design a no-tune amp on your computer
ICOM IC-751A

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

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

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

Unsurpassed Quality and Reliability. Quality and Reliability is important to you and it's important to ICOM. ICOM now covers you and your investment with its exclusive one year warranty. There's more! The IC-751A's receiver boasts 105dB dynamic range for superb listening. The 100% duty cycle transmitter defies abuse and delivers 100 watts of exceptionally stable and clean RF output. Reliability. Quality. One year warranty. That's ICOM.

All Bands, All Modes Included. Operates 160 through 10 meters, it's easily modified for MARS operation, plus it includes general coverage reception from 100kHz to 30MHz. No compromise, no comparison!

32 Tunable Memories. Store both frequency and mode information. Use them to quick-access your favorite spots or as 32 preferred frequency-remembering VFOs.

A Modern Amateur's Delight! Special attractions include an electronic keyer, semi or full break-in rated to 40 WPM, panel selectable 500Hz/FL-32A CW filter and volume control tracking sidetone. SSB transmissions are enhanced with an RF speech processor and tone control to produce sparkling clear audio. PLUS there's a new rubberized tuning knob for velvet-smooth tuning and a full line of accessories and filters.

RF Power Control. Varies output independent of mic gain. ALC and speech processor action. Enjoy maximum "talk power" at any drive level!

To see the IC-751A, contact your local ICOM dealer.

ICOM America, Inc., 2380-116th Ave NE, Bellevue, WA 98004 Customer Service Hotline (206) 454-7619
3150 Premier Drive, Suite 126, Irving, TX 75063 / 1777 Phoenix Parkway, Suite 201, Atlanta, GA 30349
ICOM CANADA, A Division of ICOM America, Inc., 3071 - #6 Road, Unit 9, Richmond, B.C. V6X 2T4 Canada

All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emissions. 751A187
NOW — ALL KANTRONICS KPCs and KAM ARE TCP/IP NETWORKING COMPATIBLE INCLUDE THE PACKET MAILBOX AND COME WITH 32K RAM

EXTRA FEATURES — NO EXTRA CHARGE

That’s right! Now all Kantronics packet units* include the Personal Packet Mailbox**, come with 32K RAM, and are TCP/IP Networking compatible — ALL AT NO EXTRA CHARGE. And there’s more . . .

KAM and KPC owners** — you can add the Packet Mailbox and TCP/IP compatibility for the special low price of just $15.00.

At Kantronics we’re committed to keeping you current. Check below and see — we offer more features and the best customer support around.

KPC-2™ This low cost/high performance Kantronics TNC features a built-in HF/VHF modem, the Personal Packet Mailbox, full duplex operation, and multiple connect capability. The serial RS-232/TTL port allows easy interfacing with all computers, even Commodores. KPC-2 is TCP/IP Networking compatible, includes 32K RAM, and uses only five front panel indicators for easy operation. Like all Kantronics units, KPC-2 is fully compatible with existing TNCs.

KAM™ KAM is the fully programmable All Mode unit that lets you operate VHF Packet, HF Packet, CW/RTTY/ASCII/ and AMTOR. But that’s not all . . .

Only KAM’s dual VHF/HF radio ports work together for simultaneous Connects, Digipeating, and VHF/HF GATEWAY operations. And now KAM is TCP/IP Networking compatible, comes with 32K RAM, and has the Personal Packet Mailbox ALL STANDARD.

KAM includes watchdog timers on each port, an RS-232/TTL serial port, and a bargraph tuning indicator for HF operation. KAM even comes with an external modem connection point for optional 2400 b/s packet operation. For the greatest degree of sensitivity and flexibility, turn to KAM, Kantronics All Mode.

KPC-4™ Only KPC-4 features simultaneous Connects, Digipeating, and Gateway functions on two fully functional VHF radio ports — each of which includes a watchdog timer. What’s more — you can add 2400 b/s operation to port 2 with Kantronics optional 2400 Modem**.

KPC-4 includes the Personal Packet Mailbox and 32K RAM (expandable to 64K), and is TCP/IP Networking compatible. The RS-232/TTL serial port assures easy interfacing with any computer. Make KPC-4 your GATEWAY into packet flexibility.

* KAM, KPC-2, KPC-4, and KPC-2400 units shipped 7-31-87 or later.
** KAM-1 (Packet Communicator), KPC-2, KPC-4, KPC-2400

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

Suggested Retail $169.00

Suggested Retail $319.00

Suggested Retail $329.00
"DX-citing!"

TS-440S Compact high performance HF transceiver

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

- Covers All Amateur bands
  - General coverage receiver tunes from 100 kHz - 30 MHz. Easily modified for HF MARS operation.
- Direct keyboard entry of frequency
- All modes built-in USB, LSB, CW, AM, FM, and AFSK. Mode selection is verified in Morse Code.

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

100% duty cycle transmitter
Super efficient cooling permits continuous key-down for periods exceeding one hour. RF input power is rated at 200 W PEP on SSB, 200 W DC on CW, AFSK, FM, and 110 W DC AM. (The PS-50 power supply is needed for continuous duty.)

- Adjustable dial torque
- 100 memory channels
- Frequency and mode may be stored in 10 groups of 10 channels each. Split frequencies may be stored in 10 channels for repeater operation.
- TU-8 CTSS unit (optional)
- Subtone is memorized when TU-8 is installed.
- Superb interference reduction
  - IF shift, tuneable notch filter, noise blanker, all-mode squelch, RF attenuator, RIT/XIT, and optional filters tight QRM.
- MC-43S UP/DOWN mic. included
- Computer interface port
- 5 IF filter functions
- Dual SSB IF filtering
- A built-in SSB filter is standard. When an optional SSB filter (YK-88S or YK-86SN) is installed, dual filtering is provided.
- VOX, full or semi break-in CW
- AMTOR compatible

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

Kenwood takes you from HF to OSCAR!
Ham Radio

September 1987

Volume 20, Number 9

Contents

8 Design a no-tune amplifier with your personal computer
W.J. Byron, W7DHD

25 Lightning location and detection
Bill Richardson, VY1CW

30 Designing a microwave amplifier
Stanley J. Domanski, ex-WA1WSD

37 Simple VHF/UHF multiple quarter-wave filters
Ernie Franke, WA2EWT

49 Practically Speaking: revisiting the "poor man's spectrum analyzer"
Joe Carr, K4IPV

57 Ham radio techniques
Bill Orr, W6SAI

65 VHF/UHF world: minimum requirements for 2-meter EME — part 2
Joe Reisert, W1JR

101 Elmer's Notebook: an introduction to AMTOR
Tom McMullen, W1SL

106 Advertisers index and reader service
98 Ham Mart
82 Ham notes
89 New products
4 Reflections
81 Short circuits

6 Comments
85 DX forecaster
96 Flea market

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, $29.95; two years, $53.95; three years, $73.95
Canada, Japan, South Africa, and other countries: $37.00
Europe (via KLM air mail): $37.00
All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

International subscription agents:
Communications Technology, Inc.
Greenville, New Hampshire 03048-0498

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
Copyright 1987 by Communications Technology, Inc.
Title registered at U.S. Patent Office
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

September 1987 3
a sentimental technocrat speaks

Thanks to the rapid evolution of electronic technology, Amateur Radio has seen significant changes during the past few years. While many of us fully endorse this advancement of the radio art, some of us are hopelessly sentimental technocrats who sense, over time, a qualitative change for the worse.

Therefore, I hereby submit my opinions on a wide range of issues confronting Amateur Radio. You won’t find any engineering measurements, quantified results, or empirical thinking — just unabashed emotionalism. Some of it might be totally wrong. But that’s OK — this is a guest editorial, not a technical article. Besides, there comes a time when a guy’s got to say what he really thinks!

I’ve divided my list of issues into two parts: the stuff I don’t like and the stuff I do like. “Stuff,” by the way, can be anything. Nothing is too sacred for scrutiny.

I really don’t like:

PLL synthesizers, radios with memories, plastic cabinets, RCA jacks, circuit boards that disintegrate when they’re touched, aluminum capacitors, fm, antenna traps, monolithic radios, on-board rf white noise generators (i.e., microprocessors), cable TV connectors, computer-generated QSL cards, articles that prove Yagis better than quads (even if they’re right), FCC dockets (that’s right — all of them), the Woodpecker, consumer electronics (Have you listened to your high-tech digital readout clock radio lately? I bought one because I like to wake up to music rather than a buzzer. But with my clock radio, I can’t tell the difference!), multiple-choice code exams, profanity on the air, anti-antenna ordinances, cable TV “installation” charges, the technical quality of cable TV, fm stereo separation on cable systems, cable TV customer service, 2-meter video channels on cable systems, anything with 75-ohm impedance, disassociation of call districts, lamp dimmers, and the notion that the electromagnetic spectrum exists exclusively for commercial use.

On the other hand, I really do like:

Station logs, any radio component made from ceramic, glass, copper, or silver; oil-filled capacitors (toxic or not), vacuum variable capacitors, open-wire transmission lines, wire beam antennas (double extended zepps, stacked, phased, and fed with open-wire line), old QSL cards, old “How’s DX?” columns (the kind with the grass-thatched shack, palm tree, and precarious dipole . . . where did the romance go?), Jeeves cartoons, the old smaller-sized ham radio and QST magazines (In high school I could hide them under my history book. How can kids hide them nowadays?); old E. F. Johnson, National, Collins, and Hammarlund radios; new radios built for radio performance, front panels that look like they belong on radios instead of computers, moonbounce, really big quads, astronomically large parabolas, computerized RTTY (Here’s where a computer in the shack makes sense. Remember those noisy old electromechanical clunkers?), anything homebrew, GaAs LNAs, prop-pitch motors, PTO oscillators, houses built around the ham shack, XYLs who really do understand, kids who don’t sneak ham magazines into history class, tubes, FETs (they’re more like tubes than bipolar), volunteer examinations (taking the old exams was like visiting the Spanish Inquisition), mountain-top QTHs, analog clocks in the shack (especially the 24-hour brass ship’s clocks with chimes), multicolored great circle maps not centered on Kansas (somebody in Kansas sure has a lot of clout!), Silicon Valley and New York-area surplus dealers, very expensive linear amplifiers, high-dynamic range anything, low-noise anything, high-gain anything, anything simple yet adequate, anything slightly more complicated yet outstanding, two miles of buried No. 8 copper wire, full-size 160-meter antennas (they work on 80 as well), antennas too high for W2PV, receivers that confound W7ZOI (I’m still waiting for that day), my copy of Terman’s Radio Engineer’s Handbook, the W6GO QSL list, W6SAI’s columns (he really likes tubes), ham dealers who sell used parts (good stuff, cheap), big heavy rigs with rf ammeters, Smith charts, swap meets (lots of good stuff, cheap), and finally, magazines crazy enough to publish this.

Robert J. Zavrel, Jr., W7SX
Tucson, Arizona
Ultimate Affordable HT!

TH-205AT

Affordable 5-watt hand-held transceiver. Ultimate Affordability!

It's here now! The affordable, "Kenwood Quality" hand-held transceiver. Standard features include a large, easy-to-read LCD display, wide-range power requirements (operates on 7.2 VDC-16 VDC), 3-channel memory, built-in battery saver circuit, and, when operated on 12 VDC, a robust five watts of power! The die-cast metal rear panel/heat sink assures cool, reliable operation.

Receiver frequency coverage from 144-148 MHz is also standard— you can even listen to the "weather channels" at 162.40 or 162.55 MHz!

- Monitor switch—to check frequency when PL encode/decode switch is on.
- Extended frequency coverage for certain MARS and CAP operations.
- 3 memory channels store frequency and offset. And so easy to use! Simply press the memory channel number to recall your favorite channels!
- Night light, offset/reverse.
- 16-key DTMF pad for repeater autotransmission is standard.

- NEW! Twist-Lok Positive-Connect™ battery case. A wide range of quick-change commercial duty battery packs are available.

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.
The following is a copy of a letter addressed to the FCC by W.G. Welsh, who kindly shared it with us. — Ed.

I am pleased that you separated Technician and General written examination material. I had suggested this step in two previous letters I wrote to you about 30 years ago. I hope you will continue this trend and separate code tests. At present, Novice and Technician applicants must pass element 1-A, which is 5 WPM. At present, General and Advanced applicants must pass element 1-B, which is 13 WPM. The Extra Class requirement is element 1-C at 20 WPM.

I believe a separate code test requirement is appropriate for each class of license. I think the code test speeds would be appropriate at 4 (Novice), 8 (Technician), 12 (General), 16 (Advanced), and 20 (Extra Class).

Most beginning Novices send code about 3 WPM. A code test at 4 WPM is more appropriate to their initial needs. The receiving test should be restored to forward-reading plain language text that just includes letters. Punctuation marks, numerals, and work signs were previously restricted to the sending test, which should still be suitable. The international requirement is that all applications for Amateur Radio operator licenses, that involve operating privileges below 30 MHz, must prove their ability to receive (by ear) and to send (by hand) the International Morse Code. I believe that this requirement can be met more easily at the Novice level than in the VE (Technician through Extra Class) test program.

The jump from 5 to 13 WPM is drastic. Allowing candidates to move up in increments of 4 WPM should be beneficial. The proposed 8 and 12 WPM Technician and General code test requirements should help increase upgrades.

Similarly, the difference between 13 and 20 WPM is pronounced. The proposed 16 WPM Advanced code test requirement would be more conducive to upgrading to the 20-WPM Extra Class requirement.

Each step up in license grade entails increased operating spectrum wherein code may be used. It seems reasonable that the associated code test speed requirements should be separate and evenly stepped from the lowest to the highest license.

I have conducted Amateur Radio operator licensing courses every year since 1948. I am very active helping students. I know their problems and needs.

I hope you will give this matter prompt attention.

William G. Welsh, W6DDB, Burbank, California 91504-3297.

KLM balun

Dear HR:

Over the past year there it has been stated that some of our antennas (the 11X, 13LBA, and 16 LBX for 2 meters and the 14X and 22LBX for 220 MHz) had extremely high VSWR because the baluns were of the wrong length. These antennas are very sensitive; their leads must be as short as possible and balanced.

To remove any possibility of connecting the antennas improperly, we have developed a connector that is being supplied on all new antennas. In addition, anyone who has one of the antennas identified above may call us, toll-free, at 1-800-538-2140 (outside California) or 408-779-7363 (collect, from within California), and we'll be happy to send a connector free of charge.

W.M. Scott
Mirage/KLM Communications Equipment, Inc.
P.O. Box 1000
Morgan Hill, California 95037

novice calling frequency

Dear HR:

The 10-meter Novice band still needs an easy-to-remember calling frequency. I suggest making 28.1010 MHz the Novice 10-meter calling frequency. So, get in 28.1010 and give a call!

Henry Hampel, KAO7UP, St. Louis, Missouri 63116

elmers at work

Dear HR:

Received my ham radio today and as usual found some interesting reading. I think your new column, "Elmer's Notebook," by Tom McMullen, W1SL, can become a very useful part of the magazine, depending upon how it's handled.

We've established an Elmer committee in our club. Committee members are available to help out new Novices, and the committee has a supply of equipment to lend to the new hams until they can get some of their own.

In checking back on about 100 Novices licensed in the past several years, we found that many of them never became active. By actively working with new Novices as they become licensed, perhaps we'll be able to keep them interested.

George A. Diehl
Chatham, New Jersey 07928-1179
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 are easy to read 2 color lighted needle (needs 12 V). A handsome black brush 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 to 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 access to each of the room. 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, 4½x7½ inches. MFJ-107, 2½x4½ 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. 4½ balun. 250 pf, 6 kv variable capacitors. 12 position ceramic inductor switch. Smaller size matches 10% 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.

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

MFJ ... making quality affordable

TO ORDER OR FOR YOUR NEAREST DEALER CALL TOLL FREE

800-647-1900
Call 601-323-5869 in Miss. and outside continental USA. Telex 53 4590 MFJ STKV
Try a broadband approach for instantaneous coverage

**tank design**

Two obvious possibilities for the tank design are Pi-section and L-section tank circuits. In the former, $Q$ is selectable (down to some minimum value), and in the latter, it usually isn't. Because the no-tune concept requires a lower $Q$, and because there's one less component, the L-section was chosen. This particular design is based on an amplifier with two 3-500Zs whose plate load resistance has been calculated as 2080 ohms. The design center frequency is 14.2 MHz. The amplifier also has plug-in tank and filter circuits (shades of World War II!), but that bears little on the design calculations.

**L-section calculations**

The algebraic equations for the tank circuit design, available from several sources,¹ are:

$$X_L = \sqrt{R_1 \cdot R_2 - R_2^2}, \quad \text{and} \quad X_C = \left( -R_1 \cdot R_2 / X_L \right) \text{ for } R_1 > R_2$$

A small BASIC program for computing the values is provided in fig. 2. Although $Q$ isn't mentioned in the program, it can be calculated easily in this case by:

$$Q = X_L / R_2 = 318.6/50 = 6.372$$

The value calculated is adequately low for our purposes, but too low to be used without some kind of a follow-up filter; one wouldn't build an amplifier with only these characteristics, however. **Figure 3** shows the values of $Q$ for L-sections that convert to 50 ohms. Coincidentally, they’re the minimum values obtainable with the Pi-section.

**By W. J. Byron, W7DHD, P.O. Box 2789, Sedona, Arizona 86336**
the low-pass filter

Low-pass filters can be designed either from scratch or from tables produced by others. The first filter selected has the following characteristics:

- f(-3 dB): 1.638 MHz
- f(-20 dB): 2.349 MHz
- f(-50 dB): 4.48 MHz

L1, L5 (µH): 4.377
C2, C4 (pF): 3300
L3 (µH): 9.747

These numbers represent the values necessary for the listed frequencies. The table from which this filter came lists filters designed around "standard-value" components — in this case, the 3300-pF capacitors. As a result of this compromise, the VSWR of the network terminated by 50 ohms will be 1.06. The component values for a 10X increase in frequency will be one tenth of the values shown for the capacitors and inductances. The latter values were used for the first investigation. Another filter was designed from scratch (with the aid of the W1JR/WA1GRC CAD program); the results are also presented here. It was selected to have the same 16.38-MHz cutoff as the filter above. Both have the Chebyshev response.

The amplifier's performance can be simulated by actually calculating all the voltages and currents around the circuit. The combination of the L-section and five-element filter plus the 50-ohm terminating resistor makes a four-unknown set of equations. Power output is \( R2 \cdot I_2^2 \). The plate voltage is indicat-

---

fig. 1A. Basic matching circuit: the L-section on the left transforms 2080 to 50 ohms; the symmetrical low-pass filter on the right operates at 50 ohms input and output, and has a cut-off frequency of 16.38 MHz.

fig. 1B. Basic matching circuit: inductances L5 and L1 are combined into a new inductance, L1. The four loop currents used in deriving the equations in the text are shown with their orientation.

---

10 REM R1 MUST BE LARGER THAN R2
20 INPUT "ENTER THE LARGER RESISTANCE";R1
30 INPUT "ENTER THE SMALLER RESISTANCE";R2:PRINT
40 XL = SQR(R1*R2-R2^2)  
50 XC = -(R1*R2)/XL
60 PRINT "XL = ";XL; " Ohms, and" XC = ";XC; " Ohms":PRINT
70 INPUT "ENTER THE FREQUENCY IN MHZ";F:PRINT
80 F = F*1000000!
90 W = 2*3.14159*F
100 PRINT "L = ";(XL/W)*1000000!; " Microhenrys"
110 PRINT "C = ";-(1/(W*XC))*1E+12; " Picofarads"
120 END

RUN
ENTER THE LARGER RESISTANCE? 2080
ENTER THE SMALLER RESISTANCE? 50

XL = 318.5906 Ohms, and XC = -326.4377 Ohms

ENTER THE FREQUENCY IN MHZ? 14.2

L = 3.570797 Microhenrys
C = 34.33459 Picofarads
Ok

fig. 2. BASIC program for computing L-section elements. The values shown for L and C are for the example described in the text.
Val Comm Inc. now offers from SSB Electronics of West Germany the newest development in linear transverters designed with previously unobtainable technical specs. The transverters and converters are offered from 6 meters through 10 GHz. IF's are available for 10 M (28.300MHz) and 2 M (144-146MHz). The above photo shows LT23S, 1296 MHz transverter with 144 MHz IF. Power output is 10 watts with IF drive (28-144MHz) internally adjustable to accept 100 MW to 10 watt input. The low noise figure GaAs-FET preamp and mixer gives an overall noise figure of 1.8 DB or better. A complete line of in-line and RF switched preamps are available from 2M thru SHF. Receive only converters are available for all bands.

Look to SSB Electronics from Val Comm Inc. for the best in VHF through SHF for weak signal to satellite communications. Val Comm Inc. is the only factory authorized sales and service of SSB Electronics in the U.S.A.

TECHNICAL DATA
(Call for latest product developments):

<table>
<thead>
<tr>
<th>Transverter</th>
<th>Converters - Receive Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT02S 144/28</td>
<td>K5001 50MHz w/28 IF</td>
</tr>
<tr>
<td>LT23S 1296/144</td>
<td>K2001 144MHz w/28 IF</td>
</tr>
<tr>
<td>LT33S 902/144</td>
<td>K7001 432MHz w/28 IF</td>
</tr>
<tr>
<td>LSM 24 Oscar Model L</td>
<td>K2301G 1296MHz w/144 IF</td>
</tr>
</tbody>
</table>

Also 2M and 70 CM Transverters

<table>
<thead>
<tr>
<th>Preamp</th>
<th>DCW15A Sequence for all MV series Preamps</th>
</tr>
</thead>
<tbody>
<tr>
<td>MV 144S-01 Preamp 0.5 NF 15/25 DB RF Switched</td>
<td></td>
</tr>
<tr>
<td>MV 432S-01 Preamp 0.7 NF 15/25 DB RF Switched 500W</td>
<td></td>
</tr>
<tr>
<td>MV 1296S-01 Preamp 1.0 NF 16 DB RF Switched 200W</td>
<td></td>
</tr>
</tbody>
</table>

SHF

| 2304 | SLO 13 L/Oscil |
| SLA 13 Amp 4 Watts |
| SRM 13 Rec/Mixer — 144MHz |
| STM 13 Xmit |
| 10.3 GHZ | XRM-1 Rec/Mixer — 144MHz |
| XTM-1 Xmit/Mixer — 144MHz 100MW | (Option 01-200MW) |
| XLO-1 L/Oscil 2566MHZ |

For the best in VHF through SHF, SSB Electronics.
ed as “E” in fig. 1B. Four equations are needed to solve for the four currents (Kirchoff’s loops require this). All have complex coefficients. The equations below are in simplified form, but they’re the ones that must be solved:

\[ I_1(R_p + X_{C1}) - I_2(0 + X_{C1}) + I_3(0 + 0) + I_4(0 + 0) = (E + j0) \] (1A)

\[-I_1(0 + X_{C1}) + I_2(0 + X_{C1} + X_{L1} + X_{C2}) - I_3(0 + X_{C2}) + I_4(0 + 0) = (0 + j0) \] (1B)

\[ I_1(0 + 0) - I_2(0 + X_{C2}) + I_3(0 + X_{C2} + X_{L3}) - I_4(0 + X_{C4}) = (0 + j0) \] (1C)

\[ I_1(0 + 0) + I_2(0 + 0) - I_3(0 + X_{C4}) + I_4(R_3 + X_{L5} + X_{C4}) = (0 + j0) \] (1D)

A short program following the simplified form above is used to evaluate the currents. The only real numbers in the equations are \(R_p\), \(R_2\), and \(E\), plus the leading zeros inside the parentheses. All other numbers are imaginary. The \(X_L\)’s are intrinsically positive, and the \(X_C\)’s are negative (\(X_C = -j/(2\pi fC)\)). The “coefficients” program is listed in fig. 4. Lines 100 through 240 provide a listing of the reactances, which were useful during the design. They can be eliminated if desired, because the coefficients themselves are produced in lines 250 through 510 (including, of course, lines 10 through 90). An example of the output of the coefficients program is shown in fig. 5.

Now the equations must be solved. One of the best

---

**UNADIL</p>
2x4Z BASE REPEATER ANTENNA

THE HIGHEST GAIN DUAL BAND BASE/REPEATER ANTENNA

HIGH POWER 200 WATTS

FREQUENCY: BROAD BAND
140-170 MHz
410-470 MHz

GAIN:
VHF - 8.2dB
UHF - 11.5dB
VSWR - 1.1-1.2 or less

CONNECTOR:
N TYPE FEMALE

LIGHTNING PROTECTION
GROUNDED DIRECT

LENGTH: 16 FT.
WEIGHT: 5 LBS. 3 OZ.
WIND LOAD: 90 MPH
MOUNTING: UP TO 2 IN. MAST
CAN SIMULCAST ON BOTH BANDS

WATERPROOF
CONNECTING JOINTS

UPS SHIPPABLE

AMATEUR SPECIAL

1275 NORTH GROVE ST.
ANAHEIM, CALIF. 92806
(714) 630-4541
CABLE: NATCOLGIZ
FAX (714) 630-7024

--

fig. 4. BASIC program for calculating the coefficients for the Gauss-Jordan elimination solutions.

- The ORIGINATOR of the VHF AMP/PREAMP COMBO!
- YOU KNOW THE LUNAR NAME...NOW OWN THE BEST.
- Solid State Amplifiers for 50, 144, 220, 440 MHz

NEW! GaAs FET Receive Preamp Built-In!
NEW! UHF Models of Latest Design!
NEW! Model V2-500 for Two Meters...
500 Watts Output in a Deluxe Package!

See your dealer or call

177

12 September 1987
techniques available is known as the Gauss-Jordan elimination. The main program, listed in fig. 6, is taken from what is probably the best source of scientific and engineering programs currently available. Its input requires that the coefficients be entered in order; the first real number of the first equation (Rp in this case) through the imaginary component of the last constant (j0 of the right-hand side of the equation for I4).

**solving the problem**

The first attempt was to use the values for the calculated L-section above, followed by the filter from reference 2. Because the L-section has an inductor as the output and the filter was selected to have an inductor as an input element (one can also choose a filter with a capacitive input), these were combined into one inductor (see fig. 1B). With the values so determined, they were typed into the coefficients program. It will yield pages of coefficients, depending on the range and increments (steps) one chooses in the FOR-NEXT loops.

As it turned out, although an amplifier constructed around these components would have worked moderately well, it would show the effects of the compromises in the filter designed around standard values. By sweeping the frequency, it was easy to see that the L-section capacitor was too small. Nevertheless, the capacitor would have delivered 90 percent of the power delivered by the matched L-section alone. The next step was to “tune” C1 by modifying the coefficients program to fix the frequency at 14.2 MHz, and then vary the value of C1. The results of this are shown in fig. 7. The output follows the typical resonance response, just as if the capacitor were tuned by hand in a real amplifier. From this plot, it’s evident that the value for C1 should be changed from 34 to 37 pF. The results are shown in fig. 8; also shown is the response of an L-section and filter designed for that use, with exact-size components employed.

The output of the Gauss-Jordan routine, an example of which is shown in fig. 9, gives currents in both polar and Cartesian coordinates. The “magnitude” is the same as a scalar value. If it appears as, say, the current in R2, there’s no complication; use it as it stands. If it’s necessary to know what current is flowing in C2, however, one must take the vector difference between the two currents flowing in “opposite” directions through C2. The source voltage for these problems is arbitrary; I’ve specified it as E + j0. All other listed phase angles are referenced to that voltage. They’re important only when the design requirement might be a specific phase angle. Here it’s not a design criterion — but as described above, the phase angles must be considered when determining the ratings of components used in the amplifier.

**sizing components**

The curves of fig. 7 were calculated by assuming an ac plate voltage of 3000. The power outputs were between 900 and 1100 watts. It requires just over 3500 volts to achieve 1500 watts output. When 3500 + j0 is used for the input to the program, I4 reaches 5.39
of Varian EIMAC's 50 Years of Engineering Expertise.

Why do EIMAC tubes deliver more reliable hours of operation than the competition? Look inside the EIMAC 8122W. You'll see a ceramic pin in the top of the grid-screen structure that assures alignment, even under the most strenuous environmental conditions. And you'll note that the grids are made of high-strength molybdenum, not yielding copper. But these improvements don't tell the whole story.

The invisible ingredient built into each EIMAC tube is the careful attention to detail, the continual testing and evaluation, and the engineering knowledge that has characterized EIMAC products for over 50 years.

Other members of the EIMAC 8122W long-life family are the 8121W, 8072W, 4657 and the 4662 tube types. Try them in your equipment. You won't see the difference but you will know the difference.

For quality, experience and dependability, rely on the Varian EIMAC name. The tradition of excellence lives on.

For more information on the 8122W family of ruggedized tetrodes, call or write, Varian EIMAC. Ask about our 3,000 hour warranty.

Varian EIMAC Division
301 Industrial Way
San Carlos, CA 94070
Telephone: (415) 592-1221
fig. 6. The Gauss-Jordan elimination routine in BASIC. (Reproduced from BASIC Programs for Scientists and Engineers, by Alan R. Miller, copyright 1982, SYBEX, Inc., Alameda, California 94501. All rights reserved.)

```basic
10 REM SIMULTANEOUS SOLUTION OF COMPLEX EQUATIONS
20 REM BY THE GAUSS-JORDAN ELIMINATION TECHNIQUE
30 REM
40 A$ = "#### !!!!!!"
50 B$ = " = #### !!!!!!"
60 C$ = " !!!!!! !!!!!! !!!!!! !!!!!! !!!!!! !!!!!! !!!!!! "
70 M1% = 8
80 DIM Z(8), A(8,8), C(8), W(8,1), B(8,8), I2%(6,3)
90 DIM D4(4,4), D5(4,4), V(4,2)
100 P8 = 180/3.14159
110 REM
120 REM
130, REM
140 GOSUB 410: REM INPUT ROUTINE
150 GOSUB 790: REM GAUSS-JORDAN ROUTINE
160 REM
170 IF (N1%>5) THEN 250
180 PRINT "MATRIX CONSTANTS"
190 FOR I% = 1 TO N1%
200 FOR J% = 1 TO N2%
210 PRINT USING A$; A(I%, J%)
220 NEXT J%
230 PRINT USING B$; Z(I%)
240 NEXT I%
250 PRINT
260 IF (E1% = 1) THEN 400
270 PRINT "REAL IMAGINARY MAGNITUDE ANGLE"
280 PRINT
290 FOR I% = 1 TO N2%/2
300 J% = 2*I% - 1
310 R2 = C1(J%)
320 I6 = C1(J% + 1)
330 M3 = SQR(R2*R2+16*I6)
340 IF (R2>0) THEN A1 = ATN(I6/R2)*P8
350 IF (R2 = 0) THEN A1 = SGN(I6)*90
360 IF (R2<0) THEN A1 = ATN(I6/R2)*P8+180
370 PRINT USING C$; R2, I6, M3, A1
380 NEXT I%
390 PRINT
400 GOTO 140: REM NEXT SET OF EQUATIONS
410 REM
420 REM INPUT DATA
430 REM
440 INPUT "HOW MANY EQUATIONS"; N1%
450 IF(N1%>(M1%/2)) THEN 440
460 IF(N1%<2) THEN 1860
470 N2% = N1%
480 FOR I% = 1 TO N1%
490 PRINT "EQUATION"; I%
500 K% = 0
510 L% = 2*I% - 1
520 FOR J% = 1 TO N1%
530 K% = K% + 1
540 PRINT "REAL "; J% " ";
550 INPUT D4(I%, J%)
560 A(L%, K%) = D4(1%, J%)
570 A(L%+1, K%+1) = D4(1%, J%)
580 K% = K% + 1
590 PRINT "IMAG "; J% " ";
600 INPUT D5(1%, J%)
610 A(L%, K%) = -D5(1%, J%)
```

Hustler VHF and UHF antennas offer a combination of gain, durability and value which have made them the antenna most often demanded for repeater applications.

Reliability and Performance - Beyond Your Expectations

**G7 - 144**

**Electrical**
- Gain 7dBi
- VSWR 3 MHz under 1.5:1
- Lightning Protection
  - Shunt Fed - DC ground
- Termination
  - Type N Female

**Mechanical**
- Length 15'4"
- Weight 10 lbs.
- Wind Survival 100 mph
- Mounting Up to 2" mast.

**G7 - 220**

**Electrical**
- Gain 7dBi
- VSWR 4 MHz under 1.5:1
- Lightning Protection
  - Shunt Fed - DC ground
- Termination
  - Type N Female

**Mechanical**
- Length 10'2"
- Weight 7.0 lbs.
- Wind Survival 110 mph
- Mounting Up to 2" mast.

**G6 - 440**

**Electrical**
- Gain 8dBi
- VSWR 8 MHz under 1.5:1
- Lightning Protection
  - Shunt Fed - DC ground
- Termination
  - Type N Female

**Mechanical**
- Length 7'3"
- Weight 16 lbs.
- Wind Survival 125 mph
- Mounting Up to 2" mast.

HUSTLER, INC. • One Newtronics Place • Mineral Wells, Texas 76067 • (817) 325-1386
620 \text{A(L\%+1,K%-1) = D5(I\%,J\%)}
630 \text{NEXT JK}
640 \text{INPUT "REAL CONST "; V1(I\%,1)}
650 \text{Z(L\%) = V1(I\%,1)}
660 \text{INPUT "IMAG CONST "; V1(I\%,2)}
670 \text{Z(L\%-1) = V1(I\%,2)}
680 \text{NEXT 1\%}
690 \text{PRINT: REM PRINT ORIGINAL MATRIX}
700 \text{FOR I\% = 1 TO N1\%}
710 \text{FOR J\% = 1 TO N2\%}
720 \text{PRINT D4(I\%,J\%);D5(I\%,J\%);}
730 \text{NEXT JK}
740 \text{PRINT V1(I\%,1);V1(I\%,2)}
750 \text{NEXT 1\%}
760 \text{N1\% = 2*N1\%}
770 \text{N2\% = N1\%}
780 \text{RETURN: REM FROM INPUT ROUTINE}
790 \text{REM GAUSS-JORDAN ROUTINE}
800 \text{REM}
810 \text{REM}
820 \text{E1\% = 0}
830 \text{I5\% = 1}
840 \text{N3\% = 1}
850 \text{FOR I\% = 1 TO N2\%}
860 \text{FOR J\% = 1 TO N2\%}
870 \text{B(I\%,J\%) = A(I\%,J\%)}
880 \text{NEXT JK}
890 \text{W(I\%,1) = Z(I\%)}
900 \text{I2\%(I\%,3) = 0}
910 \text{NEXT 1\%}
920 \text{D3 = 1}
930 \text{FOR I\% = 1 TO N2\%}
940 \text{REM}
950 \text{REM}
960 \text{REM}
970 \text{B1 = 0}
980 \text{FOR J\% = 1 TO N2\%}
990 \text{IF (I2\%(J\%,3)=1) THEN 1060}
1000 \text{FOR K\% = 1 TO N2\%}
1010 \text{IF (I2\%(K\%,3)>1) THEN 1850}
1020 \text{IF (I2\%(K\%,3)=1) THEN 1070}
1030 \text{IF (B1=ABS(B(J\%,K\%))) THEN 1070}
1040 \text{13\% = J\%}
1050 \text{14\% = K\%}
1060 \text{B1 = ABS(B(J\%,K\%))}
1070 \text{NEXT K\%}
1080 \text{NEXT J\%}
1090 \text{I2\%(I4\%,3) = I2\%(I4\%,3)+1}
1100 \text{12\%(I\%,1) = 13\%}
1110 \text{12\%(I\%,2) = 14\%}
1120 \text{REM}
1130 \text{IF (I3\% = 14\%) THEN 1270}
1140 \text{D3 = -D3}
1150 \text{FOR L\% = 1 TO N2\%}
1160 \text{H1 = B(13\%,L\%)}
1170 \text{B(13\%,L\%) = B(14\%,L\%)}
1180 \text{B(14\%,L\%) = H1}
1190 \text{NEXT L\%}
1200 \text{IF (N3\%<1) THEN 1270}
1210 \text{FOR L\% = 1 TO N3\%}
1220 \text{H1 = W(I3\%,L\%)}
1230 \text{W(I3\%,L\%) = W(I4\%,L\%)}
1240 \text{W(I4\%,L\%) = H1}
1250 \text{NEXT L\%}
1260 \text{REM}
"MTI" is the only smart interface box that works with SilicoNE Solutions™ software.

"MTI" Offers automatic tracking of any orbiting body.

"MTI" keeps antennas aimed correctly at all times.

"MTI" comes with a one year warranty from Mirage/KLM.

"MTI" offers one year software support to registered owners.

"MTI" is available from Mirage/KLM only. Call for more details...

(408) 779-7363 or outside CA, (800) 538-2140

CALL YOUR DEALER TO ORDER ONE NOW!

**CJ2M**

**ELECTRICAL:**
- BANDWIDTH: 144-148 MHz
- GAIN: 1.6 dBi
- VSWR: 1.5:1
- FEED IMP: 50 ohms

**MECHANICAL:**
- NO GROUND PLANE REQUIRED
- HEIGHT: 40°
- WEIGHT: 2 lbs.
- MAST: 1½" o.d.

**CJ220**

**ELECTRICAL:**
- BANDWIDTH: 220-224 MHz
- GAIN: 1.8 dBi
- VSWR: 1.5:1
- FEED IMP: 50 ohms

**MECHANICAL:**
- NO GROUND PLANE REQUIRED
- HEIGHT: 40°
- WEIGHT: 2 lbs.
- MAST: 1½" o.d.

**CJ440**

**ELECTRICAL:**
- BANDWIDTH: 420-470 MHz
- GAIN: 1.8 dBi
- VSWR: 1.5:1
- FEED IMP: 50 ohms

**MECHANICAL:**
- NO GROUND PLANE REQUIRED
- HEIGHT: 19¾°
- WEIGHT: 1 lb.
- MAST: 1½" o.d.
1270 P1 = B(I4%, I4%)
1280 D3 = D3 * P1
1290 B(I4%, I4%) = 1
1300 FOR LX = 1 TO N2X
1310 B(I4%, LX) = B(I4%, LX) / P1
1320 NEXT LX
1330 IF (N3% < 1) THEN 1390
1340 FOR LX = 1 TO N3X
1350 W(I4%, LX) = W(I4%, LX) / P1
1360 NEXT LX
1370 REM
1380 REM
1390 FOR L1% = 1 TO N2X
1400 IF(L1% = 1) THEN 1450
1410 T = B(L1%, I4%)
1420 B(L1%, I4%) = T
1430 FOR LX = 1 TO N3X
1440 B(L1%, LX) = B(L1%, LX) - B(I4%, LX) * T
1450 NEXT LX
1460 IF (N3% < 1) THEN 1500
1470 FOR LX = 1 TO N3X
1480 W(L1%, LX) = W(L1%, LX) - W(I4%, LX) * T
1490 NEXT LX
1500 NEXT L1%
1510 NEXT LX
1520 REM
1530 REM
1540 FOR I% = 1 TO N2X
1550 L% = N2X - I% + 1
1560 IF(I% = 1) THEN 1570
1570 IF(I% = 1) THEN 1650
1580 I3% = 12%(L%, I%)
1590 I4% = 12%(L%, 2)
1600 FOR K% = 1 TO N2X
1610 H1 = B(K%, I3%)
1620 B(K%, I3%) = B(K%, I4%)
1630 B(K%, I4%) = H1
1640 NEXT K%
1650 NEXT I%
1660 FOR K% = 1 TO N2X
1670 IF(K% = 1) THEN 1680
1680 NEXT K%
1690 E1% = 0
1700 FOR J% = 1 TO N2X
1710 C1(J%) = W(I%, J%)
1720 NEXT J%
1730 IF(I% = 1) THEN 1740
1740 PRINT
1750 PRINT " Matrix Inverse"
1760 FOR I% = 1 TO N2X
1770 FOR J% = 1 TO N2X
1780 PRINT USING A$; B(I%, J%);
1790 NEXT J%
1800 PRINT
1810 NEXT I%
1820 PRINT
1830 PRINT " Determinant = "; D3
1840 RETURN; REM IF INVERSE IS PRINTED
1850 E1% = 1
1860 PRINT " ERROR - Matrix is Singular"
1870 RETURN; REM From Gauss-Jordan Subroutine
1880 END
amperes. Thus the calculated power output is about 1453 watts.

What stress is there on the rf amplifier components? The first thing we see is the voltage across C1. Common sense dictates that C1 should have a voltage rating of perhaps 4000 volts. The current through it is less than that flowing through C2. It doesn't seem to be a problem; there's less stress on that capacitor than there would be if the circuit had been a Pi-section. One normally assumes that the heaviest currents are locked up in the tank. But that's not so in this case; the heaviest rf current in the whole system is in the midsection of the filter! It's nearly 10 amperes for \( E = 3000 \) peak ac volts, and will be even higher for the 3500+ volts required for maximum legal output power.

Let's calculate the current through \( C_4 \), the difference between \( I_3 \) and \( I_4 \). The vector difference is:

\[
I_3 = -7.327 + j2.835 \\
I_4 = 2.356 + j4.844 \\
I_{C4} = I_3 - I_4 = -9.683 - j2.009 \\
I_{C4} \text{ (scalar)} = 9.89 \text{ amperes}
\]

The voltage across \( C_4 \) is:

\[
I_{C4} \cdot (X_{C4}) = (9.89)(34.4) = 340 \text{ volts}
\]

Similar calculations can be made for all the other com-
ponents. While “postage-stamp” capacitors could stand the voltage, they wouldn’t tolerate the nearly 10-ampere current. Large transmitting-type or homemade capacitors must be used.

The capacitors for this amplifier are constructed from thin copper sheet, aluminum, and 0.030-inch Teflon™ sheet. For the 20-meter band, C2 and C4 are both approximately 300 pF. A homemade two-plate capacitor would measure only a few square inches in area; one side would be the amplifier chassis (or in this case, the bottom plate of the plug-in). All coils are fabricated from No. 10 copper wire. Had this been a Pi-section tank or even a Pi-L tank with the equivalent attenuation ratio of this design (without follow-up filter) the loaded Q would have had to be greater than 30, and the tank coil itself would have to be made of 1/4-inch diameter or larger copper tubing.

The same Gauss-Jordan routine may be used to calculate the attenuation at higher frequencies. Use the design values for components in the coefficients program, but change the frequency range and steps. The calculated attenuation at the second harmonic of this design is better than 50 dB; it’s plotted in fig. 10.

All of the foregoing involves calculations with complex numbers. Figure 11 contains BASIC routines that can be used as they stand, included as subroutines that can be used as is, or be included as subroutines in a larger program. The solution in the figure is for $I_{c4}$.

**Conclusion**

While the bulk of this work was done on a Tandy™ 2000 and the programs are written in MS-DOS BASIC, even the large matrix-handling program
fig. 10. Calculated total network responses from 14.0 to 30.0 MHz. Both the text-designed and the CAD designed network responses are plotted.
This article has defined a design problem, outlined the steps used to solve it with a PC, and produced a viable design that could probably be built with reasonable assurance that the final product would work. What began with an innocent question — "How is a no-tune amplifier designed?" — has ended with an amplifier actually under construction. Every design number and every program necessary to duplicate or extend that design have been presented here.

**acknowledgments**

I wish to thank Forrest Gehrke, K2BT, and Frank Chess, K3BN, for their useful suggestions and for their help in organizing this article.

**references**

1. The Radio Amateur's Handbook, American Radio Relay League, 54th edition, 1984, page 54. (Note: the erroneous equation in the handbook has been corrected in this article.)


3. RF CAD Electronics Design Program, Joe Reisert, W1JR, and Gary Field, WA11RC. Available from Ham Radio's Bookstore, Greenville, New Hampshire 03048, for $39.95 plus 35.50 shipping and handling.

4. Basic Programs for Scientists and Engineers, Alan R. Miller, SYBEX, 2021 Challenger Drive No. 100, Alameda, California 94501.
RF POWER AMPLIFIERS

- Lowest NF GaAs FET Preamp
- Finest Quality Military Construction
- Off-The-Shelf Dealer Delivery

For the past five years, amateurs worldwide have sought quality amplifier products from TE Systems. Renowned for the incorporation of high quality, low-noise GaAs FET preamplifiers in RF power amplifiers, TE Systems offers our line of products through select national distributors.

All amplifiers are linear (all-mode), automatic T/R switching with adjustable delay and usable with drive levels as low as 1/2 Watt. We incorporate thermal shutdown protection and have remote control capability. All units are designed to ICAS ratings and meet FCC part 97 regulations. Approx. size is 2.8 x 5.8 x 10.5" and weight is 5 lbs.

Consult your local dealer or send directly for further product information.

TE SYSTEMS
P.O. Box 25845
Los Angeles, CA 90025
(213) 476-0591

INTERFERENCE?

- Interference Location
- Stuck Microphones
- Cable TV Leaks
- Security Monitoring

New Technology (patent pending) converts any VHF or UHF FM receiver into an advanced Doppler shift radio direction finder. Simply plug into receiver's antenna and external speaker jacks. Uses four omnidirectional antennas. Low noise, high sensitivity for weak signal detection. Call or write for full details and prices.

DOPPLER SYSTEMS, INC. P.O. Box 31819
Phoenix, AZ 85064
(602) 488-9755

INTERFERENCE?

- Interference Location
- Stuck Microphones
- Cable TV Leaks
- Security Monitoring

New Technology (patent pending) converts any VHF or UHF FM receiver into an advanced Doppler shift radio direction finder. Simply plug into receiver's antenna and external speaker jacks. Uses four omnidirectional antennas. Low noise, high sensitivity for weak signal detection. Call or write for full details and prices.

DOPPLER SYSTEMS, INC. P.O. Box 31819
Phoenix, AZ 85064
(602) 488-9755

COAX SALE!

High-quality precut 50 ohm coax lengths with "N" connectors that are better substitutes for RG-8, unused AT&T surplus: #RG-213-15, 15 ft. RG-213-4, 4 ft. sh. .............. $8.95 ea; 2 for $16.00
#RG-214-45, 45 ft. RG-214, silver-tinned conductor, double shield for low DC resistance; 15 ft. sh. .............. $24.95 ea; 2 for $49.00
CENTRALAB 850 7.5 V RF capacitors: 25, 50, 75, or 100 pf (specify). Used ...... $3.00 ea; 2 for $5.00
4CX250 tube. 6.3 V ft; used-checked ...... $35.00 ea
CEMAC/Johnson Socket for 4CX250, used $12.00
Prices F.O.B. Lima, O. - VISA, MASTER CARD Accepted, Allow for Shipping - Write for latest Catalog Supplement
Address Dept. HR - Phone 419-227-6572

This publication is available in microform from University Microfilms International.

COAX SALE!

High-quality precut 50 ohm coax lengths with "N" connectors that are better substitutes for RG-8, unused AT&T surplus: #RG-213-15, 15 ft. RG-213-4, 4 ft. sh. .............. $8.95 ea; 2 for $16.00
#RG-214-45, 45 ft. RG-214, silver-tinned conductor, double shield for low DC resistance; 15 ft. sh. .............. $24.95 ea; 2 for $49.00
CENTRALAB 850 7.5 V RF capacitors: 25, 50, 75, or 100 pf (specify). Used ...... $3.00 ea; 2 for $5.00
4CX250 tube. 6.3 V ft; used-checked ...... $35.00 ea
CEMAC/Johnson Socket for 4CX250, used $12.00
Prices F.O.B. Lima, O. - VISA, MASTER CARD Accepted, Allow for Shipping - Write for latest Catalog Supplement
Address Dept. HR - Phone 419-227-6572

This publication is available in microform from University Microfilms International.
lightning location and detection

Modern analog, digital techniques probe Nature’s electrical generator

Lightning is an everyday occurrence, feared by some, accepted by most, but generally overlooked. Some 2000 thunderstorms are active at any moment throughout the world; this results in 100 lightning strokes every second of the year, or 40 million strokes per year in the United States alone.

Accurate detection of lightning is necessary for many reasons, including forest fire detection and control, power grid monitoring, flight planning, and public safety; NASA monitors lightning activity at various missile launch sites. Fortunately, technology now provides the means to accomplish these tasks with a high degree of accuracy.

North America has several extensive detection systems. Mexico, South Africa, Japan, Australia, Norway, Sweden, and recently China, have installed similar systems.

theory of detection

A lightning discharge to ground contains several large current surges or strokes. A stepped leader proceeds from the cloud to the ground in a series of short steps. After this leader reaches ground, a large return stroke travels rapidly back up the ionized path left by the leader. After a pause of 30 to 50 milliseconds, a dart leader usually forms; this is followed by one or more return strokes traveling upwards. Typically, a lightning stroke contains three, four, or more return strokes.

Until recently it was thought that a negative charge was transferred to ground during a lightning strike. But we now know that the incidence of positive charges increases as latitude increases towards the Earth’s poles. Japanese researchers have also detected a large amount of positive lightning, which appears to emanate from the tops of clouds and be of higher current levels than negative lightning. There’s still a considerable amount of research to be done in this area.

The current in return strokes attains levels of up to 40 kiloamps in 1 to 10 microseconds. The rise time and pulse width of this discharge form a distinctive waveform or signature that can be processed by the detection equipment to yield such data as azimuth bearings, real time, amplitude, polarity, and repetition of return strokes. When the data from two or more sites are triangulated and decoded by a central microprocessor, it’s possible to pinpoint strike locations accurately to within 0.5 km at distances of 500 km.

detection system components

A typical detection system consists of two or more direction finders and a microcomputer; a block diagram of such a system is shown in fig. 1. Data is usually transmitted to a central position analyzer (PA) by means of dedicated telephone lines. Some installations use a polling system in which each direction finding site is polled. These systems require the use of asynchronous telephone lines. Recently, sites in remote areas (see fig. 2), especially in Third World countries, have used data transfer systems consisting of VHF and UHF radio links, using the principles of packet radio.

The electromagnetic field generated by a lightning stroke is sensed on two broadband orthogonal loop antennas and on an electric field, or “E” field, antenna. The latter consists of three flat plates stacked one above the other and separated by a few inches. The E field antenna senses the ambient noise level at a particular site to provide a comparison level for the loop antenna. The bandwidth of the antennas is 1 kHz to 1 MHz; this wide bandwidth is necessary to preserve the shape and polarity of the waveforms resulting from the lightning stroke.

Direction finding is done according to conventional techniques. The signal received by each loop is proportional to the lightning stroke’s magnetic field multiplied by the cosine of the angle between the plane of the loop and the direction of the incoming signal.

By Bill Richardson, VY1CW, Site 20, Comp. 63, RR No. 1, Whitehorse, Yukon, Canada, Y1A 4Z6
Therefore, the azimuthal bearing can be calculated from the signal strength ratio of the signals at the two loops.

The direction finding electronics are designed to respond to a waveform that's typical of a cloud-to-ground lightning stroke. Cloud-to-cloud lightning has an entirely different waveform and thus is ignored by the equipment.

These waveforms are identified by rise time, pulse width, and secondary peak structure. The rise time and bipolar shape requirements eliminate very distant lightning, because propagation delay increases the rise time of those waveforms. Ionospheric reflections of the signal don't pose a problem because they're typically inverted with respect to a ground wave signal. Some users employ both positive and negative stroke sensing.

The direction finder uses parallel low- and high-gain analog circuits. The waveshapes of near and distant lightning strokes are slightly different; therefore, the two analog circuits are set to switch automatically to values appropriate for subsequent strokes after the first stroke is detected. This provides maximum detection efficiency over a wide dynamic range.

Magnetic direction is determined at the time at which the radiation field of the return stroke reaches its peak; this point is attained while the return stroke is within approximately 300 feet of the ground. This provides an accurate indication of the ground contact point and eliminates errors that could be induced by multiple branch currents.

Detection efficiency is shown in fig. 3. The low efficiency at very close distances is caused by signals of sufficient magnitude to overrange the electronics. Peak efficiency is reached in the 20- to 250-km range and decreases beyond this because of lowering of signal amplitude and change of waveshape because of propagation delay.

As previously mentioned, accuracy can be within 0.5 to 1 kilometer at 300 kilometers, assuming enough direction finding sites are used for full area coverage. The electronics must be precisely aligned and calibrated — a very tedious procedure, I assure you. Alignment of the loop antennas must also be done.
accurately. The presently accepted method uses a shadow cast upon the antenna base plate by the northsouth loop at precisely solar noon. Each direction finder has a built-in lightning simulator that can be set to duplicate acceptable and unacceptable lightning waveforms; this allows the system to be configured for peak detection efficiency.

**system configuration**

Sometimes a direction finder is used in a stand-alone mode, usually in conjunction with a weather radar. In this case, lightning data is plotted on an X-Y recorder. Clusters of vectors show the bearing to a storm cell; since vector length is proportional to the peak amplitude of the first return stroke, the length of the vectors can be translated into the distance to the strike.

The most common system configuration involves several direction finders reporting to a central position analyzer. Each direction finder has an integral microcomputer subsystem that digitizes and stores data for up to 14 return strokes. Each stroke is displayed on a front panel LED display. Time, angle to stroke, signal amplitude, polarity, and multiplicity of strokes are shown. This data is then transmitted to the position analyzer, a preprogrammed microcomputer system that automatically computes, maps, and records all lightning data. This data is then printed as hard copy and displayed on a CRT as lightning strikes superimposed on a map.

All computations and displays are done in real time. Data can be stored and replayed to determine storm

---

fig. 2. The solid dots show the locations of all LLP lightning direction finders installed in North America at the end of 1982. The shaded area represents the effective area covered by these systems.

---

fig. 3. Detection efficiency versus range for two medium-gain LLP networks.
direction, intensity, growth, and decay. For example, a program can be selected to periodically delete strike locations older than a preset time interval, with various colors assigned to strikes occurring within different time periods. This accumulated data can then be replayed at an accelerated rate to display the storm's life cycle.

**communications system**

Time has shown that the communications links are the greatest source of problems in the system. Two basic systems — the "star" and the polled — are in common use. The polled system stores data until the PA requests it. In the star system, the simpler of the two, remote sites are connected to the PA via dedicated half-duplex telephone lines, and data is transmitted to the PA in real time. Though costs are higher with this system because of the dedicated line, which is in constant use, the system's simplicity often compensates for its higher costs.

In the past two years, many Third World countries have installed lightning detection equipment. Because standard communications links are almost non-existent in many of these areas, UHF radio links using packet radio have been used; to date, the results are very encouraging. Many such UHF links will be installed in northern and otherwise remote areas of North America over the coming year. This will not only allow new areas to be covered, but also decrease communications costs.

The manufacturer of the equipment described in this article has introduced a simplified direction finder which can be operated on solar power. This feature will help increase coverage, since AC power sources will no longer be required.

I'll be working closely with the manufacturer to experiment with the possibility of relaying data by radio transmissions reflected from the ionized trails created by the lightning stroke, much like the method used in meteor scatter communications.

**conclusion**

Space limits the depth of description of lightning detection equipment and techniques, but the foregoing should provide a general overview of this new technology. Because the field is still in its infancy, systems are especially challenging. Much research and development can and is being done by field personnel.

**acknowledgements**

My thanks to Leon Byerly of Lightning Location and Protection, 1001 South Euclid Avenue, Tuscon, Arizona 85719, for his help in preparation of this article.
<table>
<thead>
<tr>
<th>**IC SOCKETS</th>
<th>**</th>
<th><strong>PC XT &amp; AT CASES</strong></th>
<th><strong>ACCESSORIES</strong></th>
<th><strong>MEMORY</strong></th>
<th><strong>MATH CO-PROCESSOR</strong></th>
<th><strong>HIGH SPEED</strong></th>
<th><strong>POWER SUPPLY</strong></th>
<th><strong>IBM PC/XT AT Compatible</strong></th>
<th><strong>DISKETTES</strong></th>
<th><strong>UV ERASERS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Profile Bolted</strong></td>
<td><strong>WW Wirewrap</strong></td>
<td><strong>Hrs High Reliability</strong></td>
<td><strong>Conductor</strong></td>
<td><strong>Channel</strong></td>
<td><strong>Flap Controller</strong></td>
<td><strong>Case Flip Top</strong></td>
<td><strong>1/2 Height Disk Drive</strong></td>
<td><strong>Floppy Controller</strong></td>
<td><strong>5150 Style Keyboard</strong></td>
<td><strong>Monochrome Card</strong></td>
</tr>
<tr>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>FLIP-TOP CASES</strong></td>
<td><strong>AT MULTI-FUNCTION</strong></td>
<td><strong>5.25in Multi-Function</strong></td>
<td><strong>Bus Port</strong></td>
<td><strong>Serial Port</strong></td>
<td><strong>Power Supply</strong></td>
<td><strong>IBM AT I/O CARD</strong></td>
<td><strong>IBM PS/2 &amp; AT Compatible</strong></td>
<td><strong>150 Watt</strong></td>
<td><strong>200 Watt</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>IBM PC XT</strong></td>
<td><strong>IBM MC</strong></td>
<td><strong>IBM 3270</strong></td>
<td><strong>IBM 3270</strong></td>
<td><strong>IBM 3270</strong></td>
<td><strong>IBM 3270</strong></td>
<td><strong>IBM 3270</strong></td>
<td><strong>IBM 3270</strong></td>
<td><strong>IBM 3270</strong></td>
<td><strong>IBM 3270</strong></td>
<td><strong>IBM 3270</strong></td>
</tr>
<tr>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>ATUO</strong></td>
<td><strong>$69.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>Serial Port</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>Parlalox Printer Port</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>POWER SUPPLY</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>IBM PS/2 &amp; AT Compatible</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>150 Watt</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>200 Watt</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
<tr>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
<td><strong>$99.00</strong></td>
</tr>
</tbody>
</table>
designing a microwave amplifier

Step-by-step procedure
starts with specs,
ends with results

Most people who aren’t familiar with microwave technology regard microwave engineering as somewhat mysterious. Nothing could be further from the truth.

Often this opinion stems simply from limited knowledge of the subject, from a misconception that all power transmission requires a waveguide or “plumbing,” or from a general lack of interest. Knowing that in microwave design, circuit performance is exceptionally dependent on layout* and understanding the mathematics associated with field theory and the use of distributed parameters for impedance matching, it’s possible to conclude that microwave engineering is an arcane art limited to the very few. Not so!

S-parameters

Manufacturers of microwave electronic components, namely transistors, characterize these devices according to scattering parameters known also as “S” parameters. S parameters are simply voltage reflection coefficients that possess both magnitude and phase. Consider a 25-ohm resistor at the end of a 50-ohm transmission line (Fig. 1). The reflection coefficient of the 25-ohm load is computed as follows:

\[ \Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{25 - 50}{25 + 50} = \frac{-25}{75} = -\frac{1}{3} \]  

(1)

\( \Gamma \) can be complex and is simply a reflection coefficient; that’s what an S parameter is — nothing more than a reflection coefficient. The S parameters are measured values and give an indication as to the performance of the device, and are generally measured in a 50-ohm system. It’s more practical to construct a 50-ohm termination than to rely upon open circuits and short circuits and attempt to characterize a device with “Y” or “Z” parameters. The four S parameters specified are S11, S12, S21, and S22 (see Fig. 2).

\[ S11 = \frac{b_1}{a_1} \text{ with } a_2 = 0 \text{ and } \]  

is a measure of input impedance

\[ S22 = \frac{b_2}{a_2} \text{ with } a_1 = 0 \text{ and } \]  

is a measure of output impedance

\[ S21 = \frac{b_2}{a_2} \text{ with } a_2 = 0 \text{ and is a measure of } \]  

forward power gain

\[ S12 = \frac{b_1}{a_2} \text{ with } a_1 = 0 \text{ and } \]  

is a measure of reverse power gain

S parameters are simply related to power gain and mismatch loss, quantities which are often of more interest than the corresponding voltage functions.

\[ |S11|^2 = \frac{\text{Power reflected from network input}}{\text{Power incident on the network input}} \]

\[ |S22|^2 = \frac{\text{Power reflected from network output}}{\text{Power incident on the network output}} \]

\[ |S21|^2 = \frac{\text{Power delivered to a } Z_0 \text{ load}}{\text{Power available from } Z_0 \text{ source}} \]

\[ |S12|^2 = \frac{\text{Reverse transducer power gain}}{\text{with } Z_0 \text{ load and source}} \]

It’s important to understand that S parameters are measured parameters and give the designer a real-world indication as to how the particular transistor will work. Generally, a designer’s most important considerations are power gain, noise figure, stability, biasing, and a necessary matching structure for reasonable VSWR.

A transistor is a bilateral device, with the amount of bilateral interaction defined by S12. Analyzing the performance of an amplifier operating as a bilateral device is a tedious process, and one has to resort to the use of computers and commercially available programs.

By Stanley J. Domanski, ex-WA1WSD, 3 Lessard Street, Nashua, New Hampshire 03060
such as Super-Compact,** a rather powerful microwave circuit design optimization program. For the purpose of illustration, we will assume a unilateral device (S12 = 0).

**using the data sheet**

Suppose someone gives you several NEC NE388 GaAsFET transistors and a data sheet, then asks you to design an amplifier that's to operate at 3 GHz. Approximately how much gain should you expect to achieve? What would the input and output matching network look like?

Start by reviewing the data sheet for the FETs. (For this design, noise figure is not a consideration.) The load impedance and source impedance are both 50 ohms. The device is a GaAsFET. You'll also notice that the S parameters are specified at $V_{DS} = 3.0$ volts and $I_D = 10$ mA. Therefore, for the matching network to be effective and for the gain calibration to be meaningful, the device must be biased at these values of $V_{DS}$ and $I_D$. Try to get a feeling for maximum usable gain, i.e. the Gain Transducer Unilateral (GTU). This was derived from the more general equation for GT (Gain Transducer) under the conditions specified above.

$$GTU_{max} = \frac{I}{l - |S11|^2} \cdot \frac{|S2|}{l - |S22|^2}$$

At 3000 MHz,

$$S11 = 0.892 \cdot 63^\circ, S21 = 2.368 \cdot 133^\circ$$

$$S22 = 0.772 \cdot 41^\circ, S12 = 0.034 \cdot 52^\circ$$

$$GTU = \frac{l}{l - (0.892)^2} \cdot \frac{(2.368)^2}{l - (0.772)^2}$$

$$\frac{l}{1 - 0.892^2} \cdot \frac{2.368^2}{1 - 0.772^2} = (4.893) \cdot (5.607) \cdot (2.475) = 67.90 \text{ or } 10 \log GTU = 18.32 \text{ dB}$$

This computation is consistent with the data sheet. Notice that in addition to providing a table of S parameters for the packaged devices, S parameters are given for NE388 chips as well, and the S parameter data is listed for frequencies from 2 to 10 GHz in 0.5-GHz step increments. Note that S11 and S12 are both capacitive, but become more inductive as frequency increases.

S11 represents approximately $10 - j80$ ohms and S22 represents approximately $50 - j120$ ohms. For optimum performance and power gain, the transistor's input and output impedances should be matched to 50 ohms.

One suitable way of constructing this amplifier is a technique called microstrip. Microstrip possesses transmission line characteristics and is essentially just conductive runs over a conducting ground plane, with an intermediate substrate in between.

**matching procedure**

The idea is to “move” S22 and S11 to the 50-ohm center of the Smith Chart (fig. 3). In both cases, this is done by rotating on a length of transmission to the constant conductance circle that is coincident with the center of the Smith Chart or the 50-ohm location and then adding a parallel capacitor of the appropriate size. For the S22 match, a length of line $0.194\lambda + 0.055\lambda = 0.249\lambda$ is used to rotate to constant conductance circle coincident with 50 ohms; for S11 the length of line is:

$$0.163\lambda + 0.038\lambda = 0.201\lambda.$$  
$$Y(S22) = 2.4 = Y/B0$$

Since our transmission line characteristic is Z0 and is 50 ohms,

$$B0 = 1/Z0 = 1/50 \text{ or } 0.02$$  
$$Y = Y/B0 = 2.4 \cdot 0.02 = 0.048 \text{ mhos}$$  
$$Y = 2\pi fC \text{ mhos}$$

$$C = \frac{Y}{2\pi f} = \frac{0.048}{2\pi \times 3 \times 10^9} = 2.54 \times 10^{-12} \text{ farads}$$

A $2.54 \cdot 10^{-12}$F (2.54 pF) capacitor shunting the transmission line to ground will add enough susceptance to complete the output match to 50 ohms.

A similar procedure is used to match the input to 50 ohms.
$$y(S_{11}) = \frac{Y}{B_0} = 3.9 \text{ mhos}$$

$$Y = y \cdot B_0 = 3.9 \times 0.02 = 0.078 \text{ mhos}$$

$$Y = 2\pi f c \text{ mhos} \quad C = \frac{Y}{2\pi f} = \frac{0.078}{2\pi \times 3 \times 10^9}$$

$$= 4.138 \times 10^{-12} \text{ Farad}$$

A $4.138 \times 10^{-12}$F (4.138 pF) capacitor shunting the transmission line to ground will add enough susceptance to complete the input match to 50 ohms. Thus far, what we have represented is shown schematically in fig. 4.

fig. 3. GaAsFET. NE388 matching using Smith Chart.

fig. 4. Component values determined for GaAsFET input/output match.
microstrip components used

The microstrip substrate is a teflon material with a dielectric constant of 10.0. The distributed characteristics of microstrip will be utilized to synthesize the 50-ohm transmission line and shunt capacitors. The lengths of the input and output transmission lines are 0.201λ, and 0.249λ, respectively.

The equation relating frequency and wavelength is \( c = f\lambda \), where \( c \) is the velocity of light and is \( 3 \times 10^{10} \text{ cm/sec} \). In air, the wavelength of a 3-GHz signal is

\[
\lambda = \frac{c}{f} = \frac{3 \times 10^{10} \text{ cm/sec}}{3 \times 10^9 \text{ Hz}} = 10 \text{ cm}
\]  

or approximately 3.937 inches. The effective wavelength in a material other than free space is the wavelength in free space divided by the square root of the dielectric constant. For a substrate whose dielectric constant is 10.0, the effective wavelength is

\[
\lambda_{\text{eff}} = \frac{10.0 \text{ cm}}{\sqrt{10}} = 3.16 \text{ cm}
\]  

or 1.2449 inches. The length of the input matching section is 0.201λ and the length of the output matching section is 0.249λ. This in air would represent (0.201λ) (3.937 inches/λ) = 0.7913 inches and (0.249λ) (3.937 inches/λ) = 0.9803 inches.

In a substrate with a dielectric constant of 10.0, the real lengths of the input and output become (0.7913 inches) (0.3162) = 0.2502 inches and (0.9803 inches) (0.3162) = 0.3099 inches, respectively.

The characteristic impedance of microstrip, \( Z_0 \) is:

\[
\frac{h}{w} x 377 x \frac{1}{\sqrt{\varepsilon_r}}
\]

The impedance selected for our line is 50 ohms and \( \varepsilon_r = 10.0 \). The substrate thickness is 0.020 inches. Solving for \( W \):

\[
\omega = \frac{377 x h}{Z_0 x \sqrt{\varepsilon_r}} = \frac{377 x 0.020}{50 x \sqrt{10}} = 0.0476 \text{ in}
\]

Thus the width of a conductor whose characteristic impedance is 50 ohms on a substrate whose thickness is 0.020 inches, with a dielectric constant of 10.0, is 0.0476 inches. The original schematic takes on a new aspect — dimensions (see fig. 5).

The input capacitance of 4.138 pF and output capacitance of 2.54 pF will be synthesized using microstrip techniques. Generally, if the width of a segment is twice as wide as the length, the section looks like a shunt capacitor.

The capacitance of a parallel plate capacitor is:

\[
C (\text{pF}) = \frac{0.224 A \varepsilon_r}{d}
\]

where:

- \( A \) is the area of the plate in square inches
- \( d \) is the separation of the plates in inches
- \( \varepsilon_r \) is the dielectric constant

Solving for \( A \):

\[
A_1 = \frac{(C_1) (d)}{(0.224) (\varepsilon_r)} = \frac{(4.138) (0.020)}{(0.224) (10)} = 0.0369 \text{ in}^2
\]

Similarly:

\[
A_2 = \frac{(C_2) (d)}{(0.224) (\varepsilon_r)} = \frac{(2.54) (0.020)}{(0.224) (10)} = 0.0227 \text{in}^2
\]

fig. 5. Transmission line physical parameters determined from requirements.

fig. 6. Input and output matching structure dimensions.
**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

**RM SERIES**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Continuous Duty (Amps)</th>
<th>ICS* (Amps)</th>
<th>Size (IN)</th>
<th>Shipping Wt. (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM-12A</td>
<td>9</td>
<td>12</td>
<td>5 1/4 x 19 x 8 1/2</td>
<td>16</td>
</tr>
<tr>
<td>RM-35A</td>
<td>25</td>
<td>35</td>
<td>5 1/4 x 19 x 12 1/2</td>
<td>38</td>
</tr>
<tr>
<td>RM-50A</td>
<td>37</td>
<td>50</td>
<td>5 1/4 x 19 x 12 1/2</td>
<td>50</td>
</tr>
</tbody>
</table>

- Separate Volt and Amp Meters

**RS-3A SERIES**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Continuous Duty (Amps)</th>
<th>ICS* (Amps)</th>
<th>Size (IN)</th>
<th>Shipping Wt. (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS-3A</td>
<td>2.5</td>
<td>3</td>
<td>3 1/4 x 4 x 5 1/2</td>
<td>4</td>
</tr>
<tr>
<td>RS-4A</td>
<td>3</td>
<td>4</td>
<td>3 1/4 x 4 x 5 1/2</td>
<td>5</td>
</tr>
<tr>
<td>RS-5A</td>
<td>4</td>
<td>5</td>
<td>3 1/4 x 4 x 5 1/2</td>
<td>7</td>
</tr>
<tr>
<td>RS-7A</td>
<td>5</td>
<td>7</td>
<td>3 1/4 x 4 x 5 1/2</td>
<td>9</td>
</tr>
<tr>
<td>RS-7B</td>
<td>5</td>
<td>7</td>
<td>4 1/4 x 7 1/4 x 10 1/4</td>
<td>10</td>
</tr>
<tr>
<td>RS-10A</td>
<td>7.5</td>
<td>10</td>
<td>4 1/4 x 7 1/4 x 10 1/4</td>
<td>11</td>
</tr>
<tr>
<td>RS-12A</td>
<td>9</td>
<td>12</td>
<td>4 1/4 x 7 1/4 x 9</td>
<td>13</td>
</tr>
<tr>
<td>RS-12B</td>
<td>9</td>
<td>12</td>
<td>4 1/4 x 7 1/4 x 10 1/4</td>
<td>13</td>
</tr>
<tr>
<td>RS-20A</td>
<td>16</td>
<td>20</td>
<td>5 1/4 x 9 x 10 1/2</td>
<td>18</td>
</tr>
<tr>
<td>RS-35A</td>
<td>25</td>
<td>35</td>
<td>5 1/4 x 11 x 11</td>
<td>27</td>
</tr>
<tr>
<td>RS-50A</td>
<td>37</td>
<td>50</td>
<td>6 1/4 x 13 3/4 x 11</td>
<td>46</td>
</tr>
</tbody>
</table>

**RS-50A SERIES**

- Switchable volt and Amp meter
- Separate volt and Amp meters

**VS-M AND VRM-M SERIES**

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

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Continuous Duty (Amps)</th>
<th>ICS* (Amps)</th>
<th>Size (IN)</th>
<th>Shipping Wt. (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VS-12M</td>
<td>@13.8VDC</td>
<td>5 1/2</td>
<td>12</td>
<td>4 1/4 x 8 x 9</td>
</tr>
<tr>
<td>VS-20M</td>
<td>@10VDC</td>
<td>9 4</td>
<td>20</td>
<td>5 1/4 x 10 1/2</td>
</tr>
<tr>
<td>VS-35M</td>
<td>@5VDC</td>
<td>15 7</td>
<td>35</td>
<td>5 1/4 x 11 x 11</td>
</tr>
<tr>
<td>VS-50M</td>
<td>@13.8VDC</td>
<td>37 20</td>
<td>50</td>
<td>6 1/4 x 13 3/4 x 11</td>
</tr>
</tbody>
</table>

- Variable rack mount power supplies

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Continuous Duty (Amps)</th>
<th>ICS* (Amps)</th>
<th>Size (IN)</th>
<th>Shipping Wt. (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRM-25M</td>
<td>25</td>
<td>15</td>
<td>5 1/4 x 19 x 12 1/2</td>
<td>38</td>
</tr>
<tr>
<td>VRM-50M</td>
<td>37</td>
<td>22</td>
<td>5 1/4 x 19 x 12 1/2</td>
<td>50</td>
</tr>
</tbody>
</table>

**RS-S SERIES**

- Built in speaker

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Continuous Duty (Amps)</th>
<th>ICS* (Amps)</th>
<th>Size (IN)</th>
<th>Shipping Wt. (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS-7S</td>
<td>5</td>
<td>7</td>
<td>4 1/4 x 7 1/4 x 10 1/4</td>
<td>10</td>
</tr>
<tr>
<td>RS-10S</td>
<td>7.5</td>
<td>10</td>
<td>4 1/4 x 7 1/4 x 10 1/4</td>
<td>12</td>
</tr>
<tr>
<td>RS-12S</td>
<td>9</td>
<td>12</td>
<td>4 1/4 x 7 1/4 x 9</td>
<td>13</td>
</tr>
<tr>
<td>RS-20S</td>
<td>16</td>
<td>20</td>
<td>5 1/4 x 10 1/2</td>
<td>18</td>
</tr>
</tbody>
</table>

*ICS—Intermittent Communication Service (50% Duty Cycle 5min. on 5 min. off)
The circuit now takes on the appearance of that shown in fig. 7.
The basic radio frequency input and output matching structure is now defined.

This matching structure was based on S parameters which were stated for a given $V_{DS}$ and $I_{DS}$. A GaAs-FET device is a transconductance device; this simply means that it’s a voltage-controlled current source.

**feedback and biasing**

This brings up the means by which the devices should be biased. A quick glance at the data sheet reveals the NE388 will require a $V_{GS}$ of approximately $-3.0$ volts to maintain a $V_{DS} = 3.0$ volts and $I_{DS} = 10.0$ milliamperes. But the $V_{GS}$ necessary to maintain

We wish to make the width of the section twice as wide as the length. Therefore,

\[ \frac{2l^2}{A_1} = \frac{A_1}{2} \]

\[ l = \sqrt{\frac{A_1}{2}} = \sqrt{\frac{0.0369}{2}} = 0.1358 \text{ in} \]

Similarly:

\[ \frac{l^2}{A_2} = \frac{A_2}{2} \]

\[ \sqrt{\frac{A_2}{2}} = \sqrt{\frac{0.0227}{2}} = 0.1065 \text{ in} \]

these aforementioned bias conditions can vary between $-2.5$ to $-3.5$ volts — a production nightmare, especially if the unit must operate between $-55$ and $+70$ degrees C. Solution: use a servo — i.e., a feedback circuit!

I suggest the circuit shown in fig. 8 because I know it works well over a wide range of temperatures. The microwave matching network components are left out for simplicity.

The three critical items in this circuit are the stability of the $+5.0$ volts, the accuracy and stability of the
The solution to most interference, intermod, and desense problems in AMATEUR and COMMERCIAL systems.

- 40 to 1000 MHz - tuned to your frequency
- 5 large helical resonators
- Low noise - High overload resistance
- 8 dB gain - ultimate rejection
- 10 to 15 volts DC operation
- Size: 1.6 x 2.6 x 4.75" exc. connectors

FANTASTIC REJECTION!

Typical rejection:
- 600 kHz at 144 MHz: -26dB
- 1.6 MHz at 220 MHz: -40dB
- 5 MHz at 450 MHz: -50dB

SUPER HOT! GaAs Fet option $20

AUTOMATIC IDENTIFIERS

ID-1

- For transceivers and repeaters - AMATEUR and COMMERCIAL
- Automatic operation - adjustable speed and amplitude
- Small size - easy installation - 7 to 15 volts DC
- 8 selectable, reprogrammable messages - each up to 2 min. long
- Wired, tested, and programmed with your message(s)

Model ID-1 - $49.95
Model ID-2 w/2 to 10 minute timer - $69.95

We offer a complete line of transmitter and receiver strips and synthesizers for amateur and commercial use.

Request our free catalog. Allow $2 for UPS shipping. Mastercard and VISA welcome.

GLB ELECTRONICS, INC.
Dept H
151 Commerce Pkwy, Buffalo, NY 14224
716-675-6740 9 to 4

200-ohm resistor, and the 3.0-volt reference. The diode prevents the possibility of a positive voltage being applied to the gate. A positive voltage on the gate without considerable current limiting would damage the device.

The voltage divider consisting of the 37.4-k and 27.4-k resistors prevent the gate to source voltage from exceeding -8.0 volts during initial turn-on. The dc bias, namely the $V_{DS}$ and $V_{GS}$, is applied to the NE388 through the use of high-impedance, quarter-wave, short-circuited stubs. The short circuit at 3 GHz is accomplished by wire-bonding the end of the stub to a 100-pF chip capacitor that is connected to ground. Remember, a quarter-wave long transmission line short-circuited on one end looks like an open circuit on the other. The design procedure results in the realizable 3-GHz amplifier circuit shown in fig. 9.

ham radio

SAY YOU SAW IT IN HAM RADIO

Manufacturers Rep Weekend
Friday and Saturday
August 28 & 29

Friday 9-6  Saturday 8-5

Come in and meet reps from Yaesu, Telex-HyGain, AEA

- In Store Demonstrations  
- Drawings  
- Prizes  
- Fun  
- Service and Maintenance Information

Special Pricing on Entire Inventory All Weekend.

Call Early to Take Advantage of All the Bargains.

---

Discounts on Rigs and Accessories From: AEA, ARRL, ALINCO, ALLIANCE, ALPHA-Delta, AMECO, AMERITRON, AMP SUPPLY, ANTENNA SPECIALISTS, ASTRON, BENCHER, BUTTERNUT, B & W, CSI, CALLBOOK, CUSHCRAFT, DAIWA, DIAMOND, ENCOMM, HAL, HEIL, HUSTLER, ICOM, KDK, KANTRONICS, KENPRO, LARSEN, MFJ, MICROLOG, MIRAGE/KLM, NYE, PALOMAR, RF CONCEPTS, ROHN, SANTEC, SHURE, TE SYSTEMS, TELEX/HYGAIN, TEN-TEC, TOKYO HY-POWER, VIBROPLEX, W2AU BALUNS, WELZ, YAESU

For Orders and Price Checks Call 800-523-7731

Indiana and Information Call 1-812-422-0231

36 September 1987
simple VHF/UHF
multiple quarter-wave filters

Individual
or cascaded sections
provide required
harmonic suppression

Thanks to the simplicity of its design, construction, and alignment, the half-wave, low-pass configuration is one of the most popular transmitter filters at VHF and UHF.

The half-wave filter, consisting of two pi sections of inductors and capacitors in cascade (see fig. 1), is so named because the output signal is delayed one-half wavelength at the highest design pass frequency. Just as in the case of a half-wavelength transmission line, the same impedance seen at the output terminals of the half-wave filter is presented to the amplifier at the filter input terminals. The principal use of this filter is simply to reduce transmitter harmonics.

This article shows how to calculate the values for quarter, half, three-quarter, and full-wave VHF/UHF filters. The effects of varying the circuit Q will be explored. If reasonable construction techniques are used, a guaranteed minimum level of attenuation can be expected for transmitter harmonics, even without using test equipment for alignment. Multisection filters have been constructed using lumped constants for the 6, 2, and 1-1/4 meter bands, with very good agreement to theoretical values. Microstrip quarter-wave and half-wave filters have also been built for the 432- and 1296-MHz bands. Half-wave filters for the hf band can be constructed using standard values contained in tables without need for adjustments. At VHF however, construction techniques dictate that the filter actually be adjusted for best performance, usually with a grid-dip meter. At UHF, construction practices require the use of a reproducible pattern found in microstripline form. If the same printed circuit board type and thickness are used, similar performance can be assured without any alignment.

reducing interference

There are many reasons — legal, environmental, and ethical — for reducing spurious and harmonic emissions. According to Part 97.73 of the FCC Rules and Regulations for the Amateur, "Spurious emissions (including harmonics) must be 40 dB below the carrier power for a transmitter operating below 30 MHz. If the transmitter has an output power of 5 watts or less, the spurious at the transmitter output need only be reduced by 30 dB. Harmonics for transmitters and power amplifiers operating in the 30- to 235-MHz range must be reduced 60 dB below the carrier level. Transmitters below 25 watts output need to attenuate harmonics by only 40 dB."

With a typical amplifier, the second harmonic is only 20 to 30 dB down and the third harmonic is 30 to 40 dB down from the fundamental carrier (fig. 2). When the harmonic content of a transmitter, exciter, or oscillator is monitored on a spectrum analyzer or sensitive receiver, the carrier should be "notched-out" as much as possible. The input mixer of the spectrum analyzer or the front end of a receiver is prone to generate harmonic energy when driven by a large carrier signal, and will indicate greater harmonic energy than is actually present. The common method of determining if the amplitude of a transmitter harmonic is real is to place an attenuator in front of the spectrum analyzer. If the harmonic drops by an amount greater than the value of the inserted attenuation, then the harmonic was generated in the mixer of the analyzer.

In a balanced (i.e., push-pull) amplifier design, the second harmonic power will typically be down better than 30 dB (depending on circuit balance). The odd order (third, fifth) harmonics, however, will remain high (−20 dB). Thus the principal filtering response

By Ernie Franke, WA2EWT, 10484 138th Street, Largo, Florida 33544

*The signal is delayed 180 degrees or the equivalent that would occur in a properly terminated half-wave electrical transmission line. — Ed.
The half-wave filter is popular because of the simplicity of its calculation, construction, and adjustment. Figure 1 shows the basic configuration:

\[ X_L = 2\pi f L = 50 \text{ ohm}, \]
\[ X_C = 1 / 2\pi f C = 50 \text{ ohm} \]  

The value of inductance and capacitance is then simply computed as

\[ L = 50 / 2\pi f \text{ henries}, \quad C = 1 / 2\pi f (50) \text{ farads} \]

where \( f \) is the highest design pass frequency in Hz. The values of \( L \) and \( C \) may be directly scaled up or down, depending on the source and load impedances.

The basic quarter-wave pi network may be considered as two L-networks connected together, fig. 5. The \( Q \) of each L-network is given as

\[ Q1 = R1 / X_{C1} = 2\pi f C1 R1 \text{ and} \]
\[ Q2 = R2 / X_{C2} = 2\pi f C2 R2 \]

The total circuit \( Q \) is equal to the sum of the individual \( Q \)’s:

---

**fig. 2.** Typical power spectrum from a 2-meter, 100-watt transistor power amplifier.

---

**fig. 3.** The quarter-wave filter, composed of two L-networks, represents the basic building block.

---

**fig. 4.** Theoretical frequency responses of various section VHF filters, showing the slope of the stop-band.

---

**fig. 5.** Experimental results for the inductive and capacitive reactances of the quarter-wave filter, chosen to be equal to the source and load impedances, typically 50 ohms.

---

**fig. 1.** The half-wave filter is popular because of the simplicity of its calculation, construction, and adjustment.
Let's face it. It's easy to bump, drop, or get rain on an HT. But if your HT is Yaesu's mini 2-meter FT-23R or 440-MHz FT-73R, such mishaps are a lot less worrisome. They're built to last, with rugged aluminum-alloy cases that prove themselves reliable in a one-meter drop test onto solid concrete. Plus, their moisture-resistant seals really help keep the rain out.

**Built for the realities of operating.** Despite their miniature size, both radios have all the operating capabilities of larger microprocessor-controlled HTs. Yet operating them couldn't be easier. Consider: You get a 7.2-volt, 2-watt battery pack. (Optionally, a 12-volt, 5-watt pack, or 7.2-volt miniature 2-watt pack.) 10 memories that store frequency, offset and PL tone. (7 memories can store odd splits.) Memory scan at 2 frequencies per second. Band scan at 10 frequencies per second. Tx offset storage. Priority channel scan. Tuning via tuning knob, or up/down buttons.

- Options available: Dry cell battery case for 6 AAA-size cells. Dry cell battery case for 6 AA-size cells. DC car adapter/charger. Programmable CTCSS (PL tone) encoder/decoder. DTMF keypad encoder. Mobile hanger bracket. External speaker/microphone. And much more.
- So get the intelligent mini HT that's built for life's realities. Yaesu's 2-meter FT-23R, or 440-MHz FT-73R.

**YAESU**

Yaesu USA 17210 Edwards Road, Cerritos, CA 90701 (213) 404-2700. Repair Service: (213) 404-4884. Parts: (213) 404-4477.

Yaesu Cincinnati Service Center 9070 Gold Park Drive, Hamilton, OH 45011. (513) 874-3100.

*Modification required. Prices and specifications subject to change without notice. PL is a registered trademark of Motorola, Inc.*
NEW PRICE!

ANTENNA POLARITY SWITCHER MODEL APS-1

The APS-1 is a self-contained control head designed to allow remote polarity switching of circular antennas such as the Mirage/KLM range of crossed yagis.

The APS-1 may be powered by the power adaptor (included) or may alternately be powered from a vehicle or other 13-17 VDC source.

In addition to switchable outputs for two antennas, the APS-1 also contains a 6-13 volt regulated DC power supply. This feature is designed for powering items such as preamplifiers, VHF/UHF converters, etc., but may also be used whenever a low-current stabilized variable voltage source is required.

SPECIFICATIONS:

<table>
<thead>
<tr>
<th>Power Requirement (AC)</th>
<th>117V ± 10% AC 50/60 Hz 15 Watt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Requirement (DC)</td>
<td>11-16 VDC 500 mA</td>
</tr>
<tr>
<td>Outputs</td>
<td>Two 12 VDC unregulated, switched (antenna relay supply). One 6-13 VDC variable regulated auxiliary supply.</td>
</tr>
<tr>
<td>Total output current</td>
<td>500 mA with AC transformer that is included, 1 amp with optional high current transformer or external DC supply. This unit has our popular five year warranty.</td>
</tr>
</tbody>
</table>

The RC-85 Repeater Controller . . .
the affordable controller for your repeater.

The RC-85 controller offers the high tech basics of repeater control, plus! Of course, much of what we consider to be the "basics" aren't found anywhere else, at any price.

Remote programming lets you configure the operating characteristics of your repeater and change them at any time — without a trip to the hill. Non-volatile memory remembers your parameters, even after a power loss.

Synthesized speech makes it easy for users to interact with the repeater. Commands are acknowledged and information is available to users through remotely programmable ID, tail, and bulletin board messages. The new, larger speech vocabulary is ideal for repeater groups, emergency and public service needs. And since your repeater talks, it's friendly and fun to use.

The patch provides ten Emergency autodial numbers and 190 user loadable autodial slots. With toll restrict, "cover tone", and more.

The remote base port lets you hook up a transceiver to your repeater for remotely controlled linking to other repeaters and simplex channels. With full frequency control! Frequency agile linking is invaluable for public service uses, and it's fun!

There's even more ... a talking S-meter so users can check how well they're getting into the repeater, a site alarm for security, paging, and remote control outputs for controlling equipment at the site.

Any repeater can be brought up-to-date at a price that's right with ACC's RC-85 Repeater Controller.
CUT-OFF FREQUENCY

 fig. 4. Frequency response of the quarter-, half-, three-quarter, and full-wave filters.

fig. 5. The basic building block may be split into two L matching networks.

\[ Q_T = Q_1 + Q_2 \]  
(4)

and because of symmetry,

\[ Q_T = 2Q_1 \]  
(5)

The reactance, \( X_L \), of the inductor and the reactance, \( X_C \), of each capacitor is

\[ X_L = R_1 Q_T / [(Q_T^2 / 4) + 1] = \frac{2R_1 Q_1}{(Q_1^2 + 1)} = 2\pi f L; \]
\[ L = R_1 Q_1 / \pi f (Q_1^2 + 1) \]
\[ X_C = R_1 / Q_1; C = Q_1 / R_1 2\pi f \]
(7)

fig. 6. The overall loaded Q of the filter may be increased to yield greater harmonic attenuation — at the expense of greater in-band amplitude ripple.

fig. 7. Several quarter-, half-, three-quarter, and full-wave filters were constructed using scrap PC boards.

For a 50-ohm source and load,

\[ L = \frac{50Q_1}{\pi f (Q_1^2 + 1)} \text{ and } C = \frac{Q_1}{50(2\pi f)} \]
(8)

In an L-network for a \( Q \) of 1, which yields an overall network \( Q_T \) of 2, the value of the inductance and each capacitance is

\[ L = \frac{50 (1)}{\pi f (2)} = \frac{50}{2\pi f}, \]
\[ C = \frac{(1)}{50(2\pi f)} = \frac{1}{50(2\pi f)} \]
(9)

The filter for several values of overall \( Q_T \) have been calculated using the elements calculated according to

\[ L = \frac{R_1 Q_T}{[(Q_T^2 / 4) + 1](2\pi f)} \]
\[ C = \frac{Q_T}{R_1 4\pi f} \]
(10)
Table 1. Basic quarter-wave filter elements.

<table>
<thead>
<tr>
<th>Shunt Capacitor</th>
<th>Frequency</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Wire Size</th>
<th>Number Turns</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>54 MHz</td>
<td>59 pF</td>
<td>147 nH</td>
<td>No. 14</td>
<td>4T</td>
<td>3/8 inch</td>
</tr>
<tr>
<td></td>
<td>148 MHz</td>
<td>22 pF</td>
<td>54 nH</td>
<td>No. 14</td>
<td>2T</td>
<td>1/4 inch</td>
</tr>
<tr>
<td></td>
<td>25 MHz</td>
<td>14 pF</td>
<td>35 nH</td>
<td>No. 14</td>
<td></td>
<td>1 inch, 1/2 inch wide hairpin</td>
</tr>
</tbody>
</table>

The response of the quarter-wave filter for various values of total $Q$ is plotted in fig. 6.

The simple quarter-wave pi section may be thought of as consisting of two L-section matching networks, with the first L-network transforming the source impedance of 50 ohms to a lower value and the second L-section transforming this virtual impedance back to 50 ohms. If the network has a $Q$ of 1, the virtual impedance will be 25 ohms. The value of the virtual impedance depends on the circuit $Q$:

$$R_{virtual} = \frac{R_{source}}{(Q^2 + 1)} \quad (11)$$

The half-wave filter in fig. 1 is formed by cascading two quarter-wave filters. The shunt capacitors at the junction of the two quarter-wave filters may be combined into a single capacitor. As the power through the filter is increased, it is better to use two capacitors to support the increased current.

**Construction**

At VHF and UHF, the ground plane of a filter must be given careful thought (see figs. 7 and 8 and Table 1). Appreciable inductance in the ground path will cause extra resonances to appear, especially at the higher frequencies. Harmonic energy must not be allowed to "sneak around" the filter due to extraneous ground paths. The capacitors must also have low-inductance leads. Metal-clad, uncased precision mica and teflon capacitors can be used at VHF to minimize this lead inductance by soldering the case directly to the ground plane. The coils are self-supporting.

**Diagrams**

- Fig. 8. At 220 MHz, the inductors take the shape of hairpin inductors.
- Fig. 9. High-power filters require larger size wire and larger capacitors.
- Fig. 10. Microstripline filters use either printed or hairpin inductors.
and wound with No. 14 formvar-covered wire. Higher power filters (fig. 9) require larger wire and more capacitors in parallel to handle the increased current.

432- and 1296-MHz quarter-wave filters can use a microstrip line structure with either (fig. 10) printed or hair pin inductors. The lumped capacitors are shaped to have minimal series inductance and the pc inductors are formed by "necking down" the center conductor (0.025-inch wide and 1.225 inches long at 450 MHz and 0.424 inches long at 1.3 GHz.) Type N launchers were added at the edge of the printed circuit boards. Table 2 includes dimensions for these same two filters using hair-pin inductors. The experimental results, comparing hairpin inductors with etched printed lines, are shown in fig. 11.

**adjustment**

Because most hams don't have sweep generators for checking filter response at the second, third, and fourth harmonics, it's best to construct simple VHF filters using lumped elements, which can be readily adjusted using a grid-dip meter. If reasonable construction practices are followed, one can expect a certain minimum guaranteed performance at the harmonics because adjustments have been made to ensure minimum loss at the design frequency. The simple quarter-wave filter is adjusted to the design frequency by shorting out a capacitor at either end of the pi network and adjusting the inductor for resonance, with the source and load impedances removed, as shown in fig. 12A. This effectively forms a parallel resonant circuit with C and L. The short circuit should be placed close to the common ground plane to decrease series inductance. Using a grid-dip meter, adjust the coil to resonate with the open capacitor at the design frequency. Adjust the half-wave filter in a similar manner by shorting the "double-value" capacitor and then adjusting each coil to resonance, as in fig. 12B. Adjust the three-quarter wave filter in a similar manner, as shown in fig. 12C. The center coil is simply adjusted to physically resemble the outer coils. Each of the filters for which data is shown in fig. 4 was adjusted in this manner and then measured with no further peaking.

The coils may also be adjusted for resonance with-

<table>
<thead>
<tr>
<th>Design Frequency</th>
<th>Dimensions</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>450 MHz</td>
<td>0.334&quot;</td>
<td>0.694&quot;</td>
</tr>
<tr>
<td>1,300 MHz</td>
<td>0.228&quot;</td>
<td>0.472&quot;</td>
</tr>
</tbody>
</table>

Table 2. Hairpin inductor multiple-quarter-wave filter dimensions.
out the short circuit. The inductor in the quarter-wave circuit of fig. 12A will resonate with the series combination of the end capacitors. The value of capacitance will then be one-half the value of either capacitor, with a resonant frequency of

$$f_{resonant} = \sqrt{2} f_0 = 1.414 f_0$$  \hspace{1cm} (12)

The resonant frequency is 76 MHz, for example, for a 6-meter low-pass filter designed for an upper cutoff frequency of 54 MHz. The half-wave circuit shown in fig. 12B may be adjusted without using a short in a similar manner if only one inductor is connected at a time. The resonant frequency formed by 2C, L, C is

$$f_{resonant} = \sqrt{3/2} f_0 = 1.225 f_0$$  \hspace{1cm} (13)

which is 66 MHz for an upper cutoff frequency of 54 MHz. If both inductors are present, the circuit will resonate at \( \sqrt{2} f_0 \). The resonant circuit will be composed of a capacitor of 2C in parallel with two series circuits of L and C.

Hairpin inductors are adjusted for minimum loss using the transmitter and a power meter. As the hairpin is adjusted closer to the ground plane, the resonant frequency is decreased. The inductance is decreased, but the shunt capacity increases by a greater amount. The insertion loss of the multiple quarter-wave filter increases if low quality components are used. Coils typically have a lower inherent Q than capacitors. The dissipative insertion loss for a quarter-wave filter is given by

$$\text{Dissipative Loss (dB)} = 10 \log \left[ 1 - \frac{Q_T}{Q_{COIL}} \right]$$  \hspace{1cm} (14)

The loss for a half-wave filter is simply twice the loss of a quarter-wave filter.

references
5. Standex Electronics, 4538 Camberwell Road, Cincinnati, Ohio 45209.
6. SEMCO, Route 6 North Windham Road, Willimantic, Connecticut 06226.

HAMS SHOULD BE SEEN
AS WELL AS HEARD!

TVC-4G 70cm ATV Downconverter
Now only $99
Delivered UPS surface in cont. USA

- See live action color & sound like broadcast TV
- Many areas have ATV Repeaters (call us or see the 87/88 ARRL: Repeater Directory pg. 328 for your area)
- Most ATVers use home cameras and VCRs to show the shack, projects, home video tapes, public service events like parades, races, etc.
- Some repeaters also have weather radar, Space Shuttle video, BBS, & computer video

It's easy to start watching: 70cm antenna, a TV-4G 4G and any TV set tuned to ch2, 3 or 4. Our TVC-4G tunes the whole 420-450 mHz band & includes GaAsfet preamp & mixer, AC/12vdc wall plug, attractive shielded 4x2.5x7 cabinet. We also have wired & tested boards for the builder starting at $39. See ARRL Hbk chapter 20.

Hams, Call or Write for our full catalog of ATV gear!
(818) 447-4565 m-f 8am-5:30pm pst.

P.C. ELECTRONICS
2522 Paxson Ln Arcadia CA 91006

Tom (W6ORG)
Maryann (WB6YSS)
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, boolegth 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 ft², weight 14.3 lbs.,
- Excellent gain, F/B ratio 24 dB.

Another Boomer First

Bill Daval, K5UGM of Irving, Texas, created VHF history on June 14, 1987, by making the first ever 280 MHz sporadic E contact during the June VHF QSO party. He contacted W5H/U4/4 in Florida at 1544 UTC.

Bill used the high performance Cushcraft 2201B "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.
The only repeaters and controllers with REAL SPEECH!

Create messages just by talking. Speak any phrases or words in any languages or dialect and your own voice is stored instantly in solid-state memory. Perfect for emergency warnings, club news bulletins, and DX alerts. Create unique ID and tail messages, and the ultimate in a real speech user mailbox — only with a Mark 4.

Call or write for specifications on the repeater, controller, and receiver winners.

MICRO CONTROL SPECIALTIES
Division of Kendecom Inc.
23 Elm Park, Groveland, MA 01834 (617) 372-3442

HERE NOW! 1987-88 ARRL Repeater Directory
$5.00 postpaid from ham radio Bookstore
Greenville, NH 03048 (603) 878-1441

Save Time-Money with HAZER
• Never climb your tower again with this elevator system.
• Antenna and rotator mount on HAZER, complete system trams tower in vertical upright position.
• Safety lock system on HAZER operates while raising-lowering & normal position. Never can fail.
• Weight transferred directly to tower. Winch cable used only for raising & lowering. Easy to install and use.
• Will support most antenna arrays.
• High quality materials & workmanship.
• Safety - speed - convenience - smooth travel - inexpensive.
• Complete kit includes winch, 100' ft of cable, hardware and instructions. For Rohn 25 G Tower.

Hazer 2-Heavy duty alum. 12 sq. ft load $207.00 each.
Hazer 3-Standard alum. 8 sq. ft load 213.00 each.
Hazer 4-Heavy galy. steel, 16 sq. ft. load 278.00 each.
Ball thread bearing TB-25 for any size above $125.00 each.

Satisfaction guaranteed. Call today and charge to Visa or MasterCard.

As an alternative purchase a Martin M-13 or M-16 aluminum tower engineered specifically for the HAZER system, or a truly self-supporting steel tower. Send for free details.

THE RF CONNECTION
213 North Frederick Ave. #11
Gaithersburg, MD 20877
(301) 840-5477
CASH PRICES

THE RF CONNECTION
"SPECIALIST IN RF CONNECTORS AND COAX"
Part No. Description Price
83-825 BNC 2 PST 28 volt coaxial relay, Amphenol $1.00
UHF Male Silver Teflon, USA N Male RG-8, 213, 214, #1.75
UG-216/U N Male RG-8, 213, 214, King 3.75
UG-218/U N Male RG-8, with 9913 Pin 4.75
UG-21G/9913 N Male for RG-8 with 9913 Pin 3.95
UG-218/9913 N Male for RG-8 with 9913 Pin 4.75
UG-146/U N Male to SO-239, Teflon USA 5.00
UG-63/U Female to SO-239, Teflon USA 5.00

"THIS LIST REPRESENTS ONLY A FRACTION OF OUR HUGE INVENTORY"

THE R.F. CONNECTION
213 North Frederick Ave. #11
Gaithersburg, MD 20877
(301) 840-5477

CASH PRICES

SSB ELECTRONIC TRANSVERTERS & PREAMPLIFIERS
LT-25 144/220 MHz GaAsFET DBM...$549 LT-35S 90/144, 220 MHz GaAsFET...$499
LT-35 90/144, 220 MHz GaAsFET...$499 LT-35SE 1296/144, 220 MHz GaAsFET...$499
LT-35CC 1296/144/220 MHz GaAsFET...$499
MICRO-10 1080/144 MHz DM GaAsFET...$499
DX series low noise GaAsFET preamps...$199
MV series mast mounted GaAsFET preamps...$199
MV series coaxial GaAsFET DBM...$199

TRANSVERTER UNLIMITED
T2120/2W 220 MHz Xvnt 26 or 50 ft, 20 W...$220 144 MHz Xvnt 28 or 50 ft, 25 W...$199
PA3320 902 MHz, 2 tube PA, 200W...$499 PA23150 1296/220 MHz, 150 +W...$499
PA23325 1296/220 MHz, 2 tube PA, 250 + W...$199
HF 100 High power relay 26 w 220 MHz...$129
UKT 500 Medium power relay 1KW at 144 MHz...$199

Call or write for catalogue.
UNPRECEDENTED WIDE FREQUENCY RANGE: Covers 140,000-153,000 MHz in steps that can be set to any multiple of 5 kHz up to 50 kHz.

CAP/MARS/NAVY MARS, BUILT IN: The wide frequency range facilitates use of CAP and all MARS FREQUENCIES including NAVY MARS. COMPARE!

TINY SIZE: Only 2 inches high, 5 1/2 inches wide and 7 1/4 inches deep!

MICROCOMPUTER CONTROL: Gives you the most advanced operating features available.

UP TO 11 NONSTANDARD SPLITS: COMPARE this with other units!

20 CHANNELS OF MEMORY IN TWO SEPARATE BANKS: Retains frequency, offset information, PL tone frequency.

DUAL MEMORY SCAN: Scan memory banks separately or together.

ALL memory channels are tunable independently.

COMPARE!

MEMORY SCAN LOCKOUT: Allows you to skip over channels you don't want to scan.

TWO RANGES OF PROGRAMMABLE BAND SCANNING: Limits are quickly reset. Scan ranges separately or together with independently selectable steps in each range. COMPARE!

BUSY SCAN AND DELAY SCAN: Busy scan stops on an occupied channel. Delay scan provides automatic auto-resume.

DISCRIMINATOR CENTERING (AZDEN EXCLUSIVE PATENT): Always stops on frequency desired when scanning.

PRIORITY MEMORY AND ALERT: Unit constantly monitors one memory channel for signals, alerting you when channel is occupied.

LITHIUM BATTERY BACKUP: Memory information can be stored for up to 5 years even if power is removed.

FREQUENCY REVERSE: Allows you to listen to repeater input frequency.

ILLUMINATED KEYBOARD WITH ACQUISITION TONE: Keys are easily seen in the dark, and actuation is positively verified audibly.

CRISP, BACKLIT LCD DISPLAY: Easily read no matter what the lighting conditions!

DIGITAL S/R F METER: Shows incoming signal strength and relative transmitter power.

MULTI-FUNCTION INDICATOR: Shows a variety of operating parameters on the display.

FULL 16-KEY TOUCHTONE PAD: Keyboard functions as auto-patch when transmitting.

MICROPHONE CONTROLS: Up/down frequency control and priority channel recall.

PL TONE GENERATOR BUILT IN: Instantly program any of the standard PL frequencies into the microcomputer. COMPARE!

TRUE FM, NOT PHASE MODULATION: Unsurpassed intelligibility and audio fidelity. COMPARE!

HIGH/LOW POWER: Select 25 watts or 5 watts output — fully adjustable.

SUPERIOR RECEIVER: Sensitivity is better than 0.15 microvolt for 20-dB quieting. Commercial-grade design assures optimum dynamic range and noise suppression. COMPARE!

DIRECT FREQUENCY ENTRY: Streamlines channel selection and programming.

OTHER FEATURES: Rugged dynamic microphone, built-in speaker, mobile mounting bracket, remote speaker jack, and all cords, plugs, fuses and hardware are included.
Get lightning, EMP and static protection for receivers, transceivers, amplifiers...

With EMP Series Transi-Trap® Surge Protectors

Model R-T and LT EMP Series Arc-Plug cartridges are designed to protect against nuclear electromagnetic pulse (EMP), as well as lightning surge voltages. The EMP Series design is based on the National Communications System Technical Information Bulletin 85-10 covering EMP protection for communications equipment.

All Transi-Trap Protectors feature "isolated ground" to keep damaging arc energy from the chassis.

Don't hook up your coax without a protector against nuclear electromagnetic pulse (EMP). Use the EMP Series Surge Protectors. Model R-T and LT EMP Series Surge Protectors are best for RCVRS and XCVRS.

See Data Sheet for surge limitations.
revisiting the “poor man’s spectrum analyzer”:
digitally generating sawtooth (and other)
waveforms
In the March, 1987 column we discussed the “Poor Man’s Spectrum Analyzer,” which I built from an article published by W4UCH. The design was originally put together by Murray Barlowe, WA2PZ0, of Science Workshop. In that column I mentioned that the sawtooth generated for that project left something to be desired, and offered a digitally generated improved sawtooth generator design to anyone who sent me a No. 10 SASE. Nearly 30 people wrote to me either via ham radio, my old callbook QTH, or my new QTH (see end of this article). As a result, I’ve decided to publish that circuit here. The response to my offer delighted me because it indicates that the doomsayers are wrong: Amateur construction is not dead!

Figure 1 shows part of the problem with the original sawtooth generator circuit. In my previous column on this subject, I showed several different sawtooth waveforms that were worse than fig. 1; this version is the best case. The waveform has two defects which adversely affect the operation of the spectrum analyzer. First, the rising ramp part of the sawtooth isn’t linear. Because the original design was a capacitor charge/discharge circuit in the form of a Miller integrator, the ramp naturally has a shape like the normal capacitor charge waveform. What’s required of a proper sawtooth is a linear ramp. The second defect is the fall-time: it’s too long. Use of a few low-cost digital components produces a better sawtooth waveform.

fig. 1 Best waveform available from the sawtooth generator.

The circuit for the new sawtooth generator is shown in fig. 2. The heart of this circuit is U1, a DAC0806 eight-bit digital-to-analog converter (DAC). This DAC, based on the Motorola MC-1408 family of DACs, was selected because it’s well behaved and available through mail order sources such as Jameco Electronics or in blister packs through Jameco’s local distributor line of Jim-Paks.

A DAC produces an output voltage that is proportional to the reference voltage or current and the binary word applied to its digital inputs. The transfer function of this DAC is:

\[ I_0 = I_{REF} \cdot \frac{A}{256} \]  

where:

- \( I_0 \) is the output current from pin 4;
- \( I_{REF} \) is the reference current applied to pin 14, and
- \( A \) is the decimal value of the binary word applied to the eight binary inputs (pins 5-12).

The reference current is the reference voltage divided by the series resistor value at pin 14. In data systems the reference voltage is a precision, regulated potential. But in this case we don’t need that precision, so we can use the V+ power supply as the reference voltage. Therefore, the reference current is \((+12 \text{ Vdc})/R4\). With the value of R4 shown (6800 ohms), \( I_{REF} \) is 0.0018 amperes, or 1.8 mA. Values from 500 pA are permissible with this device. If you elect to change the reference current, be sure to keep R4 equal to R5.

The reference current sets the maximum value of output current, \( I_0 \). When a full-scale binary word (11111111) is applied to the binary inputs, the output current \( I_0 \) is:

\[ I_0 = \left( 1.8 \mu A \right) \cdot \frac{255}{256} = \left( 1.8 \mu A \right) \cdot 0.996 = 1.78 \mu A \]

the DAC0806 is a current output DAC, so we must use an op amp current-to-voltage converter in order to make a sawtooth voltage function. A circuit that accomplishes this is an ordinary...
inverting follower without an input resistor. The output voltage ($V_0$) will rise to a value of ($I_0 \times R3$).

The waveform produced by this circuit is shown in fig. 3. This waveform has a period, $T$, of about 5 ms ($1/T = 200$ Hz), and an amplitude of about 5 volts. In fig. 3A, notice that the falling edge is too fast for the oscilloscope camera to photograph (contrast this with the fig. 1 waveform). The leading edge of this latter waveform also represents an improvement. An expanded view of the positive-going ramp is shown in fig. 3B.

The actual output waveform is a staircase of binary steps, each equal to the 1-LSB (Least Significant Bit) current of U1 (or the 1-LSB voltage of $V_0$). The 1-LSB voltage is the smallest step change in output potential caused by changing the least significant bit (B1) either from 0 to 1, or from 1 to 0. You don't see it in fig. 3 because the frequency response of the 741 operational amplifier used for the current-to-voltage converter acts as a low-pass filter to smooth the waveform. If a higher frequency op amp is used, then a capacitor shunting R3 will serve to (low-pass) filter the waveform. Although I haven't tried other op amps in this application, I suspect a -3 dB cutoff frequency in Hz;

where:

- $C$ is the capacitance in microfarads;
- $f$ is the -3 dB cutoff frequency in Hz;
- $R3$ is expressed in ohms.

This circuit is synchronized by a clock oscillator consisting of a single 555 IC timer. Although not a TTL device, the 555 is TTL-compatible when the V+ potential applied to pins 4 and 8 is limited to +5 Vdc. The 555 is connected in the astable multivibrator configuration and generates a +4 volt amplitude series of pulses. The operating frequency is set by three resistors ($R1$, $R2$, and $RW$) and capacitor $C7$. The actual frequency is:

$$f = \frac{1.44}{((R1 + RW) + 2R2) C7}$$ (4)
where:

- \( f \) is the frequency in Hz;
- \( C_7 \) is in farads;
- \( R_1, R_2 \) and \( R_W \) are in ohms.

Select a clock frequency that is 256 times the desired sawtooth sweep frequency. For most spectrum analyzer projects the sweep frequency range will be 10 to 200 Hz. Slower rates make viewing on the CRT screen difficult, while faster rates may tend to "ring" the bandpass filter used in the i-f amplifier section.

**waveform selection**

As electronic music buffs will testify, we can get almost any waveform we need by applying the right binary words to the digital inputs of the DAC0806. Because I wanted a sawtooth waveform, the DAC inputs were connected to the outputs of an eight-bit binary counter built from a pair of 7493 TTL base-16 counter chips. Each chip is a four-bit counter, so they are cascaded to produce the eight-bit binary word needed to drive the DAC. If you want a detailed description of this chip, I recommend Don Lancaster's book *TTL Cookbook.*

The function of this counter is to increment in steps from 00000000 to 11111111 under control of a clock signal applied to the input (pin 14) of U2. You could use any eight-bit counter that outputs a TTL-compatible signal in place of the 7493 devices that I selected. The 7493 was chosen for the best of all engineering reasons: I had a pair of them in my junkbox.

If you want a triangular waveform, then it's possible to replace the 7493 devices with a base-16 up/down counter chip. Arrange the digital control logic to reverse the direction of the count when the maximum state (11111111) is sensed.

There are two ways to generate waveforms other than a sawtooth or triangle, and both of them involve using computer memory. The binary bit pattern representing the waveform, and then output in the right sequence, are stored in memory. One method uses a ROM that you pre-program with the bit pattern. A binary counter circuit connected as an address generator selects the bit pattern sequence. The second method stores the bit pattern in a computer, then outputs it under program control via an eight-bit parallel output port. This method is usable for both generating special waveforms and for linearizing the tuning characteristic of the spectrum analyzer.

The varactor TV tuner that forms the basis of this project has a nonlinear voltage vs. frequency characteristic. This is due to both the nature of varactor diode voltage vs. capacitance curves, and to the fact that the change of frequency in an LC tank circuit is proportional to the square root of the change in capacitance. For this reason I suspect that the actual mathematical function of the curve is basically parabolic (i.e., it looks as if it might approximate a quadratic "aX^2 + bX + c" function).

There are a couple of methods that can be used for the linearization process. First, the analog method involves the use of an XY/Z analog multiplier divider circuit (a special IC). These devices can be connected as a "square rooter" stage. There are two problems with this: first, that the values of the constants must be determined (which is not so easy) and second, that many of these ICs tend to be either expensive or temperamental, especially to changes in temperature. However, there is a digital solution.

The digital solution to the linearization problem involves storing a look-up table in either a ROM or computer memory. I learned this system in a medical electronics laboratory where it was once used to linearize low-level pressure transducer measurements.

*Figure 4* shows a generic version for a voltage that represents some parameter \( P \), which in our case might be the frequency of the spectrum analyzer local oscillator. The actual nonlinear curve could be any shape, including parabolic, while the "ideal" curve is a linear function \( Y = mX + b \), where \( b = 0 \). The idea is to measure the ideal voltage (which in our case is generated by the sawtooth or tuning control) with an A/D converter, and then output a binary word to a DAC that represents the actual required voltage. For example, at point P1 the ideal voltage is 0.9 Vdc, while the actual voltage is 0.68 Vdc. When the computer senses an ideal voltage of 0.9, it creates an actual voltage of 0.68 in order to drive the tuning to the correct frequency.

Another concept is to go all digital, except for the DAC that creates the actual tuning voltage. We could, for example, divide the spectrum up into \( N \) segments and store the binary codes for the correct tuning voltages in memory for each discrete point. The value of \( N \) corresponds to the bit length of the DAC. *Figure 5* shows a simplified block diagram of such a system. Tuning is controlled by a clock that drives the binary counter. The \( N \)-bit binary word output from the counter is routed to the address pins on the ROM. Contained in the ROM is the bit pattern for each of the \( 2^N \) discrete vol-

---

**fig. 3A.** Waveform from the digital sawtooth generator: three successive waves.

**fig. 3B.** Waveform from the digital sawtooth generator, expanded to show greater detail.
One reader wrote about an “inverted scope image” problem, which I am at a loss to describe. If anyone has had this problem and solved it, then please pass the solution on to me and I’ll pass it on to the affected reader. If it’s of sufficient interest, perhaps we’ll find space to cover it in a future issue.

WA2PZO now has a tracking generator kit available for the “Poor Man’s Spectrum Analyzer.” It consists of a modified tuner and some extra parts that go on the SW-6006 i-f board. Write to him for details. In the meantime, I’m planning to build it and evaluate it in this space sometime in the future. I don’t want to devote much space to this project because of all the other pressing issues that interest readers . . . but a tracking generator has definite possibilities!

references

1. Science Workshop, Box 393, Bethpage, New York 11714.
3. Jameco Electronics, 1355 Shoreway Road, Belmont, California 94002. (Catalog available for $1.00 postage and handling.)
5. Dick Smith Electronics, P.O. Box 2249, Redwood City, California 94064. (148-page catalog available for $1.00 postage and handling.)

Joe Carr, K4IPV, can be reached by mail at P.O. Box 1088, Falls Church, Virginia 22041.

ham radio
Now You Can Have the Best of Both . . .
Radio Data Communications and PC-Compatibility!

The DS-3200 is the NEW terminal from HAL Communications Corp. that combines the best features of both a computer-based terminal and a radio data terminal.

Now you can have the BEST in a radio data communications terminal with the NEW DS-3200.

Recognizing the chief weakness of previously available computer-based terminals is RFI generation and susceptibility, HAL has designed the fully-shielded DS-3200 for operation in the radio data communications environment. No longer do you have to QRT when that rare DX station's signal dips near the noise level!

The DS-3200 is provided with an extensive RTTY software package which emulates the operation of our MPT3100/DSDK3100 combination for message processing and handling. Continuous save to disk of all received text, direct transmission of selected files from disk, and full editing capability are just a few of the features of this "user-friendly" software package. Plus, we have included the latest release of MS-DOS with GW BASIC!

The built-in RS-232C serial port allows the use of the DS-3200 with an external demodulator such as the HAL ST-5000, ST-6000, or ST-8000. Or, add the HAL PCI-2000 for a completely self-contained RTTY/CW terminal and demodulator. Also, with the use of a second RS-232C serial port the DS-3200 can be used with your favorite TNC on Packet!

The DS-3200 with its IBM PC XT-style architecture gives you virtually unlimited flexibility for future expansion. Here is a list of just some of its hardware features: 8088 CPU, 640KB RAM, RS-232C Serial Port, Parallel Printer Port, Clock/Calendar with Battery Back-Up, Two 380KB Floppy Disk Drives OR One 360KB Floppy and One 20MB Hard Disk Drive, HERCULES-compatible Monochrome Graphics Adapter with High-Resolution 12 Inch Monochrome Video Monitor.

The DS-3200 is THE choice for modern radio data communications.

Write or call for complete specifications on the NEW DS-3200.

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

 Trademarks: IBM, International Business Machines Corporation
 MS-DOS, Microsoft Corporation
 GW BASIC, Microsoft Corporation
 HERCULES, Hercules Computer Technology
Tell 'em you saw it ~ HAM RADIO!

KENWOOD TS-940S

TOP-OF-THE LINE HF TRANSCEIVER
GREAT PRICE, CALL

KENWOOD TM-3530A

The First Comprehensive 220 MHz FM Transceiver.
ARE YOU READY FOR 220 MHz OPERATION?

Gordon West's 21 DAY NOVICE

$19.95

CODE TAPES • 112 PAGE BOOK • BANDS CHART
ALL FCC FORMS • SIMPLE TESTS • PLUS MORE!
Free ICOM 520 equipment certificate when you receive call letters.
Ham radio equipment "Wish Books".
ARRL membership forms.
Online for student questions.
Course completion certificate.

Alpha Delta
Model DELTA-4
Lightning Surge Protected 4-Position RF Coax Switch
- Exclusive center "off" (ground) position.
- Uses ceramic Arc-Plug® protector.
- Micro-strip circuitry—no water switch.

Model DELTA-4 (UHF Connectors) $69.95
Model DELTA-4/N (N-type Connectors) $89.95

All Major Brands in Stock Now!

CALL TOLL FREE (800) 854-6046

Tell 'em you saw it in HAM RADIO!
HAM RADIO OUTLET
LARGEST HAM OUTLET IN THE WORLD

7 STORE BUYING POWER

ICOM IC-761
HF SUPERIOR GRADE TRANSCEIVER
SALE! CALL FOR PRICE

ICOM IC-275A/275H
138 - 174 MHz
IC-275A (25w) IC-275H (100w)
GREAT PRICE!

ICOM IC-28A/28H
2-METER MOBILES
IC-28A (25w) IC-28H (45w)
LOW PRICE!

ICOM IC-735
The Latest in ICOM's Long Line of HF Transceivers
CALL FOR LOW, LOW PRICE

ICOM IC-R7000
25 MHz-1300 MHz
IN STOCK FOR IMMEDIATE DELIVERY

ICOM IC-1271A
1.2 GHz Transceiver:
The First Full-featured 1240-1300 MHz Transceiver
ARE YOU READY FOR 1.2 GHz OPERATION?

HAND HELD VHF/UHF

NOW! RAPID DELIVERIES
COAST TO COAST
FROM STORE NEAREST YOU

CALL TOLL FREE (800) 854-6046
Toll free including Hawaii. Phone hrs. 7:00 am to 5:30 p.m. Pacific Time. California, Arizona and Georgia customers call or visit nearest store. California, Arizona and Georgia residents please add sales tax. Prices, specifications, descriptions subject to change without notice.
New PK-232 Breakthrough

Six Digital Modes - Including Weather FAX

Your home computer (or even a simple terminal) can be used for radio data communication in six different modes. Any RS-232 compatible computer or terminal can be connected directly to the PK-232, which interfaces with your transceiver. The only program needed is a simple terminal program, like those used with telephone modems, allowing the computer to be used as a data terminal. All signal processing, protocol, and decoding software is in ROM in the PK-232.

The PK-232 also includes a no compromise VHF/HF/CW modem with an eight pole bandpass filter, four pole discriminator, and 5 pole post detection low pass filter. Experienced HF Packeteers are reporting the PK-232 to have the best Packet modem available.

Operation of the PK-232 is a breeze, with twenty-one front panel indicators for constant status and mode indication. The 240 page manual includes a “quick start” section for easy connection and complete documentation including schematics. Two identical back panel radio ports mean either your VHF or HF radio can be selected with a front panel switch. Other back panel connections include external modem disconnect, FSK and Scope Outputs, CW keying jacks, and RS-232 terminal interface.

The RS-232 connector is also used for attaching any Epson graphics compatible parallel printer for printing Weather Fax. Weather maps and satellite photos, like the one in this ad, can be printed in your shack.

Contact your local AEA dealer today for more information about the one unit that gives you six modes for one low price, the PK-232.

$319.95
AMATEUR NET
$379.95 AEA RETAIL

A new software enhancement makes the AEA PK-232 the only amateur data controller to offer six transmit/receive modes in a single unit.

* Morse Code
* Baudot (RTTY)
* ASCII
* AMTOR
* Packet
* Weather FAX

Brings you the Breakthrough
happy days are here again?

Something happened last spring. After many months of mediocre conditions, the DX bands came alive. Twenty meters was open until almost midnight, alive with mouth-watering signals. Long-distance DX contacts, heretofore a weak, watery S1 to S2, were now booming in S9-plus. I amazed myself by working a UA1 on 15 meters, something that hadn't happened for many years. DX signals were even coming through on 10 meters!

Although this activity decreased somewhat with the summer lull and high static level, it seems to be picking up with increased vigor this fall. For Amateurs licensed within the last five years, radio conditions over the next several years — as the sunspot cycle increases rapidly — are going to hold big surprises... you ain't seen nothin' yet!

the two-band loop antenna

It's not easy to get an effective DX antenna that will work on both 80 and 40 meters. By "80 meters," I mean both CW operation at the low end of the band and SSB operation near the DX slot at 3.8 MHz. It looks as if Jack McCullough, W6CHE, has found an answer — providing you have a modest tower and a small amount of real estate. Jack's solution to the 80/40-meter dilemma is shown in fig.
1. The basic antenna is a single 80-meter diamond-shaped Quad loop measuring 65 feet on a side and hung from the top of a 75-foot tower. Since the overall height of the diamond from base to apex is about 90 feet, the loop plane is tilted out at the base, away from the tower. The assembly, thus, is not in the vertical plane. If you have a higher tower, the loop can be mounted in the vertical plane.

The loop is fed with a 50-ohm coax line, plus a 48-foot section of RG-11/U (75 ohm) coax which serves as a matching transformer. The line is cut to 3850 kHz with the aid of a dip meter.

80-meter operation

A double-pole relay is placed between the matching section and the feedpoints of the loop. When the relay is closed, the loop is resonant at 3.8 MHz. When the relay is open, the loop is lengthened by means of an 18-foot section of 450-ohm open-wire line. The loop is now resonant near 3.6 MHz (see fig. 2). Thus, by the flick of a switch, the antenna can be made resonant at either end of the 80-meter band, providing a low value of SWR to the transmitter.

40-meter operation

Operation across the lower portion of the 40-meter band is possible when the relay is either open or closed. The best situation is shown in fig. 3, with the relay in the open position. The operating range, as defined in the curves, is about 7.0 to 7.25 MHz.

The secret of moving the Quad loop about in frequency is the length of the matching stub. Obviously a different length stub is required for operation at the high end of the 40-meter band.

The final W6CHE loop design is shown in fig. 4. Two relays and two stubs are used. One stub is 15 feet long and the other is 4 feet long. In series connection, they represent a stub about 19 feet long. The stubs are switched in and out of the circuit by means of a two-pole, three-position rotary switch at the operating position. Power is applied to the relays by means of a separate switch which energizes the dc supply. Switching sequence for the various frequency ranges is listed in table 1.

A temporary wire antenna for 80, 40 and 20 meters

A friend of mine moved into a temporary location and wanted to get on the high frequency bands with an unobtrusive antenna. He and I thought about it for a while and finally decided on an end-fed wire working against a radial ground system (fig. 5). On 160 meters, the antenna is about 3/16 wavelength long; on 80 meters, about 3/8 wavelength; on 40 meters, about 3/4 wavelength; and on 20 meters, about 3/2 wavelengths. On all bands except 160 meters, the feedpoint impedance runs between 65 and 180 ohms. On 160 meters, it's about 10
Table 1. Switching sequences for W6CHE loop.

<table>
<thead>
<tr>
<th>Frequency Range (kHz)</th>
<th>SW1</th>
<th>SW2</th>
<th>Total Stub Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>3500-3650</td>
<td>open</td>
<td>—</td>
<td>19 feet</td>
</tr>
<tr>
<td>3650-3750</td>
<td>closed</td>
<td>Position 1</td>
<td>15 feet</td>
</tr>
<tr>
<td>3700-3800</td>
<td>closed</td>
<td>Position 2</td>
<td>4 feet</td>
</tr>
<tr>
<td>3750-4000</td>
<td>closed</td>
<td>Position 3</td>
<td>—</td>
</tr>
<tr>
<td>7000-7125</td>
<td>open</td>
<td>—</td>
<td>19 feet</td>
</tr>
<tr>
<td>7125-7300</td>
<td>closed</td>
<td>—</td>
<td>15 feet</td>
</tr>
</tbody>
</table>

fig. 4. Dual-relay arrangement for operation on the different segments of the 40- and 80-meter bands (see table 1).

Successful operation depends upon two ground rods, plus quarter-wave radials. A good radial ground termination at the base of the antenna. A combination of two ground rods, plus quarter-wave radials.
radials laid upon the surface of the ground will do the job. The more radials, the better.

In this particular installation, the vertical portion of the antenna is about 35 feet, or approximately a half-wavelength on 20 meters.

Since the antenna terminates just outside the radio room, the network is placed in a waterproof box that can be reached in seconds when a band change is desired.

The antenna was adjusted first on 80 meters. The terminals at A-A were shorted together with a one-turn loop and the antenna cut for resonance at 3.5 MHz, with the aid of a dip meter. The flat-top was pruned to achieve the proper electrical length. This makes the antenna slightly short for operation on 40 and 20 meters, but the L-network takes care of the situation. It also permits operation of the antenna at the high-frequency end of the 80-meter band with a low value of SWR at the transmitter. The L-network capacitor is reversed by S1 for 160-meter operation, and the frequency response without retuning on this band is only about 25 kHz.

While its performance on 20 meters isn’t equal to that of a Yagi on a 60-foot tower, it does permit plenty of enjoyable QSOs in a location where a more robust and permanent antenna would be impossible to erect.

15-meter Yagi

I received a letter from “Mac” McDaniel, W4PFZ, that brought joy to my heart. Mac says:

Back in the February, 1955, issue of CQ, you described a two-element Yagi with data for making it a three-element array. I was living in Richmond, Virginia, at the time and made an exact copy of the beam. It had plenty of gain, and local hams were surprised at the front-to-back ratio, which seemed to be about 36 dB.

Over the course of many years I have moved frequently and the beam has been disassembled and reassembled several times. I now have the original beam up on a 55-foot wooden pole. Every time I check the front-to-back ratio on ground wave I come up with numbers between 32 and 38 dB.

I adhere to the philosophy of “if it ain’t broke, don’t fix it,” and have never changed a single dimension since first building the beam in 1956. I’ve replaced the variable gamma capacitor several times and reset it for resonance at 21.3 MHz, which takes about 10 minutes.

The last time I reworked the gamma match, I did it with the beam near the ground, pointed up at the sky. It was easier than working atop the pole and the final result is no different than adjusting the match at the top of the pole.

I thought you might like to hear about the success obtained from following your construction information in an article written over 30 years ago!

Designed long before computer-aided programs were available, the beam Mac speaks about represents a configuration determined by field strength measurements made on a crude antenna range. The inner portions of the elements were made of 12-foot lengths of 1-inch diameter aluminum tubing and the tip sections were made of 7/8-inch diameter tubing. Elements were attached to the boom by means of 8 x 8-inch aluminum plates oriented diagonally so the actual contact with the boom and the elements was about 11 inches.

The ends of each center element were slotted with a hacksaw to a depth of about 1 inch and stainless steel hose clamps were tightened around the slots. A band of red paint was put around each outer section so it could be reassembled exactly as it was originally.

Since 15 meters is coming back to life, I’m reprinting my original Yagi design for those DXers who might want to build their own beam (fig. 6.).

The boom is a single section of heavy-wall tubing, 1 inch in diameter. Dimensions are given for resonance at 21.3 MHz.

The only adjustment required is that of the gamma matching device. Length and spacing of the gamma rod are set as illustrated and a small amount of power is fed to the beam via an SWR meter. The variable capacitor is adjusted for the lowest value of SWR. In some cases, it may be necessary to move the shorting strap between the driven element and the matching rod a few inches one way or the other to achieve a near-unity SWR figure.
Although I've never done it, W4PFZ suggests that the beam can be adjusted on the ground by supporting it in a vertical position, with the director pointing up at the sky and the reflector clear of the ground by a few feet. This sounds a lot easier than hanging by your heels atop the tower to adjust the gamma capacitor!

In the original design, the gamma capacitor was mounted inside a 3 x 4 x 5-inch aluminum "minibox." It was isolated from the box by means of an insulating plate. The box was grounded to the antenna boom. A coax fitting for the feed line was placed on one end of the box and a ceramic feedthrough insulator at the other end of the box supported the gamma rod. The shaft of the capacitor could be adjusted through a hole in the box. After adjustment, the hole was closed with several layers of tape to prevent water from entering the box. The seams of the box were coated with roofing compound for the same reason.

Commercial 6061 or aircraft alloy 2024 tubing are recommended for construction of the elements. To retard oxidation at the element joints, a special lubricant, such as the grease employed in industrial power installations that use aluminum conduits, is used. (Some of the trade names for this compound are Penetrox®, Cual-aid®, and Ox-guard®). The compound is smeared lightly over the tubes before they are joined.

I don't know whether many Amateurs build their own beams from scratch today, or if they buy pre-cut kits from a manufacturer. I'll be interested to hear if anyone duplicates this proven antenna and what kind of results they achieve with it. Good luck!

Figure 6 shows the W4PFZ version of the original W6SAI beam for 15 meters using 12-foot boom.
WELCOME—NOVICES
Call for Special
Prices on
220 MHz
Radios &
Antennas

*LABOR DAY
SPECIALS
Sept. 1 — Sept. 12
Receive an extra 5% discount off our
already discounted prices
Limited to
in-house stock
This offer does not apply to
special close-out items.

OPEN SIX DAYS A WEEK
Telephone 617/486-3400, 3040
675 Great Rd., (Rte. 119) Littleton, MA 01460
1½ miles from Rte. 495 (Exit 31) toward Groton, Mass.

"INSTANT" MORSE CODE
Beginners:
Deliciously Easy
Experts:
Automatically Fast
CURLYCODE™ MANUAL
ONLY $6.50
Guaranteed

Electronic Repair Center
Servicing
Amateur Commercial Radio
The most complete repair facility on
the East Coast.
Large parts inventory and factory
authorized warranty service for
Kenwood, Icom and Yaesu.
SEND US YOUR PROBLEMS
Servicing "Hams" for 30 years, no rig
too old or new for us.

Minds eye Publications
Dept. H29, Suite 115-199
1350 Beverly Rd.
McLean, VA 22101

VHF-UHF POWER DIVIDERS
RF power dividers provide the
best way to feed phase 2 and 4
antenna arrays to maximize system
gain and at the same time reduce
losses to a minimum. Coverage
144 thru 1296 MHz, this series of VHF/
UHF power dividers are premier RF
devices designed for a long service
life with low SWR and broad operat-
ing bandwidth.
Extensive aluminum body with a
durable enamelled finish in addition to
silicon sealing at connector flanges
results in a ruggedized unit for all
array installations. Available with
N-type connectors only, these units are
unconditionally guaran-
teed for 2 years.

MODEL
144-3P
220-2P
290-2P
330-2P
430-2P
900-2P
902-4P
1296-2P
1296-4P
SHIPPING NOT INCLUDED
CONFIG.
(2 ports)
(2 ports)
(2 ports)
(4 ports)
(4 ports)
(4 ports)
(4 ports)
(4 ports)
(4 ports)
PRICE
$50.00
$57.00
$57.00
$48.00
$56.00
$56.00
$56.00
$56.00
$57.00

Electronic Repair Center
Servicing
Amateur Commercial Radio
The most complete repair facility on
the East Coast.
Large parts inventory and factory
authorized warranty service for
Kenwood, Icom and Yaesu.
SEND US YOUR PROBLEMS
Servicing "Hams" for 30 years, no rig
too old or new for us.

HAMTRONICS, INC.
4033 Brownsville Road
Trevose, Pa. 19047
215-357-1400
You've put your finger on it!

The biggest problem with existing batteries is never knowing how much operating time you've got left. MOLICEL® rechargeable lithium batteries eliminate that problem.

By simply pressing a button, you'll know exactly where you stand. No more surprises.

And that's not all. In addition to state-of-charge indication, MOLICEL® batteries offer:
- Charge retention of years instead of weeks.
- Long life because there's no memory effect to reduce capacity.
- More operating time between charges.

MOLICEL® replacement battery packs compatible with several popular handheld transceivers are available from MoliKit. Order yours now!

MOLICEL® replacement battery packs (in kit form) are available with plastic cases for ICOM transceivers only. Please enquire about compatibility with other makes. The MoliKit includes a 6-cell pack, PC board, electronic components, charger and instruction book. Price: $99. U.S. (includes shipping). Order by credit card on our toll-free line: Call MoliKit, 1-800-663-6658. PO Box 82460, N. Burnaby, BC, Canada V5C 5Z1 (See "The Magic of Moli." QST, June 1987, pp. 22-25).

1500 + WATT TRANSMATCH KIT $154.95

OTHER KITS

<table>
<thead>
<tr>
<th>Article Reprints (refundable)</th>
<th>$1.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>G3RPH, PsK Packet Modem, Sat./Terrestrial</td>
<td>$99.00</td>
</tr>
<tr>
<td>PC Board for above only, delivered</td>
<td>$27.99</td>
</tr>
<tr>
<td>Ten-Tec Designer Cabinet for above</td>
<td>$12.00</td>
</tr>
<tr>
<td>K9GW Memory Contest Keyer</td>
<td>$109.00</td>
</tr>
<tr>
<td>CMOS Keyer w/Paddle</td>
<td>$45.00</td>
</tr>
<tr>
<td>Yaesu FRG-9600, 200 MHz-Converter</td>
<td>$94.95</td>
</tr>
<tr>
<td>20m CW, 15W Transceiver (H.R. 687)</td>
<td>$149.95</td>
</tr>
<tr>
<td>50W 75M SSB XVCVR</td>
<td>$199.95</td>
</tr>
</tbody>
</table>

Factory Wired

- Nei-Tech DVK-100 | $229.00 |
- B&W PT-2500A Amp | $1,670.00 |
- B&W VS1500A Tuner | $364.00 |

Shipping Extra Unless Noted

1987 catalog $1.00

RADIOKIT • P.O. Box 973-H
Pelham, NH 03076 • (603) 635-2235

diats, terminals, chassis, ceramic standoff, hardware, toroids, amp components, B&W coil stock, etc.

NEW

snap-on-choke

$1.59 pkg. of 4
* $2 for shipping

ELIMINATES RADIO FREQUENCY INTERFERENCE

ELIMINATES RF INTERFERENCE IN TV sets, Radios, Hi-Fi, PA systems, Telephones, VCRs, Test equipment, Burglar and Fire alarms, Modern, Monitors, Computers
due to domestic appliances, Radio Transmitters (CB, Ham Radio, Commercial, Industrial machinery, Gards, Telephones, Computers, Switching Systems, EASY TO USE: fits onto small, large and ribbon cables. We need to remove connectors, nope, split ferrite core design fits up to RG8U coax cables. WORKS IN "COMMON MODE". Filters current induced in the band of shielded cables and ground wires. Special ferrite material effective 0.5 - 200 MHz.

MANUFACTURING

4957 Harvester Rd., Unit #10
Burlington, ONT. L7K 5M3

Manufactured and available in Canada from:
THROW AWAY YOUR FALCON CATALOGS

Falcon Communications, THE source for quality, American made, MOS-FET repeater, base station and mobile power amplifiers announces a major re-design of our line.

See your dealer, or contact the factory, for the latest information on our new MOSFET and bipolar power amplifiers.

FALCON COMMUNICATIONS
P.O. Box 8979 • Newport Beach, CA 92658
(714) 760-3622
minimum requirements for 2-meter EME: part 2

Last month’s column was an introduction to 2-meter EME communications, including explanations of EME terminology. With that information in place, we can concentrate on the minimum requirements, recommended equipment, and operating techniques.

the minimum station

As I stressed in earlier articles, the goal should be to build a station that allows you to hear your own echoes if all conditions are favorable; I call this the “minimum station” (fig. 1). This setup includes the “built-in test” feature described in reference 1 so you’ll be able to verify that your gear is functioning properly. You’ll not only be able to have successful EME contacts — you’ll be able to quickly evaluate system changes and improvements as well.

Table 1 shows the typical minimum parameters and equipment necessary. As you can see, the path loss is staggering compared with path loss on hf, where signals are typically attenuated only 75 to 175 dB. This is part of what makes EME communications such a challenging sport!

It may be worthwhile for those who are mathematically inclined to see how EME path loss is calculated. Sometimes the so-called “radar equation” is used:

\[
R_{\text{max}} = \left(\frac{P_1 G A_e \delta}{\left((4\pi)^2 S_{\text{min}}\right)}\right)^{1/4}
\]

where \(R_{\text{max}}\) is the range in kilometers, \(P_1\) is the transmitter power in watts, \(G\) is transmitter antenna gain in dBi, \(A_e\) is the effective aperture of the antenna in meters squared, \(\delta\) is the radar cross section of the target in meters squared, and \(S_{\text{min}}\) is the minimum detectable signal in watts.

Because eqn. 1 isn’t easily adaptable for Amateurs on EME, I prepared eqn. 2, which is oversimplified and not applicable to the higher bands, where the sky noise is very low. This simplified “2-meter EME radar equation” is useful for evaluating the elements of a station that uses the same antenna for transmitting and receiving. The reference is the received signal level at the antenna feedpoint based on a 50-ohm impedance:

\[
P_r = P_t + 2(G_d) - P_t
\]

where \(P_t\) is the received signal power in dBm (level with respect to 1 milliwatt), \(P_t\) is the transmitted power in dBm measured at the antenna feedpoint, \(G_d\) is the antenna gain in dBi referenced to the feedpoint, and \(P_t\) is the path loss in dB.

For example, let’s evaluate the minimum station shown in table 1. \(P_t\) is the transmitted power at the antenna feedpoint, 500 watts or +57 dBm. \(G_d\) is the antenna gain, +20 dB. \(P_t\) is the nominal path loss, or 252.5 dB. Therefore, the received power level at the feedpoint is approximately \(-155.5\) dBm (0.0038 microvolts), a very weak signal! (More on this shortly.)

Antenna gain deserves some further comment. As mentioned before, when calculating EME performance, antenna gains are usually specified in dBi (dB over isotropic), since the path loss is specified in the same terms. Just add 2.15 dB to any antenna gain specified in dBi (gain over a dipole) and you’ll be all set. If you use stacked antennas, you’ll have to estimate the overall system gain (see references 5 through 7). When estimating antenna system gain, don’t forget to subtract the phasing line loss.

As discussed in last month’s column, it is common EME practice to use the same antenna on both transmit and receive. The most important EME parameter in eqn. 2 is antenna gain; every time the EME antenna gain increases by 1 dB, the total system performance improves by 2 dB (1 dB stronger on transmit and 1 dB on receive). Therefore, eqn. 2 clearly shows that you should spend most of your EME efforts on perfecting your antenna system.

The transmitted power is well understood. Any increase here is on a dB-for-dB basis. Generally, increasing transmitted power helps the other station hear you better. If you have a 1-dB feed line loss between the output of your final power amplifier and the antenna system, a typical setup on 2 meters, 625 watts is required in the shack so that the required 500 watts will be present at the antenna. Therefore, increasing the transmitter output to the new FCC limit of 1500 watts will increase your signal by only about 3.8 dB, at a considerable expenditure in power amplifier cost.

Finally, there are the receiver considerations. The one most often discussed parameter is the noise figure. Usually, the lower the noise figure, the more sensitive the receiver, and the better you can hear the weak signals returning from the moon. However, on
Please see the complete REVEX line of laboratory instruments and accessories.

**AVERAGE AND PEP RF MONITORING BUILT INTO ALL UNITS.**

1.6 to 1300 mHz.

1 watt to 5kw

**IN LINE TYPE SWR & POWER METERS**

EXCLUSIVE!!! PATENTED WIDEBAND Z COUPLER, AVAILABLE IN NO OTHER UNIT AT ANY PRICE, PROVIDES LABORATORY ACCURACY AND QUALITY AT AMATEUR PRICES...

**REVEX IN LINE WATT METER**

<table>
<thead>
<tr>
<th>RF</th>
<th>144/220/430</th>
<th>RF/50/144/430</th>
<th>RF/445/430/1380</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL</td>
<td>WS 1 0</td>
<td>WS 6 0</td>
<td>WS 5 0</td>
</tr>
<tr>
<td>FREQUENCY RANGE</td>
<td>1.0 MHz ~ 3000 MHz</td>
<td>1.6 - 3500 MHz</td>
<td>1.6 - 3500 MHz</td>
</tr>
<tr>
<td>MEASURABLE POWER RANGE</td>
<td>50W/20W/500W</td>
<td>200W/20W/4W</td>
<td>200W/20W/4W</td>
</tr>
<tr>
<td>SWR SENSITIVITY</td>
<td>1N</td>
<td>1N</td>
<td>1N</td>
</tr>
<tr>
<td>MEASURABLE FUNCTIONS</td>
<td>PEP POWER</td>
<td>PEP POWER</td>
<td>PEP POWER</td>
</tr>
<tr>
<td></td>
<td>PEP POWER</td>
<td>PEP POWER</td>
<td>PEP MONITOR</td>
</tr>
<tr>
<td></td>
<td>PEP POWER</td>
<td>PEP POWER</td>
<td>PEP MONITOR</td>
</tr>
<tr>
<td>IMPEDANCE</td>
<td>50Ω</td>
<td>50Ω</td>
<td>50Ω</td>
</tr>
<tr>
<td>IN/OUT CONNECTOR</td>
<td>100230</td>
<td>100230</td>
<td>100230/50Ω</td>
</tr>
<tr>
<td>METER</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SENSOR</td>
<td>1-BUILT IN TRIMABLE CORE</td>
<td>1-BUILT IN TRIMABLE CORE</td>
<td>2-BUILT IN TRIMABLE CORE</td>
</tr>
<tr>
<td></td>
<td>STRIP LINE</td>
<td>STRIP LINE</td>
<td>1/2W TQ SENSIBLE CORE</td>
</tr>
<tr>
<td>Dimentions (a/b)</td>
<td>129 x 72 (10 x 4) x 35 (143 x 136)</td>
<td>129 x 150 (10 x 6) x 35 (143 x 136)</td>
<td>129 x 150 (10 x 6) x 35 (143 x 136)</td>
</tr>
<tr>
<td>WEIGHT</td>
<td>APPROX 700g</td>
<td>APPROX 56g</td>
<td>APPROX 670g</td>
</tr>
</tbody>
</table>

For your nearest Dealer or to order:

**TOLL FREE..800-327-3102**

Telephone (404) 769-8706 Telex: 4930709 ITT

---

**SYNTHESIZED SIGNAL GENERATOR**

**MADE IN USA**

**MODEL** SG 100F

**$429.95 delivered**

- Covers 100 MHz to 199,999 MHz in 1 kHz steps with thumbwheel dial
- Accuracy +/– 1 part per 10 million at all frequencies
- Internal FM adjustable from 0 to 100 kHz at a 1 kHz rate
- External FM input accepts tones or voice
- Spurious and noise at least 60 dB below carrier
- Output adjustable from 0-500 mV at 50 Ohms
- Operates on 12 Vdc @ ½ Amp
- Available for immediate delivery

**VANGUARD LABS**

196-23 Jamaica Ave., Hollis, NY 11423
Phone: (718) 468-2720 Mon. thru Thu.

---

**MICROCOMPUTER REPEATER CONTROL**

**$129**

Introducing the MICRO REPEATER CONTROLLER RPT-2A, a new concept of LOW COST EASY TO INTERFACE microcomputer repeater control. Replace old logic boards with a state of the art controller.

**NEW FEATURES:**
- LOW POWER
- SMALL SIZE
- FULL DOCUMENTATION

Contact: Jim Georgias, W9JUG
DeVry VEC
3300 No. Campbell Avenue
Chicago, IL 60618
(312) 929-8500
(800) 327-2444 (outside of Illinois)
Table 1. This table shows the minimum requirements for successful 2-meter EME echoes as discussed in the text.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path loss</td>
<td>252.5 ± 1 dB</td>
</tr>
<tr>
<td>Minimum antenna gain</td>
<td>20 dBi</td>
</tr>
<tr>
<td>Minimum transmitted power at antenna feed</td>
<td>500 watts (+ 57 dBm)</td>
</tr>
<tr>
<td>Maximum receiver noise figure referenced to the antenna feedpoint</td>
<td>1.5 dB</td>
</tr>
<tr>
<td>Receiver bandwidth</td>
<td>50 Hz</td>
</tr>
</tbody>
</table>

2-meter EME the law of diminishing returns applies. You’re limited not only by the feed line loss in the antenna system, but by the noise the antenna “sees” as well (see reference 1). If your antenna feed line loss ahead of your preamplifier is low (i.e., 0.5 dB maximum), you probably won’t gain much improvement by using a noise figure below 1.0 dB. This will be discussed below.

**a marginal 2-meter EME station**

By now you’re probably wondering, “But what if I don’t want to go all the way and build a minimum EME station? What are the minimum requirements?” All other parameters being equal, the only requirement that has to be satisfied is that the sum of the antenna gains at both stations be equal to or greater than 40 dBi. Therefore, if the other station has a 25-dBi antenna gain, you can have successful QSOs with only a 15-dBi antenna gain — the gain of a single high-performance Yagi on a boom measuring three wavelengths or longer.

If you have the minimum 20-dBi antenna gain and schedule a station sporting 25 dBi of gain, you can use power levels down to 5 dB lower, or as low as 150 watts at the antenna feedpoint! This explains why the “super stations” have been so successful; they have much greater gain than is required for the minimum station and usually have very low feed line losses, with very low-noise receivers with the preamplifier mounted at the antenna feedpoint. Running the maximum legal power of 1500 watts, they’ve obviously overcome the inadequacies of smaller stations.

Other EME tradeoffs are possible. Sometimes conditions are particularly favorable, especially if Faraday rotation cooperates, some scintillation enhancement is present, the moon is near perigee, and the sky temperature is low. Furthermore, as mentioned in last month’s column, “ground gain,” though elusive, can sometimes result in several dB of enhancement. This is particularly important to stations that don’t have antenna elevation control.
they're usually low-noise on receive, them so they could be rotated not only foot diameter reflector at Arecibo, failure. tended, were among the first really and then by first successful Amateur EME echoes, cy is high. Though collinears are large, in azimuth and elevation, but also the difference between success and tune and usually have open wire phas- tennas. They're not difficult to build or a fixed configuration for horizon shots in a narrow EME window. Rhombics also have many sidelobes, so they can't be considered low-noise receiv- ing antennas.

Collinears, both standard and ex- tended, were among the first really successful rotatable 2-meter EME an- tennas. They're not difficult to build or tune and usually have open wire phasing lines so losses are low and efficien- cy is high. Though collinears are large, some Amateurs were able to arrange them so they could be rotated not only in azimuth and elevation, but also in polarity; this option often makes the difference between success and failure.

Parabolic dishes such as the 1000-foot diameter reflector at Arecibo, Puerto Rico, and the 150-foot at Stanford, California, were used several times for 2-meter EME in the 1960s. However, parabolic dish type antennas aren't too efficient (typically only 50 to 55 percent), and really have to be at least 28 feet in diameter to be worthwhile for 2-meter EME. Despite their shortcomings, dish type antennas require only a simple feed system, they're usually low-noise on receive, loss to the receive preamplifier can be negligible, and they can be easily adapted to polarity rotation. Moreover, they can usually be operated on higher frequency bands if the the feed system is changed.

Nowadays, the Yagi is "king" on 2-meter EME. Over the last ten years Amateurs have expended a great deal of effort towards improving Yagi gain and decreasing sidelobe levels. The result is vastly improved arrays with as many as 32 separate Yagis — with no end in sight! Furthermore, Yagis pack a lot of gain based on volume and form factor. No wonder back yard EME is now so popular.

Table 2, which shows the gain of some of the most popular individual 2-meter EME antenna designs, can be used as a guide to antenna selection. It's interesting to note that the majority of the popular commercial Yagis presently in use on 2-meter EME are based on either the NBS or DL6WU Yagi designs. The gains shown on this table have been either measured or calculated using some of the latest computer modeling techniques and represent true gain.

Because long Yagi designs may be expensive to build — given the high cost of materials — many antennas used on 2-meter EME are commercial types. Homebrewed Yagis are still very popular, however, despite the cost. Both the NBS and DL6WU designs are highly recommended; reference 8 discusses the advantages and disadvantages of these and other Yagi designs. If you want to start small, consider the simple eight-element Yagi design on a 12-foot boom described in reference 9. Four of these antennas stacked only 9 feet horizontally and 8 feet vertically will make an excellent compact, low-cost, back yard starter EME anten- na just shy of the minimum gain in table 1. The array can later be expanded to six or eight of these Yagis if greater gain is desired.

| table 2 | This table shows some of the most common individual antennas presently used on 2 meter EME along with boomenlength, number of elements, and estimated gain. The gains shown represent my best judgment and are based on tests and reported results at 144 MHz; they may vary ±0.25 dB. |
| name and/or manufacter | boomenlength in wavelengths | no. elements | gain dBi | gain dBi |
| W1JR short Yagi | 1.73 | 8 | 11.35 | 13.5 |
| NBS Yagi | 2.2 | 12 | 11.85 | 14.0 |
| Cushcraft 214B Jr. Boomer Yagi | 2.2 | 14 | 12.1 | 14.25 |
| Cushcraft DX-120 collinear | na | 20 | 12.5 | 14.65 |
| Tonna (F9FT) 20116 Yagi | 3.15 | 16 | 12.5 | 14.65 |
| KLM 13LBA Yagi | 3.2 | 13 | 12.5 | 14.5 |
| CueDee Yagi | 3.1 | 15 | 12.85 | 15.0 |
| NBS Yagi | 3.2 | 17 | 13.06 | 15.2 |
| Tonna (F9FT) 20117 Yagi | 3.15 | 17 | 13.15 | 15.3 |
| Cushcraft 3219 Boomer Yagi | 3.2 | 19 | 13.2 | 15.35 |
| NBS Yagi | 4.2 | 15 | 13.55 | 15.7 |
| KLM 16LBX Yagi | 4.1 | 16 | 14.15 | 16.3 |
| Cushcraft 4218XL Yagi | 4.2 | 18 | 14.3 | 16.45 |
| KLM 17LBX Yagi | 4.7 | 17 | 14.5 | 16.65 |
| M² Enterprises (K6MYC) 2M-5WL | 4.8 | 18 | 14.5 | 16.65 |
| 28-foot dish | na | na | 17.55 | 19.7 |
| 32-foot dish | na | na | 18.65 | 20.8 |
| 40-foot dish | na | na | 20.55 | 22.7 |
CODE COURSE
This computer program is broken into three user-friendly parts. Part one introduces to the beginner the different morse characters. The student simply presses a key and the character is sent and displayed on the screen. Part two generates the morse character and the student is required to press the correct key on the computer. If the student answers incorrectly, the character is automatically repeated. Part three sends morse characters in random groups of five. The computer can tailor what is sent to their particular needs, numbers only, letters only or a combination of both. Speeds are from 5 to 20 groups per minute. The computer can also be configured to send the Farnsworth method (high speed/low spacing code) V 2.2.

承担 (For C-64) $9.95

KODE MASTER (for Novice, General or Extra Class students)
Prepare for your next code exam using computer generated QSO's. Each QSO contains callsigns, names, OTH's equipment info plus many of the other exchanges commonly found in Ham QSO's. QSO's can be displayed on the screen by one character at a time, by each sentence or after the completion of the QSO for checking. With a printer you can print out a hard copy. Available in 5 wpm for Novices, 13 wpm for Generals and 20 wpm for Extra class students.

承担 (For C-64)$14.95

承担 (For C-64)$14.95

承担 (For C-64)$14.95

ANTENNA SYSTEM
This nifty antenna modeling and development program will help you get the most from your antenna projects while eliminating much of the drudgery of antenna calculations. Part one covers standard antenna designs—dipoles, verticals and Yagi designs. Part two designs shorted dipole antenna for space limited hams. Great for shortened 160/80 meter antennas. All dimensions are listed. At this price it's not an engineering program but a neat program to have around.

承担 (For C-64) $9.95

RADIO AMATEUR CALLBOOK SUPPLEMENT
(both NA and international calls)
Invaluable operating aid to all classes of Radio Amateur. Includes all calls issued since publication of the 1987 edition of the North American and International editions. The ONLY way to be fully up-to-date is to have the Callbook supplement in your shack. 296 pages. 1987 Edition.

承担 87 $3.95

Please enclose $3.50 shipping & handling.

COMMUNICATION CONCEPTS INC.
121 Brown Street * Dayton, Ohio 45402 * (513) 220-9677
NOVICES

ARE YOU CONFUSED ABOUT YOUR NEW PRIVILEGES? CALL US FOR THE UP-TO-THE-MINUTE INFORMATION AND ASSISTANCE WITH YOUR GEAR.

PK 232

- Make any RS-232 compatible computer or terminal a complete digital operating position.
- Morse, Baudot, ASCII, AMTOR, Packet
- Loaded with features.
Yagi antennas, especially on weak signals. Yagis need a little more antenna gain to strengthen their competitive edge. A 2-times increase in size over four antennas for about 1.6-dB gain increase. This configuration is particularly recommended for Amateurs who just can’t swing eight Yagis but need a little more antenna gain to strengthen their competitive edge.

The six-Yagi configuration is best accomplished by stacking them three high and two wide. In the late 1970s, I built the power dividers and phasing lines for such a configuration and sent all the parts and information along with two extra antennas to Alaskan 2-meter EME station WA0LPK. Jim immediately installed the “kit” and went from 10-percent success on schedules to highly installed the “back plane” configuration, where the first individual power divider is mounted in close proximity to the feedpoint in the individual antennas, is particularly recommended.

Fifty-ohm Heliax® and hardline or Alumifoam® are highly recommended, especially for the transmitter feed line (fig. 1). While they’re expensive, they can often be found at flea markets for reasonable prices. Especially in large arrays, very low-loss transmission lines need be used only on the long runs from the individual power dividers to the central antenna feedpoint.

Several 2-meter EMEs are using CATV hardline. (Ask super stations WA1JXN, K1WHS, and W5UN.) It’s inexpensive and has very low loss, especially below 300 MHz, where it’s closely specified by suppliers. Although it has an impedance of 75 ohms, it can easily be designed into the antenna system and later converted back to 50 ohms with a simple quarter-wave section of 61-ohm line. Heretofore, it’s been common Amateur practice to make phasing lines multiples of a half wavelength. This theory was debunked in reference 7. Since then, some Amateurs have tried using the odd number of quarter-wavelength techniques recommended.

Table 3. This table shows the typical stacking gain improvements for optimally stacked Yagi antennas, excluding any phasing line losses.

<table>
<thead>
<tr>
<th>configuration</th>
<th>gain increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 antennas</td>
<td>2.75</td>
</tr>
<tr>
<td>4 Yagis</td>
<td>5.5</td>
</tr>
<tr>
<td>6 Yagis</td>
<td>7.1</td>
</tr>
<tr>
<td>8 Yagis</td>
<td>8.25</td>
</tr>
<tr>
<td>12 Yagis</td>
<td>9.85</td>
</tr>
<tr>
<td>16 Yagis</td>
<td>11.0</td>
</tr>
<tr>
<td>24 Yagis</td>
<td>12.6</td>
</tr>
<tr>
<td>32 Yagis</td>
<td>13.75</td>
</tr>
</tbody>
</table>

Transmission line losses, even at 144 MHz, can be significant. This is especially true when long Yagis are used in large arrays where many phasing lines are required. Tradeoffs and different types of feed lines are discussed in detail in reference 10, so they won’t be repeated here.

If you can keep it well sealed from water penetration, type 9913 coax is highly recommended, especially for the phasing lines between the individual Yagis and the first power divider. Even RG 8 and 213-U coax types are usable in phasing lines if lengths are kept short. In this regard, the “back plane” configuration, where the first individual power divider is mounted in close proximity to the feedpoint in the individual antennas, is particularly recommended.

Fifty-ohm Heliax® and hardline or Alumifoam® are highly recommended, especially for the transmitter feed line (fig. 1). While they’re expensive, they can often be found at flea markets for reasonable prices. Especially in large arrays, very low-loss transmission lines need be used only on the long runs from the individual power dividers to the central antenna feedpoint.

Several 2-meter EMEs are using CATV hardline. (Ask super stations WA1JXN, K1WHS, and W5UN.) It’s inexpensive and has very low loss, especially below 300 MHz, where it’s closely specified by suppliers. Although it has an impedance of 75 ohms, it can easily be designed into the antenna system and later converted back to 50 ohms with a simple quarter-wave section of 61-ohm line.

Heretofore, it’s been common Amateur practice to make phasing lines multiples of a half wavelength. This theory was debunked in reference 7. Since then, some Amateurs have tried using the odd number of quarter-wavelength techniques recommended.

Table 4. This table shows some typical 2-meter EME arrays with estimated gains.

<table>
<thead>
<tr>
<th>antenna and/or manufacturer</th>
<th>gain</th>
<th>gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>in dBi in dBi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 W1JR 8-el Yagis</td>
<td>16.85</td>
<td>19.0</td>
</tr>
<tr>
<td>4 Cushcraft 214B Jr. Boomers</td>
<td>17.60</td>
<td>19.75</td>
</tr>
<tr>
<td>4 16-el 99FT 2016 or KLM 13 LBA Yagis</td>
<td>18.00</td>
<td>20.15</td>
</tr>
<tr>
<td>80-el Cushcraft collinear</td>
<td>18.00</td>
<td>20.15</td>
</tr>
<tr>
<td>4 Cushcraft 3219 Yagis</td>
<td>18.70</td>
<td>20.85</td>
</tr>
<tr>
<td>4 KLM 16LBX Yagis</td>
<td>19.65</td>
<td>21.80</td>
</tr>
<tr>
<td>160-el Cushcraft collinear</td>
<td>20.75</td>
<td>22.90</td>
</tr>
<tr>
<td>6 KLM 16LBX Yagis</td>
<td>21.25</td>
<td>23.40</td>
</tr>
<tr>
<td>8 Cushcraft 3219 Yagis</td>
<td>21.45</td>
<td>23.60</td>
</tr>
<tr>
<td>8 KLM 16LBX Yagis</td>
<td>22.40</td>
<td>24.55</td>
</tr>
</tbody>
</table>

Table 5. This table shows the estimated antenna gain of some of the 2-meter EME “super stations.”

<table>
<thead>
<tr>
<th>antenna and/or manufacturer</th>
<th>gain</th>
<th>gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>in dBi in dBi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K1WHS 24 Cushcraft</td>
<td>24.7</td>
<td>26.85</td>
</tr>
<tr>
<td>214B Yagis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WA6MGZ 16 KLM</td>
<td>25.15</td>
<td>27.30</td>
</tr>
<tr>
<td>16LBX Yagis</td>
<td>25.15</td>
<td>27.30</td>
</tr>
<tr>
<td>WA1JXN 16 KLM</td>
<td>25.5</td>
<td>27.65</td>
</tr>
<tr>
<td>17LBX Yagis</td>
<td>25.5</td>
<td>27.65</td>
</tr>
<tr>
<td>YL3MVW 24 12-el</td>
<td>26.0</td>
<td>28.15</td>
</tr>
<tr>
<td>J-Slots</td>
<td>26.0</td>
<td>28.15</td>
</tr>
<tr>
<td>KB8BO 32 Cushcraft</td>
<td>26.95</td>
<td>29.10</td>
</tr>
<tr>
<td>3219 Yagis</td>
<td>26.95</td>
<td>29.10</td>
</tr>
<tr>
<td>W5UN 32 KLM 17LBX Yagis</td>
<td>28.25</td>
<td>30.40</td>
</tr>
</tbody>
</table>

Table 6. This table shows the typical stacking gain improvements for optimally stacked Yagi antennas, excluding any phasing line losses.
PACKET RADIO TERMINAL SOFTWARE
PAC PRO FOR THE IBM PC

- Split screen display
- Automatic file transfer protocol
- On-line help screens
- Hard disk support
- Connect alarm
- Full color control
- Multiple buffers
- On-screen clock

Program diskette and operations manual \$29.95 postpaid
Demonstration Disk \$2.00
Also available: Digipack and Message Pack Software

TNC-200
HF/VHF PACKET CONTROLLER

• Two radio ports
• 7910 single-chip modem
• 300 and 1200 bauds
• Enhanced command set
• Multi-color status LED's
• Supports RS-232 and TTL computers
• Active HF band-pass filter
• Tuning indicator option

Shown with Tuning Indicator
MADE IN U.S.A.

AMATEUR DIRECT PRICES
KIT \$129.95
ASSEMBLED \$159.95
OPTIONS:
32K RAM \$9.95
INTERNAL LED BAR GRAPH
TUNING INDICATOR \$39.95

ORDERED ONLY
800-223-3511
CALL OR WRITE FOR MORE INFORMATION

Pac-Comm Packet Radio Systems, 3652 West Cypress St., Tampa, FL 33607

HERE'S A NEAT GIFT IDEA

When we first saw the Casio PQ-40U Portable World Time Clock, we knew instantly that Ham Radio Bookstore customers would love this one.

This time piece is more than a simple clock. Besides all the standard features, alarm, snooze, lightweight portable design and digital readout, this clock gives you time at 21 different locations around the world at the twist of a dial. DX'ers will delight at being able to get rid of their cumbersome manual time calculators: determining band and path to use will be greatly simplified. Contesters can simultaneously display both local and UTC times for logging purposes. In fact, every Amateur will find at least a dozen uses for this nifty clock. You can take it with you when you go on "Your V2PV articles are priceless. Your magazine is Super!" Rush Drake, W7RM

"Let me congratulate you on a very impressive magazine. Just what I've been looking for as a DXer and Contesteer!"
Dick Moen, N7RO

"RADIOSPOTTING, once received, cannot be tossed aside until it is read from cover to cover. Then reviewed again and again."
Chas Browning, W4PKA

Subscription rates: 1 year USA \$18, Canada CDN\$26, Overseas US\$23; 2 years \$35, S\$42 respectively. Single issue \$2.
USA First Class Mail add \$8/year, Dl Air Mail add \$15/year.

TRY US! SUBSCRIBE OR SEND \$1 FOR YOUR SAMPLE COPY.

RADIOSPOTTING Magazine
PO Box 282, Pine Brook, NJ 07058, USA

Casio
8:03

ham radio magazine BOOKSTORE
GREENVILLE, NH 03048
603-878-1441
in reference 7 and have been quite pleased with the results. Lower side-lobes and higher gain were immediately evident because of the improved power distribution.

**EME receivers and preamplifiers**

Table 1 shows that a 2-meter EME receiver should have maximum a noise figure of 1.5 dB and a maximum bandwidth of 50 Hz. Earlier in this column, I briefly mentioned a receiver sensitivity of −155.5 dBm. You’re probably wondering how these parameters are related.

Receiver sensitivity is primarily a function of noise figure and bandwidth. If the antenna noise temperature is near room temperature (298 degrees K), the typical situation on 2-meter EME, the receiver sensitivity can be calculated using the equation shown below:

\[
\text{Receiver sensitivity} = -174 \text{ dBm} + \left( NF + 10 \log BW \right)
\]

where receiver sensitivity is in dBm, NF is noise figure in dB, and BW is bandwidth in Hz.

For example, if the receiver overall noise figure is 1.5 dB and the bandwidth is 50 Hz, the overall receiver sensitivity will be −155.5 dBm (−174 + 1.5 + 10 log 50). But how do you get a bandwidth of 50 Hz as shown in table 1 when your i-f bandwidth is 500 Hz? Use your ears! As the final link on the end of the receiver chain, the human ear has a typical bandwidth of only 50 Hz.11

If you’re still not convinced, you can use a narrow i-f bandwidth. I’ve seen i-f filters advertised that claim a bandwidth of 125 Hz, but I’d hate to have to tune in a signal with such a narrow bandwidth — not to mention the frequency stability requirements of such a receiver!

If you don’t have narrow i-f selectivity and you don’t trust your ear, use an external audio filter. Some of the new solid-state active audio filters have variable bandwidth and frequency controls which will easily go down to audio bandwidths of less than 25 Hz.

The one major difference between a conventional VHF/UHF or hf receiver and an EME receiver lies in the external preamplifier that’s usually mounted at or very close to the antenna feedpoint. This is almost always necessary for two reasons. The first is that the line loss to the shack is usually over 0.5 dB, so the weak signal is further attenuated. The second is that there are no conventional receivers with 1- to 1.5-dB overall noise figures as required in table 1.

First a word about preamplifiers. There are many options. Although I used only a U-310 JFET preamplifier (shack-mounted at that) to obtain my 2-meter WAS Award, I now recommend the use of a GaAsFET preamplifier mounted in a small enclosure as close to the antenna feedpoint as possible. Many preamplifier circuits — as well as commercially manufactured units — are available.

However, one mustn’t get carried away with specifications. For instance, there’s practically no justification for 2-meter EME preamplifier gains in excess of 25 dB; even 20 dB may be overkill. Very often I see 144-MHz GaAsFET circuits using tuned output stages. When this is done below about 1000 MHz, the circuit is almost always on the verge of oscillation. This can result in an input impedance off the Smith chart when a preamplifier is measured on a network analyzer. Instability is also evident if a preamplifier oscillates when placed in the antenna system where the impedance is not constant at all frequencies! Furthermore, excessive preamplifier gain may cause your receiver to intermodulate because of the presence of other Amateurs, fm repeaters, or even commercial fm and TV signals that often pass through the preamplifier.

At 144 MHz, I prefer GaAsFET preamplifiers with tuned input tanks and untuned outputs such as those that use a 4:1 broadband output transformer. Some recommended GaAsFET preamplifier circuits are described in reference 12. If you have any doubt about preamplifier stability, measure the forward gain and reverse isolation with a very weak signal source. If the reverse isolation isn’t at least 4 to 6 dB higher than the forward gain, the preamplifier is potentially unstable.

If you use an external low-noise preamplifier as recommended above, and mount it at the antenna feedpoint, the loss and type of the transmission line between the preamplifier and the receiver usually isn’t critical, since the overall gain of the preamplifier is typically 20 to 25 dB. Hence moderately lossy coax cable such as RG-8 or RG-231/U is perfectly acceptable (see fig. 1).

Two-meter EME receivers offer many options. A decade ago most 2-meter EMEers used a downconvert-

---

Table 6. This table shows the recommended stacking distance for some of the more popular 2-meter Yagi antennas per reference 6 with updates.

<table>
<thead>
<tr>
<th>Antenna Type</th>
<th>Stacking in E &amp; H plane in wavelength</th>
<th>Stacking in E &amp; H plane in inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1JR short Yagi (ref. 9)</td>
<td>1.35 1.20</td>
<td>110 98</td>
</tr>
<tr>
<td>NBS 2.2 wavelength Yagi</td>
<td>1.55 1.40</td>
<td>127 115</td>
</tr>
<tr>
<td>Cushcraft 214B Jr. Boomer</td>
<td>1.55 1.40</td>
<td>127 115</td>
</tr>
<tr>
<td>Tonna (F9FT) 2016 Yagi</td>
<td>1.60 1.50</td>
<td>131 123</td>
</tr>
<tr>
<td>KLM 3LBA Yagi</td>
<td>1.80 1.55</td>
<td>147 127</td>
</tr>
<tr>
<td>CueDee Yagi</td>
<td>1.70 1.40</td>
<td>139 115</td>
</tr>
<tr>
<td>NBS 3.2 wavelength Yagi</td>
<td>1.80 1.55</td>
<td>147 111</td>
</tr>
<tr>
<td>Tonna (F9FT) 2017 Yagi</td>
<td>1.55 1.40</td>
<td>127 115</td>
</tr>
<tr>
<td>Cushcraft 3219 Boomer Yagi</td>
<td>1.80 1.55</td>
<td>147 111</td>
</tr>
<tr>
<td>NBS 4.2 wavelength Yagi</td>
<td>1.95 1.75</td>
<td>160 144</td>
</tr>
<tr>
<td>KLM 16L BX Yagi</td>
<td>2.00 1.75</td>
<td>164 144</td>
</tr>
<tr>
<td>Cushcraft 4218XL Yagi</td>
<td>1.95 1.75</td>
<td>160 144</td>
</tr>
<tr>
<td>M8 Enterprizes 2M-5WL Yagi</td>
<td>1.95 1.80</td>
<td>162 147</td>
</tr>
</tbody>
</table>
er or transverter followed by an hf receiver for the i-f. This setup has lots of system flexibility.

When choosing an hf i-f for EME operation, look for a receiver that has good frequency stability, a slow tuning rate (25 or less kHz per turn), frequency readout that has good resolution and accuracy, narrow bandwidth i-f options, an SSB/CW product detector, and an automatic noise blanker. An i-f bandwidth of 250 to 500 Hz is recommended, as discussed above. Some of the favorite EME i-f receivers of yesteryear were the old Collins 75A4 and the Drake R4C with appropriate modifications. More recently, the Kenwood TS 830 and TS 430 have become popular.

Many multimode 2-meter transceivers are available. Until recently, the Yaesu FT-726R was a favorite because of its built-in narrow bandwidth CW filter. Other 2-meter transceivers now offer this option. You can use a transceiver with a 2- to 3-kHz i-f bandwidth if your ears don’t mind all the excess noise; better yet, follow the transceiver with an external audio filter as mentioned previously. This is the setup at one of the 2-meter super stations!

transmitters and power amplifiers

If you have either a 2-meter transverter, upconverter, or one of the new multimode transceivers, you have the basic building block for a 2-meter EME exciter. Frequency stability is important. Remember that the station trying to work you may be listening in a 50- to 100-Hz bandwidth, so any chirp or drift on your part will significantly degrade success.

Probably the biggest choice lies in deciding how to generate power. If you build a marginal station and expect to work only the super stations, a typical beginner’s approach, a solid-state “brick” will probably be sufficient. Many circuits can be found in reference 13; commercial solid-state amplifiers are also available.

However, always build or buy one of the linear amplifier types. You may later use this amplifier as a driver for a high-power final. Class C or fm amplifier types often exhibit erratic power output levels when their drive levels are varied. This could make output power setting very difficult or damage a follow-up final amplifier.

There are many choices of high-power amplifiers. Remember that even 500 to 750 watts of output power is sufficient for operating 2-meter EME. There are still plenty of plumbers’ delights or parallel tube finals around — especially those that use the venerable 4CX250Bs. Often available quite inexpensively, especially from Amateurs who are upgrading to the new FCC 1500-watt output power levels, they’ll easily generate as much as 1000 watts of output if they’re properly cooled. More information on these finals is contained in references 14 and 15. The 8874 and 3CX800A7 tubes have become popular, especially where single-tube amplifiers are preferred. Other tubes such as the 7650, 7213, and 4CX1000 are usable. Other finals are described in references 16 and 17. The most popular 2-meter EME final for generating the full legal limit is the W6PO power amplifier, which uses an 8877. This amplifier has excellent stability, and is conservatively rated and reasonably efficient (i.e., greater than 60 percent). Furthermore, individual components, parts kits, or even a completed amplifier using this circuit are now available. Finally, several commercially manufactured tube type finals are now available for 2-meter operation.

azimuth and elevation rotators

Any detailed discussion of this subject would require an entire article of its own. Some of the systems presently in use on 2-meter EME range from simple single Yagis on a tropo setup to complex arrays with exotic rotating systems occupying an entire acre of land. Most EMEers will simply use their own ingenuity, building a rotator according to the requirements of the station and the materials most easily pressed into service.

Reference 9 showed my simple back yard/portable array, resting on a small, ground-mounted 11-foot tower for the base. A conventional Ham-M or equivalent rotator is used for azimuth control. Elevation is set by a small boat winch mounted on the vertical mast just above a hinged plate that holds the horizontal boom. Elevation angles are measured with a hand-calibrated plate and lead weight attached to the main boom. This setup is simple and relatively inexpensive.

Several large commercial rotators are now available with accuracies approaching 1.0 degree. While separate selsyn indicators used to be common, auxiliary azimuth indicators that use a linear potentiometer are becoming quite popular now that low-cost digital voltimeters are available.

Some Europeans have cascaded two or more of the elevation rotators used for typical OSCAR antenna control. For large antenna systems, the venerable “prop pitch” motor is still alive and well. Several years ago, many different EME rotator systems were described in Eimas’s EME Notes.

polarity rotation

So far I’ve only touched on the subject of polarity rotation. Circular polarization would greatly improve the Faraday rotation problem on 2-meter EME, but it’s very difficult to implement on large Yagi arrays. As mentioned before, circular polarization would reduce the signal levels from linearly polarized stations by up to 3 dB.

For these reasons, some Amateurs have devised polarity rotation schemes for collinear (VE7BOH) and Yagi arrays (K5GW), but describing them in detail would require discussion of mechanical considerations beyond the scope of this column. In this regard, the parabolic dish has much to offer despite its low efficiency and size. The rest of us will just have to trust our luck to the Faraday rotation present during our schedules!

*Gene Shea, K87Q, 417 Staudaher Street, Bozeman, Montana 59715.
THE MOST AFFORDABLE REPEATER
ALSO HAS THE MOST IMPRESSIVE PERFORMANCE FEATURES
(AND GIVES THEM TO YOU AS STANDARD EQUIPMENT)

BAND WIR ED 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 ±1kHz. Helical
  resonator front end to combat desense & intermod.
• Futter-proof squelch. Automatic frequency control,
  separate spkr amplifier.
• CLEAN, EASY-TUNE TRANSMITTER, up to 20W output.
  50W with additional PA.

ACCESSORIES

• TD-2 DTMF DECORDER/CONTROLER kit only $78.
  Full 16 digits, 5 functions, toll call restrictor, program-
  mable. 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.

• CWD kit, new low price $48.
  Field programmable, timers, the works!
• COR-2 kit. $38. Audio mixer, local spkr amplifier, tail &
  time outs timers.
• COR 3 kit. $46, 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.

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

HIG HQUALITY XMTR & RCVR
MODULES FOR REPEATERS,
LINKS, TELEMETRY, ETC.

• FM EXCITERS:
  Kits only $68. W/1 $146.
  TCXO and xtal oven available.
  2W cont. Up to 3W intermitten.
• TA51 for 10M, 6M, 2M, 150-174, 220 MHz.
• TA51 kit for xtal
  FCC TYPE ACCEPTED FOR COMMERCIAL BANDS.
• VHIF & UHF LINEAR AMPLIFIERS. For FM or SSB. Power
  levels from 10 to 45 Watts. Several models, kits starting
  at $78.

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

RECEIVING CONVERTERS

<table>
<thead>
<tr>
<th>Transmitter</th>
<th>Receiver</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHF MODELS</td>
<td>100-180</td>
<td>50.5</td>
</tr>
<tr>
<td>Kit with Case</td>
<td>$40</td>
<td>145-180</td>
</tr>
<tr>
<td>Kit less Case</td>
<td>$39</td>
<td>145-180</td>
</tr>
<tr>
<td>Wired w/case</td>
<td>$69</td>
<td>145-180</td>
</tr>
<tr>
<td>UHF MODELS</td>
<td>200-230</td>
<td>50.5</td>
</tr>
<tr>
<td>Kit with Case</td>
<td>$59</td>
<td>230-250</td>
</tr>
<tr>
<td>Kit less Case</td>
<td>$52</td>
<td>230-250</td>
</tr>
<tr>
<td>Wired w/case</td>
<td>$75</td>
<td>230-250</td>
</tr>
</tbody>
</table>

TRANSmit CONVERTERS

<table>
<thead>
<tr>
<th>Mode</th>
<th>28-30</th>
<th>45-46</th>
<th>70-74</th>
<th>145-146</th>
</tr>
</thead>
<tbody>
<tr>
<td>For VHF</td>
<td>$29</td>
<td>$48</td>
<td>$89</td>
<td>$146</td>
</tr>
<tr>
<td>Model XV2</td>
<td>$29</td>
<td>$48</td>
<td>$89</td>
<td>$146</td>
</tr>
<tr>
<td>Kit</td>
<td>$36</td>
<td>$70</td>
<td>$120</td>
<td>$190</td>
</tr>
<tr>
<td>Wired</td>
<td>$45</td>
<td>$82</td>
<td>$142</td>
<td>$224</td>
</tr>
</tbody>
</table>

• 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

Reader Service CHECK — OFF Page 106
THE MULTIPLE RECEIVER SOLUTION

4 Channel Signal-to-Noise Voter
- Expandable to 32 Channel by Just Adding Cards
- Continuous Voting
- LED Indicators of CDR and Voted Signals
- Built as Calibrator
- Remote Voted Indicators Potted Out
- 4 x 6 Double Solid Gold Plated Pin Card
- Remote Disable Inputs
- Price
Built, tested and calibrated with manual
$350.00
Telephone interface now available
For more information call or write:
HALL ELECTRONICS
Voter Department
815 E. Hudson Street
Columbus, Ohio 43211
(614) 261-8871

DOUBLE BAZOOKA HF ANTENNAS
40 METER $35.95
10 METER $25.95
GSRV HF ANTENNA $39.95
MOBILE HF BUG CATCHERS
80-10M 250W $28.50
40-10M 1kw $48.50
40-10M 1kw $34.00
STAINLESS STEEL MAST
2 FT 3/8-24 $9.95
3 FT 3/8-24 $11.95
4 FT 3/8-24 $11.95
VHF 2 METER SSB MOBILE
2 METER SQUARED $40.00
WE STOCK BUTTERFLY, DIAMOND AND OTHER ANTENNAS
SHIPPING WORLD WIDE
VISA/AMERICAN EXPRESS
MISSION COMMUNICATIONS
11995 Alabama Drive
Suite 506
Houston, Texas 77082
(713) 879-7764
Telex 166872 MCON UT

ARRL Central Division
Convention HAMFEST
Saturday, October 31
Sunday, November 1
8 a.m. to 2 p.m. - both days
Norris Sports Center - St. Charles, IL
All indoors • Commercial Exhibits • Flea Market • ARRL Booth
FCC License Exams • Contests • Demonstrations • Hot Food
Admission: Adv. $3 • Gate $4 • Talk-In: 145.47 (-600) & 145.21 (-600)
Sponsored by the
Fox River Radio League

Tickets
P. Fors. N9FXQ
104 May St.
W. Chicago, IL 60185
312-231-8841

Dealers
G. Isely. W99GIG
736 Fellows St.
St. Charles, IL 60174
312-584-4925

ARRL Central Division
Convention HAMFEST
Saturday, October 31
Sunday, November 1
8 a.m. to 2 p.m. - both days
Norris Sports Center - St. Charles, IL
All indoors • Commercial Exhibits • Flea Market • ARRL Booth
FCC License Exams • Contests • Demonstrations • Hot Food
Admission: Adv. $3 • Gate $4 • Talk-In: 145.47 (-600) & 145.21 (-600)
Sponsored by the
Fox River Radio League

Tickets
P. Fors. N9FXQ
104 May St.
W. Chicago, IL 60185
312-231-8841

Dealers
G. Isely. W99GIG
736 Fellows St.
St. Charles, IL 60174
312-584-4925

** Super Com shack 64 **
Programmable Repeater Controller/ HF & VHF Remote/patch
Rotor Control/Voice & Sub Tone Paging/Expandable/Low Cost

** REPEATER/DUPLEX RADIO
**

** AUTO PATCH & REVERSE
**

** CONTROL DATA for all CAT radios
**

** REPEATER CONTROLLERS
**
- Change all access codes remotely
- Synthesized male/female voice
- Program personal mailbox or tail mail with T.T. from HT
- Alarm clock & auto execute mode
- String commands; 22 digits max
- 32 CTCSS manual & auto paging
- Cool practice; voice readback
- Multi-function voice alarm clock

** H.F. REMOTE = 1
- 10 Memories/auto mode sel.
- Scan up/down sel. rate or 100Hz
- Voice echo, all control commands
- 300 Auto/quick dial recall
- 300 calls entered/32 sub tone
- 50 enable/disable tel #’s
- Hi/Lo priority access codes
- Directed/general/rev. page
- Full or Half duplex operation
- Secure mode/T/T repeat/ont/off
- Store MCI/Sprint tel #’s
- Reverse Patch active all modes
- Call waiting/patch auto reset

** VHF/REMOTE = 2
- Dual VOX’s/rev/SLT/CTCSS
- Set Scan/bell/vol/resume

** FULL-DUPE REPEATER
**
- Total stack control, Free upgrades
- User support
- Com shack users’ net meets/14.280 Mhz Sundays, 11:00 PST

** MINI (BEAR CAT) SCANS/PROGRAM FT-727R
**
Programs and Scans 100 ch. in Ham/General coverage. Converts HT into a powerful 100 ch. scanner & programs all for field use
- Digital “S” meter; stops scan (1-9); Auto resume
- Loads & programs all
- FT-727 parameters in 15 sec.
- Includes hardware kit & software for CAT/128/364

** Touchtone Decoder 4 DIGIT SEQUENCE on/off latch; all 16 Digits

** 3.5" Repeater Patcher on/off
- Low power CMOS 5/12 vdc
- Program 50,000 4 digit codes
- Dig code toggle latch on/off
- Latch drives relay directly
- LED displays latched state
- Optional extra 4-digit custom latch IC’s $3.95 ea.

** Model TSD $59.95

** AUTO PATCH

** SUPER COM SHACK 64
**
Model CS64S $349.95
Plus $4.00 shipping USA includes Interface, disk, cables, manual
SYSTEM OPTIONS
- Relay Control: 3 DPDT & 5 Open collector outputs, CS-8 $79.95
- EEPROM 72k CMOS Autorun
- Conventional custom) CART $99.95
- Rotor Control voice beam tuning
- Voice & "S" meter HP $49.95
- Manual (Refunded MM $15.00
- Rotor control RAR $149.95

** Audio Blaster
**
IC02/04/2AT, U16, FT727/208
Module installs inside the 15 Min. Boosts audio to 1 watt! Low standby drain, Corrects low audio
1000’s of happy users. Miniature audio amplifier module – Used by Police, Fire, Emergency

** Touchtone Decoder:

** Touchtone Decoder: All

** 12Y TOUCH TONE TO RS232

** Decode touchtone strings, alarms, secret codes, display on any computer 300 baud out, inc.
- basic program example included
- Decode-A-Ped

** Model TTK $22.95

** Model DAP $99.95

** ENGINEERING CONSULTING

** 583 CANDLEWOOD ST.

** BREA, CA, 92621

** TELEPHONE

** 714-671-2009

** 1-800-433-WIRE

** FOR ALL AMATEUR WIRE & CABLE

** Belden & Equivalent

** (803) 895-4195 (SC & Ragchew)

** CERTIFIED COMMUNICATIONS

** PITTMAN ROAD, ROUTE 2, LANDRUM, SC 29356

** The Wireman

** September 1987

** 76
relays and control systems

The simplicity or complexity of this part of the system is a matter of personal choice. Figure 1 shows most of the components required for a complete minimum station. Rotator cables and the like are quite straightforward.

The one area that deserves some special consideration is the antenna changeover and receiver protection relays. There are two major problems with these in EME operation. The first is the leakage or isolation of the main T/R relay. When running over 500 watts of output power, the leakage across this relay when in transmit can be sufficient to burn out your receiver preamplifier unless the isolation is greater than 50 dB. Many of the T/R relays used by Amateurs offer marginal isolation at 144 MHz. Second, the switching time on the T/R relay is critical because if the high power is applied before the relay is fully transferred, the preamplifier is again subjected to rf burnout levels.

Most of these problems can be solved if you have a short built-in time delay before rf or high voltage is applied to your final power amplifier. Additional isolation in the form of a second relay in series with the preamplifier is also recommended. This relay can be a low-power type and preferably will terminate the preamplifier input, with a 50-ohm load during transmit. If the length of the coax between the relays is 0.1 to 0.25 wavelength, it will increase isolation.3

These features should be wired into the station control system, with a foot switch to further control the sequences of events. Therefore, I recommend that you review the scheme and schematic of the recommended switching technique described in reference 3.

system checkout

Before you try to fire up and listen for EME signals, it's best to make sure that your system is functioning properly. If it's convenient, disconnect the preamplifier and test the antenna system for VSWR. If everything was properly installed, the VSWR should be well below 1.5:1. Then increase your power to confirm that there's no output power problem.

Next, reconnect your preamplifier and receive system. Check your receive system by pointing your antenna towards different areas of the sky. The noise level should vary as you point to radio "hot spots." Aiming your antenna at the sun — the largest hot spot — should increase the noise output of your receiver by at least 6 to 8 dB.

After peaking your receiver on the sun, sight up the antennas and verify that the sun is reasonably close to boresite. Next point your antenna away from the sun and try to measure your first sidelobes, which should be detectable but many dB below the main beam. If the sidelobes are high or the antenna doesn't boresite well, check your phasing lines for possible phase inversions.

Now try some echo testing. Send a letter or two and listen carefully for an echo. Remember that the returned signal may be up to 500 Hz above or below the transmitted signal, depending on whether the moon is approaching or leaving you, as described in reference 1. If you don't hear anything, don't be discouraged. Faraday may be unfavorable. Try again in 15 to 30 minutes.

Next listen for other EME signals. There's almost always activity on weekends and evenings whenever the moon is above the horizon at north declination. Tune between 144.000 and 144.020 and see if you find any EME signals; this is where most of the super stations congregate and where most random CQs take place.

If you don't hear any signals, activity may be low or Faraday rotation may be unfavorable. Wait a while and try again. Check the 144-MHz EME Directory for someone you can contact locally.21 Better yet, set up a schedule with one of the active EME stations, who can usually be found on 14.345 MHz on Saturdays and Sundays between 17 and 1900 UTC on the 2-meter EME net usually MC'ed by Lionel, VE7BQH.

scheduling

This is a subject in itself which is again beyond the scope of this month's column. Many scheduling tips and recommendations can be found in references 1 and 22. Try to make schedules near perigee, when the moon is at northerly declinations away from the galactic plane, and when there are no local objects obstructing the antenna view. Perigees are always listed at the end of each month's column, and an EME calendar appears monthly in VHF/UHF and Above.* Unless there are no other possibilities, don't make schedules when the moon is in the galactic plane, at the new moon phase, or when the moon is at low elevation angles (except for horizon shots where there may be no other possibilities).

When you run a schedule, it's best to follow the standard techniques and scheduling sequences that have become well established procedures. First, the scheduled frequency is your zero beat frequency. Since doppler is usually present, leave your transmitting frequency fixed and tune only your receiver until you find the desired station.

Most schedules conducted on 2-meter EME are for either one-half or one hour's duration. Each station usually transmits and receives alternately for two minutes at a time. The easternmost station generally transmits during the first two-minute period at the start of the hour. This is often referred to as "standard sequencing."

For example, if a W2 station schedules a W6 station between 1900 and 2000 UTC, the W2 station, as the eastern station, would transmit from 1900 to 1902 UTC and listen from 1902 to 1904 UTC, and so forth. If, however, the schedule is from 1930 to 2030, the W6 station would transmit first from 1930 to 1932, since sequencing is based on the hour, and with 2-minute sequencing, there are an odd number of periods in the first half of the hour.

— Rusty Landes, KAOHPK, "VHF/UHF and Above Information Exchange," P.O. Box 270, W. Terre Haute, Indiana 47885.
The reporting system used on 2-meter EME is different from the one used on 432 MHz and above. "T" designates detectable signals, "M" means letters or portions of calls, and "O" verifies that both call signs have been copied. Therefore, an exchange of an "O" report and appropriate "Rs" are required for a valid QSO. Never transmit an "O" report or an "R" until you have complete call sets and reports respectively, because the reporting sequence can only go forward!

Most 2-meter operators make up a standard schedule sheet with each 2-minute time block designated. They then write in all information sent and received in the appropriate time blocks; this will help if there are deep fades or partial copy, Faraday rotation problems, or if authentication is required later on.

**other tips**

Have someone in your area check your frequency to confirm that you're transmitting where you think you are.

A secondary frequency standard such as the one described in reference 23 is recommended. Use the 2-meter EME net to make schedules or to see who's active, when they're active, and what frequency they're on. The 144-MHz EME Directory is a must if you want to know what other stations are active and what equipment they use. Published monthly, The 2-Meter EME Bulletin includes good tips and information about the activity of other 2-meter EME stations.*

**summary**

So there you have it — all the necessary basic information needed to get you started on 2-meter EME. Let me know if I missed any necessary information. Some of the topics discussed had to be dealt with only briefly, but the references cited or the EME nets are excellent sources for further details or clarification. As is often the case, it sometimes takes longer to explain a

---

particular item in print than to demonstrate it in a hands-on situation.

If you have only a small antenna, consider listening for EME signals in the 144.000-144.020 MHz region, especially during the EME contest on October 17-18 and November 14-15, 1987. Even if you’re not ready to get started in EME, try putting up a simple antenna in your back yard and see what you can hear. Who knows—the bug might bite! See you on EME shortly!

new records

In Oregon on March 8, 1987 at 1950 UTC, Tom Hill, WA3RMX/7 (CN85PL), and Lynn Hurd, WB7UNU (CN85NH) did it again by breaking their own North American DX record on 47.040 GHz. This time they extended the distance to almost 14 miles, and again had a two-way QSO on SSB with good signal-to-noise ratios. Tom was running 3.5 milliwatts to a 28.5-inch dish, while Lynn was running just 44 microwatts to a 9.5-inch dish!

Meanwhile, as predicted in last month’s column, new EME records were being made. On April 12, 1987 at 0530 UTC, Lucky Whitaker, W7CNK/5, Oklahoma City, Oklahoma (EM15FI), worked Keith Ericson, K0KE, who was operating portable in Denver, Colorado (DM79NO), on 3456.1-MHz EME for a new worldwide EME DX record of 498 miles. Lucky was using a 5-meter dish and 80 watts, while Keith borrowed the use of a 10-meter satellite dish and was running only 12 watts of output power! Signals were copied easily off a speaker with a 2.5-kHz receiver bandwidth!

Not content with this record, Lucky, W7CNK/5 (EM15FI), converted his setup to 5760.1 MHz. Then he completed the first Amateur two-way EME contact on that band on April 24, 1987 at 1620 UTC with Rick Fogle, WASTNY, Grapevine, Texas (EM12KV), for a 174-mile record. Lucky was running 100 watts to his 5-meter dish and Rick was running only 25 watts to a 10-foot TVRO dish. After the initial contact, Dave Hallidy, KD5RO, jumped in, using Rick’s station to give
Packet radio is the fastest growing mode in Amateur operation today. No wonder — it combines the power of today’s microcomputer with worldwide digital communications. Newcomers will find this book to be full of helpful tips, tricks and information that will help get them on Packet as quickly as possible. Providing you first with packet basics, this book progresses through the inner workings and operational aspects of packet to a look at future technology still in developmental stages. Also includes: using bulletin boards, traffic handling on packet, modulation methods and networking principles, protocols (both AX.25 and VADCG) and a thorough discussion of the various TNCs and accessories available.


T-2722 Softbound $14.95

Please enclose $3.50 shipping & handling.

THE DIGITAL NOVICE
by Jim Grubbs, K9EI

Now that novices have digital privileges, there are thousands of new Amateurs anxiously awaiting to get on-the-air. Who’s going to answer their questions, however? Jim Grubbs’ new book, The Digital Novice, is written with beginner’s needs in mind. Each of the popular digital modes is fully covered with a brief history and full description of how it works. Hardware and software are covered in clear, concise terms. The book finishes with a look toward the future. Four appendixes cover Morse, Baudot, AMTOR and ASCII Codes and has a glossary full of commonly used but misunderstood terms. Great for beginners and experts alike. ©1987 1st edition

JG-DN Softbound $9.95

Please enclose $3.50 to cover shipping and handling.
W7CNK/5 his second 5760.1-MHz contact.

Congratulations to Tom, Lynn, Lucky, Keith, Rick, and Dave. The spring of 1987 may go down in history as one of the greatest record-breaking periods in UHF/SHF history.

important VHF/UHF events

September 5-6  International Region 1 VHF Contest, 2 meters only
September 6  EME perigee
September 10-13  Microwave Update 1987 Conference, Estes Park, Colorado (contact W0PW)
September 12-14  ARRL September VHF QSO Party
September 19-20  ARRL 10-GHz Cumulative Contest, second weekend ± 2 weeks. Optimum time for TE propagation
September 21  International Region 1 UHF/SHF Contest, 70 cm and up
October 4  EME Perigee
October 9  Predicted peak of the Draconids meteor shower at 0900 UTC
October 10-11  Mid-Atlantic States VHF Conference, Warminster, Pennsylvania (contact WA2OMY)
October 17-18  ARRL EME Contest, first weekend
October 21  Predicted peak of the Orionids meteor shower at 0830 UTC
October 30  EME Perigee

references


short circuits

In fig. 2 of W1JR’s April, 1987, column (page 74), the spacing dimensions listed for the fourth director, D4, of the 46-element loop Yagi do not agree with the drawing. The drawing is correct; the listing should be corrected to show the spacing for D4 as 14.1721 (TXN K5DUT).

In fig. 6, the length of the inductors is not shown because it is assumed that the specified enclosure will be used. If it is not used, the height of the inductor above ground should be about 1.5 inches.

missing table

Table 1, omitted from W1JR’s VHF/UHF World column in the April issue (page 55), is shown below.

Table 1. Some citizens-band type fm transceivers are available in Japan but not yet in the USA.

<table>
<thead>
<tr>
<th>Company</th>
<th>Part No.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICOM</td>
<td>GTX</td>
<td>NA</td>
</tr>
<tr>
<td>Shinwa</td>
<td>SC-905GI</td>
<td>NA</td>
</tr>
<tr>
<td>Yaesu</td>
<td>FYA903</td>
<td>NA</td>
</tr>
<tr>
<td>Yaesu</td>
<td>FYA905A</td>
<td>80,000 Yen</td>
</tr>
</tbody>
</table>

220 Notes

In table 5 of W1JR’s July, 1987 column (page 38), 220 Notes was intended as being issued quarterly. This is incorrect; 220 Notes is published bi-monthly. To subscribe ($5/year), contact Walt Altus, WD9GCR, 215 Villa Road, Streamwood, Illinois 60103.

20-meter travel radio

Planning to build K1BTQ’s compact CW transceiver (June, 1987)? Send an SASE (with 39 cents postage) to ham radio, Greenville, NH 03048, for a complete list of corrections.
improving the WB3CEH programmable call sign identifier

When Gene Colson, KL7YM, was constructing a new repeater for our mountain top site in Fairbanks, WB3CEH's article describing his programmable call sign identifier\(^1\) caught my eye. The identifier appeared to be perfect for our needs. But when I began ordering the parts, I couldn't find the MC14557 64-bit shift register IC specified, and neither KL7YM/R, WB3CEH (the author's call), nor KL7XO (my own call) would fit into 64 bits.

A search through catalogs revealed a substitute for the MC14557: the CD4031, also a 64-bit shift register. A phone call to Jameco\(^*\) brought several of them within a week. I cascaded two for a total of 128 bits and reversed the A and B inputs to reduce standby power consumption.

I built the first one. It worked, with measured current consumption of 0.0005 mA on standby, 0.17 mA running without the buzzer, and 0.55 mA with the buzzer. Over two years later, it's still on the bench in my shack - with the original 9-volt battery. KL7YM built the production model, which is still in use on the repeater.

The construction and programming instructions in the original article still apply. The schematic of the modified circuit is shown in fig. 1.

**Steve Estes, KL7XO**

**reference**


*Jameco, 1355 Shoreway Road, Belmont, California 94002.

**carpet samples in the ham shack**

While shopping for new carpet several years ago, I stumbled upon a pile of 18 by 24-inch samples with nicely finished borders being sold for a dollar each. I bought several.

What does this have to do with Amateur Radio? Well, one sits on my workbench to protect the surface from scratches and wear. It also protects radios from scratches and dings while I'm working on them. I selected a tightly woven, light-colored pattern for this so that small screws and parts wouldn't disappear. Another sample ended up beneath my very large, heavy Qume Sprint 5 daisy-wheel printer, helping to silence its operation. Another found its home under a fairly large HF linear amp.

When you have to move something heavy (like an overstuffed filing cabinet) across hardwood or linoleum floors, try sliding two or more of these carpet samples face-down under the object; it will then slide easily across the floor without scratching.

Most carpet shops sell these samples quite reasonably. Pick up a few and see how many uses you can find for them!

**Peter Bertini, K1ZJH**

*Ham Radio*
This new book from the RSGB is an invaluable aid in evaluating which radio best suits your personal operating needs. Author McKenzie spent hundreds of hours testing and measuring each radio’s parameters—over 10,000 measurements and 500 analyzer plots were made. Equipment was also subjected to many months of on-air testing by hams throughout the UK and around the world. There are more than 100 full equipment reviews and nearly 100 more products with brief reviews. © 1986 472 pages.

AR-HR Softbound $14.95

1987-88 ARRL REPEATER DIRECTORY

• Fits in your shirt pocket 3¼" x 5¼" x 3/4".
• Over 12,000 listings from 28 MHz to 10 GHz.
• Lists all repeaters.
• Now includes CTCS5 (PL) tone chart, VHF/UHF and Repeater Advisory committee addresses. Special mode repeaters (packet and TV) and plans for repeater operating practices, ARRL Frequency Coordinators, and Special Service Clubs.

AR-RD7 Softbound $4.00

MORSE CODE TRAINER (for the Apple II)

by David Fahnestock

This new program turns your Apple II into a complete 5-25 wpm code trainer. You can configure the program to generate random code groups, transmit letters from the keyboard in learning mode and output to either the printer or to a cassette tape recorder. Elegant in its simplicity and a great value to either students or new hams looking to improve their code. © 1985.

HR-MCT (Apple II) Introductory price $9.95

ENGLISH SHORTWAVE BROADCASTS

(MS-DOS) by Tom Sundstrom, W2XO

Here’s a new two disk MS-DOS program and database that provides you with one of the most thorough listings of English shortwave broadcasts available. Allows you to scan by time, frequency, or country and print your findings. A quarterly update is available from the author for just $6 including shipping. Super value to SWL’s and hams alike. Should be considered for anyone setting up a new DX station. © 1986.

TS-SWL (MS-DOS) $19.95

Please enclose $3.50 shipping & handling.

h.m. radio BOOKSTORE

GREENVILLE, NH 03048 603-787-1441

MULTI-BAND SLOPERS


Books are $.95 each.

WRITE for complete details of these and other unique publications.

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

BULBS

Get POWER to your antenna! Our Baluns are already wound and ready for installation in your transmatch or your antenna. The weatherproof box and connect them directly at the antenna. They are designed for 3-30 MHz operation. (See ARRL CATLOG pages 199-200 for construction details.)

100 Watt (6, 15, 91, or 1.5 kHz ± 1 Tolerance) $18.00

Universal Transmatch 1 kW 4 kHz $14.00

Universal Transmatch 1 kW 2 kHz $14.00

Universal Transmatch 1 kW 1 kHz $14.00

Universal Transmatch 1 kW 0 kHz ± 1 Tolerance $18.00

Please send large SASE for info.

CADDELL COIL CORP.

All Electronics Corp.

ALL ELECTRONICS CORP.

ALL ELECTRONICS CORP.
Join AMSAT...Today

Amateur Radio Satellite OSCAR 10 provides:

- A New Worldwide DX Ham Band open 10 hours a day.
- Rag Chew With Rare DX Stations in an uncrowded, gentlemanly fashion.
- Popular Modes In Use: SSB, CW, RTTY, SSTV, Packet
- Full Operating Privileges open to Technician Class licensee or higher.

Other AMSAT Membership Benefits:

Newsletter Subscription: Dependable technical articles, satellite news, orbital elements, product reviews, DX news, and more.

Satellite Tracking Software Available for most popular PCs.

QSL Bureau, AMSAT Nets, Area Coordinator Support, Forum Talks

Construction of Future Satellites For Your Enjoyment!

AMSAT Membership is $24 a year, $26 outside North America. VISA and MC accepted.

AMSAT P.O. Box 27 Washington, DC 20044 301 589-6062
more sporadic E

Before the Sporadic E (Eₘ) propagation season — June through September — is over, the results of some recent experiments are worth mentioning.

An ionosonde is a low-frequency, mf-hf radar that provides information about ionospheric layers by transmitting a signal vertically and measuring the duration of its round trip.* Using an ionosonde located in Hawaii, researchers have been able to identify and measure Eₘ cloud formation and movement, determining the east-west, north-south, and height changes of the signal's reflection point by means of doppler frequency shift data.

At altitudes below approximately 72 miles, there's a neutral particle "sandwich"; its upper level moves in a westerly direction, while its lower level travels in the opposite direction. Collisions between the particles in these layers and gyromagnetic interaction result in vertical ion movement from below and above the region. Very thin, intense, long-lived layers develop at the specific height at which the net ion vertical velocity is zero.

These metallic ions are of meteoric origin; it is the variations in their content that accounts for Eₘ patch differences, locations, and diurnal behavior. These differences — in turn manifested by varying layer shape (gradient), thickness, and intensity — account for changes in the maximum frequency that can be reflected.

For a clearer idea of the magnitude of these variations, consider this: over a period of only 20 minutes, the maximum usable frequency changed from 4 to 8 MHz in a patch that was only 6 miles long. Such clouds, however, can cover areas as large as 36,000 square miles (60 x 600 miles) and last up to 2 hours, resulting in long 10- or 15-meter openings.

last-minute forecast

During the first week and the ten days of September, expect low values of flux, resulting in the lower frequency bands being best. Nighttime openings will occur on these bands on the east-west and northern paths. If the geomagnetic field is disturbed on September 1st through 4th and 24th through the 29th, expect lower signal strengths and QSB. The second and third weeks are expected to offer very good higher hf-band DX openings in southerly directions. Some of the openings may be the result of transequatorial propagation, particularly in the evening and during disturbed conditions.

The moon will be full on September 7th and at perigee on the 6th. The autumnal equinox will occur on the 23rd at 1345 UTC. No significant meteor showers are expected this month.

band-by-band summary

Six meters may have a few Eₘ openings around local noon, but don't count on them during this last month of the season.

Ten, twelve, and fifteen meters should provide a few short-skip openings and many long-skip openings to most southern areas of the world, especially if there is any solar flux increase during the daylight hours this month. Some of these openings will result from transequatorial propagation, mainly during disturbed conditions.

Twenty, thirty, and forty meters will support propagation from the eastern, western, and northern areas of the world during daytime and on into the evening hours almost every day. Distances to 2000 miles via long-skip or some short-skip Eₘ to 1000 miles per hop are usual.

Thirty, forty, eighty, and one-sixty meters are all good for nighttime DX. The bands will be open in the east soon after sundown, swing toward the north and south about midnight, and end in the Pacific areas during the hour or so before dawn. The time-and-frequency stations in England and Hawaii make good band monitors. On some nights these bands will be as good as they are during the winter DX season; on others, QRN may be a problem. Distances will be a little shorter than those mentioned above.

*Other analog ionosondes transmit signals obliquely and work in pairs; more advanced digital ionosondes generate phase and polarization information in addition to the standard amplitude data. — Ed.
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.*
LOW BAND DX'ING
by John Devoldere ON4UN
Now Available! The new, 2nd edition of the definitive book on Low Band DX'ing. Based upon years of practical on-the-air experience, learn the secrets of how ON4UN has been so successful on the low bands. Extensive coverage is given to transmit and receive antennas with clear concise explanations and plenty of illustrations—dipoles, inverted V's, slopers, phased arrays and Beverages—they're all in this book. Also covered: propagation, transmitters, receivers, operating, software and an extensive Low Band bibliography. Going to be a best seller! Get yours today. © 1987 2nd Edition 200 pages
$9.95

LOW BAND DX-ING
COMPUTER PROGRAMS
by John Devoldere, ON4UN, for Apple IIe/c, MS-DOS, Commodore C-128 Apple Macintosh and Kaypro CPM Computers
Here's a collection of 30 super programs written by ON4UN. Just about every interest or need is covered—from antenna design and optimization to general operating programs. Antenna programs include: shunt and series input L network design, feedline transformer, shunt network design, SWR calculation, plus 11 more! General Ham programs include: sunrise/sunset, great circle distances, grayline, vertical antenna design program, sunrise calendar plus 9 more! Phew. When you sit down to use these programs you'll be amazed at what you have. The best value in computer software available today. © 1986.

SPECIAL OFFER
Softbound $9.95

LOW BAND DX-ING
COMPUTER PROGRAMS

□ UN-Apple IIe/c $19.95
□ UN-MS (MS-DOS) $19.95
□ UN-CPM/Kaypro $19.95
□ UN-C-128 (COMMODORE) $19.95
□ UN-MAC (MACINTOSH) $24.95
Cushcraft 2-meter boomer

In 1979 Cushcraft introduced its 2-meter "Boomer" line of antennas, thus launching a new generation of long-boom, high-performance Yagis. A few years later, in response to a growing need for a 2-meter Yagi with even higher gain and a cleaner radiation pattern, Cushcraft introduced its new 2-meter Boomer 4218 XL Yagi.

This antenna is basically an enhanced NBS type Yagi. The trigon reflector, a "trademark" of the Boomer Antennas, improves the gain slightly but primarily enhances the front-to-back ratio. An extra director has been added between the driven element and the original first director for extra gain.

Cushcraft engineers found they could also improve gain and radiation pattern even more by moving the position of the original first director and extending all director lengths to compensate for errors in the original NBS design.

The "T" match and half-wave balun used are other Boomer trademarks. Cushcraft retains the UHF connectors, which are not waterproofed, but supplies silicon grease and vinyl connector boots to keep the balun and feed line connectors relatively waterproof. I'd still prefer the use of type N connectors.

This antenna is quite well designed. The center section of the boom is a healthy 1.5 inches in diameter. The remainder of the boom is tapered but still very strong. The rigid boom support braces should prevent wind vibrations, and can be placed either above or below the main boom — a big advantage where stacking frames are used and you want to keep all vertical mast lengths to a minimum.

The trigon assembly has been completely redesigned since the earlier Boomers to considerably decrease wind loading. In fact, this antenna has a wind load that's only slightly higher than the original 2-meter 32-19 Boomer, which has over a 6-foot shorter boom length. I'm sure the Boomer XL will withstand our New England winters.

assembly

It took about 2 1/2 hours to assemble the 4218 XL. The directions, while brief, were adequate. All directors taper downward in length as clearly shown on the assembly instructions so element lengths can be easily verified. However, the rear boom section wasn't labeled, and, naturally, I assembled it backwards! However, when I tried to attach the trigon reflector, I noticed my error and quickly reassembled this boom section.

As with other Cushcraft products, all holes were precisely drilled and all the pieces fit together very nicely. All the hardware — even the "U" bolts — is stainless steel, a real plus. (There wasn't a spare piece of hardware, however, so don't lose anything during assembly!) Notice also that there are spare holes in the brace supports and trigon assembly that don't require hardware.

Before you assemble the balun, I'd recommend that you first check the connectors to see if they're tightened into the connector bracket. All that's needed is to grasp the connectors carefully on the back side of the plate with gas pipe pliers and turn them clockwise. Also solder the tips of the crimp type connectors used on the coax balun. Don't forget to apply the silicon grease provided, but only to the connector threads.

After final assembly, check all dimensions carefully, especially the boom sections and element lengths as shown on the diagrams provided. Next, mount the antenna on a 7- to 10-foot high mast or tower and test the VSWR using a 5- to 10-foot transmission line between the antenna and the VSWR meter. This test is highly recommended because it will often catch any assembly problems before the antenna is mounted in a hard-to-reach spot on the top of a tower. If desired, you can also take a few minutes to adjust the T-match strap position to minimize the VSWR at your favorite operating frequency.

test results

The 2-meter Boomer 4218 XL has a clean radiation pattern with high gain per unit boom length. From on-the-air tests I made, supplemented with computer analysis, a gain of 14.3 dBi was measured. This is as high or higher than any of the competition's antennas. VSWR measured at 144.2 MHz was less than 1.2:1 as specified, so I didn't even have to adjust the T-match! The measured VSWR was less than 1.5:1 from 144 through 144.8 MHz.

One final recommendation: during the manufacture of these antennas, an oily film apparently develops on the elements. This normally isn't a problem, but before it wears off, rain droplets may cling to the ends of the elements, thereby degrading the radiation pattern. So I'd recommend cleaning the ends of the elements with acetone or an equivalent solvent before assembly.

If you use a single 2-meter Boomer 4218 XL Yagi, it will probably work best mounted clear of other antennas. If this isn't possible, try to mount it at least one-half wavelength or at least 40 inches away from any other antennas on the same mast.

These antennas will stack very well; four should make a great 2-meter EMF array. Cushcraft recommends 13 1/2 feet in the H (horizontal) plane and 12 1/2 feet in the V (vertical) plane. From my stacking experience, I think that these
A. Microwave Associates 10 GHz Gunnplexer. Two of these transceivers can form the heart of a 10 GHz communication system for voice, M, video, or data transmission, not to mention mountaintop DXing! MA87634 ($1,295.00 for 10 mW transceivers) MA87620-4 ($1,495.00 for 4-W transceivers). B. Microwave Associates 24 GHz Gunnplexer. Similar characteristics to the 10 GHz unit, MA87620-4 (pair of 20 mW transceivers) $739.20. C. This support module is designed for use with the MA87141 and MA87820-2 and provides all of the tracking for a full duplex analog transceiver system. The board contains a low-noise, 30-MHz IF receiver, modulators for voice and mow operation, Gunn diode regulator, and varactor supply. Meter outputs are provided for monitoring received signal levels, discriminator output and varactor tuning voltage. RXM300D assembled and tested $1,119.55. D. Complete, ready-to-use communication system for voice or mow operation. Ideal for remote linking. A power supply capable of delivering 13 volts dc at 250 mA (for a 10 mW version), microphone, and headphone and loudspeaker are the only additional items needed for operation. The Gunnplexer can be removed for remote mounting to a tower or 2- or 4-foot parabolic antenna. TR100A (10 GHz, 10 mW) $399.85. Higher power units available. TR242A (24 GHz, 20 mW) $639.95. Also available: horn, 2- and 4-foot parabolic antennas, Gunn, varactor and detector diodes, search and lock systems, oscillator modules, waveguide, flanges, etc. Call for additional information. Let ARR take you higher with quality 10 and 24 GHz equipment!

NEMAL ELECTRONICS

*Complete Cable Assembly facilities MIL-STD-45208
*Commercial Accounts welcome! Quantity pricing * Factory authorized distributor for Alpha, Amphenol, Belden, Kings, Times Fiber

Call NEMAL for computer cable, CATV cable, Flat cable, semi-rigid cable, telephone cable, crimping tools, D-sub connectors, heat shrink, cable ties, high voltage connectors.

HARDLINE 50 OHM

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>FX112 1/2&quot; Aluminum Black Jacket</td>
<td>...</td>
<td>$0.95</td>
</tr>
<tr>
<td>PLC12 1/2&quot; Cablewave corr. copper blk jkt</td>
<td>...</td>
<td>$1.59</td>
</tr>
<tr>
<td>PLC12 1/8&quot; Cablewave corr. copper blk jkt</td>
<td>...</td>
<td>$3.90</td>
</tr>
<tr>
<td>NM122C N conn 1/8&quot; corr copper m/f</td>
<td>...</td>
<td>$3.23</td>
</tr>
<tr>
<td>NM122C N conn 1/4&quot; corr copper m/f</td>
<td>...</td>
<td>$5.40</td>
</tr>
</tbody>
</table>

COAXIAL CABLES (per ft)

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belden 9913 very low loss</td>
<td>$0.96</td>
</tr>
<tr>
<td>RG6/U 50% shielded and low 11-ga.</td>
<td>$0.92</td>
</tr>
<tr>
<td>RG11XG 50% shield (mini)</td>
<td>$1.15</td>
</tr>
<tr>
<td>RG11XG 95% shield (mini)</td>
<td>$1.00</td>
</tr>
<tr>
<td>RG213/U 95% shield mi spec NCV jkt</td>
<td>$1.65</td>
</tr>
<tr>
<td>RG214/U dbl silver shield mi spec</td>
<td>$1.85</td>
</tr>
<tr>
<td>RG214/U dbl silver shield, tin</td>
<td>$2.00</td>
</tr>
<tr>
<td>RG174/U 50 ohm 5000 watt dbl shield</td>
<td>$0.85</td>
</tr>
<tr>
<td>RG174/U 50 ohm 100&quot; od mi spec</td>
<td>$1.14</td>
</tr>
</tbody>
</table>

GROUND STRAP-GROUND WIRE

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS30 3/8&quot; stranded copper wire</td>
<td>$0.90</td>
</tr>
<tr>
<td>GS12 1/2&quot; stranded copper wire</td>
<td>$1.20</td>
</tr>
<tr>
<td>GS500 1-1/2&quot; heavy stranded copper wire</td>
<td>$2.00</td>
</tr>
<tr>
<td>AWG 6-ga insulated stranded wire</td>
<td>$0.35</td>
</tr>
<tr>
<td>AWG 12-ga stranded copper wire</td>
<td>$0.12</td>
</tr>
</tbody>
</table>

ROTOR CABLE-8 CONDUCTOR

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>9C1822 0.18&quot; and 0.22&quot;</td>
<td>$1.50</td>
</tr>
<tr>
<td>9C1820 0.18&quot; and 0.22&quot;</td>
<td>$1.50</td>
</tr>
</tbody>
</table>

CONNECTORS-MADE IN USA

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE720 Type N plug for Belden 9913</td>
<td>$3.95</td>
</tr>
<tr>
<td>NE723 Type N jack for Belden 9913</td>
<td>$4.95</td>
</tr>
<tr>
<td>PL259 standard UHF plug for RG8/213</td>
<td>$1.00</td>
</tr>
<tr>
<td>PL259AM Amphenol PL259</td>
<td>$0.89</td>
</tr>
<tr>
<td>PL259AM Amphenol male-female (baret)</td>
<td>$1.45</td>
</tr>
<tr>
<td>PL17G/17G176 reducer for RG58/A (specify)</td>
<td>$2.25</td>
</tr>
<tr>
<td>UG210N Q jack for RG8/213, 214 Silver</td>
<td>$3.15</td>
</tr>
<tr>
<td>UG9266 N jack to PL259 adapter, teflon</td>
<td>$6.00</td>
</tr>
<tr>
<td>UG9266N 50 ohm teflon adapter, tin</td>
<td>$6.00</td>
</tr>
<tr>
<td>UG255 SQ239 to BNC plug adapter, Amphenol</td>
<td>$3.29</td>
</tr>
<tr>
<td>SQ239AM UHF chassis mi receptacle, Amphenol</td>
<td>$6.90</td>
</tr>
</tbody>
</table>

NEWMODEL 8 CONDUCTOR

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE210 #210 #214 stranded Amphenol wire CCS</td>
<td>$0.30</td>
</tr>
</tbody>
</table>

CALLING CALLING CALLING

For details, contact Cushman Corporation, 48 Perimeter Road, Manchester, New Hampshire 03108.

SAY YOU SAW IT IN HAM RADIO

NEW products

220-MHz base station xcvr

ICOM has introduced the first 220-MHz base station transceiver, the IC-375A, a deluxe all-mode radio that covers 216-230 MHz and has 99 tunable full function memories, pass band tuning, a notch filter, a noise blanker, a built-in SWR bridge, semi- or full CW break-in, a multifunction meter, "velvet touch" tuning, and an easy-to-read amber LCD readout with variable backlight. Four scanning systems are available: band, programmable, plus mode and memory scan with selectable lock-out that scans 99 memories in 5 seconds. All subaudible tones are built-in; the actual subaudible frequency is displayed. Standard repeater splits are built-in and odd splits are programmable.

For details, contact ICOM America, Inc., 2380 116 Avenue N.E., P.O. Box C-90029, Bellevue, Washington 98009-9029.

Circle #301 on Reader Service Card.
new high-powered VHF amplifiers

The new HL-250V25 high-power VHF amplifier for 2 meters from Tokyo HY Power Labs, Inc., features a special combination of two separate modules, each capable of delivering over 125 Watts. It also provides an internal GaAs FET preamplifier for pulling in weak signals.

Priced at $459.95, the HL-250V25 requires 13.6 Vdc at 38 Amps maximum for power output of 250 Watts. For information, contact Encomm, Inc., 1506 Capital, Plano, Texas 75074.

Circle #03 on Reader Service Card.

active audio CW filter

The CW-1 Active Audio CW Filter is BELTEK's latest addition to its line of kits. The CW-1 eliminates ORM for easier copying and easily connects between your transceiver and speaker. The CW-1 has three selectable bandwidths (90, 130, and 200 Hz), with a center frequency of 800 Hz.

Priced at $19.95, the CW-1 measures 2 x 3.4 inches and can be powered by a 9-volt battery.

repeater control board

The latest additions to the Creative Control Products line are the SRC-10 smart repeater control board and the PI-10/SM link synthesizer board. The SRC-10 is a low-cost, low-power, self-contained microprocessor-based repeater controller. All repeater functions have been incorporated onto a 4 x 6-inch G-10 glass epoxy printed circuit board with one interfacing connector for ease of installation and reliability.

Priced at $148, the SRC-10 controller provides up to seven buffered auxiliary function control outputs selected remotely via a three-digit DTMF command. The SRC-10 controller responds with Auxiliary Function Tone Responses to indicate an ON or OFF condition. Courtesy Tone Responses are also available to indicate

Barry Electronics Commercial Radio Dept. offers the Best in two-way communications for Businesses, Municipalities, Civil Defense, Broadcasting Companies, Hospitals, etc. Sales and Service for all brands: Maxim, Yaesu, Icon, Tad, Octagon, Regency/Wilson, Midland, Standard, Uniden, Shinway, Fujitsu, Seals, Spiltsbury, Neutec, etc. Call or write for information. 212-925-7000.

Iron Powder and Ferrite
e

TOROIDAL CORES

Shielding Beads, Shielded Coil Forms
Ferrite Rods, Pot Cores, Baluns, Etc.

Small Orders Welcome
Free "Tech-Data" Flyer

AMIDON

Since 1963

12033 Otsego Street, North Hollywood, Calif. 91607
In Germany, Elektronikladen Wilhelm - Mellies Str 88, 4930 Detmold 18, West Germany
In Japan, Toyopura Electronics Co., Ltd., 7-9-7 Chiome Soka Kanda, Chiyoda-ku, Tokyo, Japan

September 1987
repeater or link COS activity. There's also a lock command that's especially useful for dealing with jammers or hackers; when selected, the controller ignores all DTMF commands until the unlock command is received.

With the optional PI-10/S synthesizer board ($39), the frequency and offsets of the link radio may be programmed remotely. After the frequency and offset are sent in serial format from the controller, it is converted into parallel outputs to interface with the link radio's frequency synthesizer. A readback command can be used to verify the link frequency.

For details, contact Creative Control Products, 3185 Bunting Avenue, Grand Junction, Colorado 81504.

Circle 1302 on Reader Service Card.

three new antennas

MFJ Enterprises, Inc. has announced the release of several new antennas. The MFJ-1710 ($9.95) is a 3/8-wave, 2-meter telescoping antenna with BNC. It measures 5-3/4 inches collapsed and 24 1/2 inches fully extended.

The MFJ-1712 ($14.95) is a 1/4-wave 20-meter and 5/8-wave 440-MHz telescoping antenna with BNC. It measures 7-1/4 inches collapsed and 19 inches fully extended.

MFJ-1714 ($16.95) is a 1/2-wave 20-meter telescoping antenna with BNC. This unit is an end-fed, short-end dipole, which is shorter, lighter, has more gain and places less stress on the connector than a 5/8-wave mounted on a handheld. When collapsed, it performs like a rubber duck.

These MFJ products come with a 100% guarantee: order any product from MFJ. Try it. If you're not satisfied — for any reason — return it within 30 days for a complete refund (less shipping). MFJ products are also covered by a one-year unconditional warranty, so customers are assured of continued service.

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

Circle 1305 on Reader Service Card.

hardware and software for Yaesu transceivers

The HF-Link line of hardware and software products provides a unique approach to controlling the Yaesu FT-980 and FT-757GX HF transceivers. Designed to interface with the Atari 8-bit family of microcomputers, the new products allow control of these transceivers with a standard joystick and eliminate the need for typing operating commands. They provide an accurate, on-screen graphic depiction of the tran-
receiver's operational status; memory channel scanning at rates determined by the user; rapid updating of station logs; unlimited disk storage of log and memory channel data files; and performance of other functions even when the operator is absent.

For details, contact Wald-Easterday Associates, Inc., P.O. Box 16166, Columbus, Ohio 43216.

Circle #306 on Reader Service Card.

new antenna catalog

A new full-color, 12-page brochure shows Centurion International's complete line of antennas for portable radios, pagers, and cordless telephones, as well as accessory adapters and cable assemblies. Included is a connector identification chart and list of radio models on which each style is used, making it easy to order the correct antenna.

For a free copy, contact Centurion International, Inc., P.O. Box 32848, Lincoln, Nebraska 68501.

Circle #307 on Reader Service Card.

satellite receiver/descramblers

The new 250OR integrated satellite TV receiver and descrambler from General Instrument's VideoCipher Division combines the features and benefits of a receiver and a descrambler in a single unit. With the 250OR, consumers can purchase authorization to receive the descrambled signals of nine premium television programmers currently scrambling their satellite broadcasts (another 20 programmers intend to scramble their signals by the end of 1987).

Priced at approximately $1250, the VideoCipher 250OR, with wireless remote control, uses advanced circuitry that provides a threshold improvement of up-to 2 dB over other receivers, reduces "sparklies," and provides crisper images.

Other key features include two methods of parental supervision for controlling access to specific programming, a built-in terrestrial interference filter optimized for use with the VideoCipher II descrambler, programming for 24 C-band and 32 Ku-band channels, and digital stereo audio. An optional antenna positioner power supply allows users to program up to 21 satellites in memory and to program 10 channels on any satellite. The instant recall by remote control.

The VideoCipher II 2400R, a new lower-priced ($1050) integrated unit comes standard with wireless remote control, two methods of parental program supervision for controlling access to selected programming, fully programmable antenna positioner, programming for 24 C-band and 32 Ku-band channels, and digital stereo audio.

---

Measure Up With Coaxial Dynamics Model 83000A RF Peak Reading Wattmeter

Take a PEAK with Coaxial Dynamics' "NEW" Model 83000A, designed to measure both FWD/RFL power in CW and FM systems simply and quickly. Then with a "FLIP" of a switch, measure "PEAK POWER" in most AM, SSB or pulse systems. Our Model 83000A features a complete selection of plug-in-elements plus a 2 year warranty. This makes the Model 83000A an investment worth looking at. So go ahead, take a "PEAK", you'll like "WATT" you see!

Contact us for your nearest authorized Coaxial Dynamics representative or distributor in our world-wide sales network.

---

GEM QUAD PRODUCTS (1987) LTD.

Chosen By Amateurs For Over 15 Years.
Winner of the Manitoba Design Institute Award of Excellence.
Will Accommodate New Bands From 2 To 20 Meters.

Fiber Glass Quad Antenna For 10, 15, and 20 Meters.
2 Element $235.00
3 Element $399.00
4 Element $563.00
Price is F.O.B. Boissevain.
Includes U.S. Customs Duty.
Kit Includes: Spider, Arms, Wire, Balun
Kit and Boom Where Needed

Boissevain, Manitoba, Canada R6K 8E0
P.O. Box 291, Telephone (204) 534-6184

---

VHF COMMUNICATIONS

915 North Main Street
Jamestown, New York 14701
PH. (716) 664-6345

---

September 1987
Crystal Filters
For most Ham Rigs from:
KENWOOD • YAESU • HEATHKIT
Also Drake R-4C7 Line, COLLINS 75S3/B/C
and ICOM FL44A, FL52A, FL53A clones.
Finest 8-pole Construction
ALL POPULAR TYPES IN STOCK
CW • SSB • AM
ASK ABOUT OUR MONTHLY
UNADVERTISED SPECIALS
Phone for Information or to Order.
VISA/MC or COD accepted
Why risk disappointment? Buy time-tested Fox-Tango Filters to be sure!
FOX-TANGO Corp.
Box 15944, W. Palm Bch, Fl 33416
Telephone: (305) 683-9587
European Agent: INGOMTEX, Post Fach 2449,
D-8070 Ingolstadt, West Germany

YOU NAME IT.
WE'VE GOT IT!
At Consolidated Electronics Inc. we carry over 10,000 parts and products such as fuses, semiconductors, batteries, capacitors, resistors, wire, cables, connectors, antennas, chemicals, speakers, test equipment, soldering equipment, stylus and cartridges, video heads, telephone accessories, and more. Consolidated Electronics is an authorized distributor for:
Action * GE * Pumpt
Anep * LPS * SAMS TM
Amphenol * Lock * Simpson *
Amphenol * Knob * Tech Spray TM
Burch * Keeler * Thorcadion *
B&K Precision TM * Nicholson *
Bogen * C. White *
Burgett * D. Koch *
CSTS * FaVe *
Electro-Voice *
Fluke *
Gould *
Hammond *
Heathkit *
Janssen *
Kooler *
Kooler *
Koch *
Kaplow *
Kelts *
Labs *
Moseley *
Neiman *
Oscilloscope *
Perkin Elmer *
Philips *
Plumb *
Spike *
Taylor *
Thordarson *
Thorn (?)
Torrance *
Vallance *
Wahl *
Wahns *
Wobber *
Xcelte *
All part orders shipped in 24 hours. 2 Year Warranty on all parts. Call toll free today.
1-800-543-3568

SOCIALIZED ELECTRONICS
702 Waterfront Ave. Oconomowoc, Wi 53066
Telephone: 268 229 Fax: 513 252 4066

For further information, contact General Instrument, Videocipher Division, 6262 Rusk Road, San Diego, California 92121.
Circle #303 on Reader Service Card.

ATV transmitter
The TX70-1 1-watt, 70-cm (420 to 450 MHz) ATV transmitter is a small (6 × 5.2 × 2.5-inch) unit designed to enable Technician or higher-class Amateurs to transmit live-action color or black and white composite video and audio from cameras, VCRs, or computers to other hams. The TX70-1 is a companion to the TVC-4G receiving downconverter.
For information, contact Kalt and Associates, 2440 E. Tudor Road, Suite 138, Anchorage, Alaska 99507.
Circle #311 on Reader Service Card.

For further information, contact General Instrument, Videocipher Division, 6262 Rusk Road, San Diego, California 92121.
Circle #303 on Reader Service Card.

circuit analysis program for the C-64
The new ALADYN-64 interactive circuit analysis program from Interceptor Electronics allows users to design linear ladder networks, commonly found in rf amplifiers and filters, on the Commodore 64 computer.
Formatted to simulate a vector network analyzer, the program permits the designer to select the frequency range over which the circuit will be tested. Output is in the form of S parameters on either a rectangular grid or Smith chart.
A disk drive is required; a printer is optional. The program, priced at $59.95 (postpaid) is written in BASIC and compiled for increased speed of operation.
For further information, contact Interceptor Electronics, Route 1, Box 439, Round Hill, Virginia 22141.
Circle #308 on Reader Service Card.

communications software packages
Kalt & Associates offers packet radio and multi-mode traffic handlers and other users several software packages for IBM and IBM-compatible PCs. Their Digipac II, for example, includes such exclusive features as full-screen editing (split-screen mode), full NTSC traffic macro system, an alarm alert system with visual/audible/paper and disk control modes, “make-your-own” pop-up help screens, multi-source alarms, “format-your-own” time/date/operator stamp, and user-defined function keys. Also available are full message forms, a pop-up help system, split screen, ASCII/binary file transfer, macro keys, macro files, DOS shell, character and line buffer mode, auto line-feed, disk logging, and other features. Scrolling function keys eliminate all the confusing ALT/command common to other programs. Digipac II is priced at $49.95 plus $3.00 postage ($8.00 foreign).
The Message Form system is available independently for users who already have other communications software; it’s priced at $29.95, with the same shipping rates.

Sub Problem?
Contact Sue. She’ll fix it for you!
(603) 878-1441
Ham Radio
Greenville, N. H. 03048
Summon Some
Aluminum Conundrums

EGE VIRGINIA
4003 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
2 Shles Road
Salem, New Hampshire 03079
New Hampshire Orders.*
Info & Service (603) 898-3750
Store Hours: MTWSat: 10-4
Th-F: Noon—8
*Order & we'll credit you $1 for the call.

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

R 5000
General Coverage Receiver

TH 215AT
2m FM Handheld

TH 21BT/31BT/41BT
Mini Handhelds
for 2m/220 MHz/440 MHz

For Orders & Quotes Call Toll Free: 800-336-4799
In New England (except NH): 800-237-0047
In Virginia: 800-572-4201
MINNESOTA: September 26. The Viking ARS will host its 17th annual Hamfest. High School, Waseca. Doors open 8 AM. Talk on in 34-94. For more information contact VAR, PO Box 3, Waseca, MN 56093.

CONNECTICUT: September 17. The Candlewood ARC’s annual ARF Day at Candlewood Lake, Danbury. 9 AM to 3 PM. Admission $3. 50. Taigeting 55. Talk in on 147.275. For table reservations send checks or money orders to G.A. Darden, SCARC, 409 Red Oak Drive, Galesville, MD 20737 or call Gene at (301) 426-8802.

GEORGIA: September 27. The Lander ARC will hold its 14th annual Hamfest. New Location: Georgia Mountain Center near Helen. On Hwy. 60, Helen. Gates open 9 AM to 3 PM. VE 9 AM to 4 PM. Free admission. For table reservations calling 4 PM. Talk in on 147.925.

ALABAMA: September 12 and 13. The Mobile ARC sponsored Hamfest, Texas Street Recreation Center, Mobile. Doors open 8 AM to 5 PM. Admission $1.00. swaps tables, no ham activities, free parking. Also free overnight parking for SCV’s. Hospital room Saturday night. Talk on in 146-27-92. For table reservations call, MARC, POB 723, Mobile, AL 36607. Phone N/M:HF 245-4711 or KB4JET 1265-4404.

CONNECTICUT: September 27. The 5th annual Natchaug ARC giant flea market, Elks-Horne, 186 Pleasant Street, Willimantic. Starts 9 AM. Dealers: 8 AM. Admission $2.00, Under 12 free. Advanced admission includes ARF at no extra charge. Natchaug Regional Flea Market. For more information contact, Zayer Zwyers, KAJN1F, 1048 Crestwood Lane, O’Fallon, MO 63366.

NEW YORK: September 20. LIMARC ARRL Long Island Hamfest, Southards Point, Southold, Long Island. Talk in on 147.080. For information on 646-8432-4232.

MISSOURI: September 27. The St. Peters ARC will hold its third annual Hamfest. The St. Peters High School. 8 AM to 3 PM. Admission $2.00. Talk in on 146.52. For information KADY, Ken, (314) 648 5037 or KEOY, Tom, (314) 264-2593.

MICHIGAN: October 5. The Southwest Michigan AR Team and the Great Lakes VHF ARF Day. 9 AM to 4 PM. Talk in on 146.50. For more information contact, John Atwill, W9MOB, 11801 Bracken Drive, Galesburg, MI 49010.

PENNSYLVANIA: October 11. The Pack Rats (affiliated with the ARRL) invites all Amateurs and friends to the 11th annual Mid Atlantic ARF Day. At the South Hills Cruise Inn, Rte 611. Talk on 146.50. For information, ASK W2AIC, Highway 42, Douglassville, PA 19518.

NEW JERSEY: September 26. The Burlington County ARC will hold its annual ARF at Rancocas High School, 5700 Fine Road, Burlington, NJ 08016. Talk in on 147.015.

PENNSYLVANIA: September 26. The W3PN Uniontown ARC will hold its annual ARF. Uniontown High School, Uniontown. Pre registration $1 each or $2.50. Free parking, free swap and sale. 9 AM to 4 PM. Talk in on 147.015. For more information N2FEP, Dave Atwell, Box 155, RD 5, Hall- ston Spa, NY 12020.

NEW MEXICO: September 26-27. The Northern New Mexico ARC’s 4th annual Hamfest, Camp Stovall, 8 miles east of Sandia Rd. Fees 8 AM to 3 PM. Free: talk in on flea market dealer, dealers and Sat. AM VEC exams. Also no ham programs. For more information contact,lightning, K7VR, Rt. 3 Box 165, Santa Fe, NM 87505.

NEW YORK: September 12. Saratoga County R.A. C.E. As- sociation’s 2nd annual Hamfest. Saratoga County Fairgrounds, Ballston Spa, 1 block off route 7. 9 AM to 4 PM. Admission $1.50, $1.00 to 12. Contest entries and more for admission. $3.00 outside selling space. Inside space $3.50. Talk in on 147.280. For more information N2ZEPVE, Dave Atwell, Box 155, RD 5, Hallston Spa, NY 12020.

PENNSYLVANIA: September 12. The WP3NE Uniontown ARC will hold its annual ARF. Uniontown High School, Union- town. Pre registration $1 each or $2.50. Free parking, free swap and sale. 9 AM to 4 PM. Talk in on 147.015. For more information N2FEP, Dave Atwell, Box 155, RD 5, Hallston Spa, NY 12020.

W1GB during the first annual Trader-O-Ree at Camp Sequoia, Mountain Center, CA. For more information send a letter to W1GB, 121 West Dayton Hill, Wallingford, CT 06492.

September 18-20: The Wright-Patterson AFB MARS, ARIFF and the Dayton AR Club’s MARS Association, W200, will go on the air to commemorate the celebration of the Air Force’s 40th anniversary. For further information write Paula Daggett, KAJH6J, 710016 Drive, Hubert Heights, Ohio 45424.

September 19-20: The Wellesley Mass ARS will operate W1P during the new Novice 10 meter privileges. 3:00 to 010Z. All amateurs are welcome especially Novices and Technicians. For a special USL call send OSL and SASE to Wellesley ARS, 211 Washington St, Wellesley, MA 02181.

September 19: The South Canadian Amateur Radio Society will celebrate its 10th year of operation by operating special event station W0U0S. For further details send OSL and SASE to W0U0S, Box 11, Linton, ND 58261.

September 27-28: 1987 Fall Classic and Homebrew Radio Ex- change, 2006 UTC Sunday to 0000 UTC Monday. Our object is to restore, operate and enjoy old and/or homebrew equipment of any vintage. CW call “CDX”: phone “CDX Classic-Exchange”. For further information write CDX, Box 2745, 29170 Park Lane, Norman, OK 73061.

September 15-19: The Southern Counties ARC will operate W3P during the Miss America Pageant, Atlantic City, New Jer- sey. OSL, SASE via SCARCA, Box 121, Linwood, NJ 08221.

September 26-27: The Council of Eastam Mass. Amateur Ra- dio Clubs “ICEMAR” will operate special event stations during the Amateur Radio Expo, at the Museum of Science in Bos- ton, MA. Each station will use the call sign K1ATM.

HAM EXAMS: The MIT UH-Repeat Association and the MIT HAM will offer monthly Ham Exams. All classes Novice to Extra. Wednesday September 29 7 PM, MIT Room 1-510, 77 Mass Ave, Cambridge, MA. Applications requested 2 days in advance. Contact Ray Hoffmann at (617) 466 1614. Exam fee $4.25. Bring a copy of your current license if any, two forms of picture ID, and a completed form 610 available from the FCC in Quincy, MA (617) 770 4023.

MOVING? KEEP HAM RADIO MOVING!

If possible let us know four to six weeks before you move and we will make sure your HAM RADIO Magazine arrives on schedule. For mailing label from this magazine and affix below. Then complete your new address (or any other corrections) in the space provided and we’ll take care of the rest.

WANTED: The author who has a lot of time to spend on writing for HAM RADIO Magazine. Send your resume, mailing label from this magazine and affix below. Then complete your new address (or any other corrections) in the space provided and we’ll take care of the rest.

Thanks for helping us to serve you better.
Ham Radio’s guide to help you find your local

California

A-TECH ELECTRONICS
1033 HOLLYWOOD WAY
BURBANK, CA 91505
(818) 845-9203
New Ham Store and Ready to Make a Deal!

JUN’S ELECTRONICS
3919 SEPULVEDA BLVD.
CULVER CITY, CA 90230
213-390-8003
800-882-1343 Trades
Habla Espanol

Colorado

COLORADO COMM CENTER
525 EAST 70th AVE.
SUITE ONE WEST
DENVER, CO 80229
(303) 288-7373
(800) 277-7373
Stocking all major lines
Kenwood Yaesu, Encomm, ICOM

Connecticut

HATRY ELECTRONICS
500 LEDYARD ST. (SOUTH)
HARTFORD, CT 06114
203-527-1881
Call today. Friendly one-stop shopping at prices you can afford.

Delaware

AMATEUR & ADVANCED COMMUNICATIONS
3208 CONCORD PIKE
WILMINGTON, DE 19803
(302) 478-2757
Delaware’s Friendliest Ham Store.

DELAWARE AMATEUR SUPPLY
71 MEADOW ROAD
NEW CASTLE, DE 19720
302-328-7728
800-328-7728
800-441-7008
Icom, Ten-Tec, Microlog, Yaesu,
Kenwood, Santec, KDK, and more.
One mile off I-95, no sales tax.

Florida

AMATEUR ELECTRONIC SUPPLY
1898 DREW STREET
CLEARWATER, FL 33755
813-461-4267
Clearwater Branch
West Coast’s only full service
Amateur Radio Store.
Hours M-F 9-5:30, Sat. 9-3

AMATEUR ELECTRONIC SUPPLY
621 COMMONWEALTH AVE.
ORLANDO, FL 32803
305-894-3238
Fta. Wats: 1 (800) 432-9424
Outside Fls: 1 (800) 327-1917
Hours M-F 9-5:30, Sat. 9-3

Georgia

DOC’S COMMUNICATIONS
702 CHICKAMAUGA AVENUE
ROSSVILLE, GA 30741
(404) 866-2302 / 861-5610
ICOM, Yaesu, Kenwood, Bird...
9AM-5:30PM
We service what we sell.

Hawaii

HONOLULU ELECTRONICS
819 KEAAUMOKU STREET
HONOLULU, HI 96814
(808) 949-5564
Kenwood, ICOM, Yaesu, Hy-Gain,
Cushcraft, AEA, KLM, Tri-Ex Towers,
Fluke, Belden, Astron, etc.

Idaho

ROSS DISTRIBUTING COMPANY
78 SOUTH STATE STREET
PRESTON, ID 83263
(208) 852-0830
M 9-2; T-F 9-6;
S 9-2
Stock All Major Brands
Over 7000 Ham Related Items on Hand

Illinois

ERICKSON COMMUNICATIONS, INC.
5456 N. MILWAUKEE AVE.
CHICAGO, IL 60630
312-631-5161
Hours: 9:30-5:30 Mon. Tu, Wed & Fri;
9:30-8:00 Thurs.; 9:00-3:00 Sat.

Indiana

THE HAM STATION
220 N. FULTON AVE.
EVANSVILLE, IN 47710
812-422-0321
Discount prices on Ten-Tec, Cubic,
Hy-Gain, MFJ, Azden, Kantronics,
Santec and others.
SASE for New & Used Equipment List.

Maryland

MARYLAND RADIO CENTER
8576 LAURELDALE DRIVE
LAUREL, MD 20707
301-725-1212
Kenwood, Ten-Tec, Alinco, Azden. Full
service dealer.
M-F 10-7

Massachusetts

TEL-COM, INC.
675 GREAT ROAD, RTE. 119
LITTLETON, MA 01460
617-486-3400
617-486-3040
The Ham Store of New England
You Can Rely On.

Michigan

ATLANTIC SOLAR POWER/ENCON
(SINCE 1979)
37677 W. SIX MILE RD.
LIVONIA, MI 48152
(313) 591-7745
Solar Electric Power for Repeaters,
Ham Shacks, Packet Radio.
Call Paul, WD8AHO

Minnesota

TNT RADIO SALES
4124 WEST BROADWAY
ROBBINSDALE, MN 55422 (MPLSIST.
PAUL)
TOLL FREE: (800) 328-0250
In Minn: (612) 535-5050
M-F 9 AM-6 PM
Sat 9 AM-5 PM
Ameritron, Bencher, Butternut, ICOM,
Kenwood

Missouri

MISSOURI RADIO CENTER
102 NW BUSINESS PARK LANE
KANSAS CITY, MO 64150
(800) 821-7323
Missouri: (816) 741-8118
ICOM, Kenwood, Yaesu
Same day service, low prices.

Nevada

AMATEUR ELECTRONIC SUPPLY
1072 N. RANCHO DRIVE
LAS VEGAS, NV 89106
702-647-3114
Dale Porraty "Squeak," AD7K
Outside Nev: 1 (800) 634-6227
Hours M-F 9-5:30, Sat. 9-3

Dealers: YOU SHOULD BE HERE TOO!
Contact Ham Radio now for complete details.
Amateur Radio Dealer

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

New Jersey
ABARIS SYSTEMS
275 ORIENTAL PLACE
LYNDHURST, NJ 07071
201-939-0015
Don WB2OPU
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/SA

KJI ELECTRONICS
66 SKYTOP ROAD
CEDAR GROVE, NJ 07009
(201) 239-4389
Gene K2KJI
Maryann K2RVH

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
26940 EUCLID AVE
WICKLiffe, OH 44092 (Cleveland Area)
216-585-7398
Ohio Wats: 1 (800) 362-0290
Outside Ohio: 1 (800) 321-3594
Hours M-F 9:5:30, Sat. 9-3

DEBRO 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.
1208 AIDA DRIVE
REYNOLDSBURG (COLUMBUS), OH
43068
614-866-4267

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

LaRUE ELECTRONICS
1112 GRANDVIEW STREET
SCRANTON, PENNSYLVANIA 18509
717-343-2124

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, Miracle, Ameritrack, 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, Wl 53216
414-442-4200
Wisc. Wats: 1 (800) 242-5195
Outside Wisc: 1 (800) 559-0411
M-F 9:30- 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
Karl Ober
Pachtgasse 24a
1231 Vienna, Austria
West Germany
Ham Radio Belgium
Benedicte Cornets de Sainte-Croix
16, Rue Walewille
B-9118 Gant-Belgium
Ham Radio Holland
P.O. Box 12
NL 7890 Ar Ermenonville
France
Ham Radio Europe
53 Lindsenbury Street
Edinburgh EH9 3ST
Scotland
Ham Radio France
41 Rue de la Poste
25, Rue des Écrans
75116 Paris 01
France
Ham Radio Germany
Karl Owert
Gutenberg Strasse 18
D-7500 Lahr
Germany
Ham Radio England
C/o R S G B
Lamberts House
Cradley Road
Walsall
England

Ham Radio France
Karl Owert
41 Rue de la Poste
75116 Paris 01
France

Ham Radio Germany
Karl Owert
Gutenberg Strasse 18
7500 Lahr
Germany

Ham Radio England
C/o R S G B
Lamberts House
Cradley Road
Walsall
England

September 1987 / 99
Gordon West's

21 DAY NOVICE

$19.95

Plus $2.50

Postage and Handling

Free ICOM 520 equipment certificate when you receive call letters.

Ham radio equipment "Wish Books".

ARRL membership forms. Free CQ Magazine coupon

Hotline for student questions. Dealer distributor

School pen. Course completion certificate.

GORDON WEST RADIO SCHOOL

2414 College Drive • Costa Mesa, CA 92626 • (714) 549-5000
an introduction to AMTOR

It’s digital communications time again, after a brief detour into discussion of the 28- and 220-MHz bands. July’s column covered the basics of RTTY and ASCII, two foundations for more advanced teleprinter communications techniques. This month we’ll continue with a look at AMTOR, another aspect of modern digital communications.

In referring to teleprinters, by the way, I’m not limiting the discussion to mechanical devices that print on paper; the term can also apply to electronic systems that “print” their output on a cathode-ray-tube screen (CRT).

QRN here...

One of the problems that has plagued teleprinter communications from the beginning is noise. Oh, sure, noise bothers CW and voice operators too, but that computer most of us have between our ears has a marvelous ability to fill in missing portions of a word or phrase when a static crash or some other noise blots out the signal for a brief period of time. The machinery of teleprinting isn’t so smart — it can’t infer what was “probably” sent by examining the context of the message. In mechanical systems such as RTTY, a mangled or missing bit of data will result in either a wrong character or no character being printed. In electronic systems using computers or “dumb” terminals, improper data can still print a wrong character, but if the noise mangled an instruction, the system is likely to “lock up.” Often, the only recovery is to shut the equipment off and then turn it on again, which loses any data already received. (And you thought first-contact jitters were bad! Be thankful you’re not a computer.)

As all good traffic handlers know, when the message must get through despite poor conditions, a solution to the noise problem is to repeat what’s being sent. Accuracy is improved, but throughput (that’s a buzzword referring to amount of information transferred per unit of time) is reduced. It’s a tradeoff that’s acceptable when accuracy is most important.

AMTOR to the rescue

AMTOR is a modern way of doing just that — repeating what is sent. The system was adapted from a commercial scheme devised to improve the reliability of communications with maritime units where garbled text could result in costly delays. The acronym AMTOR comes from AMateur Teleprinting Over Radio.

AMTOR comes in two flavors, Mode A and Mode B. In addition to repeating what’s sent, both use a unique code characteristic to allow the receiving station to reject bad data. Figure 1 shows the letter “Y” in both Baudot and AMTOR codes.

The AMTOR code was developed from the Baudot (or RTTY) code, and there’s a direct correlation in most of the characters. The binary representation of “Y” in Baudot is 10101; you’ll note that the center five bits of the AMTOR “Y” are also 10101.

Here’s where AMTOR gets clever. There’s always a ratio of four marks (ones) to three spaces (zeros). This is accomplished by adding ones or zeros to the original five-bit code. If the receiving station finds a character without that ratio, it rejects it as bad data.

In Mode A AMTOR, one station is called a “master,” and the other a “slave.” The master station is the station that initiates the contact. After contact is established, the master is known as the information-sending station, or ISS. The slave becomes the information-receiving station, or IRS. These roles can be reversed during the contact by either station sending the proper control code to the other. Mode B doesn’t use the master/slave concept, but instead repeats the characters being sent in a pattern designed to minimize errors.

* A “dumb” terminal is one that can only receive, display, and transmit text; a “smart” terminal contains a microprocessor and circuitry that allows it to also perform complex computing and data-manipulating functions.

Note that packet radio, through computerized error-checking, offers the advantage of noise-free, error-free communication; we’ll discuss packet radio in a future column.

September 1987
fig. 1. The letter “Y” in AMTOR code at (A), and in Baudot (RTTY) code at (B). The seven-bit AMTOR code was developed from the five-bit Baudot code by adding 1s and 0s to permit checking for accuracy of received bits. Compare these to the ASCII letter “Y” in my July column.
ter or number, but rather ring a bell, advance the paper, or shift to upper case, for example.)

Now suppose I repeat the message so you can fill in the missing pieces. On the first transmission you receive “a-en-a h-e is-e —en te-bea.” The second time, you receive “nte-na e-ere -s3 —emen —am.” You can fill in the missing pieces and recover the whole message easily enough, but now the beauty of it all is that your receiving machinery can do the same, and a whole lot faster. Instead of repeating the whole sentence, suppose that I know that the average noise burst is likely to be approximately two to three characters long. If I repeat the text in groups of four, the chances of the message getting through are much greater, and the amount of time spent repeating is kept to a minimum. Again, transmission is at 100 baud, so each character takes 70 msec, for a total of 280 msec for the first transmission; repeat the first four characters, then send the next four and repeat them. The sending sequence for the message above might be:

Ante ante ena inna here here is | is thre thre el el elemen ement beat beiam. am.

I’ve inserted the vertical bar (|) to mark off the groups of four characters; it isn’t sent as part of the message. Note that spaces between words count as “characters” too; in AMTOR code, each space is indicated as 0011101 (bit 0 first).

In Mode B, the transmitter is on continuously, so it might overheat unless it’s designed to handle continuous duty cycle. If this is the case, reduce the power level to something that the transmitter can handle. (Like AMTOR operation, RTTY also requires that most transmitters be operated at reduced power to prevent overheating. Check your equipment instruction manual for duty-cycle information.)

If all this seems complicated and confusing, don’t worry — it probably is. The good news is that you don’t have to think too much about it; today’s equipment has a lot of “smarts” built in. All you need is a teleprinter, a terminal, or a personal computer; add an AMTOR encoder/decoder box, connect it to your transceiver, and watch the lights blink.

Well, maybe it’s not quite that easy, but it’s not too hard, either. You’ll still have to learn how to tune in a station, and what the operating procedures are, but a little careful listening (make that “monitoring”) will take care of the latter. For practice in tuning in a station (and learning what one sounds like) tune in W1AW, the Maxim Memorial Station at ARRL headquarters in Newington, Connecticut. The station transmits bulletins on AMTOR Mode B on 14,095 kHz at scheduled times. Novices: remember, you can receive (listen) in Mode B on hf bands other than 10 meters, but you can’t transmit (reply) in either mode only between 28.1 and 28.3 MHz.

Other “listening” spots are 14,075 and 3637.5 kHz. Many stations start there and then move a few kHz up or down to continue QSOs. If you hear a “chirp-chirp” type of operation, it’s probably two stations using Mode A. If a signal sounds very much the same as a continuous RTTY signal, it could be either RTTY or Mode B. If you tune it in and the lights on your AMTOR box come on, you’re doing something right. Try some schedules on 10 meters and have a ball.

There’s more interest in AMTOR in Europe than in the United States, so here’s a chance to grab some very interesting DX on a relatively new and fascinating mode of communication.

reference
QUALITY TEST GEAR
YOU CAN COUNT ON

INCLUDES 2 HOOK-ON PROBES
20 MHz DUAL TRACE
$369.95*

20 MHz DUAL TRACE
wire form bandwidth — optimal sensitivity — delayed
trigger setting — ALT trigger — single sweep TV sync
SX magnification — XY or Xy operation — HF/LL noise reduction

INCLUDES 2 HOOK-ON PROBES
35 MHz DUAL TRACE
$499.95*

35 MHz DUAL TRACE
wire form bandwidth — optimal sensitivity — delayed
trigger setting — ALT trigger — single sweep TV sync
SX magnification — XY or Xy operation — HF/LL noise reduction

INCLUDES 2 HOOK-ON PROBES
15 MHz DUAL TRACE PORTABLE
$499.95*

15 MHz DUAL TRACE PORTABLE
Field test applications — bench charger and battery pack
— up to 2 hours operation per charge — SX 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.

$119.95
CHARGER, NSABS BATTERIES, ADAPTOR INCLUDED

MINI-100 COUNTER
7 DIGIT 525 MHZ

$139.95
WORLDWIDE AC ADAPTER INCLUDED

CT-90 DIGIT 600 MHZ

$199.95
WORLDWIDE AC ADAPTER INCLUDED

CT-50 8 DIGIT 600 MHZ

$199.95
WORLDWIDE AC ADAPTER INCLUDED

CT-125 9 DIGIT 1.2 GHZ

$199.95
WORLDWIDE AC ADAPTER INCLUDED

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 coun-
ters 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. $995.

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

TOY GENERATOR
A complete toy generator on a single PCB: Features: 400-5000 Hz adjustable range with 4 step/5 sec adjustment, starts
at 900 Hz, and runs at 1000 Hz. Complete kit $8.95
Mini kit $5.95

MICRO ASSEMBLY KIT
Features: 555 timer. Complete kit $7.95
Mini kit $6.95

COLOR GENERATOR
Features: 3 different colors. Complete kit $8.95
Mini kit $6.95

VIDEO MODULATOR
Features: 50 kHz to 500 MHz TV video modulator. Complete kit $14.95
Mini kit $12.95

WIRE ACTIVATED SWITCH
Features: 50 kHz to 50 MHz. Complete kit $12.95
Mini kit $10.95

LED Blinky Kit
Features: 50 kHz to 50 MHz. Complete kit $12.95
Mini kit $10.95

UNIVERSAL TIMER
Features: 50 kHz to 50 MHz. Complete kit $12.95
Mini kit $10.95

WIRELESS LIGHTING
Features: 50 kHz to 50 MHz. Complete kit $12.95
Mini kit $10.95

ACCESSORIES FOR RAMSEY COUNTERS

Telescopic whip antenna — BNC plug $8.95
High impedance probe, light indicating $12.95
Low pass probe, audio use $18.95
Direct probe, general purpose use $18.95
Tilt ball, for CT-70, 90, 125 $13.95

PHONE ORDERS CALL
716-586-3950
TELEX 46673 RAMSEY CI
FAX 716-586-4754

RAMSEY ELECTRONICS, INC. 2911 Third Ave. Dept. WR
Buffalo, N.Y. 14216
ALL TRAP ANTENNAS are Ready to use - Factory assembled - Commercial Quality. Handle full power - Comes complete with Deluxe traps, deluxe center connector, 14 ga Stranded CopperWire antenna wire and end insulators. Automatic Band Switching - Tuner usually not required - For all Transmitters, Receivers & Transceivers - For all class amateurs - One feedline works all bands - Instructions included - 10 day money back guarantee!

SINGLE BAND DIPOLES (Kit form):

<table>
<thead>
<tr>
<th>Band</th>
<th>Length</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>40</td>
<td>$11.95</td>
</tr>
<tr>
<td>80</td>
<td>50</td>
<td>$19.95</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>$21.95</td>
</tr>
<tr>
<td>40</td>
<td>50</td>
<td>$31.95</td>
</tr>
</tbody>
</table>

Includes assembly instructions, Deluxe center connector, 14 ga Stranded CopperWire Antenna wire and end insulators.

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

<table>
<thead>
<tr>
<th>Length</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>$8.00</td>
</tr>
<tr>
<td>50</td>
<td>$10.95</td>
</tr>
</tbody>
</table>

DELUXE CENTER CONNECTOR

- No Rust - Brass terminals
- No jumper wires used
- No soldering
- Built-in Lightning Arrestor
- With (1) 1/4 wave pi/4
- Handles full power
- Completely sealed - Weatherproof
- Easy 2-element adjustments
- Commercial Quality

$9.95

DELUXE ANTENNA TRAPS: Completely sealed & weatherproof - Solid brass terminals - Handles full power - NO jumpers - NO soldering - Instructions included

For 4-band Dipole Antenna
40/20/15/10 $36.00/pr
40/40/20/15/10 $38.00/pr

ORDER DIRECT FROM FACTORY. All orders shipped US Postpaid. VISA/MC (give card #, Exp. Date, Signature).

WI-RO MANUFACTURING, INC.
Dept. 103, P.O. Box 1588
Hendersonville, NC 28793
Dealers Inquiries Invited

FERRITE DEVICES

Power dividers / combiners
Directional Couplers
Quadrature Hybrids
0.4 - 900MHz

WI-COMM ELECTRONICS INC.
P.O. Box 5774, MAssena, N.Y. 13662
(315) 769-8334

Reader Service CHECK-OFF Page 106
## Adsvertiser'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 to make a check mark in the space provided. Mail this form to

**HhO Radio, Reader Service, I.C.A., P.O. Box 2558, Woburn, MA 01801.**

### Name: **Call**

### Address:

<table>
<thead>
<tr>
<th>City</th>
<th>State</th>
<th>Zip</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Please contact this advertiser directly.

**Please use before October 31, 1987.**

### Reader Service # | Page #
--- | ---
197  | Advanced Computer Controls, Inc.  | 40
146  | Advanced Receiver Research.       | 90
109  | AEA                                | 56
141  | All Electronics Corp               | 83
107  | Alpha Delta Communications          | 48
144  | Aluma Tower Co.                    | 89
105  | Amateur Wholesale Electronics      | 47
124  | Amateur Wholesale Electronics      | 66
148  | Amidon Associates                  | 91
164  | AMSAT                              | 84
160  | Antique Radio Classified           | 100
123  | APRIL                              | 79
194  | Astronomy Corp                     | 34
167  | Bilti Company                      | 106
156  | Bittex Publishing                  | 94
159  | Buckmaster Publishing              | 100
157  | Business Dynamics, Inc             | 93
119  | Communication Concepts, Inc        | 69
165  | Communications Technologies        | 107
200  | Computer Information/1.M.H.O.      | 83
114  | Computeradio                       | 63
155  | Consolidated Electronics           | 94
186  | Creative Design/Onion Hi-Tech     | 23
138  | CTM                                | 80
190  | Cushcrall Corp                     | 45
152  | Detection Dynamics                 | 92
192  | Delco Computer Products            | 29
188  | Doppler Systems                    | 34
185  | Down East Microwave                | 23
154  | EGE, Inc.                          | 95
194  | Engineering Consulting             | 76
189  | Fair Radio Sales                   | 24
110  | Falcon Communications              | 64
110  | Filke Manufacturing Co.            | 61
104  | Fox River Radio League             | 76
104  | Fox Tango Corp                     | 94
156  | Gem Quad Products (1987 Ltd)       | 93
195  | GLS Electronics                    | 36
161  | Gordon West School Radio           | 100
106  | HAL Communications Corp            | 53
131  | Hall Electronics                   | 76
108  | Ham Radio Outlet                   | 54, 55
108  | Ham Radio's Bookstore              | 23, 28, 48, 69, 72, 78
108  | Ham Radio's Bookstore              | 80, 83, 84, 87, 88
108  | The Ham Station                    | 36
108  | Haydenics, NY                      | 75
108  | Haydenics, PA                      | 62
179  | Hudler, Inc.                       | 16
170  | ICOM America, Inc.                 | 86
112  | IIX Equipment Ltd.                 | 63
134  | Jensen Tools, Inc.                 | 78
157  | Juno's Telsis                      | 103
171  | Kentronics                         | 11
182  | Kennedy Associates                 | 19
196  | Kenwood U.S.A. Corp                | 2, 5, CIV
118  | Larsen Electronics                 | 69
176  | Lunar Electronics                  | 12
143  | Madison Electronics & Supply       | 87
103  | Gland Martin Engineering, Inc      | 46
172  | MFJ Enterprises                    | 7

### Reader Service # | Page #
--- | ---
101  | Micro Control Specialties          | 46
151  | Milward Technologies               | 92
116  | Minds Eye Publications             | 62
180  | Mirage Communications              | 18
196  | Mirage Communications              | 40
132  | Mission Communications             | 76
128  | Missouri Radio Center              | 70
111  | Mob Energy Ltd.                    | 63
148  | Monitoring Times                   | 22
136  | Motion Electronics                 | 78
177  | NEC                               | 12
137  | Net Tech Labs, Inc                 | 81
117  | Nematronics                        | 90
145  | Nets & Volts                       | 88
169  | OFF/Communications                 | 106
198  | P.C. Electronics                   | 44
129  | Pac-Comm Packet Radio Systems, Inc.| 72
126  | Palomar Engineers                  | 19
126  | Processor Concepts                 | 11
127  | The PX Shack                       | 79
175  | Radio Amateur Callbook             | 15
113  | Radiosporting                      | 93
123  | Ramsey Electronics, Inc.           | 104
102  | RF Connection                      | 46
153  | Reensch Microwave                  | 92
122  | Radiant Arrays                     | 64
121  | - S-Com Industries                 | 64
129  | Sommer                            | 84
139  | Spec^Com                          | 89
191  | Spectrum International             | 78
163  | Stalc-1 Manufacturing, Inc.        | 105
117  | Stradburg Engineering Co.          | 62
183  | STV-ON Sat                        | 20
181  | Synthetic Textiles, Inc            | 19
187  | TE Systems                        | 24
115  | Tel-Com                           | 62
104  | Transmitters Unlimited             | 46
174  | Unadilla/Annenas Etc              | 11
158  | Unity Electronics                  | 100
153  | University Microfilm Int           | 24
173  | Val Comm, Inc                      | 10
129  | Vanguard Labs                      | 66
178  | Van McEAM                          | 14
150  | VHF Communications                 | 93
143  | W1N9N Antennas                     | 83
190  | Western Electronics                | 24
164  | W9Comm Electronics Inc             | 105
166  | World Data Enterprises             | 106
168  | Yaesu USA                          | 31
193  | Yaelc USA                          | 39
130  | E.H. Yost Co                       | 79

### Product Review/New Products

<table>
<thead>
<tr>
<th>Product Review/New Products</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>304 - BEL TEK</td>
<td>91</td>
</tr>
<tr>
<td>307 - Continuum Internation, Inc.</td>
<td>93</td>
</tr>
<tr>
<td>302 - Creative Control Products</td>
<td>91</td>
</tr>
<tr>
<td>* Cushtac Corp</td>
<td>89</td>
</tr>
<tr>
<td>303 - Excite, Inc.</td>
<td>91</td>
</tr>
<tr>
<td>309 - General Instrument</td>
<td>93</td>
</tr>
<tr>
<td>301 - ICOM America, Inc.</td>
<td>90</td>
</tr>
<tr>
<td>308 - Interactive Electronics</td>
<td>94</td>
</tr>
<tr>
<td>311 - Kilt and Associates</td>
<td>94</td>
</tr>
<tr>
<td>305 - MFJ Enterprises</td>
<td>92</td>
</tr>
<tr>
<td>310 - P.C. Electronics</td>
<td>94</td>
</tr>
</tbody>
</table>

---

**TURBO PC-XT COMPATIBLE**

- 4.77-8 Mhz
- 256K RAM (to 640)
- 360K DD w/Controller
- Mono monitor
- Monitor card
- AT/XT Keyboard
- 150 Watt P/S

**MAIL TO:**

World Data Enterprises

P.O. Box 652737

Pacoima, CA 91335

(303) 551-4023

1-800-634-3547

Call for Free Brochure

- 20 mg ST-255 w/cont.
- $225.00
- 30 mg ST-238 w/cont.
- $455.00

**OFFER EXPIRES 10/31/87**

Offer only on Turbo XT System

**BRAND NAME DISKS**

<table>
<thead>
<tr>
<th>5.25&quot; DDS, DDSF, SOFT SECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>BY BOX</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>MAXELL</td>
</tr>
<tr>
<td>NASHUA</td>
</tr>
<tr>
<td>3M</td>
</tr>
<tr>
<td>DYSAN</td>
</tr>
<tr>
<td>VERBATIM</td>
</tr>
<tr>
<td>IDEX</td>
</tr>
</tbody>
</table>

**PRICE PER DISK**

**BULK DISKS 5.25" DDSF, DDSF-RH**

<table>
<thead>
<tr>
<th>25</th>
<th>50-400</th>
<th>425-1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDS</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>LIBRARY CASE - 10 DISKS</td>
<td>199</td>
<td></td>
</tr>
<tr>
<td>QVS FILE BOX - 75 DISKS</td>
<td>8.50</td>
<td></td>
</tr>
<tr>
<td>FLIP-N-FILE BOX - 100 DISKS</td>
<td>15.95</td>
<td></td>
</tr>
</tbody>
</table>

**CALL FOR FREE BROCHURE OF MORE COMPUTER SUPPLIES**

(303) 551-4023

1-800-634-3547

HOURS: 10 AM - 7 PM EST

Mail to: World Data Enterprises

P.O. Box 652737, Miami, FL 33285

---

**166**

**THE AUTRON ANTENNAS FROM 16-100 TIMES**

NO TUNERS!
NO RADIALS!
NO RESISTORS!
NO COMPROMISE!

THREE EXCELLENT REVIEWS JUST DON'T HAPPEN BY CHANCE, CALL US FOR A FREE CATALOGUE.

**BILL COMPANY**

S.R. 2, Box 62, Dept. 2

Lucha, OK 73442

(918) 751-4394

---

**We've Got Books**

**Plenty of Books**

Send SASE for free flyer

**Ham Radio's Bookstore**

Greenville, N. H. 03048

---

106 September 1987
We just struck gold with a miniature, high quality and very reliable DTMF decoder at a rock bottom price of $59.95. Our DTD-1 will decode 5040, 4 digit codes with the security of wrong digit reset. It contains a crystal controlled, single chip DTMF decoder that works great in bad signal to noise environments and provides latched and momentary outputs. Why carry that heavy gear when its size is only 1.25 x 2.0 x .4 inches and it comes with our etched in stone, legendary, one year warranty.

Instead of sifting through the field...searching, use our super quick one day delivery and cash in on a rare find.
NEW POCKET SIZE

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

$99.95 - $150.00

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 indispensable 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

ORDER FACTORY DIRECT

FLA(305) 771-2050

1-800-327-5912

OPTOelectronics inc

5821 N.E. 14th Avenue

Ft. Lauderdale, Florida 33334

Available NOW!

Orders to US and Canada add 5% of total (52 min., $10 max)

Florida residents add 5% sales tax. COD fee $2.

Because the FT-757GX/II packs all its HF performance into one highly compact, action-ready case. A case so small, it even fits under airplane seats.

Of course, you've probably noticed a similarity to its predecessor, the FT-757GX. That's purely intentional. And now its performance is even better.

With new features like memory storage of operating mode, Slow/fast tuning selection. Automatic step-change according to mode. IF notch filter. 10 memories. And VFO to VFO scan.

Plus you get an iambic electronic keyer, Woodpecker noise blanker, 600-Hz CW filter. AM and FM modes. AP speech processor. And 25-kHz marker generator. All at no extra charge.

Three microprocessors. Dual VFOs. Single-button VFO/memory swap. Receive coverage from 500 kHz to 30 MHz. Transmit coverage from 10 to 160 meters, including WARC bands. All-mode coverage (LSB, USB, CW, AM and FM). 100-watt RF output.

QSK operation. Massive heatsink and duct-flow cooling system for continuous RTTY operation for up to 30 minutes.

Computer Aided Transceiver (CAT) System for computer control via optional interface (software is available from your Yaesu dealer).

Of course, the FT-757GX/II offers the kinds of options you'd expect from Yaesu, too. Including standard and heavy-duty power supplies, automatic antenna tuner, and more.

So no matter where you work the DX, take along Yaesu's FT-757GX/II. The full-featured HF rig you'll have a real field day with.

Yaesu

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

Yaesu Cincinnati Service Center 9070 Gold Park Drive, Hamilton, OH 45011 (513) 874-3100.

Prices and specifications subject to change without notice.
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)
- 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-22W/ 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/volt 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-95** 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.