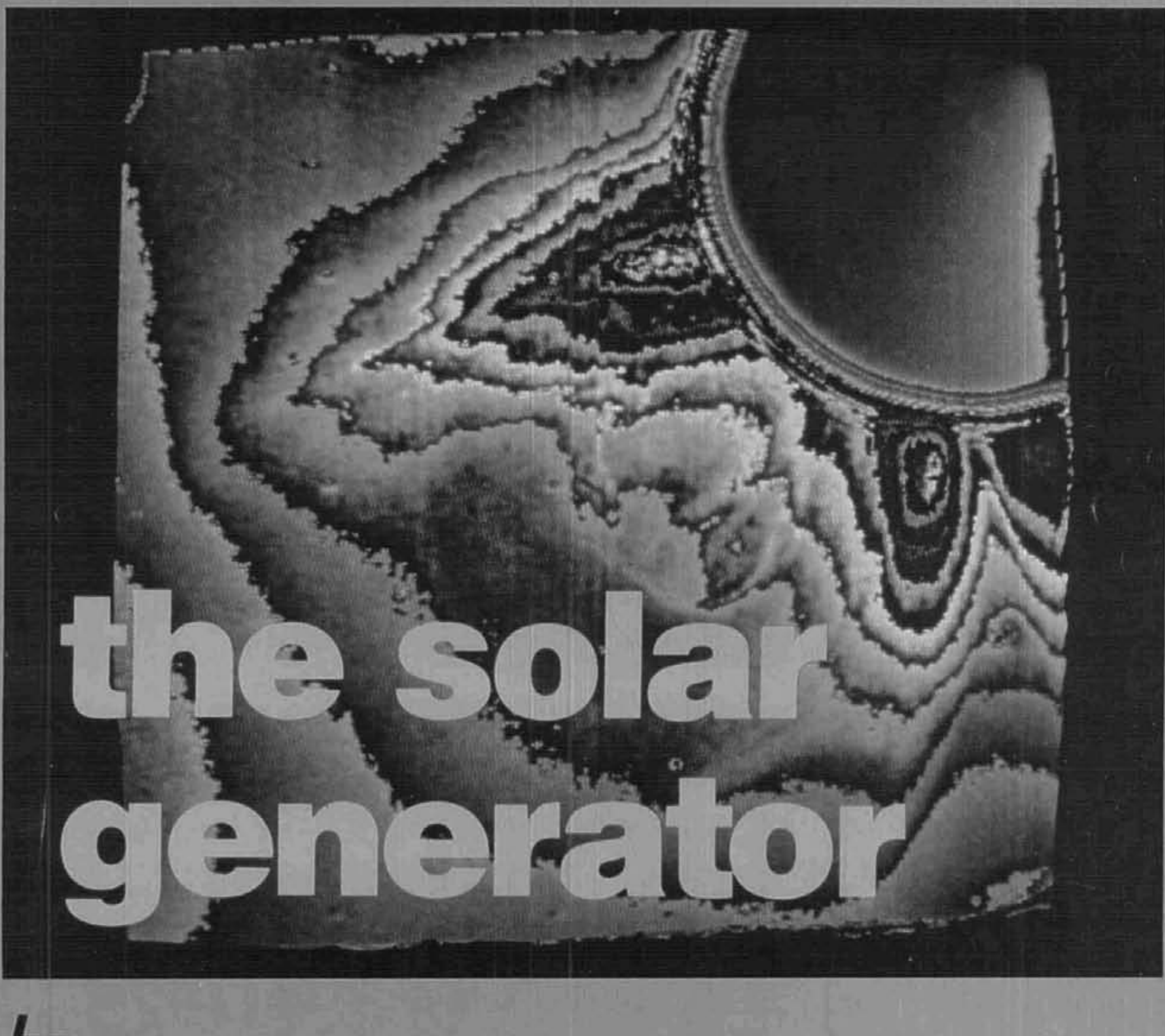
AUGUST 1987 / $2.50

ham radio
magazine



the solar generator

hr

focus
on
communications
technology

ICOM IC-28A/H
THE ONE FOR THE ROAD

- **Compact Size**
- **Simple to Operate**
- **Large LCD Readout**
- **25 Watt IC-28A**
- **45 Watt IC-28H**
- **Packet Compatible**
- **21 Memory Channels**

The IC-28H has all the features you need for carefree 2-meter mobile operation. The only thing it doesn't have is a big price.

45 Watts. The IC-28H provides a full 45 watts of powerful output. The **IC-28A** 25-watt version is also available. Both units have a selectable low power.

Large LCD readout. A wide-view LCD readout can be easily read even in bright sunlight. An automatic dimmer circuit reduces the brightness for evening operation.

Wideband Coverage. The IC-28H performs from 138–174MHz (specifications guaranteed from 144.00–148MHz) and includes weather channels. Ideal for MARS and CAP operation.

Compact Size. The IC-28H measures only 2 inches high by 5½ inches wide by 7¼ inches deep (IC-28A is 5¼ inches deep). Great for mobile installations where space is limited.

The IC-27H 45 watt and IC-27A 25 watt ultra compact 2-meter mobiles continue to be available.

21 Memory Channels. Store 21 frequencies into memory, or lock out certain memory channels. All memories are backed up with a lithium battery.

Scanning. Scan the entire band or the memory channels from the provided HM-12 mic.

Easy to Operate. With only 11 front panel controls, the IC-28H is simple to operate.

Available Options. IC-HM14 DTMF mic, PS-45 13.8V 8A power supply, UT-29 tone squelch unit, SP-10 external speaker, IC-HM16 speaker mic and HS-15/HS-15SB flexible boom mic and PTT switchbox.

ICOM
First in Communications

✓ 179

ICOM America, Inc., 2380-116th Ave NE, Bellevue, WA 98004 **Customer Service Hotline (206) 454-7619**
3150 Premier Drive, Suite 126, Irving, TX 75063
ICOM CANADA, A Division of ICOM America, Inc., 3071 - #5 Road, Unit 9, Richmond, B.C. V6X 2T4 Canada
All stated specifications are approximate and subject to change without notice or obligation. All radios significantly exceed FCC regulations limiting spurious emissions. 28H986

Work VHF or HF Packet On Any Computer With Kantronics Complete Packet Communicator

PRICE REDUCED

KPC-2

From IBM to C-64, or any computer with an asynchronous serial port, you can now work packet on VHF or HF with one TNC, the KPC-2! Extra cost options are unnecessary. KCP-2 is packed full of features and backed by our full-time customer support departments. KPC-2 has totally new hardware and software, Kantronics designed. For more information contact Kantronics or a Kantronics dealer.

Suggested Retail ~~$ 219.00~~ $169

Features

- AX.25 Version 2.0 software
- Supports multiple connects, up to 26
- RS232 or TTL compatible (C-64 too!)
- HF modem included! (both U.S. and European tones)
- Carrier Detect, and software squelch operation
- FCC Part 15 Certified
- Kantronics industry standard extruded aluminum case
- Power supply and cabling included
- All EPROM software is Kantronics sourced and copyrighted
- 128K EPROM, 16K RAM — expandable to 32K, 4K EEPROM.
- Advanced software HDLC routines, eliminating costly out-of-date chips

Customer Support

- Extensive dealer network
- In-house programmers/engineers
- In-house service representatives
- Periodic software updates (like 2.0!)

Want more information on Packet?
Contact us about our new **PACKET VIDEO.**
$ 25.00 (shipping included), VHS or BETA format.

178

Kantronics
RF Data Communications Specialists
1202 E. 23 Street Lawrence, Kansas 66046 (913) 842-7745

KENWOOD

...pacesetter in Amateur radio

#1 Rated HF

"DX-cellence!"

TS-940S

The new TS-940S is a serious radio for the serious operator. Superb interference reduction circuits and high dynamic range receiver combine with superior transmitter design to give you no-nonsense, no compromise performance that gets your signals through! The exclusive multi-function LCD sub display graphically illustrates VBT, SSB slope, and other features.

- **100% duty cycle transmitter.** Super efficient cooling system using special air ducting works with the internal heavy-duty power supply to allow continuous transmission at full power output for periods exceeding one hour.
- **High stability, dual digital VFOs.** An optical encoder and the flywheel VFO knob give the TS-940S a positive tuning "feel."
- **Graphic display of operating features.** Exclusive multi-function LCD sub-display panel shows CW VBT, SSB slope tuning, as well as frequency, time, and AT-940 antenna tuner status.
- **Low distortion transmitter.** Kenwood's unique transmitter design delivers top "quality Kenwood" sound.
- **Keyboard entry frequency selection.** Operating frequencies may be directly entered into the TS-940S without using the VFO knob.
- **QRM-fighting features.** Remove "rotten QRM" with the SSB slope tuning, CW VBT, notch filter, AF tune, and CW pitch controls.
- **Built-in FM, plus SSB, CW, AM, FSK.**
- **Semi or full break-in (QSK) CW.**
- **40 memory channels.** Mode and frequency may be stored in 4 groups of 10 channels each.
- **Programmable scanning.**
- **General coverage receiver.** Tunes from 150 kHz to 30 MHz.
- **1 yr. limited warranty.** Another Kenwood First!

Optional accessories:
• AT-940 full range (160-10m) automatic antenna tuner • SP-940 external speaker with audio filtering • YG-455C-1 (500 Hz), YG-455CN-1 (250 Hz), YK-88C-1 (500 Hz) CW filters; YK-88A-1 (6 kHz) AM filter • VS-1 voice synthesizer • SO-1 temperature compensated crystal oscillator • MC-43S UP/DOWN hand mic. • MC-60A, MC-80, MC-85 deluxe base station mics. • PC-1A phone patch • TL-922A linear amplifier • SM-220 station monitor • BS-8 pan display • SW-200A and SW-2000 SWR and power meters.

Interface IF-232C/IF-10B

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

More TS-940S information is available from authorized Kenwood dealers.

KENWOOD

KENWOOD U.S.A. CORPORATION
2201 E. Dominguez St., Long Beach, CA 90810
P.O. Box 22745, Long Beach, CA 90801-5745

ham radio magazine

AUGUST 1987
volume 20, number 8

ham radio magazine is published monthly by
Communications Technology, Inc.
Greenville, New Hampshire 03048-0498
Telephone: 603-878-1441

subscription rates

United States:
one year, $22.95; two years, $38.95; three years, $49.95
Canada and other countries (via surface mail):
one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 89

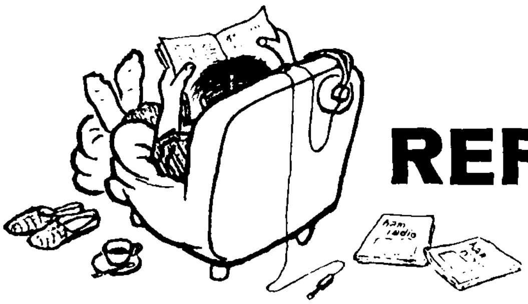
Microfilm copies are available from
University Microfilms, International
Ann Arbor, Michigan 48106
Order publication number 3076

Cassette tapes of selected articles from *ham radio* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107

Second-class postage paid
at Greenville, New Hampshire 03048-0498
and at additional mailing offices
ISSN 0148-5989

**Send change of address to *ham radio*
Greenville, New Hampshire 03048-0498**

contents



REFLECTIONS

evolution

In September, 1983, we published a survey soliciting your opinion on a number of subjects. In that survey, we asked about your use of computers, including any that you owned or had access to. In your responses, 50 percent of you answered affirmatively. Many of you — even those who were "computerized" — indicated clearly that you did not wish to see *ham radio* turn into yet another "computer book."

Since that time, however, the complexion of Radio Amateurs has changed. What used to be packet freckles can now be likened to a full tan after basking in the warmth of this useful and entertaining mode of communication. Most who predicted the yearly growth rate of this digital phenomenon were wrong, erring on the low side. *ham radio*, for its part, published articles that emphasized some of the more technical aspects of packet radio, such as TEXNET's recent three-part series on packet networking (March, April, and June, 1987).

Concurrently, even though statistics indicated a higher median and mean age of Radio Amateurs, some of the faces started to look younger, with Novice Enhancement bringing in a welcome influx of youth.

One concern raised by many readers responding to the survey brings new wrinkles to the face of Amateur Radio; many voiced and continue to voice the opinion that no one's building any more. Does anybody build any more? Well, it depends on how you define building. Yes, it's true that far fewer of us design and build our own receivers and transmitters nowadays, but this is quite understandable in light of the abundance of high performance and versatile commercial units available. With few exceptions, there's simply no need to build equipment today; without running a cost analysis, I'd almost be willing to bet that on a percentage basis the cost of a present-day rig eats up less of your earned income than a state-of-the-art rig would have consumed 10, 20, or 30 years ago.

From what I see in the manuscripts that arrive here, it appears that there's been a redirection or refocusing of attention to the more sophisticated technologies and techniques. A trend seen years ago in the Aerospace industries — a "systems" approach to construction — is now evident in Amateur projects. Recognizing that "soup-to-nuts" designs were no longer cost-effective, aerospace industries turned to modular construction, letting those individuals or companies who could build a better mixer, for example, supply that component. This same trend, I believe, has permeated Amateur Radio; it's just not cost-effective to build a 2-meter station when, for a few hundred dollars, you can buy a multi-function miniaturized unit. Personally, I'll still repair them . . . but try to compete on a design/construction basis? No way! I don't know how you value your time, but I can assure you that the price tag I'd put on a similar unit that I'd built would have to be a lot higher than the one you'd find on any off-the-shelf unit.

There's an inherent danger lurking in this path of reasoning, however: we don't want to become jacks of all trades and masters of none. I reconcile this dilemma by reading more, zeroing in on several specific areas of technical interest, and using computers more than ever before. Sometimes I just have to sit back and laugh at the amount of time I spent preparing a 24-hour propagation forecast by hand for just one point-to-point path a few years ago. It took hours. This process is now reduced to seconds with affordable computers . . . which is my next point: we're *still constructors — but what we're "building," in many cases, are computer routines instead of hardware.* I don't think it's fair to say which is more related to Amateur Radio. Like everything else, Amateur Radio is evolving through a logical sequence of events.

All I ask of you is to provide me with a glimpse of your new interests, regardless of the form (i.e., hardware or computer programs) they take. Let us help in the evolutionary process by sharpening the focus and providing a few more details.

Rich Rosen, K2RR
Editor-in-Chief

KENWOOD

...pacesetter in Amateur Radio

220 MHz TM-321A Coming Soon!

Here's One for You!

TM-221A/321A/421A

2 m and 70 cm FM compact mobile transceivers

The all-new TM-221A, TM-321A and TM-421A FM transceivers represent the "New Generation" in Amateur radio equipment. The superior Kenwood GaAs FET front end receiver; reliable and clean RF amplifier circuits, and new features all add up to an outstanding value for mobile FM stations! The optional RC-10 handset/control unit is an exciting new accessory that will increase your mobile operating enjoyment!

- **TM-221A provides 45 W, TM-321A, 25 W. The TM-421A is the first 35 W 70 cm mobile!** All three models have adjustable 5 W low power.
- **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.) *(Specifications guaranteed for Amateur band use only.)*
- **TM-321A covers 220-224.995 MHz. The TM-421A covers 438-449.995 MHz.**
- **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.**
- **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.)
- **Packet radio compatible!**
- **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.**

RC-10 Remote Controller

For TM-221A/321A/421A. 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 two transceivers 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.)

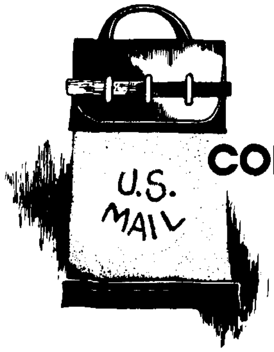
Optional Accessories:

• **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 Kenwood transceivers and most accessories.

KENWOOD

KENWOOD U.S.A. CORPORATION
2201 E. Dominguez St., Long Beach, CA 90810
P.O. Box 22745, Long Beach, CA 90801-5745



comments

improving writing skills

Dear HR:

I'm writing this letter in response to conversations I had at the recent Dayton Hamvention™ with you [Rich Rosen, K2RR], Bob Grove (editor of *Monitoring Times*), and several others of us who write for radio communications journals. There was considerable interest expressed by these persons in the possibility of organizing a meeting at next year's Hamvention that would be oriented toward those who write — or would like to write — for radio communications journals.

The program could present several speakers who would cover various areas of interest. The first speaker, probably an editor from one of our popular journals, could address the question of what beginning writers need to know in order to begin writing for the journals. Another speaker, or perhaps better yet, a panel of speakers, could offer ideas for already-published writers who want to improve their skills. Thirdly, a well-known, successful writer such as Joe Carr, K4IPV, Ed Noll, W3FQJ, or Bill Orr, W6SAI, might offer words of wisdom to aspiring writers who want to move up the ladder of professionalism in writing on the subject of radio technology.

As far as I know, there is no organized way for radio communications writers to contact one another, exchange information, or share ideas. In addition to being useful in its own right, the meeting proposed above might present a good opportunity for the founding of a writer's group or writer's newsletter for those of us who write for radio communications journals.

I hope that writers — both published and potential — who are interested in any of these ideas will contact me with lists of the kind of information they'd like to see covered in such a program, and which writers and editors they would like to hear speak. If the feedback is sufficiently positive, perhaps I could approach the appropriate committee to see if such a program could actually be arranged for next year's Hamvention.

W. Clem Small, KR6A
Salisbury, Vermont 05769

grounding, shielding

Dear HR:

I enjoyed reading K4IPV's column, "Practically Speaking: Grounding, Shielding, and Isolating — Part 2," in the May issue of *ham radio*. However, I felt a few comments might be in order.

First, I think that readers would be more satisfied with the performance of one-inch, or even half-inch, copper strap in place of the suggested braid. Braid becomes increasingly inductive faster than strap or even heavy wire at the TVI frequencies the author is concerned with.

Second, I would strongly suggest that if brazing is inconvenient, silver solder should be used for all soldering that may be exposed to the elements. Regular solder seems to "decompose" when exposed to weather, leaving a joint that is electrically and often visually similar to a cold solder joint.

I hope these suggestions will improve someone's hamshack.

Gary D. Sharpe, KA8DKT
Beaumont, Pennsylvania 18618

continuous phase tones

Dear HR:

Richard Ferranti's article, "Amateur FSK: A Spectral Analysis" (December, 1986, page 42) clearly makes the case for continuous phase tones for radio modems. This theme is even more pertinent if we directly modulate coherently the radio frequency carrier instead of using tones.

Modems were evolved for cables and telephone lines in order to make data look like a sound spectrum. Their purpose was to overcome the inductance and capacitance of cables, and though the same technique will work on a radio channel, we have a much more linear system with a wider useful bandwidth.

I feel we should be using our data signals to shift the radio frequency carrier directly — i.e. without the use of audio tones.

Had the author extended his discussion from fm to SSB, he would have found that an on-the-air signal would be more or less two separate frequencies separated by the difference in the tones and the advantages of phase coherence would be very marked. However, the SSB method is complex and wasteful of power, and to apply the data in the generation of the carrier is simpler and cheaper. All that's required is to switch a small capacitor across the crystal — but beware of the effect of the synthesizer, which may turn the square waves into triangular ones.

Another way of generating coherent phase fm is to impress the data as ripple on the supply to a free-running oscillator. Work is going on along these lines for a radio link between computers and peripherals in an effort to overcome interference and security problems.

R.J. Redding, G3VMR
Maidenhead, Berks, SL63EL

modifying the MLA-2500 amp

Dear HR:

A lot of us still have Dentron MLA-2500 amps, which use the Eimac 8875s. You know what they cost to replace.

How about an article on modifying this amp to use less expensive tubes? I've had mine since 1978, and it's still OK, but when the 8875s go, I doubt if it will be worth $700 or so for new ones.

Thanks for your fine magazine and keep up the good work!

Joe W. Williamson, KB5YA
Killeen, Texas 76541

Ideas, anybody? — Ed.

MFJ ACCESSORIES

MFJ's BEST 300 WATT TUNER HAS A CROSS-NEEDLE METER THAT READS SWR, FORWARD AND REFLECTED POWER – ALL AT A GLANCE

MFJ-949C $149.95

MFJ's best 300 watt tuner is now even better! The MFJ-949C all-in-one Deluxe Versa Tuner II gives you a tuner, cross-needle SWR/Wattmeter, dummy load, antenna switch and balun in a compact cabinet. You get quality conveniences and a clutter-free shack at a super price.

A cross-needle SWR/Wattmeter gives you SWR, forward and reflected power -- all at a single glance. SWR is automatically computed with no controls to set. 30 and 300 watt scale on easy-to-read 2 color lighted meter (needs 12 V).

A handsome black brushed aluminum cabinet matches all the new rigs. Its compact size (10 x 3 x 7 inches) takes only a little room.

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

A 300 watt 50 ohm dummy load gives you quick tune ups and a versatile six position antenna switch lets you select 2 coax lines (direct or thru tuner), random wire or balanced line and dummy load.

A large efficient airwound inductor -- 3 inches in diameter -- gives you plenty of matching range and less losses for more watts out. 100 volt tuning capacitors and heavy duty switches give you safe arc-free operation. A 4:1 balun is built-in to match balanced lines.

Order your convenience package now and enjoy.

MFJ 12/24 HOUR LCD CLOCKS

MFJ-108 $19.95 **MFJ-107 $9.95**

Huge 5/8 inch bold black LCD numerals make these 24 hour LCD clocks a must for your ham shack. Choose from a dual clock that displays UTC and local time or the single unit that displays 24 hour time.

Mounted in a brushed aluminum frame, these clocks feature 5/8 inch LCD numerals and a sloped face for easy across the room reading. Both also feature easy set month, day, hour, minute and second functions that can be operated in an alternating time-date display mode. MFJ-108, 4½x1x2 inches; MFJ-107, 2¼x1x2 inches. Battery included.

MFJ-962B VERSA TUNER III

MFJ-962B $229.95

Run up to 1.5KW PEP and match any feedline continuously from 1.8 to 30 MHz: coax, balanced line or random wire.

Lighted Cross-needle Meter reads SWR, forward and reflected power in one glance. Has 200 and 2000 watt ranges. 6 position antenna switch handles 2 coax lines, random wire and balanced lines. 4:1 balun. 250 pf, 6 kv variable capacitors. 12 position ceramic Inductor switch. Smaller size matches new rigs: 10¾ x 4½ x 14 7/8 inches. Flip stand for easy viewing. Requires 12V for light.

MFJ RANDOM WIRE TUNER

MFJ-16010 $39.95

MFJ's ultra compact 200 watt random wire tuner lets you operate all bands anywhere with any transceiver using a random wire. Great for apartment, motel, camping. Tunes 1.8-30 MHz. 2x3x4 inches.

REMOTE ACTIVE ANTENNA

54 inch remote active antenna mounts outdoor away from electrical noise for maximum signal and minumum noise pickup. Often outperforms long-wire hundreds of feet long. Mount anywhere-atop houses, buildings, balconies, apartments, ships.

Use with any radio to receive strong clear signals from all over the world. 50 KHz to 30 MHz. High dynamic range eliminates intermodulation. Inside control unit has 20 dB attenuator, gain control. Switch 2 receivers and auxiliary or active antenna. "On" LED. 6 x 2 x 5 in. 50 ft. coax. 12 VDC or 110 VAC with MFJ-1312, $9.95.

MFJ-1024 $129.95

CROSS-NEEDLE SWR/WATTMETER

MFJ-815 $59.95

MFJ's cross-needle SWR/Wattmeter gives you SWR, forward and reflected power -- all at a single glance! SWR is automatically computed -- no controls to adjust. Easy-to-use push buttons select three power ranges that give you QRP to full legal limit power readings. Reads 20/200/2000 W forward, 5/50/500 W reflected and 1:1 to 1:5 SWR on easy-to-read two color scale. Lighted meter needs 12 V. ±10% full scale accuracy. 6½x3¼x4½ inches.

COMPACT SPEAKER

MFJ-280 $18.95

Mobile speaker. Tilt bracket on magnetic base. 3½ mm phone plug. Use with 8 and 4 ohm impedances. Handles 3 watts audio.

HANDHELD TELESCOPING ANTENNAS WITH BNC

MFJ-1710, $9.95, 3/8 wave 2 meter. Pocket clip. 5¾" - 24½".

MFJ-1712, $14.95, ¼ wave 2 meter; 5/8 wave 440 MHz, 7¼" - 19".

MFJ-1714, $16.95, ½ wave 2 meter. End-fed halfwave dipole. Shorter, lighter, more gain, less stress than 5/8 wave mounted on handheld. When collapsed it performs like rubber duck.

MFJ "DRY" DUMMY LOADS

MFJ-262 $64.95 **MFJ-260 $26.95**

MFJ's "Dry" dummy loads are air cooled -- no messy oil. Just right for tests and fast tune up. Non-inductive 50 ohm resistor with SO-239. Full load to 30 seconds, de-rating curve to 5 minutes. **MFJ-260 (300 watt),** SWR 1.1:1,1-30 MHz, 1.5:1, 30-160 MHz, 2½x2½x7 inches. **MFJ-262 (1 KW),** SWR 1.5:1,30-160 MHz. 3x3x13 in. Alum. housing.

MFJ DELUXE ELECTRONIC KEYER

MFJ-407B $69.95

MFJ-407B Deluxe Electronic Keyer sends iambic, automatic, semi-auto. or manual. Use squeeze, single lever or straight key. Plus/minus keying. 8-50 WPM. Speed, weight, tone, volume controls. On/Off. Tune. Semi-auto switches. Speaker. RF proof. 7x2x6 inches. Uses 9 V battery. 6-9 VDC or 110 VAC with AC adapter, MFJ-1305, $9.95.

ANTENNA CURRENT PROBE

MFJ-206 $79.95

MFJ Antenna Current Probe lets you monitor RF antenna currents -- no connections needed! Determine current distribution, RF radiation pattern and polarization of antennas, transmission lines, ground leads, building wiring, guy wires and enclosures.

- **Determine if ground** system is effective.
- **Pinpoint RF leakage** in shielded enclosures.
- **Locate best place** for mobile antenna.
- **Use** as tuned field strength meter.
- **Indicate transmission line radiation** due to high SWR, poor shielding, antenna unbalance.
- **Detect re-radiation** from gutters, guy wires that can distort antenna field patterns.

Monitors RF current. 1.8-30 MHz. Has sensitivity, bandswitch, tune controls, telescoping antenna for field strength meter. 4x2x2 inches.

ORDER ANY PRODUCT FROM MFJ AND TRY IT-NO OBLIGATION. IF NOT SATISFIED RETURN WITHIN 30 DAYS FOR A PROMPT REFUND (less shipping).
• One year **unconditional** guarantee • Add $5.00 each shipping/handling • Call or write for free catalog, over 100 products.

MFJ

MFJ ENTERPRISES, INC.
Box 494, Miss. State, MS 39762

TO ORDER OR FOR YOUR NEAREST DEALER CALL TOLL FREE

800-647-1800

Call 601-323-5869 in Miss. and outside continental USA. Telex 53-4590 MFJ STKV

MasterCard VISA

MFJ . . . making quality affordable

solar activity
and the earth's magnetosphere

A close look at the energy source responsible for worldwide communications

Although Amateurs have been aware of a relationship between solar activity and ionospheric conditions since the earliest days of radio, concentrated studies in these areas did not begin until after the end of World War II. While many questions remain unanswered, we now have a large body of knowledge about solar activity and its effects on the Earth's magnetosphere, the region of charged trapped particles above the Earth controlled by our magnetic field. This information allows us to predict, with some degree of certainty, ionospheric activity and its effects on the parameters of hf radio propagation.

Such knowledge can provide some measure of solace to the intrepid DXer who, with an hour to spare from family obligations, has discovered that a Sudden Ionospheric Disturbance is in progress or that Polar Cap Absorption has wiped out the short path to Europe. These disruptions are the result of changes within the ionosphere, brought about by earlier flares and eruptive prominences on the surface of the Sun; this activity, in turn, results from still earlier processes originating deep within the Sun's interior.

historical perspective

Our understanding of solar activity began when physicists calculated and tried to explain the enormous output of energy from the Sun. In 1871, Hermann von Helmholtz calculated its energy production as the equivalent of burning 1500 pounds of coal per hour on each square foot of the solar surface. Since ordinary chemical reactions cannot produce these energy levels, scientists realized that solar energy could not be explained in terms of conventional chemistry.

Some years later, Lord Kelvin proposed a solution to the problem, suggesting that solar energy could be attributed to the energy released from gravitational contraction; even if the solar surface contracted by 100 feet per year, the Sun could shine for 30 million years. However, geologists soon produced evidence that the Earth had existed for much longer than 30 million years, and astronomers were then compelled to devise new theories of solar energy.

nuclear energy

In the 1920s, scientists realized that nuclear reactions could provide the necessary vehicle for energy production. Chemical reactions involve interactions only between the electron structures of various atoms. Nuclear reactions — whether by fission or fusion — involve the release of energy through the restructuring of an atom's nucleus. Nuclear fusion reactions, they found, do two things within a star: they provide a tremendous amount of energy and, over long periods of time, change its composition. In a dwarf star such as our Sun, the primary reaction is believed to be the proton-proton cycle, in which hydrogen nuclei fuse into helium nuclei. However, studies done in recent years question this supposition, asserting that the proton-proton cycle involves the release of neutrinos (neutral, massless, high-energy particles) as part of the reaction. Fewer neutrinos than expected, however, have been detected, and it's not known whether this is the result of experimental error, prediction error, or stellar core inactivity.

In larger stars, with their higher core temperatures, the CNO (carbon-nitrogen-oxygen) cycle is dominant. Either fusion process liberates energy by changing a small amount of mass into energy. In the proton-proton cycle, about 0.007 grams of matter are converted to energy for each gram of hydrogen processed into helium. Every second, the Sun converts 4 million

By Bradley Wells, KR7L, 1290 Puget Drive East, Port Orchard, Washington 98366

tons of solar matter into 400 trillion trillion watts of energy and radiates it into space.

30,000-year trip

Most of the energy generated within the core of the Sun heats its photosphere, the bright surface layer of gas that radiates the visible light of the Sun. The energy that heats the photosphere today, however, was generated eons ago.

The gas within the Sun's core, compressed to a density 150 times that of water, prevents radiation from traveling directly to the Sun's surface. The movements of photons within the Sun's interior move in a highly erratic motion known as "random walk" (rather than straight-line free flight). The thermal radiation associated with the 15 million degrees Kelvin temperature of the solar core is hard* X-rays, which move an average of only half a centimeter before they crash into a material particle and are absorbed or scattered in a completely different direction. Through this process, these X-rays are gradually degraded into optical photons with lower energy levels. Consequently, it takes 30,000 years for a photon to "walk" out of the Sun; a photon in free flight, on the other hand, would be freed in 2 seconds. Thus, the current appearance and activities of the photosphere were determined by the core conditions some 30 millennia ago.

The temperature of the photosphere can be determined from the following relationship:

$$T = \frac{0.290}{W} \quad (1)$$

where W = wavelength in cm, and
T = temperature in degrees K.
Since the wavelength of maximum radiation in the solar spectrum is 5.1×10^{-5} cm, this corresponds to a temperature of 5700 degrees Kelvin.

The apparent sharply defined surface of the Sun is attributable to changes in the opacity of its surface gas. The gas at the bottom of the photosphere has a high proportion of negative hydrogen ions that obstruct light, causing high opacity. A few hundred kilometers above this layer, near the top of the photosphere, negative hydrogen ions are fewer; this renders the gas clearer and less opaque. Most of the Sun's light comes from this layer. This layer — where photons make the transition from "walking" to flying — is very thin, measuring only 0.1 percent of the Sun's radius. Because it's thin, and because of its abrupt changes in opacity, it appears as a sharply defined surface, just as cumulus clouds in the sky appear to be solid.

* X-rays have wavelengths (10^{-7} to 10^{-10} cm) which are considerably shorter than visible light. Hard X-rays are at the short wavelength end of that 1000:1 spectrum. — Ed.

The gases of the Sun and solar atmosphere comprise a plasma, often referred to as the fourth state of matter. Relatively rare on Earth, plasma normally exists only in regions of extreme temperatures and is composed of positive ions and free electrons, although it's electrically neutral in bulk composition. In the magnetic fields of the Sun, these ions and electrons cannot move freely, but must stream in directions dictated by magnetic lines of force. For this reason, much of the solar atmosphere moves in particular patterns following twisted and intricate magnetic fields.

Photographs of the solar surface show a pronounced *granulation*. Each of these "grains" is a convection cell measuring 1000-2000 km across, rising at a vertical rate of 2 to 3 km/sec, and lasting only a few minutes. The dark areas between grains mark the regions where cooled gas descends again into the Sun. Large-scale patterning of individual granules is called supergranulation; this involves areas some 30,000 km in diameter, with gas flowing horizontally toward the outer edge of each cell. Surging motions, with wavelengths of 5000 km and periods of 5 minutes, have been observed within these areas.

Between these areas of supergranulation are spicules, small needle-like structures that form the lower half of chromospheric loops and are best seen on the limb of the Sun, where they appear in emission. Since the temperature is too high or the density is too low to scatter much light in the upper part of the loop, these portions tend to remain invisible. Consequently, what is seen of this gas are flames that erupt and fade in periods lasting from 2 to 5 minutes. They form a transition from the photosphere to the overlying chromosphere, the lower layer of the solar atmosphere. Visible to the naked eye during a total eclipse as a ring of small, intense red flames encircling the Sun, the chromosphere is about 2500 km thick, and the temperature in its upper regions exceeds 10,000 degrees Kelvin.

the corona

Above the chromosphere is the solar corona, a pale glowing halo of gas surrounding the Sun. Gas density here is very low, having dropped by a factor of 10,000 from the photosphere to the chromosphere and again by 10,000 between the chromosphere and the lower corona. Like the chromosphere, the corona is normally visible to the naked eye only during a total eclipse. This region emits only one millionth the amount of light produced by the photosphere, yet its temperature is 1 to 2 million degrees Kelvin.

When gases are heated, they become ionized, losing one or more electrons. In the corona, hydrogen and helium are essentially bare nuclei, while the electron shells of heavier elements are severely depleted. This

Wide Dynamic Range and Low Distortion – The Key to Superior HF Data Communications

- Dynamic Range > 75 dB
- 400 to 4000 Hz
- BW Matched to Baud Rate
- BER < 1×10^{-5} for S / N = 0 dB
- 10 to 1200 Baud
- Linear Phase Filters

ST-8000 HF Modem

Real HF radio teleprinter signals exhibit heavy fading and distortion, requirements that cannot be measured by standard constant amplitude BER and distortion test procedures. In designing the ST-8000, HAL has gone the extra step beyond traditional test and design. Our noise floor is at -65 dBm, not at -30 dBm as on other units, an extra 35 dB gain margin to handle fading. Filters in the ST-8000 are all of linear-phase design to give minimum pulse 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:

- 8 Programmable Memories
- Set frequencies in 1 Hz steps
- Adjustable Print Squelch
- Phase-continuous TX Tones
- Split or Transceive TX/RX
- CRT Tuning Indicator
- RS-232C, MIL-188C, or TTL Data
- 8, 600, or 10K Audio Input
- Signal Regeneration
- Variable Threshold Diversity
- RS-232 Remote Control I/O
- 100-130/200-250 VAC, 44-440 Hz
- AM or FM Signal Processing
- 32 steps of M/S filter BW
- Mark or Space-Only Detection
- Digital Multipath Correction
- FDX or HDX with Echo
- Spectra-Tune and X-Y Display
- Transmitter PTT Relay
- 8 or 600 Ohm Audio Output
- Code and Speed Conversion
- Signal Amplitude Squelch
- Receive Clock Recovery
- 3.5" High Rack Mounting

Write or call for complete ST-8000 specifications.

HAL Communications Corp.
Government Products Division
Post Office Box 365
Urbana, Illinois 61801
(217) 367-7373 TWX 910-245-0784

176

high degree of ionization is one characteristic of extremely high temperatures.

These high temperatures were deduced from early spectroscopic studies. For a number of years, however, this evidence was discounted because it apparently violated the second law of thermodynamics, which states that heat cannot spontaneously flow from a cool object (the photosphere at 5700 degrees Kelvin) to a hotter one (the corona at 1 to 2 million degrees Kelvin). So fundamental was this objection that for several decades physicists refused to accept spectroscopic analysis at face value. Finally, in the 1940s, the idea of a truly hot corona was accepted and progress was made in coming to terms with this apparent contradiction. It now appears that magnetic effects and shock waves from subsurface convection are responsible for the transfer of large amounts of energy to the corona.

Early photgraphs of the corona taken during total eclipses showed it as a bland sphere of gas whose shape was dependent upon the phase of the solar cycle. During the years of high solar activity, it completely surrounded the Sun. In years of minimal activity, it was concentrated along the equator, with little gas visible in the polar regions. More recent studies conducted at a variety of wavelengths, particulary ultraviolet and X-ray, confirm this phenomenon and also show that the corona is not static, but rather an area of complex activity and turbulent motion.

Transient features of the corona include loops, streamers, and holes that seem so prevalent that some astronomers believe there may be no such thing as a "quiet" corona. Coronal features may be even more transient than once believed. Multiple photographs taken during any solar eclipse provide some evidence of movement in these features even during this very short period of time.

magnetic field has major influence

Individual loops and streamers suggest the patterns formed when iron filings are sprinkled near a magnet. The structure of the Sun's magnetic field imposes itself on the coronal gas. The interaction of this gas and the Sun's magnetic field is governed by the basic laws of electromagnetism. A charged particle in a magnetic field is subjected to a force that depends on its charge, its velocity, and the strength of the magnetic field. Only components of the particle's motion that are at right angles to the field are affected, with the net result that charged particles move in helical paths around the magnetic lines of force. Put another way, a particle is free to move in the direction of the field, but if it's pushed at right angles to the field, it moves in a circle rather than in a straight line. Thus, charged paticles in a magnetic field are said to be "frozen" to the field, and free to move only in the direction of the field's lines of force.

Since the coronal plasma is highly ionized, the corona is an excellent electrical conductor and can sustain large electric currents. These currents, in turn, give rise to magnetic fields that modify the original magnetic fields. This two-way interaction gives the corona a complexity that is simply unavailable in a nonconducting gas.

Studies have indicated that transient events, such as coronal loops, may be uplifted by magnetic buoyancy. Regions with strong magnetic fields are buoyed up by the surrounding gas within the corona. These loops may suddenly become unstable and rise rapidly through the corona. Causes of this instability may be the random motion of photospheric gas at the base of a magnetic loop or the response to a violent photospheric event such as a solar flare.

generation of solar wind

Since magnetic loops are bound to the solar surface at both ends, there's no way for the coronal gas in these loops to escape into interplanetary space. However, in the regions where the Sun's magnetic lines of force stretch infinitely outward, the solar wind can escape along these field lines. It's now believed that much of the solar wind material, especially the high-speed streams, originates within these coronal holes.

Coronal transient events may provide another avenue for escape of material into space. If a closed loop becomes unstable, it can rise and expand to the point at which its field lines open up, ejecting material from the Sun. Observations have also revealed the existence of coronal "bullets" — knots of cool, dense material that are accelerated through the corona and may contribute to this outflow from the Sun.

sunspots

Sunspots are the Sun's most obvious surface feature. Very large groups may be visible to the naked eye, particularly when the solar disk is obscured by thin clouds or fog.

A sunspot is essentially a broad, shallow depression in the photosphere. The umbra, or central floor of the depression, appears dark because its temperature is 1700 degrees Kelvin below the temperature of the surrounding photosphere. At this lower temperature, it emits only one-quarter the light of the surrounding gases. It's believed that the lower temperatures associated with the umbra are due, in part, to intense magnetic fields, first discovered by observation of Zeeman splitting in spectral emission lines.* Individual

---

* Splitting of the line spectrum of a light source by the influence of a magnetic field. — *Ed.*

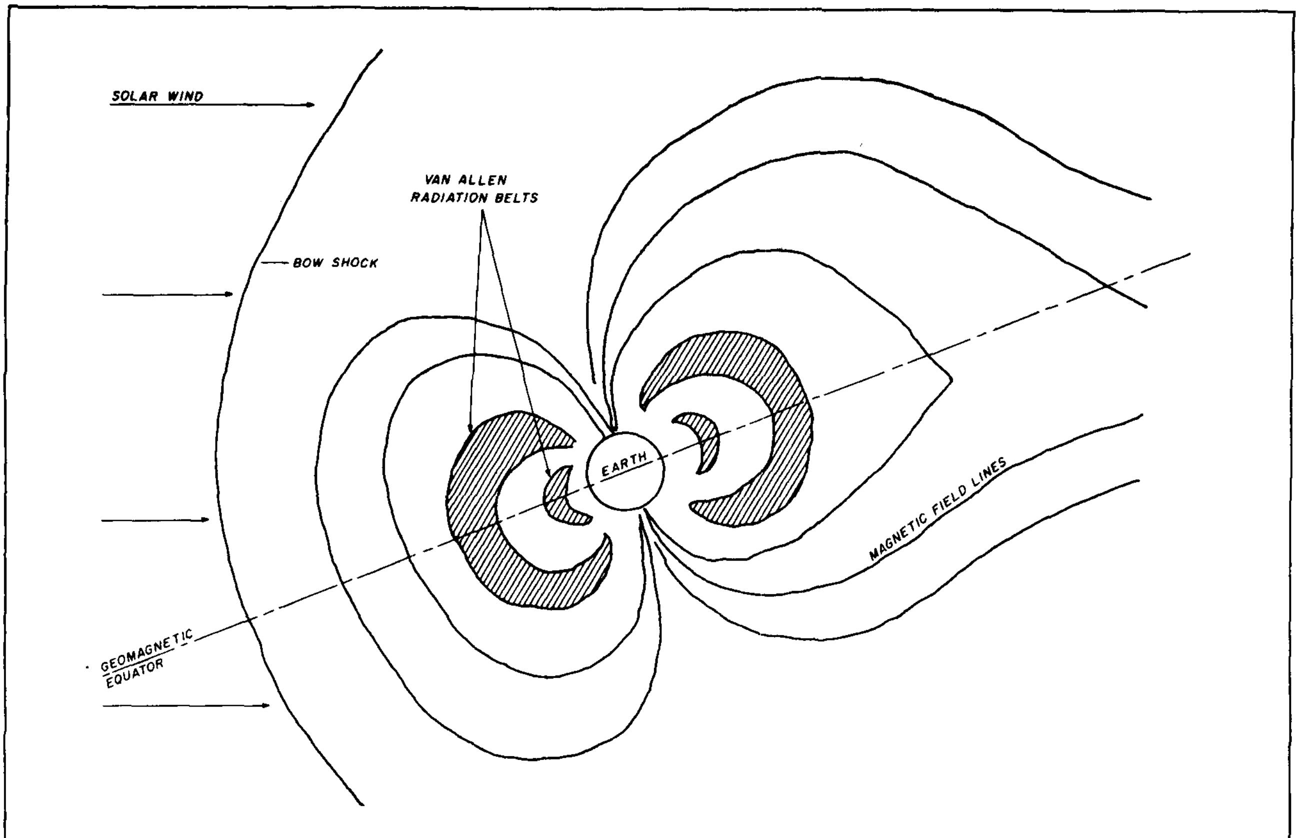


fig. 1. How various types of radio bursts may be produced by solar flares.

magnetic fields, centered in the umbra, have a typical intensity of 3000 gauss* and are confined and compressed by the surrounding gases. Magnetic fields of this strength can be duplicated on a small scale within a laboratory environment. It's interesting to note that in such a field it's nearly impossible to maintain your grip on a metallic object; a wrench or screwdriver will literally tear itself out of your hand and slam up against one pole of the magnet.

The sunspot umbra is surrounded by the penumbra, a gray striated border of material that slopes up and outward from the umbra to the surrounding photosphere. The magnetic field emerging from the umbra spreads out across the penumbra. At some distant point, this field is again compressed and reenters the solar surface, often in a neighboring sunspot of opposite magnetic polarity. As the magnetic lines of force arch up between the two sunspots, a "moat" – an area outside the sunspot, beneath the magnetic arch, that is essentially free of any magnetic influence – sometimes forms.

Sunspots are normally found in bipolar groups with opposite magnetic polarities. Their magnetic fields normally run east and west and are of opposite polarities on either side of the solar equator. The differential rotation of the Sun is the mechanism thought responsible for this. Because the Sun behaves as a fluid rather than solid sphere, surface rotational velocities vary with distance from its equator. The time required for one complete rotation ranges from 27 days in equatorial regions to 33 days near the poles. This unequal movement drags the entrapped magnetic lines of force around, under the solar surface, winding them tighter and tighter. The formation of sunspots, with their associated disturbances, begins to disrupt these fields. They become increasingly chaotic and, eventually, are neutralized as a new cycle of opposite polarity begins.

sunspot cycle

Individual sunspot groups may last from a few weeks to several months. The first spots in a new 11-year cycle appear in a broad band centered around the 40-degree north and south latitudes. As the cycle progresses, succeeding new spots migrate toward the equator. The regions of sunspot formation die out as they approach the equator and, simultaneously, sunspots of a new cycle appear at midlatitudes.

Huge clouds of gas called prominences are ejected from these sunspot regions. There are two types:

* Compare this to the considerably smaller magnetic field surrounding the Earth. – Ed.

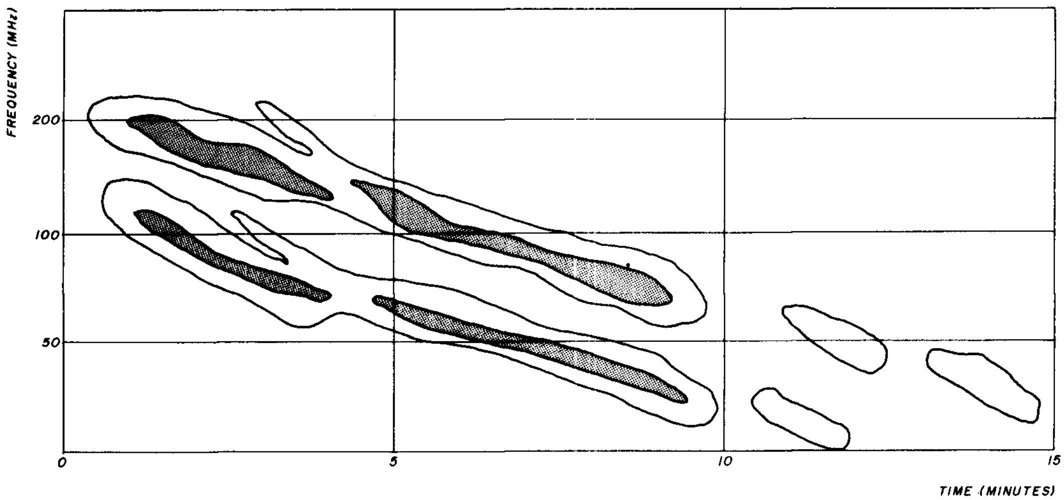


fig. 2. Model of a shock wave and ejecta some 6 minutes after the explosive phase.

eruptive and quiescent. Eruptive prominences move outward from the photosphere with velocities of 1000 km/sec. Quiescent prominences are masses of flowing gas held in relatively fixed positions above the Sun for hours or days by constraining magnetic fields.

flares

The largest blasts of energy and material on the surface of the Sun are flares. A single large solar flare may release the explosive power of 100 million hydrogen bombs, each with a yield of 100 megatons. Flares are normally observed in the light of hydrogen or ionized calcium. The largest, called "white-light" flares, are visible to the naked eye. All involve the high-speed ejection of material from the surface of the Sun. Not visible to optical telescopes is the cloud of electrons ejected by a flare, which is detectable only by radio telescope.

The regions of the Sun where flare energy is released are probed most directly by observation of centimeter radio emissions (listen to WWV at 18 minutes after the hour for the solar flux — 10.7 cm numbers) and the detection of hard X-rays. Continued observations at these wavelengths has led to some understanding of pre-flare conditions and flare activity. Pre-flare buildup is observed at centimeter wavelengths as small areas of increased brightness that exhibit shifts in polarization. At times, these regions show polarization increases of 100 percent and brightness temperatures of 10 million degrees (a measure of radio intensity rather than actual temperature).

Three types of flare models, each with their own distinctive magnetic structure (**fig. 1**), have been proposed. In one type, currents run along field lines arranged in isolated loops to form a sheared magnetic field capable of producing instabilities. The second type involves current sheets at the interface of two loops having opposite magnetic polarities. The third type offers large-scale current sheets between open magnetic field lines. The variation of radio wave polarization with time indicates the primary release of energy occurring by magnetic reconnection in very localized areas. This energy release is rapid, being distributed throughout the magnetic loop in less than 10 seconds. In every case, the size and shape of the magnetic field undergoes major transformations an hour or so before a flare, with the primary release of energy occurring in the upper portions of isolated loops.

The progress of a flare (**fig. 2**) may be divided into two phases. In the first, the visually observable flare appears with strong emissions in the hydrogen (Balmer) alpha line (6560 Å units, red light) and is accompanied by the ejection of an electron jet at velocities up to half the speed of light. As they recede from the Sun, these particles are slowed through interactions with the solar magnetic field and the surrounding solar atmosphere. During this initial phase, X-rays and centimeter radio waves are generated in the region of the optical flare. As the flare moves upward through the layers of the solar atmosphere, radio energy is detected at progressively longer wavelengths. This "synchrotron" radio emission originates as these relativistic electrons spiral in the magnetic fields. The initial radio energy from a flare is designated as a Type II radio burst; it serves as the chief diagnostic tool for investigation of flare activity and the solar corona. Type II bursts (**fig. 3**) are characterized by narrow bands of intense radio emission that drift slowly toward lower frequencies. Generally composed of a fundamental frequency and second harmonic, this dual-frequency emission is characteristic of oscillations within a plasma.

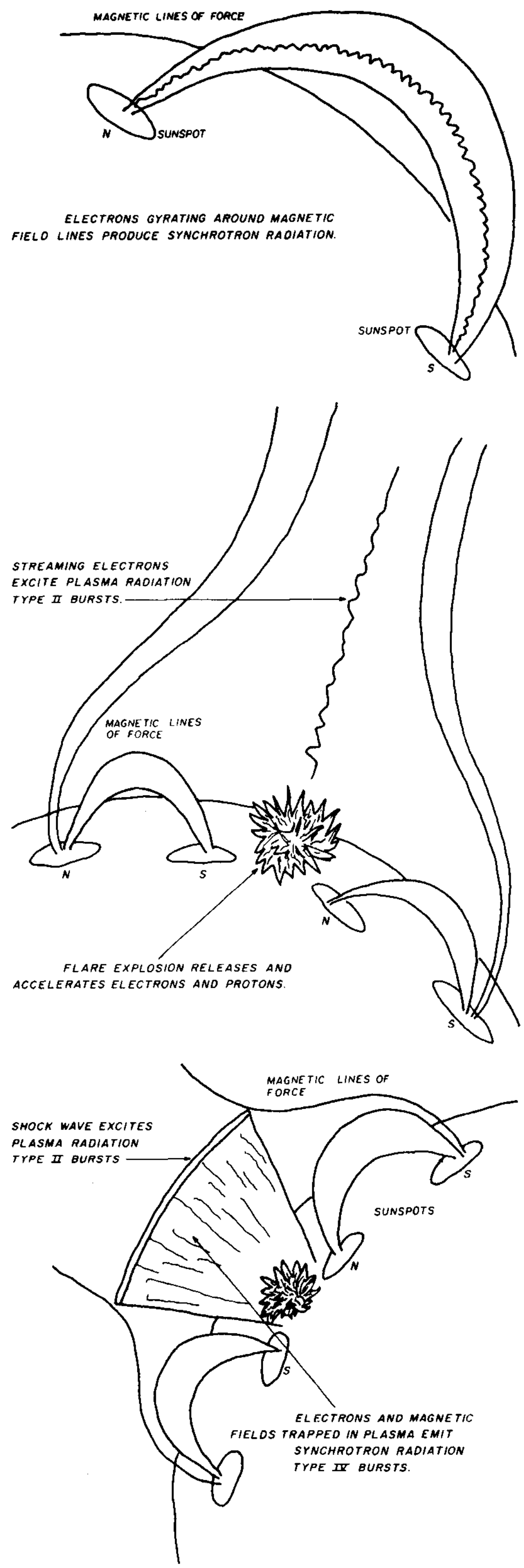


fig. 3. Contour plot of solar radio burst and its second harmonic (flux level proportional to gray scale).

The natural vibration frequency of a plasma is directly related to its electron density. Density decreases with altitude above the Sun's surface; therefore, the lower the frequency, the greater the height of origination above the photosphere. The velocity of a shock wave can be determined by its frequency drift; shock wave velocities up to 3000 km/sec have been observed.

The shock front formed by a solar flare is believed to be quite thin, averaging only 1000 km from front to back. As such, it will move through a given point in the solar atmosphere in less than a second. Shock fronts form only when the wave velocity exceeds a critical value called the Alfven velocity, which is to magnetic waves what the speed of sound is to acoustic waves. It is determined by the strength of a region's magnetic field and electron density.

In the second phase of flare activity, a gas cloud moves up behind the electron jet, but at a much lower velocity. If this material is expelled at a speed greater than 500 km/sec, it will also generate a shock wave that expands outward ahead of it. Since the solar atmosphere has a relatively low density and strong magnetic field, this shock wave becomes a fast-moving magnetic disturbance rather than the more familiar pressure wave. Rising through the corona, it generates radio emission at the leading edge of the cloud as it pushes through the tenuous solar atmosphere. The ejection of this material is also accompanied by a Type IV radio flare, which takes the form of broadband emission over a wide range of frequencies.

During a solar flare, the total visible radiation changes by much less than 1 percent; however, ultraviolet and X-ray radiation may increase a hundredfold. When this radiation strikes the ionosphere, it changes the amount and distribution of free electrons. These shifts in electron density, in turn, affect the refractive characteristics of the ionosphere.*

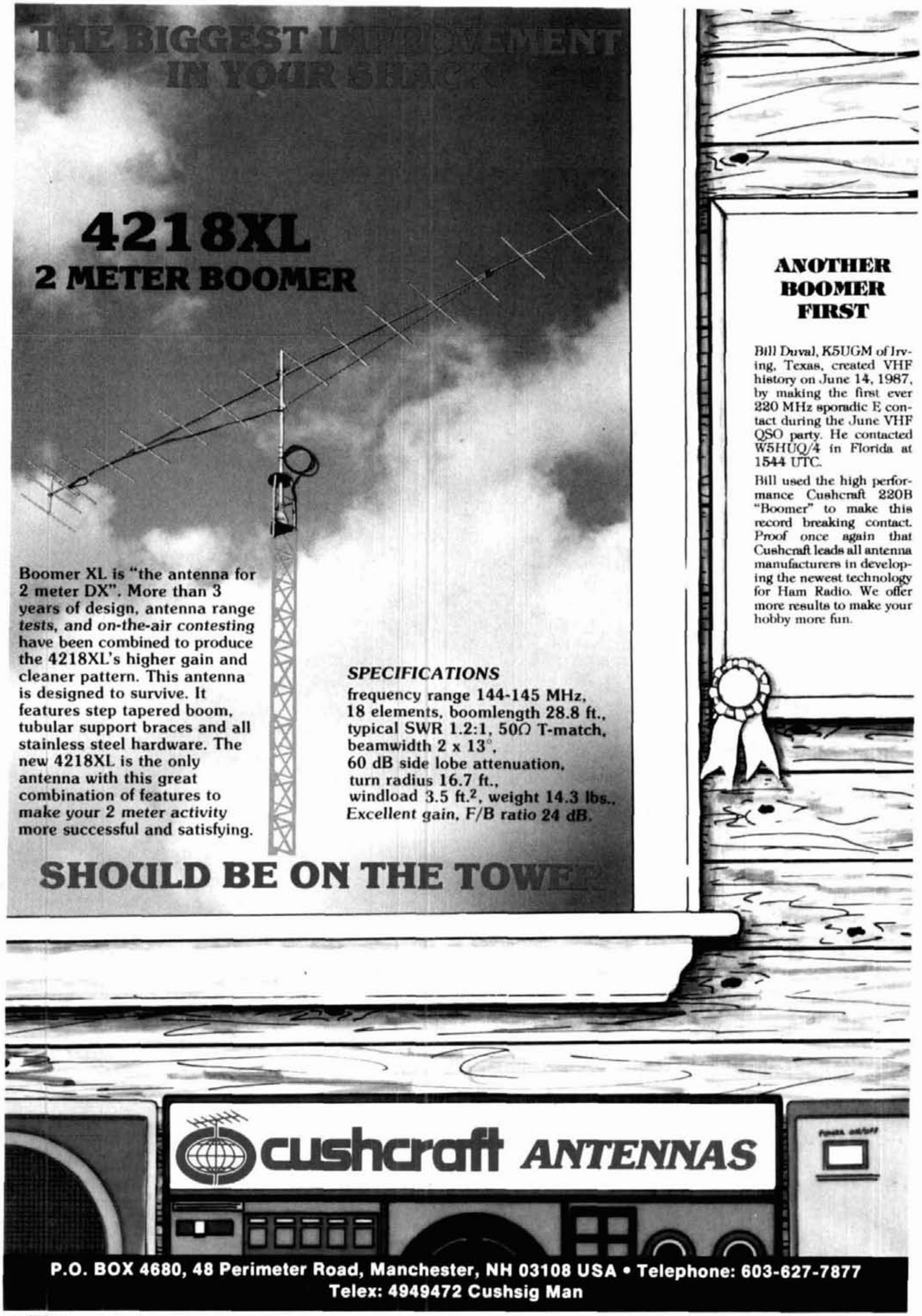
Although the radio output of the Sun is very small in comparison to its output at visible wavelengths, radio output is highly variable and tends to follow the 11-year solar cycle. During a large flare, the radio energy of the Sun may increase a millionfold for short periods.

In spite of this increased activity outside the visible spectrum, the radiative output of the Sun remains relatively constant, with short-term variations of less than 1 percent. This energy amounts to 1400 watts per square meter at the distance of the Earth. Small-scale, long-term variations in this "solar constant" follow the 11-year sunspot cycle and other, longer, less easily determined cycles.

delay effects of solar "bombardment"

Solar particles ejected from the Sun travel much

* Which, of course, is the main focus of our attention. — Ed.


THE BIGGEST IMPROVEMENT IN YOUR SHACK
4218XL
2 METER BOOMER
Boomer XL is "the antenna for 2 meter DX". More than 3 years of design, antenna range *tests*, and *on-the-air contesting* have been combined to produce the 4218XL's higher gain and cleaner pattern. This antenna is designed to survive. It features step tapered boom, tubular support braces and all stainless steel hardware. The new 4218XL is the only antenna with this great combination of features to *make your 2 meter activity* more successful and satisfying.
SPECIFICATIONS
frequency range 144-145 MHz, 18 elements, boomlength 28.8 ft., typical SWR 1.2:1, 50Ω T-match, beamwidth 2 x 13°, 60 dB side lobe attenuation, turn radius 16.7 ft., windload 3.5 ft.², weight 14.3 lbs., *Excellent gain*, F/B ratio 24 dB.
SHOULD BE ON THE TOWER
ANOTHER BOOMER FIRST
Bill Duval, K5UGM of Irving, Texas, created VHF history on June 14, 1987, by making the first ever 220 MHz sporadic E contact during the June VHF QSO party. He contacted W5HUQ/4 in Florida at 1544 UTC.
Bill used the high performance Cushcraft 220B "Boomer" to make this record breaking contact. Proof once again that Cushcraft leads all antenna manufacturers in developing the newest technology for Ham Radio. We offer more results to make your hobby more fun.
cushcraft ANTENNAS
P.O. BOX 4680, 48 Perimeter Road, Manchester, NH 03108 USA • Telephone: 603-627-7877
Telex: 4949472 Cushsig Man

✓ 174

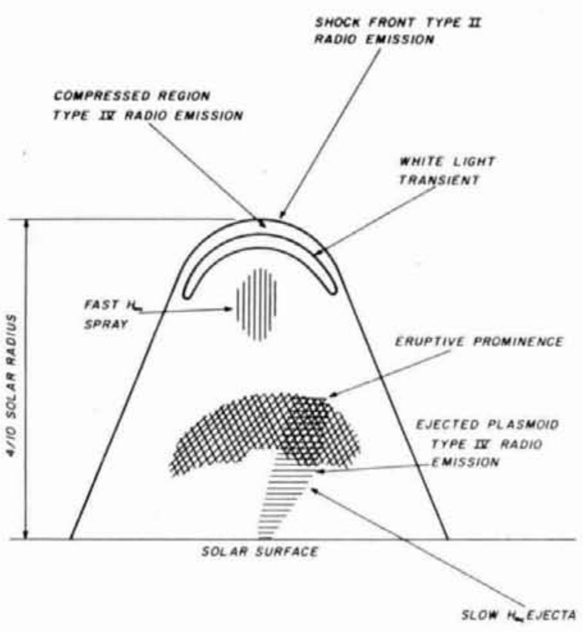


fig. 4. Earth's magnetosphere as charted by satellites.

more slowly than its electromagnetic radiation. It takes some 24 to 36 hours after an event before they impinge on the upper atmosphere, changing its chemistry and creating aurorae.* These colored, swirling patterns of light are visible around the Earth's north and south magnetic poles.

Magnetic fields from the surface of the Sun are frozen into the solar wind and drawn out by the flow. The magnetized plasma of the solar wind cannot easily penetrate the closed magnetic field of the Earth. Consequently, as the solar wind encounters the Earth's magnetosphere, a shock wave (**fig. 4**) develops. This bow shock, formed 60,000 km on the "upwind" side of the Earth, is analogous to the shock wave that forms in front of an aircraft moving at supersonic speeds. However, the Earth's bow shock isn't fixed in position, but moves back and forth in response to pulses of energetic particles streaming out of the Sun. Beyond this wave, the solar wind plasma flows much more slowly around the Earth's magnetic field.

the Van Allen belt

If captured by the Earth's magnetic field, particles from the Sun form two doughnut-shaped belts or rings around the Earth. These were discovered in 1958 by James Van Allen, using particle counters aboard Explorer 1, the first United States satellite. The inner Van Allen belt is about 2500 km and the outer Van Allen ring is about 15000 km above the Earth's magnetic equator. Particles temporarily stored in these

* This helps explain short-term F2 layer enhancement followed a day or two later by higher absorption — as experienced on 80 meters, for example. — Ed.

belts oscillate back and forth along the lines of force of the Earth's magnetic field. Eventually they leak out the ends of these magnetic "bottles" and into the Earth's atmosphere. Here, these ions collide with upper atmosphere air molecules, causing spectral emission lines whose color is determined by the elements and collision energies involved.

The Van Allen belts are one manifestation of the interaction of the Earth's magnetosphere with the solar wind. The supply of ions and electrons forming the Van Allen belts is continuously replenished by the solar wind. By the time it reaches the Earth, this wind has a density of 5 ions per cubic centimeter and moves with an average velocity of 500 km/sec (about a million miles per hour). These values increase dramatically during periods of intense solar activity.

The electrons circulating in the Van Allen belts also generate an enormous amount of radio energy. This synchrotron radio emission may reach power levels of 1 billion watts at frequencies between 100 and 300 kHz. Fortunately, the ionosphere forms a normally effective barrier preventing radio energy with wavelengths greater than 100 meters from reaching the Earth's surface. It's interesting to note that Grote Reber, the amateur radio astronomy pioneer, constructed a large dipole array in Tasmania which can "see" through the ionosphere at a wavelength of 300 meters on the occasional nights when the electron density of the ionosphere falls to abnormally low values.

The ability of the various layers within the ionosphere to refract radio energy is determined by a number of factors. The time of day, season of year, phase of the sunspot cycle, transient solar events, and the Sun's core conditions 30,000 years ago all affect hf radio communications *at this moment*. The continued study of the Earth's magnetosphere and the Sun's atmosphere may eventually allow us to forecast, with increasing certainty, the hourly state of the ionosphere and its impact on hf communications.

bibliography

1. Briggs, John, "Shortwave Detection of Solar Flares," *Sky and Telescope*, November, 1984, page 452.
2. Foukal, Peter, "Magnetic Loops in the Sun's Atmosphere," *Sky and Telescope*, December, 1981, page 547.
3. Hartmann, William K., *Astronomy: The Cosmic Journey*, *Wadsworth Publishing Company*, Belmont, California, 1978.
4. Kraus, John, *Our Cosmic Universe*, *Cygnus-Quasar Books*, Powell, Ohio, 1980.
5. Kundu, M.R., "Probing The Radio Sun," *Sky and Telescope*, July, 1982, page 6.
6. Maffie, Paolo, *Beyond The Moon*, The MIT Press, Cambridge, Massachusetts, 1979.
7. Maran, Stephen, "The Sun's Violent Flares," *Popular Science*, June, 1981, page 66.
8. Maxwell, Alan, "Solar Flares and Shock Waves," *Sky and Telescope*, October, 1983, page 285.
9. Moore, Patrick, *The Rand McNally New Concise Atlas of the Universe*, Rand McNally and Company, New York, New York, 1978.
10. Parker, E.N., "The Sun," *Scientific American*, September, 1975, page 43.
11. Shields, John, "Backyard Radio Astronomy," *Astronomy*, March, 1982, page 75.
12. Shu, Frank H., *The Physical Universe*, University Science Books, Mill Valley, California, 1982.
13. Stafford, Edward, *Sun, Earth and Man*, NASA, Washington, D.C., 1982.
14. Van Allen, James, "Interplanetary Particles and Fields," *Scientific American*, September, 1975, page 161.
15. Wild, J.P., "Radio Waves From the Sun," *Scientific American*, June, 1955, page 40.
16. Wolfson, Richard, "The Active Solar Corona," *Scientific American*, February, 1983, page 104.

ham radio

better frequency stability
for the Drake TR7

Adding a circuit board improves performance without affecting appearance

Although the TR7 has a rather stable VFO, it can still be improved. With this modification, its stability becomes comparable to that of synthesized frequency generators; consequently, it becomes more useful in the following ways:

- If you're operating on AMTOR, retuning is not necessary.
- Your operating frequency is stable within a second or so after switch-on, even in a cold shack.
- The frequency setting remains stable for an indefinite length of time, making the rig usable for remotely controlled installations such as AMTOR repeaters.

Improved frequency stability is achieved by means of a Digital Automatic Frequency Control (DAFC) circuit. A frequency counter with a crystal-controlled reference measures the frequency to be stabilized. If the count is above or below a defined fixed value, a dc voltage controlling a varicap within the VFO is altered so as to counteract any frequency deviation. The divider ratios used in this design produce a series of stable frequencies which are separated from each other by 30.5 Hz. Actually, the frequency slowly varies about the *nearest* 30.5-Hz point. This is because the output is either too low or too high, but never exactly on. That's why the control voltage continues to hunt.

These fluctuations are generally not noticed when operating in CW, SSB, AMTOR, or RTTY. If you connect a frequency counter, you can see that the VFO frequency excursions amount to not more than ±10 Hz. PA0KSB has designed a circuit that can be incorporated into existing VFOs; he describes the theory behind this kind of frequency control in detail in reference 1.

The present circuit provides VFO frequency control by applying the correcting voltage to the RIT-line. This also enables a possibly connected external VFO to be frequency controlled when switched on.

The reference frequency used is the TR7's 500-kHz signal drived from the 40-MHz main crystal reference, thereby eliminating the need for a separate crystal oscillator. PA0KSB's circuit uses a pointer instrument to indicate the tuning voltage and an UP/DOWN switch for manual control of this voltage.

I wanted to find a way to avoid drilling holes into the front panel of the transceiver for additional switches and a meter. The TR7 already has UP/-DOWN keys; when you depress the STORE key, the UP/DOWN keys are assigned to the DAFC circuit for as long as the STORE key is held down. The rest of the time the UP/DOWN keys perform their usual functions. This means that the initial function of the STORE key can no longer be used — a sacrifice which is more than justified by the advantages of the DAFC circuit. But I couldn't find a way to have the S-meter indicate the DAFC control voltage; instead I adopted an idea proposed by K6EHV.[2] Two lamps indicating the upper and the lower limit of the control voltage are sufficient to display this information. The FIXED lamp (the *upper* one) indicates that the control voltage has exceeded its upper limit. The SET BAND lamp (the *lower* one) shows that the control voltage has gone below its lower limit. Besides being DAFC indicators, both lamps still serve their traditional purpose; in normal operation the control voltage does not reach either limit, so the double use of the lamps presents no problem.

circuit description

The circuit for this modification is shown in **fig. 1**.

By Urs Hadorn, HB9ABO, Im Riedtli 1, CH-8154 Oberglatt, Switzerland

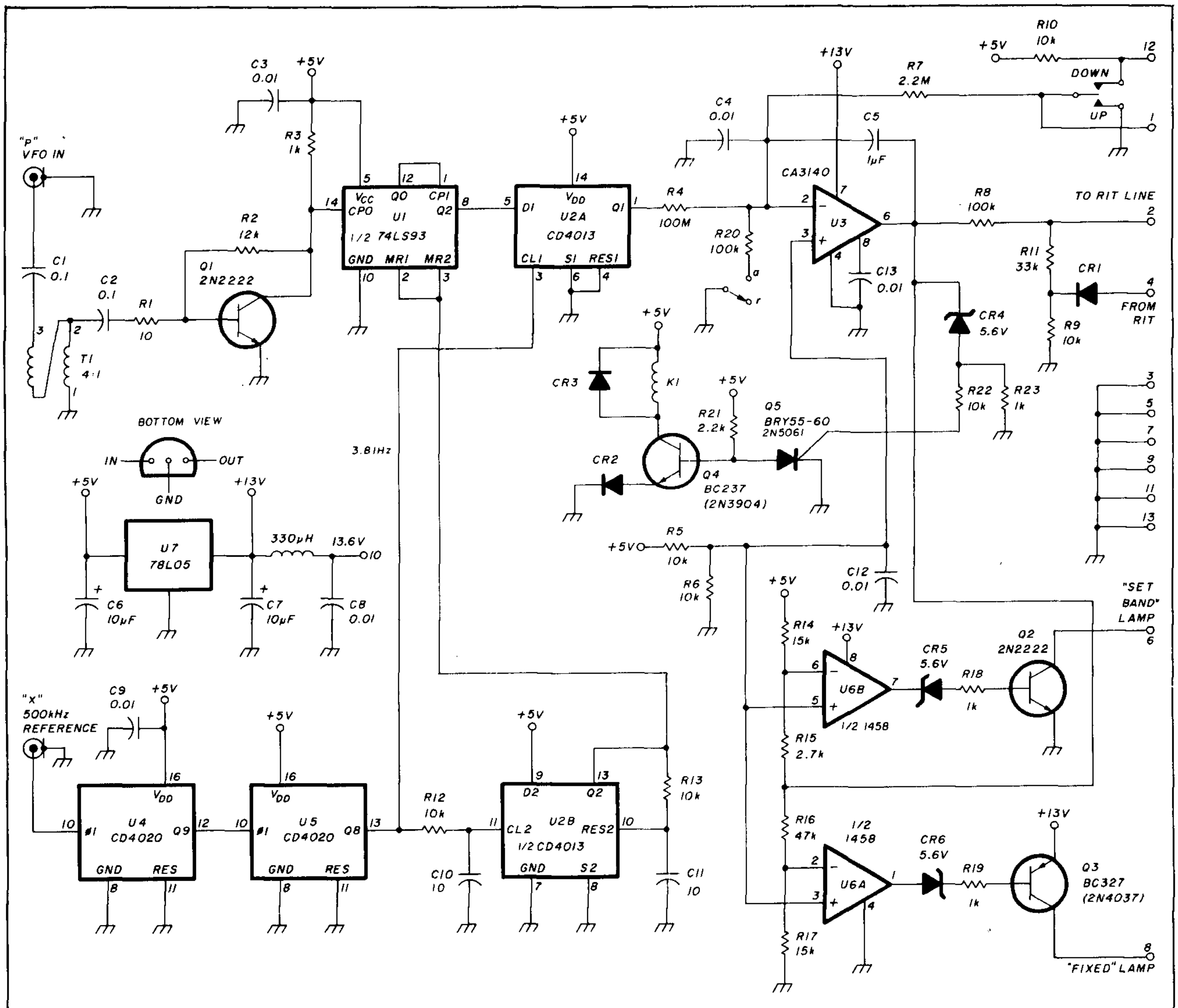


fig. 1. TR7 frequency correction schematic diagram.

The VFO signal enters the DAFC circuit at terminal P. A broadband autotransformer, T1, steps down the signal to match it to the low impedance input of Q1, where it is amplified to TTL level to enable it to drive the frequency counter chip U1. U1 divides the VFO frequency by 8. After each counting period, the count (1 bit) is stored in U2A and the counter is reset to zero. The binary counters U4 and U5 divide the 500-kHz reference by 2^{17}, thus establishing the counting period of 262 ms. A short time (determined by R12, C10) after the rising edge of the counter clock, U2B generates the reset pulse for the counter. The reset pulse width is given by R13, C11. The integrator U3 transforms the 1-bit count result into a slowly rising and falling dc voltage which is used to control the VFO frequency. The integrator time constant is established by R4 and C5. This control voltage and the former RIT voltage entering the circuit at terminal 4 are combined via R8 and R11. The resulting dc voltage is put onto the RIT line at terminal 2 for the VFO in use (internal or external). CR1 and R9 reduce the original RIT voltage so that the combined voltage looks like the former RIT voltage when RIT and DAFC voltages are at mid-range. The integrator output voltage, and with it the VFO frequency, can be raised or lowered manually by applying either +5 volts or 0 volts via R7 to the integrator input.

The circuit associated with thyristor Q5 ensures that the integrator output voltage starts at mid-range at power-up. After switch-on, Q4 conducts, thereby pulling the integrator input down via R20 and the relay contact to ground. U3's output voltage rises at a rate determined by R20 and C5. As soon as it reaches approximately 6 volts, SCR Q5 fires and cuts off the relay driver Q4, which releases the integrator input by floating R20. This mechanism is not repeatable because Q5 remains on (i.e., conducting) via R21 until the power is turned off.

The two op amps of U6 are used as comparators. The upper comparator drives Q2 into saturation when the integrator output voltage drops below the lower limit of about 2 volts. Q2 turns on the SET BAND lamp. The lower op amp drives Q3 and with it the FIXED lamp when the output voltage rises above the upper limit of about 10.5 volts.

construction

Component layout is not critical. I have built several versions of this circuit mostly using Veroboard. Follow sound rf construction techniques in the area of T1, Q1, and U1: provide a low impedance common ground, keep leads short, and pay attention to shielding. The components used are easy to obtain and low in cost. Impedance transformer T1 is wound on a ferrite toroid core (Philips Part No. 4322 020 97170) with an OD of approximately 0.37 inch and an ID of approximately 0.22 inch. There is no reason why other suitable types — for example, an Amidon FT37-63 or FT37-67 — could not be used.

The winding consists of ten turns of a twisted transmission line you can make yourself. Stretch out a 23.6-inch length of enameled copper wire with a diameter of about 0.016 inch (AWG 26) to smooth out any bends, then cut it in half. Using a hand drill, twist the two pieces to obtain about five turns per inch. Wind ten turns of this transmission line on the toroidal core, taking care that the windings are equally spaced on the circumference. Then connect one end of one wire with the opposite end of the other wire. This connection is the low impedance port (2) of the transformer. The other two ends form the high impedance input (3) and the ground end (1), respectively. They may be interchanged without any effect because the transformer is symmetrical.

The relay may be replaced by a 12-volt type, in which case it has to be connected to the 13.6-volt bus. The capacitor at C5 should be a polystyrene or similar type. Electrolytic or tantalum capacitors would exhibit too much leakage at this point of extremely high resistance. To keep the height of the pc board low, we used three 0.33-μF capacitors instead of one 1-μF capacitor. The voltage divider chain for the comparators (R14, R15, R16, R17) should be selected to be within 2 percent of nominal value to define the range limits of the control voltage accurately.

initial tests

The completed circuit board should be tested before it's incorporated into the transceiver. The following hints assume that there are no leads and signals connected, except for the 13.6-volt supply and those mentioned. When removing and replacing ICs, be sure to disconnect the power supply first.

power supply

Remove all ICs except regulator U7. Verify that there is + 5 volts at the regulator output. Check whether there is 2.5 volts at pins 3 and 5 of U6. The current drain from the 13.6-volt supply should be around 10 mA. Insert all ICs. The current drain should now be around 30 mA.

integrator

Remove U2. After power is connected, the relay should actuate momentarily and drop out immediately. The output voltage at pin 6 of U3 should be in the vicinity of 6 volts. Connect terminal No. 1 of the board to ground (corresponding to a depressed UP switch). The output voltage of U3 should rise within a few seconds to 11 volts. Connect terminal 1 with terminal 12, (corresponding to a closed DOWN circuit). The output voltage of U3 should decrease within a few seconds to about 0.1 volts.

comparators

The following maneuvers are performed by manipulating the UP and DOWN contacts as described above. Lower the integrator output voltage, starting from 6 volts. When the 2-volt level is crossed, output pin 7 of U6 should jump from 2 volts to about 12 volts.

Raise the integrator output voltage, starting from 6 volts. When the 10.5-volt level is crossed, output pin 1 of U6 should jump from 12 volts to about 2 volts.

time base

Remove U2. Apply the 500-kHz signal to terminal X. (You may use either the 500-kHz signal from the TR7 or a signal from another source. In any case, it should be a square wave of 4 to 5 V_{pp}.) At pin 13 of U5 there should be a square wave of 3.81 Hz.

frequency counter

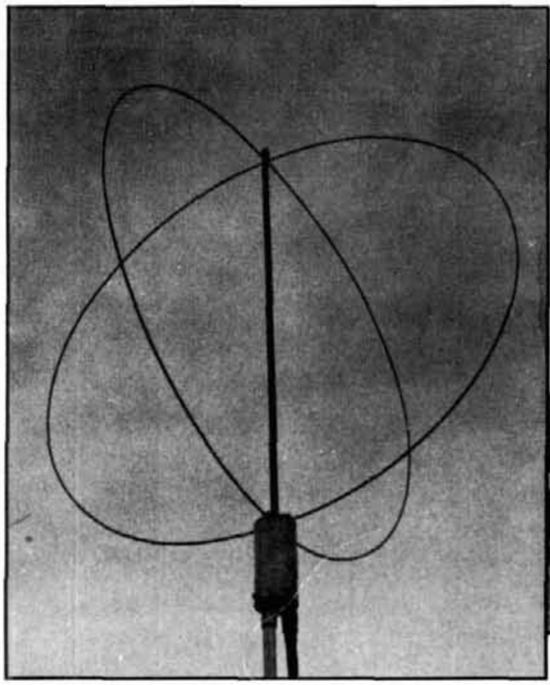
Remove U2, grounding pins 2 and 3 of U1. Connect the VFO signal (from the main board of the TR7) to terminal P. At pin 8 of U1, you should now detect a square wave measuring one-eighth of the VFO frequency. You can verify this by connecting the DAFC terminal P to the VFO line of the main board; doing this should cause just a minor drop of the VFO (PTO) voltage in the TR7.

installation

The DAFC circuit board is mounted to the lower side of the main board as shown in **fig. 2**. Insert a sheet of flexible pressure-resistant insulating material between the two soldered sides. The circuit board and

VAL COMM INC.

MOBILE OMNI-DIRECTIONAL HORIZONTAL EGGBEATER ANTENNA



Val Comm Inc. offers an exciting New Mobile Antenna for 2 meter operations for the SSB/FM mode. The original antenna, designed by Mike Staal in conjunction with Val Comm Inc. was to produce a mobile antenna in the VHF band for government satellite communication networks. Its outstanding performance is now offered to the amateur operator for mobile or fixed communications.

Orientation of the Eggbeater is unimportant as it produces an omni-directional horizontally polarized pattern. As an omni-directional satellite antenna, the Eggbeater is very effective as it produces a right hand circular polarization off the top. When placed 1/8 wavelength over a metallic surface, such as a vehicle roof top, the signal level off the top portion of the antenna increases by as much as 6 dB. No rotation or steering is necessary. Circularity is optimized in the 144 to 146 MHz region, ellipticity will increase either side of that range but the antenna is still effective from 135 to 150 MHz.

Base station, contest and field day use of the Eggbeater will allow rapid fire communications in all directions with other horizontally polarized stations. While the Eggbeater won't replace a good directional antenna, it is certainly a valuable addition to any mobile or fixed station.

EGG BEATER SPECIFICATIONS:

Spec. Freq. Range	144 to 148 MHz
Usable Freq. Range	135 to 150 MHz
Impedance	50 OHMS
VSWR Max.	1.5:1
Pattern	Omni-directional at horizontal, circular off the top.
Polarity	Horizontal
Power Handling Max	1 kilowatt
Mounting	Requires 3/8-24 male thread
Connector	SO-239
Size	34" high x 28" wide
Wind Speed Max	100 MPH
Materials:	
Loops	17-7 stainless
Loop Support	3/8" fiberglass
Body	Delrin & anodized alum
Hardware	Stainless & brass

VC Eggbeater	Price $119.95
Options:	
Magnetic Mounts	39.95
Spring Coil	9.95
Bumper Mounts	15.95
54" Bumper Mount Extension	22.95
Folding Extension	29.95

Warranty: This product is guaranteed for a period of one year from date of purchase against defective workmanship and materials. It is the option of Val Comm Inc. or M2 Enterprises to repair or replace the defective part. This specialty antenna product has been carefully manufactured by M2 Enterprises, (408) 683-2067, and serviced and marketed thru Val Comm Inc.

Val Comm Inc. is a small business, woman-owned corporation specializing in design and fabrication of prototype special applications communications systems in RF links, video transmitters, data communications and security communications.

✓ 166

VAL COMM INC.
249-B MURIEL N.E.
ALBUQUERQUE, NEW MEXICO 87123 • (505) 292-7509

"Let us help you meet your requirements."

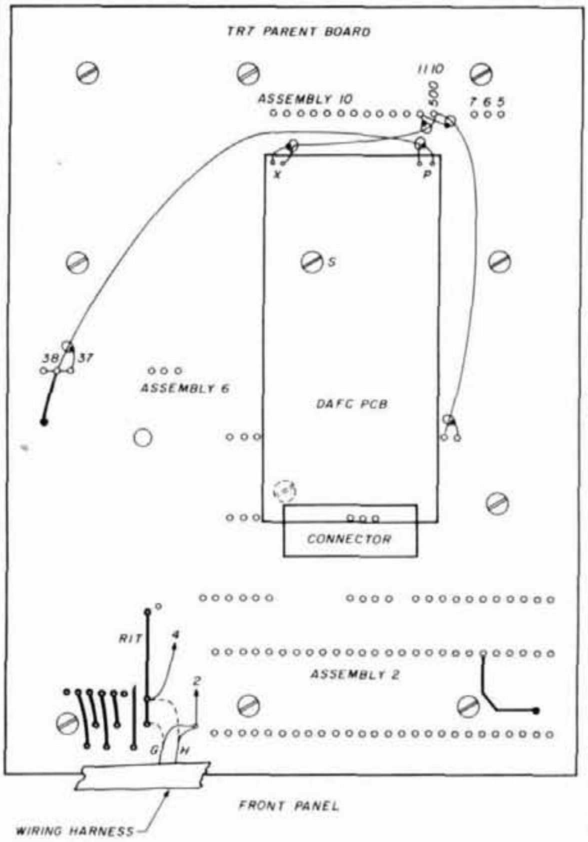


fig. 2. Positioning of the DAFC PCB on the TR7 main board and arrangement of the different connecting points.

the insulating sheet are fixed to the main board by means of a screw (S in **fig. 2**) and two insulating spacers, each about 0.08 inch thick. To be on the safe side, insulate the bottom cover of the TR7 with insulating tape or sheet. The connection of the board to the TR7 is via a 13-pin connector and two small-diameter coaxial cables. (See **photo B**.)

switch wiring

Label all applicable wires before modifying (see **fig. 3**). After identifying wires A through F, unsolder all connections from the three switches and remove the spring hook from the STORE switch so that it can no longer lock when depressed. The new wiring of the switches is shown in **fig. 4** and **fig. 5**. Wire F of the former STORE function is no longer used. Insulate its dead end and bend it into a safe place. The two wires from D2a and S2m are dressed together with the wire from the FIXED RCV switch towards the bottom side of the main board. The various connections to the DAFC board are shown in the figures, with their respective connector numbers circled.

Parts list for digital AFC:

C1,C2	0.1 μF
C3,C4,C8,C9, C12,C13	0.01 μF
C5	1 μF (or three 0.33 μF)
C6,C7	10 μF 16 V
C10,C11	10 pF
CR1,CR2,CR3	1N4148
CR4,CR5,CR6	5.6-volt Zener 1N708A or 1N4626
K1	Reed relay
L1	330 μH ferrite choke
Q1,Q2	2N2222
Q3	BC327 or 2N4037
Q4	BC237 or 2N3904
Q5	BRY55-60 = 2N5061
R1	10 ohms
R2	12 k
R3,R18,R19	1 k
R4	100 megohms
R5,R6,R9,R10, R12,R13,R22	10 k
R7	2.2 megohms
R8,R20	100 k
R11	33 k
R14,R17	15 k
R16	51 k
R21	2.2 k
U1	74LS93
U2	CD4013BE
U3	CA3140
U4,U5	CD4020BE
U6	CA1458
U7	LM78L05

connections on the main board

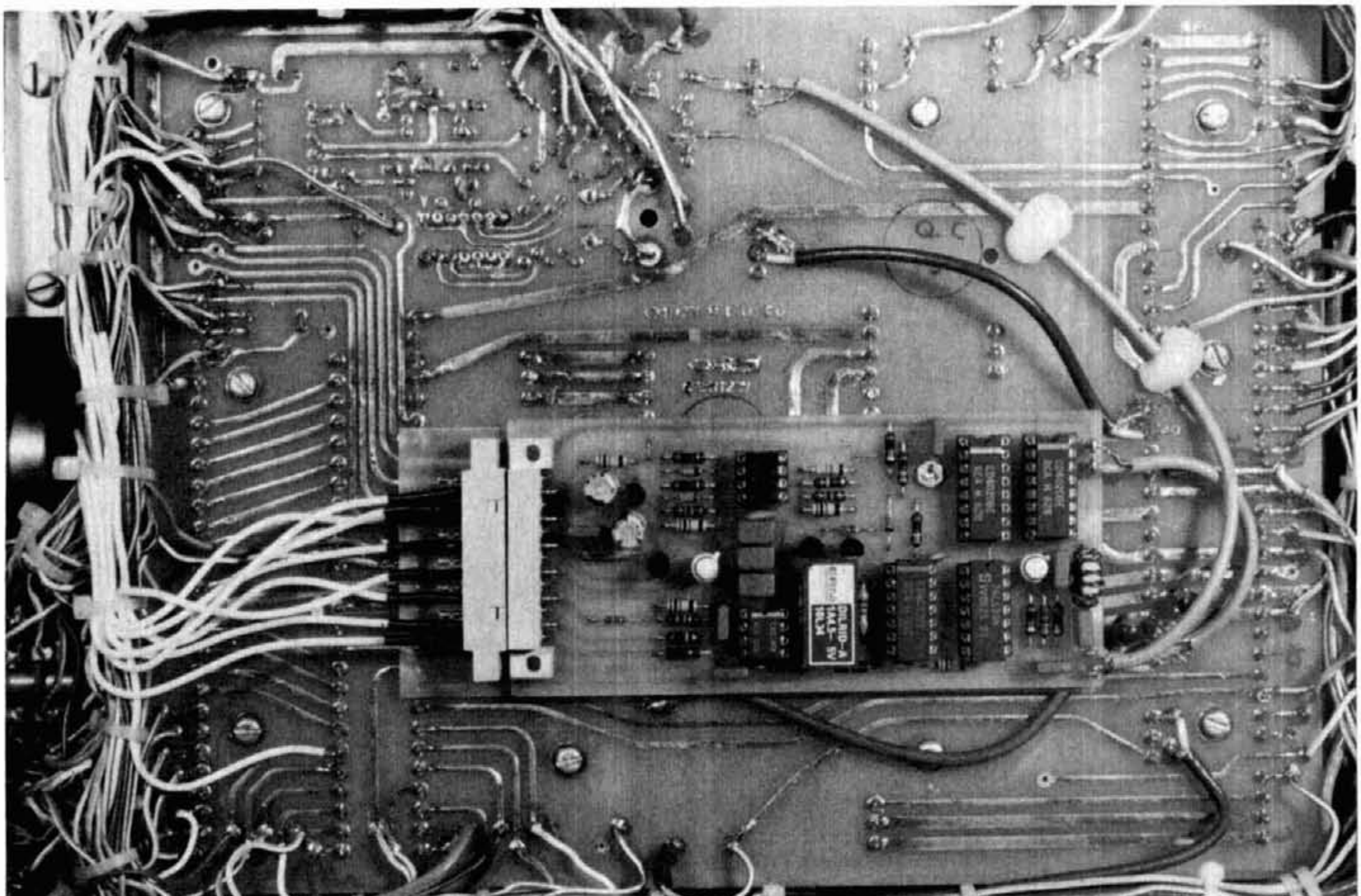
Figure 2 shows the bottom side of the TR7 main board. The connecting points which are used to install the DAFC board are labeled with assembly and pin numbers according to the TR7 service manual. The power supply board is not part of the main board; it is located to the left of the main board between the PA radiator and the rf and a-f gain controls. The 13.6-volt supply voltage is picked up from pin 9 (counted from the left) of the power supply board. The RIT control voltage is available on the conductor labeled RIT in **fig. 2**. In the original wiring the RIT voltage is run from this conductor to the internal and external VFOs with one wire each.

Two wires (labeled G and H) have to be removed from the RIT conductor and connected instead to the DAFC connector, pin 2. The RIT conductor is connected to DAFC connector, pin 4. This completes the installation. It might now be necessary to realign the RIT control center setting according to the service manual (section 3.16).

To gain confidence in this modification, zero-beat a strong a-m broadcast station. Switch on the passband tuning at its center position to allow for maximum response at the carrier center frequency. Try the best zero-beat setting you can obtain; it will be somewhere between 0 and 15 Hz. Don't worry if you hear a rather unsteady beat note. The fluctuations are in the order of a few Hz — less than you will ever notice in one of the stability-sensitive operating modes. If you leave the rig untouched and check in after hours or even days, the beat note will still be moving back and forth, but will be near the same 30.5 Hz point — and by the same few Hz!

operation

This DAFC circuit controls any undesirable frequency excursions under 2 kHz. If the drift exceeds this range, one of the two lamps — either FIXED (upper limit) or SET BAND (lower limit) — will light to announce that the DAFC cannot compensate for any further drift. It is obvious that with the inherent stability of the TR7 VFO, this condition is not very likely to occur. Holding down STORE momentarily DOWN



Closeup shows new board placement and wiring in the TR7.

162

163

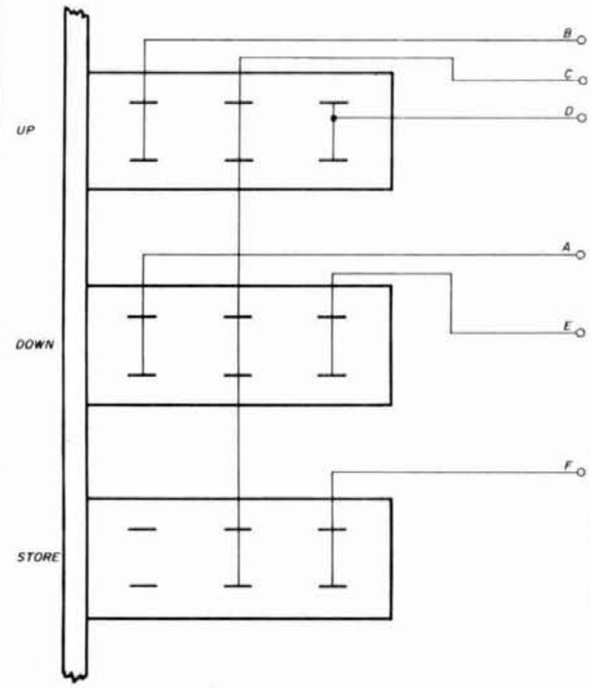


fig. 3. Original wiring of the UP, DOWN, and STORE keys.

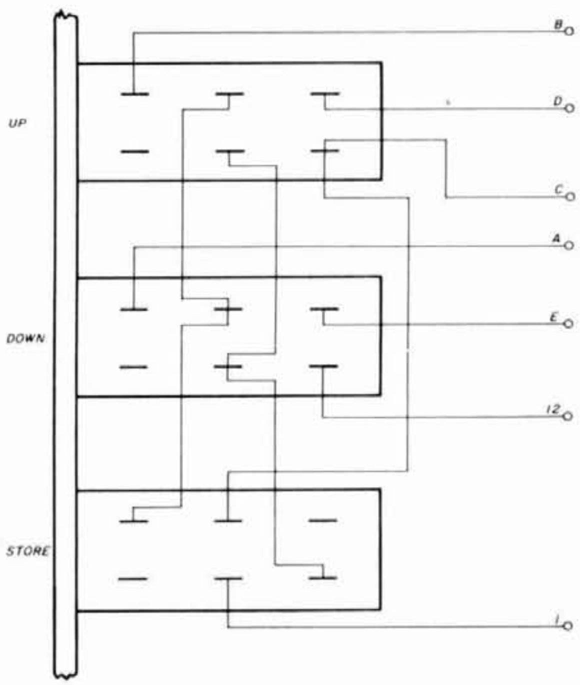


fig. 4. Modified wiring of the UP, DOWN, and STORE keys.

or UP, as is appropriate, brings the DAFC voltage back into its operating range. (UP and DOWN can also be used as a fine tuning, but I think the main tuning knob does a better job.) After several months of operation with more than one modified TR7, the range limits were never reached. It is therefore left to the reader to decide whether to build the circuit with or without the comparator stage and with or without making the connections to the lamps and switches. Tuning behavior and the traditional functions of the UP and DOWN keys are not impaired at all by the DAFC.

limitations

When operating with RIT switched on, you have to take into account that after an RX/TX/RX transition it is not necessarily true that the frequency will be on the same 30.5-Hz spot as it was before. The DAFC has no means of remembering previous voltage/fre-

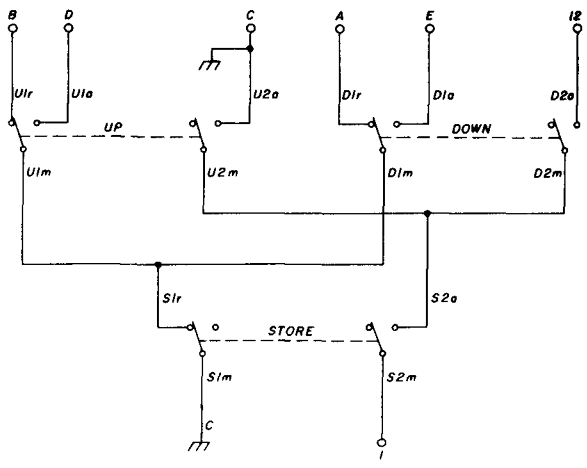


fig. 5. Modified circuit of the UP, DOWN, and STORE keys.

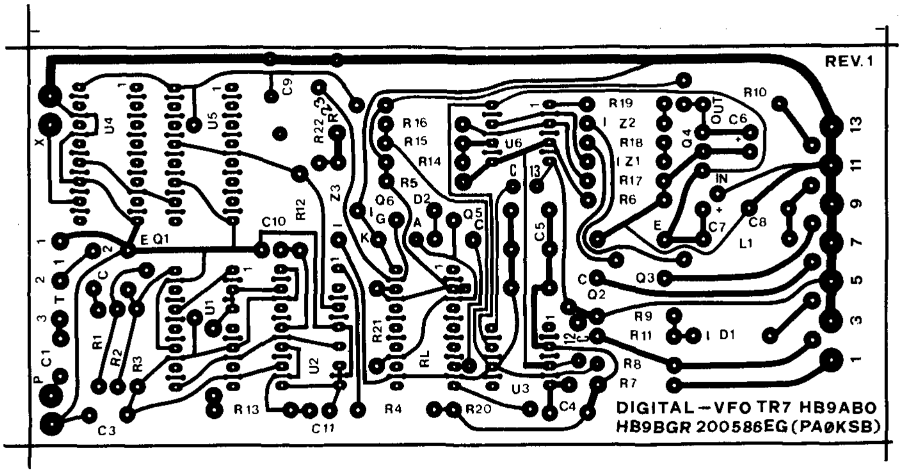
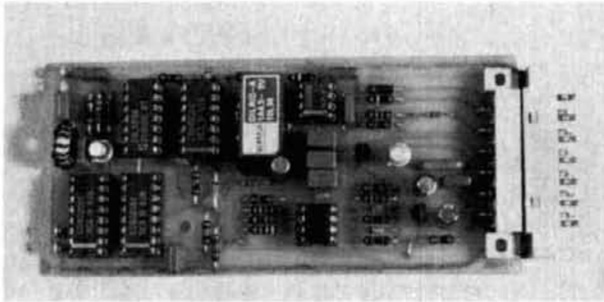


fig. 6. TR7 frequency correcting circuit pc board (foil side).

Table 1. Interconnections between the board and the transceiver. (See figs. 2 and 5.)

designation on DAFC board	connector pin number	Destination within TR7
VFO (PTO) signal (P)	-	assembly No. 06, pin 38
braid (coax VFO)	-	assembly No. 06, pin 37
500-kHz reference (X)	-	assembly No. 10, pin 10
braid — 500 kHz	-	assembly No. 10, pin 11
13.6-volt supply	10	assembly No. 21, pin 9 (power supply board)
RIT voltage from RIT circuitry	4	conductor labeled RIT
RIT output voltage	2	to wires G and H
+5 volts via R10	12	DOWN switch lug D2a
integrator input via R7	1	STORE switch lug S2m
SET BAND lamp	6	assembly No. 02, pin 6
FIXED lamp	8	FIXED RCV key
ground	3, 5, 7, 9, 11, 13	ground solder lug near assembly No. 21



Frequency correcting circuit improves TR7 stability.

quency conditions once the controlling voltage has been changed externally. (That's what happens when RIT is in operation.)

After the power is turned on, you might occasionally hear a short chirp. This is caused by the control voltage being driven into mid-range. Because there are spurious responses at 21266.7 and 28050.0 kHz due to harmonics of the VFO frequency generated by the nonlinear amplifier at Q1, it is important to use good shielding at that stage.

conclusion

Working with the modified TR7 is very rewarding: no longer is there any need to warm up before a sked. Just switch your rig on and tune in. Should a frequency difference arise during a QSO, you can be confident that it's caused by the other station's equipment!

Although this modification isn't difficult, it's a good idea to review references 1 and 2 as well as the TR7 service manual. Doing so will help you understand what you're doing at every step along the way.

Materials for this project can be obtained from HB9BGR (Charlie Egli, HB9BGR, Rümelbachstrasse 9, CH-8153 Rümlang, Switzerland). A list of available items, with prices (U.S. currency, air mail delivery included), follows.

Printed circuit board, undrilled	$12.00
Drilled circuit board	$15.00
Kit with all components and undrilled PCB	$61.00
Kit with all components and drilled PCB	$64.00
Assembled and tested unit	$92.00

For those who wish to etch their own full-size printed circuit board, artwork is provided in **fig. 6**. Follow the foil side labels and detail shown in the photos for parts placement.

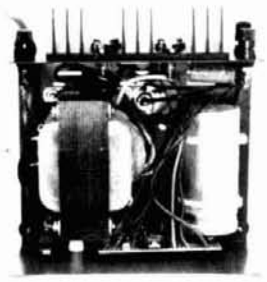
references

1. "Drift Correction Circuit for Free-Running Oscillators," Klaas Spaargaren, PA0KSB, *ham radio*, December, 1977.
2. "AFC Circuit for VFOs," by Read Easton, K6EHV, *ham radio*, June, 1979.

ham radio

ASTRON CORPORATION

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



INSIDE VIEW — RS-12A

ASTRON POWER SUPPLIES

• HEAVY DUTY • HIGH QUALITY • RUGGED • RELIABLE •

SPECIAL FEATURES

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

PERFORMANCE SPECIFICATIONS

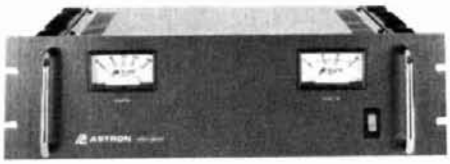
- INPUT VOLTAGE: 105-125 VAC
- OUTPUT VOLTAGE: 13.8 VDC ± 0.05 volts (Internally Adjustable: 11-15 VDC)
- RIPPLE Less than 5mv peak to peak (full load & low line)
- **Also available with 220 VAC input voltage**

MODEL RS-50A

MODEL RS-50M

MODEL VS-50M

RM SERIES



MODEL RM-35M

19″ × 5¼ RACK MOUNT POWER SUPPLIES

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

RS-A SERIES

MODEL RS-7A

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

RS-M SERIES

MODEL RS-35M

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

VS-M AND VRM-M SERIES

MODEL VS-35M

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

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

RS-S SERIES

MODEL RS-12S

- Built in speaker

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

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

BASIC program analyzes simple ladder networks

BASIC or PASCAL — which is best for you?

This article is written in response to a recent article discussing a compiled PASCAL network analysis program.[1] The author of the PASCAL program contended that a network analysis program written in an interpreted language such as BASIC would result in unacceptably long execution times; he also claimed that BASIC doesn't lend itself to structured programming techniques. The intent of this article is to offer an alternative viewpoint and to demonstrate a simple and useful BASIC network analysis program.

The main fault with the BASIC language — from the programming teacher's point of view — is that BASIC lends itself to unstructured programming techniques, and consequently, self-taught programmers (most of us) tend to start writing code without having worked out the overall structure of the program. This is not a fault of the BASIC language, but of the programmer. A BASIC program can be just as well structured as a PASCAL program, but this is seldom so because one can start writing BASIC code without worrying about how it will finally end! In fact, that is why Dr. Niklaus Wirth developed the PASCAL language —- to *force* the programming student to use good structuring techniques. However, this forced method of programming is of little interest to the Radio Amateur wanting to learn only enough about programming to perform some network analysis on relatively simple ladder circuits.

The contention that BASIC programs have unacceptably long execution times is subjective and relative; that is, if you are required to analyze circuits on a daily basis, a reduction in calculation time of more than half is very important. If you want to analyze only a few circuits with some minor modifications now and then — and if a tabular output instead of a graphical output is sufficient — then it doesn't matter too much whether the calculations take 5 seconds or 20 seconds per run. Consequently, a slower, non-compiled BASIC network analysis program may be quite satisfactory. The BASIC network program discussed in the following article will permit *ham radio* readers to decide which network approach they prefer.

simple vs. complex BASIC programs: — which do you need?

Although many powerful and versatile BASIC network analysis programs have been published in the electronics trade journals, the length and complexity of these programs make them unattractive.[2,3,4,5] Instead of considering these more complex programs, why not first try the following simple BASIC program to see if it meets your requirements?

short BASIC program solves simple ladder networks

Computer analysis of a proposed circuit is preferable because many circuit variations can be more quickly and conveniently evaluated by computer than by actual circuit construction and measurement. The BASIC program discussed in this article permits you to evaluate networks consisting of alternating single-element shunt and series branches, such as Chebyshev high-pass or low-pass filters. By using "null" branches, the program can also evaluate more complex networks with series-tuned series branches or parallel-tuned shunt branches. You can specify the actual measured component values and *Q*s so you can be assured that your circuit, when properly assembled, will perform the same as your computer model.

BASIC listing

Figure 1 is a listing of a BASIC network analysis program that requires less than 3K of memory and is short enough to be entered into your computer at one sitting. Because of its simplicity, the program can't analyze networks having a parallel-tuned circuit in a series branch or a series-tuned circuit in a shunt branch. Elliptic low-pass and high-pass filters are examples of the circuits this program cannot analyze.

Ed Wetherhold, W3NQN, Honeywell Inc., Signal Analysis Center, P.O. Box 391, Annapolis, Maryland 21401

```
10 REM Written by W3NQN on SANYO MBC-550 computer using MS-DOS BASIC, Ver. 1.1. For publication in HAM RADIO.
20 REM Program gives filter Atten (dB) vs. Freq (MHz) for simple ladder networks with equal source & load resistances.
30 REM RL=Load resistance. List first branch starting at load end with shunt element or a null shunt branch.
40 REM  List in Data Statements  TYPE (1=R, 2=L, 3=C),  VALUE (ohms, uH or pF) and  Element Q (1E10 = no loss).
50 DIM M(15), X(15), P(15) : PI=3.14159 : RL=50 : FU=1E+06 : LU=.000001 : CU=1E-12 : REM Max. branches = 14.
60 DATA -3,1100,1E10 : REM Negative sign indicates prior null shunt branch in filter network shown in Figure 2.
70 DATA  2, 1.75, 1E10
80 DATA  3,  560, 1E10
90 DATA  2, 1.75, 1E10
100 DATA 3, 1100, 1E10
110 DATA -1,  50, 1E10 : REM Negative sign indicates a null branch prior to resistor.  For a resistor, 1E10 does
120 DATA 0, 0, 0        : REM  not refer to Q.  The 1E10 is used only to maintain a proper data READ order.
130 INPUT "ENTER FREQUENCY START (MHz),  STEP (MHz),  NO. STEPS";  FS, ST, NS
140 FOR N=1 TO 15 : READ M(N), X(N), P(N) : IF M(N)=0 THEN 160
150 P(N) = 1/P(N) : NEXT N
160 PRINT "Output data in Pairs" : PRINT "Freq (MHz)  Atten. (dB)"
170 FOR FX=FS TO FS+(NS*ST) STEP ST : REM  Selected range of test freqs (MHz) and start of FOR/NEXT loop.
180 OM=2*PI*FX*FU : BR=1 : BI=0 : DR=0 : DI=0 : CR=RL : CI=0 : K=0 : N=0 : F1=0
190 K=K+1 : N=N+1 : MK = M(N) : IF F1>0 THEN MK = -MK
200 F1= 0
210 GOSUB 360
220 IF K=1 THEN V1 = AR : REM AR = Real (Resistance).
230 IF K=1 THEN V2 = AI : REM AI = Imaginary (Reactance).
240 IF MK= 0 THEN 370
250 IF MK< 0 THEN 280
260 ON MK GOSUB  290, 310, 330
270 GOTO 190
280 CR=0 : CI=0 : N=N-1 : F1=1 : GOTO 190 : REM Null Branch.
290 CR=X(N) : CI =0 : IF K =INT(K/2)*2 THEN RETURN : REM Resistor.
300 CR = 1/CR : RETURN
310 CI = OM*X(N)*LU : CR = CI*P(N) : IF K=INT(K/2)*2 THEN RETURN : REM Inductor
320 DD = P(N)*P(N)+1 : CR =P(N)/DD/CI : CI = -1/DD/CI : RETURN
330 CI = OM*X(N)*CU : CR = CI*P(N) : IF K=INT(K/2)*2 THEN 320 : REM Capacitor
340 RETURN
350 REM  Complex Linear Update -
360 AR=BR*CR-BI*CI+DR : AI=BI*CR+BR*CI+DI : DR=BR : DI=BI : BR=AR : BI=AI : RETURN
370 IF K=INT(K/2)*2 THEN 390
380 AR=BR : AI=BI : BR=DR : BI=DI : DR=AR : DI=AI
390 DEM= V1^2 + V2^2 : RNUM= DR*V1 + DI*V2 : REM Following calculations for Freq (MHz) vs. Atten (dB).
400 INUM = DI*V1-DR*V2 : RTXF = RNUM/DEM : ITXF = INUM/DEM
410 MTXF = 1/(SQR(RTXF^2 + ITXF^2)) : ATXF = -2*ATN(ITXF/(MTXF + RTXF))
420 AA = -20*(LOG(2)/LOG(10)) - 20*LOG(MTXF)/LOG(10) : REM Filter Atten (corrected for source resis V-drop).
430 PRINT USING "####.## " ; FX; : IF AA>1 THEN 450 : REM  Prints Freq (MHz) to two decimal places.
440 PRINT USING "  .#### " ; AA : GOTO 460 : REM Formats output for Atten less than one dB.
450 PRINT USING "  ###.# " ; AA :          REM Formats output for Atten greater than one dB.
460 NEXT FX : END : REM Program ENDS after completion of FOR/NEXT loop.
```

fig. 1. Listing of BASIC network analysis program for attenuation vs. frequency.

However, the program can analyze all networks consisting of alternating shunt and series branches composed of single elements, or those networks that can be configured to simulate alternating single-element shunt and series branches by the insertion of null branches. The BASIC program was derived from a listing found in reference 6.

using the program

Starting at the load end of the network and progressing towards the voltage source, the coding for each component TYPE, VALUE, and *Q* is entered in separate program DATA statements in the same order the components appear in the network. The coding of all DATA statements starts with a number indicating the component type (1 = resistor, 2 = inductor, or 3 = capacitor), followed by a second number indicating the component value (ohms, μH, or pF) and concluding with a third number indicating the component *Q*.

This program always expects to start with a shunt branch across the load. Consequently, the coding in the first DATA statement must be for a shunt branch. However, if your circuit has no shunt branch across the load, then a negative sign must immediately precede the coding of the first series branch TYPE number to indicate to the program that there is a prior null shunt branch. Whenever there is a prior null branch (either series or shunt), a negative sign must be placed before the next component TYPE number.

The next-to-last DATA statement is the coding for the source resistance, and it must have the same value as the load resistance. For this program listing, a 50-ohm load and source resistance is used, but you may change this value by changing RL in **line 50** and the source resistance in the DATA statement. The DATA statements conclude with 0,0,0 to indicate to the program that all data entries are completed. An example will demonstrate the coding of the network components and the running of the program.

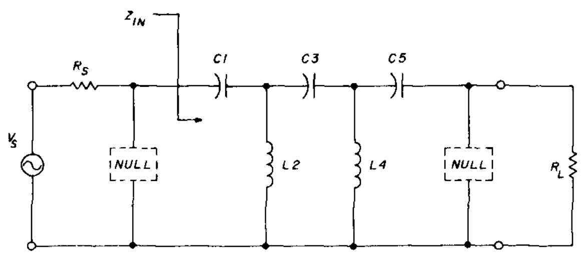


fig. 2. Schematic diagram of 50-ohm Chebyshev high-pass filter.

design application and network analysis example

Assume we want to protect an 80-meter direct-conversion receiver from overload caused by a nearby 1-MHz broadcast transmitter. Measurements showed that an attenuation of 50 dB at 1 MHz eliminates the receiver overload. A five-element Chebyshev standard-value capacitor (SVC) high-pass filter with a cutoff frequency of 3.37 MHz is selected from table 16 of reference 7. The schematic diagram of this filter (design No. 54) and the frequencies at the 3-, 20-, and 40-dB attenuation levels are shown in **fig. 2**. We will use the network analysis program to find the expected attenuation at 1 MHz to see if this filter design is suitable.

The analysis program shown in **fig. 1** requires that the network branches be listed in the DATA statements starting with a shunt element at the load end, but because this high-pass filter configuration does not have a shunt element across the load, we must simulate in the DATA coding the null branch indicated by the dashed box in **fig. 2**. The first branch coding entered in the DATA statement is for a 1100-pF capacitor. The first number in the coding is a negative 3 to indicate to the program that a prior null branch exists, and that the following series branch is a capacitor. The 1100 indicates the capacitance in pF and the 1E10 indicates *no loss*. This completes the coding for the first DATA statement. For this first example, we will assume all components have no loss. The coding for the remaining components is entered into the DATA statements in a similar manner, concluding with the series source resistance (with a negative sign because the previous shunt branch was a null). A DATA statement with three zeroes indicates to the program that it has worked back to the network's voltage source and that the input element (the source resistance) has been processed. Note that this program considers the source resistance to be part of the network being analyzed. See **lines 60** to **120** in **fig. 1** for the coding of the network illustrated in **fig. 2**.

After the DATA statements are completed, the program is run and the responses to the prompts for FREQUENCY START and STEP (both in MHz) and NUMBER OF STEPS are entered. For our evaluation, we start at 1 MHz with steps of 0.2 MHz, and enough steps will be used to provide frequency and attenuation data to 4.2 MHz. The output for this run is shown in **fig. 3A**. The filter attenuates the broadcast transmitter signal at 1 MHz by 52.9 dB, but this was for perfect components. Let's see if the filter attenuation at 1 MHz is still adequate when we assign typical *Q*s of 1000 and 150 to the capacitors and inductors, respectively.

After the *Q* values are changed in the DATA statements, the program is run again; the output is shown in **fig. 3B**. We see there is less than 0.4 dB change in attenuation between 1 and 4 MHz (between the filters that use ideal rather than real components) and therefore the filter should provide the required attenuation when built with real components.

Note that the validity of the program's operation is confirmed by checking the frequency and attenuation output values of the program against the published frequencies at the 3-, 20-, and 40-dB attenuation levels shown in **fig. 2**. This was done with frequency increments of 0.01 MHz and component *Q*s of 1E10. **Figure 3C** shows the results of runs covering the frequencies corresponding to the 3-, 20-, and 40-dB attenuation levels. Because the program's calculated frequency and attenuation data (for no-loss components) are essentially identical to the data in **fig. 2**, it means that the network analysis program is functioning correctly, and it may be used with confidence.

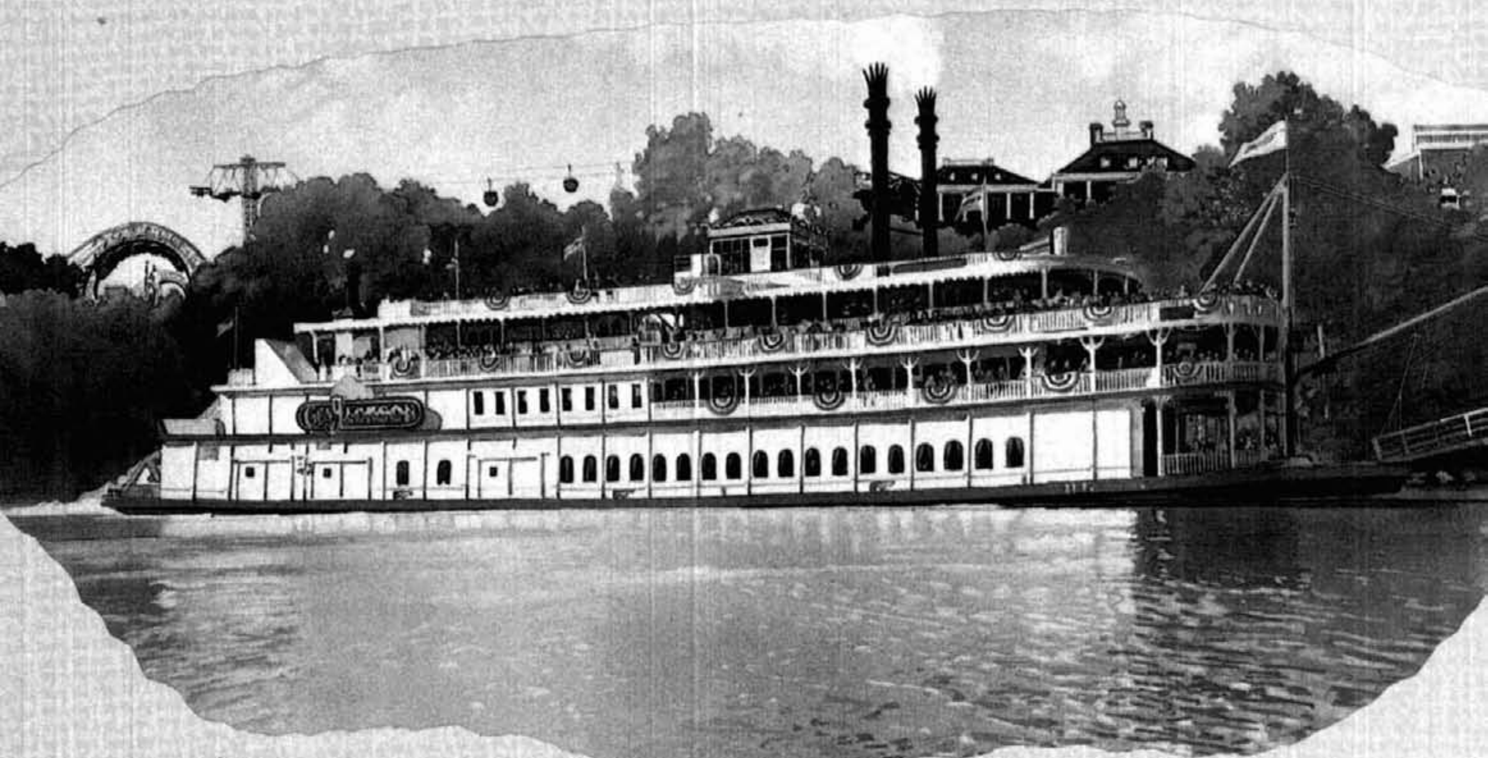
additions and refinements

The program listing in **fig. 1** gives only attenuation vs. frequency data; however, input impedance (Z-input) vs. frequency of the filter network is also often desired. To obtain Z-input vs. frequency, the program in **fig. 1** is modified by adding **line 470** and by chang-

THE LARGEST AND MOST SPECTACULAR SATELLITE SEMINAR/TRADE SHOWS IN THE WORLD HAPPEN WITH SBCA/STTI!

COME TO NASHVILLE

FOR THE BEST OF SATELLITE TVRO
OPRYLAND HOTEL
SEPTEMBER 7-8-9, 1987!



Over 500 Exhibit Booths!
Hundreds of Operating Antennas!
Major Manufacturers & Programmers!
Satellite Seminar Training!
Marketing! Sales Opportunities!
Fun in the Music Capital!

FOR DETAILS: Call STTI at 1-800-654-9276 or 702-367-1471 or Write STTI, 4970 S. Arville, Suite 108, Las Vegas, Nevada 89118

output data in pairs freq (MHz)	atten (dB)
1.00	52.9
1.20	44.5
1.40	37.2
1.60	30.8
1.80	24.8
2.00	19.3
2.20	14.2
2.40	9.4
2.60	5.2
2.80	2.2
3.00	0.6974
3.20	0.1490
3.40	0.0136
3.60	0.0011
3.80	0.0118
4.00	0.0199
4.20	0.0217

output data in pairs freq (MHz)	atten (dB)
1.00	52.9
1.20	44.5
1.40	37.2
1.60	30.8
1.80	24.9
2.00	19.4
2.20	14.3
2.40	9.5
2.60	5.4
2.80	2.5
3.00	0.9274
3.20	0.3432
3.40	0.1743
3.60	0.1375
3.80	0.1316
4.00	0.1280
4.20	0.1212

freq (MHz)	atten (dB)
2.72	3.2
2.73	3.1
2.74	3.0
2.75	2.8

freq (MHz)	atten (dB)
1.96	20.4
1.97	20.1
1.98	19.9
1.99	19.6

freq (MHz)	atten (dB)
1.30	40.7
1.31	40.4
1.32	40.0
1.33	39.7

fig. 3. Program outputs for five frequency scans. (A) Both the inductors and capacitors are considered lossless. The run time is 25 seconds. (B) A capacitor Q of 1000 and an inductor Q of 150 are assumed. (C) Closer response examination around 2.74 MHz. (D) Closer response examination around 1.97 MHz. (E) Closer response examination around 1.32 MHz.

```
160 PRINT " Freq.  Z-Input  Phase  R-Input  X-Input":PRINT " (MHz)  (ohms)  (deg)  ---- (ohms) ----"



390 AI=BR*BR + BI*BI  :  AR=(DR*BR + DI*BI)/AI  :  AI=(DI*BR - DR*BI)/AI : REM Sub-routine for Z-input.
400 AR=AR-RL         : REM Removes source resistance from Z-in calculation.
410 PRINT USING "###.## ";FX;                : REM Frequency (MHz).
430 PRINT USING "  ####.#" ; SQR(AR^2 + AI^2) ; : REM Z-input magnitude (ohms).
440 PRINT USING "  ####.#" ; ATN(AI/AR)*180/PI; : REM Phase angle (degrees).
450 PRINT USING "  ####.#" ; AR ;            : REM Real part (ohms).
460 PRINT USING " #####.#" ; AI              : REM Imaginary part (ohms).
470 NEXT FX : END
```

fig. 4. Listing of changes to fig. 1 program to get Z-input vs. frequency.

ing **lines 160** and **390** to **460**, as shown in **fig. 4. Figure 5** shows an output run using this Z-input subroutine. In addition to the input impedance magnitude, the impedance phase and the resistive and reactive components of the impedance are calculated and tabulated. (Those wishing to calculate both the attenuation and Z-input of the network should combine the appropriate lines for the two subroutines within the analysis program.)

The program in **fig. 1** can be used to analyze filters in the audio-frequency range if the inductance and capacitance units in **line 40** and in the DATA statements are changed to millihenries and nanofarads, and if the frequency unit "MHz" is changed to "kHz" in lines 20, 130, 160, 170, 390, and 430. If these changes are made to the program, the DATA statements are correct for a 50-ohm, 3.37-kHz high-pass filter, and the same attenuation vs. frequency data listed in **fig. 3A** applies to this filter, except the frequency unit in the table heading is kHz, not MHz.

The output statements of the programs shown in **figs. 1** and **4** direct the calculated results to the CRT

Freq. (MHz)	Z-Input (ohms)	Phase (deg)	R-Input ---- (ohms)	X-Input ----
1.00	133.2	-90.0	0.0	-133.2
1.20	106.5	-90.0	0.1	-106.5
1.40	86.6	-90.0	0.1	-86.6
1.60	70.6	-90.0	0.0	-70.6
1.80	57.2	-89.9	0.1	-57.2
2.00	45.2	-89.7	0.3	-45.2
2.20	33.9	-88.8	0.7	-33.8
2.40	22.5	-85.3	1.8	-22.4
2.60	11.3	-65.6	4.7	-10.3
2.80	11.5	11.1	11.2	2.2
3.00	26.6	26.5	23.8	11.8
3.20	41.0	17.6	39.1	12.4
3.40	48.6	6.2	48.3	5.2
3.60	50.0	-1.8	50.0	-1.6
3.80	49.0	-5.8	48.7	-5.0
4.00	47.6	-7.2	47.2	-6.0
4.20	46.6	-7.0	46.2	-5.7

fig. 5. Z-input vs. frequency for the same test conditions used in fig. 3A.

monitor; however, if hard copy is preferred, the user should modify all PRINT statements to cause the table headings and outputs to be directed to the printer. See your printer manual for the proper coding.

precautions to observe when copying the program

When copying the program into your computer, be careful not to confuse the number 1 with the letter I or the number 0 with the letter O. After the transfer is completed, be sure to SAVE the program to disk or tape before attempting to RUN it. If you don't save the program, and the program crashes on the first run, you may have to reset your computer and the program will be wiped out. After saving the program, make a trial run for attenuation vs. frequency by duplicating the input parameters shown in **fig. 3A**. If your data output is the same as shown, you have copied the program correctly and it is ready for use. Test the Z-input subroutine the same way if you plan to use it later.

acknowledgment

The author gratefully acknowledges the assistance of Matt Fivash of Honeywell in providing the attenuation vs. frequency program subroutine and for reviewing the manuscript.

references

1. J. A. Koehler, "Top-down Filter Design," *ham radio*, January, 1987, page 41.
2. E. Niemeyer, "Network-Analysis Program Runs on Small Computer Systems," (written in HPL for the H-P 9825 computer), *EDN*, February 4, 1981.
3. R. Steincross, "BASIC Program Performs Circuit Analysis," *EDN*, September, 1982.
4. K. D. Wyatt, "A Ladder Network Analysis Program," *rf design*, November, 1986.
5. B. K. Erickson, "Network Analysis on the Personal Computer," *rf Design*, December, 1986.
6. T. R. Cuthbert, Jr., *Circuit Design Using Personal Computers*, John Wiley & Sons, Inc., 1983, Program B4-1, page 434.
7. *The 1987 ARRL Handbok for the Radio Amateur*, 64th Edition, Table 16, page 2-48. Published annually by the American Radio Relay League, Newington, Connecticut.

ham radio

THE STANDARDS OF EXCELLENCE

SUPERIOR WEAK SIGNAL PERFORMANCE COMMERCIAL MODEM

COMPARE with *ANY* unit at *ANY* Price

Now Available With PACKET RADIO

THE WORLD OF VHF/HF PACKET*, CW, RTTY, ASCII AND NEW DUAL AMTOR IS AS CLOSE AS YOUR FINGERTIPS WITH THE BRILLIANTLY INNOVATIVE STATE-OF-THE-ART MICRO-COMPUTER CONTROLLED EXL-5000E.**

SPECIAL SALE
$795

SHOWN WITH OPTIONAL KANTRONICS KPC2400 AND MFJ-1270 TNC-2

Everything built in — nothing else to buy!

• AUTOMATIC SEND/RECEIVE—*ANY* SPEED *ANY* SHIFT • BUILT IN COMPUTER GRADE 5" MONITOR • EXTERNAL MONITOR JACK • TIME CLOCK ON SCREEN • TIMED TRANSMISSION AND RECEIVING • SELCAL • CRYSTAL CONTROLLED AFSK MODULATOR • PHOTOCOUPLER CW, FSK KEYER • ASCII KEY ARRANGEMENT • 15 CHANNEL BATTERY BACK-UP MEMORY • 1,280 CHARACTER DISPLAY MEMORY • SPLIT SCREEN TYPE-AHEAD BUFFER • FUNCTION SCREEN DISPLAY • PARALLEL PRINTER INTERFACE • SPEEDS: CW 5-100 WPM (AUTOTRACK), 12-300 BAUD (ASCII AND BAUDOT); 12-600 BAUD TTL; 100 BAUD ARQ/FEC AMTOR • ATC • RUB-OUT FUNCTION • AUTOMATIC CR/LF • WORD MODE • LINE MODE • WORD WRAP AROUND • ECHO • TEXT CURSOR CONTROL • USOS • DIDDLE • TEST MESSAGES (RY AND QBF) • MARK AND BREAK (SPACE AND BREAK) SYSTEM • VARIABLE CW WEIGHTS • AUDIO MONITOR CRICUIT BUILT IN • CW PRACTICE FUNCTION • CW RANDOM GENERATOR • BARGRAPH LED METER FOR TUNING • OSCILLOSCOPE OUTPUTS • BUILT IN 100-120 / 220-240 VAC 50/60HZ AND 13.8VDC POWER SUPPLIES • AND MUCH, MUCH MORE • SIZE: 14W x 14D x 5H •

EXCLUSIVE DISTRIBUTOR: DEALER INQUIRIES INVITED FOR YOUR NEAREST DEALER OR TO ORDER:
AMATEUR-WHOLESALE ELECTRONICS **TOLL FREE...800-327-3102**
46 Greensboro Highway, Watkinsville, Georgia 30677 Telephone (404) 769-8706 Telex: 4930709 ITT

MasterCard

MANUFACTURER:
TONO CORPORATION
98 Motosoja Machi, Maebashi-Shi, 371, Japan

VISA

**PLEASE CALL FOR DETAILS*

***Dual Amtor: Commercial quality,* the EXL-5000E incorporates *two completely separate modems* to fully support the amateur Amtor codes and *all* of the CCIR recommendations 476-2 for commercial requirements.

Specifications Subject to Change.

✓ 159

RFI KIT

Use ferrite beads and toroids to keep RF out of your TV, stereo, telephone, etc.

Free catalog and interference tip sheet on request.

PALOMAR ENGINEERS
Box 455, Escondido, CA 92025
Phone: (619) 747-3343

CADDELL COIL CORP.

35 Main Street
Poultney, VT 05764
802-287-4055

BALUNS

Get POWER to your antenna! Our Baluns are already wound and ready for installation in your transmatch or you may enclose them in a weatherproof box and connect them directly at the antenna. They are designed for 3-30 MHz operation. (See ARRL Handbook pages 19-9 or 6-20 for construction details.)

100 Watt (4:1, 6:1, 9:1, or 1:1 Impedence—select one)	$10.50
Universal Transmatch 1 KW (4:1 Impedence)	14.50
Universal Transmatch 2 KW (4:1 Impedence)	17.00
Universal Transmatch 1 KW (6:1, 9:1, or 1:1—select one)	16.00
Universal Transmatch 2 KW (6:1, 9:1, or 1:1—select one)	18.50

Please send large SASE for info.

We've Got Books
Plenty of Books

Send SASE for free flyer

Ham Radio's Bookstore
Greenville, N. H. 03048

TELL YOUR FRIENDS about ham radio

 Joe Reisert W1JR

minimum requirements for 2-meter EME: part 1

First postulated in the early 1930s in *Short Wave Craft*, edited by Hugo Gernsbeck,[1] the concept of Earth-Moon-Earth (EME) communications has been around for over 50 years. However, it wasn't until March, 1946, that authenticated echoes were heard off the moon. This was accomplished with a commercial radar operating at approximately 112 MHz.[2] Amateurs weren't successful at using the EME path until 1950, when W3GKP first heard W4AO off the moon on 144 MHz.[3] The first Amateur two-way EME QSO didn't occur until ten years later, when W1BU contacted W6HB on 1296 MHz on September 12, 1960[4]; four years after that, OH1NL and W6DNG completed the first 2-meter EME QSO, on April 12, 1964.[5]

EME communications differs from conventional propagation in one major way: the time it takes the signal to reach the other station. In conventional terrestrial propagation, if a signal circumscribes the Earth (such as on the long path) and returns to the point of origin, it will do so in less than 140 milliseconds or one-seventh of a second (excluding, of course, the mysterious long delay echoes, or LDE). Since this is a relatively short time period, it's difficult for the average Amateur to determine whether the signal transmitted ever arrived at the desired destination. (This is the so-called "dead band" or "black hole" syndrome — was the band open, or was there just no one listening in Tibet?)

Because the distance to the moon is always greater than 221,450 miles (356,375 km) from the Earth, a radio signal traveling from the Earth to the moon and back will always take at least 2.38 seconds to complete the trip! Therefore, if you listen and hear your echo return from the moon, you can be sure your equipment is functional, propagation is favorable, and you are definitely completing the desired path.

EME communications is maturing rapidly. Only a decade ago it took a sizable commitment in time, money, and effort to be successful on EME. That is no longer true for the following reasons:

- Suitable equipment — either homebrew or commercial — is now readily available.
- On August 29, 1983, the FCC raised the USA Amateur power limit to 1500 watts output (versus 1000 watts dc input); this represents a potential 3- to 4-dB improvement.
- Improved antennas and antenna systems are now available.
- Many so-called "super stations" are now active.

I still receive many questions about EME and am often asked what band I recommend. Naturally, I'd like to recommend 70 cm (432 MHz), since that's where I began and still continue most of my EME work. However, it's definitely easier to get on 2 meters, where there's a higher concentration of super stations, all states are available, and over 50 DXCC countries have been active. Two meters is a good place to start your EME career, especially if larger antenna systems don't frighten you!

With the first weekend of the ARRL EME contest just around the corner (October 17-18, 1987) I decided to devote this and next month's column to 2-meter EME. This month's column will be primarily an introduction into EME background information and jargon. Next month's will address the minimum requirements for successful 2-meter EME communications as well as the various pieces of equipment required. By the time this material appears, you should be able to set up your own 2-meter EME station with little or no assistance.

terminology

It would be foolish to jump into EME communications headfirst without knowing and understanding the jargon. Some of the more common terms are listed in **table 1**.

Probably the most common one, ***hearing echoes***, means that you can hear your own signal returning from the moon (**fig. 1**). As mentioned, the round-trip time on the EME path is greater than 2.38 seconds. There's plenty of time to send at least one or two letters or numbers on CW or a full call sign on SSB and then listen for your echo.

A related term, ***self-test***, involves listening for your echoes. Whenever you change equipment, you can quickly evaluate the effect of that change on your system by listening to the strength of your echoes. If you can adjust and measure your output power level accurately, you can reduce your transmitter power until your echoes are barely perceptible; you'll now have a reference point for any future changes.

Measuring approximately 2160 miles in diameter, the moon travels around the Earth in a slightly elliptical orbit with an eccentricity of 0.0549. When the moon is closest to the Earth, it is said to be at ***perigee***. At minimum this distance is about 221,450 miles.[6] Perigee occurs once every 25 to 29 days throughout the year,[7] at all phases of the moon during any one-year period, not just at the full-moon phase.

Table 1. Common EME terms (see text).

Echo
Self-test
Perigee
Apogee
Semi-diameter (S.D.)
Finding the moon
Greenwich hour angle (GHA)
Declination
Right ascension
Local azimuth
Local elevation
EME window
See the moon
Common window
Rising or setting moon
European, North American, and Asian EME window
Faraday rotation
Cross polarized
Doppler shift
Libration fading
Scintillation
Ground, sky, and sun noise
Cold sky
Hot spot
Horizon shot
Ground gain

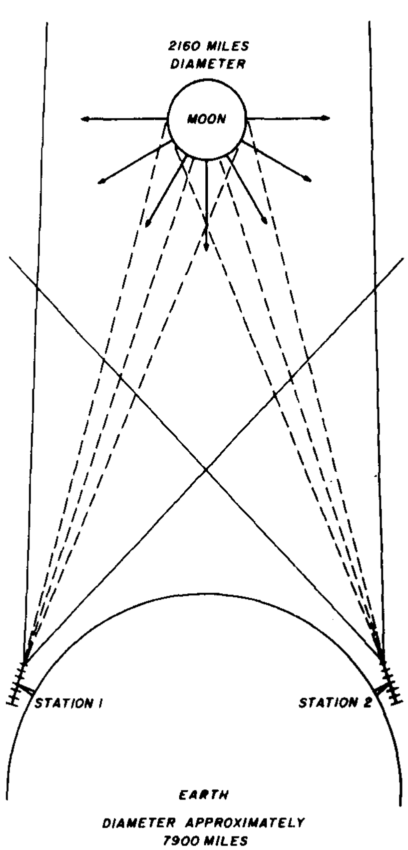


fig. 1. This figure shows the essential elements of the EME path. Note that most of the radiated signal misses the moon entirely. Of the signal that does hit the moon, some is absorbed and the rest scatters in all directions, with only a very small amount arriving back at the point of origin or at any monitoring station.

Since the moon orbits the Earth in a sinusoidal manner, it stays fairly close to perigee for five to seven days at a time. Then the moon rapidly moves away from the Earth, almost like a pendulum, until it reaches ***apogee***, its furthest distance from the Earth. At maximum this distance is approximately 252,736 miles (406,720 km), where the moon also stays for five to seven days. The average distance between perigee and apogee is 25 to 30,000 miles (40 to 48,000 km). Because of this property, EME signals at maximum apogee are attenuated by an additional 1.12 dB on each path direction, or overall about 2.25 dB more than at minimum perigee.

Astronomers often refer to apogee and perigee by the term ***semi-diameter***, or *S.D*; this is the apparent half-width of the moon as viewed from the Earth in minutes of arc. The daily S.D. is shown at the foot of the pages in "The Nautical Almanac."[8,9] Perigee varies greatly throughout the year; typically, it occurs with an S.D. of 16.1 to 16.7, which indicates an apparent arc of 32.2 to 33.4 minutes, or just over half a degree of angular width as viewed from the Earth. Apogee is much more uniform throughout the year, with a typical S.D. of 14.6 to 14.8.

I first published a graph showing the relationship between S.D., perigee, and apogee in the Eimac EME notes.[10] It was later published in reference 9 and has been reproduced in reference 11. **Figure 2** shows a recently revised version.

finding the moon

The moon's position is generally referred to in terms of ***Greenwich Hour Angle*** (GHA) and ***declination***. GHA is the Earth's longitude over which the moon appears to be hovering, referenced to the Greenwich Meridian. The GHA of the moon varies a slight bit less than the rotation of the Earth, or just under 15 degrees per hour.

The moon's declination is referenced to the Earth's equator. Therefore, the declination of the moon represents the angular number of degrees the moon is north or south of the Earth's equator (this is the same as the Earth's latitude). The declination of the moon varies in a sinusoidal manner. Every 25 to 29 days, the moon reaches maximum northerly or southerly declination for five to seven days at a time. Declination changes slowly, seldom varying more than a degree per day at maximum, but with large variations — up to several degrees per day — when going from northerly to southerly declination and vice versa.

The moon's maximum declination is a slow, smooth function of its location with respect to the 18- to 19-year lunar cycle and varies between about 18 and 28 degrees. In the years from 1986 through 1989, we have been and will continue to be near maximum declination. Minimum declination of 18 degrees last occurred between 1977 and 1979 and will occur again between 1995 and 1998.[7]

Sometimes the moon's position may be defined in terms of ***right ascension*** and declination. This is another astronomical coordinate system which locates the apparent position of the moon with respect to the number of degrees east of the vernal equinox and the declination as previously discussed. Right ascension can be expressed in degrees, but is usually expressed in terms of hours and minutes, with one hour representing 15 degrees. Right ascension is often used to determine which portion of the sky or constellation is behind the moon as viewed from the Earth (more on that shortly).

In the good old days, we EMEers used to find the moon either by looking up at the sky and aiming our antennas accordingly or by using the hourly GHA and declination values shown in *The Nautical Almanac* with the tabular method described in reference 9. For example, if the moon's position was at GHA 66 degrees with a north declination of 18 degrees, 26.5 minutes, we knew it would appear directly overhead in San Juan, Puerto Rico. This was a tedious procedure; sometimes we'd goof, but that was part of the challenge on EME communications.

Later some fortunate EMEers with access to large mainframe computers and moon orbital prediction programs could print out a year's worth of data showing the ***local azimuth and elevation*** angles of the moon every 10 or 15 minutes of the day. With personal computers, that's changed; accurate moon position programs are now available even for the least expensive PCs. One of the most popular is the one written by Lance Collister, WA1JXN. Just input your latitude and longitude and the program displays or prints out your ***local azimuth and elevation*** to the moon as well as the GHA, declination, and right ascension for any day, time, or increment of time desired.* **Figure 3** shows a sample printout; other output data shown will be discussed shortly.

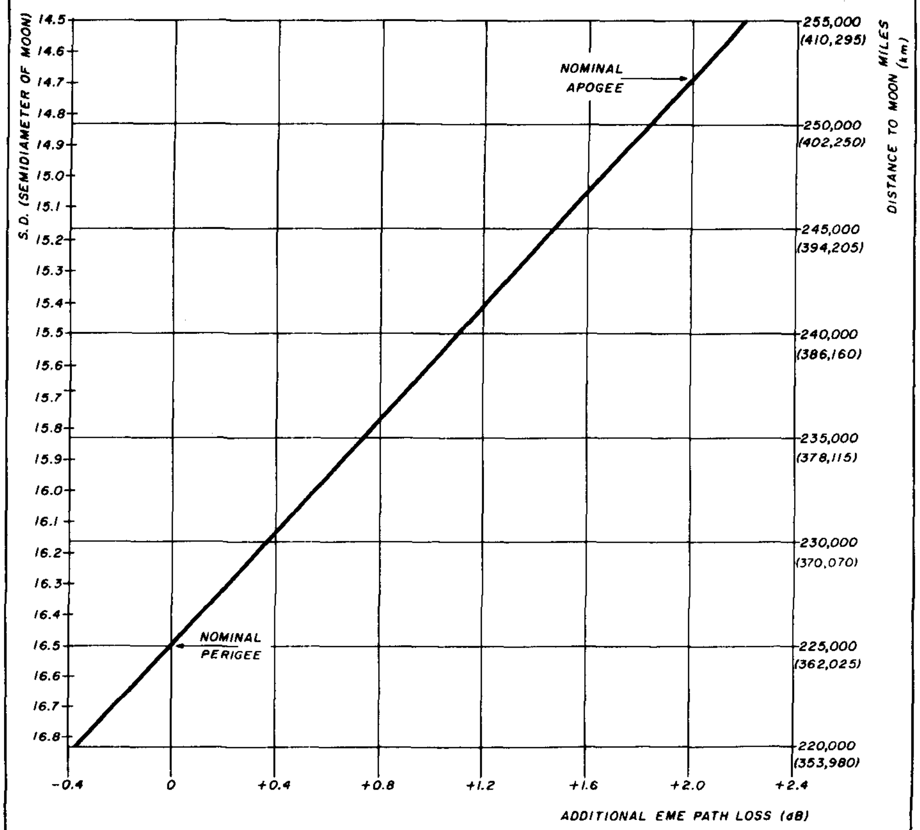


fig. 2. This graph shows the variations in EME path loss versus the distance to the moon. S.D. is the semidiameter, as explained in the text. To find additional attentuation to the moon, draw a line horizontally from either the S.D. or distance side to the pivot line and drop down to the additional path loss.

the EME window

For successful EME echoes, the moon must be above your horizon. You don't actually have to be able to ***see the moon*** for successful EME operation; you just have to be sure that you'd be able to see it if the skies were clear. The moon isn't usually visible to the naked eye — especially in daylight — when it's within one to two days of its new moon phase, but this may still be acceptable for EME operation.

Most EMEers know their local antenna azimuth and elevation limits based on the size of the antenna structure and any local obstructions. They translate these local parameters into GHA and declination limits. If you have a few different days of EME printout, typically one at maximum northerly, one at maximum southerly, and another at zero moon declination, you can easily determine your EME window. Then it's just a simple matter of comparing your window with the window of the station you want to reach to see whether you have a ***common window*** at the desired schedule time. If you do, contacts at distances greater than 10 to 11,000 miles (16 to 18,000 km) are possible.

When 2-meter EME operation took off in the early 1970s, there were many stations using large tropo antenna arrays that were rotatable only in azimuth. Therefore, they could operate EME only when the moon was low on the horizon — usually referred to as a ***rising or setting moon*** — typically below 10 degrees of elevation.

This concept was further expanded and standardized by Bob Sutherland,

*For a copy of this program suitable for IBM compatibles or the Apple Macintosh, send a double-sided, double-density diskette with sufficient return postage to Gene Shea, KB7Q, 417 Staudaher Street, Bozeman, Montana 59715.

short circuits

HW-101 readout

In **fig. 2** (top board schematic) of NU4F's article, "A True-Frequency Digital Readout for the HW 101" (January, 1987, page 8), the connection between the 600-ohm resistor and the 1.0-MHz timing crystal, which goes to pin 6, U5, is also shown connected to the run from pins 1, 2, 4, 5, and 8. This connection should go only to pin 6, U5.

U13 through U16 were omitted from the parts list on page 12; these are 74LS00 Quad NAND gates.

2-meter Yagi

In **fig. 2** of W1JR's May column (see page 95), the spacing of the first director is shown as 26 7/8 inches. This should have been indicated as 26 7/16 inches. According to the author, this discrepancy would probably not affect performance.

WELCOME— NOVICES
Call for Special Prices on 220 MHz Radios & Antennas

TEL-COM
Electronic Communications

NEW ENGLAND'S FACTORY-AUTHORIZED SALES & SERVICE FOR

KENWOOD ICOM

Also displaying the popular accessories needed to complete a HAM STATION . . .

ARRL PUBLICATIONS • AEA PRODUCTS • AMPHENOL • ALPHA DELTA • ASTRON • AUSTIN ANTENNAS • AVANTI • BELDEN • BENCHER • B & W • DAIWA • ALINCO • HUSTLER • KLM • LARSEN • MIRAGE • ROHN • TELEX/HY-GAIN • TOKYO HY-POWER LABS • TRAC KEYERS • VIBROPLEX • WELZ • ETC.

✓ 154

KENWOOD SPECIALS

TR-3600A w/extra battery pack (70 cm) $284.00

TM-401B (70 cm) $318.00

TM-411A (70 cm) $345.00

TW-4000A Dual Band 2m & 70 cm $449.00

Cash Prices Plus Shipping
Limited Stock — Order Early

OPEN SIX DAYS A WEEK

Telephone 617/486-3400, 3040
675 Great Rd., (Rte. 119) Littleton, MA 01460
1¾ miles from Rte. 495 (Exit 31) toward Groton, Mass.

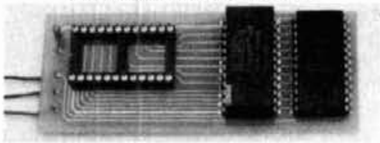
CONGRATULATIONS SWEEPSTAKES WINNERS

GRAND PRIZE
KB4IP

CALLBOOKS

N4BPX	AD9S
N7GQT	NM6U
JAMES HANSON	W1GYI
W5PSA	K6HAZ
W7DCD	W9TBZ
WB4GHY	W9DUT
W1JNX	W8CTN
W2ADK	W9SVE
BILL BROWN	WB8VSU
WD0FTS	WA8CEW
KB4OOJ	K3TKW
WD7QLD	WB4EHB
WB5FBC	WE4R
W7ISV	N4LXB
WA2PHH	W1ULF
NT8R	WB2SIH
KA9JST	W0DYL
WB3IMW	WB9ZMC
K4VDY	WA5ZIB
K4JVT	WA9KKX
W9DPO	W8PIK
W0EPB	K4TO
DK9RU	KL7GRG
KA1Z	N6OA
K9LL	WB0OWG

BATTERY BACKUP
MEMORY ADAPTER
for
KWM-380 TRANSCEIVER



- Easy installation, manual included
- WARC frequencies
- No board modifications
- Plugs into ROM socket
- Battery sealed in memory IC
- Ten year battery life
- All memories and A/B VFO saved
- **Now also available for HF-380**
- SASE for flyer and special price

Kiron Corporation 1516 Essex Road
Columbus, OH 43221
614-486-5746

✓ 156

SSB ELECTRONIC TRANSVERTERS & PREAMPLIFIERS

LT 2S	144/28 XVRTR 20W GaAsfet DBM	$549
LT33S	902/144 Xvrtr 20W GaAsfet	$599
LT23S	1296/144 Xvrtr 10W GaAsfet	$549
MICRO-13	2304/144 XVRTR 0.5W GaAsfet	$429
MICRO-X	10368/144 Xvrtr 0.1W GaAsfet	$599
DX	series low noise GaAsfet preamps from	$129
MV	series mast mounted GaAsfet preamps	$199
K	series rx cnvtrs GaAsfet DBM from	$129

TRANSVERTERS UNLIMITED

T220/28	220 MHz Xvrtr 28 or 50 IF, 20 W	$220
T144/28	144 Hhz Xvrtr 28 or 50 IF, 25 W	$199
PA33200	902 MHz 2 tube PA, 200W +	$499
PA23150	1296 2tube PA, 150 + W	$449
PA1325	2304 1tube PA, 25 + W	$429
HF400	High power relay 2Kw at 144 MHz	$129
RK500	Medium power relay 1KW at 144 MHz	$ 69

Call or write for catalogue.

TRANSVERTERS UNLIMITED
BOX 6286 STATION A
TORONTO, ONTARIO
CANADA M5W 1P3
(416) 759-5562

TRANSVERTERS UNLIMITED (US)
P.O. BOX 178
NEW BOSTON, NH 03070

✓ 157

SAY YOU SAW IT IN ham radio magazine

OPTOelectronics inc

FREQUENCY COUNTERS

TO 1.3 GHZ

NEW

POCKET SIZE

SIZE: 4" H x 3.5" W x 1" D
MADE IN USA

$99^95 - $150^00

8 LED DIGITS · 2 GATE TIMES
ANODIZED ALUMINUM CABINET
INTERNAL NI-CAD BATTERIES INCLUDED
AC ADAPTER/CHARGER INCLUDED

#TA-100S

EXCELLENT SENSITIVITY & ACCURACY

AC-DC · PORTABLE OPERATION

#P-100

#AC-1200
AC ADAPTER
CHARGER

#1200H 1.2 GHZ

Small enough to fit into a shirt pocket, our new 1.2 GHz and 1.3 GHz, 8 digit frequency counters are not toys! They can actually out perform units many times their size and price! Included are rechargeable Ni-Cad batteries installed inside the unit for hours of portable, cordless operation. The batteries are easily recharged using the AC adapter/charger supplied with the unit.

The excellent sensitivity of the 1200H makes it ideal for use with the telescoping RF pick-up antenna; accurately and easily measure transmit frequencies from handheld, fixed, or mobile radios such as: Police, firefighters, Ham, taxi, car telephone, aircraft, marine, etc. May be used for counter surveillance, locating hidden "bug" transmitters. Use with grid dip oscillator when designing and tuning antennas. May be used with a probe for measuring clock frequencies in computers, various digital circuitry or oscillators. Can be built into transmitters, signal generators and other devices to accurately monitor frequency.

The size, price and performance of these new instruments make them indispensible for technicians, engineers, schools, Hams, CBers, electronic hobbyists, short wave listeners, law enforcement personnel and many others.

STOCK NO:

#1200HKC	Model 1200H in kit form, 1-1200 MHz counter complete including all parts, cabinet, Ni-Cad batteries, AC adapter-battery charger and instructions	**$ 99.95**
#1200HC	Model 1200H factory assembled 1-1200 MHz counter, tested and calibrated, complete including Ni-Cad batteries and AC adapter/battery charger	**$137.50**
#1300HC	Model 1300H factory assembled 1-1300 MHz counter, tested and calibrated, complete including Ni-Cad batteries and AC adapter/battery charger	**$150.00**

ACCESSORIES:

#TA-100S	Telescoping RF pick-up antenna with BNC connector	**$12.00**
#P-100	Probe, direct connection 50 ohm, BNC connector	**$18.00**
#CC-70	Carrying case, black vinyl with zipper opening. Will hold a counter and accessories	**$10.00**

1.3 GHZ
#1300H

✓ 158

ORDER FACTORY DIRECT

FLA (305) 771-2050 **1-800-327-5912**

MasterCard VISA

AVAILABLE NOW!

OPTOelectronics inc
5821 N.E. 14th Avenue
Ft. Lauderdale, Florida 33334

Orders to US and Canada add 5% of total ($2 min., $10 max)
Florida residents add 5% sales tax. COD fee $2.

W6PO.[12-14] Three windows, the ***European, North American, and Asian EME windows*** were defined. All three required the moon to be at any positive (north) declination.

The start of the European EME window is two hours before the moon sets in Frankfurt, West Germany. The Asian EME window begins when the moon rises above the horizon in Kurume, Japan and ends two hours later. The North American EME window is sandwiched between the European and Asian EME window. Hence, it starts immediately after the European EME window and ends when the Asian window opens. It is centered on a GHA of 116 degrees, which can also be described as the 116-degree west longitude meridian which passes just to the west of Las Vegas, Nevada.

This may all seem confusing and difficult to remember. However, the WA1JXN moon locator program uncomplicates it by incorporating all these windows in the printout. If you look at **fig. 3**, you'll see the letters E, N, and A alongside the printout between 1500 and 2145 UTC. These letters indicate, respectively, the times when you're in the European, North American, and Asian EME window. Simple enough?

path anomalies

So far I've mentioned only the anomalies attributable to the difference in path attenuation. Many others affect not only the returned signal strength, but its quality; these include ***Faraday rotation, doppler shift, libration fading, scintillation***, and ***noise.***

On 2-meter EME, ***Faraday rotation*** is probably the biggest problem. Whenever a linearly polarized electromagnetic wave passes through an ionized region such as the ionosphere, its polarity is shifted or rotated. On EME this is a double problem because signals pass through the ionosphere twice, once on the way to the moon and again on the return. Dick Turrin, W2IMU, has suggested the following rule-of-thumb equation for maximum Faraday rotation one way on 100 MHz and above:[15]

$$\Theta \approx 200/f^2$$

where Θ is the maximum number of degrees of Faraday rotation one-way and f is frequency in GHz. For example, the maximum one-way Faraday rotation on 144 MHz can reach 9645 degrees!

Faraday rotation is usually minimal for a station operating on the equator with the moon directly overhead because the magnetic field in the direction of propagation is virtually zero. Polar stations will be most severely affected since they have to operate at low antenna elevation angles. Hence

Apr 26, 1987
Sunday
JD: 2446911.5

42D 34'58" N
71D 22'35" W
(QTH: FN42HN)

Range: 383,997 km
P + 8 Days 15.56'SD

									144 MHz		432 MHz	
GMT	Notes	W	Az	Elev	GHA	DEC	RT	ASCN	DK	DB	DK	DB
0915			82.6	0.9	338.6	6.3	0H	55M	275	2.5	20	1.3
0930			85.1	3.8	342.3	6.3	0H	56M	276	2.5	20	1.3
0945			87.5	6.5	345.9	6.3	0H	56M	276	2.5	20	1.3
1000			89.9	9.2	349.5	6.3	0H	57M	276	2.5	20	1.3
§			§	§	§	§	§	§	§	§	§	
1430			152.3	51.6	55.0	7.6	1H	6M	282	2.7	20	1.3
1445			158.0	52.7	58.6	7.6	1H	6M	282	2.7	20	1.3
1500		E	164.0	53.6	62.2	7.6	1H	7M	282	2.7	20	1.3
1515		E	170.2	54.2	65.8	7.6	1H	7M	283	2.7	20	1.3
§		§	§	§	§	§	§	§	§	§	§	
1630		E	201.9	53.1	84.0	8.0	1H	10M	284	2.7	20	1.4
1645		E	208.0	52.2	87.7	8.3	1H	10M	284	2.7	20	1.4
1700		N	213.5	50.8	91.4	8.3	1H	11M	284	2.7	20	1.4
1715		N	218.7	49.3	95.0	8.3	1H	11M	285	2.7	20	1.4
§			§	§	§	§	§	§	§	§	§	§
1930		N	253.5	29.7	127.7	8.9	1H	16M	287	2.7	20	1.4
1945		N	256.4	27.1	131.3	8.9	1H	16M	288	2.8	20	1.4
2000		A	259.1	24.5	134.9	8.9	1H	17M	288	2.8	20	1.4
2015		A	261.8	21.9	138.5	8.9	1H	17M	288	2.8	20	1.4
§			§	§	§	§	§	§	§	§	§	§
2130		A	274.6	8.6	156.7	9.2	1H	20M	290	2.8	21	1.4
2145		A	277.3	6.0	160.5	9.5	1H	20M	290	2.8	21	1.4
2200			279.7	3.3	164.1	9.5	1H	21M	290	2.8	21	1.4
2215			282.1	0.5	167.7	9.5	1H	21M	290	2.8	21	1.4

Note: § indicates data omitted.

fig. 3. Sample printout of the WA1JXN EME program as described in the text. Note: Deletions have been made in the interest of brevity. This should not affect the example given in the text.

the direction of travel of radio signals is often parallel to the magnetic field and with a greater path through the ionosphere. Likewise, even stations at the equator and midlatitudes will experience significant Faraday rotation when the moon is at low local elevation angles.

Fortunately, the number of degrees of Faraday rotation are often less, perhaps only 10 percent of the maximum value shown above. The least amount of Faraday rotation occurs late at night, during the winter, and when the ionosphere has low ionization, such as during times when solar activity is at a minimum (1984 to 1986). The polarity of 2-meter EME signals during these times will usually remain constant for up to several hours.

Faraday rotation is most troublesome during daytime and summertime, especially near sunrise when drastic ionization changes take place, and during periods of high solar activity, such as the solar cycle 22 maximum predicted for 1989 to 1992. During these times, 90- to 180-degree polarity changes can sometimes occur as often as every 15 to 30 minutes. Remember that Faraday rotation occurs each time a signal passes through the ionosphere, so at any one station it's double the one-way value.

For example, if Faraday rotation is only one-tenth the maximum value (945 degrees) going toward the moon, it will probably be 1890 degrees when the signal returns from the moon to the point of origin. This just happens to be 5.25 complete polarity rotations (1890/360), and hence the signal arriving at your antenna is now 90 degrees out of phase or ***cross-polarized***, so the chances of hearing echoes at this time are almost nil!

Furthermore, Faraday rotation is nonreciprocal. As a result, the station scheduled may have a different phase shift, which may cause the polarity of the signal to be optimum at one location but not at the other station at the same time. You have to be patient and wait for the polarity to shift back to optimum. (This will be discussed in next month's column.)

There are ways to beat Faraday rotation, but they're all complicated, especially on 2 meters. The most obvious fix is to use circular polarization. However, when a circularly polarized radio signal hits a surface such as the moon, its sense is reversed. Hence a signal transmitted using right-hand sense will return from the moon in left-hand sense and vice versa, thus being cancelled out at the antenna! Furthermore, a station using circular polarization will be penalized 3 dB when receiving or transmitting to a linearly polarized station. The only partial solution is to use linear polarization and devise a scheme to rotate your antenna polarity manually — a difficult job at best. This will also be discussed further in next month's column.

Doppler shift is another EME problem, but not a big one at 144 MHz. As viewed from any one location, when the moon is east of your local longitude, signals have an apparent positive frequency shift with a maximum at moonrise. When the moon is approximately due south (passing over your same longitude), doppler will be minimum to nonexistent and will shift negative as the moon travels westerly, with another maximum at moonset. Maximum doppler shift seldom exceeds about 500 Hz at 144 MHz. Remember that if the longitude of the station scheduled differs from yours, its doppler will also differ. Some tuning may be required to compensate for this change.

Libration fading is a minor problem on 2-meter EME. Basically speaking, the moon appears to rock slightly with respect to an observer on the Earth. Libration is worst when the moon is near apogee and perigee and diurnally when the moon is directly south or crossing your local longitude. If libration fading is severe, it can actually cause fades of up to 20 dB in very short periods of time, sometimes even during a single letter on CW. However, libration fading is more pronounced on higher (e.g., 70 cm) frequency bands.

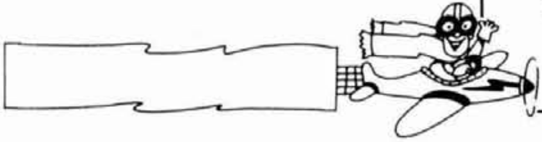
Scintillation is another sporadic 2-meter EME problem somewhat similar to libration fading. Caused by patches or blobs of ionization in the ionosphere that focus or defocus the signals, it causes fading — especially during winter nighttime and while geomagnetic storms are in progress. At times it can even enhance reception by a few dB for short periods of time. Scintillation decreases with frequency and is seldom observed on 70 cm.

Several types of noise affect EME operation — for example, ***man-made, ground, sky, and sun noise***. Manmade noise is sometimes a problem on 2 meters. If you do encounter manmade noise, it can often be decreased or eliminated with an effective automatic noise blanker on your EME receiver (or i-f if applicable) or by moving your antenna position slightly to null it out.

One of the reasons that EME is so effective on 144 MHz and above is that the local ambient noise is low. At hf, ambient noise is often 10 to 20 dB above that of a receiver looking into a shielded 50-ohm resistor. This can easily be observed. Terminate the antenna input connector on your hf receiver with a shielded 50-ohm resistor and observe the receiver noise. Now disconnect the termination and replace it with an outdoor antenna and observe the increase in noise level. It's not necessary to strive for the lowest noise figure in hf receivers because the local noise would mask internally generated noise. Repeat this same test on 2 meters or above and you may see little or no change indicating low ambient noise.

Noise can be converted to an equivalent temperature. The reference for noise is generally considered to be a temperature of absolute zero, 0.0 degrees Kelvin or −273.16 degrees Celsius (one degree change on the Kelvin scale is equal to one degree change in Celsius). The Earth's temperature is generally considered to be about 290 degrees Kelvin or approximately 17 degrees Celsius.

At 144 MHz, the ***cold sky***, that portion of the galaxy that contributes the least amount of galactic or sky noise, is typically less than 200 degrees Kel-



vin, 98 degrees Celsius below room temperature, or about −73 degrees Celsius. Therefore, if you first aim your 2-meter EME antenna a few degrees below the horizon, note the receiver output noise level and then elevate your antenna to point at one of the colder portions of the sky, all other things being equal, you'll notice a decrease in receiver noise.

Radio astronomers have measured and mapped galactic noise in terms of equivalent noise temperature at several different frequencies using very narrow beamwidth antennas.[16] These maps are now widely available; the 136- and 400-MHz versions were reproduced in one of the Eimac EME notes.[17]

Using these maps, you can find ***hot spots***, areas that have an equivalent noise temperature of over 3000 degrees Kelvin! Aim your antenna at the center of the galaxy in the Milky Way (between the constellations of Sagittarius and Scorpius), and you'll find that your antenna noise temperature will increase significantly. Because the moon moves across the sky once every 28 days, it sometimes passes directly between the Earth and one of these hot spots. C.R. Somerlock, W3WCP, showed a method of calculating your system's degradation based on the sky temperature behind the moon.[18]

Fortunately the hottest spots in the galaxy are very narrow and mostly in the southern hemisphere (southerly or negative declinations), which is not used as much by 2-meter EMEers. Since 2-meter EMEers feel that the noise in these areas significantly degrades performance, they usually avoid making schedules when the moon passes through the higher temperature portions of the sky.

Sky noise maps are usually referenced to right ascension and declination and are therefore cumbersome to use with the normal parameters of GHA and declination. However, Derwin King, W5LUU, and Lance Collister, WA1JXN, have devised tables and incorporated sky noise temperature information into the WA1JXN EME program described earlier. If you look at the sample printout in **fig. 3**, you'll note that the right ascension (RT ASCN) is shown along with the sky temperature in degrees Kelvin at both 144 and 432 MHz for each position of the moon along with potential degradation in dB. This really simplifies calculations.

Sun noise is another minor problem on EME. On a good EME system, your receiver output with a typical EME antenna will increase 6 to 10 dB when your antenna is aimed directly at the sun. Consequently, EMEers don't make schedules when the moon is within about one day of new moon.

Despite its noise, the sun is still an excellent source for antenna and system tests. Generally speaking, the more sun noise you see, the higher the gain of your antenna. To do a sun noise test, first reference your receiver noise output by aiming your antenna at a cold spot in the sky. Then aim your antenna at the sun and measure the increase in noise. One note of caution: sun noise is a function of solar activity, so if you get a very high reading, test at another time when the sun is less active.

You can check your antenna's pointing accuracy at the same time you test for sun noise. Calculate the position of the sun just as you calculated the position of the moon. Sun locator programs are also available; one is included on the WA1JXN moon locator program diskette.

horizon shot

As mentioned before, it's sometimes inconvenient for 2-meter EMEers to elevate their large tropo antenna arrays, but they still want to make EME contacts. So these operators keep schedules with the larger stations at their local moonrise or moonset, whichever is applicable.

Horizon schedules are much less reliable because ground noise may limit signal levels. Nevertheless, many EME contacts have been made in this manner. All that's necessary is to set up a schedule when the moon is at less than about 10 degrees of elevation at your location.

If you're very lucky on a horizon schedule, you may get ***ground gain***, which is somewhat analogous to the enhancement reflection you occasionally experience if you observe sunrise or sunset across a body of water. Six to 12 dB (round trip) of enhancement is theoretically possible; this can improve your chance of success significantly. Give it a try. Many stations are willing to run such schedules.

summary

This month's column was essentially a primer on EME communications, with the emphasis on 2 meters. Several techniques for locating the moon were discussed, as well as some of the terminology involved with EME communcations. Next month's column will discuss the minimum requirements and equipment required for 2-meter EME communications. With this information, you can join the fun on the cutting edge of communications technology.

new records

I'm happy to announce that the first Amateur two-way EME contact above 2320 MHz was made on April 7, 1987. Dave Hallidy, KD5RO (EM12KV), operating from Rick Fogle, WA5TNY's QTH, completed a two-way EME QSO on 9 cm (3456.1 MHz) with Les (Lucky) Whitaker, W7CNK/5 (EM15FI), for a distance of 174 miles (280 km). Then WA5TNY joined in to work W7CNK. Three- and 5-meter dishes with relatively low power (100 watts maximum) were used. Congratulations to Dave, Rick, and Lucky, who have been working very hard on this project for some time. Now that the 9-cm band has been scaled, I'll bet this record won't last long!

technical notes available

Dick Turrin, W2IMU, has recently updated the classic *Technical Reports from The Crawford Hill VHF Club*. Primarily devoted to 1296-MHz EME, it includes 20 separate notes dealing with subjects such as system considerations, transmitters, receivers, and antennas for EME. These notes are in-

valuable for the serious UHF and VHF EMEer as well as the microwave specialist. A check for $24.00 ($26.00 outside the United States) made out to Dick Turrin at P.O. Box 65, Colts Neck, New Jersey 07722, will bring a copy by return mail. Because of the high cost of cashing them, no foreign bank drafts can be accepted.

important VHF/UHF events

August 1-2	ARRL UHF Contest
August 1-3	SWOT (Sidewinders On Two) Open QSO Party (contact K5IS)
August 8	EME Perigee
August 12	Predicted peak of the Perseids meteor shower at 1300 UTC.
August 22-23	ARRL 10-GHz Cumulative Contest, first weekend.
September 5-6	International Region 1 VHF Contest, 2 meters only
September 6	EME perigee
September 10-13	Microwave Update '87 Conference, Estes Park, Colorado (contact W0PW)
September 12-14	ARRL September VHF QSO Party
September 21	Optimum time for TE propagation (±2 weeks).
September 19-20	*ARRL 10-GHz Cumulative Contest, second weekend.*

references

1. Bill Orr, W6SAI, "Ham Radio Techniques: Diana to EME in 20 Years," *ham radio*, February, 1981, page 40.
2. Herbert Kauffman, W2OQU, "A DX Record: To the Moon and Back," *QST*, May, 1946, page 65.
3. Edward P. Tilton, W1HDQ, "Lunar DX on 144 MHz!", *QST*, March, 1953, page 11.
4. Edward P. Tilton, W1HDQ, "Coast to Coast Via the Moon on 1296 mc!" *QST*, September, 1960, page 10.
5. Sam Harris, W1FZJ, "U.S. to Europe on Two Meters,"*QST*, June, 1964, page 95.
6. Jean Meeus, "Extreme Perigees and Apogees of the Moon," *Sky and Telescope*, August, 1981, page 11.
7. Berenice L. Morrison, "Perigee and Apogee of the Moon 1959-1999," *United States Observatory Circular No. 130*, April 19, 1971.
8. *The Nautical Almanac*, 1987, United States Government Printing Office, $11.00.
9. Joseph H. Reisert, Jr., W6FZJ/1, "EME Scheduling, When and Where," *QST*, July, 1974, page 25.
10. Joe Reisert, W6FZJ, "An EME Path Loss Nomogram," *Eimac Amateur Service Note 49-2: Moonbounce Operating Aids*, Varian Eimac, Inc., 301 Industrial Way, San Carlos, California 94070.
11. *The ARRL Handbook*, 1987 edition, Chapter 23, "Space Communications"; available from Ham Radio's Bookstore for $18.00 plus $3.50 shipping and handling.
12. Robert I. Sutherland, W6PO, "Universal EME Window for USA and Europe," *Eimac Amateur Service Note 49-2: Moonbounce Operating Aids*, Varian Eimac, Inc., 301 Industrial Way, San Carlos, California 94070.
13. Ken Tentarelli, W1FZA, "Proposal for a Universal EME Moonbounce Window," *Eimac Amateur Service Note 49-3: More on the Moonbounce Universal Window for 144 MHz*, Varian Eimac, Inc., 301 Industrial Way, San Carlos, California 94070.
14. Robert I. Sutherland, W6PO, "Recommendations for Moonbounce Universal Window," *Eimac Amateur Service Note 49-12: Additional Moonbounce Operating Aids*, Varian Eimac, Inc., 301 Industrial Way, San Carlos, California 94070.
15. The Crawford Hill VHF Club W2NFA, "Polarization Standardization for 1296 mc EME," *Technical Report* 1, May, 1968 **(see technical notes available, above)**.
16. Ko, "The Distribution of Cosmic Radio Background Radiation," *Proceedings of the IRE*, January, 1958, page 208.
17. Radio Sky Maps, *Eimac Amateur Service Note 49-25*.
18. C. R. Somerlock, W3WCP, "Sky Temperature Behind the Moon," *QST*, October, 1964, page 38.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

BY0AA revisited

There it is! The QSL card from BY0AA — the station located in the far western province of China, an area that had been void of Amateur Radio activity until now. But where is the town where BY0AA is located? *Wulumuqi* wasn't even on the large wall map of China a friend of mine brought back recently from Peking!

My good friend Ned Jacoby, NG6W, solved the riddle with the aid of the large *Times Atlas of the World,* which explained the variations in spelling Chinese place names. According to that source, the old English Conventional spelling had gone through various convolutions, to be followed by the Wade-Giles translations of place names, which had in turn given way to the newer Pinyin spelling. In the English Conventional system, the name of BY0AA's town was spelled *Urumchi*; in the Wade-Giles system, it was spelled *Wulumuchi*; in the Pinyin system, it's *Urumqui*. BY0AA's QSL card, on the other hand, spells it *Wulumuqi*.

In passing, NG6W pointed out that what we knew as Sinkiang Province is now *Xinjiang Uygur Zizhiqu*. Tibet is now *Xizang Zihiqu!* Lhasa seems to have remained Lhasa. Is it all clear now? (NG6W also suggests that when the pile-ups on BY0AA get too huge, you can always direct-dial them on the telephone via a satellite link!)

do you have AMI?

More and more Amateurs are having problems with AMI (Answering Machine Interference). What next? Some of these little demons seem to have rf sensitivity comparable to that of a good communications receiver. Luckily, the machine I have seems to be rf-proof. But my next-door neighbor has one that turned into a public address system every time I went on the air! The usual cures of wrapping the line cord around a ferrite toroid and placing a telephone type Z-100 filter in the phone line didn't make any difference in the level of interference.

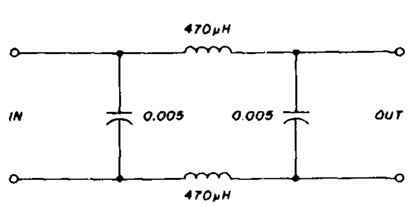


fig. 1. Simple line filter that will work with the telephone or the answering machine.

Not wishing to dig into my neighbor's answering machine, I enjoyed the luxury of indecision until an Amateur friend who had gone through this ordeal a few months earlier came up with a solution that worked for me. His opinion was that the phone company's Z-100 filter was designed mainly to filter out nearby broadcast stations and was therefore relatively ineffective at 14 MHz. He suggested wrapping the power cord of the answering machine around a "lossy" ferrite rod* and then placing a simple rf filter in the answering machine at the point where the telephone line entered the machine (see **fig. 1**). I had no option but to dig into the machine and insert the filter, which turned out to be a simple task. The gamble was worth it. The combination of a lossy line filter for the power cord and the little network filter in the phone line did the job. Keep this scheme in mind if you're unlucky enough to have AMI.

the "computerized" Yagi beam antenna

Great advances in Yagi antenna design have been accomplished in the last decade, thanks to the versatility of the computer. A number of programs for antennas such as the W2PV design and others have been generated; all seem to have been derived from an original program done by I.L. Morris for a PhD thesis at Harvard in 1965. The resulting offspring yield good Yagi

*The ferrite rod measures 7.5 inches long by 0.5 inches in diameter; manufactured by Amidon (No. R33-050-0750), with $\mu = 800$ (type 33 material).

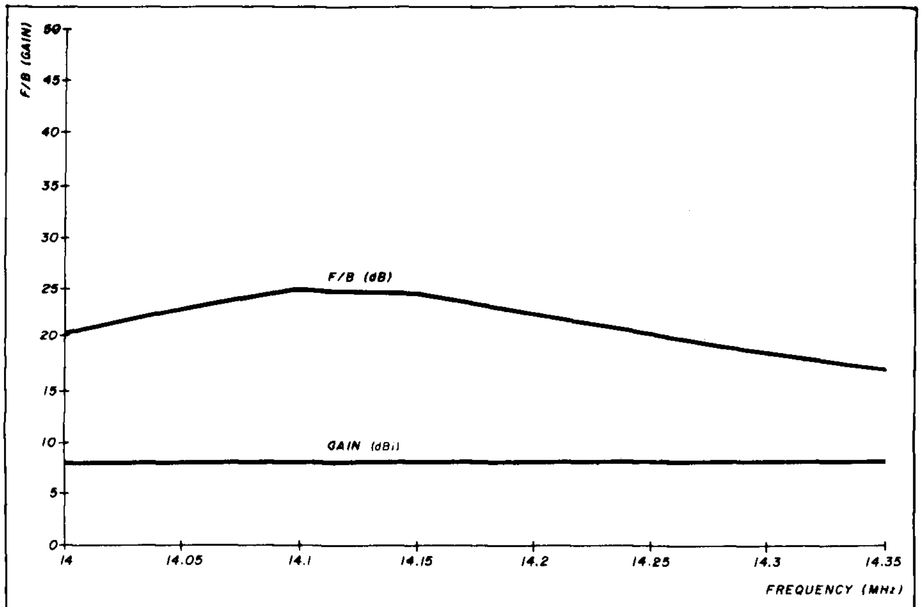


fig. 2. Hy-Gain 204BA four-element 14-MHz Yagi.

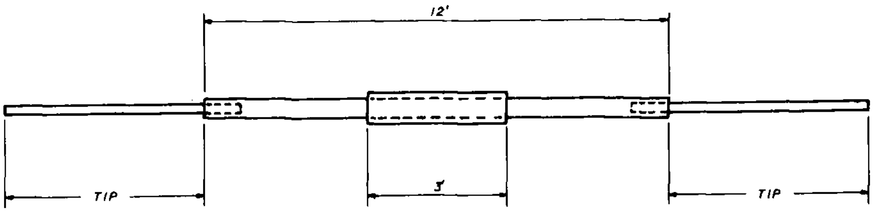


fig. 3. 20-meter Yagi element construction details and dimensions (design frequency = 14.2 MHz).

Table 1. Element dimensions for 20-meter Yagi (design frequency = 14.2 MHz). Construction details are illustrated in fig. 3.

Element	Tip lengths	Spacing
Ref	136.4 inches (346.46 cm)	122.9 inches (312.17 cm)
DE	126.9 inches (322.33 cm)	88.8 inches (225.55 cm)
D1	116.7 inches (296.42 cm)	95.6 inches (242.82 cm)
D2	112.6 inches (286.00 cm)	

data — but unfortunately, all initial conditions don't always converge to the same antenna! The taper data provided by W2PV brought these programs into greater uniformity.

Wayne Hillenbrand, N2FB, working with others, has come up with some computer-aided antenna designs that provide good gain and excellent front-to-back ratio. The data was presented at the 1986 Dayton Hamvention.

The first N2FB design involves a four-element, 14-MHz beam derived from a Hy-Gain 204BA. The gain and front-to-back ratio of the revised antenna are shown in **fig. 2**. Construction details are provided in **fig. 3**; dimensions are given in **table 1**. Each element is made up of a 3-foot length of 1.25-inch diameter sleeve which is slipped over a 12-foot length of 1.125-inch diameter tubing. The tip sections are made of 12-foot lengths of 1-inch diameter tubing.

The driven element appears to be shorter than normal, and this is correct. The length shown provides better SWR bandwidth across the entire band, but doesn't change the antenna pattern.

Details for a modification of the Hy-Gain 205BA-S are provided in **table 2** (see **fig. 3** for element assembly details). Antenna gain remains substantially the same as with the original dimensions, but the front-to-back ratio at the design frequency rises from about 15 dB to nearly 35 dB. Minimum front-to-back ratio (at the band edges) is better than 21 dB with the revised dimensions.

Data for an optimized six-element, 14-MHz beam is shown in **table 3**. The boom length is 54 feet; the boom is made of heavy-wall aluminum tubing measuring 3 inches O.D. All elements are insulated from the boom with a plastic plate. The front-to-back ratio is better than 26 dB across the band.

All beams employ a gamma match feed system. A 4-foot rod is used, with some RG-8/U center conductor fed into the tube for the capacitance adjustment. The end of the tube is crimped to keep water out.

Wayne tells me that 10-meter versions of these antennas have been built by simply scaling down the dimensions. The boom length is slightly altered to allow the use of 12-foot lengths of standard 2-inch diameter industrial tubing. Dimensions for these antennas are given in **table 4** and **table 5**; construction details are shown in **fig. 4**.

Wayne makes the interesting observation that if the driven element is removed, the remaining elements are almost equally spaced. Equal spacing of all parasitic elements produces a high front-to-back ratio, but only for a narrow bandwidth. Wayne is working on a program that compares a Yagi to an LC filter. With that, he expects he'll be able to design for very high *Q* and narrow bandwidth or lower *Q* (i.e., poorer front-to-back ratio) but wider bandwidth.

Obviously, great advances are being made in understanding the operation of the Yagi antenna, and it's now possible to custom-design a Yagi for a particular degree of gain, bandwidth, or front-to-back ratio. This demolishes the old W6SAI theory of Yagi design: "Cut the director short, the reflector long, and let 'er rip!"

a toggle-switch box for changing antennas

Use toggle switches for changing antennas? Cliff Klinert, WB6BIH, has tried it at the 100-watt level in the hf region and reports that it works well. He's taken a small aluminum box and mounted two coax receptacles on it, plus four DPDT center-off toggle switches on the face of the box (see **fig. 5**). With this arrangement, he can hook either his transmitter or receiver to any one of four antennas. The box can also be used with two transceivers.

A less obvious use of the "toggle box" is to connect two or more antennas in parallel. Cliff says that his 20-meter Yagi and his 80-meter vertical antenna, when switched in parallel, provide a low enough value of SWR to work well on 15 meters! He's found that for general coverage listening, some combination is always optimum for any frequency.

The center-off switch was chosen so that two radios can be used with minimum danger of transmitting into a receiver. To prevent confusion, all switches should be clearly labeled. The only danger is the possibility of accidentally transmitting when all toggle switches are in the center-off position, which would make any transmitter very unhappy.

75-80 meter helical antenna

Bob Walton, W6CYL, sent me information about this interesting antenna, which was developed by Gene Koenig, W6HVR. The simplified version of his design, shown in **fig. 6**, requires a space of about 40 feet.

The helix is wound from a 110-foot length of No. 15 copper-enamel (or formvar) wire. It's close-wound on a 3/16-inch diameter aluminum rod used as a temporary form.

If you don't have access to a coil-winding machine but know how to operate a lathe, you can do the job that way. You'll need an assistant to track the wire so that it doesn't kink or snarl. Once the coil is wound, the hard part of the job is over.

The helix is supported on a heavy-

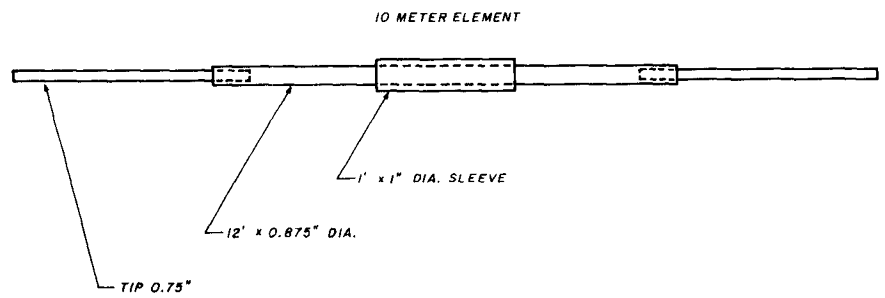


fig. 4. Optimized 28-MHz Yagi's individual element assembly.

Table 2. Dimensions of modified 14-MHz Hy-Gain Yagi (No. 205BA). See fig. 3 for assembly details.

Element	Half-length (inches)	Spacing (inches)
Reflector	213.23	65.2
Driven Element	198.68	64.8
Director 1	198.21	124.1
Director 2	188.55	153.7
Director 3	181.52	

Table 3. Dimensions of six-element, 14-MHz optimized Yagi on 0.75 wavelength boom (maximum gain = 10.71 dBI). See fig. 3 for construction details.

Element	Tip	Spacing
Reflector	139 inches (353 cm)	86.4 inches (219.5 cm)
Driven Element	124.5 inches (316.2 cm)	77.7 inches (197.4 cm)
Director 1	126.6 inches (321.6 cm)	157.5 inches (400 cm)
Director 2	121.9 inches (309.6 cm)	142.9 inches (362.9 cm)
Director 3	121.9 inches (309.6 cm)	142.9 inches (362.9 cm)
Director 4	113.5 inches (288.3 cm)	

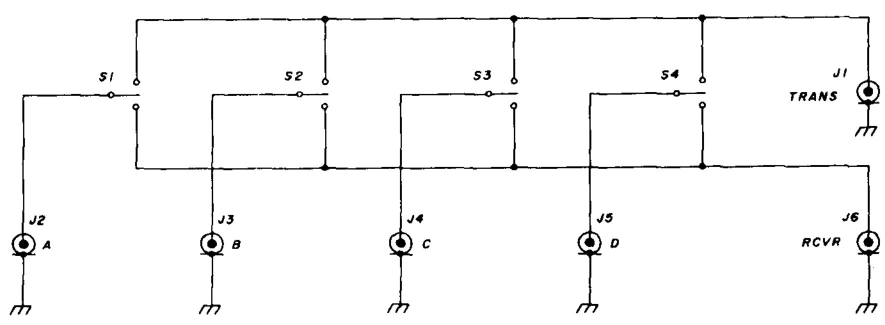


fig. 5. Toggle switch antenna box schematic.

Table 4. Optimized 28-MHz Yagi: six-element, 24-foot boom, 10-meter Yagi dimensions (see fig. 4 for construction details).

Element	Tip lengths	Spacing
Ref	33.48 inches	35.19 inches
DE	26.25 inches	35.86 inches
D1	27.32 inches	75.75 inches
D2	25.19 inches	68.43 inches
D3	24.95 inches	86.77 inches
D4	20.77 inches	

Table 5. Optimized 28-MHz Yagi: four-element, 12-foot boom, 10-meter Yagi dimensions (see fig. 4 for construction details).

Element	Tip lengths	Spacing
Ref	31.70 inches	57.55 inches
DE	26.25 inches	40.38 inches
D1	21.84 inches	43.82 inches
D2	19.82 inches	

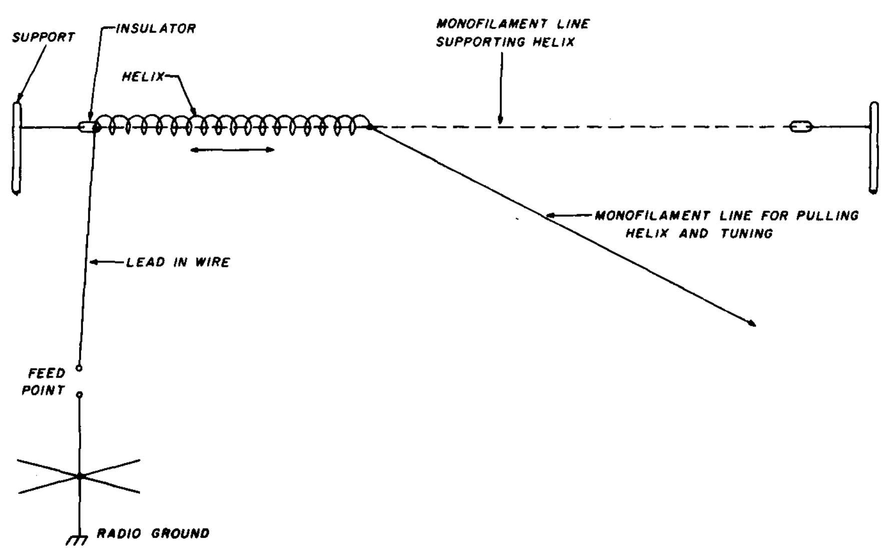


fig. 6. Simplified version of W6HVR 80-meter tunable helix antenna.

duty monofilament fishing line — the type used for ocean fishing. The helix is carefully laid out on the ground, still close-wound. A length of the nylon monofilament line is fished through the center of the helix, using an aluminum welding rod as a guide or needle. One end of the nylon line is then run to an insulator. A second length of nylon line is attached to the far end of the helix to permit expansion and compression of the coil. This line is left dangling, and the far end of the assembly is hoisted to the top of the support structure. The opposite end of the helix is attached to the feed wire. The nylon center rope is then used to pull the helix into the final position.

As an end-fed antenna, it requires a good ground system. A ground rod, plus quarter-wave radials laid on the ground, are recommended.

The antenna is capable of operation across the 80-meter band. To resonate the antenna, the helix is pulled out with the nylon cord. Bob recommends the use of a noise bridge and the station receiver for the initial adjustments. The antenna can be then be fine-tuned with the aid of an SWR meter and a little transmitter power.

Although this antenna is only about 40 feet long, its bandwidth response is quite good. It's possible to bring the nylon cord back to the operating room and tune the antenna to any portion of the 80-meter band by adjusting tension on the cord. With the use of a tuner, it will operate on the higher frequency Amateur bands.

new EME directories

A new supply of the popular "144 MHz EME Directory" has been printed. This lists many of the moonbounce stations and operators, giving the name, call, address, phone number (where applicable), and equipment. To obtain your copy, send five first-class stamps (or five IRCs) to me at EIMAC, 301 Industrial Way, San Carlos, California 94070.

ham radio

Reader Service CHECK—OFF Page 98

designing trap antennas: a new approach

Symmetrical design increases gain and directivity

Most Amateurs don't realize that the original design of a trap antenna[1,2,3,4] represents just one particular case, and is not the best possible choice of the many designs available. According to the references, a dipole designed to resonate at two frequencies, f1 and f2, contains parallel RLC circuits — or *traps* — that are resonant at the upper frequency, f2, and physically separated by a half wavelength (at f2). This approach I call the "classic" design. At f2 these circuits offer a very high impedance and, in effect, disconnect the outer portions of the antenna. The inner portion acts as a half-wave dipole. With the total antenna length made equal to one half wavelength at the lower design frequency, f1, the antenna would resonate at this frequency if the traps presented a short circuit. In practice, however, the traps introduce an inductive reactance at all frequencies lower than f2. To compensate, the total length of the antenna is slightly shortened in order to be resonant at f1.

Treatments of this subject in reference books usually ignore other existing designs and imply incorrectly that this description applies to all trapped antennas.

Extending this design approach to three bands (10, 15, and 20 meters) would require the two sets of traps to resonate at 21 and 28 MHz and be separated by approximately 3 feet (on each half-dipole element). Some of the first commercially manufactured triband antennas actually did use separated traps, but those generally available today have such pairs of traps built into a single assembly.

A vertical trap antenna, just slightly longer than a quarter wavelength at the upper frequency f2, was discussed in an earlier article; the principle upon which that antenna was based can be applied to dipoles as well.[5] In this case, the trap is placed at the base of the antenna and its parameters are selected to produce the correct inductive reactance for resonance at the lower frequency f1. At f2 the antenna is slightly longer than a quarter wavelength, and the trap provides the necessary *capacitive* reactance for resonance to be achieved.

To lower the resonant frequency of a fixed-length dipole, inductance must be added. Conversely, capacitance must be added to raise its frequency. A parallel RLC circuit can provide the required reactances at f1 and f2. (A series RLC circuit, which has a capacitive reactance at low frequencies and inductive reactance at high frequencies, cannot be used in this application.)

There's wide variation in the positioning of the traps, which affects the properties of the antenna (directivity, bandwidth, efficiency, and trap resonant frequencies). Mathematically speaking, the design of a trapped antenna is over-determined since there are *four* parameters to be adjusted in order to meet the *two* resonance conditions at f1 and f2: total length; trap position; trap resonant frequency, f0 (when removed from the antenna) and the value of the capacitance, C.

Without further information, it's impossible to say how these parameters are to be selected in order to obtain the best performance. The classic design isn't optimum because the outer portions of the dipole have little current at the upper frequency, f2. A design that causes a significant current to flow in these outer portions can improve directivity.

In addition, minimum loss reactances should be used. The capacitive loading required by a single-band antenna longer than a half wavelength can usually be supplied with negligible loss. However, inductive loading required for a single-band short dipole usually adds

By Yardley Beers, WØJF, 740 Willowbrook Road, Boulder, Colorado 80302

some losses. With a two-band trap antenna, the losses are usually greater at both frequencies than if single-band loading is used. Because losses tend to be greater if the trap resonance is near one of the operating frequencies, I'll discuss a design in which f0 is as far removed from the operating frequencies, f1 and f2, as possible, and in which the traps have equal impedances at these two frequencies. For this to occur, the trap resonant frequency, f0, must be equal to the geometrical average of f1 and f2 — that is, equal to the square root of their product. The reactances at the two design frequencies are equal in magnitude but different in sign, and the resistances are equal. I call this approach the "symmetrical" design.

a dual-band antenna

To illustrate this principle, two separate two-band trap dipoles were built; the first for 18.1 and 24.9 MHz, and the second for the 14- and 21-MHz bands. Actually, I have built two of the former; the first had minimum SWRs of 1.5 in the 18.1-MHz band and 1.4 in the 24.9-MHz band. After I had dismantled it, I improved my computer programs for designing these antennas and built the 14/21-MHz antenna, with which I obtained minimum SWRs of 1.1 on both bands. I reworked the calculations for the 18.1/24.9-MHz antenna and got slightly different values. I decided that although the original antenna was still useful, I hadn't trimmed it to best advantage. I built the second antenna with significantly different dimensions and, as shown in **fig. 1**, it has minimum SWR of 1.1 on both bands.

18.1/24.9-MHz dual-band antenna

Both antennas were developed for design frequencies of 18.118 and 24.94 MHz with a trap design frequency of 21.257 MHz, using nominal trap capacitances of 50 pF. After the second version of the dual-bander was built, the trap capacitances were measured at 51.6 pF. The trap resonances measured, on the average, 21.27 MHz. The inductors consisted of 13 turns of No. 18 plastic-coated wire wound on 1/2-inch diameter plastic rod. Since I operate at low power (about 100 watts) I was able to use No. 18 wire, but I advise those readers who intend to operate at higher power to build inductors with heavier wire. I didn't measure the *Q*s of the coils, but I assume that 200 is a reasonable value. (Resonance is independent of the *Q*.) Using these values and **eqns. 8, 10,** and **11** (see **appendix 1**), I found the magnitude of the reactances and the resistances to be 449 and 7.0 ohms, respectively.

The total antenna length is 20.0 feet. The traps are 13.8 feet apart, symmetrically placed about the center feedpoint. The earlier antenna, with similar traps, had dimensions of 20.7 feet (length) and 15.3 feet (trap separation). For comparison, the (unloaded) lengths of half-wave dipoles for these design frequencies, as given by **eqn. 6** (see **appendix 1**), are, respectively, 25.9 feet and 18.8 feet. The wire is No. 14 gauge. Standing wave measurements relative to a 50-ohm transmission line, with the antenna 20 feet above ground, are shown in **fig. 1**. The measurements take line losses into account.

Before building the second antenna, I followed the mathematical procedure discussed in **appendix 2**, which gave the following results: for S1 (the distance from the center feedpoint to one trap), 6.90 feet; for S2 (the distance from a trap to the end), 3.88 feet. With these dimensions, the SWR pattern at 24.94 MHz wasn't very different from that shown in **fig. 1**, but the f1 SWR minimum of 1.2 was at 17.4 MHz, about 5 percent too low in frequency. I tried trimming both S1 and S2. Finally I retained the original value of S1, but I reduced S2 by 0.8 feet (9.5 inches) for a final value of 3.08 feet. These dimensions apply to **fig. 1**.

Moxon gives a method for estimating the efficiency of trapped antennas.[6] It's necessary to measure or assume values for the radiation resistance. The minimum SWR at both frequencies is 1.1, which implies that the total resistance at the drivepoint is between the limits 50/1.1 = 45.5 ohms and 50 x 1.1 = 55 ohms. Because the radiation resistance is larger for dipoles greater than one half wavelength and less for those less than one half wavelength, I assumed the lower (resistance) value for f1 and the upper one for f2.

The power radiated is the current at the center multiplied by the square of the current at the center. The power lost in the traps is their resistance multiplied by the square of the current at the traps, which is smaller than at the center. The total resistances of the traps is actually 14 ohms, but a calculation shows that the losses are as though the trap resistances were at the center and had the values of 5.8 and 2.0 ohms, respectively, at f_1 and f_2. After subtracting off these transformed loss resistances, I obtain estimates for the radiation resistances at the two frequencies as 45 − 5.8 = 39.2 and 55 − 2.0 = 53 ohms, respectively. The efficiencies are then respectively 39.2/45 = 87% and 53/55 = 96%.

However, since the radiation resistance of a half-wave dipole is about 72 ohms, one would expect the radiation resistances to be slightly higher than the estimates given above; consequently, working with the same trap resistances, efficiency should actually be higher.

15/20-meter dual-band antenna

The design frequencies for this antenna are, respectively, f1 = 14.15, f2 = 21.2, and f0 = 17.32 MHz. The trap capacitors have measured values of 52 pF, on the average. The inductors are seven and a half

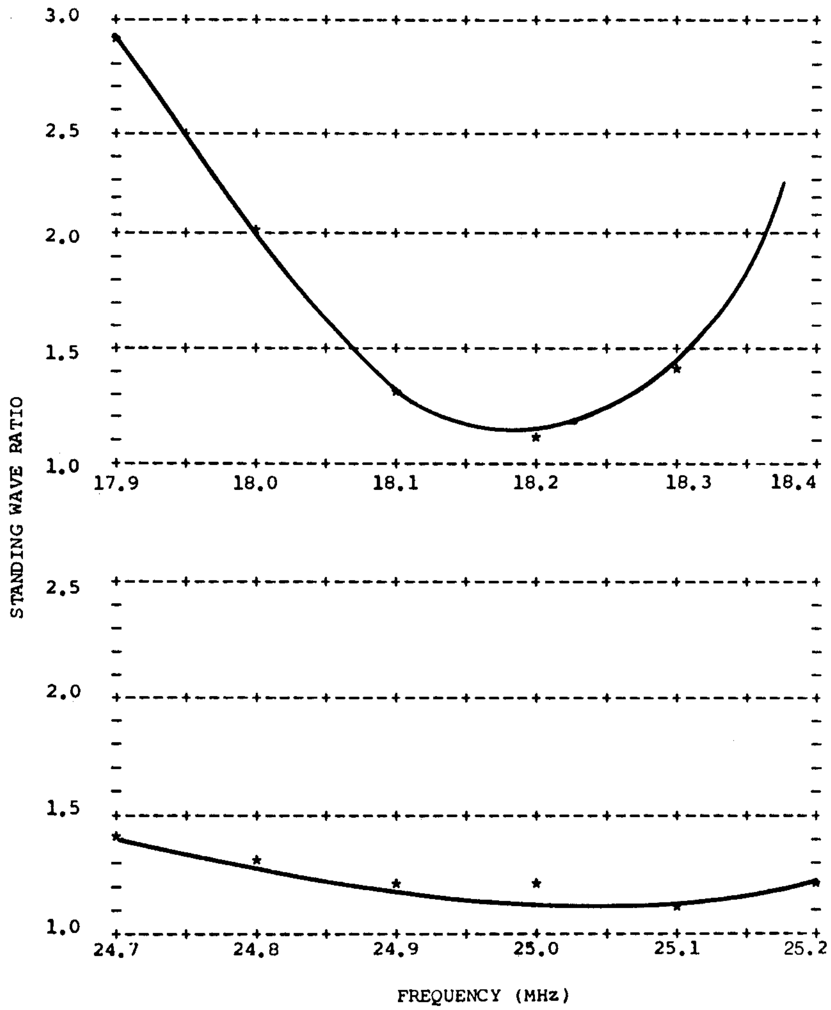


fig. 1. SWR vs. frequency for trapped dipole for use in 18.068-18.168 MHz and 24.890 -24.990 MHz bands. The antenna is 20 feet, 10 inches long and has traps placed 15 feet, 2 inches apart, equidistant from the center feedpoint. The traps use 50-pF capacitors and are self-resonant at 21.2 MHz.

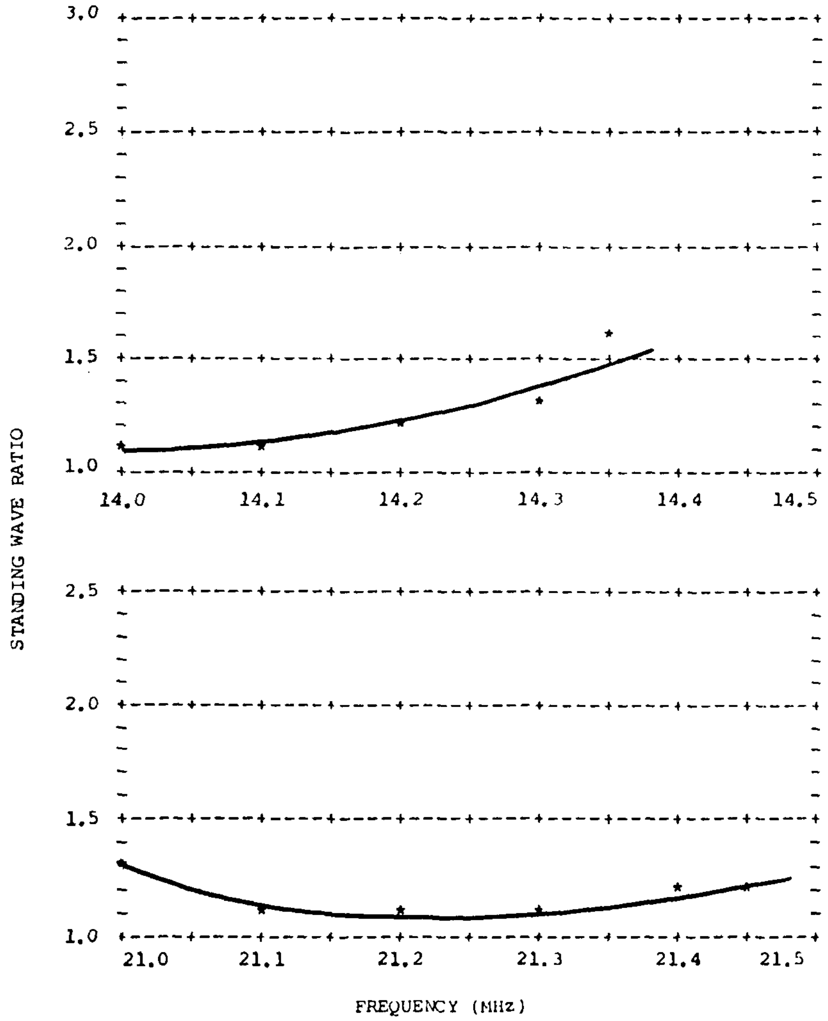


fig. 2. Standing wave ratio vs. frequency for a trapped dipole for use in the 14- and 21-MHz bands. The antenna is 24 feet, 7 inches long and has traps placed 14 feet, 5 inches apart, equidistant from the center. The traps use 50-pF capacitors and are self-resonant at 17.4 MHz.

turns of No. 18 plastic-coated wire on 1-inch plastic pill bottles. The wire spacing was varied to adjust the resonant frequencies of the traps. During coil construction, the half turn was left slack for fine tuning. The average measured resonant frequency was 17.41 MHz. The wire used in the antenna is No. 12 gauge.

Appendix 2 provides a detailed discussion of calculations which suggested the initial dimensions S1 = 7.69 feet and S2 = 5.41 feet. After I trimmed them experimentally to S1 = 7.36 feet and S2 = 5.24 feet, I obtained the standing wave pattern shown in **fig. 2**.

As the length of a loaded dipole, measured in wavelengths, increases, the bandwidth increases. Although a wider bandwidth is expected at f2 than at f1, I can't explan why bandwidths I've observed at f2 are very much wider than those at f1. These different bandwidths showed considerable sensitivity to changes in length while trimming; in each of the three cases I've dealt with, the standing wave pattern at f2 has changed hardly at all when I changed the dimensions, but a change of only a few inches made a significant change in the f1 resonance frequency. It's likely that the f1 resonance is very susceptible to changes in antenna location.

theory of the symmetrical design

The selection of a trap antenna's dimensions can be made almost entirely by experiment. The only mathematics one needs to build a two-band antenna using the symmetrical design is to calculate f0 by taking the square root of the product of f1 and f2. After installing the traps and adjusting the antenna length and trap location, a working antenna is produced. The mathematical details can usually save the designer some time by providing at least a "starting point."

In designing a trap antenna, the following conditions must be satisfied: it must resonate at f1; it must resonate at f2; the trap resonant frequency must be the geometric average of f1 and f2. The trap resistances at f1 and f2 are equal, and the reactances are equal in magnitude but opposite in sign. Arbitrarily, I chose 50 pF as a convenient value for the trap capacitances. (The effect of using other values is also considered.) The required value of the trap inductances, L, can then be determined by **eqn. 7**.

Most of the necessary formulas are listed in **appendix 1**, with detailed examples provided in **appendix 2**. The condition for resonance is that the total reactance as referred to any point on the antenna is zero. It is axiomatic that if the total reactance at *any* one point is zero, then it is zero at all other points. For convenience, I chose the trap location as a reference point and considered only half the dipole at a time.

The antenna and the ground can be thought of as forming a transmission line. Although the center is connected to the feedline, I assume that its input impedance, as viewed at the location of the trap, is the same (positive) reactance, X1, as it would be if the center were connected to ground. Calculate this with **eqn. 15**. Similarly, I consider the part between the trap and the end as a section of open-circuited transmission. Its impedance is given by the (negative) reactance, X2, in **eqn. 17**.

If S1, the distance from the center to the trap, and if S2, the distance from the trap to the open end, are a quarter wavelength long, then X1 + X2 = 0, *independent of the value of S1*. This configuration is well known as a resonator.

For resonance using arbitrary lengths of S1 and S2, it's necessary to introduce a reactance X such that:

$$X + X1 + X2 = 0 \qquad (1)$$

Various values of S1 and S2 are tried until the equation is satisfied at both f1 and f2. (See **appendix 2**.)

As a simplification, a characteristic impedance of 575 ohms was calculated for a transmission line consisting of a horizontal 12-gauge wire parallel to and 20 feet above a perfectly conducting groundplane (**eqn. 14**). Though good for a transmission line, this formula neglects the effect of radiation, and, of course, radiation is the primary purpose of the antenna.

The calculation of characteristic impedances of radiating antennas is more complicated.[7]

parallel RLC circuit properties

A complete understanding of the design of trap antennas requires a knowledge of parallel RLC circuits. Graphs of impedance, series resistance, and series reactance are shown as a function of frequency *f* in **fig. 3**. These normalized curves require that quantities plotted on the vertical scale be multiplied by the value of *R*, and the frequency shift measured from the resonant frequency be given in units of *D*, where

$$D = f0/2Q \qquad (2)$$

Losses in the inductor and capacitor are represented by a resistance, *R*, where:

$$R = \frac{500{,}000Q}{\pi C f0}\ ohms \qquad (3)$$

and *C* is the capacitance in picofarads, and *f0* is the resonant frequency in MHz.

To apply these ideas to the traps in the 18.1/24.9-MHz antenna, *f0* = 21.257 MHz, *C* = 51.6 pF, *R* = 29,002 ohms, and *D* = 0.053 MHz (53 kHz). The reactance has small positive values at low frequencies and increases to a maximum of 0.5 R = 14,501 ohms at a normalized value of − 1 (21.204 MHz), after which it decreases to zero at resonance. Then it decreases to a negative maximum − 0.5 R = − 14,001 ohms, at + 1 (21.310 MHz) and approaches zero at very large frequencies.

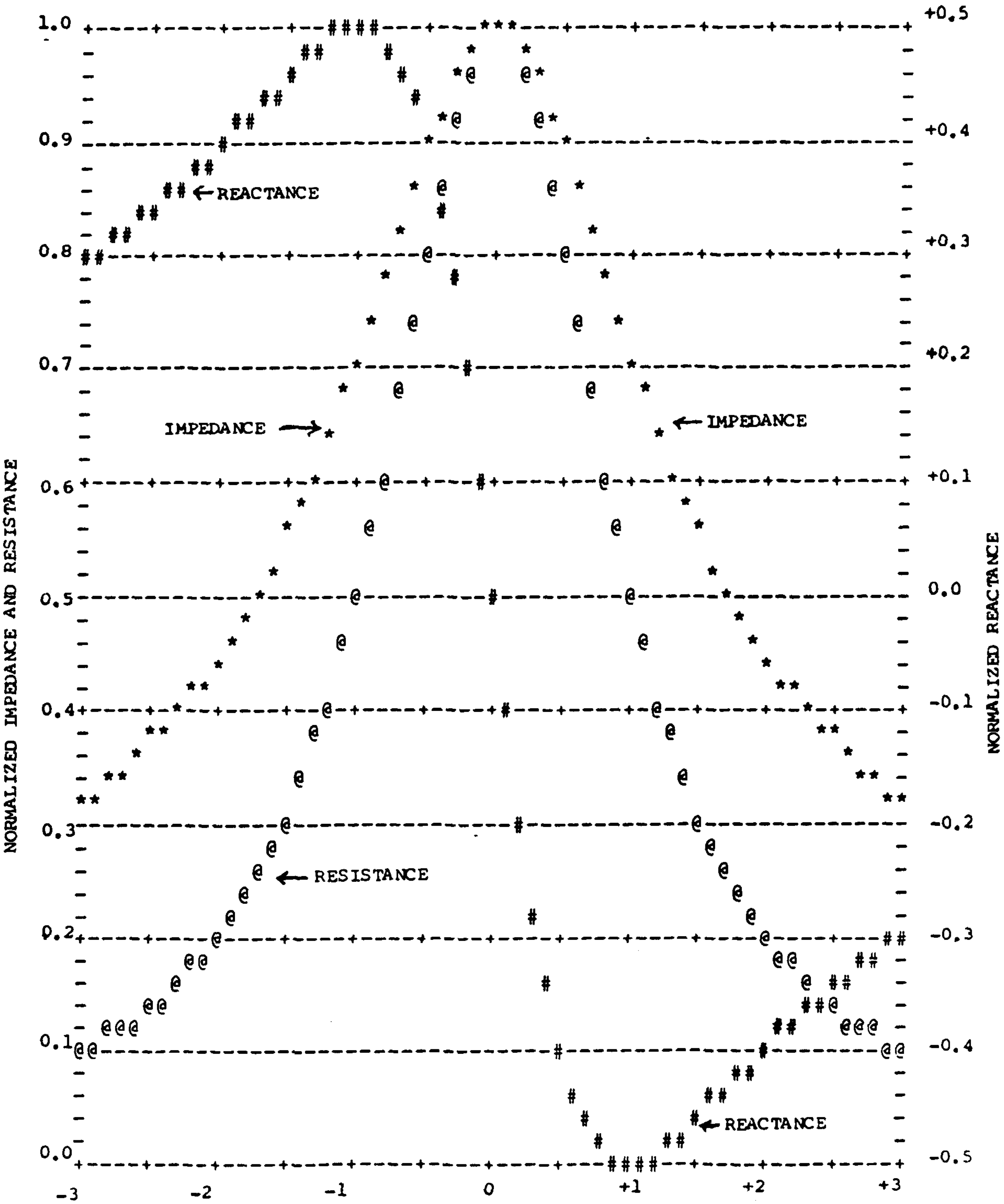


fig. 3. Normalized impedance, resistance, and reactance of a parallel RLC circuit as a function of frequency. The frequency is given in terms of the shift from the resonant frequency f0 in units of $\frac{f0}{(2Q)}$. When these curves are applied to an actual circuit the quantities plotted vertically are multiplied by the shunt impedence of the circuit at resonance which is $\frac{1}{2\pi\ f0C}$.

The design frequencies, f1 and f2, correspond respectively to −70.6 and +58.4, and lie very far off the graph in **fig. 3**. The values of the impedances, resistances, and reactances cannot be obtained from the graph and must be calculated by formulas such as those shown in **appendix 1**. The reactances, as stated previously, are ±449 ohms and the resistances are 7.0 ohms. Consequently, the circuit can be considered as a low-loss reactance.

Since the reactance goes through zero at resonance, there are two other frequencies — very close (about 10 kHz) — at which the desired reactance of ±449 ohms can be obtained. There the resistance is very close to its maximum value. Such a reactance would hardly be considered low-loss! This is the situation encountered when such a circuit is used as a trap at f2 in the classical design. In such a situation the RLC circuit becomes a "trap" in another sense of the word: as an absorber of power.

The curves shown in **fig. 3** assume that Q is at least 10 and preferably much larger, as is likely to be the case in practice. The errors resulting from this assumption are then negligible. This assumption simplifies the math. When Q is small, it is necessary to draw individual curves. **Equations 8, 9, 10,** and **11** don't have this limitation.

Another assumption is that the losses in the circuit are represented by a resistor, R, whose value is given by **eqn. 3**, and that its value is independent of frequency. Strictly speaking, this assumption is unrealistic. Most of the losses are in the inductor, and they depend upon frequency in a complicated way because of skin effect and distributed capacitance.

For physical reasons, air (dielectric) capacitors often aren't practical to use in antenna traps — but they are low-loss. The losses in solid dielectric capacitors are generally lower than those in the *inductors*, but they (the losses) mustn't be overlooked. While an air-core inductor has the shape to dissipate heat, a solid-state capacitor does not; a small amount of power dissipated in it causes its temperature to rise and its capacitance to change. If the effect is large, the antenna is detuned when the power level is raised. Thus, a solid-state capacitor has a current limitation as well as a voltage limitation. Usually one that has a high voltage rating can also pass a lot of current, but this isn't always true. Capacitors with thin pigtails, even with high voltage ratings, must be avoided. Sometimes it's necessary to use more than one capacitor in series or parallel to get sufficient current carrying capability.

conclusion

The main purpose of this article is to review the principles of design of trapped antennas and to show that there are alternative designs that are superior to the classic one. I've illustrated the principles by showing the design of practical antennas for the 18.1- and 24.9-MHz bands, and for the 14- and 21-MHz bands.

A central point of the discussion is that the operating and trap frequencies should not coincide. **Equation 12** shows that with far-off resonance the series resistance decreases with the square of the difference between the operating and trap resonant frequencies. A further argument for keeping the trap resonant frequency remote from the operating frequency is the fact that the same RLC circuits used in the 18.1/24.9-MHz antenna could be used as traps in a 14/21-MHz dual-band antenna of classic design. The total trap resistance at the new f2 (21 MHz) is about 58,000 ohms. In considering such an antenna, Moxon[6] estimates that the radiation resistance, when transformed to the trap location, is about 32,000 ohms. Therefore, the efficiency is about (32/60) = 53 percent, whereas the efficiency with the symmetrical design at f2 = 24.94 MHz is 96 percent. Furthermore, with the symmetrical design there is significant current in the outer portions, and the directivity is greater. Therefore, at the upper frequency, f2, there is a significant advantage of the symmetrical over the classic design. With the classic design, the lower frequency, f1, is further from resonance than with the symmetrical design, and therefore the loss resistance is lower and the efficiency is higher. With the symmetrical design, it is already very good — 87 percent — so this advantage is not important.

I haven't tried to optimize the value of the trap capacitances. **Equation 13** shows that the resistances of the traps' far-off resonance are inversely proportional to the product of the capacitance and the Q of the traps. With the present values of 50 pF and a Q of 200, they're about the largest acceptable. If the capacitances were lowered to 25 pF, the resistances would be double and would cause a significant reduction in efficiency at both operating frequencies. If they were made 100 pF, there would be an insignificant improvement in the efficiency.

The principle of symmetrical design should be applicable to a 14/21/28-MHz triband dipole. The traps should be resonant in the vicinity of 17 MHz and 24 MHz, respectively. Efficiency and directivity would be greater. However, there would be a problem in extending the design to many bands; the radiation resistance would be different on the lowest and highest frequency bands, and an elaborate impedance matching network would be required to get a good match to the transmission line for all bands.

This article has dealt only with a single dipole. This approach can be applied to multi-element antennas with both driven and parasitic elements.

acknowledgments

I wish to thank Les Moxon, G6XN, Francis M.

MADISON SUMMER SHOPPER

New rigs and old favorites, plus the best essential accessories for the amateur.

CALL FOR ORDERS
1 (800) 231-3057
1-713-520-7300 OR 1-713-520-0550
TEXAS ORDERS CALL COLLECT

ALL ITEMS ARE GUARANTEED OR SALES PRICE REFUNDED

EQUIPMENT

New Icom IC 761	Trades wanted
Kenwood TH205AT	Trade in your old HT
Kenwood TS 440S/AT	Call for trade
Icom R7000 25-2000 MHz	949.00
Icom IC735	849.00
KDK FM 340, 220 MHz, 25w	319.00
KDK FM 240 NT	279.00
Mirage Amps	15% OFF
Tokyo Hy-Power HL 1K AMP, no 4CX250B	699.00
New Kenwood TM-221A, 45W, mobile	Call
VJ Amplifier, VHF, built in England, 1 in-100 out, 3-100, 5-100	(ea.) 269.00
10 in-100 out	229.00
25 in-160 out	319.00
All models include preamp	
Lunar 2M4-40P	109.00

ACCESSORIES

B&W VIEWSTAR ANTENNA TUNER	89.95
Heil HC4/HC5	Stock
Heil BM10 Boom Mike headset	CALL
Tri-H 5000A Remote Phone	$189.00
Daiwa NS660A 30/300/3000 watts	135.00
Alinco ELH 230D- Excellent buy	88.00
Nye MB5-A (for the big boys!)	529.00
Shure 444D	54.95
Ameco PT-3	Soon
New Tokyo HC 200A	115.00
Astatic SilverEagle & Base	66.00
Ten-Tec Mobile Switch 3001	17.00

ANTENNAS

Isopole 144 MHz	44.95
Isopole 440 MHz	59.95
Cushcraft 124-WB (146 MHz)	33.00
Butternut HF6V, 80-10 vertical	125.00
HF2V, 80 & 40 vertical	119.00
HF4B	189.00
Hustler G7-144	119.95
Hustler 6BTV	139.00
KLM HF World Class Series Antennas	Call Don
ALPHA Delta DX-DD	63.00
Coax Seal	2.00/roll
B&W Dipoles	Less 10%
KLM KT-34A	399.00
W2AU, W2DU	Now Available
NEW KLM 1,2-44LBX	129.00
1296 Power Divider	69.00
Create CD-78 + BS 80 75/80 rotatable dipole	385.00
G5-RV	44.00

OTHER ANTENNAS

Diamond D-130 Discone 25-1300 MHz	79.00
Larsen Kulduck	17.00
Larsen 2M ½wave telescope ant.	25.00
Avanti AP151.3G on Glass Antenna	36.00
Anteco 2M, 5/8, Mag. Mount, Comp	25.00
Van Gordon ND-4, 4 band Novice dipole	45.00
Valor AB-5 Mobile	79.95
Stoner DA100 D Active Rx Antenna	190.00
DC 'Tenna Hitch 3/8-24 Thread Fits 3/4" trailer hitches	29.95

PARTS

1.5 Amp/400V full wave bridge rectifier	1.95
2.5A/1000PIV Epoxy diode	29 each or 19.00/100
.0015/10KV or .001/20KV	1.95 each
3N201	.95
4 inch ferrite rod	1.95
365pF cap	1.95
Sanyo AAA,AA Nicads w/tabs	2.00
2,4,5,6,8 pin mic plugs	3.00
1/8, 1/4, watt carbon resistors	.05 each
Meter 0-3000 VDC 0-1 Amp DC 2½" Square with shunt	19.95
Drake—Collins mike plug	2.00
Thousands of panel meters	3.95 up CALL
MICA Cap .0004/3KV	5.00 others CALL
Diodes 3A/1000 PIV	.29
Duracell 9 Volt Battery - 2 Pak MN1604	3.49
DC Fan 3½" Sq. × 1"	9.95
CINCH 12 pin conn fitz (Drake etc.) female	3.00
Aerovox 1000 pf/500 V feedthrough cups	1.95
Mallory 6 volt, 4 prong Vibrator PN/600A	

USED EQUIPMENT

All equipment, used, clean, with 90 day warranty and 30 day trial. Six months full trade against new equipment. Sale price refunded if not satisfied.

Call for latest used gear list
(800) 231-3057

AMPHENOL

831SP-PL259 Silverplate	1.25
UG176 reducer RG8X	.30
831J Double Female UHF	2.00
82-61 N Male	3.00
82-97 N Female Bulkhead	3.00
82-63 Inline Female N	4.00
82-98 N elbow	9.00
82-202-1006 N Male for 9913	4.50
31-212 BNC-RG59	1.50
31-216 UG201 A/U N Male-BNC Female	2.00
31-2 BNC-RG58	1.50
34025 N Male, RG58	3.00
34125 N Female UHF male	9.00
3128 BNC Female-PL259	3.00
4400 N Male-S0 239	7.00

ICOM

ICOM 28H/TTM	399.00

TUBES

Collins & Drake Replacement tubes	Stock
GE 6146B	12.95
3-500Z	109.95
GE Industrial Tubes	Call
GE 12BY7A	7.00
GE 6JS6C	12.95
GE 8950	16.00
12JB6 Sylvania	6.00
Hard to find Tubes 50-90% off list	
6JB6A	9.95
6JE6C/6LQ6	9.95
572B	69.00
6KD6	10.95

PACKET POWER

AEA PK-232 with new WX FAX	299.00
Kantronics KPC II	149.00
MFJ 1270	119.00
MFJ 1274	149.00
New Kantronics KAM	299.00

SERVICES

Complete KWM 2 Retube	179.00
Flat fee Collins rebuild	Call

TOWER ACCESSORIES

1/4" E H S Guy cable. Rohn US. 1000 ft.	250.00
3/16" E H S cable. Rohn US. 1000 ft.	210.00
1/4" Guy Cable. 6100 #7 × 7 strand, import	18c/ft.
3/16" Guy Cable, 3700 #7 × 7 strand, import	15c/ft.
3/8" × 6 E&J Turnbuckle	7.95
3/16" Wire Rope Clips	.40
1/4" wire clips	.50
1/4 Thimbles	.45
Porcelain 500D Guy Insulator (3/16)	1.99
Porcelain 502 Guy Insulators (1/4)	3.39

POLICIES

Minimum order $10.00. Mastercard, VISA, or C.O.D. All prices FOB Houston, except as noted. Prices subject to change without notice. Items subject to prior sale. Call anytime to check the status of your order. Texas residents add sales tax. All items full factory warranty plus Madison warranty.

DON'S CORNER

New! "World Radio Report" for SWL & Hams. Full of info. $2.50/month. Try 30 meters? N5JJ Houston has 101 countries. Have more? Contact Don at Madison.

✓ 130

Bird and Belden products in stock. Call today.

MADISON
Electronics Supply
3621 FANNIN
HOUSTON, TEXAS 77004

WHOLESALE PRICES ON CCTV

PANASONIC CCTV CAMERAS
WV-1414 • 24vac • vidicon $165
general purpose internal sync with 16mm f/1.6 lens
WV-1504X • 24vac • vidicon $272
high performance int or ext sync without lens
WV-1600/KT2 mini-camera $325
power & video on one cable with 16mm f/1.6 lens
WV-80KT/2 mini-cctv system $749
includes 2 cameras w/lenses & brackets & one monitor

PANASONIC LOW-LIGHT CCD CHIP CAMERAS
WV-CD22 • 12vdc $735
WV-CD24 • 24vac $765
510 horiz x 492 vertical elements
380 line horiz resolution
0.15 foot candle sensitivity
(auto-iris lens required)

MINI-CCTV SYSTEM

PANASONIC VIDEO MONITORS
TR-930 9" diagonal screen $167
700 line resolution
TR-124MB 12" diag. screen $207
700 line resolution

ALSO AVAILABLE:
housings, mounting brackets 24 volt transformers, video switching equipment, time/date generators, time-lapse VCRs

FULL MANUFACTURER'S WARRANTY — WE GLADLY SHIP UPS COD - ADD $2
BURGLAR/FIRE ALARM SYSTEMS & COMPONENTS
MASTERCARD/VISA -- ADD 5% SEND S.A.S.E. FOR LIST

DETECTION DYNAMICS
4700 LOYOLA LANE, SUITE 119
AUSTIN, TEXAS 78723
(512) 345-8401

✓ 129

ANNOUNCING THE

DIGITAL VOICE KEYER

Now for the first time you can enjoy the truly unique operation of a Digital Voice Announcement System, designed specifically for Amateur Radio communications. The DVK-100 represents the latest technology in digital audio processing.

Create your own natural voice contest calls, CQ's etc. Your voice is stored in digital memory, ready to be played back at the touch of a key. The Digital Voice Keyer is not a tape recorder or robotic sounding synthesizer but a true full fidelity natural voice record/playback system.

The DVK-100 is a must for the avid contester and great audio accessory for any Ham Shack.

FEATURES

- Superior natural voice quality
- Micro processor controlled
- 32 seconds of message time
- PTT/VOX operation
- Dynamic/condenser mic input
- Selectable monitor amplifier with preset level control
- Selectable audio compressor
- Sealed membrane keyboard
- 4 independent voice memories
- Positive/negative keyed PTT
- ESD/EMI/RFI shielding
- Selectable end of transmission tone generator

The sound of the future is here today. Contact your local Amateur Radio dealer or NTL for further information.

$249.00 SUGGESTED NET AMATEUR PRICE — DEALER INQUIRIES INVITED

NEL-TECH LABS, INC.
P.O. BOX 1030 • LONDONDERRY, NH 03053
603-434-8234

✓ 131

MOBILE RADIO MOUNTS

• Government • Industrial
• Commercial • Recreational

All New 1987 Y-5 Catalog FREE

IIX Equipment Ltd.
P.O. Box 9 Oaklawn, IL (312) 423-0605

✓ 132

Dukat, K6NL, and Oswald G. Villard, Jr., W6QYT, for their valuable suggestions.

appendix 1

basic equations

The formulas have been used for calculations discussed in the text. The wavelength

$$\lambda = 299.8/f \text{ in meters} \quad (4)$$

$$= 983.6/f \text{ in feet, with the frequency } f \text{ in MHz.} \quad (5)$$

The length of a half-wave dipole is

$$G = 468/f \text{ in feet.} \quad (6)$$

Equation 6 gives a length which is 95 percent of a half wavelength as given by **eqn. 5** because of corrections for end effects. This simplification valid for hf wire antennas depends on the ratio of conductor diameter to wavelength. At VHF, where the ratio is usually smaller, the correction is larger.

The inductance L (in μH) required to resonate with a capacitor C (in pF) at a frequency f0 (in MHz) is

$$L = \frac{1}{4\pi^2 C (f_0)^2} \quad (7)$$

It is convenient to define a new quantity, t

$$t = Q \cdot \frac{f^2 - f_0^2}{f \cdot f_0} \quad (8)$$

where $f0$ is the resonant frequency of the RLC circuit and f is any arbitrary frequency. The impedance is given by

$$Z = \frac{R}{\sqrt{1 + t^2}} \quad (9)$$

The series resistance is given by

$$R_s = \frac{R}{1 + t^2} \quad (10)$$

and the reactance is given by

$$X_s = \frac{R\,t}{1 + t^2} \quad (11)$$

To understand the behavior of traps far from resonance, it is desirable to derive approximate expressions for the resistance and reactance.

$$R_s = \frac{f_0}{8\pi\, CQ\, (f - f_0)^2} \quad (12)$$

The resistance is inversely proportional to the square of the frequency shift.

The reactance far-off resonance is given approximately by

$$X_s = \frac{1}{4\pi C\, (f_0 - f)} \quad (13)$$

Because reactance far from resonance is independent of Q, it isn't necessary to have values of the Qs of the traps to make calculations involving resonance conditions.

A transmission line consisting of a wire of diameter d parallel to and at a distance H from a conducting plane has a characteristic impedance of

$$Z_0 = 138\ LOG_{10}\,(4H/d) \text{ ohms} \quad (14)$$

H and d can be in any similar units.

A section of lossless transmission line of length S1 short-circuited at the far end has an input reactance of

$$X_1 = Z_0\ TAN\ A \quad (15)$$

where

$$A = \frac{360 \cdot S1}{\lambda} \quad (16)$$

A is the length S1 expressed as an angle in degrees.

A section of transmission line of length S2 open-circuited at the far end has an input reactance of

$$X_2 = \frac{-Z_0}{TAN\ B} \quad (17)$$

where

$$B = \frac{360 \cdot S2}{\lambda} \quad (18)$$

is an angle corresponding to the length S2.

Equation 1 gives the condition for resonance at a single frequency. It is necessary to derive from it an equation giving the condition for resonance at the two frequencies f1 and f2. Note from **eqns. 16** and **18** that angles A and B are inversely proportional to wavelength. Therefore they are, for fixed lengths S1 and S2, proportional to the frequency. Hence, if we now use A and B to denote the angles at the upper frequency f2, at f1 they are reduced by the factor f1/f2. Since the design is based on the assumption that the trap reactances at these two frequencies are equal in magnitude but opposite in sign, it follows from **eqn. 1** that:

$$-TAN\ \frac{Af1}{f2} + \frac{1}{TAN\ \frac{Bf1}{f2}} = TAN\ A - \frac{1}{TAN\ B} \quad (19)$$

The characteristic impedance Z_0 has cancelled out.

This equation cannot be solved exactly. It has to be solved

Table 1. Trial solutions for resonance.

Trial	Angle A (Degrees)	Angle B (Degrees)	Residual U	S1 (feet)	S2 (feet)	Reactance (ohms)
1	65	35	−0.654	—	—	—
2		33	−0.922	—	—	—
3		37	0.412	—	—	—
4		41	+0.0072	—	—	—
5		40.8	−0.012	—	—	—
7		40.9	−0.002	8.38	5.27	569
10	60	47	−0.00014	7.73	6.06	459
16	60.3	46.65	+0.00035	7.77	6.01	465
23	59.7	47.35	-0.00054	7.69	6.10	454

Note: Reactions are trap reactances needed for resonance, positive at F1, negative at F2.

numerically by trial and error. For this purpose it is convenient to define a quantity U, called the residual, as follows:

$$U = TAN\ \frac{Af1}{f^2} + \qquad \textbf{(20)}$$

$$TAN\ A - \frac{1}{TAN\ \frac{Bf1}{f2}} - \frac{1}{TAN\ B}$$

If the left side of **eqn. 19** is transposed to the right, the result is identical to the right side of **eqn. 20**, but on the left is U instead of 0. It is solved by trying values of A and B, which ideally make U equal to zero. In practice it is impossible to obtain zero exactly. The practical method is to choose a value of A and then find two values of B that are close together, one of which gives a small positive value to U and the other of which gives a small negative value to it. Then, one or the other, or some intermediate value can be taken as the desired value of B. This method is illustrated below.

appendix 2

designing a 14/21-MHz antenna

First select the design operating frequencies. In this example f1 = 14.15 MHz and f2 = 21.2 MHz. Next calculate the trap resonance frequency f0 = 17.32 MHz by taking the square root of the product of f1 and f2. As a starting point, assume a value of trap capacitance of 50 pF. **Equation 7** can then be used to calculate the inductance needed for resonance, 1.69 μH. Assuming a Q of 200, **eqns. 8, 10,** and **11** can then be used to calculate the reactance and resistance at the design operating frequencies. These turned out to be ± 451 and 5.55 ohms, respectively.

By repetitively substituting best length "guesstimates" into **eqn. 20** the final correct values for resonance are found. (See **table 1**.) The first guess was for an angular length, A, of 65 degrees and B of 35 degrees, which gave a large residual U of -0.654. Then, using the fixed value A = 65 degrees, I used B = 33 degrees as a second guess to obtain U = -0.922, which of course, is still further from zero. Therefore, it was obvious that it was necessary to increase B rather than to decrease it. B was gradually increased until U had the value +0.0072, which I considered reasonably close to zero. Next, **eqns. 5, 16** and **18** are used to determine distances S1 and S2 in feet and reactance magnitude. In the reactance calculation I assumed a value of 575 ohms for the characteristic impedance. The first value determined for reactance was 569 ohms which is significantly different from the trap reactance 451 ohms. Therefore it was necessary to repeat the process using other values of A.

For the other values of A in **table 1** I have given only the results for the final trial values of B. A reactance of 454 ohms in the last line was considered close enough to the calculated trap reactance of 451 ohms to start building the antenna.

Nevertheless S2 still had to be corrected for end effects. Half-wave wire dipoles, as suggested by **eqn. 4**, have physical lengths of 95 percent of the free space half wavelength. I assumed that a similar correction must be made to a trap antenna. In principle, the correction is slightly different at each of the operating frequencies. As a simplifying approximation, I assumed that it is the same as it would be for a half-wave dipole at f0 = 17.32 MHz, which I found to be 0.69 feet. Therefore, I reduced the computed value of S2 from 6.10 feet to 5.41 feet.

The entire calculation, starting with the calculation of $f0$ and ending with the end correction, took less than 20 minutes with the use of the programs I had written for my Commodore 64 computer.* These calculations can also be performed with any hand calculator that features trigonometric functions.

The traps were then built and measured; average resonant frequency was 17.2 MHz. Using the dimensions S1 = 7.69 feet and S2 = 5.41 feet, a minimum SWR of 1.1 occurred at 13.75 MHz and 1.2 at 20.7 MHz. These frequencies are about 3 percent lower than the design ones. This observation suggests that the dimensions should be reduced about 3 percent, or each S1 and each S2 should be shortened by 2 inches. When I made this change, the SWR was 1.2 at 14.0 MHz and 1.3 at 21.0 MHz, and in both bands it increased with frequency with the implication that the minima were at the low edges or outside the low edges. I then removed 2 more inches from each S1. Then, with the final dimensions S1 = 7.36 feet and S2 = 5.24 feet, I obtained the standing wave pattern shown in **fig. 2**.

Thus the final dimensions differed from the calculated ones by only a few percent. In view of the uncertainties that are present, the agreement between theory and experiment is as good or better than can be expected. The biggest uncertainty is the value of the characteristic impedance. The end correction is another. Then there are experimental sources of error due to the length of the leads on the traps and due to the wires wound on the insulators. At the same time, the theoretical calculation provided a useful guide which probably reduced the experimental adjustment by hours. Trial and error can be done much more rapidly by computer than by experiment!

*Copies of these programs are available; send a self-addressed business-sized envelope with two first-class stamps, plus one loose first-class stamp to cover the cost of photocopying.

references

1. Terman[2] gives the following reference as the original work on trapped antennas: Howard K. Morgan, "A Multifrequency Tuned Antenna System," *Electronics*, August, 1940, page 42. (When I looked in this publication, I failed to find this paper there; I have been unable to locate it elsewhere.)
2. F. E. Terman, *Radio Engineers' Handbook*, McGraw-Hill Book Co., New York, 1943, page 854.
3. Chester L. Buchanan, W3DZZ, "Duo Band Antenna," *Radio and Television News*, December, 1950, page 66.
4. Chester L. Buchanan, W3DZZ, "The Multimatch Antenna System," *QST*, March, 1955, page 22.
5. Yardley Beers, "Short Antennas for the Lower Frequencies — Part 1," *QST*, August, 1970, page 26.
6. L. A. Moxon, G6XN, *HF Antennas for All Locations*, Radio Society of Great Britain, London, 1982, page 109.
7. See, for example, S.A. Schelkunoff and H. T. Friis, *Antennas: Theory and Practice*, John Wiley and Sons, New York 1952, section 13.4.

ham radio

PRACTICALLY SPEAKING ... Joe Carr K4IPV

battery problems: part 2

Last month we discussed NiCd batteries; this month we'll take a look at charging systems for NiCds, as well as lead acid and gel cel batteries.

charging NiCds

There are two basic forms of charger for NiCd batteries: constant-current (CI) and constant-voltage (CV). Regardless of the type, it's important to use a charging current no greater than A-H/10 unless specifically instructed to do so by the battery manufacturer (not the equipment maker, by the way). The A-H/10 rate is one-tenth of the ampere-hour rating. For a 500-mAH AA cell, for example, a 50-mA charging current is used. Similarly, 200 mA should be used for a 2 A-H C cell, and 400 mA for the 4 A-H D cell. (Be careful not to overcharge batteries using other A-H ratings.)

Figure 1 shows the basic circuit for a low-cost constant current charger of simple design. The transformer secondary voltage should be 2.5 or more times the cell or battery voltage. The resistor in series with the rectifier limits the output current under short-circuit conditions to the A-H/10 charging rate.

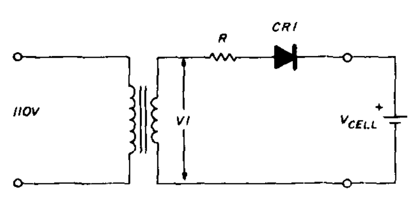


fig. 1. Simple constant-current battery charger.

Figure 2 shows two electronic CI chargers based on three-terminal IC voltage regulators. The variable circuit shown in **fig. 2A** is based on the LM-317 (up to 1 ampere) and LM-338 (up to 5 amperes). Both circuits require a filtered dc input voltage several volts higher than the battery or cell potential. The actual value isn't critical as long as it's high enough to turn on the circuit (in general, V_{in}) is greater than (V_B + 3 volts). We can adjust the charge current by setting the value of resistor R. For example, for a 400-mA charger for 4 A-H D cells, we would use a resistor value of 1.2/I = 1.2/0.4 = 3 ohms. Charging currents down to 10 mA can be accommodated by the circuit shown in **fig. 2A**, so both regular and trickle chargers can be designed.

The circuit shown in **fig. 2B** will charge batteries up to 4 A-H with ter-

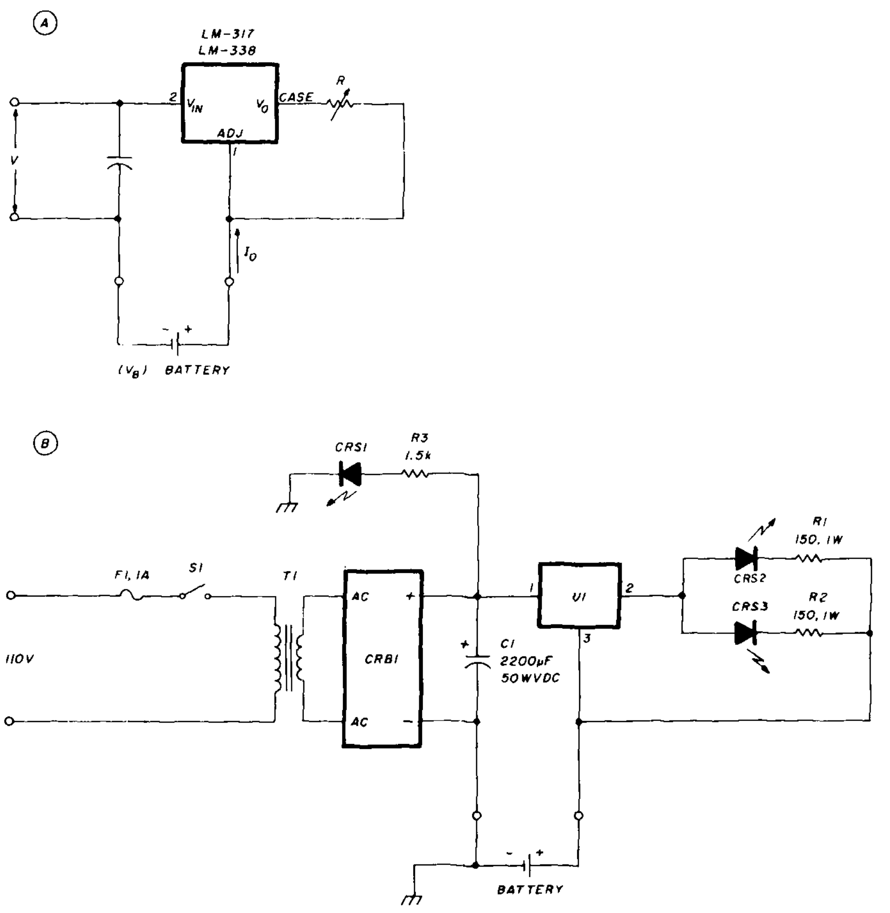


fig. 2. Constant-current chargers: (A) variable voltage charger uses LM-317 or LM-338 regulators; (B) powered from the ac line, this circuit will charge batteries up to 4 A-H and 12 vdc.

minal voltages up to 12 Vdc. Similar to the circuit shown in **fig. 2A**, it is based on 5-volt fixed regulators such as the LM-309, LM-340-05, or 7805 devices.

A constant-voltage charger is shown in **fig. 3**. The output voltage of the charger is set by the ratio of R1 and R2, and is determined by the equation:

$$V_o = 1.26\left(\frac{R2}{R1} + 1\right)$$

A series resistor, R3, is chosen to limit the short-circuit current to a maximum of A-H/10. The required charger output impedance is the resistance equivalent of V_o / I_{MAX}, where V_o is the open-terminal battery voltage and I_{MAX} is the maximum permissible charging current. For a 12-volt, 4 A-H battery, for example, the required impedance is 12/(4/10) = 12/0.4 = 30 ohms. We can solve the equation in the figure for R3 and place that resistance in series with the output of the regulator. The power rating of the resistor must be $V_o \times I_{MAX}$.

using bench power supplies

A bench power supply shouldn't be used to charge NiCd batteries unless it has both a variable output voltage control and a current-limiting control. Set the output voltage to exactly the full terminal voltage of the NiCd battery and adjust the current limiter for a short-circuit current equal to the A-H/10 value. Disconnect the output short from the power supply and connect the supply across the battery.

multiple-cell batteries

A large number of multiple-cell batteries are used in electronic equipment. Most are typically 6, 12, or 24-volt models. In most cases, these batteries are made up of individual AA, C, D, or F cells. I found it possible to take apart these battery packs and replace individual cells to restore the battery to normal operation. Some packs are put together with screws or snaps, while others are glued together.

My friend who uses a transcutaneous electronic nerve stimulator (TENS) unit for pain control (see last month's column) paid $90 each for the battery

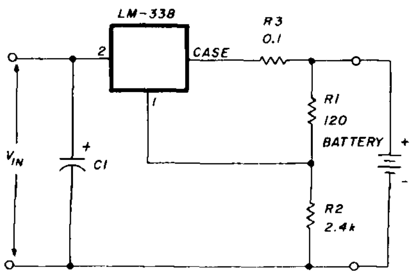


fig. 3. Constant-voltage charger uses ratio of resistor values to determine setting.

packs to power his device. One afternoon we took apart one of the packs he'd decided was bad, using a razor knife and lots of care. We found that the pack consisted of three AA cells connected in series. We went to a store that sold commercial solder-tab AA NiCd cells and returned with $18 worth of cells to make a "new" battery. I showed him how to solder them in, and then re-glued the plastic package; the pack lasted nearly 18 months.

If you don't know how to find a local source of commercial (as opposed to consumer) grade NiCd cells, then try calling the chief engineer at a local TV station. The portable video cameras used by TV news crews are powered by NiCd cells. It's a sure bet that the engineer will know a good source of fully rated cells.

When selecting cells for replacement, keep in mind several factors. First, of course, is the right size (AA, C, D, F) and the right A-H rating (as I said last month, not all C and D cells are created equal). Also keep in mind whether regular cells or solder-tab cells are needed. I've found that some consumer NiCd cells are in nonstandard packages. One brand of AA cells is a millimeter or so shorter than standard AA cells; as a result, intermittent operation is sometimes experienced. To avoid solder-shimming these cells or re-tensioning the contact spring, I simply avoid buying this brand and use standard-size batteries instead.

other batteries

Several other types of batteries are used in communications equipment. For mobile and some portable applications, for example, there's the lead acid automobile battery. These are the familiar batteries used to start automobile engines; though they're very heavy and quite dangerous because of their contents, they're popular because they're generally well behaved and easily available. In addition, many Amateur Radio sets are designed to operate from the nominal 13.6 Vdc produced by the typical automobile battery.

In addition to the 13.6-volt (nee "12 volt") battery, there are also 6, 24, 28, and 32-volt lead acid batteries on the market. Some of these are marine batteries, others are military batteries (28 Vdc), and still others are truck batteries. The terminal voltage can be increased by connecting batteries in series, while current availability is increased by connecting batteries in parallel.

Mobile operation is usually carried out with the regular vehicle battery. But in certain cases, it's wise to have a separate battery for the radio communications equipment in order to have battery power in the event of a main vehicle power supply failure. Boaters, four-wheel drive "boondockers," hunters, and others may want to consider the type of system shown in **fig. 4**. This system, common in recreational vehicles, powers the creature comforts separately from the vehicle battery. The point is to keep your communications capability, even if you accidentally discharge the vehicle battery by leaving the lights on or suffer some other problem. The backup battery could then be used to start the vehicle or summon help, depending upon the situation.

The charger will be a generator or alternator installed in the vehicle. Although the ideal system would be to have separate charging and regulating systems, that ideal isn't always achievable for certain practical reasons. Thus, we have a single charger and voltage regulator for two or more batteries. Isolation between the batteries is provided by a pair of large-current

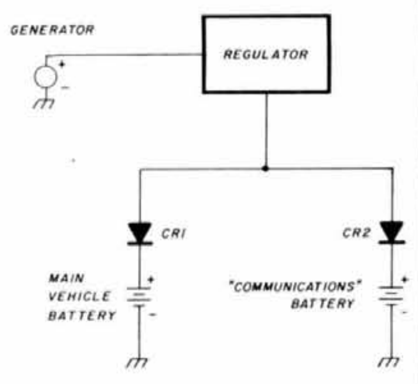


fig. 4. Simple method of charging main and auxiliary mobile batteries.

silicon diodes (CR1 and CR2). The rating of these diodes should be at least 1.5 times the maximum charge rate of the charger. In most cases, large stud-mounted diodes are used for CR1 and CR2, and they're mounted on a finned heat sink. In vehicular installations, keep in mind that ambient temperature is high in some locations, and will affect diode reliability.

For portable operations, some means must be provided to charge the lead acid battery. In most cases, a small gasoline or kerosene engine-powered generator is used to provide battery power. In some cases, an automotive type battery charger is needed to convert the ac output from the generator to dc for the battery. It's increasingly common, however, to find small 500- to 2000-watt gènerators that include a "12-volt" output that provides from 6 to 35 amperes for purposes of powering radio equipment or charging batteries.

Other forms of chargers are also used. Some people use wind power, while others use falling water (which is somewhat easier in isolated locations than you might think possible), and still others use sunlight. I once met a Swedish Pentecostal missionary who worked in the deserts of Sudan. In the area of Africa to which he was sent, the roads are littered with the corpses of dead animals — even camels — which should give you an idea of just how dreadful the place is. His organization doesn't allow him to set up camp without a 6-MHz Stoner Communications transceiver and an Amateur Radio transceiver (he uses a Kenwood TS-120). One thing that's plentiful in those latitudes is sunshine, so a set of solar panels (intended originally for boaters) was procured to charge the lead acid batteries. A 6-ampere charging system cost him about $2300 at the time it was purchased several years ago, but it's probably cheaper now.

Regular maintenance of lead acid batteries is relatively easy and absolutely essential. The water level in each cell must be checked periodically; those whose need for the battery is critical should check the level weekly. Although it's best to fill the cells with distilled water (because of the lack of additional chemicals), ordinary tap water will also work. The vents in the caps that cover the cells mustn't be blocked; if dirt obscures the opening, replace the cap or clean it.

Warning: lead acid batteries produce hydrogen as a normal by-product. If you fail to observe proper procedures, this hydrogen may cause the battery to explode, causing serious injury to people and damage to equipment.

Never* allow the battery to become overcharged.** ***Turn off all circuits connected to the battery — ***especially*** the charger — before disconnecting the wires to the battery. If current is flowing in those circuits, then a spark will occur . . . and that spark can create an explosion. This is not a hypothetical possibility, but a real danger. I've seen it happen twice in my career, and one time it darn near cost a fellow two-way radio technician his eyesight. He made the mistake of disconnecting the wires from a battery charger before turning off the charger and all peripheral circuits.

gel cell batteries

Another form of battery popular in portable radio equipment is the gel cell. I've seen these batteries in commercial, medical, and Amateur Radio equipment. Several years ago I worked with

High Performance vhf/uhf preamps

Receive Only	Freq. Range (MHz)	N.F. (dB)	Gain (dB)	1 dB Comp. (dBm)	Device Type	Price
P28VD	28-30	<1.1	15	0	DGFET	$29.95
P50VD	50-54	<1.3	15	0	DGFET	$29.95
P50VDG	50-54	<0.5	24	+12	GaAsFET	$79.95
P144VD	144-148	<1.5	15	0	DGFET	$29.95
P144VDA	144-148	<1.0	15	0	DGFET	$37.95
P144VDG	144-148	<0.5	24	+12	GaAsFET	$79.95
P220VD	220-225	<1.8	15	0	DGFET	$29.95
P220VDA	220-225	<1.2	15	0	DGFET	$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	$79.95
P432VD	420-450	<1.8	15	−20	Bipolar	$32.95
P432VDA	420-450	<1.1	17	−20	Bipolar	$49.95
P432VDG	420-450	<0.5	16	+12	GaAsFET	$79.95
Inline (rf switched)						
SP28VD	28-30	<1.2	15	0	DGFET	$59.95
SP50VD	50-54	<1.4	15	0	DGFET	$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	$109.95
SP144VD	144-148	<1.6	15	0	DGFET	$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	$67.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	$109.95
SP220VD	220-225	<1.9	15	0	DGFET	$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	$109.95
SP432VD	420-450	<1.9	15	−20	Bipolar	$62.95
SP432VDA	420-450	<1.2	17	−20	Bipolar	$79.95
SP432VDG	420-450	<0.55	16	+12	GaAsFET	$109.95

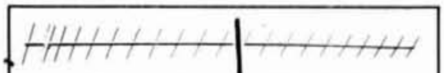
Every preamplifier is precision aligned on ARR's Hewlett Packard HP8970A/HP346A state-of-the-art noise figure meter. RX only preamplifiers are for receive applications only. Inline preamplifiers are rf switched (for use with transceivers) and handle 25 watts transmitter power. Mount inline preamplifiers between transceiver and power amplifier for high power applications. Other amateur, commercial and special preamplifiers available in the 1-1000 MHz range. Please include $2 shipping in U.S. and Canada. Connecticut residents add 7-½% sales tax. C.O.D. orders add $2. Air mail to foreign countries add 10%. Order your ARR Rx only or inline preamplifier today and start hearing like never before!

Advanced Receiver Research

Box 1242 • Burlington, CT 06013 • 203 582-9409

MasterCard VISA

✓ 119



RUTLAND ARRAYS

PRESENTING THE FINEST 432 MHZ ANTENNAS AVAILABLE

NOW AVAILABLE: FO-33 17.9 DBD GAIN 33EL 24FT **$159.95**

THE FO-22 15.8 DBD MEASURED GAIN 22EL 14FT $76.64

AN OUTSTANDING ANTENNA FOR EME—WEAK SIGNAL—TROPO

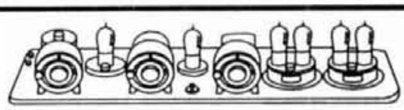
THE RIW-19 14.9 DBD MEASURED GAIN 19EL 13FT $69.95 FOR EME—TROPO—ATV

Assembly time 1 hr. per antenna.
Add $6 UPS, S/H for single or pair of antennas, $8 west of the Mississippi. PA residents add 6% state tax.

ALSO AVAILABLE: Power Dividers—Stacking frames
Write for details and Price Sheet

RUTLAND ARRAYS
1703 WARREN STREET
NEW CUMBERLAND, PA 17070

✓ 121



IF YOU BUY, SELL OR COLLECT OLD RADIOS, YOU NEED...

ANTIQUE RADIO CLASSIFIED

Antique Radio's Largest-Circulation Monthly Magazine

Articles - Classifieds - Ads for Parts & Services
Also: Early TV, Ham Equip., Books, Telegraph, 40's & 50's Radios & more...

Free 20-word ad each month. Don't miss out!

Sample - Free. 6-Month Trial - $10.
1-Year: $18 ($24 by 1st Class). Foreign - Write.

A.R.C., P.O. Box 2-A3, Carlisle, MA 01741

✓ 122

CREATE
Creative Design Co., Ltd.

ROOF TOWERS!

A size to fit your needs 6, 10, or 15 ft.

800-255-7020
Excluding California

Galvanized Steel Bracing and Hardware

Dist. by

ORION HI-TECH
P.O. Box 8771,
Calabasas, CA.
91302
(213) 663-2541

✓ 123

VISA ICOM MasterCard

VHF COMMUNICATIONS

Contact us for all of your amateur radio needs. FEATURING:

ICOM, AEA, LARSEN, VAN GORDEN, VIBROPLEX, NYE-VIKING, FALCON COMM, LEADING EDGE, ARRL PUBLICATIONS, KAGLO, HAMTRONICS, PROWRITER, ELEPHANT DISKS, DEBCO, TRIONYX

✓ 120

915 North Main Street
Jamestown, New York 14701

Western New York's finest ... amateur radio dealer!

PH. (716) 664-6345

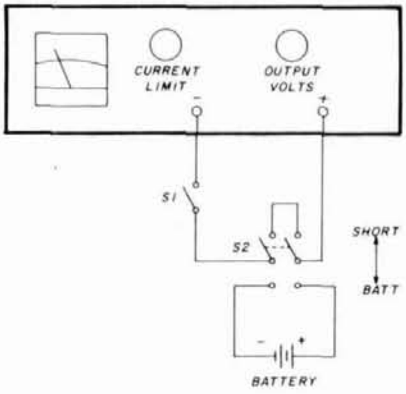


fig. 5. Method of adjusting current and voltage in charging system.

a piece of equipment that kept failing because of "premature" battery failure. The equipment manufacturer sent us a newly designed internal battery charger, but it too was deficient. All our battery chargers were high-tech models that depended upon sensing small variations in terminal voltage to determine a charge or discharge state. Unfortunately, the analog sensing circuitry had enough dc drift to produce bad results. In desperation, the engineer in our laboratory called the battery manufacturer — instead of the manufacturer of the device — and asked *him*. The manufacturer's applications engineer asked if we'd ever heard of Kirchoff's Voltage Law. Allowing that we'd heard that one before, we let the applications engineer guide us to a solution (see **fig. 5**).

The circuit shown in **fig. 5** shows a simple method of charging gel cells (and other forms of batteries). The charger power supply must have two features: a precisely controlled output voltage and a current-limit control. With switch S1 open, set the output voltage to exactly the value of the fully charged voltage of the battery, or perhaps a small amount higher (100 to 200 mV). Place S2 in the shorting position and then close S1. Adjust the current-limit control for a short-circuit current equal to the maximum permitted charge current of the battery (A-H/10 for many batteries). After the current and voltage are set, place switch S2 in the BATT position and charge the battery. When the battery voltage is less than the power supply output voltage, current flows into the battery. But when the battery voltage equals the power supply voltage, current flow ceases.

conclusion

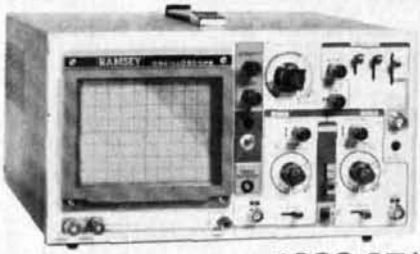
Batteries can provide freedom of operation for electronic equipment. But they can also be a nuisance if not maintained correctly. Proper maintenance of the battery will provide long and reliable life.

ham radio

RAMSEY

RAMSEY ELECTRONICS

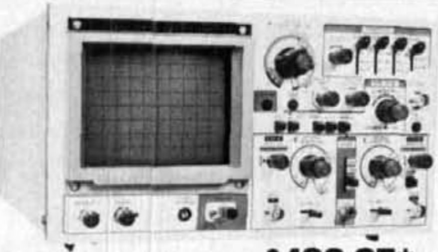
QUALITY TEST GEAR YOU CAN COUNT ON



INCLUDES 2 HOOK-ON PROBES **$369.95***

20 MHz DUAL TRACE

Features component testing circuit for resistors, capacitors, digital circuits and diodes—TV sync filter—high sensitivity—Z axis—XY mode—built-in calibrator—5X horizontal magnifier



INCLUDES 2 HOOK-ON PROBES **$499.95***

35 MHz DUAL TRACE

wide frequency bandwidth—optimal sensitivity —delayed triggering sweep—hold off—ALT trigger—single sweep TV sync 5X magnification—XY or XYZ operation— HF/LF noise reduction

NEW

INCLUDES 2 HOOK-ON PROBES **$449.95***

15 MHz DUAL TRACE PORTABLE

Field/bench applications—built-in charger and battery pack —up to 2 hours operation per charge—5X horizontal magnification—high brightness CRT—front panel trace rotator

RAMSEY OSCILLOSCOPES

All Ramsey oscilloscopes feature unsurpassed quality at an unbeatable price. Of heavy duty construction, they are suitable for hobby, service and production applications.

***Add an additional $10.00 for each unit for shipping.**

MODEL	BAND WIDTH	# TRACES	CRT SIZE	VERTICAL SENSITIVITY	MAXIMUM TRIG FREQ	USEABLE MAXIMUM BANDWIDTH
2200	20 MHz	(2)	8x10CM	5 mV per div	35 MHz	30 MHz
2500	15 MHz	(2)	3.5 inch	2 mV per div	30 MHz	25 MHz
3500	35 MHz	(2)	8x10CM	1 mV per div	50 MHz	60 MHz

All include high quality 1:1, 10:1 hook on probes, instruction/service manual with schematic and component layout. 1 year warranty.

MINI-100 COUNTER

$119.95 CHARGER, NICAD BATTERIES, AC ADAPTER INCLUDED

CT-70 7 DIGIT 525 MHz

$139.95 WIRED, INCLUDES AC ADAPTER

CT-90 9 DIGIT 600 MHz

$169.95 WIRED INCLUDES AC ADAPTER

CT-50 8 DIGIT 600 MHz

$189.95 WIRED INCLUDES AC ADAPTER

CT-125 9 DIGIT 1.2 GHz

$189.95 WIRED INCLUDES AC ADAPTER

MODEL	FREQ RANGE	SENSITIVITY	ACCURACY	DIGITS	RESOLUTION	PRICE
MINI-100	1-500 MHz	Less than 250mv	1 PPM	7	100 Hz, 1 KHz	119.95
CT-70	20 Hz-550 MHz	< 50mv To 150 MHz	1 PPM	7	1Hz, 10Hz, 100Hz	139.95
CT-90	10 Hz-600 MHz	< 10mv To 150 MHz < 150mv To 600 MHz	1 PPM	9	0.1Hz, 1Hz, 10Hz	169.95
CT-50	5 Hz-600 MHz	LESS THAN 25 mv	1 PPM	8	1Hz, 10Hz	189.95
CT-125	10 Hz-1.25 GHz	< 25mv @ 50 MHz < 15mv @ 500 MHz < 100 mv @ 800 MHz	1 PPM	9	0.1Hz, 1Hz, 10Hz	189.95
CT-90 WITH OV-1 OPTION	10 Hz-600 MHz	< 10mv To 150 MHz < 150mv To 600 MHz	0.1 PPM	9	0.1Hz, 1Hz, 10Hz	229.90

RAMSEY FREQUENCY COUNTERS

Ramsey Electronics has been manufacturing electronic test gear for over 10 years and is recognized for lab quality products at breakthrough prices. Our frequency counters have features and capabilities of counters costing twice as much. BP-4 Nicad battery pack for CT-70, CT-90 and CT-125 Frequency Counters. $8.95.

✓ 118

RAMSEY D-4100 COMPACT DIGITAL MULTITESTER

$24.95

test leads and battery included

Compact sized reliability and accuracy. This LCD digital multitester easily fits in *your pocket, you can take it anywhere. It* features full overload protection • 3½ digit LCD readout • recessed input jacks • safety probes • diode check function • 2000 hours battery life

NEW

RAMSEY D-5100 HANDHELD DIGITAL AUTORANGING METER

$49.95

Includes Probes
1 Year Warranty

Has TOUCH-HOLD feature to allow readings to be logged or referred to before *making the next reading. Up to 10 AMP* current capability and a continuity function which beeps on zero Ohms.

$44.95 wired includes AC adapter
PR-2 kit **$39.95**

PR-2 COUNTER PREAMP

The PR-2 is ideal for measuring weak signals from 10 to 1,000 MHz • flat 25 db gain • BNC connectors • great for sniffing RF • ideal receiver/TV preamp

$69.95 *wired*
PS-2 kit **$49.95**

PS-2 AUDIO MULTIPLIER

The PS-2 is handy for high resolution audio resolution measurements, multiplies Up in frequency • great for PL tone measurements • *multiples by 10 or 100 • 0.01 Hz resolution* & built-in signal preamp/conditioner

$89.95 wired includes AC adapter

PS-10B 1 GHz PRESCALER

Extends the range of your present counter to 1 GHz • 2 stage preamp • divide by 1000 circuitry • super sensitive (50 mV typical) • BNC connectors • 1 GHz in, 1 MHz out • drives any counter

MINI KITS—EASY TO ASSEMBLE—FUN TO USE—FOR BEGINNERS, STUDENTS AND PROS

TONE DECODER
A complete tone decoder on a single PC board. Features: 400-5000 Hz adjustable range via 20 turn pot, voltage regulation, 567 IC. Useful for touch-tone burst detection, FSK, etc. Can also be used as a stable tone encoder. Runs on 5 to 12 volts.
Complete kit, TD-1 **$5.95**

40 WATT 2 mtr PWR AMP
Simple Class C power amp features 8 times power gain 1 W in for 8 out, 2 W in for 15 out, 5 W in for 40 W out. Max output of 50 W, incredible value, complete with all parts, less case and T-R relay.
PA-1, 40 W pwr amp kit **$22.95**
TR-1, RF sensed T-R relay kit **6.95**

COLOR ORGAN
See music come alive! 3 different lights flicker with music. One light each for, high, mid-range and lows. Each individually adjustable and *drives up to 300 W. runs* on 110VAC.
ML-1 Kit. **$8.95**

VOICE ACTIVATED *SWITCH*
Voice activated switch kit provides switched output with current capability up to 100 mA. Can drive relays, lights, LED or even a tape recorder motor. Runs on 9 VDC.
VS-1 KIT **$6.95**

VIDEO MODULATOR
Converts any *TV to video monitor. Super* stable, tunable over ch 4-6. Runs on 5-15V accepts std. video signal. Best unit on the market! Complete kit, VD-1 **$7.95**

LED BLINKY KIT
Alternately flashes 2 jumbo LEDs. Use for name badges, buttons, warning panel lights. Runs on 3 to 15 volts.
BL-1 Kit. **$2.95**

MAD BLASTER
Produces LOUD ear shattering and attention getting siren like sound. Can supply up to 15 watts of obnoxious audio. Runs on 6-15 VDC.
MB-1 Kit **$4.95**

UNIVERSAL TIMER
Provides the basic parts and PC board required to provide a source of precision timing and pulse generation. Uses 555 timer IC and includes a range of parts for most timing needs.
UT-5 Kit **$5.95**

WHISPER LIGHT
An interesting kit, small mike picks up sounds and converts them to light. The louder the sound, the brighter the light. Includes mike, controls up to 300 W, runs on 110 VAC.
WL-1 Kit **$6.95**

FM WIRELESS MIKE
Transmits up to 300' to any FM broadcast radio, *uses any type of mike.* Runs on 3 to 9V. Type FM-2 has added sensitive mike preamp stage.
FM-1 Kit **$3.95**
FM-2 Kit **$4.95**

SIREN
Produces upward and downward wail. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.
Complete kit, SM-3 **$2.95**

SUPER SLEUTH
A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker.
BN-9 Kit **$5.95**

60 Hz TIME BASE
Runs on 5-15 VDC
Low current (25ma)
1 min/month accuracy
TB-6 Kit **$5.50**
TB-6 Assy **$9.95**

NEW

TELEPHONE TRANSMITTER
Low cost with professional performance. Fea*tures include: self phone* line powered, tunable from 76 to 100 MHz, polarity antisensitive, compact size (½" x 1¼"), easily installs anywhere on the phone line or inside the instrument itself.
PB-1 KIT **$14.95**

NEW

FM RECEIVER
For built-in applications or hobby experimentation. Full fledged superhetrodyne receiver, microvolt sensitivity, *10.7 MHz IF. Integrated* Circuit detector, 50 mw audio amplifier, 9V external power source, operation on standard FM broadcast band as well as large portions on each side, compact (6" square), for bug detection or reception
FR-1 KIT **$14.95**

FM MINI MIKE
A super high performance FM wireless mike kit! Transmits a stable signal up to 300 yards with exceptional audio quality *by means of its built in* electret mike. Kit includes case, mike, on-off switch, antenna, battery and super instructions. This is the finest unit available.
FM-3 Kit **$14.95**
FM-3 Wired and Tested **19.95**

ACCESSORIES FOR RAMSEY COUNTERS

Telescopic whip antenna—BNC plug	$ 8.95
High impedance probe, light loading	16.95
Low pass probe, audio use	16.95
Direct probe, general purpose use	13.95
Tilt bail, for CT-70, 90, 125	3.95

VISA

PHONE ORDERS CALL 716-586-3950

TELEX 466735 RAMSEY CI
FAX 716-586-4754

MasterCard

TERMS: • satisfaction guaranteed • examine for 10 days; if not pleased, return in original form for refund • add 6% for shipping and insurance to a maximum of $10.00 • foreign add 15% for surface mail • COD add $2.50 (COD in USA only) • orders under $15.00 add $1.50 • NY residents add 7% sales tax • 90 day parts warranty on all kits • 1 year parts & labor warranty on all wired units.

RAMSEY ELECTRONICS, INC.
2575 Baird Ave.—Dept. HR
Penfield, N.Y. 14526

convert a $25 CB HT
for 6 meters

New crystals, alignment put you on the air

Radio Shack's new TRC-501 is intended for unlicensed 49-MHz CB operation. While most units sold for this band commonly use a-m and super-regenerative receivers, this unit is a unique full-fledged fm transceiver aimed at the semi-professional user who needs inexpensive, very local communications. At its low price (about $25), this unit obviously can't be compared with commercial quality HTs — but it still represents a surprising value for Amateur experimenters. This article shows how to convert this transceiver for the 6-meter Amateur band.

The schematic supplied with the transceiver is unfortunately very tiny and impossible to read. (I did try enlarging the print to produce a more legible copy, but the optical limitations of my copying machine produced only larger, even more illegible prints.) Since very little other useful technical information accompanies the transceiver, I'll provide a quick description of the circuits used in this frugally engineered package.

receiver

The rf amplifier is a common-base stage. Most of the front-end selectivity is provided by L2, the interstage coupling transformer between the rf amplifier and mixer. Another bipolar transistor serves as the mixer stage. The first of two ceramic filters, an inexpensive wideband 10.7-MHz type commonly found in fm broadcast i-f stages, follows the mixer. A third-overtone crystal oscillator provides LO injection.

The heart of the receiver is a Motorola MC1355 integrated circuit. This chip provides all of the i-f functions, including the second LO oscillator and mixer, fm detection and audio squelch circuits. The second i-f is on 455 kHz. The ultimate receiver selectivity is determined by the 455-kHz ceramic filter. An LM386 audio amplifier delivers surprisingly good audio.

transmitter

The transmitter signal starts with a 16-MHz oscillator, triples, and finally ends up in a low-power amplifier stage. Direct fm — via a varicap modulator — is applied to the 16-MHz oscillator. A deviation control (RV1) is included in the audio chain. The internal electret mic element produces good quality audio.

order crystals

The first thing to do is order the crystals for the desired receiver and transmitter channels. The transmitter crystal operates at one-third the actual transmitting frequency. For example, for 52.525-MHz (the national simplex channel), order a crystal for 17.508333 MHz.

The receiver crystal operates 10.7 MHz below the desired receive frequency. Again, using 52.25 MHz as an example, the crystal would be on 41.825 MHz. Specify a third-overtone series-resonant cut when ordering.

Most crystal companies will gladly, and without cost, correlate new crystals against customer samples. For best results I suggest carefully removing the crys-

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

tals from the TRC-501 and sending them along with your order. They'll be returned undamaged. Since I chose to order my crystals before the TRC-501 was available, I gambled and guessed that a 20-pF load capacitance was correct for the transmit crystals. I was wrong, and the transmitter was nearly 25 kHz low in frequency. By inserting a 22-pF capacitor in series with the crystal, I was able to persuade the crystal to oscillate on the proper frequency. This involved cutting a run on the bottom of the board. I strongly recommend sending the 49-MHz crystals to the crystal company for proper correlation on the new frequencies. Mention that these crystals are for 49.830-MHz operation. Otherwise, I'd suggest ordering crystals about 8.333 kHz higher in frequency than calculated to correct for my errors. (For 52.525 MHz, the crystal would be at 17.516666 MHz instead of 17.508333 MHz when specified for 20-pF load capacitance, fundamental cut.) Also be sure that the new wire lead crystals are physically no larger than the ones supplied with the TRC-501; if they're larger, you'll find (as I did) that you won't be able to fit the radio back into its case without expending considerable effort in repositioning the crystals. Most crystal manufacturers will have no problem in supplying a crystal package equal to or smaller than those supplied with the TRC-501.

disassembly

Opening the TRC-501 is somewhat of a challenge. Start by removing the belt clip from the rear of the radio and the battery compartment cover. This will expose a single phillips-head screw which must be removed. The front and rear covers are clamshelled together; looking into the battery compartment reveals two of the four plastic clips locking the pieces together. Try to pry the case open carefully while working on one of the small exposed hooks with a pick or small screwdriver. Once the case pops open, be careful not to misplace the call button or push-to-talk bar. The call button must be reinstalled exactly as removed upon reassembly — the button's switch shaft-hole is not symmetrically oriented.

Once the pc board is exposed, remove the phillips screw located at the top of the board. The board may be lifted and laid to one side of the front of the case, but be careful not to stress the speaker or mike leads unduly. Note that the component part numbers, referenced to the schematic, are silkscreened on the component side of the board. Remove the solder from the leads mounting crystals X2 and X3 carefully. Once the holes are completely clear of solder and the leads are free, remove the crystals.

transmitter alignment

When the new crystals arrive, install the transmit crystal at X3 and the receive crystal at X2. Receiver alignment requires an adjustable level signal source. Transmitter alignment requires a field-strength meter and some means of setting the frequency; either a counter or receiver equipped with a zero discriminator meter will be useful.

I found it easiest to tune the transmitter using a field-strength meter. Coils L6, L5, and L1 are peaked for maximum field strength with the antenna fully extended. These three coils are clustered together in the lower right-hand section of the pc board, below crystal X3. Repeak the coils several times until no further improvement is noted. Transmitter frequency is adjusted by coil L7, directly above X3. The coil wax should be removed before the coil is adjusted. Heat the wax with a small iron and use tissue paper to wick away the wax when it's molten. The coils might tend to peak with cores almost fully removed from the forms. By going further into the forms (i.e., clockwise, rather than upwards) there's more adjustment for raising frequency.

The transmitter deviation is controlled by RV1, located above X3. The audio sensitivity is very good, and the deviation limiting is excellent, as is the modulation symmetry and quality.

receiver alignment

When crystal X2 is installed, a strong local signal should be audible. If not, the crystal may not be oscillating, and a slight readjustment of L4 may be needed. Remove the coil wax from L4 before adjusting. Coil L4 is below X2 in the bottom left-hand corner of the board. Receiver alignment is done by setting coils L4 and L2 for best quieting on a weak signal. Coil L2 is located near center at the board bottom. If the audio sounds slightly distorted, adjusting coil L4 will clear up the problem. (Although the factory setting is just fine, coil L3 may be adjusted for best recovered audio.)

performance

Because I had some difficulty finding a true 50-ohm termination point in this transceiver, the actual performance specs may be better than those I've measured, and certainly no worse. The manufacturer specifies 0.5-μV sensitivity for 20 dB-s/n; I measured about 2 μV. Transmitter power is rated at 10,000 μV/M at 3 meters, the maximum allowed by the FCC for unlicensed 49-MHz operation. Actual power, with a fresh alkaline battery, was measured at +11 dBm (roughly 10 mW).

There's a dearth of 6-meter fm activity here in Connecticut, and I've converted only one of these units so far, so I can't boast about great DX contacts made with the TRC-501. For local line-of-sight communications, I suspect the TRC-501 will be hard to beat.

ham radio

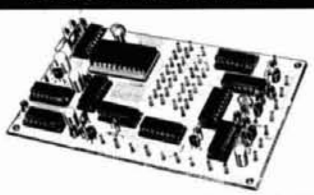
THE MOST AFFORDABLE REPEATER
ALSO HAS THE MOST IMPRESSIVE PERFORMANCE FEATURES
(AND GIVES THEM TO YOU AS STANDARD EQUIPMENT!)

BAND	WIRED	KIT
6M,2M, 220	$880	$630
UHF	$980	$730

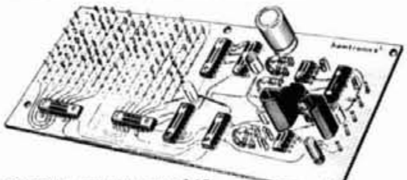
(Also available for commercial bands!)

FEATURES:
- •SENSITIVITY SECOND TO NONE! 0.15uV Typ.
- •SELECTIVITY THAT CAN'T BE BEAT! Both 8 pole xtal filter & ceramic filter for >100dB at ±12kHz. Helical resonator front end to combat desense & intermod.
- •Flutter-proof squelch. Automatic frequency control, separate spkr amplifier.
- •CLEAN, EASY-TUNE TRANSMITTER, up to 20W output. 50W with additional PA.

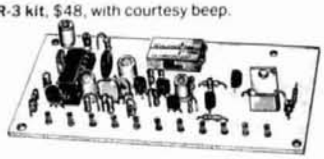
ACCESSORIES



- •TD-2 DTMF DECODER/CONTROLLER kit only $78. Full 16 digits, 5 functions, toll call restrictor, programmable. Much more. Great for selective calling too!
- •AP-1 AUTOPATCH kit only $78. Reverse patch & phone line remote control std.
- •AP-2 Simplex Autopatch. Use with above.



- •CWID kit, new low price $48. Field programmable, timers, the works!
- •COR-2 kit, $38. Audio mixer, local spkr amplifier, tail & time-out timers.
- •COR-3 kit, $48, with courtesy beep.



- •MO-202 FSK DATA MODULATOR kit $38. Run up to 1200 baud digital or packet radio signals through any FM transmitter.
- •DE-202 FSK DATA DEMODULATOR kit $38.

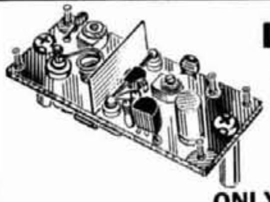
GaAs FET PREAMPS
at a fraction of the cost of comparable units!

LNG -(*) GaAs FET PREAMP

ONLY **$49!** WIRED/TESTED

FEATURES:
- •**Very Low Noise:** 0.7dB VHF, 0.8dB UHF
- •**High Gain:** 13-20dB, depending on freq
- •**Wide Dynamic Range:** to resist overload
- •**Stable:** new-type dual-gate GaAs FET

* Specify tuning range desired: 26-30, 46-56, 137-150, 150-172, 210-230, 400-470, or 800-960 MHz.



LNW -(*) MINIATURE GaAs FET PREAMP

Unbelievably Low Price - - -

ONLY **$19**/kit, **$34** Wired/tested

GaAs FET Preamp similar to LNG, except designed for **low cost & small size**. Only 5/8"W x 1-5/8"L x 3/4"H. Easily mounts in many radios.

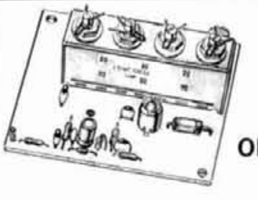
* Specify tuning range desired: 25-35, 35-55, 55-90, 90-120, 120-150, 150-200, 200-270, or 400-500 MHz.

LNS-(*) IN-LINE PREAMP

ONLY $59/kit, $79 wired/tested

GaAs FET Preamp with features similar to LNG series, except **automatically switches out of line during transmit.** Use with base or mobile transceivers up to 25W. **Tower mtg. hardware supplied.**

* Specify tuning range desired: 120-175, 200-240, or 400-500 MHz.



HRA -(*) HELICAL RESONATOR PREAMP

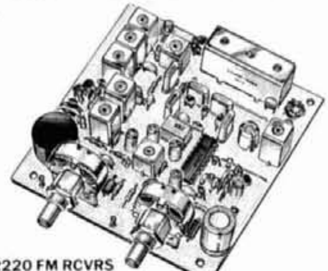
ONLY **$49** VHF or **$64** UHF

Low-noise preamps with helical resonators **reduce intermod & cross-band** interference in critical applications.

* Specify tuning range desired: 143-150, 150-158, 158-162, 162-174, 213-233, 420-450, 450-465, or 465-475 MHz.

HIGH QUALITY XMTR & RCVR MODULES FOR REPEATERS, LINKS, TELEMETRY, ETC.

- •**FM EXCITERS:** Kits only $68. W/t $146. TCXO and xtal oven available. 2W cont. Up to 3W intermittent.
- •**TA51 for 10M, 6M, 2M, 150-174, 220 MHz.**
- •**TA451 for uhf.** FCC TYPE ACCEPTED FOR COMMERCIAL BANDS.
- •**VHF & UHF LINEAR AMPLIFIERS.** For FM or SSB. Power levels from 10 to 45 Watts. Several models, kits starting at $78.



- •**R144/R220 FM RCVRS** for 2M, 150-174, or 220 MHz. 0.15uV sens, 8-pole xtal & 10 pole ceramic i-f filters, helical resonator front end for exceptional selectivity, >100dB at ±12kHz (best available anywhere!) Flutter-proof squelch. AFC tracks drifting xmtrs. Xtal oven avail. Kit $138, w/t $198.
- •**R451 FM RCVR.** Same as above but UHF. Tuned line front end. 0.2uV sensitivity. Kit only $138, w/t $198.
- •**R76 VHF FM RCVR** for 10M, 6M, 2M, 220. As above, but w/o AFC or hel.res. Kits only $98 to $118.
- •**R110 VHF AM RCVR** for VHF aircraft or ham bands or UHF. Kit only $98.

NOW—FCC TYPE ACCEPTED TRANSMITTERS, RECEIVERS, AND REPEATERS AVAILABLE FOR HIGH-BAND AND UHF. CALL FOR DETAILS.

RECEIVING CONVERTERS

		Antenna Input Range	Receiver Output
VHF MODELS		28-32	144-148
		50-52	28-30
		50-54	144-148
		144-146	28-30
Kit with Case	$49	145-147	28-30
		144-144.4	27-27.4
Kit less Case	$39	146-148	28-30
		220-222	28-30
Wired w/case	$69	220-224	50-54
		222-224	28-30
UHF MODELS		432-434	28-30
		435-437	28-30
Kit with Case	$59	432-436	144-148
		432-436	50-54
Kit less Case	$49	439.25	61.25
		902-928	422-448
Wired w/case	$75	902-922	430-450

TRANSMIT CONVERTERS

For SSB, CW, ATV, FM, etc. Can be linked with receive conv for tranceive. 1 to 2 W out. Linear PA's available up to 50W.

	Exciter Input Range	Antenna Output
For VHF, Model XV2 Kit $79 Wired $149 (specify band)	28-30	144-146
	28-29	145-146
	28-30	50-52
	27-27.4	144-144.4
	28-30	220-222
	50-54	220-224
	144-146	50-52
	144-146	28-30
For UHF, Model XV4 Kit $79 Wired $139	28-30	432-434
	28-30	435-437
	61.25	439.25
	144-148	432-436

HAMTRONICS, INC.
65-E Moul Rd.; Hilton NY 14468-9535

☐ High quality equipment at reasonable prices surely appeals to me; but I want more details before I buy! Rush my copy of the 40-page Hamtronics catalog by return first class mail. I enclose $1 ($2 for overseas air mail).

Name ____________________

Address ____________________

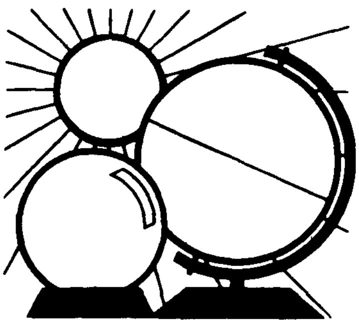
City ____________ State/ZIP ____________

• Order by phone or mail • Add $3 S&H per order
(Electronic answering service evenings & weekends)
• Use VISA, MASTERCARD, Check, or UPS COD.

hamtronics, inc.

65-E MOUL ROAD•HILTON NY 14468-9535
Phone: 716-392-9430

Hamtronics® is a registered trademark



DX FORECASTER

Garth Stonehocker, KØRYW

summertime DX

You've probably noticed some changes in operating conditions between this spring and summer's DX season. One obvious difference is that the daytime bands are open for more hours, from early morning till late evening. This translates to more hours for DXing during your summer leisure time.

Even though the 15- and 20-meter bands are open for long skip, the 10- and 12-meter bands don't open often, and when they do, they're not open for very long. Signal levels also appear to be down. All these effects are attributable to the fact that the sun is in the northern hemisphere. During the daytime, the sun's ultraviolet light generates a thicker, more dense ionosphere over a larger area. Because this increase in ion production occurs in the D, E, and lower F regions of the ionosphere (i.e., 48 to 100 miles above the surface of the earth), it's more difficult for ions to diffuse and drift upward to the higher F2 layer, about 180 miles above the Earth. Consequently, the maximum usable frequencies (MUFs) don't build up as high in summer as they do during the other seasons of the year. The lower MUF signal loses more of its energy as it travels through the thicker, more dense D, E, and lower F regions. The loss can be up to 7 dB on 20 meters in the mid-latitudes. As a result, summertime long-skip conditions on 10 and 12 meters include shorter openings — if the bands are open at all — and weaker signal levels. Thunderstorm noise is also prevalent.

So what can we say that's positive about this season? Well, there are sporadic E short-skip openings. The *upper bands retain their MUFs longer,* and the MUFs are higher and nearly constant over the north polar regions because of the continuous daylight there. The sporadic E openings (up to 1200 miles and multiples) produce signal levels that are sometimes 25 dB greater than those received during long skip; they also account for 6-meter (and lower) band openings for a few hours nearly every day. You can also expect an improvement in 20 meters, with long-skip paths increasing in duration and available in more northern latitudes. This opportunity may provide contacts you haven't thought of working before. So the summer season is good for some decent DX after all!

last-minute forecast

The month opens with the lower bands favored in spite of the high probability of thunderstorm QRN in the late afternoon and evening. Solar flux levels are expected to be low during the first and second weeks; work DX from early morning till noon. A typical day might start with a mix of short-skip propagation from Sporadic E openings around sunrise and long-skip paths from the darkness periods traveling from the west but shifting to the east. As the sun rises — and with it, the ionospheric layer and consequent signal absorption — expect short-skip conditions to reoccur. If the signals weaken too much, move up to 15 or 20 for awhile. Look for E_S openings closer to noontime. Try the higher bands for E_S also. These higher frequencies are expected to be best around August 20. Don't expect many transequatorial one-long-hop openings this summer, but look for the E_S openings to the south. Geomagnetic disturbances may be experienced around August 4, 17, 22, and 28. These disturbances will affect the nighttime bands the most.

For the VHF/UHF enthusiast, the moon's perigee will occur on the 8th, with the full moon on the 9th. The *Perseids meteor shower will occur from* the 10th to the 14th, with a maximum rate of better than 50 meteors per hour expected on the 11th and 12th. This is an excellent shower to work with.

band-by-band summary

Six-meter sporadic E short-skip conditions will occur for 30 minutes to a couple of hours around local noon on some days, for this last good month of this summer's E_S season. Expect about 1000 miles per hop.

Ten, twelve, and fifteen meters will experience quite a few short-skip E_S openings and some long-skip openings during the 27-day solar flux peaks to southern areas of the world during daylight hours. Fifteen meters will be best for only an hour or two as the maximum usable frequency decreases during the late afternoon.

Twenty, thirty, and forty meters will be useful for DX communications to most eastern, western, and northern areas of the world during daylight hours and into the evening almost every day, via long skip to 2000 miles per hop or by means of short-skip E_S, with 1000-mile hops. The period of daylight is still relatively long, but will be noticeably shorter by the end of the month.

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

AUGUST

WESTERN USA

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

MID USA

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

EASTERN USA

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

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

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

ham radio

NEW products

universal temperature probe

The 8OT-15OU Universal Temperature Probe from the John Fluke Manufacturing Company, Inc., is a measurement accessory that converts any digital multimeter into a thermometer. The 8OT-15OU uses a P-N junction temperature sensor housed in a low thermal mass tip to provide fast, highly accurate readings.

Switch-selectable for readouts in F or C, the 8OT-14OU can make temperature measurements of live circuits, with 350-volt peak ac standoff capability. Small components can be accurately measured without cooling caused by the mass of the probe tip.

The 8OT-15OU has a range of −58 to +302 degrees F (−50 C to +150 C). Its basic accuracy is ± 1.8 degrees F (1 C) from 32 to 212 degrees F (0 to 100 C), thereby providing more accurate readings than most thermocouple devices. The unit uses a standard 9-volt battery, with a built-in battery check feature using the external DMM. Average battery life is 1600 hours.

The 8OT-15OU has a suggested U.S. list price of $129.

For more information, contact John Fluke Manufacturing Company, Inc., P.O. Box C9090, Everett, Washington 89206.

Circle #301 on Reader Service Card.

new tuning indicator

MFJ Enterprises, Inc. has released a new tuning indicator for users of TAPR TNC-1s, TNC-2s, and clones such as the MFJ-1270.

The MFJ-1273 ($49.95) lets you tune in hf, OSCAR and other non-fm packet stations fast because it shows you in which direction to tune your radio. Just center a single LED and you're precisely tuned in to within 10 Hz.

Twenty high-resolution LEDs and wide frequency coverage make tuning easy.

The MFJ-1273 tuning indicator plugs into the MFJ-1270 and all TNC-1s, TNC-2s, and clones that have the TAPR tuning indicator connection.

This MFJ product comes with a double guarantee. If ordered directly from MFJ, it may be returned within 30 days for a prompt refund (less shipping). It's also covered by MFJ's one-year unconditional guarantee.

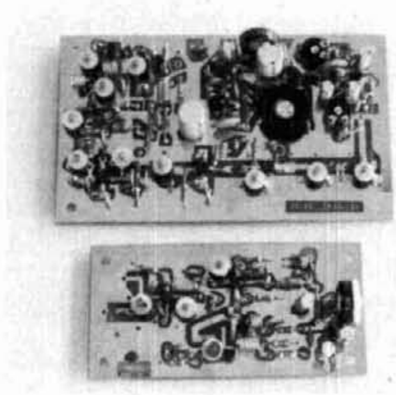
For more information, contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762.

Circle #302 on Reader Service Card.

ATV exciter/modulator for 33 cm

P. C. Electronics' Model TXA5-33 1-watt ATV exciter/modulator board for the 33-cm (902-928 MHz) band allows Amateurs of Technician class license or higher to transmit live-action color or black and white composite video from cameras, VCRs, or computers to other hams.

Most ATV activity has been on the 70-cm (420-450 MHz) band up until now. By also having a 33-cm ATV station, hams can now run full duplex video and audio crossband with another station on 70 cm. The TXA5-33 board should also make putting up a short-distance video link, crossband ATV repeater, bulletin board video repeater, and public service applications such as Space Shuttle video and weather radar video easy — without tying up one or both of the usual 70-cm ATV channels.



The 3 x 5-inch wired and tested TXA5-33 board accepts the standard 1-volt peak-to-peak composite video from any source. For sound, the P.C. Electronics FMA5 or XFMA5 Sound Subcarrier board is connected to the 4.5-MHz input pad of the TXA5-33 modulator circuit. The board takes 12 to 14 Vdc. At 13.8 Vdc, the board draws about 400 mA and puts out over 1 watt PEP into 50 ohms on the sync tip.

Using the 1-watt TXA5-33 and 23-element Tonna 20923 beams (16.2 dBd), the snow-free line-of-sight video range is 10 miles. This distance assumes a 4.2-dB loss in 100 feet of Columbia 1180C or Belden 9913 coax and the P.C. Electronics TVC-9G GaAsFET Downconverter ahead of any good TV set tuned to channel 3. Distance will be greater with shorter coax length or by mounting the antenna on the downconverter (every 6 dB doubles the distance).

Video quality is about as good as what you'd see fromyour own camera on your home VCR. The TV set's i-f bandwidth is the major limitation on resolution. Since ATV uses the same standards as broadcast TV, receiving is as easy as connecting a downconverter and antenna for Amateur frequencies to your TV set or VCR tuner set for channel 2, 3, or 4, depending on which one is unused in your area.

The TXA5-33 transmitter board is priced at $139; the TVC-9 GaAsFET downconverter board at $69; and the TVC-9G downconverter — ready to go in a cabinet with power supply — is $109. The Tonna 20923 23-element Yagi is $59. All prices include UPS surface shipping in the contiguous USA.

For a complete catalog of product information, contact P.C. Electronics, 2522 Paxson Lane, Arcadia, California 91006.

Circle #303 on Reader Service Card.

1.2-GHz transceiver

ICOM has announced the release of its compact new IC-1200, a 1.2-GHz transceiver for mobile or base operation that covers 1240-1300 MHz.

Featuring a simple-to-use front panel and a large LCD readout with an automatic dimmer circuit, the IC-1200 has 21 memory channels, 10 watts output power (including a low-power position for Novices), and memory scan. All subaudible tones are built-in.

The IC-1200 incorporates ICOM's AFC (Automatic Frequency Control) function, which automatically adjusts the receive frequency to the frequency of the transmitting station.

Two new options for the IC-1200 are the UT-28 digital code squelch unit, which incorporates a system of digital coding and decoding, and the UT-29 tone squelch unit, which encodes and decodes subaudible tones.

For further information, contact ICOM America Inc., 2380 116 Avenue N.E., P.O. Box C-90029, Bellevue, Washington 98009-9029.
Circle #304 on Reader Service Card.

packet radio handbook

In the new *Packet Radio Handbook* from TAB, Jonathan Mayo, KR3T, covers just about everything a beginner needs to know to put a packet radio station on the air. In addition, he discusses the history and development of packet radio; the people and organizations who introduced it to Amateurs; using packet with other modes for emergency communications and traffic handling, and more.

For newcomers, the book serves as a comprehensive introduction to packet radio theory and operation. Experienced operators will find a thorough review of basic techniques, along with more detailed technical information about modulation methods and networking principles, the use of protocols such as AX.25 and VADCG, an explanation of how TNCs work, and a discussion of bulletin board operation.

Also included are a complete glossary of common packet radio terms, listings of available equipment, and names and addresses of packet manufacturers, clubs, and newsletters.

The Packet Radio Handbook can be ordered from Ham Radio's Bookstore for $14.95, plus $3.50 shipping and handling.

software for Novices

Heathkit's updated computer-assisted instruction (CAI) software offers FCC-approved questions for all five Amateur Radio examination elements, including the latest Novice, Technician, and General class examinations. Menu-

✓ 117

NEW products

driven programs on disk feature all nine subelements plus the entire data base of FCC-approved questions. Users can create sample tests with multiple-choice questions and a CW practice program.

The software can be used with Heathkit, Zenith Data Systems, IBM, and other PC-compatible computers.

For information, contact Heath Company, Department 150-905, Benton Harbor, Michigan 40922. (In Canada, contact Heath Company, 1020 Islington Avenue, Department 3100, Toronto, Ontario M8Z 5Z3.)

Circle #305 on Reader Service Card.

new terminal program for C-64, 128

Kantronics has introduced a comprehensive terminal program written for use with the Commodore 64 and 128 computers. Offering split screen display, message buffers, disk storage, a type-ahead buffer, and other features, the C-128 program runs in 128 mode and provides for 80-character lines. It be used with almost all the Kantronics "smart" modems, including the KPC-1, KPC-2, KPC-4, KPC-2400, KAM, and UTU-XT/(P). Kanterm 64 and 128 are included on a single diskette. The suggested retail price is $29.95.

For details, contact Kantronics, 1202 E. 23rd Street, Lawrence, Kansas 66046.

Circle #306 on Reader Service Card.

compact VHF amplifier

The HL-160V25A is the compact version of the HL-160V25 VHF amplifier. The HL-160V25A has all the performance of the original, with a simplified control panel to reduce costs without sacrificing quality.

Multi-mode operation for FM, SSB, and CW plus a new GaAsFET type internal pre-amplifier make the HL-160V25A the best choice for high-power mobile or base operation with today's 25-watt output radios. The HL-160V25A produces 160 watts output from 25 watts drive across the entire 2-meter band. The amplifer can be keyed by a remote contact or by the rf signal from the transceiver or transmitter.

Currently in stock at local Encomm, Inc. dealers, its suggested retail price is $269.95. For details, contact Encomm, Inc., 1506 Capital, Plano, Texas 7507.

Circle #307 on Reader Service Card.

new dual-band antenna coupler

Larsen Electronics, Inc. has introduced its new AD-2/70 Dual-Band Antenna Coupler, which allows simultaneous operation in both VHF and UHF bands with a common dual-band antenna.

The AD-2/70 will connect separate VHF and UHF radios with a common dual-band antenna, such as one from the Larsen 2/70 series, or allow separate VHF and UHF antennas to be used with a single-port dual-band radio.

The Dual-Band Coupler, designed for operation in Amateur 2-meter and 70-centimeter bands, can be used for commercial VHF and UHF applications as well. Crossband isolation is suppressed to -50 dB or more, permitting interference-free simultaneous transmission or reception. Maximum power rating is 200 watts PEP composite VHF/UHF power.

For additional information, contact Larsen Electronics, Inc., P.O. Box 1799, Vancouver, Washington 98668.

Circle #312 on Reader Service Card.

weather satellite converter

Hamtronics, Inc. recently announced a new receiving converter for reception of weather fax pictures transmitted from satellites operating in the 137-MHz band. Basically a modified version of the CA144 2-meter Amateur converter, the CA137-28 Converter translates all signals received in the 136-138 MHz satellite band for reception on tunable 28-30 MHz wideband fm receivers. To make the conversion in dial frequency, simply subtract 108.000 from the frequency you want to receive. The receiver uses a low-noise front end to provide sensitivity of less than 0.2 μV. It operates on + 13.6 Vdc at 30 mA.

The CA137-28 Converter is available in three versions: wired and tested in the 4 x 4 x 2-inch cabinet shown at $69; in kit form at $49; and a kit for just the pc board module (less case) at $39. Shipping and handling is $3.

GaAsFET preamps of various types are also available for this band for those who'd like to take advantage of reduced cable loss by mounting a preamp at the antenna. An LNG-144 GaAsFET preamp enclosed in a 2 x 2-inch metal case is $49 wired and tested. An LNW-144 Preamp, which is the same basic circuit without a case, is available for $34 wired and tested or $19 in kit form. All three have a noise figure less than 1 dB. By using one of these preamps, the sensitivity of the converter can be made as low as 0.1 μV.

Other Hamtronics products include VHF and UHF transmitter and receiver modules and complete repeaters, "202"-type fsk modulators and demodulators for digital data interface, low-noise GaAsFET receiver preamps, 806-MHz scanner converters, transmitting and receiving converters for various amateur bands, VHF and UHF am receivers, repeater COR and CWID units, simplex and repeater autopatches and DTMF decoders, and many other products related to VHF and UHF fm systems.

For a complete 40-page catalog of Hamtronics™ products by return first-class mail, please send $1 ($2 for overseas mailing) to Hamtronics, Inc., 65-F Moul Road, Hilton, New York 14468-9535.

new interference suppression device

Computeradio has announced the availability of a new rfi suppression device, the TEXPRO Snap-On-Choke, which simplifies the application of an anti-interference technique that has long been appreciated by experts. Useful for minimizing interference to radios, TV sets, VCRs, TV converters, computers, digital data cables, telephones, process control and telecommunications systems, The TEXPRO Snap-On-Choke consists of a two-piece ferrite core and a plastic clamp. Its performance is similar to the toroidal ferrite cores, and is effective within a 0.5 to 200 MHz range. The choke can be clamped onto cables of a diameter up to 10 mm (0.4 inch) or can take

many turns of a thinner cable that will fit in the opening (9.9 x 21.6 mm). Installation does not require the removal of connectors or the unsoldering of connections — and doesn't void the warranty on equipment. A number of chokes can be snapped together if necessary.

The TEXPRO Snap-On-Choke is a "common-mode" choke that reduces radiation from the currents associated with cables — even shielded cables — acting as transmitting or receiving antennas. They can be used in place of a balun at the antenna feedpoint.

Single chokes are priced at $4.00 each. A package of four costs $15.00 plus $2.00 for shipping. Chokes come with a specification sheet and installation instructions. If you're not satisfied, you can return them within 30 days for a refund (less shipping).

For more information, contact COMPUTERADIO, Box 282, Pine Brook, New Jersey 07058.

Circle #308 on Reader Service Card.

computer-aided design

RF Notes No. 1, Version 3.0, aids in the design of resonant circuits, filters, basic stripline and microstrip projects, as well as cross-product and VSWR analysis. Version 3.0 incorporates improved schematic and graphics, in addition to allowing on-screen "what if" calculations. Priced at $85, the fully menu-driven program is easy to use and includes tutorial sections.

For details, contact Etron RF Enterprises, P.O. Box 4042, Diamond Bar, California 91765.

Circle #309 on Reader Service Card.

five new antennas

Mirage has announced the release of five new antennas, including three omnidirectional antennas of a "closed J" design and two upgraded designs for 440 MHz designed with through-the-boom elements rather than molded-on elements, for greater durability. ATV users will be especially interested in the 440-10X and 440-6X models, which were designed to replace the 440-6 and the 440-14.

Mirage will continue to replace parts and service older models. For details, contact Mirage/KLM Communications Equipment, Inc., P.O. Box 1000, Morgan Hill, California 95037.

Circle #310 on Reader Service Card.

novice "quick course"

In his new 21-day code and theory course, consisting of two long-play, stereo code cassettes and a fully illustrated Novice voice-class license preparation manual, Gordon West covers learning the code in a humorous and educational manner. The cassette code learning course is designed for students with absolutely no background in code copy.

Written by West and Fred Maia, W5YI, the accompanying manual includes every Novice class exam question, plus a thorough explanation of each as well as a discussion of each of the right and wrong answers. Several other chapters cover a detailed introduction to the Amateur Radio service.

Both the tapes and the book contain sections specifically for hams preparing administer the Novice test. An FCC Form 610 as well as a sample examination are included, as is a full-color ICOM frequency-band chart.

The course is available through local dealers or directly from Gordon West Radio School, 2414 College Drive, Costa Mesa, California 92626 for a total cost of $19.95 plus $2.00 for postage and handling.

Circle #311 on Reader Service Card.

✓ 116

HAM MART

Ham Radio's guide to help you find your loca

New Hampshire

RIVENDELL ELECTRONICS
8 LONDONDERRY ROAD
DERRY, N. H. 03038
603-434-5371
Hours M-S 10-5; THURS 10-7
Closed Sun/Holidays

New Jersey

ABARIS SYSTEMS
276 ORIENTAL PLACE
LYNDHURST, NJ 07071
201-939-0015
Don WB2GPU
Astatic, Azden, B&W, Butternut, Larsen, Mirage/KLM, Kenpro, Nye, Santec, THL, and many others.
M-F 10 am-9 pm
SAT 9 am-7 pm
VISA/MC

KJI ELECTRONICS
66 SKYTOP ROAD
CEDAR GROVE, NJ 07009
(201) 239-4389
Gene K2KJI
Maryann K2RVH
Distributor of: KLM, Mirage, ICOM, Larsen, Lunar, Astron. Wholesale - retail.

New York

BARRY ELECTRONICS
512 BROADWAY
NEW YORK, NY 10012
212-925-7000
New York City's Largest Full Service Ham and Commercial Radio Store.

VHF COMMUNICATIONS
915 NORTH MAIN STREET
JAMESTOWN, NY 14701
716-664-6345
Call after 7 PM and save! Supplying all of your Amateur needs. Featuring ICOM "The World System." Western New York's finest Amateur dealer.

North Carolina

F & M ELECTRONICS
3520 Rockingham Road
Greensboro, NC 27407
1-919-299-3437
9AM to 7PM Closed Monday
ICOM our specialty — Sales & Service

Ohio

AMATEUR ELECTRONIC SUPPLY
28940 EUCLID AVE.
WICKLIFFE, OH 44092 (Cleveland Area)
216-585-7388
Ohio Wats: 1 (800) 362-0290
Outside Ohio: 1 (800) 321-3594
Hours M-F 9-5:30, Sat. 9-3

DEBCO ELECTRONICS, INC.
3931 EDWARDS RD.
CINCINNATI, OHIO 45209
(513) 531-4499
Mon-Sat 10AM-9PM
Sun 12-6PM
We buy and sell all types of electronic parts.

UNIVERSAL AMATEUR RADIO, INC.
1280 AIDA DRIVE
REYNOLDSBURG (COLUMBUS), OH 43068
614-866-4267
Featuring Kenwood, Yaesu, Icom, and other fine gear. Factory authorized sales and service. Shortwave specialists. Near I-270 and airport.

Pennsylvania

HAMTRONICS, DIV. OF TREVOSE ELECTRONICS
4033 BROWNSVILLE ROAD
TREVOSE, PA 19047
215-357-1400
Same Location for over 30 Years

LaRUE ELECTRONICS
1112 GRANDVIEW STREET
SCRANTON, PENNSYLVANIA 18509
717-343-2124
ICOM, Bird, Cushcraft, Beckman, Larsen, Amphenol, Astron, Belden, Antenna Specialists, W2AU/W2VS, Tokyo Hy-Power Labs, WELZ, Daiwa, Sony, Saxton, Vibroplex, Weller.

Tennessee

MEMPHIS AMATEUR ELECTRONICS
1465 WELLS STATION ROAD
MEMPHIS, TN 38108
Call Toll Free: 1-800-238-6168
M-F 9-5; Sat 9-12
Kenwood, ICOM, Ten-Tec, Cushcraft, Hy-Gain, Hustler, Larsen, AEA, Mirage, Ameritron, etc.

Texas

MADISON ELECTRONICS SUPPLY
3621 FANNIN
HOUSTON, TX 77004
713-520-7300
Christmas?? Now??

KENNEDY ASSOCIATES
AMATEUR RADIO DIVISION
5707A MOBUD
SAN ANTONIO, TX 78238
512-680-6110
Stocking all major lines. San Antonio's Ham Store. Great Prices — Great Service. Factory authorized sales and service.
Hours: M-F 10-6; SAT 9-3

MISSION COMMUNICATIONS
11903 ALEIF CLODINE
SUITE 500 (CORNER HARWIN & KIRKWOOD)
HOUSTON, TEXAS 77082
(713) 879-7764
Now in Southwest Houston—full line of equipment. All the essentials and extras for the "ham."

Wisconsin

AMATEUR ELECTRONIC SUPPLY
4828 W. FOND DU LAC AVE.
MILWAUKEE, WI 53216
414-442-4200
Wisc. Wats: 1 (800) 242-5195
Outside Wisc: 1 (800) 558-0411
M-F 9-5:30 Sat 9-3

Invitation to Authors

ham radio welcomes manuscripts from readers. If you have an idea for an article you'd like to have considered for publication, send for a free copy of the *ham radio* Author's Guide. Address your request to *ham radio*, Greenville, New Hampshire 03048 (SASE appreciated).

Foreign Subscription Agents for Ham Radio Magazine

Ham Radio Austria
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio Belgium
Stereohouse
Brusselsesteenweg 416
B-9218 Gent
Belgium

Ham Radio Holland
Postbus 413
NL-7800 Ar Emmen
Holland

Ham Radio Europe
Box 2084
S-194 02 Upplands Vasby
Sweden

Ham Radio France
SM Electronic
20 bis, Ave des Clarions
F-89000 Auxerre
France

Ham Radio Germany
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Canada
Send orders to
Ham Radio Magazine
Greenville, NH 03048 USA
Prices in Canadian funds
1 yr. $41.85, 2 yrs. $74.25
3 yrs. $99.90

Ham Radio Italy
Via Maniago 15
I-20134 Milano
Italy

Ham Radio Switzerland
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio England
c/o R.S.G.B.
Lambda House
Cranborne Road
Potters Bar
Herts EN6 3JW
England

flea market

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

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

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

DEADLINE 15th of second preceding month.

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

COMING EVENTS

Activities — "Places to go . . ."

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

MAINE: September 12. Windsor Hamfest, sponsored by the Augusta Emergency Amateur Radio Unit. Southern Kennebec Agricultural Society Fairgrounds, Windsor. Flea Market, outdoor spaces free, indoor tables available. Forums, distributors, Saturday night homebaked beans and casseroles. Gate donation $2.00. Overnight camping $3/night or $5/two nights. Talk in on W1TLC 146.22/82 repeater. For information: Phil and Dot Young, W2JTH and W1TGY, 47 Longwood Avenue, Augusta, ME 04330. Telephone (207) 622-1385.

TENNESSEE: August 30. The Lebanon Hamfest sponsored by the Short Mountain Repeater Club, Cedars of Lebanon State Park, US 231, 7 miles south of Lebanon. All outdoors. Bring your own tables. Food and drinks available. For further information contact Mary Alice Fanning, KA4GSB, 4936 Danby Drive, Nashville, TN 37211.

INDIANA: August 16. The Lafayette Hamfest, Tippecanoe Co. Fairgrounds, on Indiana 25 in Lafayette. Indoor setup 5 PM to 8:30 PM EST Saturday night. No overnight camping on fairgrounds. Outdoor setup 5 AM.

OHIO: September 27. The Cleveland Hamfest Association's annual Hamfest and Computer Show, Cuyahoga County Fairgrounds, Berea. Doors open 8 AM to 4 PM. Early setup 6 AM. VE exams 9 AM. Tech forums and non-ham activities all day. Talk in on 146.52. Admission $3.50 advance; $4.00 at the gate. Inside tables $10. Outside flea market $4.00. Saturday night banquet. For more information write C.H.A., POB 81252, Cleveland, OH 44181-0252.

COLORADO: August 8. The Ski Country ARC will host its 6th annual Hamfest in conjunction with the Colorado Council of ARC summer meeting, CMC Building, 1402 Blake Avenue, Glenwood Springs. 9 AM to 3 PM. Admission free. Tables $5. Refreshments and lunch available. VE exams 9 AM. Videotapes, packet and AMSAT demos. For information contact Bob Ludtke, K9MWM, 406 Yale Circle, Glenwood Springs, CO 81601. (33) 945-8722.

ALABAMA: August 15 and 16. The Huntsville Hamfest and ARRL State Convention, Von Braun Civic Center, 700 Monroe Street, Huntsville. 9 AM to 5 PM Saturday. 9 AM to 3 PM Sunday. Amateur exams August 15 by CAVEC. Walk-ins welcome. Flea market, dealers/distributors and non-ham activities. All air-conditioned. No admission fee. Light refreshments available. Talk in on .34/.94. For further information contact Gwin Givens (205) 883-2760 or Don Tunstill (205) 536-3904.

OHIO: September 13. The Findlay Hamfest, Hancock County Fairgrounds, Findlay. Doors open 8 AM. Admission prior to 9/1 $3.00. After 9/1 $4.00. Flea market spaces $4.00 at door. Reserved indoor tables $6.00. For tickets and table reservations send check and SASE to FRC Hamfest, POB 587, Findlay, OH 45839.

WASHINGTON: August 22-23. The Radio Club of Tacoma presents Hamfair '87 and the ARRL Northwestern Division Convention, Pacific Lutheran University, Tacoma. Friday evening entertainment. Doors open 9 AM August 22. Registration $5.00 til August 12. $6.00 at the door. Banquet $10.00 by August 12. RV spaces $2.00. No hookups. Technical seminars, forums, flea market (tables $18/6') non-ham activities, VE exams all classes. For reservations and/or flea market tables write Al Wittich, KA7SBJ, 3832 Gay Rd E. Tacoma, WA 98443 or call Bill Morgan, W7GRP (206) 531-3821 or Marion O'Neal, WB7SQU (206) 838-3126.

MISSOURI: September 13. The Ozarks Amateur Radio Society will hold its 6th annual Ozarks Club Congress and Swapfest, City Park in Monett. Tailgating starts 9 AM. Potluck dinner

(continued on page 92)

ELMER'S NOTEBOOK

Tom McMullen, W1SL

oops!

Thanks to K4TG for pointing out an error. Please see the "short circuit" at the end of this month's column.

outguessing the ionosphere

From what I've been hearing on the bands and reading in newsletters and magazines, the 10-meter band ushered in the era of Novice Enhancement with an impressive demonstration of the fun it can provide. Reports abound of Novices working some terrific DX, and the enthusiasm shown by the lucky operators has been truly contagious. This is a perfect time for you Novices to get acquainted with Garth Stonehocker's "DX Forecaster" column in this magazine and make some notes about what you've heard or worked. You can then check against the column to build up a "prediction data base" for your location. Many an old hand at the Amateur game considers the thrill of outguessing the ionosphere to be as gratifying as collecting the QSL cards from the DX they've worked.

We'll continue last month's discussion of digital communications next month; in this column, we'll take a look at 220 MHz, a band that's sure to provide plenty of exciting local communications.

220 MHz: background

Years ago, Amateurs had a band known as 2-1/4 meters, or 112 MHz. A natural offshoot of this was another experimental band at 224 MHz — I say "natural" because the common practice was to use harmonics of lower frequencies to generate output on the VHF and UHF bands. Later, the 2-1/4 meter band was changed to 2 meters (144 MHz), but 224 remained unchanged, and the harmonic relationship obviously fell apart.

At the time, only true experimenters were willing to invest the time and money necessary to build separate stations for the 220-225 MHz "orphan." The appearance of surplus commercially made fm equipment on the 2-meter band encouraged manufacturers to produce equipment that would lead to our present crop of compact, solid-state, VHF-fm and all-mode rigs; the 220-MHz band, however, remained of little interest to most manufacturers — partly because of its very low occupancy, which was brought on by repeated attempts by government and commercial interests to grab all or part of the band for their use.

These attempts are still being made and fought off. There's an important difference, however, in that there's immensely greater occupancy now, and there will be more activity as Novices learn to use this part of the spectrum to its full potential. Consequently, finding equipment for 220 MHz won't be a problem.

equipment

A visit to any Amateur equipment dealer or a scan through Amateur publications will show that there are plenty of rigs to choose from. Among the most obvious are Kenwood's TM-3530A mobile and TH-31BT/31A hand-held; Icom's IC-375A base station, IC-37A and IC-38A mobile units, plus their IC-03AT and IC-3AT hand-helds; and Yaesu's FT-109RH hand-held. There will undoubtedly be more models available soon — perhaps even before you read this. Repeaters, too, are being manufactured for Amateur 220 MHz use.

While I'm talking about equipment, let me point out that a rig advertised as a mobile unit can be used as a base station too. A good (i.e., well filtered) power supply that provides the required 12 volts dc at sufficient current will afford many hours of home use. In fact, many operators get double duty out of their rigs by operating them both at home and in their cars. Some have done as I have — i.e., installed a newer mobile rig with more bells and whistles in the car, then put the older one to work at home.

antennas

Every major manufacturer of Amateur antennas offers models for the 220-MHz band. They're available in the form of beam (Yagi) antennas, groundplane antennas, magnet-mount and fixed-mount mobile whips of various sizes, and the ubiquitous "rubber-duckie" that's so useful for portable and hand-held use.

Making your own antennas is always fun, however, and the size of the elements required for 220 MHz makes doing so much easier. Anything from new aluminum rod or tubing to salvaged TV antenna parts can be used to produce high-performance antennas that will let you extend your 220-MHz contacts to ever-expanding distances. You can find directions and

12:30. Special activities throughout the day. Free coffee and soft drinks provided by the Club. Talk in on 146.37/97. Free admission.

INDIANA: August 2. The Porter County ARC presents the Northwest Indiana Hamfest and Computer Fair, 49'er Drive-In Theater, Rt. 49, north of Valparaiso. Gates open 7 AM. 6 AM for vendors. Admission $3.00. Children under 12 free. VE testing, food available. Free parking. Many beautiful area attractions. Talk in on 146.775/175 and 145.45/144 950. For further information: Rich Stahl, K9LBO, POB 1782, Valparaiso, IN 46383.

WASHINGTON: August 22 and 23. The Radio Club of Tacoma presents Hamfair '87 and the ARRL N.W. Division Convention, Pacific Lutheran University, Tacoma. Friday evening entertainment for early arrivers. Doors open 9 AM on 8/22. Flea Market, commercial exhibits, VE testing, all classes. Registration $5.00 until August 12. $6.00/door. Banquet $10.00 by August 12. Flea market tables $18/6' includes one reservation. For reservations and/or flea market table write Al Wittich, KA7SBJ, 3832 Gay Road, E. Tacoma, WA 98443 or call Bill Morgan, W7GRP (206) 531-3821 or Marion O'Neal, WB7SQU (206) 838-03126.

IOWA: August 1 and 2. Summerfest '87 sponsored by the Cedar Valley ARC, Five Seasons Center, downtown Cedar Rapids. 8 AM to 5 PM Saturday and 8 AM to 3 PM Sunday. Admission $5 adult; $3 student advance. $6 adult, $4 student at the door. Seminars, FCC exams, vendors, flea market and non-ham activities. For information/reservations Duane Rinderknecht, 2825–23 Avenue, Marion, Iowa 52302. (319) 277-2761 days. (319) 377-2761 nights.

TEXAS: August 7-9. Austin SummerFest, sponsored by the Austin ARC and Austin Repeater Organization, Villa Capri Motor Hotel, 2400 North Interstate 35 near center of Austin. Indoor flea market, ARRL forum, tech program transmitter hunt and VE exams for all license classes. Saturday evening barbeque and Midnight Wouff Hong ceremony. Non-ham arts and crafts and Austin Aqua Festival available during convention. General registration $5 advance; $7/door. Children 15 and under free. To register write Austin SummerFest, PO Box 13473, Austin, TX 78711.

MISSOURI: August 23. The St. Charles ARC will sponsor Hamfest 87 at Blanchette Park, St. Charles. 6:30 AM to 3:30 PM. Free admission and parking including handicapped spaces. $2. donation requested for tailgate flea market. Food available. Forums and FCC license exams at 10 AM. Talk in on 146.07/67 repeater and 146.52 simplex. Contact Eric Koch, NF0Q, 2805 Westminister, St. Charles, MO 63301 (314) 946-0948.

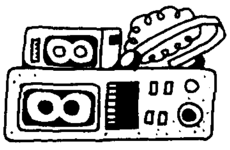
ONTARIO: September 19. The Hex-9 Group of the Barrie Amateur Radio Club is holding its third PACKET RADIO SYMPOSIUM co-sponsored by and held at Georgian College, Barrie. Talks for beginners at 9:30 AM. Main discussions start 1 PM. Registration $5.00. Inquire Hex-9 Group, Box 254, Barrie, Ontario, L4M 4T2. Pre-register via packet VE3FJB-1.

OHIO: August 23. The 11th annual Marysville Hamfest and Computer Show, Marysville Fairground. Admission $3.00 advance; $4.00 at the gate. Giant flea market. Free overnight camping available on grounds. Free entertainment Saturday night plus good food and lots of fun. For further information or tickets write Gene Kirby, W8BJN, 13613 US 36, Marysville, OH 43040 (513) 644-0468.

KENTUCKY: August 9. The Central Kentucky ARRL Hamfest sponsored by the Bluegrass Amateur Radio Society, Scott County High School, Longlick Road and US 25, Georgetown. 8 AM to 4 PM. Tech forums, license exams, awards and commercial exhibits in air-conditioned facilities. Free outdoor flea market space with paid admission. Tickets $5/advance; $6/gate. Talk in on 146.16/76 repeater. For information or tickets SASE to Bill DeVore, N4DIT, 112 Brigadoon Parkway, Lexington, KY 40503.

TEXAS: August 8-9. The Panhandle Amateur Radio Club's 13th annual PARC-Golden Spread Hamfest, Inn of Amarillo, 601 Amarillo Blvd West, Amarillo. Starts 9 AM both days. Preregistration $5. Admission at door $6. Distributors, dealers, flea market tables $5. VE testing, walk-ins only, both days. For more information write PARC Hamfest, Box 10221, Amarillo, TX 79116.

1987 "BLOSSOMLAND BLAST" Sunday, September 20, 1987. Write "BLAST" PO Box 175, St. Joseph, MI 49085.



OPERATING EVENTS

"Things to do . . ."

August 2: The South Hills Brasspounders and Modulators will operate W3PIQ to commemorate their 50th Hamfest and 200th anniversary of Allegheny County. 20, 15 and 10 meter General phone bands. For certificate QSL and SASE to Bill Gardiner, N3DXE, 4756 Child Drive, Pittsburgh, PA 15236.

August 16: The Arapahoe Radio Club will operate from several of Colorado's 14,000-ft mountain peaks. 1000-12000 MDT (1600-1800 UTC). SSB on 14.285 MHz. CW 14.060 MHz. A certificate will be available listing all Colorado Fourteeners Operations with checkoff of all stations worked. A special memento will be sent to any station working all Fourteener stations. Send QSL and legal SASE to K9AY, 7277 S. Clermont Drive, Littleton, CO 80122.

September 6: The Schaumburg Amateur Radio Club will operate WB9TXO from the Schaumburg Septemberfest site from 1500-2000Z. Suggested frequencies 7.250, 14.250 and 28.400 MHz. For a confirming certificate send QSL to SARC, POB 68251, Schaumburg, IL 60168-0251.

August 1-23. Special event station W9PAX (W9 Pan American Ten) will operate during the 10th Pan-American Games being held in Indianapolis, August 7-23. For additional information contact Cornelius M. Head, WB9ZOE, 9046 Mercury Drive, Indianapolis, IN 46229. (317) 263-5281 (O) (317) 898-2792 (H).

September 5. The Old Pueblo Radio Club of Tucson will sponsor the 6th annual Labor Day Special Event Station W7GV from the OK Corral in Tombstone, Arizona, site of the famous shootout between the Earps and the Clantons in 1881. On new Novice/Tech 10 meter SSB frequencies. 0000Z September 5 to 2200Z September 7. For more information contact Bill Croghan, WB0KSW, 1854 W. Dominy Street, Tucson, AZ 85713. (602) 622-1535.

August 29: The Antietam Radio Association will operate special event station W3CWC to celebrate the 25th anniversary of the club. 80,40,20,15 and 10 meters phone, CW and RTTY. For a commemorative certificate send QSL and legal SASE to Special Events Station W3CWC, Antietam Radio Association, Inc., POB 52, Hagerstown, MD 21741.

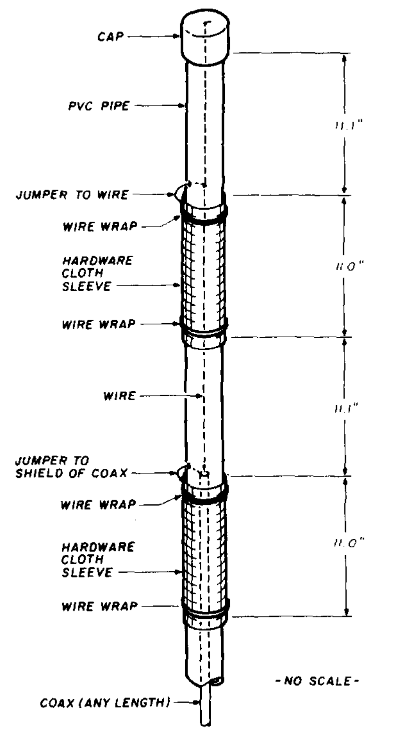


fig. 1. Two-meter antenna modified for 220 MHz.

formulas for building antennas in many handbooks; just drop a note or postcard to *ham radio's* Bookstore and ask for a catalog.

An increase in coverage that's especially useful for simplex operation can be obtained by using an antenna that's larger in terms of wavelength; a half-wave 220-MHz antenna is only seven inches longer than a quarter-wave whip for 144 MHz, and has more gain and a better angle of radiation from a car-top location. A 5/8-wave antenna element for 223 MHz is approximately 33 inches long, compared with 50 inches for 146 MHz. This difference in size isn't visible in most mobile antennas because a loading coil in the base of the antenna allows a shorter 2-meter radiator to perform as if it were 5/8-wavelength; it will be apparent, however, in home-station antennas such as multi-section verticals or ground-plane types with 5/8-wave vertical radiators.

A neat 2-meter antenna was described in Bill Orr's column in the May, 1987 issue of *ham radio* (see page 55). A few minutes with a calculator produced some dimensions that will let you adapt the 2-meter design for 220 MHz; see **fig. 1**. Note that neither version has elements that are exactly one-quarter or one-half of a free-space wavelength. A quarter-wave in space at 144 MHz is approximately 20 inches; at 223 MHz, it's approximately 13.2 inches. When you allow for the capacitive loading at the end of the elements, the coupling to the wire mesh "sleeves," and the dielectric effects of the PVC tubing, the element dimensions get shorter.

distances

The normal operating range of stations on the 220-MHz band is amazingly close to what can be expected on 2 meters. Well-located repeaters with good antennas can provide coverage that's virtually identical to 144 MHz. And because of the short space a wavelength occupies, peaks and nulls in signal strength experienced by stations in motion in urban or weak-signal areas aren't as bothersome at 220 as they might be at 144 MHz. There's also more "fill" of shadowed areas because of the slightly increased reflectivity of many materials at 220 MHz — but by the same token, many materials absorb 220 MHz more readily, thus causing some signal loss.

the ins and outs of repeaters

Band plans allow orderly occupancy of our sometimes crowded VHF spectrum and provide a basis for compatibility among various makes of fm transceivers and the repeaters through which they work. There's been a band plan for 220 ever since repeaters began appearing in VHF circles. Rather than use a lot of space to reproduce the entire 220-MHz band plan here, I'll just make a few comments about it.

The separation between a 220-MHz repeater's input and output frequencies is 1.6 MHz. When you transmit on 223.10 MHz from your mobile or handheld rig, the repeater retransmits your signal on 224.70 MHz; this higher frequency is where your receiver is listening. *Don't worry about 224.70 being out of the Novice "band"*; this type of operation is authorized by the FCC. At 223.10, your transmitter is operating within the limits of the Novice subband, which is what counts. (Novices beware: be sure that you never transmit "direct" on the repeater's output frequency. Never use the "reverse" or "inverted" mode of operation that's available on many current rigs.)

The band plan allows for 20 kHz between each repeater input; for example, 223.02, 223.04, 223.06, and so on. Each input has its corresponding output 1.6 MHz higher. There are a few "gotcha's," though. In some areas, 223.4 is designated as an input frequency. But if you add 1.6 to 223.4, you get 225.0. Obviously, you can't have a repeater output on the very edge of the band, so watch out for that one. In some areas, repeater input and output frequencies are reversed by local agreement; this usually means that the input is somewhere near the current input range, but the output of the repeater is 1.6 MHz *lower*.

Many simplex frequencies have been agreed upon, starting at 223.40 or 223.42 MHz and occurring every 20 kHz up to 223.88 or 223.90 MHz. Many stations use 223.50 MHz as a calling frequency to establish initial contact, then move to another simplex channel for a QSO.

This arrangement of repeater frequencies and simplex channels could change, however. Novices will no doubt want to use other modes such as CW, SSB, or packet in their segment of 220 MHz, and some changes will have to be worked out to accommodate them. I'll keep you abreast of changes in this column. For a listing of current repeaters and band plans on 220 MHz (and others), try *The ARRL Repeater Directory* — a neat, pocket-sized little guide that's been a best-seller everywhere. Again, *ham radio's* Bookstore has it.

For any of you who'd like to exercise your computer, **fig. 2** shows a short program that will generate a printout of common repeater and simplex


MISSOURI RADIO CENTER
102 N.W. Business Park Lane, Kansas City, MO 64150 816-741-8118
Call Toll Free — 9am - 6pm Mon. - Fri., 9am - 2pm Sat.
In Missouri Call — 816-741-8118
1-800-821-7323
TRADE INS ACCEPTED
MasterCard — VISA — COD Welcome
KENWOOD
TS940S "DX-cellence"
• Programmable Scanning
• High Stability, Dual Digital VFO's
• 40 Channel Memory
• General Coverage Receiver
KENWOOD
TS440S "DX-CITING"
• 100% Duty Cycle
• 100 memories
• Direct Keyboard Entry
• Optional Built-in AT
On Sale Now, Call For Price!
KENWOOD
TM-3530A
220 MHZ MOBILE FM TRANSCEIVER
• 220-225 MHz with 25 Watts
• 7-Digit Telephone No. Memory
• Direct Frequency Entry
• 23-Channel Memory
KENWOOD
NEW
TH-215A
"FULL FEATURED 2m HT"
• 141-163 MHz Receive
• 144-148 MHz Transmit
• 2.5w Output (5w Optional)
• 10 Memories
• Built-in CTCSS Encoder
• Nine Types of Scanning
YAESU
FT-757GX "CAT SYSTEM"
• All Mode Transceiver
• Dual VFO's
• Full Break-in CW
• 100% Duty Cycle
CALL FOR BEST PRICE!
YAESU
FT-767GX HF/VHF/UHF BASE STATION
• Add Optional 6m, 2m & 70cm Modules
• Dual VFO's
• Full CW Break-in
• Lots More Features
YAESU
FT23/73R
• Zinc-Aluminum Alloy Case
• 10 Memories
• 140-164 MHz, 440-450 MHz
• 600 MAh Standard Opt. 5w New "super handie"
YAESU
FT-109RH
220 MHz H.T.
• 5 Watts Output
• Battery Saver
• 10 Memories
• Multiple Scanning Routines
• Power Meter
ICOM
IC-735 "NEW"
Can you put a price tag on reliability? Now ICOM offers a ONE YEAR WARRANTY on its HF Transceivers & Receivers purchased after August 1, 1986
ICOM
IC-751A "NEW"
• 100 KHz - 30 MHz
• FM Standard
• 32 Memories
• QSK (Nominal Speed 40 WPM)
ICOM
IC-38A
• Full 25W, 5W low
• 21 memories
• Subtones built in RX 215-230 MHz
CALL FOR BEST PRICE
ICOM
IC-μ2AT
• 140-163 MHz
• 10 Memories
• 1W, 1.5W optional
• 32 tones built-in
IC-03AT
• 220 to 224.995 MHz
• 2.5W, 5W Optional
• Built in subtone
• 10 Memories
Kantronics
KAM
Kantronics All Mode
• CW, RTTY, ASCII, AMTOR, HF & VHF Packet
• RS-232/TTL, Universal Compatability
• Transmit and Receive CW 6-99 wpm, RTTY/ASCII 45-300 Baud, ARQ, FEC, SELFEC, Listen ARQ, VHF and HF Packet
MFJ
MFJ-1274
TNC 2 PACKET RADIO
• VHF and HF Packet
• Precision Tuning Indicator
• AX.25 Level 2 Version 2 Software
• TTL Serial Port
• More!
ASTRON CORPORATION
Power Supply
• RS7A $48
• RS12A $68
• RS20A $88
• RS20M $105
• VS20M $125
• RS35A $133
• RS35M $149
• VS35M $165
• RS50A $189
• RS50M $215
• RM50A $219
• VS50M $229
NOVICES
ARE YOU CONFUSED ABOUT YOUR NEW PRIVILEGES? CALL US FOR THE UP-TO-THE-MINUTE INFORMATION AND ASSISTANCE WITH YOUR GEAR.
113
AEA
PK 232
• Make any RS-232 compatible computer or terminal a complete digital operating position.
• Morse, Baudot, ASCII, AMTOR, Packet
• Loaded with features.
AEA ALINCO AMERITRON ASTRON AVANTI B&W BENCHER BUTTERNUT COMM SPEC CUSHCRAFT DAIWA
YAESU WELZ VANGORDON SANTEC QUATRON NYE VIKING MIRAGE MFJ LARSEN KLM KENWOOD KENPRO
HUSTLER HYGAIN ICOM • MOST ORDERS SHIPPED SAME DAY • J.I.L. KANTRONICS KDK

```
5 LPRINT "REPEATER AND SIMPLEX FREQUENCIES"
10 LPRINT "IN THE 220-MHz BAND"
15 LPRINT
20 A=222.28
30 B=224.98
40 I=0
50 FOR I=1 TO 150 STEP 1
60 A=A+.02
65 A=INT(A*100)/100
70 IF A<223.4 THEN PRINT A;"INPUT":LPRINT A;"INPUT"
75 IF A<223.9 AND A=>223.4 THEN PRINT A;"SIMPLEX":LPRINT A;"SIMPLEX"
80 IF A=<225 AND A=>223.9 THEN PRINT A;"OUTPUT":LPRINT A;"OUTPUT"
85 IF A=B THEN 100
90 NEXT
100 END
```

fig. 2. This short program generates a printout of common repeater and simplex frequencies on 220 MHz.

frequencies on 220 MHz. I've found that it works without **line 65** on the Radio Shack TRS-80® Model III and their PC-5 Pocket Scientific Computer. When used on an IBM PC® or compatible, however, the algorithm used in the computer causes it to "round up," which adds two extra decimal places! **Line 65** takes care of that glitch. I haven't tried it on other computers, but it's a simple BASIC program that should be easy to translate. The printout will be approximately 2-1/2 pages long.

ham radio

short circuit novice privileges

Because of a profusion of announcements early in the Novice Enhancement program, I used information about Novice privileges on the 10-meter band from a bulletin that was erroneous and missed a later correction. As a result, the information depicted in **fig. 1** of the June, 1987 column (page 95) is incorrect.

The correct Novice 10-meter modes and segments are: CW and digital, 28.1 to 28.3 MHz; CW and voice, 28.3 to 28.5 MHz. — W1SL

✓ 106

✓ 107

✓ 108

✓ 109

ADVERTISER'S INDEX AND READER SERVICE NUMBERS

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

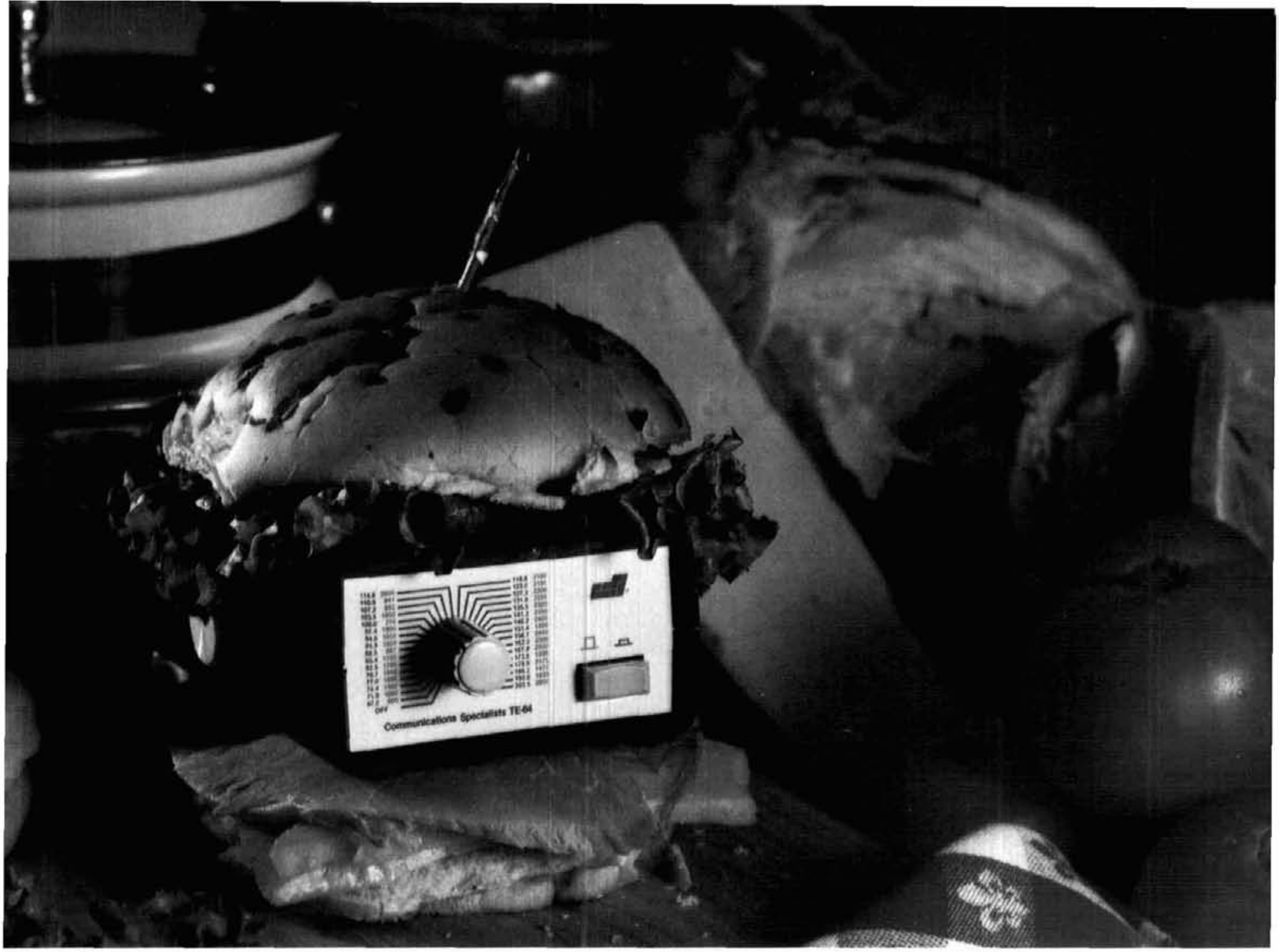
Name ______________________ Call ____________

Address ______________________________________

City ______________ State ________ Zip ________

*Please contact this advertiser directly. Please use before September 30, 1987.

PRODUCT REVIEW/NEW PRODUCTS



Food for thought.

Our new Universal Tone Encoder lends its versatility to all tastes. The menu includes all CTCSS, as well as Burst Tones, Touch Tones, and Test Tones. No counter or test equipment required to set frequency - *just dial it in.* While traveling, use it on your Amateur transceiver to access tone operated systems, or in your service van to check out your customers' repeaters; also, as a piece of test equipment to modulate your Service Monitor or signal generator. It can even operate off an internal nine volt battery, and is available for one day delivery, backed by our one year warranty.

- All tones in Group A and Group B are included.
- Output level flat to within 1.5db over entire range selected.
- Separate level adjust pots and output connections for each tone Group.
- Immune to RF
- Powered by 6-30vdc, unregulated at 8 ma.
- Low impedance, low distortion, adjustable sinewave output, 5v peak-to-peak
- Instant start-up.
- Off position for no tone output.
- Reverse polarity protection built-in.

Group A

67.0 XZ	91.5 ZZ	118.8 2B	156.7 5A
71.9 XA	94.8 ZA	123.0 3Z	162.2 5B
74.4 WA	97.4 ZB	127.3 3A	167.9 6Z
77.0 XB	100.0 1Z	131.8 3B	173.8 6A
79.7 SP	103.5 1A	136.5 4Z	179.9 6B
82.5 YZ	107.2 1B	141.3 4A	186.2 7Z
85.4 YA	110.9 2Z	146.2 4B	192.8 7A
88.5 YB	114.8 2A	151.4 5Z	203.5 M1

- Frequency accuracy, ± .1 Hz maximum - 40°C to + 85°C
- *Frequencies to 250 Hz available on special order*
- Continuous tone

Group B

TEST-TONES:	TOUCH-TONES:		BURST TONES:			
600	697	1209	1600	1850	2150	2400
1000	770	1336	1650	1900	2200	2450
1500	852	1477	1700	1950	2250	2500
2175	941	1633	1750	2000	2300	2550
2805			1800	2100	2350	

- Frequency accuracy, ± 1 Hz maximum - 40°C to + 85°C
- Tone length approximately 300 ms. May be lengthened, shortened or eliminated by changing value of resistor

Model TE-64 **$79.95**

COMMUNICATIONS SPECIALISTS

426 West Taft Avenue, Orange, California 92667
(800) 854-0547/ California: (714) 998-3021

MasterCard VISA

✓ 105


Soak Up Our
Salubrious Savings
ege, inc.
EGE VIRGINIA
14803 Build America Drive, Bldg. B
Woodbridge, Virginia 22191
Information: (703) 643-1063
Service Dept: (703) 494-8750
Store Hours: M-Th: 10—6
F: 10—8
Sat: 10—4
Order Hours: M-F 9—7
Sat: 10-4
EGE NEW ENGLAND
8 Stiles Road
Salem, New Hampshire 03079
New Hampshire Orders,*
Info & Service: (603) 898-3750
Store Hours: MTWSat: 10—4
ThF: Noon—8
*Order & we'll credit you $1 for the call.
VISA
DISCOVER
Terms: No personal checks accepted. Prices do not include shipping. UPS COD fee: $2.35 per package. Prices are subject to change without notice or obligation. Products are not sold for evaluation. Authorized returns are subject to a 15% restocking and handling fee and credit will be issued for use on your next purchase. EGE supports the manufacturers' warranties. To get a copy of a warranty prior to purchase, call customer service at 703-643-1063 and it will be furnished at no cost.
ege, inc.
Spring
Buyer's Guide
Catalog Available
—Send $1.
Antennas
Amateur HF Bands
Cushcraft, Butternut, KLM, Mosley, Hy-Gain, Mini-Products, B&W, Van Gorden, Hustler, Larsen, Antenna Specialists, Centurion, Smiley
Antennas in Stock
for Mobiles, Base Stations, and Handhelds
Everything from mini rubber duckies to huge monobanders
ASK FOR PACKAGE DEALS ON ANTENNAS AND ACCESSORIES
Also...
Antennas for Scanners, CBs, Marine, Commercial, and Short Wave Listening
YAESU
ICOM
KENWOOD
FT 23/73
Mini Handhelds
for 2m/440 MHz
FT 727R
2m/440 MHz Dual Band HT
FT 767GX
All Mode Transceiver
with CAT System
NEW
FT 757GX Mark II
HF Transceiver with
General Coverage Receiver
FRG 9600
Scanning Receiver
for 60-905 MHz FM/AM/SSB
IC 751A
HF Transceiver with
General Coverage Receiver
IC 3200
2m/440 MHz Mobile
IC 275A
All-mode Transceiver
R 7000
General Coverage Receiver
Micro 2AT
Mini 2m Handheld
IC 02AT/03AT/04AT
Handheld for 2m/220/440
TS 440S
HF Transceiver
with Antenna Tuner
TS-940S
HF Transciver with
General Coverage Receiver
New TM 221A/421A
2m/440 MHz Mobile
TH 215AT
2m FM Handheld
TH 21BT/31BT/41BT
Mini Handhelds
for 2m/220 MHz/440 MHz
R 5000
General Coverage Receiver
TRIPP LITE
ASTRON CORPORATION
Power Supplies
TEN-TEC
RX 325
Short Wave Receiver
Paragon
Amateur Transceiver with
General Coverage Receiver
ALINCO ELECTRONICS
ALR-22T
Compact 2m Mobile
More Radios
KDK
FM 240 2m Mobile
SONY
Receivers
REGENCY
BEARCAT
Scanners
MIDLAND
CB Radios
COBRA
CBs, Radar Detectors, Phones
UNIDEN
CBs, Radar Detectors
WHISTLER
Radar Detectors
Towers
UNARCO-ROHN
TRI-EX
HY-GAIN
Ask for package quotes on complete tower assemblies including Phillystran, guy wire, antennas, rotators, etc.
ROTATORS
Kenpro, Alliance, Daiwa, Telex Hy-Gain
Computer Stuff
Packet Controllers
Kantronics and MFJ
Amateur Software
Ham Data Software for Commodore Computers
Ask for Descriptions
RTTY/Morse/Amtor
Hardware and Software and packages by Kantronics, Microlog, HAL, MFJ, & more
Accessories
AMPLIFIERS
Vocom, Daiwa, TE Systems, Amp Supply, Mirage, Alinco, Ameritron, Tokyo Hy-Power, RF Concepts
ANTENNA TUNERS
Amp Supply, Ameritron, MFJ
Switches, Couplers, Filters, Connectors, Mikes, Keyers, Paddles, Headsets, Clocks, Books, Power Supplies
For Orders & Quotes Call Toll Free: 800-336-4799
In New England (except NH): 800-237-0047
In Virginia: 800-572-4201
ege, inc.

KENWOOD

...pacesetter in Amateur radio

220 MHz TH-315A Coming Soon!

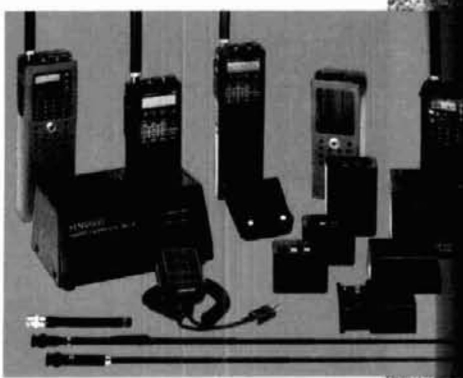
This HT Has it All!

TH-215A/315A/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 hamshack 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 key-pad 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

KENWOOD

KENWOOD U.S.A. CORPORATION
2201 E. Dominguez St., Long Beach, CA 90810
P.O. Box 22745, Long Beach, CA 90801-5745

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