replacement semiconductors, stocked by many local distributors, carries a good replacement number.

There's nothing critical about the parts layout, and perf board can be used for construction. The diodes (CR1 and CR2) are used to prevent the charge in the output capacitors from damaging the voltage regulators at turn-off. Don't delete them, even though you may see many circuits using these regulators without charge dump diodes. The shielded construction and the 0.1- μ F output capacitors are needed because one might be using this device in close proximity to a high-power transmitter. The capacitors must be mounted on the output terminal, or at least as close as physically possible.

performance

Figure 6 shows an oscilloscope

**Dick Smith Electronics, P.O. Box 8021, Redwood City, California, 94063-8021.

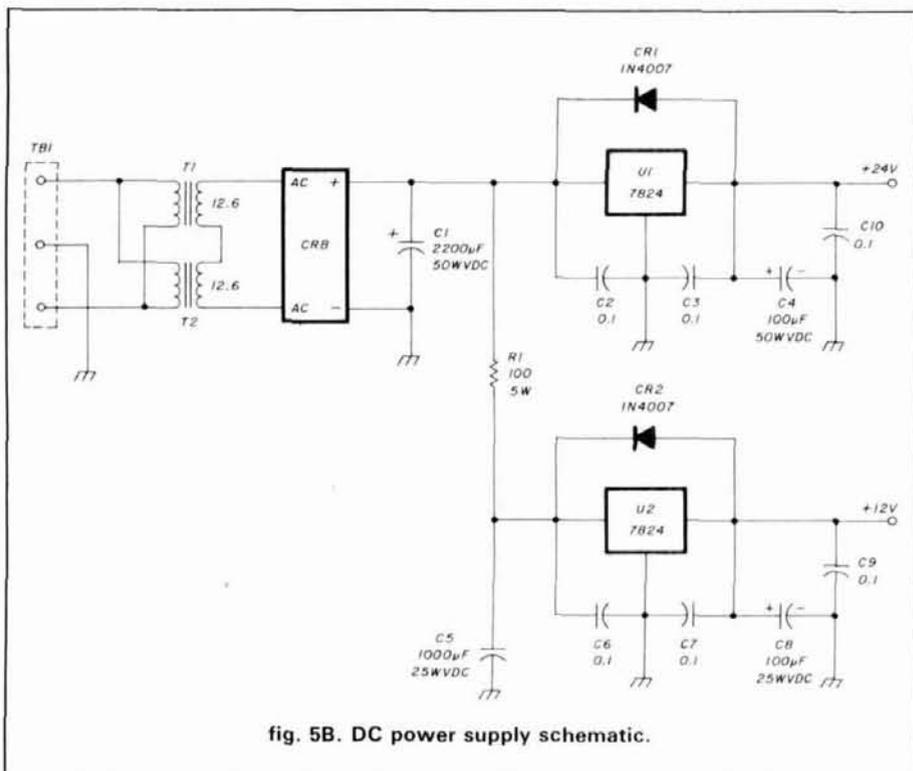


fig. 5B. DC power supply schematic.

photo of the spectrum analyzer display. The center frequency was adjusted to the low end of the fm broadcast band. The large center spike is the signal from my Measurements Model 80 signal generator set to approximately 85 MHz. The small spike to its right is WAMU-FM (88.5 MHz), my favorite public radio station; the other spikes are other fm band signals. The large signal barely visible on the left side is, I believe, Channel 5 TV in Washington, DC.

Those who don't have a horizontal input must use the sawtooth to trigger the sweep through the EXTERNAL TRIGGER input. I recommend using the negative trailing edge of the sawtooth waveform for this purpose (set TRIGGER SLOPE — or equivalent switch — to the negative position). Also, be sure to make the sweep time across the entire horizontal aspect of the 'scope graticule equal to the period of the sawtooth leading edge. Otherwise, the 'scope and sawtooth won't sweep in sync.

future projects

The spectrum analyzer project has

given me a few ideas for changes or improvements. First, I plan to redesign the sawtooth generator (possibly generating the sawtooth digitally). Second, I plan to add an amplifier/attenuator based on Mini-Circuits fixed attenuators and a Signetics NE-5205 amplifier.¹ The range will be -60 to +19 dB. Third, there may be a converter for hf, and tuners to band-limit the spectrum analyzer at will to certain VHF Amateur bands. This modification will punch out certain local signals that tend to drive receivers into intermod problems at my QTH. Fourth, WA2PZO is working on a tracking oscillator circuit, and in fact has a tentative approach to its design. A tracking oscillator produces an output at the spectrum analyzer's center frequency. Besides its obvious use as a signal source, it's also useful for driving a frequency counter. Presently, tuning indication is by seat-of-the-pants calibration of the voltage control. I plan to buy the WA2PZO tracking oscillator kit if, and when, it becomes available.³

Varactor tuners are inherently nonlinear in their voltage-vs-frequency

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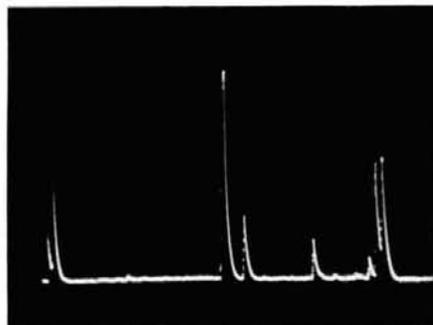


fig. 6. FM broadcast band signals from my spectrum analyzer project. Central spike is a signal generator on 85 MHz (\pm 25-year-old dial calibration).

characteristic and the resulting curve looks parabolic in shape. Digitally generating the sawtooth signal is a worthwhile consideration. If you want to try it yourself, write to me and I'll send you a brief on the method. (Please enclose a No. 10 SASE.) A very brief discussion of the digital linearization method is given on pages 300-302 of my book, *How to Design and Build Electronic Instrumentation*.² Although my method is based on discrete logic circuits, it can easily be applied to digital computers should you want to provide computer control of your spectrum analyzer.

conclusion

WA2PZO deserves accolades (and our business) because of the Poor Man's Spectrum Analyzer project, which offers opportunity for experimentation in areas previously closed to Amateurs solely for reasons of cost. If you have an idea for its use, a new or different modification, or a particularly well-built version of the W4UCH/WA2PZO project, send me the details.

references

1. Michael E. Gruchalla, "NE-5205 Wideband RF Amplifier", *ham radio*, September, 1986, page 30.
2. Joe Carr, K4IPV, *How to Design and Build Electronic Instrumentation*, Second Edition, Tab Books, Blue Ridge Summit, Pennsylvania 17214. (\$17.95 from the author, publisher, or Ham Radio's Bookstore, Greenville, New Hampshire 03048. Add \$3.50 shipping and handling for HR Bookstore orders.)
3. For ideas on building your own, see also Wayne Ryder's "Spectrum Analyzer Tracking Generator," *ham radio*, September, 1978, page 30.

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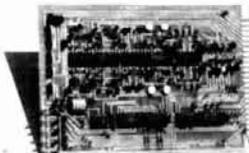
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0508G	50-54	170	1	.6 15
0510	50-54	170	10	- -
0510G	50-54	170	10	.6 15
1410	144-148	160	10	- -
1410G	144-148	160	10	.6 15
1412	144-148	160	30	- -
1412G	144-148	160	30	.6 15
2210	220-225	130	10	- -
2210G	220-225	130	10	.7 12
2212	220-225	130	30	- -
2212G	220-225	130	30	.7 12
4410	420-450	100	10	- -
4410G	420-450	100	10	1.1 12
4412	420-450	100	30	- -
4412G	420-450	100	30	1.1 12

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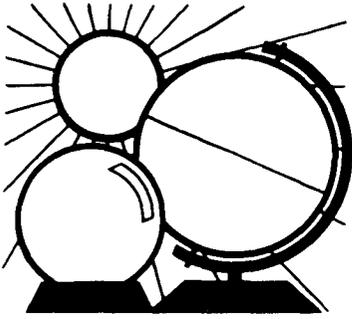
1. Models with G suffix have GaAs FET preamps. Non-G suffix units have no preamp.
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equinox problems

Most of the year, strong, stable DX reception occurs when one operates close to the MUF (maximum usable frequency). There are, however, two seasons during which the ionosphere doesn't "cooperate." These are the equinoctial periods (from March through April and from September through October), when the Earth's geomagnetic field is anything but stable. This field guides ion diffusion and drift from the D, E, and lower F layers (where ionization occurs) up to the higher part of the F layer, the main region used for DX.

The geomagnetic field's variability is related to the characteristics of the solar wind. Variations in solar wind particles streaming out from the sun are passed on to the geomagnetic field. This in turn affects the ionosphere's ions and electrons — and, consequently, the propagated signals.

It's the alignment of the Earth's polar regions to the sun's spiraling solar wind (see **fig. 1**) that makes the equinox seasons troublesome. Subsequent ionospheric variations influence a signal's azimuthal and elevation angle of arrival as well as its amplitude and phase.

Paths that have high latitude (i.e., greater than 50 degrees north or less than 50 degrees south) reflection points are most affected; equatorial regions are less disturbed. Mid-latitude reflection points at about 25 through 50 degrees are the least affected and therefore the most stable. There is also a diurnal variation superimposed on this seasonal occurrence. This variation is divided into two parts: one, a

period from midnight to 0400 *universal* time; and two, the period from 10 pm to 5 am, *local* time. Consequently, nighttime (from 10 pm to 5 am) is a more unstable time for everyone. The universal time segment, on the other hand, is different for each location, depending upon where (i.e., at which longitude) you live. If the two time periods overlap at your QTH, then the effects of the disturbed conditions are even greater. Such is the case for Amateurs who live between 75 degrees East and 150 degrees West longitude; unfortunately, this area encompasses Europe and the Americas. This effect is particularly potent along the east coast of the USA. On the positive side, this phenomenon often lets us work DX from unusual locations. Check WWV at 18 minutes after the hour for geomagnetic K figures of four to seven as a guide to the unusual DX openings.

last-minute forecast

DX conditions for the higher frequency bands, 10 through 30 meters, are expected to be excellent toward the end of the first week and through the second week of March. The favorable conditions are partly due to transequatorial openings at southeast through southwest headings.

From about March 6 through the 10th, expect some increase in solar flare SIDs (sudden ionospheric disturbance), which will appear as increased attenuation of signals for up to an hour during the daytime. A geomagnetic disturbance (signal attenuation and QSB, mainly at night) can be expected two to three days later. The same

situation will occur during the third week of the month. The lower bands are more affected by these disturbances, but are still expected to be very good for evening and nighttime DX the third and fourth weeks of the month. Some thunderstorm QRN can be experienced as springtime weather fronts pass your QTH. Spring equinox occurs on March 21st at 0352 UTC. The moon is full on the 15th and at perigee on the 24th.

band-by-band summary

Ten, twelve, fifteen, and twenty meters provide many openings during the daytime. As you go up in frequency (i.e., into the higher bands) the openings will be shorter, centered around noon, and mainly toward southerly directions. Fifteen meters is now only a transition band between 12 and 20. Twenty meters, the mainstay daytime band, will be useful toward the south in the evenings for northerly directions. Transequatorial openings might occur in evening hours to locations up to 2000 miles if antenna radiation angles are down to 10 degrees.

Thirty, forty, eighty, and one-sixty meters are all good for nighttime DX. Thirty and 40 meters are the night frequencies for the east-west and northerly directions and for distances of 1600 miles if increased solar activity has occurred. With little solar activity, the MUF will approach 80 meters and signals will usually be stronger. These bands should generally be quiet, since thunderstorm activity is still not pronounced.

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WESTERN USA

GMT	PST	N	NE	E	SE	S	SW	W	NW
0000	4:00	20	40	20	10	12	10	10	15
0100	5:00	20	40	20	10	12	10	10	15
0200	6:00	20	40	20	12	12	10	10	20
0300	7:00	20	40	20	12	12	10	10	20
0400	8:00	20	40	20	15	15	10	10	20
0500	9:00	30	40	20	20	20	12	12	30
0600	10:00	30	40	20	20	20	12	12	30
0700	11:00	40*	40	20	20	30	15	15	30
0800	12:00	40	40	20	20	30	20	20	40
0900	1:00	40	40	30	20	30	20	20	40
1000	2:00	40	40	30	20	30	20	20	40
1100	3:00	40	40	30	20	30	20	20	40
1200	4:00	40	30	20	20	30	20	20	40
1300	5:00	40	20	12	20	30	20	20	40
1400	6:00	30	20	10	15	40*	30	20	40
1500	7:00	30	20	10	12	20	30*	20	40
1600	8:00	40	20	10	10	20	30	20	40
1700	9:00	40	20	10	10	15	20	20	40
1800	10:00	40	20	10	10	15	20	20	40
1900	11:00	40	20	10	10	12	15	20	20
2000	12:00	40	20	12	10	12	12	15	20
2100	1:00	40	30	12	10	12	12	12	20
2200	2:00	40	30	15	10	12	10	12	20
2300	3:00	20	40	20	10	12	10	10	15

MID USA

GMT	MST	N	NE	E	SE	S	SW	W	NW
0000	5:00	40	40	20	10	12	10	10	15
0100	6:00	30	40	20	12	12	10	10	20
0200	7:00	30	40	20	12	15*	10	10	20
0300	8:00	30	40	20	15	15	10	10	20
0400	9:00	40	40	20	20*	15	12	12	30
0500	10:00	40	40	20	20	20	12	15	30
0600	11:00	40	40	20	20	30	15	20	30
0700	12:00	40	40	20	20	30	20	20	40
0800	1:00	40	40	30	20	30	20	20	40
0900	2:00	40	40	30	20	30	20	20	40
1000	3:00	40	30	30	20	30	20	20	40
1100	4:00	40	20	15	20	30	30	20	40
1200	5:00	20	20	12	20	30	30	20	40
1300	6:00	20	20	10	15	30	30	20	40
1400	7:00	20	20	10	12	20	20	20	40
1500	8:00	20	20	10	10	20	20	20	40
1600	9:00	30	20	10	10	15	20	20	40
1700	10:00	40	20	10	10	15	20	20	40
1800	11:00	40	20	10	10	12	20	20	40
1900	12:00	40	20	10	10	12	15	20	20
2000	1:00	40	20	12	10	12	12	15	20
2100	2:00	40	30	12	10	12	12	12	20
2200	3:00	40	30	15	10	12	10	10	20
2300	4:00	40	40	20	10	12	10	10	20*

EASTERN USA

GMT	EST	N	NE	E	SE	S	SW	W	NW
0000	7:00	30	40	20	10	12	10	10	20
0100	8:00	30	40	20	12	12	10	10	20
0200	9:00	30	40	20	12	15	12	12	30
0300	10:00	40	40	20	15	15	15	15	30
0400	11:00	40	40	20	20	20	20*	20	30
0500	12:00	40	40	20	20	20	20	20	40
0600	1:00	40	40	20	20	30	20	20	40
0700	2:00	40	40	20	20	30	20	20	40
0800	3:00	40	40	20	20	30	20	20	40
0900	4:00	40	30	20	20	30	30	20	40
1000	5:00	20	20	15	20	30	30	20	40
1100	6:00	20	20	12	20	30	30	30	40
1200	7:00	20	20	10	15	30	20	20	40
1300	8:00	20	20	10	15	20	20	20	40
1400	9:00	20	20*	10	12	20	20	20	40
1500	10:00	30	20	10	10	20*	30	20	40
1600	11:00	30	20	10	10	15	20	20	40
1700	12:00	40	20	10	10	15	20	20	40
1800	1:00	40	20	10	10	12	20*	20	40
1900	2:00	40	20	10	10	12	15	20	30*
2000	3:00	40	20	10	10	12	12	15	20
2100	4:00	40	30	12	10	12	12	12	20
2200	5:00	40	40	15	10	12	10	10	20
2300	6:00	40	40	20	10	12	10	10	20

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

*Look at next higher band for possible openings.

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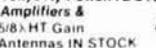
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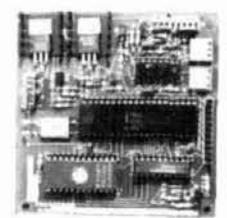
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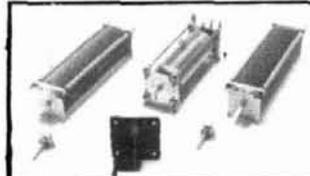
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OPTO 1.3 GHz shirt pocket frequency counter

A friend has something he calls his "\$4000 gutbuster." A sixties-vintage 1-MHz Beckman-Berkeley nixie tube digital frequency counter, it claims a fair plot of acreage in his closet-sized ham shack, sitting atop a \$2000 gutbuster and supporting a \$5000 gutbuster — all treasures acquired, long past their prime, for a few dollars each at some long-forgotten flea market.

For those of us who grew up with solid-state equipment (and therefore take it pretty much for granted), OPTO's new 1.3 GHz shirt pocket frequency counter is impressive in terms of size (3-1/2 x 4 x 1 inches), cost (\$99.95 in kit form), maximum frequency (1.3 GHz), and sensitivity. For our friend, it's nothing short of miraculous.

Operating from either ac or a 9-volt internal rechargeable NiCAD battery pack, the Model 1300 covers 1 through 1300 MHz. Though we didn't have the opportunity to check it out on the 1296-MHz band, it worked like a champ on 2 meters and hf.

The OPTO counter sports two switch-selected sensitivity ranges. In the high range with the optional telescoping antenna attached, front end gain causes a continuous spurious count that's easily identified by the randomizing of the three or four least significant digits. In the presence



of even a weak signal (i.e., for a counter), the count stabilizes and you know the unit's working. In one quick test, the counter performed faultlessly on a handheld unit pushing 500 mW into a rubber duck over distances up to about 50 feet through an exterior (wooden) wall.

In addition to two sensitivities (with accuracy said to be within ± 1 count LSD, thanks to an RTXO time base), the counter offers two gate periods, 0.25 and 2.5 seconds. (As with any counter, if the source either comes on or goes off during the gate period, the count will be incorrect).

Both the mechanical and electronic quality of

the OPTO counter are excellent. Housed in a sturdy anodized aluminum case — which, by the way, you don't have to open to adjust calibration — it has endured several months' careless handling without complaint. Eight bright red 0.28-inch LEDs make reading it easy, even under a variety of difficult lighting situations.

Priced at \$150 assembled, it's also available in kit form for \$99.95. Both the finished unit and kit include NiCads and a 110 VAC/9 VDC adapter for ac operation and charging. Optional accessories include a carrying case, probe, and the abovementioned telescoping antenna.

For details, contact OPTOelectronics, Inc., 5281 Northeast 14th Avenue, Fort Lauderdale, Florida 33334.

— KA1LBO

Circle #301 on Reader Service Card.



orbital predictions

Project OSCAR, Inc. is preparing a new set of orbital predictions for 1987. The predictions will provide the UTC times and longitude for all south-to-north equatorial crossings of the two active Russian satellites carrying Mode A transponders (RS5 and RS7), the two University of Surrey-AMSAT scientific satellites (O9 and O11), and the recently launched JARL/JAMSAT satellite, JAS-1, recently renamed Fuji OSCAR 12 (FO12), which carries both analog and digital Mode J transponders.

Used with the appropriate plotter, these predictions allow the user to determine the access times to all presently available Amateur Radio satellites. The cost in the U.S., Canada, and Mexico is \$10 (\$12 for overseas).

For details, write Project OSCAR Inc., P.O. Box 1136, Los Altos, California 94023-1136.

Circle #311 on Reader Service Card.

6- and 8-pole crystal filters

IRI has announced the addition of 14 new 6- and 8-pole crystal filters designed for both general experimental use and for use in recent Kenwood and ICOM hf transceivers and receivers. These filters vary in bandwidth from 250 Hz to 2.2 kHz. Kenwood and ICOM filter models range in price from \$99 to \$125. The 6-pole experimenter's filters are priced at \$50; the 8-pole filters, \$60.

For details on models and specifications, contact International Radio, Inc., 747 South Macedonia Boulevard, Port St. Lucie, Florida 33452.

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D-52	10/15/20/40/80	2	105'	84.95
D-56	10/15/20/40/80	6	82'	109.95
D-66	10/15/20/40/80/160	6	163'	129.95

TRAP VERTICALS - "SLOPERS":*

Model	Bands	Traps	Length	Price
V5-41	10/15/20/40	1	28'	44.95
V5-52	10/15/20/40/80	2	49'	59.95
V5-53	10/15/20/40/80	1	42'	69.95
V5-64	10/15/20/40/80/160	4	73'	89.95

*Can be used without radials.

*Feed line can be buried if desired.

*Permanent or Portable Use

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SINGLE BAND DIPOLES (Kit form):

Model	Band	Length	Price
D-15	15	22'	18.95
D-20	20	33'	19.95
D-40	40	66'	27.95
D-80	80/75	130'	25.95
D-160	160	260'	34.95

Includes assembly instructions, Deluxe center connector, 14 ga Stranded CopperWeld Antenna wire and End insulators

COAX CABLE: (includes PL-259 connector on each end)

Type	Length	With antenna purchase	Separately
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RJ-58	90'	12.00	16.95

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ultra-compact VHF transceiver

ICOM's new IC-275 is a new ultra-compact all-mode VHF transceiver that's jam-packed with all the most wanted features. It boasts 25 watts (the IC-275A includes a built-in power supply) or 100 watts (IC-275H with an external optional power supply) output, 99 tunable memories, wideband receive coverage from 138-174 MHz (Tx from 140.100-150.000 MHz), 32 built-in subaudible tones (actual subaudible frequency is displayed), odd offset capability, and a call channel.

Ideal for satellite operation, it also features full scan of the entire frequency spectrum, program scan, memory scan (20 memories in only 1 second), memory lock-out in scan function, and mode scan.

The packet-compatible IC-275 incorporates a data switch for 5-ms switching time, a new velvet-touch tuning knob, and an easy-to-read amber LCD readout. It comes ready to operate with an HM-12 up/down scanning mic and dc cord.

Options include a tone squelch unit, speech synthesizer, a module for OSCAR operation that allows tracking with its new IC-475 UHF companion and an FL-83 500 Hz 10.7491 MHz CW filter. The AG-25 mast-mounted preamp is also available.

The IC-275A is priced at \$1199. ICOM America, Inc., 2380 - 116 Avenue, N.E., P.O. Box C-90029, Bellevue, Washington 98009-9029.

Circle #309 on Reader Service Card.

international satellite receiver

The AVCOM COM-3R International is a high-performance receiver designed for easy operation plus powerful and versatile earth station receiver capabilities.

Special threshold extension circuitry is used in the COM-3R International to enable it to produce high-quality video, even in the fringes of a satellite footprint. For international reception, optional threshold peaking and selectable triple i-f filters, optimized for this purpose, are available.

For details, contact AVCOM of Virginia Incorporated, 500 Southlake Boulevard, Richmond, Virginia 23236.

Circle #302 on Reader Service Card.

hand set and phone patch

NCG's Hotline 107 Hand Set, developed in response to requests from both Amateurs and Land Mobile radio users, includes the following features: a dynamic 100-ohm speaker, adjustable volume control, in-cradle dialing, vertical or horizontal mounting, and a noise-cancelling microphone. Model 107M's features include all of the above plus auto-dial, 10-number memory, super-capacitor-based 14-day memory backup, plus 3-button memory set, storage, and recall. ANI is installable by the system's owner.

Features of the new Hotline-007 MK III, already one of the best selling phone patches, include all-mode operation (a-m, fm, SSB), easy hookup (no internal wiring is required to the base), a dial restrict switch (to inhibit 0 and 1, preventing unauthorized long distance calls), and owner-programmable access code and CW ID.

New features include a manual connect/disconnect switch. More importantly, the MK III is switchable from simplex to full duplex, which greatly improves the quality of phone conversations and increases the Hotline's versatility. Besides use as a phone patch, it can be used as a repeater interconnect and a quick field mini-repeater.

Both units are available through independent dealers or through the manufacturer. For details, contact NCG Company, 1275 N. Grove Street, Anaheim, California 92806.

Circle #308 on Reader Service Card.

KDK FM-240 service manuals

Service manuals for the Encomm FM-240 are now available. The technical manual - plus an updated version of the owner's manual, schematic diagram, and board layouts - are included in a hardbound notebook for easy access. The suggested retail price is \$15.95.

For details, contact Encomm, Inc., 1506 Capital, Plano, Texas 75074.

Circle #320 on Reader Service Card.

pocket digital multimeter

Eaglestone, the new direct marketing division of Siber Hegner North America, offers a card-size digital multimeter with increased voltage and ohm ranges to 500 volts ac/dc and 20 megohms, respectively. Model DM1000 folds to approximately 4.5 x 3 x 0.5 inches and weighs only 3 ounces.

Complete with velcro-attached probes, the DM1000 offers 0.7 percent basic dc accuracy, autoranging, diode testing and an easy-to-read LCD. During wiring checks, a tone sounds to indicate continuity. A single rotary switch immediately accesses all functions - dc or ac volts, ohms, and continuity/diode.

Model DM1000 sells for \$35 with a risk-free, 30-day money-back return and a full one-year warranty. For details, contact Eaglestone, 5 Landmark Square, Stamford, Connecticut 06901.

Circle #307 on Reader Service Card.

service monitor

CT Systems of Beech Grove, Indiana, has introduced the Model 3100 Communications Service Monitor, which includes such features as duplex/offset generation, spectrum analysis, sweep testing, filter alignment, cellular testing, and tone/digital signalling — all in a lightweight, compact unit. Simple to operate, the unit offers built-in "real time" self-diagnostics, SINAD, dc and ac oscilloscope, RMS ac voltmeter, DTMF and digital coded squelch, and other features. Priced at \$9,650, the 3100 can store 20 complete sets of instrument parameters, allowing radio data and various test conditions to be saved into memory.

For details, contact CT Systems, Inc., 5245 Hornet Avenue, Beech Grove, Indiana 46107.

Circle #303 on Reader Service Card.

new rf power meter

Bird Electronic Corporation has announced the release of its Model 4421 RF Power Meter, a programmable, microprocessor-based instrument which measures forward and reflected rf power, VSWR, and return loss in watts or dBm. The model 4421's accuracy is ± 3 percent of the reading. The 4421 package includes a new remote sensor head based on Bird's proven ThruLine[®] principles for in-line, unterminated measurements to 1kW without the need for directional couplers or attenuators.

The frequency range of 1.8 MHz to 1 GHz is covered by only two sensors for fast, flexible operation. Each sensor carries its own calibration profile in a reprogrammable memory. Bird plans other sensors to extend the measurement range into the milliwatt and microwatt region. Optional interfaces provide for remote, programmed operation. Under control of a personal computer, the 4421 can both acquire and store data. Other highlights include simple front panel operation with push-button function selections and auto or manual ranging.

The model 4421 RF Power Meter is priced in the \$2,000-\$3,000 range, depending on accessories. For more information on the 4421 or other Bird products, contact Bird Electronic Corporation, 30303 Aurora Road, Cleveland (Solon), Ohio 44139.

Circle #304 on Reader Service Card.

portable communications service monitor

Ramsey Electronics' new COM-3 Service



Monitor, designed for analyzing and testing transceivers in the 100-kHz to 1000-MHz range, features a programmable microprocessor memory that stores and recalls up to ten commonly used test set-ups. It covers every band and frequency, and i-f parameters of 100 kHz to 1000 MHz in 1 kHz steps. The keyboard features programmable offset keys that simplify frequency entry for duplex or repeater radios, and incremental step keys to facilitate receiver testing.

The COM-3 monitor weighs less than 10 pounds and has a built-in, rechargeable battery pack. A Cordura travel case with zippered pockets and shoulder strap is optional.

The manufacturer's introductory list price for the COM-3 is \$1995. For details, contact Ramsey Electronics Inc., 2575 Baird Road, Penfield, New York 14526.

Circle #305 on Reader Service Card.

new shortwave "sloper"

Universal Shortwave's new Alpha Delta DX-SWL Sloper Antenna covers medium-wave and all major shortwave bands, as well as the 90- and 120-meter bands, often overlooked by dipole antennas.

The overall length of the slope wire is 60 feet. It includes a single 50-ohm coaxial feedpoint (for PL259) at the apex for user-supplied 50-ohm coaxial lead-in. The American-made DX-SWL Sloper, constructed with heavy-duty components and stainless steel hardware, utilizes broadband low-Q rf choke resonators for multiband frequency selection. It is fully assembled and requires no adjustments or "trimming"; only one end of the antenna needs to be elevated (25 feet or higher). The price is \$69.95 plus \$2.75 for shipping and handling.

For information, contact Universal Shortwave, 1280 Aida Drive, Reynoldsburg, Ohio 43068.

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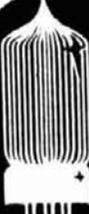
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COMING EVENTS

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SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: Please indicate in your announcements whether or not your Hamfest location, classes, exams, meetings, flea markets, etc., are wheelchair accessible. This information would be greatly appreciated by our brother/sister hams with limited physical ability.

FLORIDA: March 21-22. The Playground Amateur Radio Club's 17th annual North Florida Ham Swapfest, Shrine Fairgrounds, north Ft. Walton Beach. Doors open 8 AM both days. FCC exams Saturday only. ARRL, MARS, and OCWA meetings. Banquet Saturday night. RV parking. Talk in on 146.19/79 and 52. For more information write PARC, PO Box 873, Ft. Walton Beach, FL 32548.

GEORGIA: March 7. The Dalton Amateur Radio Club's 5th annual Hamfest, North Georgia Fairgrounds, Dalton. Indoor flea market with tables provided for sellers/traders. VE upgrade

exams nearby. For information: DARCI, PO Box 143, Dalton, GA 30722-0143.

ILLINOIS: March 29. **LAMARFEST '87** sponsored by the Libertyville and Mundelein Amateur Radio Society. Lake County Fairgrounds, Grayslake. Doors open 8 AM. Commercial setup time (by reservation only) 6 AM. Admission \$2.00 advance by March 20; \$3.00 at the door. Indoor swapfest, exhibitors, code speed testing and exams, free parking, public cafeteria. Talk in on 147.63-.03 Waukegan repeater. 146.52 simplex. For information and reservations: Lamars c/o Marc Abramson, PO Box 751, Libertyville, IL 60048. (312) 255-0642 8PM to 10PM CST.

ILLINOIS: March 15. The Chicago ARC will hold a continous seminar entitled "Introduction to Amateur Radio", Noon to 5 PM, North Park Village, Community Room, 5801 N. Pulaski Rd, Chicago. The Amateur Radio Novice Class license seminar will start Monday, March 16 at 7:30 PM, same address in "J" building. For information call (312) 545-3622.

KENTUCKY: March 28 and 29. **LTARC Hamfest** sponsored by the Lincoln Trail ARC, Pritchard Community Center, Elizabethtown. Admission \$5.00 advance; \$6.00 at the door. Dealer tables \$10.00/day or \$15.00 both days. Flea market \$5.00/day or \$8.00 both days plus admission ticket. Activities include ARRL State Convention, Walk-in testing, numerous forums. Free parking. Nearby motels, reasonable rates. Talk in on 146.52, 146.38/98. For tickets or reservations: Hubert Hensley, WD4GDA, PO Box 342, Vine Grove, KY 40175. Tel (502) 877-2234.

KENTUCKY: March 7. The annual Glasgow Swapfest will be held at a NEW LOCATION, the Cave City Convention Center, Cave City. Starts 8 AM, ends when everyone goes home. Admission \$3.00 per person with no extra charge for exhibitors. Activities include DX and ARRL forums, flea market, FCC VE tests beginning 10 AM. Walk-ins only. Bring original license and photocopy. Talk in on 146.34/94 and 144.59/145.19. For more information: N4HCO, Rt 9, Box 112B, Glasgow, KY 42141.

MARYLAND: March 28 and 29. The Baltimore Amateur Radio Club will present the Greater Baltimore Hamboree and Computerfest, Maryland State Fairgrounds Exhibition Complex at Timonium. Indoor flea market and large dealer display area. Amateur radio, personal and small business computers featured. Hard surfaced outdoor flea market area. Food service, plenty of free parking and more. Gates open 8 AM each day. Admission \$4.00/day or \$6.00/both days. Children under 12 free. For additional information and display space reservations: GBH&C, PO Box 95, Timonium, MD 21093-0095 or call (301) HAM-FEST.

MICHIGAN: March 21. The Michigan Crossroads Hamfest. Sponsored by the Southern Michigan Amateur Radio Society and the Marshall High Photo Electronics Club. 8 AM to 3 PM. Marshall High School, Marshall, MI. Tickets \$2.00 advance SASE; \$3.00 at the door. Packet radio demonstration and forum, free parking, full food service. License exams Novice thru Extra. Preregistration requested. Send Form #10. SASE and \$4.25 payable to ARRL/VEC to License Exam, PO Box 2, Pleasant Lake, MI 49272. Walk-ins on availability basis. Talk in on 146.67 or 146.52 or 223.94. For more information SASE to Louis Ryason, WBBWXS, 23 So. 27th Street, Battle Creek, MI 49015.

MICHIGAN: April 5. The South Eastern Michigan Amateur Radio Association's 29th annual Hamfest Swap and Shop, 8 AM to 3 PM, Grosse Pointe North High School, 707 Vermer Road, Grosse Pointe Woods. ARRL, DX and Packet forums. Tickets \$1.00 advance; \$3.00 at the door. Tables \$8.00 advance; \$10.00 at the door. Talk in on SEMARA repeater 147.70/10 and 146.52 simplex. For information: SEMARA Hamfest, PO Box 646, St. Clair Shores, MI 48080 or phone Fred Lweis, NK8M (313) 881-0187.

MINNESOTA: April 4. 10th annual Rochester Area Hamfest sponsored by the Rochester ARC, John Adams Junior High School, 1525 NW 31st Street, Rochester. Doors open 8:30 AM. Large flea market, speakers, programs, refreshments and plenty of free parking. Talk in on 146.22/82. W0MXW. For further information contact: RARC c/o WBOYEE, 2253 Nordic Ct. NW, Rochester, MN 55901.

MISSOURI: March 13. The Jefferson Barracks Amateur Radio Club's 27th annual Amateur Radio Auction, Concordia Turners Hall, 6432 Gravois, south St. Louis City. Starts 7:30 PM.

NEW HAMPSHIRE: March 14. The Interstate Repeater Society of Derry, NH will hold its annual Flea Market, Lions Club Hall, Lions Avenue, Hudson. Doors open 8 AM. Admission \$1.00 at the door. Tables \$8.00 each. For table reservations (603) 623-0628 or (603) 883-9441. Write I.R.S., PO Box 693, Derry, NH 03308.

NEW JERSEY: March 28. Ham Radio Flea Market sponsored by the Chestnut Ridge Radio Club, Education Building, Saddle River Reformed Church, East Saddle River Road and Weiss Road, Upper Saddle River. Admission \$1.00. Tables \$10/first. \$5.00 each additional. Tailgating \$5.00. Contact Jack Meagher, W2EHD (201) 768-8360.

NEW JERSEY area Chaverim, an organization of Jewish Amateur radio operators completing its 4th successful year, invites all hams and those interested in Amateur Radio to join, particularly those in Monmouth and Ocean counties of NJ. We meet the first Sunday of the month in the Jewish Community Center, Grant Avenue, Deal. Write POB 192, West Long Branch, NJ 07764.

NEW JERSEY: March 22. **HAMCOMP '87**, 15th annual flea market sponsored by the Delaware Valley Radio Association. 8 AM to 2 PM, the New Jersey National Guard 112th Field Artillery Armory, Eggerts Crossing Road, Lawrence Township (Trenton) 2 miles north of I-95. Admission \$3.00 advance; \$4.00 at the door. Indoor selling space \$10.00 (wall space) and \$7.00. Outdoor spaces \$6.00. Sellers bring own tables. Doors open for setup 6 AM. General public 8 AM. Free parking. Re-

freshments available. Talk in on 146.07.67. For more information and space reservations: HAMCOMP '87, c/o KB2ZY, Box 441B, RD 1, Stockton, NJ 08559. Please SASE.

NEW JERSEY: March 13. The Splitrock Amateur Radio Association's 2nd annual Evening Hamfest, Drew University Center, Room 107, Rt. 24, Madison. Setup 6 PM. Doors open 7 PM. Admission for buyers \$2.00. Tables available from \$2.00 to \$8.00 per table. Talk in on 146.985 outside Madison area, 146.58 in Madison area. For information write SARA, PO Box 3, Whippany, NJ 07981 or call Steve Halliburton, WA2SOC (201) 366-9642.

NEW JERSEY: March 28. The Shore Points ARC invites everyone to Springfest '87, 9 AM to 2 PM, Atlantic County 4-H Center, Rt. 50, Egg Harbor City, approx. 15 miles west of Atlantic City. Indoors, heated. Sellers \$5 per space, bring own tables. Buyers \$3. Outdoor tailgating, weather permitting. Food and drink available. Talk in on 146.985 and .52. For information write SPARC, PO Box 142, Absecon, NJ 08201.

OHIO: April 24, 25, 26. DAYTON HAMVENTION.

The Dayton Amateur Radio Association is now accepting applications for its 1987 Scholarship Program. Any licensed Amateur graduating from high school in 1987 is eligible to enter. For information and application forms write DARA Scholarship Committee, 317 Ernst Avenue, Dayton, Ohio 45405. **OHIO:** April 24. The 18th annual BCACSCHC will be held on FRIDAY NIGHT of the Hamvention, at the Conference Center (Madison Room) of the HARA ARENA AND CONFERENCE CENTER, (the same location as the Hamvention) starting at 7:00 PM. There is no admission charge, and free continuous entertainment. Hot dinner, sandwiches, snacks and beverages are available. Two exciting top awards, and many others. Stay right at HARA when the Hamvention closes on Friday evening and meet your friends and join us for an evening of fun and entertainment. Sponsored by the Miami Valley FM Association, PO Box 263, Dayton, Ohio 45401.

PENNSYLVANIA: March 15. The Beaver Valley Amateur Radio Association's third annual Tri-State Hamfest 8 AM to 4 PM. Community College of Beaver County "Golden Dome", Monaca. All indoors. Amateur license testing, forums, refreshments. Free vendor spaces. Table rental available. Talk in on 145.31/71 W3SGJ/R and 52 Contact Mike Pasterik, KA3JRR, 115 West Woodland Drive, Aliquippa, PA 15001.

TEXAS: March 14. The Midland Amateur Radio Club will hold its annual St. Patrick's Swapfest, 10 AM to 5 PM, Midland County Exhibit Building, Highway 80, east of Midland. Pre-registration \$5.00. \$6.00 at the door. Tables \$6.00 each. Refreshments and food available. VE tests for all categories. For further information and reservations: Midland ARC, PO Box 4401, Midland, Texas 79704.

WEST VIRGINIA: April 5. Charleston WV Area Hamfest and Computer Show in Charleston Civic Center, 8 AM to 5 PM. Admission \$4.00. Forums, SSTV, Packet, Flea Market and Swap Tables. Computer demos, ARRL booth. Talk in on 6.28/6.88. For information: Ollis Rinehart, KA8TIK, 1258 Ridge Drive, South Charleston, WV 25303. (304) 768-9534.

WISCONSIN: March 7. The Milwaukee School of Engineering ARC, W9HHX, will hold its annual Hamfest, 8 AM to 2 PM, 1121 N. Milwaukee Street, downtown Milwaukee. Tickets \$2.00. 4' tables \$3.00. Talk in on 146.19/146.79 and 146.52. For information, tickets or tables: SASE to W9HHXFEST, POB 644, Room C-6, Milwaukee, WI 53201-0644.

WISCONSIN: March 22. The Triu-County ARC, W9MQB, will hold its annual Hamfest, 8 AM to 3 PM, Jefferson County Fairgrounds, Jefferson. Tickets \$2.50 advance; \$3.00 at the door. Tables \$3.00 advance; \$4.00 at the door. Plenty of FREE parking. Amateur exams by the Milwaukee Volunteer Core Group. Doors open at 7 AM for sellers. Talk in on 144.89/145.49 or 146.52. For more information, tickets or tables SASE to Bob Barker, K9RIJ, 724 Burdick, Milton, WI 53563.

WISCONSIN: April 5. The Madison Area Repeater Association, (M.A.R.A.) is please to announce its 15th annual Madison Swapfest, Dane County Exposition Center Forum Building, Madison. Doors open 7:30 AM for flea market sellers and 8 AM for the general public. An all-you-can-eat pancake breakfast available at the Swapfest. Admission \$2.50 advance and \$3.00 at the door. Children twelve and under admitted free. Flea market tables \$5.00 each/advance and \$6.00/door plus admission. The deadline for tickets and table reservations is March 31, 1987. For tickets, tables or information write M.A.R.A., PO Box 3403, Madison, WI 53704 or call (608) 274-5153 day or night.

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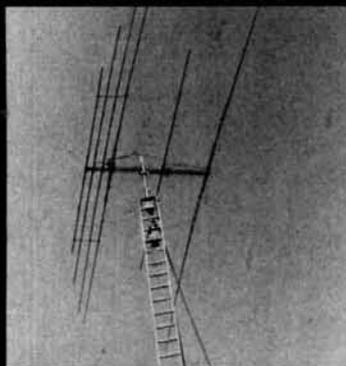
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D510	\$179.95	50 Hz-1.0 GHz			50 to 100 MV to 1 GHz	AC-12 REQ. FOR 110 VAC	
D612	\$259.95	50 Hz-1.2 GHz	0.1 PPM 20°-40°C PROPORTIONAL 10 MHz OVEN	9	15 to 50 MV	2 to 20 MV to 450 MHz	8-15 VDC
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Gunnplexers & accessories 10 & 24 GHz



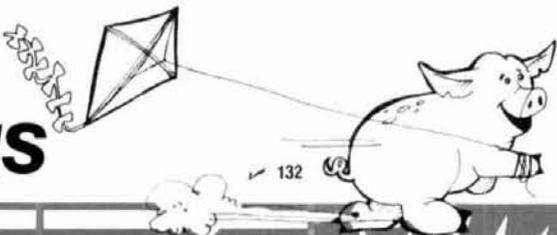
A. Microwave Associates 10 GHz Gunnplexer. Two of these transceivers can form the heart of a 10 GHz communication system for voice, mcw, video or data transmission, not to mention mountaintop DXing! MA87141-1 (pair of 10 mW transceivers) \$251.95. Higher power units (up to 200 mW) available. B. Microwave Associates 24 GHz Gunnplexer. Similar characteristics to 10 GHz unit. MA87820-4 (pair of 20 mW transceivers) \$739.20. C. This support module is designed for use with the MA87141 and MA87820 and provides all of the circuitry for a full duplex audio transceiver system. The board contains a low-noise, 30-MHz fm receiver, modulators for voice and mcw operation, Gunn diode regulator and varactor supply. Meter outputs are provided for monitoring received signal levels, discriminator output and varactor tuning voltage. RXMR30VD assembled and tested \$119.95. D. Complete, ready to use communication system for voice or mcw operation. Ideal for repeater linking. A power supply capable of delivering 13 volts dc at 250 mA (for a 10 mW version), microphone, and headphone and/or loudspeaker are the only additional items needed for operation. The Gunnplexer can be removed for remote mounting to a tower or 2 or 4 foot parabolic antenna. TR10GA (10 GHz, 10 mW) \$399.95. Higher power units available. TR24GA (24 GHz, 20 mW) \$639.95. Also available: horn, 2 and 4 foot parabolic antennas, Gunn, varactor and detector diodes, search and lock systems, oscillator modules, waveguide, flanges, etc. Call or write for additional information. Let ARR take you higher with quality 10 and 24 GHz equipment!

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ICOM



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Packet Controllers

Kantronics and MFJ

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TH 21BT/31BT/41BT
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R 5000
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2 Meters



440 MHz



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Prices and specifications subject to change without notice.

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- Selectable frequency steps for quick and easy QSY.

- TM-221A receives from 138-173.995 MHz. This includes the weather channels! Transmit range is 144-148 MHz. Modifiable for MARS and CAP operation. (MARS or CAP permit required.)
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- Built-in front panel selection of 38 CTCSS tones. TSU-5 programmable decoder optional.
- Simplified front panel controls makes operating a snap!
- 16 key DTMF hand mic., mic. hook, mounting bracket, and DC power cable included.
- Packet radio compatible!
- Kenwood non-volatile operating system. All functions remain intact even when lithium battery back-up fails. (Lithium cell memory back-up—est. life 5 yrs.)

- 14 full-function memory channels store frequency, repeater offset, sub-tone frequencies, and repeater reverse information. **Repeater offset on 2 m is automatically selected.** There are **two channels** for "odd split" operation.
- Programmable band scanning.
- Memory scan with memory channel lock-out.
- Super compact: approx. 1-1/2"Hx5-1/2"Wx7"D.
- New amber LCD display.
- Microphone test function on low power.
- High quality, top-mounted speaker
- Rugged die-cast chassis and heat sink.



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Optional telephone-style handset remote controller RC-10 is specially designed for mobile convenience and safety. All front panel controls (except DC power and RF output selection) are controllable from the RC-10. One RC-10 can be attached to **either or both** TM-221A and TM-421A with the optional PG-4G cable. When both transceivers are connected to the RC-10, **cross band, full duplex repeater** operation is possible. (A control operator is needed for repeater operation.)



Optional Accessories:

• **RC-10** Multi-function handset remote controller
• **PG-4G** Extra control cable, allows TM-221A/TM-421A full duplex operation
• **PS-50/PS-430** DC power supplies
• **TSU-5** Programmable CTCSS decoder
• **SW-100A** Compact SWR/power/volt meter (1.8-150 MHz)
• **SW-100B** Compact SWR/power/volt meter (140-450 MHz)
• **SW-200A** SWR/power meter (1.8-150 MHz)
• **SW-200B** SWR/power meter (140-450 MHz)
• **SWT-1** Compact 2 m

antenna tuner (200 W PEP) • **SWT-2** Compact 70 cm antenna tuner (200 W PEP) • **SP-40** Compact mobile speaker • **SP-50B** Mobile speaker
• **PG-2N** Extra DC cable • **PG-3B** DC line noise filter
• **MC-60A, MC-80, MC-85** Base station mics
• **MC-55** (8 pin) Mobile mic. with gooseneck and time-out timer
• **MA-4000** Dual band antenna with duplexer (mount not supplied)
• **MB-201** Extra mobile mount

Specifications and prices subject to change without notice or obligation.
Complete service manuals are available for all Trio Kenwood transceivers and most accessories.

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