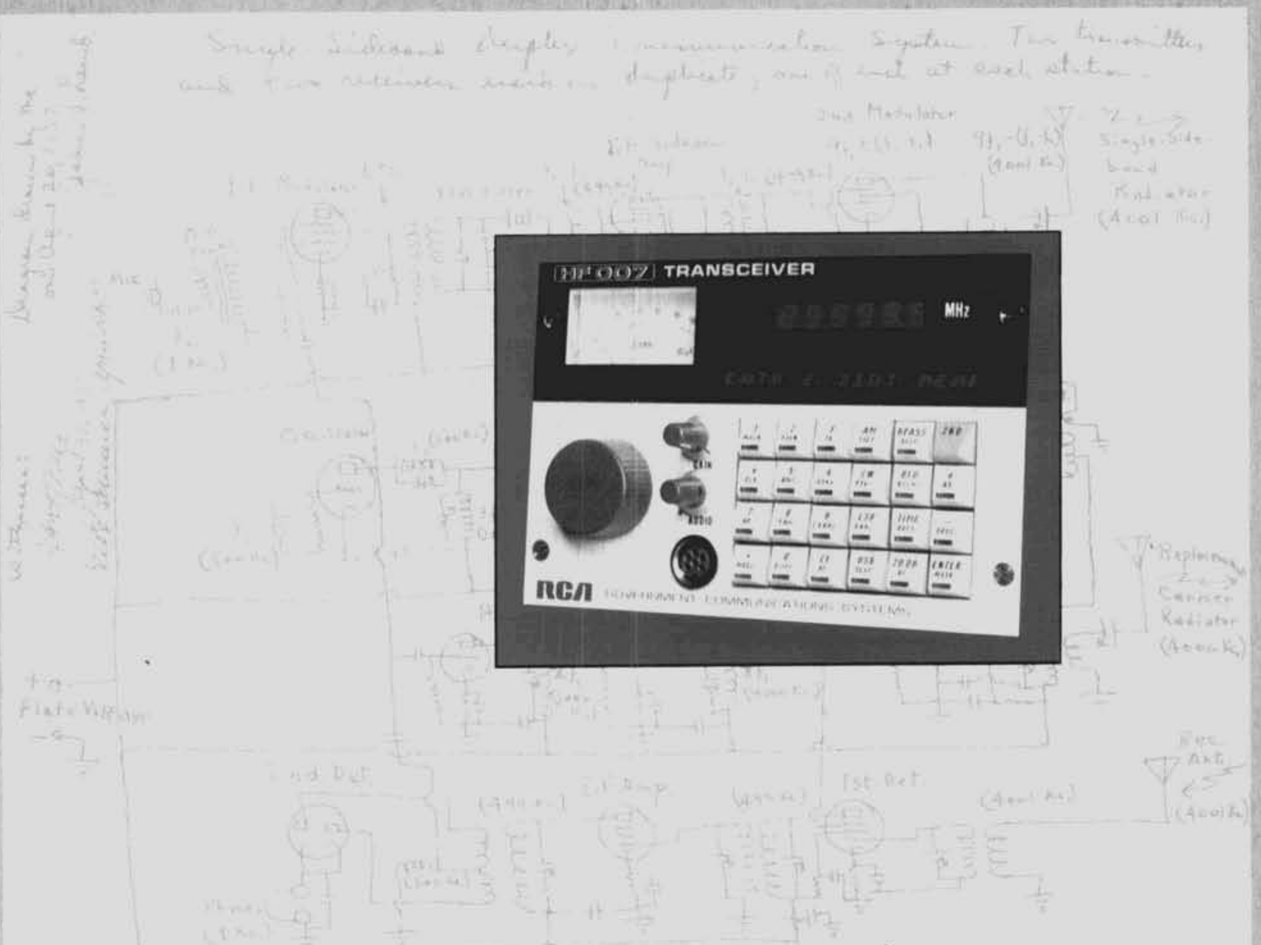
SEPTEMBER 1984 / $2.50

EXCLUSIVE PHOTOS: FIRST HT-TO-HT SATELLITE QSO

ham radio magazine



CELEBRATING 70 YEARS OF PROGRESS: THE DEVELOPMENT OF SSB

hr focus on communications technology

specialized communications: work OSCAR 10 with your HT • a software approach to packet radio • the FM advantage • interrupt-driven RTTY reader • ALSO: a short, efficient end-fed dipole • improving ALC's • optimizing Yagi gain • an audio AGC • W6SAI's "shortwave circus" • W1JR on 220 MHz EME • and more


ICOM's IC-02A
Digital Readout, Scanning, Memories and...
ICOM introduces the new top-of-the-line IC-02A and IC-02AT to compliment its existing line of popular handheld transceivers and accessories. The new direct entry microprocessor controlled IC-02A is a full-featured 2-meter handheld.
Some of its many features are: Scanning, 10 memories, duplex offset storage in memory, odd offsets, 32 keyboard selectable PL tones which store in memory, and internal lithium battery backup.
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An easy-to-read custom LCD readout indicates frequency, memory channel, signal strength and transmitter output, PL tone, and scanning functions.
The new IC-02A has a battery lock, frequency lock, and lamp on/off switch. An aluminum case back is provided for superior heat sinking when the IC-02A is run at the standard 3 watt level or 5 watts (optional battery pack).
A variety of batteries are available for the IC-02A and IC-02AT including the new long-life 8.4 volt IC-BP8 and 13.2 volt IC-BP7. The IC-BP7 and BP8 may be charged from a top panel connector for 13.8 volts which will also power transceiver operation.
ICOM's IC-2A(T) continues to be available...and its complete line of accessories work with the new IC-02A.
The IC-02A comes standard with IC-BP3 NiCd battery pack, BC-25U wall charger, flexible antenna, wrist strap and belt clip.
ICOM
VHF FM TRANSCEIVER
IC-02A
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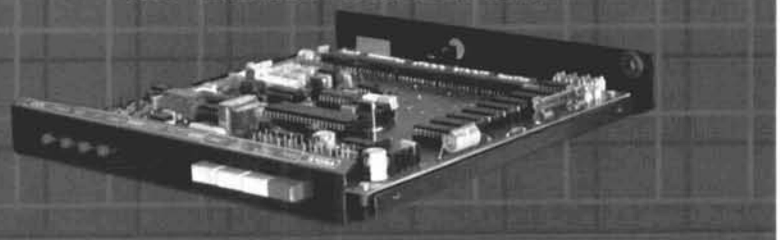
The World System
ICOM America, Inc., 2112-116th Ave NE, Bellevue, WA 98004 (206)454-8155 / 3331 Towerwood Drive, Suite 307, Dallas, TX 75234 (214)620-2780
All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emissions. 02AT284

With SMART PATCH You are in CONTROL

With CES 510SA Simplex Autopatch, there's no waiting for VOX circuits to drop. Simply key your transmitter to take control.



SMART PATCH is all you need to turn your base station into a personal autopatch. SMART PATCH uses the only operating system that gives the mobile complete control. Full break-in capability allows the mobile user to actually interrupt the telephone party. SMART PATCH does not interfere with the normal use of your base station. SMART PATCH works well with any FM transceiver and provides switch selectable tone or rotary dialing, toll restrict, programmable control codes, CW ID and much more.

To Take CONTROL with Smart Patch – Call 800-327-9956 Ext. 101 today.

hat To ook For In A hone Patch

e best way to decide at patch is right for you to first decide what a tch should do. A patch ould:

- Give complete control to the mobile, allowing full break in operation.
- Not interfere with the normal operation of your base station. It should not require you to connect and disconnect cables (or flip switches!) every time you wish to use your radio as a normal base station.
- Not depend on volume or squelch settings of your radio. It should work the same regardless of what you do with these controls.
- You should be able to hear your base station speaker with the patch installed. Remember, you have a base station because there are mobiles. ONE OF THEM MIGHT NEED HELP.
- The patch should have standard features at no extra cost. These should include programmable toll restrict (dip switches), tone or rotary dialing, programmable patch and activity timers, and front panel indicators of channel and patch status.

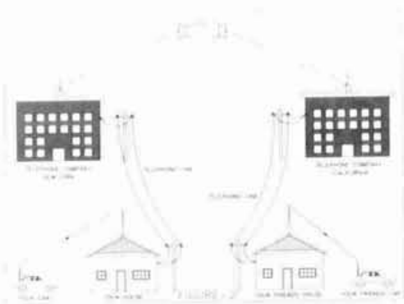
ONLY SMART PATCH HAS ALL OF THE ABOVE.

low Mobile)perators Can Enjoy An Affordable Personal Phone Patch. . .

- Without an expensive repeater.
- Using any FM tranceiver as a base station.
- The secret is a SIMPLEX autopatch, The *SMART PATCH.*

SMART PATCH s Easy To Install

o install *SMART PATCH*, onnect the multicolored omputer style ribbon cable o mic audio, receiver iscriminator, PTT, and ower. A modular phone ord is provided for connection to your phone system. Sound simple? . . . T IS!



How To Use *SMART PATCH*

Placing a call is simple. Send your access code from your mobile (example: *73). This brings up the Patch and you will hear dial tone transmitted from your base station. Since *SMART PATCH* is checking about once per second to see if you want to dial, all you have to do is key your transmitter, then dial the phone number. You will now hear the phone ring and someone answer. Since the enhanced control system of *SMART PATCH* is constantly checking to see if you wish to talk, you need to simply key your transmitter and then talk. That's right, you simply key your transmitter to interrupt the phone line. The base station automatically stops transmitting after you key your mic. *SMART PATCH* does not require any special tone equipment to control your base station. It samples very high frequency noise present at your receivers discriminator to determine if a mobile is present. No words or syllables are ever lost.

SMART PATCH Is All You Need To Automatically Patch Your Base Station To Your Phone Line.

Use *SMART PATCH* for:

- Mobile (or remote base) to phone line via Simplex base. (see fig 1.)
- Mobile to Mobile via interconnected base stations for extended range. (see fig. 2.)
- Telephone line to mobile (or remote base).
- *SMART PATCH* uses SIMPLEX BASE STATION EQUIPMENT. Use your ordinary base station. *SMART PATCH* does this without interfering with the normal use of your radio.

WARRANTY?

YES, 180 days of warranty protection. You simply can't go wrong.

An FCC type accepted coupler is available for *SMART PATCH.*

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P.O. Box 2930, Winter Park, Florida 32790
Telephone: (305) 645-0474 **Or call toll-free (800)327-9956**

SEPTEMBER 1984

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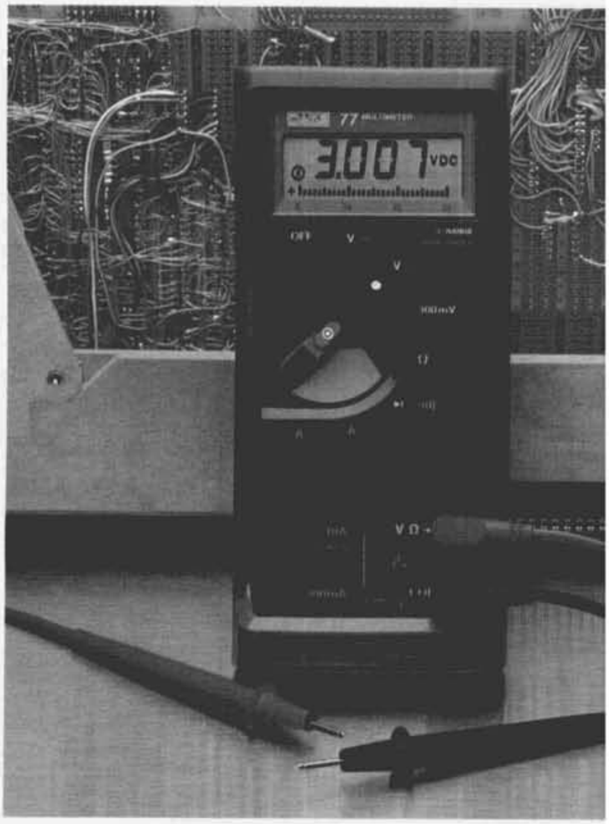
ham radio

magazine

contents

You touch. It holds.



$129* gets you the world's first handheld digital/analog multimeter with "Touch Hold."

The Fluke 77

Its unique "Touch Hold"** function automatically senses and holds readings, leaving you free to concentrate on positioning test leads without having to watch the display.

Then, when you have a valid reading, it signals you with an audible beep.

The Fluke 77 is perfect for those test situations where accessibility is a problem, or when extra care is needed for critical measurements.

It's the top model in the world champion Fluke 70 Series line — the first industrial quality autoranging multimeters to combine digital and analog displays. These tough, American-made meters feature a three-year warranty and 2000+ hour battery life.

So call now for the complete story on the Fluke 77 with "Touch Hold." Because if you don't deserve the world's first, who in the world does?

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Autorange	Audible continuity	Audible continuity
0.7% basic dc accuracy	Autorange/range hold	"Touch Hold" function
2000+ hour battery life	0.5% basic dc accuracy	Autorange/range hold
3-year warranty	2000+ hour battery life	0.3% basic dc accuracy
	3-year warranty	2000+ hour battery life
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		Multipurpose holster

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** Patent pending.

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REFLECTIONS

taking care of business

There are some controversial arguments to be made in behalf of software piracy. These are some of the arguments we've heard:

> *Software is overpriced. Piracy gets it into the hands of users at prices they can afford.*
>
> *Piracy encourages the development of new and improved programs to meet the rising expectations of a sophisticated (and possibly saturated) market.*
>
> *As pirated programs circulate, product visibility and name recognition are enhanced. This helps manufacturers market current and future products.*
>
> *Software piracy is no more than a logical extension of the problem of trying to protect copyrights in the audio and video industries. As such, it can't be stopped.*

One industry maverick even claims that by providing real competition to software manufacturers, piracy actually helps keep software prices *down.*[1]

It occurred to us that similar, even identical, arguments could be made in defense of burglary. Burglary, after all, provides part-time employment to some (the burglars) and full-time employment to many (the police). It supports free enterprise and R&D — in security systems, insurance, medical care, and penology. It also gets consumer goods into the hands of users at a price they can afford.

We understand that nobody cares more about copyright law than those whose livelihood is directly affected by copyright infringement. Publishers — of books, music, software, and magazines — care very much, because illegal reproduction of thier product affects their ability to continue producing that product. Is it unreasonable to ask or expect the general public to care? Perhaps. But we think it's not unreasonable to ask the Amateur Radio fraternity to care.

We asked one software publisher how many hours his firm had invested in the development of a program for CW/RTTY/ASCII transmission and reception. "Thousands," he said, and explained that it had taken the firm's chief programmer *six months* of full-time effort to develop the program. Add to this the cost of support services and debugging; of developing associated hardware; of writing clear, comprehensive manuals; and of advertising and overhead. Suddenly the $29.95 or even $99.95 price tag on a package of Amateur Radio software becomes a little more understandable. The software pirate, on the other hand, needs nothing more than a computer, a disk drive, a supply of disks, and access to a photocopier for duplicating original documentation to go into business.

Some consumers don't know that unwrapping a package of software constitutes acceptance of a *limited* license to use the program inside. We'd like to think that anything we buy is ours, to do with what we will. After all, we can buy a Hershey® chocolate bar and share it with a friend, but we can't take it home, duplicate the recipe, pour our own chocolate bars, stamp them with Hershey's good name, and sell them as our own. The license to use isn't a license to steal.

The fact is that none of the manufacturers who serve the Amateur Radio market exclusively, or nearly so, are listed among the Fortune 500. Some are virtual mom-and-pop operations. Others are small groups of entrepreneurs. A few have grown and diversified. Many have prospered. But there's not one among them who can afford to keep fighting software piracy without sacrificing continued investment in new products.

Every dollar the Amateur Radio software industry spends fighting piracy is a dollar that can't be invested in R&D. If we want products that can keep pace with our rapidly expanding interest and needs, we'd best put our money where it can help make the difference — not in some pirate's pocket.

Dorothy Rosa, KA1LBO
Assistant Editor

1. "Can Software Makers Win the War Against Piracy?" *Business Week,* April 30, 1984.

presstop de W9JUV

ADDITIONAL PHONE BAND FREQUENCIES WILL BECOME AVAILABLE on September 1, following the Commission's adoption of a further Report and Order on PR Docket 82-83 July 18. The new phone subbands will be exactly as proposed in the FCC's Further Notice of Proposed Rule Making that came out over a year ago: for 75 meters, 3750-3775 kHz, Extra; 3775-3850 kHz, Extra/Advanced; 3850-4000 kHz, Extra/Advanced/General. On 15, 21200-21225 kHz, Extra; 21225-21300 kHz, Extra/Advanced; 21300-21450 kHz, General as well. For 10, the phone band bottom edge was moved down to 28300 kHz for all three license classes.

40-Meter Phone Was Unchanged For Continental U.S. Amateurs, but Amateurs in Alaska and the Pacific were given 7075-7100 kHz to make their operation compatible with Amateurs in ITU Region 3 and avoid Region 3 short wave broadcasters on 40 meters' high end.

THE VULNERABILITY OF 220 MHZ TO TAKEOVER BY ANOTHER SERVICE was sharply underscored by FCC Private Radio Bureau Chief Bob Foosaner at the July 21, NYC ARRL National Convention's FCC Forum. His remarks and responses to questions left listeners little doubt that Amateur use of part of the band, probably the bottom 2 MHz, could end in the very near future.

220 MHz For Commercial Users Was Also Addressed in a petition filed with the FCC in late June by the Land Mobile Communications Council. In its petition the LMCC, a trade group of 2-way users and manufacturers, reviewed various spectrum options for the ever-increasing needs of the land mobile service. 220-225 MHz was cited due to its "relatively low" Amateur activity along with its availability to land mobile in ITU Region 2.

THE ARRL WAS APPOINTED A VEC IN ALL 13 DISTRICTS in a ceremony at the ARRL National Convention in New York July 21. The proposal accepted by the FCC was actually the ARRL's second; its earlier proposal had raised questions about the "Chinese Wall" between League publishing efforts and its VEC administration, but the new one (submitted only July 20!) cited organizational changes which seem to adequately isolate the two League activities from each other. Now that exam fees are permitted, ARRL-sponsored hamfest exams are planned in September. However, League exams for individuals still won't be available until November.

Exam Fees Up To $4 Were Authorized By The FCC July 12, when the Commissioners acted on Docket 84-265. Justification of VEC fee scheules will be required; in the beginning, VEC's must estimate the cost of their programs, then set their fees by dividing that cost by the projected number of examinees. They're then required to maintain proper expense records; if the fees later turn out to be higher than actual costs, the "excess" must be returned by adjusting fees for later applicants downward an appropriate amount. VEs as well as VECs will be permitted to recover their costs, with division to be settled between them. Fees may be collected after August 31, but there is no requirement that fees must be charged

DeVry Is Considering Applying For VEC Status In Seven More Districts, through DeVry Amateur Radio Society members on its campuses in those districts. The school has been well pleased with the results of the Society's VEC program on its Chicago campus, and feels the program would be a worthwhile addition for the other DeVry schools as well. The additional campuses are in Los Angeles, Phoenix, Kansas City (Missouri), Atlanta, Columbus (Ohio), Dallas, and Woodridge, New Jersey. The DeVry campuses in these cities would be able to offer regularly scheduled walk-in exams, as Chicago already does, plus support and even testing facilities for VECs already in place if they wished to use them. DeVry-administered VE groups are now giving exams in various parts of Illinois and Indiana, and DeVry gave its first Advanced Class exam in Chicago on July 24.

VEC District 13, The Pacific, Should Have A Resident VEC very shortly thanks to the Koolau (Hawaii) Amateur Radio Club. Now that the ARRL has also been certified, all 13 districts have at least one resident VEC.

New Identifiers For Amateurs Upgrading In The VEC Program have been adopted by the Commission for August 31 implementation. These are /KT for Technician, /AG for General, /AA for Advanced, and /AE for Extra. The unique session identifiers are being dropped.

PERMISSION TO BROADCAST ON 40 METERS FROM GUAM is being sought by Trans-World Radio Pacific, a religious broadcaster. Guam is in ITU Region 3, which allocates 7100-7300 kHz to broadcasters, but the FCC has not previously licensed 40-meter broadcasting in areas under its jurisdiction. Comments on the proposal, RM-2959, are due in mid-September.

Clarification Of Broadcasters' Use Of Amateur And CB Communications is being sought in RM-28-30, proposed by the Commission July 12. The proposal would relax present Part 73 and 97 requirements that Amateurs and CBers give prior permission before their communications could be rebroadcast. Reporters, however, would still not be permitted to operate an Amateur station for news gathering. The Comment period ended in mid-August.

TWO AMATEUR RADIO OPERATIONS FROM SPACE SEEM LIKELY IN 1985, as W5LFL has been named a crew member for Space Shuttle Mission 51H, scheduled for next November. WØORE is already scheduled for Mission 51F in March, and indications are that NASA is reacting favorably to the joint ARRL/AMSAT proposal that Amateurs on future shuttles be permitted to operate.

AN AMATEUR RADIO AUXILIARY HAS BEEN FORMED BY THE FCC'S FIELD OFFICE BUREAU, in conjunction with the ARRL's Communications Department. Assistance in monitoring and rules enforcement will be the major focus of the new Auxiliary, which, like the VEC program, is a result of Senator Goldwater's bill. Like the VEC program, coordination with the FCC will be through regional or national Amateur organizations. ARRL is the first such group to sign up. Individual Amateurs interested in joining the Auxiliary should contact John Lindholm at ARRL or Elliott Ours at the FCC, 1919 M Street N.W., Room 744, Washington, D.C. 20554 (202) 632-7090.

comments

ground rod resistance

In the interest of brevity, Mason Logan, K4MT, intentionally omitted a detailed step in the derivation of the equation shown in Appendix A of "Ground Rod Resistance" (July, 1984, page 95). For readers who wish to follow the progress of this derivation without interruption, K4MT has prepared an addendum to his article, available upon request from *ham radio*. Enclose a business-sized SASE. **Editor**

modular receiver

Dear HR:

Since publication of my article, "A Modular Two-Band Receiver," in July, 1983, I have received and answered well over 150 inquiries.

It seems there is quite a bit of interest in construction articles about communication receivers. I have had letters from all states and from India, South Africa, Australia, New Zealand, and several other countries.

Over the past year, however, some minor errors in the article have come to light. These errors have been corrected in an errata sheet available from *ham radio* (send SASE).

James J. Forkin, WA3TFS
Pittsburgh, Pennsylvania

seaworthy sealant

Dear HR:

I enjoyed Bill Orr's column in the January issue in which he explained the realities of coaxial cable construction. I was horrified, though, when he suggested use of RTV sealant for weatherproofing coaxial connectors. If you've ever tried to remove that stuff years later, you know what I mean.

May I suggest an improved method that we use aboard ship? First wrap the connector with self-adhering rubber tape (3M or similar), extending the tape approximately 2 inches past the connector end. Next, wrap in a similar fashion with regular plastic electrical tape. Then apply several coats of Scotchkote™ (3M) weatherproofing.

This technique has proven very effective in this most demanding environment. Years later, it is a pleasure to remove this "cocoon" with one slice of a knife, and find a shiny connector as good as it was on the day of installation!

Scott W. Barber, WA2DRL
USS Trenton (LPD-14)

ground plane loop

Dear HR:

I would like to call attention to a conflict in the details given in Bill Orr's February, 1983, column of the ground-plane loop antenna. Both the drawing (**fig. 1**) and the text indicate that the semicircle is to be 0.2 wavelength long. In contrast, **table 1** shows the dimension to be 0.1 wavelength. The article in *CQ-DL* doesn't clarify this either.

C.T. Atherton, WD6DUD
Bell, California

Mr. Atherton is correct. This same conflict appears in all three references (ham radio, Radio Communication and CQ-DL). Do any readers know what the correct tap distance should be?

software piracy

Dear HR:

There is a problem in the Amateur Radio fraternity: software piracy. Whether by ignorance or simple disregard for the law, many Amateurs are stealing copyrighted programs. Most do not consider their theft a crime or a serious problem, but unless this practice is discontinued Amateur Radio will suffer.

With the influx of computers into the hobby a degree of software piracy was inevitable. Unfortunately the problem has become a blemish on Amateur Radio. Thousands of dollars have been spent in litigation involving software piracy outside the hobby, and I had hoped Amateur Radio would police the problem internally and not require legal action. Sadly this is not the case.

I recently confronted two hamfest exhibitors who were selling copies of a Kantronics program. These people were copying and selling our programs to any Amateur willing to pay the price. I bought one of the programs for evidence and informed the seller that legal action would be taken. This seller was not a ham, but those buying the program were. We have several other examples of programs copied and sold.

There are a few simple steps we can all take as those interested in seeing the problem solved.

1. Never buy copied software.
2. Report pirates to the software manufacturer.
3. Don't allow illegal sales at your local hamfest.

Kantronics plans to prosecute those who steal our programs, as we have in the past. But without the assistance of the entire Amateur community the manufacturers will not be able to stop pirates from stealing their profits. If manufacturers are not able to sell enough products to make a profit other new and improved programs will not be written. Don't let the greed of a few deny the hobby of future expansion. Let's throw the bad apples out before they ruin the whole barrel.

Mike Forsyth
Marketing Director
Kantronics, Inc.

An Ohio-based dealer charged with selling pirated Amateur Radio and other types of software at a Michigan hamfest has been fined $2000 for violation of United States copyright law. In its July 17 decision, the federal court in Toledo awarded damages to Kantronics, who initiated the suit, and issued a permanent injunction against further production and distribution of the illegal software.

— Editor

FREE MFJ SOFTWARE

Free MFJ RTTY/ASCII/CW software for VIC-20 or C-64 with purchase of MFJ-1224, MFJ-1225 or MFJ-1228 from MFJ. Send/receive Baudot, ASCII, CW. Type ahead buffer. 24 hour clock. Supports VIC printer. Menu Driven. MFJ-1224/1225 cable. On tape. Available separately for $29.95.

RTTY/ASCII/AMTOR/CW INTERFACE CARTRIDGE FOR VIC-20/C-64

MFJ-1228 **$69.95**

FREE MFJ RTTY/ASCII/CW Software
INCLUDES MFJ-1228, SOFTWARE ON TAPE. ADD VIC-20 OR C-64 AND RIG TO ENJOY COMPUTERIZED RTTY/ASCII/CW. ORDER MFJ-1228/MFJ-1264 FOR VIC-20, MFJ-1228/MFJ-1265 FOR C-64.

Most versatile RTTY/ ASCII/AMTOR/CW interface cartridge available for VIC-20 and Commodore 64. Gives you more features, more performance, more value for your money than any other interface cartridge available.

Same interface cartridge works for both VIC-20 and Commodore 64. Plugs into user's port.

Choose from wide variety of RTTY/ASCII/CW, even AMTOR software. Not married to one on-board software package. Use MFJ, Kantronics, AEA plus other software cartridge, tape or disk.

850 Hz and 170 Hz shifts on receive **and** transmit.

Has mark and space outputs for scope tuning.

Normal/Reverse switch eliminates retuning.

True dual channel mark and space active filters and automatic threshold correction gives good copy when one tone is obliterated by QRM or selective fading.

Easy, positive tuning with twin LED indicators.

Narrow 800 Hz active CW filter. Automatic PTT.

Exar 2206 sine generator for AFSK output.

Shielded XCVR AFSK/PTT interface cable provided. Plus or minus CW keyed output. FSK out.

Powered by computer (few ma.), no power adapter to buy or extra wire to dangle or pick up/radiate RFI.

Glass epoxy PCB. Aluminum enclosure. 4½x4½x1".

UNIVERSAL SWL RECEIVE ONLY COMPUTER INTERFACE FOR RTTY/ASCII/AMTOR/CW

MFJ-1225 **$69.95**

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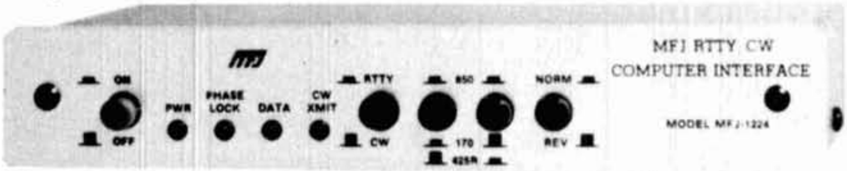
Use your personal computer and communications receiver to receive commercial, military and amateur RTTY/ASCII/AMTOR/CW traffic.

Plugs between receiver and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 and most other personal computers. Requires appropriate software. Use MFJ, Kantronics, AEA and other RTTY/ASCII/AMTOR/CW software.

Copies all shifts and all speeds. Twin LED indicators makes tuning easy, positive. Normal/Reverse switch eliminates tuning for inverted RTTY. Speaker out jack. Includes cable to interface MFJ-1224 to VIC-20 or Commodore 64. 4½x1¼x4¼ inches. 12-15 VDC or 110 VAC with optional adapter, MFJ-1312, $9.95.

UNIVERSAL RTTY/ASCII/AMTOR/CW COMPUTER INTERFACE

Lets you send and receive computerized RTTY/ASCII/AMTOR/CW. Copies all shifts and all speeds. Copies on both mark and space. Sharp 8 pole active filter for 170 Hz shift and CW. Plugs between your rig and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 or other personal computers. Uses MFJ, Kantronics, AEA software and other RTTY/CW software.



FREE MFJ RTTY/ASCII/CW Software
COMPLETE PACKAGE INCLUDES MFJ-1224, SOFTWARE ON TAPE, CABLES. YOU NEED ONLY VIC-20 OR C-64 AND RIG TO ENJOY COMPUTERIZED RTTY/ASCII/CW. ORDER MFJ-1224/MFJ-1264 FOR VIC-20, MFJ-1224/MFJ-1265 FOR C-64.

MFJ-1224 **$99.95**

New MFJ-1224 RTTY/ASCII/AMTOR/CW Computer Interface lets you use your personal computer as a computerized full featured RTTY/ASCII/AMTOR/CW station for sending and receiving. Plugs between rig and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 and most others.

Use MFJ software for VIC-20, Commodore 64 and Kantronics for Apple, TRS-80C, Atari, TI-99 and most other software for RTTY/ASCII/AMTOR/CW.

Easy, positive tuning with twin LED indicators.

Copy any shift (170,425,850 Hz and all other shifts) and any speed (5-100 WPM RTTY/CW and up to 300 baud ASCII).

Copies on both mark and space, not mark only or space only, to improve copy under adverse conditions.

Sharp 8 pole 170 Hz shift/CW active filter gives good copy under crowded, fading and weak signal conditions. Automatic noise limiter suppress static crashes for better copy.

Normal/Reverse switch eliminates retuning. +250 VDC loop output drives RTTY machine. Speaker jack.

Automatic tracking copies drifting signal.

Exar 2206 sine generator gives phase continuous AFSK tones. Standard 2125 Hz mark and 2295/2975 Hz space. Microphone line: AFSK out, AFSK ground, PTT out and PTT ground.

FSK keying output. Plus and minus CW keying. CW transmit LED. External CW key jack.

Kantronics compatible socket.

Exclusive general purpose socket allows interfacing to nearly any personal computer with most appropriate software. Available TTL lines: RTTY demod out, CW demod out, CW-ID input, +5 VDC, ground. All signal lines are buffered and can be inverted using an internal DIP switch.

Use Galfo software with Apple, RAK with VIC-20, Kantronics with TRS-80C, TI-99, N4EU with TRS-80 III, IV. Some computers with some software may require some external components.

Metal cabinet. Brushed alum. front. 8x1¼x6 in. 12-15 VDC or 110 VAC with adapter, MFJ-1312, $9.95.

MFJ-1223, $29.95, RS-232 adapter for MFJ-1224.

SUPER RTTY FILTER

MFJ-725 **$39.95**

Super RTTY filter greatly improves copy under crowded, fading and weak signal conditions. Improves **any** RTTY receiving system. 8 pole bandpass active filter for 170 Hz shift (2125/2295 Hz mark/space). 200 or 400 Hz bandwidths. Automatic noise limiter. Audio in, speaker out jacks. On/off/bypass switch. "ON" LED. 12 VDC or 110 VAC with optional AC adapter, MFJ-1312, $9.95. 3x4x1 inch aluminum cabinet.

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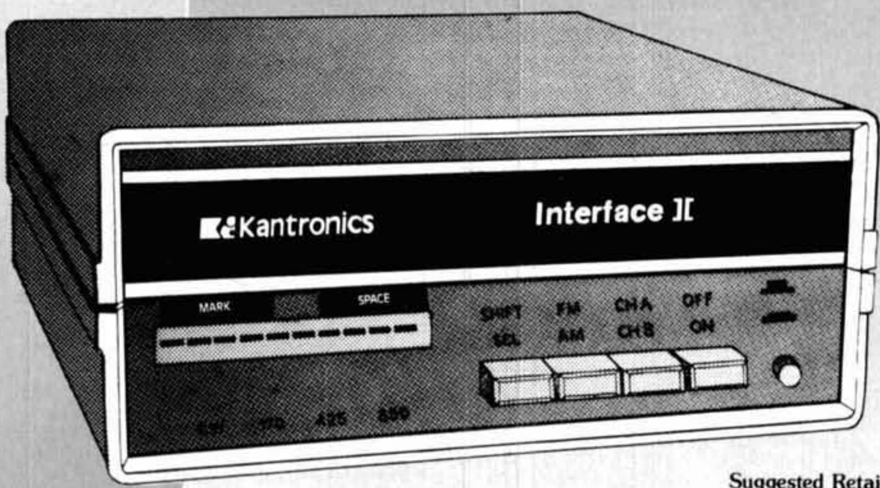

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the development of Amateur SSB: a brief history

70 years of progress marks this familiar mode

Single-sideband radio telephone transmission in the Amateur bands — even well into the VHF region — is taken for granted these days. But it wasn't always so. Many Amateurs remember the days when amplitude modulation with full carrier (AM) reigned supreme. (For some it still does — **Editor.**)

While the era of Amateur SSB is generally considered to have begun with an article published in 1948 by Arthur Nichols[1], much work was done well before; basic groundwork, in both theory and in hardware, was completed as early as 1933 by the ARRL and other groups. Unfortunately, much of this work was considered too complex for the Amateur community, and was consequently not published.

early history

The earliest written analysis of an amplitude modulated signal consisting of a carrier and upper and lower sidebands separated by the modulating frequency was made by Carl R. Englund,in a paper dated August 19, 1914.[2] Englund who worked for the Bell System, recorded his analysis in his engineering notebook, but no record of what — if any — use was made of this information survives today. There is evidence that others were aware of the existence of sidebands, but Englund's analysis is apparently the earliest record to survive. In 1915, for example, H.D. Oliver, a telephone company engineer working transatlantic radio telephone at NAA, the then-new Navy radio station at Arlington, Virginia, considered the use of SSB for solving the problem of communications. Oliver proposed to tune the antenna to eliminate the carrier and one sideband, which would have been entirely practical because the transatlantic tests were made at 5000 meters (60 kHz), where antenna *Q*s are necessarily very high. But because the tests were carried out using AM, nothing appears to have come of this idea.

The fact that SSB, with or without a carrier, was considered as a means of transmitting information implies not only knowledge of the existence of sidebands, but also of the fact that information is contained therein.

No attempt was made to develop SSB for radio communication purposes at this time, probably because of the complexity of the receiver that would be required. State-of-the-art receivers in those days consisted of several stages of RF amplification — a detector followed by several stages of audio amplification. Likewise, filter design, too, was primitive by today's standards.

first SSB transmitted on a wire

The only organization to demonstrate interest in SSB was the Bell System, which developed the technique for long distance wire-line telephony. The first commercial wire carrier system using SSB was placed in service in 1918. SSB techniques were used exclusively for long distance telephone circuits until relatively recently, when they were replaced by pulse-code modulation (PCM).

The first application of SSB to radio was made in 1922, again by the Bell System. Bell set up an SSB transmitter, operating on 57 kHz, at Rocky Point, Long Island, and the British Post Office established a receiving station at New South Gate, England, near London. One-way communication was established in January 1923, proving the feasibility of SSB for transatlantic communication. The return message from England came by transatlantic telegraph cable. When a transatlantic radio telephone circuit was put into commercial operation on long wave (57 kHz) in 1927, SSB was used. As the traffic increased and additional channels were needed, these were operated in the

By John J. Nagle, K4KJ, 12330 Lawyers Road, Herndon, Virginia 22071

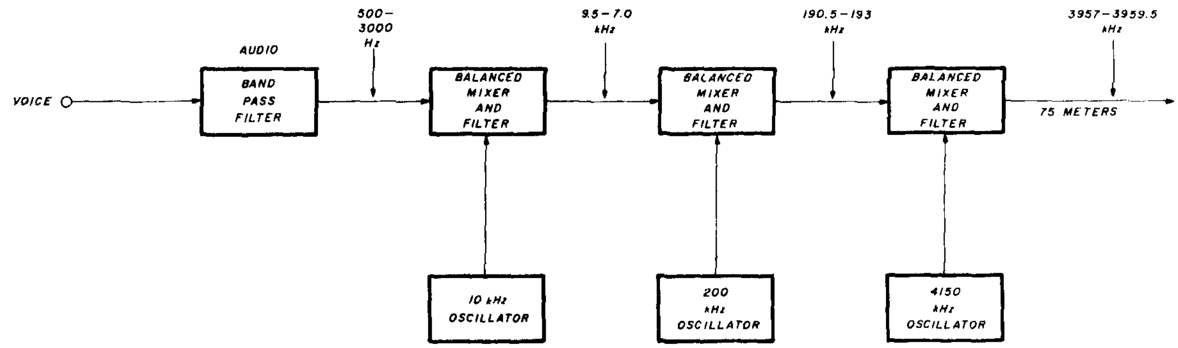

fig. 1. Block diagram of 75-meter SSB transmitter developed by Robert Moore circa 1933.

short-wave band (HF, in today's terminology). Interestingly, short-wave circuits used AM because SSB techniques for HF were not perfected until 1936.

amateur SSB

As has often been the case in the history of Amateur Radio, one or two hams or rather groups of hams developed techniques for Amateur communications that closely paralleled work going on in industry. In the early 1930's, while Bell was adapting the SSB techniques used on wire-line to HF radio for trans-atlantic telephone circuits, two Amateur groups were working on Amateur SSB.

The first record of the development of an SSB transmitter for Amateur use that I have been able to find appeared in a series of three articles by Robert M. Moore, then W6DEI, in a magazine called *R/9*; a block diagram of Moore's transmitter is shown is **fig. 1.**[3] (Old-timers will remember *R/9* as a first-rate technical magazine. In fact, one of the issues describing Moore's SSB transmitter also features an article on how to build a parabolic antenna — interesting reading even today! The name *R/9* was lost when the monthly publication merged with *Radio* in January, 1936, after which *Radio* itself became a first-rate technical magazine.) Moore acknowledges having drawn on the published data of the Bell System "for a portion of the material used" in his series.

The second group working on SSB was an ARRL team led by James J. Lamb, then Technical Editor of *QST*. At the Board of Directors' meeting held on May 12, 1933, Bernard J. Fuld, W2BEG, director of the Hudson Division, moved:

> *"That the technical staff of **QST** is instructed to investigate the feasibility, and, if feasible, is instructed to undertake the development at reasonable prices, of apparatus and methods of single-sideband and carrierless 'phone transmission'."*

The motion passed unanimously.[4]

As a result of this motion, K.B. Warner, W1EH, who was secretary of the League as well as Editor-in-Chief and Business Manager of *QST*, sent a memorandum to James Lamb; because of its historical interest and the insight it provides into the personalities of the people involved, it is reproduced in **fig. 2**.

The memorandum was followed by a short ARRL inter-office memo (**fig. 3**) adding directional antennas to SSB and encouraging a "serious attempt to accomplish something." The list of names at the top of the memo is worth reviewing; how many of these people can you remember?

Lamb and his associates did go into a huddle, as requested; Lamb wrote a 12-page report, which he forwarded to Warner on September 25, 1933. While the report is too long to reproduce here, an excerpt (**fig. 4**) is included because A.L. Budlong (then ARRL Communications Manager) wrote some comments on this part of Lamb's report. **Fig. 5** shows Budlong's comments on Lamb's SSB report.

Although Lamb's report was never published in *QST* as originally written, a later, revised version was published in the October, 1935 *QST*.[5] This article was not listed in either the table of contents for that issue or in the annual index published in the December 1935 *QST*.

The decision of ARRL management not to pursue development of SSB as a means of reducing phone band interference was apparently based on the assumption that SSB equipment was too complicated for the average Amateur in 1933-34.

At that time, it was the policy of League officials, as well as the *QST* editorial staff, to do everything possible to encourage more people to become licensed Amateurs. This was believed necessary for the preservation of Amateur frequency allocations in the short-wave bands that were (and still are) essential for its continuation. In 1933-34 there were only about 20,000 licensed Amateurs — a small force in comparison to the highly organized, well-funded

JJL:

By vote of the Board of instructors, we are instructed to investigate the feasibility of applying to amateur operation single-side-band and carrierless phone transmission, and if we find it feasibile we are further instructed to produce cheapest-possible apparatus to accomplish it.

I now place this matter in your hands. Suggest you and your cohorts do a bit of reading up on it and then go into a huddle. I shall then need a written report of what you find and what you propose to do about it. I believe that that report will either state that there is ND and give definite reasons why not, or will find ND except in a limited extent in which you propose certain investigation and further report, or (theoretically at least) will find that there is good possibility of accomplishing something and that lab work is going to be undertaken along such-and-such lines, with a further report to come.

It is my instant impression that there is ND. I think that that will be the offhand opinion of all of you. I ask you-all, however, to put on your amateur thinking-caps and look at this from the traditional amateur point of view that there is always a new way to skin a cat. Without any doubt at all any such development would be of tremendous importance -- as an amateur achievement, as a commercial development of vast worth, as an immense practical aid in congested amateur phone territory. To be acceptable, your report will have to show to the Board why it is not practicable to build such amateur phone stations, e.g., because it would have to have a filter that cannot be produced for less than $3000.

I do not know whether an autodyne receiver is capable of supplying the carrier for suppressed-carrier transmission or not. If it is not, and if it is not possible to use any local oscillator easily to supply the missing carrier, I should think that method of small interest to us.

I also wish to suggest your consideration of partial-sideband xxxxxx suppression if you do not find it practicable to attempt full suppression of one sideband. I mean, a method using a filter so as to cut off all frequencies above the value necessary for reasonably good speech, thus suppression unnecessarily high voice frequencies, harmonics, etc. I believe that a filter to do that can be built for a very small fraction of the cost of one necessary for eliminating one sideband neatly.

....

At this stage in my note-writing you and Hebie have used up my remaining time but I have just discovered that I have, compact in one booklet, all the studies made of this thing by the CCIR and I am going to conclude by handing you this publication of Opinions, calling your attention to pp. 59 to 74 relating to this subject. The booklet is to be returned to me, please.

HW?

KBW 6/6/33

PS— Ur reports, of course, are to be transmitted by me to the Board

fig. 2. K.B. Warner, League secretary and Editor-in-Chief and Business Manager of *QST*, sent this memo to *QST* Technical Editor James Lamb.

American Radio Relay League
OFFICE MEMO

Beaudin	Hebert	Mr. Maxim
Beekley	Houghton	Mr. Stewart
Budlong	Houldson	Mr. Segal
Chamberlain	Hull	
De Soto	Lamb	
Grammer	Rodimon	
Handy	Scanlan	Mr.________

Please note and return to me.
Returned noted; thanks.
Referred to you for necessary action.
For your files.
Please give me information on marked portion.
Please note and file.
What do you think about it?
For your information.
When finished with your part, please pass on to ________________

I have just discovered that it was Fuld's intention to include in that motion re sideband suppression, etc., the subject of directional antennas. That is a separate and large order, but one that you might take a look at in your conference.

I concluded my note of yesterday without saying (as I meant to, that I want you fellows to make a serious attempt to accomplish something along the desired lines if it is feasible.

fig. 3. Brief inter-office memo urged League staffers to make a "serious attempt to accomplish something."

entrepreneurs and industrialists representing commercial communications and international broadcasting, who wanted to take over the Amateur frequency assignments for their own use.

The League felt that the best way to increase the number of licensed operators was to describe equipment that was "sure-fire" in all League publications; that is, equipment that was easy to build with simple hand tools and certain to work without elaborate test equipment or much experience on the part of the builder. There was concern that if a newcomer started out in Amateur Radio by building the latest equipment — an SSB rig for example — he would probably be unable to make it work, and would become discouraged and leave Amateur Radio.

Because Amateur Radio is flourishing today, we can only speculate about what the outcome might have been if the Amateur community had actively pursued SSB in the early 1930s. If the Bell System, with all its resources, which were substantial even then, was not able to develop practical SSB equipment for HF radio until 1936, it seems likely that it would have been all but impossible for individual Amateurs to have done it in 1933 or 1934. (Even today, most Amateurs prefer to buy, rather than build, their SSB equipment.)

The League did stick to their "keep it simple" philosophy, despite the frustration of some technical people at ARRL headquarters who would have preferred to have been able to continue their pioneering developmental work in Amateur SSB for professional reasons.

Even though the ARRL did not pursue the develop-

-3-

The first of these, suppressed-carrier double-side-band transmission, would eliminate the steady-type interference resulting from the heterodyning of undesired carriers with the carrier of a desired station, and would reduce distortion from selective fading, but would require the same frequency band-width as would normal (carrier and double-side-band) transmission. Simple suppressed-carrier transmission also might have an economic advantage in that the full capability of a linear r.f. stage could be utilized for the intelligence-carrying side-band power to the exclusion of the carrier power that normally is transmitted. In a 100% sinusoidally modulated wave, 2/3 of the total power is represented by the carrier and 1/3 by the side-bands.[2,3] For instance, whereas a truly linear amplifier of 300-watt maximum capability would have but 100-watt side-band output with a normal 100% modulated wave, with the carrier suppressed the side-band power with the same amplifier theoretically could be as high as 300 watts, representing three times the intelligence-carrying power of the carrier-and-double-side-band capability. From the amateur point of view this advantage is more apparent than real, however, because a given r.f. amplifier when operating Class-B and [redacted] handling only side-band power has negligible advantage in side-band output over the same amplifier when operating Class-C with plate modulation in the system of carrier-and-double-side-band transmission generally used by amateurs. ~~Difficulty with the simple suppressed-carrier system that ... at the receiving end will be discussed under "Reception"~~.

The second system, transmission of the carrier and one side-band, with the other side-band suppressed, is technically less feasible than

-4-

suppression of the carrier and elimination of one side-band because elimination of one side band without affecting the carrier would be more difficult than suppression of the carrier with elimination of one side-band. This system hardly merits consideration. Although it would seem to offer advantages in that the frequency band required would be lessened by the one set of side-band components eliminated, it would offer no opportunity of realizing greater intelligence-carrying output from a transmitter of given peak-power rating than is obtained with carrier and double-side-band transmission. The gain would be negligible in view of the additional technical complexities involved. The heterodyne interference problem would be in no wise lessened.

The third system, ~~Of the three types mentioned,~~ single-side-band transmission with the carrier suppressed, appears to be not only the most economical in frequency-band requirement and in utilization of transmitter capability, but also to hold less technical complication in reception than the first-mentioned type (double-side-band), and still less technical complication in transmission than the second type (carrier and one side-band). It also eliminates most of the distortion from selective fading. The present objective must be primarily the minimizing of the interference problem, so far as that may be possible, to the end that greater [redacted] utilization of the available amateur 'phone bands may be hoped for. Hence, only single-side-band suppressed-carrier transmission warrants our serious consideration. This view is reinforced by the receiving considerations to be discussed later.

Carrier Suppression

Two means of suppressing the carrier-frequency component are possible. One would be a filter having sharp attenuation at the carrier frequency and passing either one set or both sets

fig. 4. Excerpt from Lamb's 12-page report, sent to Warner on September 25, 1933.

Bottom p.3, top p.4. I do not agree. The sole aim of Board's hope is to increase effective width of fone bands by changing amateur radio to a system that requires fewer kc for a transmitter. Jim departs from the point when he damns this system by saying it offers no opportunity to increase output from given tubes. Nobody cares. Nobody cares even if output is decreased -- if stations now occupy only half as much room.

Considering difficulty of replacing carrier, and of tuning at receiver with suppressed-carrier method, I hardly can embrace it. I am most reluctant to accept Jim's top of page 4 that it is too difficult to suppress just one sideband. He there makes bold statements with no supporting references. His language looks more like prejudice than logic that the reader embraces because it is self-warranting.

At this moment I've read only first 3½ pages, but I here make note that I'm pretty sure that the only feasible idea is suppression of one sideband.

Bottom of page 4 needs a statement to this effect: "All right, then, let's now have a look at methods that give this form of transmission. The first thing to consider is suppressing the carrier...." Hiatus now.

Having read it,

It is too goddamnably impartial. Too deep a subject for me to do my own deciding, I'm ready to accept the author's views, but I don't even know what he thinks. With almost no effort, he could make me think either way. It needs just a bit of bias here, since it really is headed somewhere -- to prove something or other,-- isn't it? "Further in proof of the futility of aspiring to so and so..... "Another example of the impracticability...."

(Imagine my urging bias here, condemning it in 2d paragraph)

fig. 5. A.L. Budlong, ARRL Communications Manager, added comments to this copy of Lamb's report.

ment of SSB in the 1930s, individual Amateurs did. James Lamb continued to think about it and proposed some interesting ideas — revolutionary in those days — including the transceiver concept of using the same oscillator for transmitting and receiving that is the backbone of all SSB transceivers today.

Fig. 6 shows an SSB generator using Lamb's crystal filter circuit. This sketch is dated June 18, 1933 — over 50 years ago. Notice the signatures of witnesses: F. Cheyney Beeklye, *QST* Advertising Manager, and Ross A. Hull, Associate Editor.

Another interesting and novel (in 1934) circuit for a modulator is shown in **fig. 7**. Here, two tubes are connected with the anodes in push-pull and their control grids in parallel. RF excitation is applied to the parallel connected control grids. This represents the carrier frequency, which is eliminated in the push-pull anode circuit. The audio information is connected, push-pull, into the suppressor grids. This circuit has the advantage that the RF and audio are kept separated. (This disclosure was witnessed by Ross Hull.)

Probably Lamb's most dramatic development was the SSB transceiver sketched in **fig. 8**. This is basically the same block diagram as the SSB transceivers that began to appear on the market in the early 1970s. One slight difference may be interesting, however. Lamb perceived a receiver tuning problem with SSB. With AM, the practice was to tune to maximize the carrier. With SSB, this was no longer possible, because there is no carrier. To solve the receiver tuning problem, Lamb envisioned transmitting a 1 kHz tone; the receiver would be tuned until the 1 kHz tone was *actually* 1 kHz. When SSB systems came into actual use, the tuning problem was solved by Amateurs in a much simpler manner. Amateurs simply tuned the receiver until the voice sounded the most "natural."

Unfortunately, these developments in the use of SSB for Amateur communications were not publicized.

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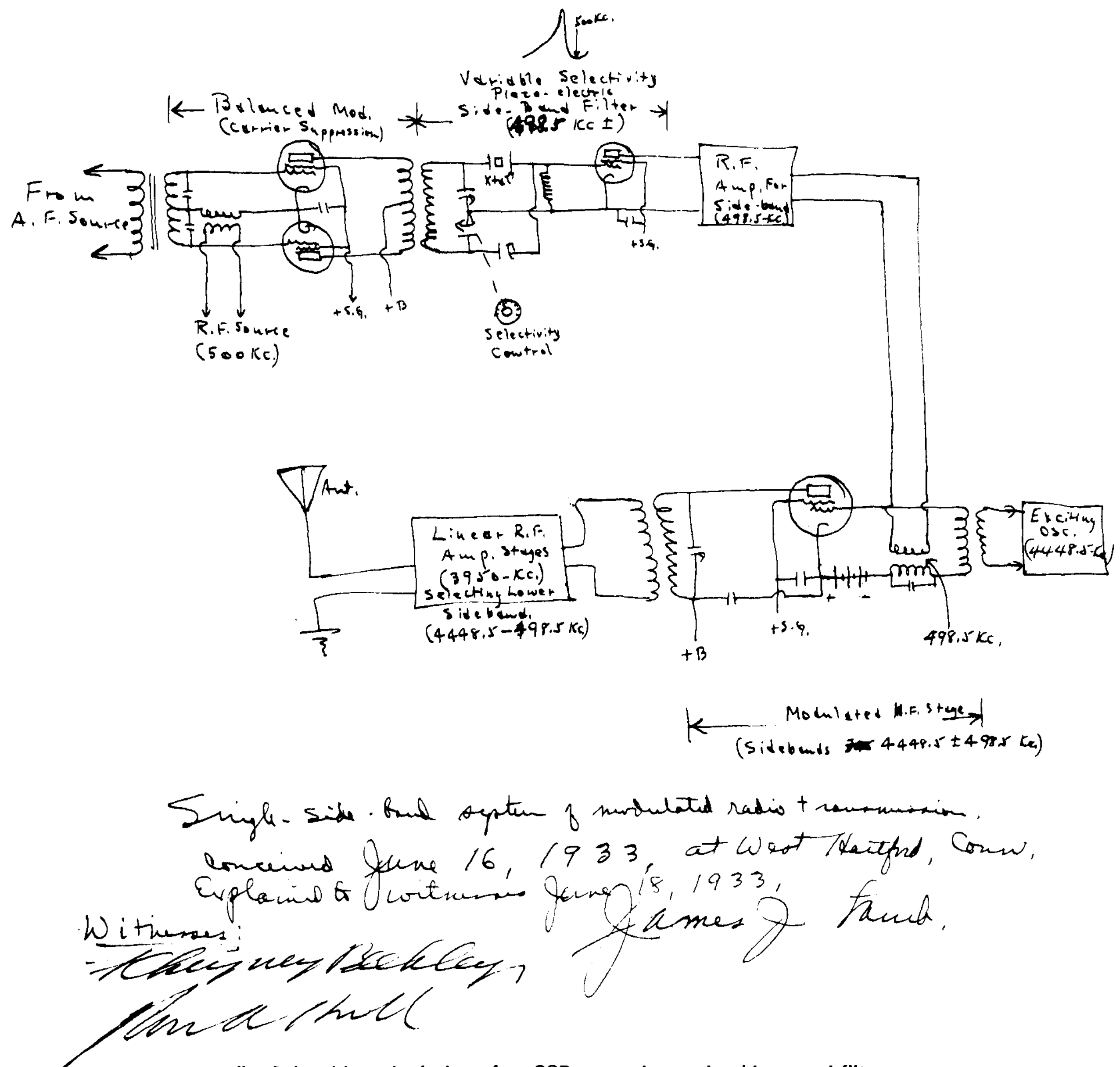

fig. 6. Lamb's early design of an SSB transmitter using his crystal filter.

Amateur SSB — phase two

The second phase in the development of Amateur SSB began during and immediately after World War II. O.G. Villard, then W6QYT, had become interested in SSB during the war. Although he was aware of Moore's work in 1934, he was intimidated by the filters required by Moore's rig. This apparent handicap led him to develop a phasing technique to generate SSB. As often happens to inventors, Villard discovered that the phasing technique had already been devised, and had been patented in the late 1920s.

The phasing technique offered the advantage of eliminating the need for elaborate filters and reducing the number of frequency translations required. Filter technology was still in its infancy, and few Amateurs had access to the test equipment necessary for verifying a filter design. The biggest component problem lay in the design and construction of the required inductors, with adequate *Q*s in the required frequency range.

As most readers will recall, with the phasing method of SSB generation, two components of the carrier 90 degrees apart in phase are developed; this was not difficult to do in the early 1940s. Similarly, two components of the audio voltage — also 90 degrees apart in phase — are developed. This posed much more of a problem for Villard, who attempted to use one phase unmodified and to develop a wide band, a 10:1 frequency range, and an audio channel shifted 90 degrees in phase. This proved to be a real problem because of the relative bandwidth required.

This problem was not solved until R.B. Dome[6] showed that it was not necessary to actually shift the audio signal 90 degrees, but only to develop two audio voltages that were 90 degrees apart and then describe networks to do this. Fortunately, Dome's networks required only resistors and capacitors — no inductors. With this development, Villard was able to proceed with the actual construction of an SSB transmitter.

At the time, Villard was teaching electrical engineering at Stanford University. He and some of his students constructed an SSB transmitter using the phasing method and operated it on 20 meters from the Stanford Amateur Radio Club's station W6YX.[7] Surprisingly, many Amateurs were able to copy SSB with their AM receivers; their reports were extremely positive. Villard's transmitter used four 813 tubes in the output stage and was capable of much more power output than the filter-type transmitters of the time. The SSB signals were generated at the operating frequency (20-meter band) so that no frequency translations were required.

About ten days after Villard's group began transmitting, another SSB signal appeared on 20 meters. Arthur Nichols, then WØTQK, had built an SSB rig using the filter approach in only about five days, after hearing W6YX's SSB signal. This was a remarkable accomplishment, especially for that time; even today, most Amateurs would have difficulty building an SSB rig in five days.

filter approach to SSB

The January 1948 issue to *QST* featured an article by Nichols describing his SSB transmitter. Two related articles also appeared in this issue: one by Byron

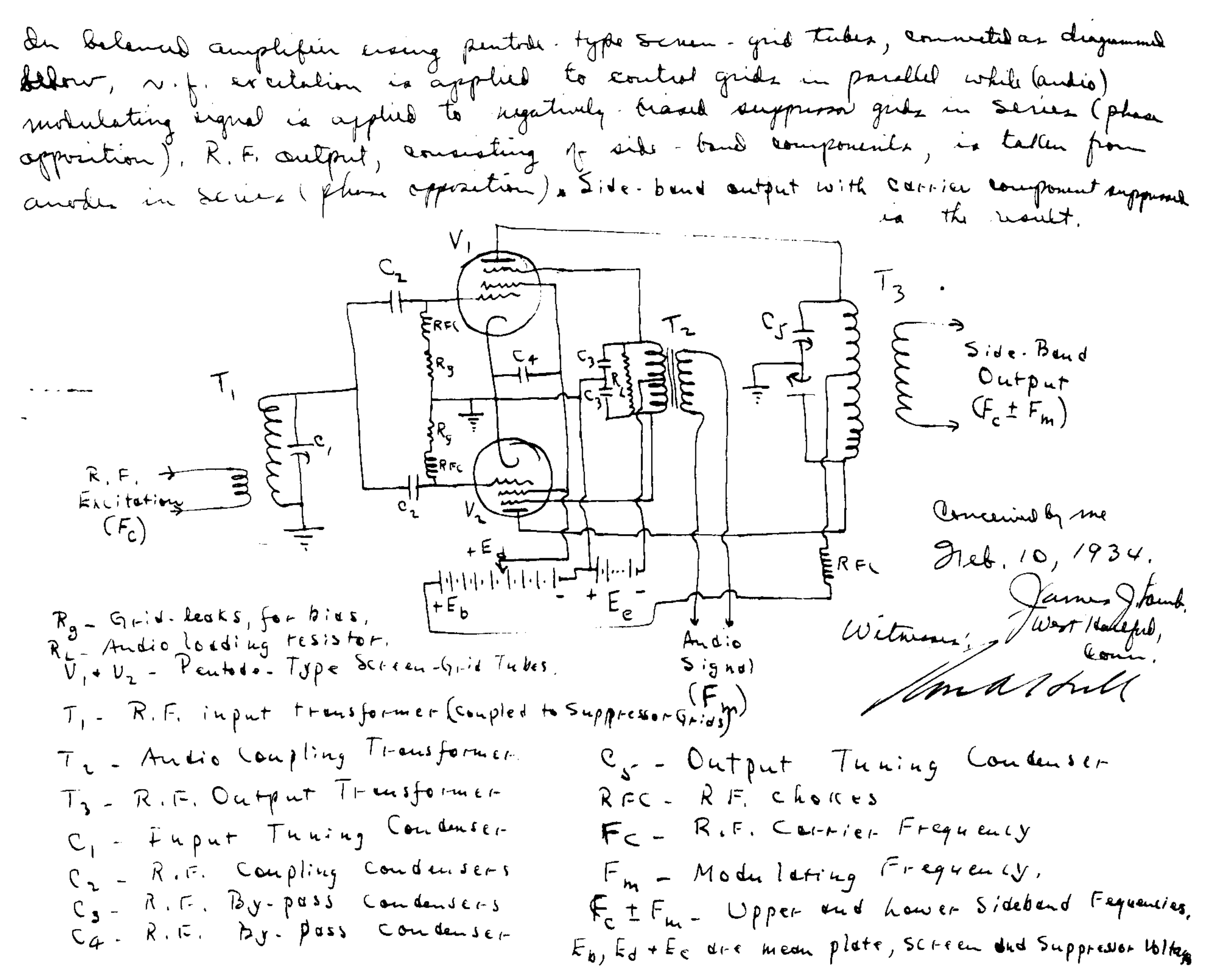

fig. 7. Modulator circuit separates RF and audio.

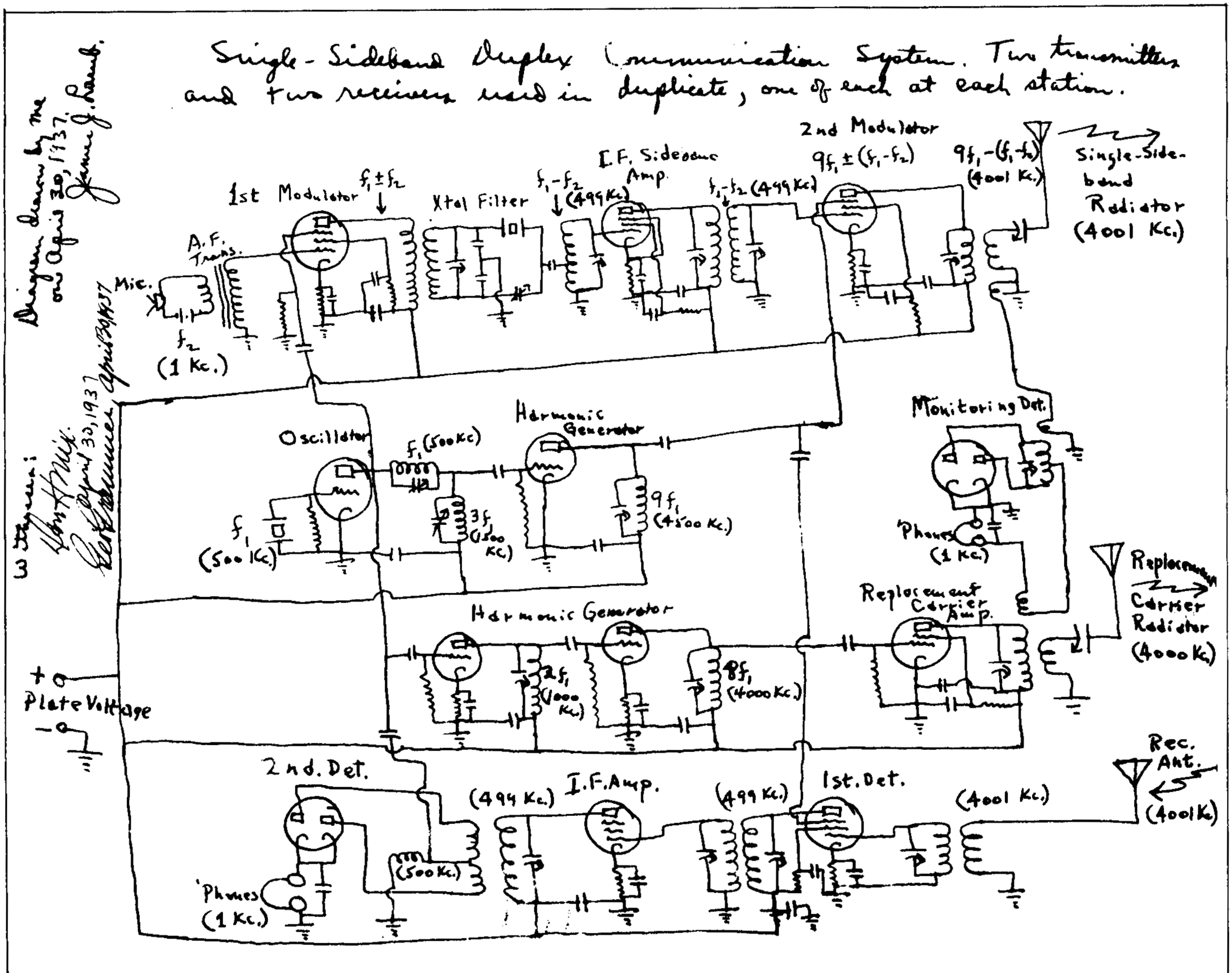

fig. 8. Lamb's SSB transceiver.

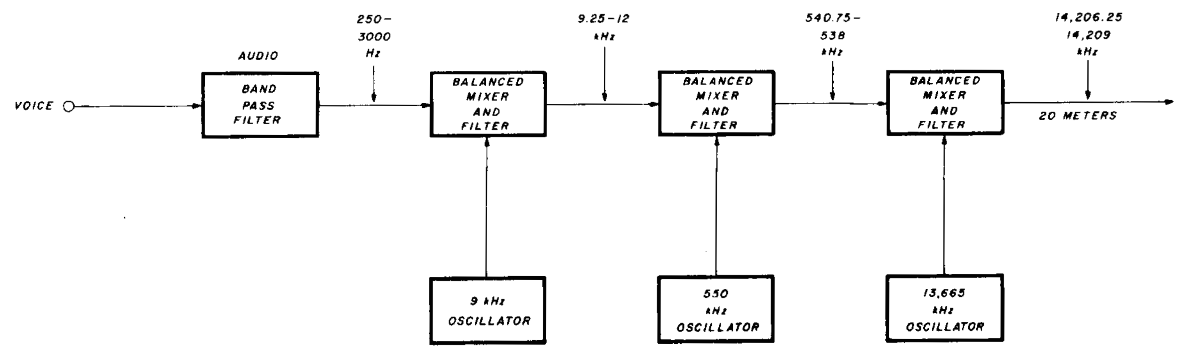

fig. 9. Block diagram of 20-meter SSB transmitter developed by Arthur Nichols circa 1948.

Goodman, W1DX,[8] who explained the theoretical aspects of SSB, and a second by Villard,[9] in which he described the early SSB on-the-air tests from W6YX.

A block diagram of Nichol's 1948 transmitter — similar to Moore's 1933 rig — is shown in **fig. 9**. Nichols used a 10-kHz filter to eliminate the carrier and undesired sideband with two frequency translations to 20 meters. Moore used two translations to 75

meters. From a cursory examination, it appears that Nichol's and Moore's filters used Bell System technology; both appear to have been based on telephone carrier filters, with Moore using the next lower carrier channel slot than Nichols. Nichols obtained his filter from the late Fred Berry, formerly WØMNN.

By this time SSB enjoyed the active support of the League and others: additional theoretical material and improved techniques and equipment appeared in rapid order. In fairness, it must also be pointed out that the level of technical sophistication of the Amateur community had been greatly raised by the rapid development of electronics during World War II and by the large number of people introduced to the new technology both at home and in the field. This — coupled with the increase in the ranks of Amateur Radio operators and the fact that work done by Amateur Radio operators was more widely recognized — improved the political posture of Amateur Radio in its struggle against commercial and international broadcast interests in the battle for frequency allocation.

final comments

Arthur Nichols designed and built his SSB transmitter independently of other workers in the field. First licensed in 1931, he has always been a home-brew type, and is currently W6EVL in Fallsbrook, California.

In addition to the SSB transmitter Nichols used himself, he built two more transmitters which he sold to the National Company of Malden, Massachusetts. At the time, National was one of the leading manufacturers of Amateur equipment. I assume Nichols' transmitters were to be prototypes for a National SSB transmitter; if so, National could have had an early lead in supplying SSB equipment to the Amateur community. But National was unfortunately having financial problems and chose not to take advantage of the opportunity.

Nichols' interest in SSB came about naturally. His father was the late Dr. H.W. Nichols, an engineer with the Bell System who worked on the development of SSB radio equipment for transatlantic radio telephony service. Dr. Nichols was sent to England in 1923 to work with the British Post Office on arrangements to receive the Bell System transmissions mentioned earlier. While in England, he presented a paper before the British Institution of Electrical Engineers on the transatlantic radio telephone problem.[10] The elder Nichols died in 1925 and did not live to see the long-term results of his work.

I have not been able to locate Robert M. Moore, formerly W6DEI, and I believe, with regret, that he may be a silent key. I would be happy to hear from anyone who knows (or knew) Moore, and particularly from anyone familiar with his interest in SSB.

acknowledgements

My thanks to Professor O.G. Villard, W6YX, Arthur H. Nichols, W6EVL, and James Millen, W1HRX, who reviewed an early draft of this manuscript and suggested changes, many of which have been incorporated.

My special thanks to James Lamb, who made his engineering notebook available to me, thus arousing my interest in the history of SSB.

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ham radio

an audio automatic gain control

Circuit converts 50 dB input dynamic range to constant output

In a recent *ham radio* column,[1] Bill Orr commented — correctly, I believe — on the relative lack of use, in Amateur Radio, of state-of-the-art developments in audio processing technology. Perhaps this is so because commercial audio processors are very expensive, or because the broadcast quality frequency response and distortion characteristics of commercial equipment represent a higher degree of precision than is really necessary in Amateur Radio applications — a kind of technological "overkill."

This article describes an automatic gain control (AGC) amplifier that can be used in several Amateur Radio applications. Simple and inexpensive to build, it will maintain, at a maximum gain, a constant output level within ±2 dB over an input level range of 50 dB.

As a broadcast engineer, I developed this circuit in hopes of eliminating the need for announcers to continually adjust levels for program material arriving by twisted pair. Amateur Radio applications could include autopatches, phone patches, and repeaters. (Imagine a repeater that is modulated to a constant level regardless of the received signal's deviation!) When used ahead of any transmitter, the AGC functions much like a compressor used in commercial broadcast operation.

circuit description

The AGC schematic is illustrated in **fig. 1**. An audio signal applied to U1, an MC3340P, is passed through to the 741 operational amplifier, U2. After being amplified, the output signal of U2 is sampled and applied to a negative voltage doubler/rectifier circuit composed of diodes CR1 and CR2 along with capacitor C1. The resulting negative voltage is used as a control voltage that is applied to the gate of the 2N5485 JFET Q1. Capacitor C2 and resistor R2 form a smoothing filter for the rectified audio control voltage.

The JFET is connected from pin 2 of the MC3340P to ground through a 1-kilohm resistor. As the voltage applied to the gate of the JFET becomes more negative in magnitude, the channel resistance of the JFET increases causing the JFET to operate as a voltage controlled resistor.

The MC3340P audio attenuator is the heart of the AGC. It is capable of 13 dB gain or nearly −80 dB of attenuation depending on the external resistance placed between pin 2 and ground. An increase of resistance decreases the gain achieved through the MC3340P. The circuit gain is not entirely a linear function of the external resistance but approximates such behavior over a good portion of the gain/attenuation range.[2]

An input signal applied to the AGC input will cause the gate voltage of the JFET to become proportionally negative. As a result the JFET increases the resistance from pin 2 to ground of the MC3340P causing a reduction in gain. In this way the AGC output is held at a nearly constant level.

Because a finite time is needed to generate the feedback to control the AGC gain, an abrupt change from soft to loud at the input will cause a short overshoot or "pop" sound. Capacitor C3 with resistor R3 form a low-pass filter in the feedback circuit of the 741 operational amplifier. This low-pass action minimizes the overshoot.

adjustments

There are three possible adjustments to the AGC. They are dynamic range, attack time, and recovery time.

The dynamic range is adjustable by selecting the value of resistor R3 in the feedback circuit of the 741. A 100 kilohm value for R3 results in the maximum obtainable dynamic range, nearly 50 dB. Because this amount of gain will probably be too large for most Amateur Radio applications, R3 may be decreased to produce the dynamic range desired. If R3 is changed, C3 must also be changed. The product of R3 and C3 must remain the same constant value to preserve the low-pass filter characteristics of the stage.

The attack time is controlled by C1. The 0.33 μF value shown for C1 produces the fastest possible at-

By Lee Barrett, K7NM, 525 North 2150 West, West Point, Utah 84015

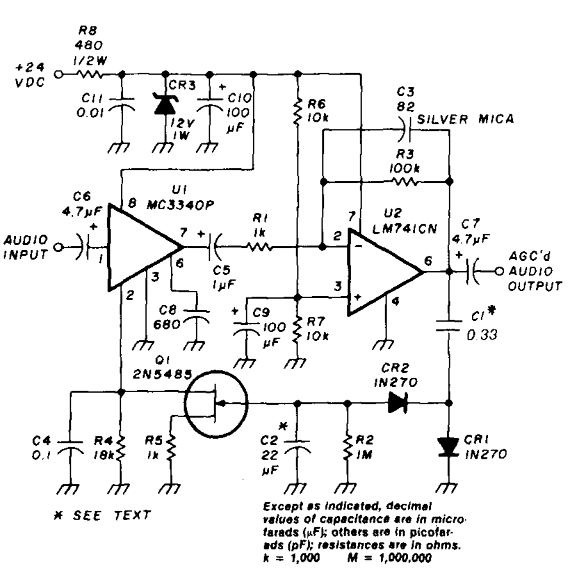

fig. 1. AGC schematic diagram.

parts list for fig. 1

item	*description*
C1	0.33 µF, 50 volt mylar
C2	22 µF, 25 volt radial electrolytic
C3	82 pF, 500 volt silver mica
C4	0.1 µF, 50 volt ceramic disc
C5	1 µF, 25 volt radial electrolytic
C6,C7	4.7 µF, 25 volt radial electrolytic
C8	680 pF, 500 volt silver mica
C9,C10	100 µF, 25 volt radial electrolytic
C11	0.01 µF, 50 volt ceramic disc
CR1,CR2	1N270 germanium diode
CR3	1N4742 12 volt, 1 watt zener diode
Q1	2N5485 N-channel JFET
R1,R5	1000 ohm
R2	1 megohm
R3	100,000 ohm
R4	18,000 ohm
R6,R7	10,000 ohm
R8	470 ohm, 1/2 watt
U1	MC3340P voltage controlled attenuator
U2	LM741CN operational amplifier
miscellaneous	
	PC board, IC sockets, optional transformers (see text), solder, wire, case, builder's choice of connectors, 24 volt or alternative power supply (see text)

Notes:
All resistors are 1/4 watt, 5 percent unless otherwise noted.
A printed circuit board with parts kit ($26.00) or the printed circuit board alone ($15.00) is available from the author, Lee Barrett, K7NM, 525 North 2150 West, West Point, Utah 84015. Please add $2.00 shipping and handling.

table 1. AGC measured parameters with 0-8 bridging transformer input.

frequency response (−3 dB):
below AGC threshold (−40 dBm input): 200 Hz - 12 kHz
in AGC range (−20 dBm input): 40 Hz - 20 kHz
AGC threshold: −38 dBm
noise floor (input shorted): −42 dB maximum

input level (dBm)	output (0 dB = 2V p-p)	distortion (percentage)
10	2	2.0
−20	0	0.5
−36	−2	0.5

tack time. In no case should C1 exceed this value or a low frequency oscillation will occur.

Capacitor C2 is the main recovery time adjustment. I have found the best value for speech applications to be 22 µF. This value can be decreased or increased to provide faster or slower recovery times, respectively.

connections

The AGC may be fed either directly with an unbalanced input or through a transformer by a balanced audio source. In broadcast applications, I used high grade transformers such as the TRW 0-8 or 0-30. In Amateur Radio applications where speech is the rule less expensive Calectro transformers have been used successfully.

The AGC output is normally unbalanced. Loads as low as 600 ohms have been driven by the AGC although a 1 kilohm or higher resistance termination is desirable. Again, a transformer could be used to create a balanced output condition if desired.

In Amateur Radio applications a level potentiometer will probably need to be added across the output to act as a level adjustment. The relatively high level output of the AGC can then be reduced to the drive level required by the intended load.

conclusion

Table 1 lists the test results of measurements made on the AGC.

The original AGC was designed to plug into the Collins/Autogram IC series broadcast mixers and operated on 24 volts DC. In your application, however, the zener may be adjusted or eliminated along with the series resistor to operate the AGC on voltages down to about 8 volts.

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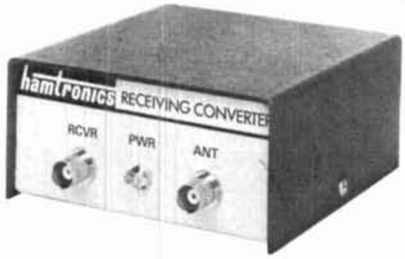

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	146-148	28-30
	144-148	50-54
	220-222	28-30
	220-224	144-148
	222-226	144-148
	220-224	50-54
	222-224	28-30

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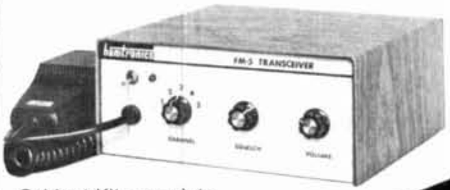

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(Specify band)	28-30	220-222*
	50-54	220-224
	144-146	50-52
	50-54	144-148
	144-146	28-30
For UHF,	28-30	432-434
Model XV4	28-30	435-437
Kit $99	50-54	432-436
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	144-148	432-436*

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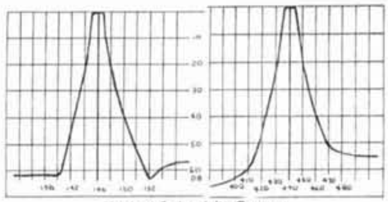

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work OSCAR 10 with your HT

Use a local gateway to work the bird

Soon, working intercontinental DX may be as simple as picking up your 2-meter HT. Using a local "gateway" facility* to relay signals to a satellite, thousands may soon sample the world of Amateur Radio space communications. How will this be possible? How can you participate?

AMSAT OSCAR 10 (AO-10) — the newest and most sophisticated Amateur Radio communications satellite ever — was launched in June, 1983, as a replacement for the ill-fated Phase IIIA. AO-10 (Phase IIIB prior to launch) has quickly established itself as the all-time DX champ of OSCARs; in the year or so since its launch, nearly 100 countries have become active on it. Intercontinental QSOs are now commonplace . . . in fact, some stations have worked over 90 countries already! Until the AO-10 was launched and operating, it took a moderately well-equipped VHF/UHF station to accomplish this; now intercontinental QSOs on modest equipment are commonplace.

AO-10 uses two linear transponders that receive inputs on one frequency and translate them downward to another band (see **fig. 1**). The transponders are functionally similar to a repeater with a wide frequency split. In the case of AO-10, a block of frequencies uplinked to it in the 435-MHz range is repeated on a correspondingly wide block of frequencies in the 145.8-MHz range; this is the Mode B transponder. A second, even broader transponder uses a 1269-MHz uplink and a 436-MHz downlink. (See **table 1** for the exact frequencies.)

*A buffer between you and the satellite which reduces your equipment requirements by interfacing your station with AO-10.

the gateway station

A gateway station provides many of the functions that an ordinary OSCAR earth station might perform. Virtually any station that can reach a gateway can get a taste of satellite activity. Here's how it works.

Let's assume the gateway station is associated with your local repeater and uses part of the repeater's equipment. In this case the gateway will, on *uplink*, take the audio feed from the repeater's FM receiver; drive a moderately powerful SSB transmitter uplink with the audio from the repeater; point the uplink antenna; and derive control signals (transmit/receive) from the repeater.

On *downlink*, the gateway will preamplify the SSB downlink signal from the satellite; feed the signal to an SSB receiver; take the audio from this receiver to the repeater FM transmitter audio input; point the downlink antenna; and derive control signals (transmit/receive) from the repeater.

The system illustrated in **fig. 2** can be considered as a standard OSCAR satellite station with multiple *remote access*.

As a broadband repeater, AO-10 takes a spectrum 150-kHz wide on the uplink, translates the frequency down, and repeats the signals with the same relative amplitude in the downlink spectrum. The Mode L transponder provides a greater capacity of 800 kHz of spectrum in which to work. That's more than all the spectrum in the 20 and 15 meter bands combined. A second type of gateway uses a linear transponder similar to the linear transponder used on the satellite, but with the frequency pairs reversed; in this manner several stations can simultaneously access AO-10 through this type of gateway. Both types of gateways have been tried successfully. WB3EYB in Harrisburg, Pennsylvania, has operated a gateway successfully in conjunction with a standard FM repeater. KE3D in

By Vern "Rip" Riportella, WA2LQQ, Executive Vice President, AMSAT, P.O. Box 177, Warwick, New York 10990

table 1. AO-10 uplink/downlink frequencies.* (Note: These do not represent "channels" per se, but show the relationship between inputs and outputs. Coverage is continuous from band edge to band edge.)

uplink (MHz)		results in downlink (MHz)
mode B		
435.032		145.972
435.050		145.955
435.070		145.935
435.090		145.915
435.110		145.895
435.130		145.875
435.150		145.855
435.170		145.835
435.175		145.830
	general beacon	145.810
	engineering beacon	145.987
mode L		
1269.050		436.950
1269.100		436.900
1269.150		436.850
1269.200		436.800
1269.250		436.750
1269.300		436.700
1269.350		436.650
1269.400		436.600
1269.450		436.550
1269.500		436.500
1269.550		436.450
1269.600		436.400
1269.650		436.350
1269.700		436.300
1269.750		436.250
1269.800		436.200
1269.850		436.150
	general beacon	436.020
	engineering beacon	436.040

*exclusive of Doppler shift.

Boulder, Colorado, and DJ4ZC in Marburg, West Germany, are known to be working on the terrestrial, broadband linear transponder approach. The FM repeater approach is simplest and can be implemented quickly using existing equipment. The terrestrial linear transponder, on the other hand, requires special equipment and techniques.

There is nothing special about the choice of input/output frequencies for the station connecting to the actual gateway. Two-meter repeaters will work as well as 6-meter or 440-MHz versions. Suitable isolation techniques must be observed, however, because a strong 2-meter FM transmitter close to the gateway station 2-meter receiver is likely to be strongly affected (desensed) by the local FM signal. Remoting, cavity filtering, and other techniques are appropriate for this and similar situations where the repeater frequencies and the gateway frequencies are in the same band.

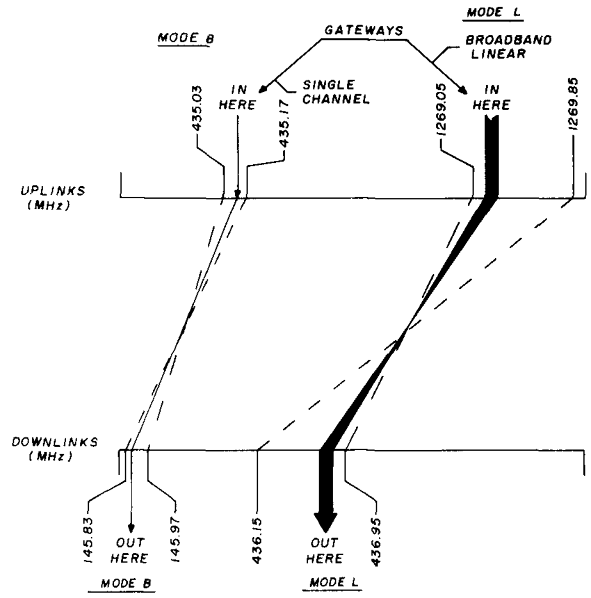


fig. 1. AO-10 modes and typical gateway operation.

operation

SSB and CW are the preferred modes of operation on AO-10. FM and full-carrier AM are discouraged because these continuous-power modes use precious solar-derived electrical power even in the absence of modulation; SSB does not. That's the reason FM inputs to the repeater are baseband converted to SSB via the audio circuitry. Under normal conditions, you should expect a received signal-to-noise ratio of 10 dB or more at the gateway. Under ideal, low-traffic conditions, the S/N ratio may approach 20 dB. The downlink power of the satellite transponder is shared among all the signals appearing in the uplink passband. A S/N ratio of 3 or 4 dB is normally sufficient for minimal copy. Thus, 10 to 18 dB will be heard, with intelligibility approaching good DX conditions on HF.

The gateway station operator needs to be especially sensitive to his or her responsibilities to both terrestrial communicators and to the manner in which the gateway "community" is introduced to the satellite community already using AO-10. The skill and courtesy of the operator are especially important when the uplinked spectrum is wider than normal, as with a terrestrial linear transponder 20 or 30 kHz wide. Future planning efforts will likely identify special gateway "zones" for uplinks to reduce the hazards of high traffic. AO-10 makes slightly more than two orbits per day. It travels in an elliptical orbit, which at times affords it a "view" of nearly one-third of the earth's surface. Its coverage area is extensive. Simply put, any station that can "see" the satellite can work any other that is simultaneously in view of AO-10, which will be in view for up to ten hours without interruption. Dur-

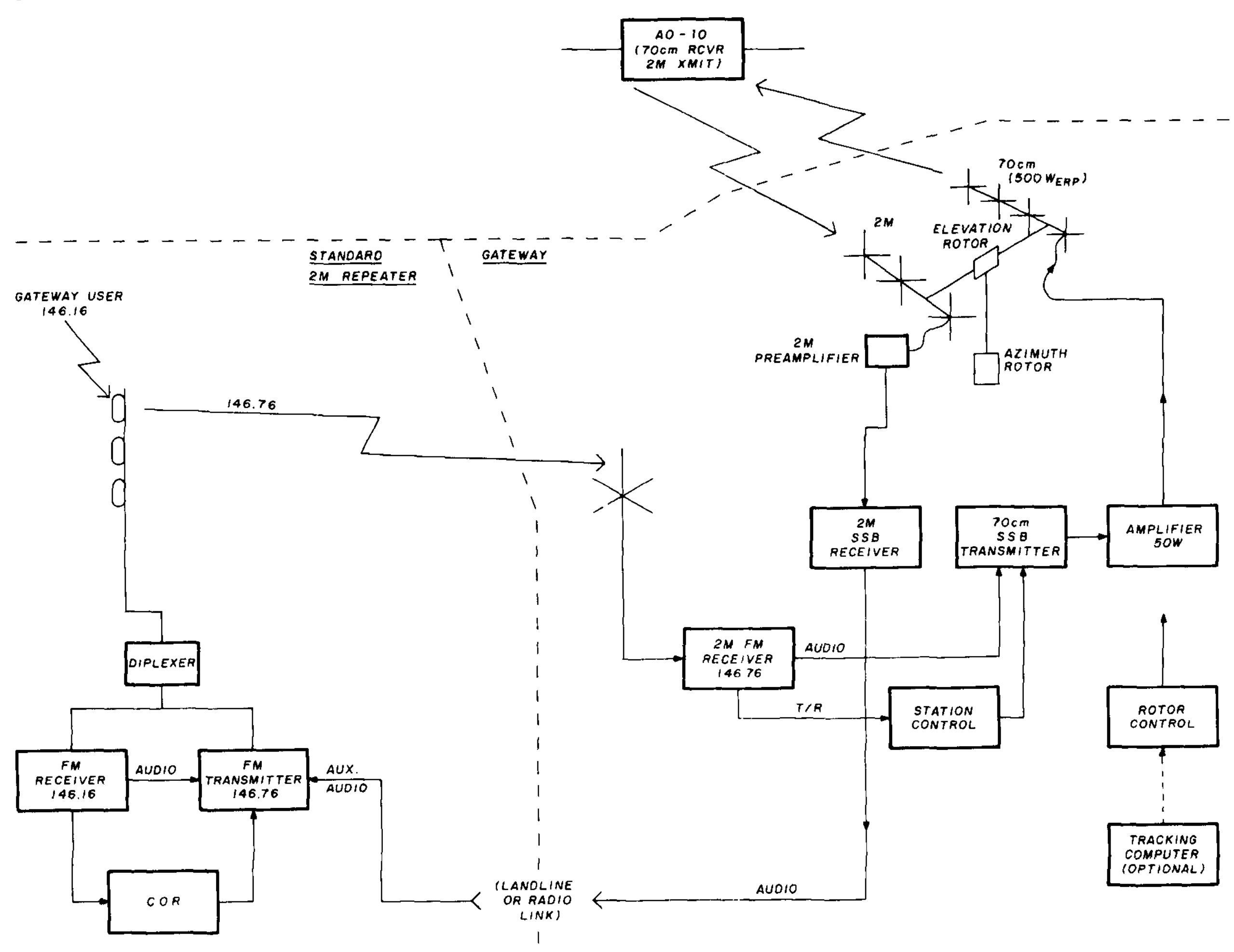


fig. 2. Typical narrowband (single channel) gateway plan using Mode B.

ing this period the satellite will move slowly across the field of view of the gateway station, whose antennas *will track* AO-10 *either manually or under computer* control. To the gateway user, however, operation will be "transparent"; that is, the gateway user does not need to know where the satellite is or the precise uplink/frequencies involved. The actual duration of gateway operation will be limited by a number of factors, including the gateway operator's schedule. For the present it appears that regulations require a full-time control operator be present; in any case, a fully automated gateway station is beyond the reach of all but a few.

Operation through a gateway is not intended, and certainly cannot, replace the fun and flexibility of establishing and operating your own autonomous satellite station. Assembling a station and learning the techniques required to be successful in satellite communications is not particularly difficult; it does, however, require some understanding of the basics. AMSAT, the organization that built and operates AO-10, invites the membership of interested individuals and orgânizations. One of AMSAT's main functions, aside from building and operating satellites, is instructing users and would-be users in their operation.

Whether working DX or just chewing the rag, nothing can beat satellite operating. Gateway access to AO-10 offers the newcomer an opportunity to "fly before you buy," in the sense that AO-10 operations can be sampled, without the expense of upgrading an existing station to full AO-10 capability. And for apartment dwellers who may experience difficulties in erecting suitable antennas (although many have done just that using a well-situated balcony, for example), using a local gateway may afford the best opportunity ever for working international DX from the comfort of your own easy chair, with your HT firmly in hand.

Further information and guidance on the use of gateways and membership in AMSAT is available from AMSAT, P.O. Box 27, Washington, D.C. 20044.

ham radio

score first HT-to-HT QSO via OSCAR 10

de **WA2LQQ**

Mike Henderson, N6JFD, at controls of his gateway station in Camarillo, California

An important milestone in Amateur Radio was reached when two Amateurs in West Virginia and California became the first to QSO through an Amateur Radio satellite using 2-meter FM HT's. KB6DDQ in Camarillo, California, and KD8GL in Wheeling, West Virginia, established contact at 1458 UTC on May 28, 1984.

The historic event was facilitated by "gateway" stations that connected local terrestial repeater systems to the high-flying AMSAT OSCAR 10 (AO-10) satellite. Though CW QSO's in which one of the stations keyed the transmit switch of an HT as a crude key have been reported, it is believed that the May 28 QSO was the first in which *both* participants used HT's.

Operating from West Virginia, KD8GL used his HT to talk through the Triple States Radio Amateur Club Repeater, KD8GL/R. Signals from the repeater were picked up by the local gateway station, WB8ZTV, which converted from FM to SSB and to the 435 MHz OSCAR 10 uplink frequency. Signals were then beamed by WB8ZTV to OSCAR 10, high over the Western Hemisphere.

In Los Angeles, meanwhile, gateway station N6JFD tuned to the AO-10 downlink frequency and converted the SSB back to FM, retransmitting the signals to the WA6OBT repeater, to which KB6DQ was tuned. The return path to Wheeling mirrored this path.

The repeaters and the gateway stations operated full duplex, and the QSO's were two-way. According to monitors, signals in both directions were excellent.

The W7LWE repeater/gateway in Lake Havasu City, Arizona, joined in later, making this the first three-way gateway operation and effectively linking Amateurs in three states via OSCAR 10's trunking capabilities.

Also participating in the May 28 linkups were KR3V, K8AN, K2QWD, N6IAW, W7MCF, and others.

Just one day before the 2-meter HT contact, the Wheeling gateway was linked for three continuous hours to the expert satellite station ZL1AOX in Christchurch, New Zealand, thereby confirming the long-duration coverage expected from OSCAR 10.

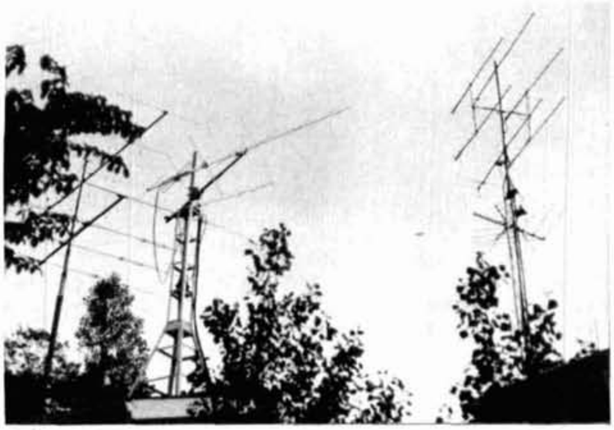
AMSAT suggests that using gateway interconnects may be the best way to demonstrate the capabilities of OSCAR 10 to prospective users, at no cost to them.

Don Knollinger, WB8ZTV, at controls of his gateway station in Moundsville, West Virginia.

Karen Henderson, KB6DDQ, operated one end of the link with only her HT from Camarillo, California.

For a free information kit, send an SASE to AMSAT, Department GW, P.O. Box 27, Washington, D.C. 20044.

Photos courtesy of Asterisk Design.



Uplink/downlink at WB8ZTV uses array at center; 70 cm up, 2 meters down.

KB6DDQ tuned to the WA6OBT/R repeater in Thousand Oaks, California, shown here with owner/operator Larry King.

Personally, I think that nothing can beat the flexibility of having your own OSCAR station, but for those just starting out, this seems to be a good way to taste the wine before you buy the bottle!

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Vol. 2 AX.25 Protocol

by Bob Richardson, W4UCH

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the FM advantage

An Amateur's view of frequency-modulation theory

Do you ever wonder why you don't hear any ignition or static noise on your 2-meter FM transceiver but at the same time, often hear nothing but static on 40 meters? Or why the local FM broadcast station always sounds so much better than its AM counterpart? *Well, the answer lies in the theory of modulation, and* in the receivers that detect this modulation.

Although VHF-FM has become the most popular mode on the 2-meter band, few Amateurs really understand what goes on inside their "black boxes." This article should help to explain some of the apparent mysteries of FM.

historical development

Although the theory of frequency modulation had been explored many years earlier, it wasn't until about 1935 that a demonstration by Major Edwin Armstrong showed the advantages of FM over conventional amplitude modulation. These tests were conducted in the Yonkers, New York, area from Amateur Radio station W2AG, using VHF equipment.

Although World War II disrupted the development of commercial FM transmission, FM had, by that time, established a strong foothold in the communications field and was used during the war on frequencies higher than 30 MHz. The years following the war saw the growth of the commercial FM-broadcast industry with *its "wideband" high-fidelity music, and programming.* The middle 1950s brought about narrowband FM (NBFM) transmission, particularly on the high end of 10 meters. In the 1960s, channel agreements were negotiated for the 2-meter band, and a whole new era began — channelized 2-meter FM. This concept has spread to all of the Amateur VHF bands.

But why is FM better than AM? Let's look at some basic ideas about modulation.

modulation theory

Modulation can be broadly defined as the transmission of data on an electromagnetic wave. For common telegraphy (A1 transmission or CW) the presence or absence of a signal with respect to time comprises the modulation. Conventional amplitude modulation imposes a modulating signal upon an RF carrier. The resultant summation of these two signals is the variance in amplitude of the RF carrier at a rate of change equal to that of the modulating signal. That is, the amplitude of the carrier physically changes from some minimum level to some maximum level in proportion with the amplitude of the modulating signal. The frequency of the RF carrier remains the same. In an FM system, the modulating signal does not vary the amplitude of the carrier. Instead, the frequency of the *carrier* changes. This is the basic difference between AM and FM transmission, (see **fig. 1**).

Now that we know what is being changed by the modulating signal in an AM or FM system, let's see why it makes a difference. Major Armstrong correctly theorized that manmade and atmospheric static, or "noise," was amplitude-specific in nature. A lightning stroke generates RF signals at many frequencies (typically the entire LF through VHF spectrum) which all have different random amplitudes. The result is that we hear a loud, scratchy sound on conventional AM broadcast receivers, and on most AM, CW, or SSB receivers as well, no matter how good they are! The reason for this is that the AM receiver has no means of discriminating between the desired transmitted AM

By R.J. Decesari, WA9GDZ/6, 3941 Mt. Brundage Avenue, San Diego, California 92111

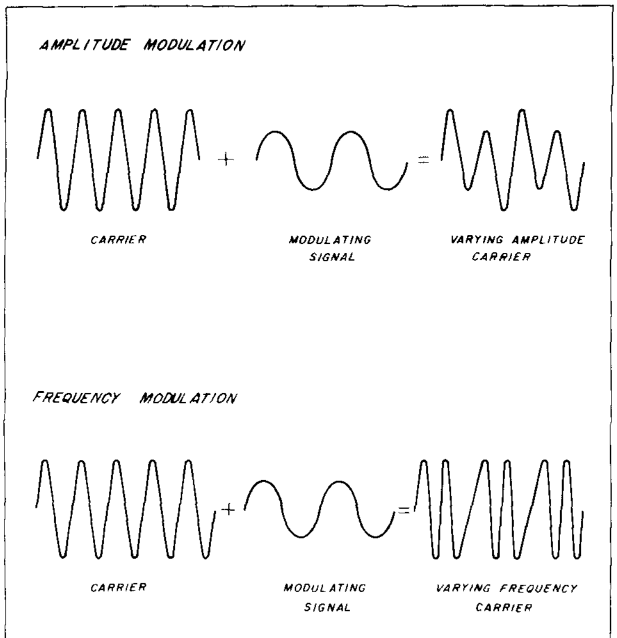

fig. 1. Basic differences between AM and FM transmission.

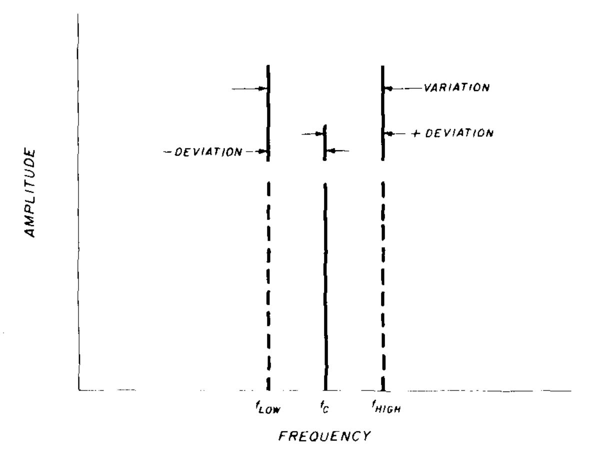

fig. 2. Relationship between carrier center frequency, deviation, and variation.

signal and the undesired AM static crash. The receiver is amplifying and detecting both signals simultaneously (as it was designed to do) and putting them both in your ear!

Consequently, amplitude-specific noise is difficult to detect with an FM system because there is no amplitude detector in an FM receiver! An FM receiver is looking for changes in frequency, not amplitude; it is for this reason that there is a qualitative improvement over an equivalent AM system with respect to static and noise.

terms

With an FM transmitter, three terms must be addressed before we can proceed with this discussion: deviation, modulation index, and deviation ratio.

Deviation is defined as the amount of frequency change of the carrier when modulated by a signal of a unique frequency — that is, if we were to apply a 1-volt peak-to-peak (e.g., +0.5 Vp and −0.5 Vp) signal of 700 Hz, it would cause the carrier to change frequency to plus and minus some specified amount at a rate equal to the modulating frequency, which is 700 Hz. This "specified amount" of frequency change is called the deviation. It is "specified" because the amplitude of the modulating signal is what specifies it; for example, a 2-volt p-p 700-Hz modulating signal creates more frequency deviation than a 1-volt p-p signal. (The deviation is adjustable by the gain of the modulating circuit.) From 0 to +0.5 volt, the carrier will deviate in the "plus-frequency" direction; from 0 to −0.5 volt, the carrier will deviate in the "minus-frequency" direction. Therefore, the total change of frequency is 2 times the deviation (see **fig. 2**).

Now that we are deviating the carrier, let's talk about *modulation index*. As we've just seen, the deviation is related to the amplitude of the modulating signal. But what about the modulating frequency? It would appear to have some effect — and it does. The modulation index is defined as:

$$mod\ index = \frac{deviation}{modulating\ frequency}$$

In effect, then, the modulation index is a ratio, or a pure number — i.e., the units of the numerator and the denominator cancel each other. It can be thought of as simply a parameter that describes the operation of the system.

The *deviation ratio* is similar to the modulation index:

$$deviation\ ratio = \frac{maximum\ frequency\ deviation}{highest\ modulating\ frequency}$$

One may consider the deviation ratio as a "maximized" modulation index. For example, a 1-volt p-p, 1 kHz modulating signal may deviate the transmitter plus and minus 25 kHz. Then:

$$mod\ index = \frac{25\ kHz}{1\ kHz} = 25$$

But what about a 1-volt p-p, 3 kHz signal?

$$mod\ index = \frac{25\ kHz}{3\ kHz} = 8.33$$

The modulation index is not necessarily the same under all conditions. However, if we define the 3-kHz tone as the highest modulating frequency that the transmitter will "see," and state that the 1-volt p-p amplitude will give the greatest frequency deviation

(25 kHz), then we define a system parameter or constant. For this sample, then:

$$deviation\ ratio = \frac{25\ kHz}{3\ kHz} = 8.33$$

Thus, the fine line between deviation ratio and modulation index has been established. But why is this important? Because the theory of FM improvement is based upon the modulation index (and deviation ratio) of the transmitted signal.

receiver noise

When there is no signal present at the input of a receiver, we hear "background noise" consisting of both ambient thermal noise generated by the movement of electrons in molecules of matter and noise generated within the components of the receiver. The magnitude of the noise may be calculated in terms of units of power — *i.e.*, watts per Hertz. Specifically, the ambient noise power in any 1 Hz of spectrum can be calculated by the equation:

$$noise\ power\ P_n = kT\ (in\ watts/Hz)$$

where K is Boltzman's constant $\approx 1.3803 \times 10^{-23}$ Joules/degrees Kelvin, and T is the absolute temperature (in degrees Kelvin) of the ambient surroundings. (Room temperature is about 290 degrees Kelvin.)

This formula can be expanded to determine the noise power of a specific range of frequencies by simply multiplying the power for 1 Hz by the total bandwidth to be analyzed:

$$noise\ power\ P_n = kTB\ (in\ watts)$$

where B, usually the receiver's IF selectivity value, is the bandwidth of spectrum under consideration in Hertz.

For a 2-meter receiver with 10 kHz of IF passband, the theoretical noise power is:

$$P_n = 1.3803 \times 10^{-23} \times 290° \times 10{,}000\ Hz$$

$$= 4.0029 \times 10^{-17}\ watts$$

Most communications engineers prefer to speak in terms of dB. This calculated power level will now be referenced to 1 watt:

$$P_n = 10\ log \frac{4.0029 \times 10^{-17}\ watts}{1\ watt}$$

$$= 163.97\ dBW$$

This number is the theoretical natural noise power level in 10 kHz of the 2-meter Amateur band at about 62 degrees F (290 degrees Kelvin).

If we had a perfect receiver whose components did not generate noise, then the noise-power level at the receiver output speaker would be the same as the noise-power input at the antenna. As we know, this is not the case; typically, our receiver might have a noise figure (the amount of internally generated noise) of, let's say, + 10 dB. Then, with the noise power as calculated, the receiver would have a noise threshold of − 153.97 dBW. That is, any carrier that arrives at the antenna terminal of the receiver with a power level of less than − 153.97 dBW would be buried in the noise.

Continuing this example, if a carrier had a power level of − 143.97 dBW, it would be + 10 dB above the noise power level. Or, stated another way, the carrier-to-noise ratio is + 10 dB. This is expressed as follows:

$$\frac{C_I}{N_I} = \frac{carrier\ power\ at\ input}{noise\ power\ at\ input}$$

$$= \frac{-143.97\ dBW}{-153.97\ dBW} = +10\ dB$$

Remember, even though division is implied by C_I/N_I, because we are working in dB, the quantities are subtracted for division operations and added for multiplication operations. This + 10 dB carrier-to-noise power is what is at the receiver's input. Now, if we listen to the output of the receiver, we have a signal coming out of the receiver at some level. If we remove that signal by, for example, turning off the transmitter, we then hear the noise level. This output relationship is defined as the output signal power divided by the output noise power:

$$\frac{S_O}{N_O} = \frac{output\ signal\ power}{output\ noise\ power}$$

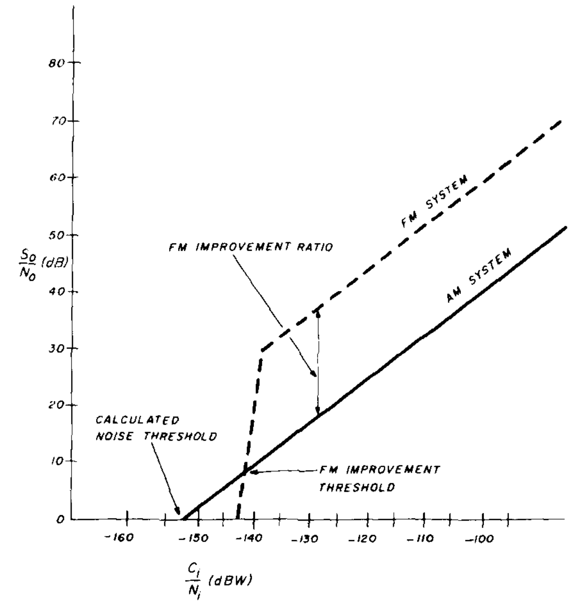

fig. 3. Typical input and output responses for AM and FM reception. Input numbers follow the example given in text.

This ratio, S_O/N_O, depends on the actual characteristics of the receiver. Obviously, a "quiet" receiver, for a given C_I/N_I, will have a relatively high corresponding S_O/N_O; if the receiver is of lesser quality, then N_O will be greater and the output S_O/N_O will consequently decrease.

AM and FM compared

This comparison between C_I/N_I and S_O/N_O is often referred to as the signal-to-noise performance of a receiver, (see **fig. 3**).

AM noise performance shows an approximate 1:1 correlation — i.e., if C_I/N_I, increases by one unit, so will S_O/N_O. However, at a specific power level above the noise, typically about 10 dB above the noise threshold (−153.97 dBW in our previous example), the FM system equals the AM response and starts shooting up more rapidly than the AM system. Therefore, for C_I/N_I, greater than about −143 dBW as in our example, we see a higher corresponding S_O/N_O with FM than with AM. The amount of improvement is called the FM-improvement ratio, and is directly related to the modulation index! The improvement ratio is:

$$FM\ improvement\ ratio = 3(mod\ index)^2$$

Between −153 dBW and approximately −143 dBW, an AM system is superior to FM. However, for practical purposes, this improvement is not really noticeable in the noise.

NBFM compared

Let's look at our Amateur NBFM signals and see how they compare to wideband FM, SSB, and AM. **Fig. 4** illustrates this relationship between S_O/N_O and input signal/noise level, S_I/N_I.* As can be seen from both **fig. 4** and the FM-improvement formula, the actual amount of improvement is greater with high modulation indices. Notice that wideband FM systems (such as are used by commercial FM broadcasting stations, and which are restricted to 75-kHz deviation by the FCC) provide the greatest amount of S_O/N_O improvement. It does this, however, at the expense of weak signal detection; in other words, your FM stereo receiver may not be as sensitive as your AM/SSB communications receiver. However, for signals just above the minimum-detection threshold level, the output level shoots up very quickly, and the FM stereo receiver provides a better S_O/N_O response to these weak signals than the AM/SSB equipment. The same is true for Amateur 2-meter NBFM transmissions (with 5-kHz deviation), with the exception that the sensitivity is improved at the expense of the amount of FM improvement. In practice, the NBFM improvement becomes apparent at such significantly low signal levels that we perceive FM detection to be invariably superior to AM. This is why FM has effectively replaced AM transmission on the 2-meter Amateur band even though AM is theoretically better at signal levels just slightly above the ambient noise level. Finally, we see that single-sideband suppressed-carrier systems offer a fixed improvement ratio over AM also. This can best be appreciated by realizing that the SSB voice channel is half of the bandwidth of a double-sideband AM system. Consequently, the ambient noise power in the SSB channel is less than in the AM voice channel. This results in a better S_I/N_I number and a correspondingly higher signal-to-noise output number.

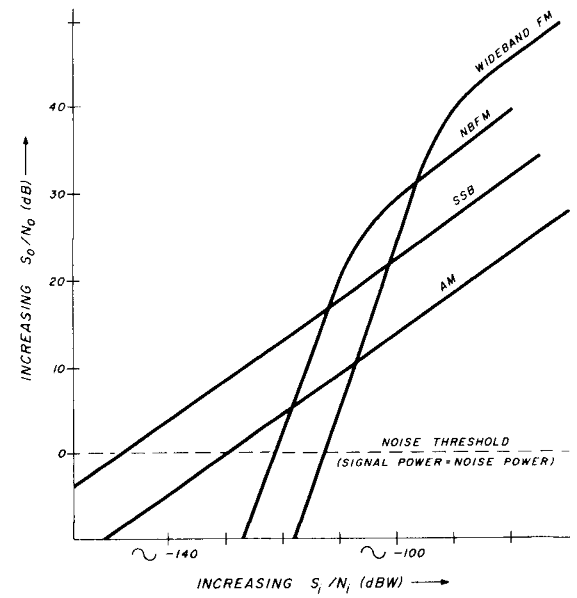

fig. 4. Typical receiver response curves for common modulation techniques. Power levels are approximate.

This is why FM 2-meter rigs seem to provide such clear voice reproduction. Next time you operate on FM, square your modulation index and multiply it by 3; you'll then know exactly how much improvement over AM is possible.

*When referring to SSB modulation, the term Ci (carrier input level) is misleading since the carrier has been suppressed. Signal input level (Si) is more accurate, and for this analysis is essentially the same as Ci.

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VHF/UHF WORLD

Joe Reisert W1JR

220-MHz EME requirements

The 220-225 MHz Amateur band has long suffered from the "I'll look into that band later" attitude. This wasn't helped by the fact that many services, especially the citizens' band radio service, had designs on this spectrum. Radars were also prevalent in some parts of the USA mainland, particularly near the coasts. Little or no commercial equipment was available for this band.

These negatives have all been turned around. The FCC has said "no" to the CB'ers and others seeking to claim this valuable frequency range; the radars have ceased operation; and commercial equipment is now available up to the Amateur Radio legal power limit.

Many VHFers have "done their thing" on 2 meters and are now looking for a new challenge. The 220-225 MHz band has much to offer them. In many ways it is like 2 meters without all the QRM! Equipment is very similar to 2 meters with smaller antennas a big plus, and local ambient noise and sky noise temperature are usually less than on 2 meters. Propagation is also similar, with meteor scatter and EME gaining increased popularity, especially since the introduction of the ARRL VUCC (VHF/UHF Century Club) award on January 1, 1983.

As this issue went to press the first intense sporadic E contact on 220-225 MHz had yet to occur.[1] The first few WAS certificates were recently awarded (in December, 1983), ironically several years after WAS was accomplished on a more difficult band, 70 cm (432 MHz). The first 220 MHz EME QSO didn't take place until 1970, well after it was accomplished on 2 meters, 70 cm, and 23 cm (1296 MHz).[2] This band has lagged behind the other bands, but that's changing fast.

With much of this month's issue dealing with specialized communications, I thought this would be a good time to review the EME (Earth-Moon-Earth) capabilities and operational requirements of this band. This information, especially in regard to equipment selection, can also be applied for those who just want to update their present gear for normal propagation modes.

minimum requirements for 220 MHz EME

The basic EME strategy should be to build a station that has the capability of hearing your own echoes, because this will allow you to evaluate your equipment and any other changes or improvements that you make.[3] Based on a 0-dB signal-to-noise ratio and no Faraday rotation (a random change in polarity that occurs when a VHF/UHF signal passes through the ionosphere), compliance with the following 220-MHz EME requirements will yield marginal echoes:

- path loss: 256 ± 1 dB
- minimum antenna gain: 22 dBi (approximately 20 dB over a dipole)
- maximum receiver noise figure: 2.0 dB (referenced to the antenna feed)
- minimum transmit power: 500 watts output (at the antenna feedpoint)
- receiver bandwidth: 500 Hertz maximum

Improvements above these minimum requirements such as increased antenna gain or output power will improve results accordingly.

antennas

As pointed out in reference 3, the most important part of an Amateur station is the antenna system because every dB of improved antenna performance yields a 2 dB system improvement: 1 dB on receive and 1 dB on transmit. This is especially important on EME, where antennas are large in comparison to those used on other modes of communications. Good clean patterns are also desirable with side, rear, and grating lobes (the lobes that result when two or more antennas are stacked) down at least 13-15 dB to get all the transmitted power aimed at the moon and to pick up the least amount of ambient or galactic noise (noise from outer space) on receive.

Yagi antennas, especially in this frequency range, are popular because they are easily constructed, easy to stack, and relatively small for the gain obtained. Hence, an array of high gain Yagis is presently the most common antenna used on 220-MHz EME.

The 4.2 wavelength NBS Yagi is the most common design presently in use on 220-MHz EME.[4,5] Properly duplicated, its gain is about 14.2 dBd. It works best when stacked 8-1/2 feet (2.6 meters) apart in the "E" (horizontal) plane and 8 feet (2.44 meters) apart in the "H" (vertical) plane. If all feedlines are kept short with equal lengths and a good in-phase power divider is used, four of these Yagis will yield close to 22 dBi of gain, the minimum requirement for 220-MHz EME communication as stated above. One commercial manufacturer offers this Yagi with a trigonal reflector.

Several 220-EME stations are using these Yagis stacked 4 wide and 2 high or vice-versa, using the same spacings indicated above. The typical gain is now about 24 dBi; this yields good echoes and improves the performance and ease of working the smaller stations who have met only the minimum EME requirements as specified above.

Some stations are using arrays of the 3.2 wavelength NBS Yagis, but they are marginal unless at least six are used or the station scheduled has a larger setup to make up the difference for the 1 dB lower gain per Yagi.[4,5] Proper stacking for this antenna is 8 feet (2.44 meters) and 6 1/2 feet (2 meters) in the "E" and "H" planes, respectively.

Another antenna that has been used on 220-MHz EME is the WB6NMT 11-element Yagi.[6] This antenna, a result of the Greenblum designs,[7] is also commercially available. WB0TEM has redesigned this particular antenna by extending the boom about 54 inches (1.37 meters) and adding 3 additional directors for increased gain. Each additional director is spaced 18 inches (45.72 cm) further down the boom and directors 4 through 11 are tapered slightly differently than they were in the original design. WB0TEM and W0SD each use arrays of 16 of these redesigned Yagis at their home stations and also have an 8-antenna array which they have used very successfully on *portable* EME from over 15 states.[8] Recommended stacking for this arrangement is 8 feet (2.44 meters) and 7 1/2 feet (2.29 meters) in the "E" and "H" plane, respectively, and slightly closer (perhaps 6 inches or 15.25 cm) for the shorter version.

A more recent trend is to use the least number of antennas in the array by designing a Yagi with the longest boomlength possible.[9] In this regard, the DL6WU designs are recommended.[10] Indeed, one commercial antenna manufacturer has just announced the availability of a long-boom (30 feet or 9.15 meters) Yagi from these designs.

A few 220-MHz EME stations use parabolic dishes varying from 24 to 42 feet (7.3-12.8 meters) in diameter. Dishes are especially popular with operators who work EME on two or more bands because only the feed system has to be switched to change frequency. Furthermore, if the feed system is properly designed, it can be rotated or switched in polarity to offset the affects of Faraday rotation and thereby improve the chances of a completed EME QSO.

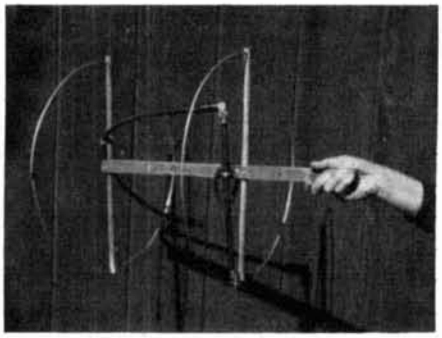

fig. 1. Antenna feed system used by K5FF/W5FF to feed their 30-foot (9.15 meter) dish. (See text for dimensions.)

A 24-foot (7 meter) diameter dish meets the minimum requirement for 22 dBi of antenna gain. As stated in reference 3, an F/D (focal length over diameter ratio) of 0.43 to 0.55 is recommended because it is the easiest to feed. At this frequency, the EIA reference feed is quite large (4 1/2 feet or 1.37 meters square) so other feed systems or variations have been used. WB5LUA modified the EIA reference feed by replacing the screen and driven elements with a pair of 2-element Yagis spaced 1/2 wavelength and placed diagonally on the corners of his 70-cm EIA feed.[3] The reflectors, approximately 5 percent longer than the driven element, are placed 1/4 wavelength behind it. His dish is 24 feet (7 meters) in diameter with a 0.49 F/D ratio. K5FF and W5FF use two circular loops spaced 14 inches (35.6 cm) apart, similar to a quad (**fig. 1**). Each element is made from 1/8-inch (3-cm) diameter wire with the driven element 54 inches (137 cm) and the reflector 56 3/4 inches (144 cm) long. A 1/4 wave 92-ohm Bazooka type balun completes the match to the 170-ohm feed point impedance. Their dish is 30 feet (9.15 meters) in diameter with a 0.43 F/D ratio.

Typical half-power beamwidths for a 22 dBi gain antenna at 220 MHz are 12 to 13 degrees, so some of the medium sized rotators such as the HAM-M series are useable on the smaller antenna arrays. For temporary operation, setting circles and a protractor/level can serve very well for determining true elevation. The later method was used on our recent New Hampshire 220-MHz EME DXpedition (**fig. 2**). However, larger Yagi arrays may require a commensurately stronger and more accurate rotator system such as a prop-pitch motor and selsyns.[3]

receivers

Most 220-MHz EMEers use antenna-mounted very low-noise preamplifiers ahead of a crystal-controlled down-converter. The latter, usually located at the operating position, feeds a suitable high-frequency receiver. The converter should have a noise figure of 2-4 dB maximum with no less than 20 dB image rejection, and should be reasonably free from overload (a potential source of interference is from TV channels 12 and 13).

If you build your own converter, I recommend the use of a high dynamic range preamplifier,[11] a double-balanced mixer,[12] and a 28.1 MHz IF. For 220.0 MHz, use a 191.9-MHz local oscillator derived from a 95.95-MHz crystal oscillator and doubler.[12] There are many commercial converters available. The IF requirements such as stability and bandwidth, among others, are spelled out in detail in reference 3.

Many operators prefer to use transverters on 220 MHz. One of the most popular early arrivals on the 220-MHz scene is the modified Microwave Modules MMT-220/28, available through VE3CRU on special orders. Other transverters are now available from commercial manufacturers. If you prefer to "roll your own" transverter, circuitry is available in references 12 and 13. If you are ambitious, W9SR has recently published a design of a complete transverter for the homebrewer.[14]

preamplifiers

Low-noise GaAs FET (Gallium Arsenide Field-Effect Transistor) preamplifiers are now in wide use on 220 EME operation. Noise figures of less than 1.0 dB are easily obtained even with low cost devices, and this is more than adequate with the sky temperatures prevalent on this band.

One of the most popular circuits is the W6PO design.[15] His original GaAs FET circuits used devices selling for $25.00, but devices such as the Mitsubishi MGF-1202 can easily provide a noise figure of 0.5 dB in this circuit at a cost of less than $10. Other choices are the newer low-cost dual-gate GaAs FETs primarily aimed at the UHF TV market. They will operate in the same circuits providing that an extra intermediate voltage (1.5-3 volts) is applied to the second gate. Some typical low-cost devices are the Mitsubishi MGF 1100, NEC NE41137, Toshiba 3SK121 and the more recent arrival, Motorola MRF966 "sleeper" ($3.55 in a single quantity).[16]

Preamplifier isolation is still a problem at 220 MHz. If you want long life for your input device, a dual relay protection scheme such as the one discussed in reference 3 is highly recommended! Reference 3 also points out that additional spacing is needed between the two cascaded relays if the ultimate isolation is to be obtained.

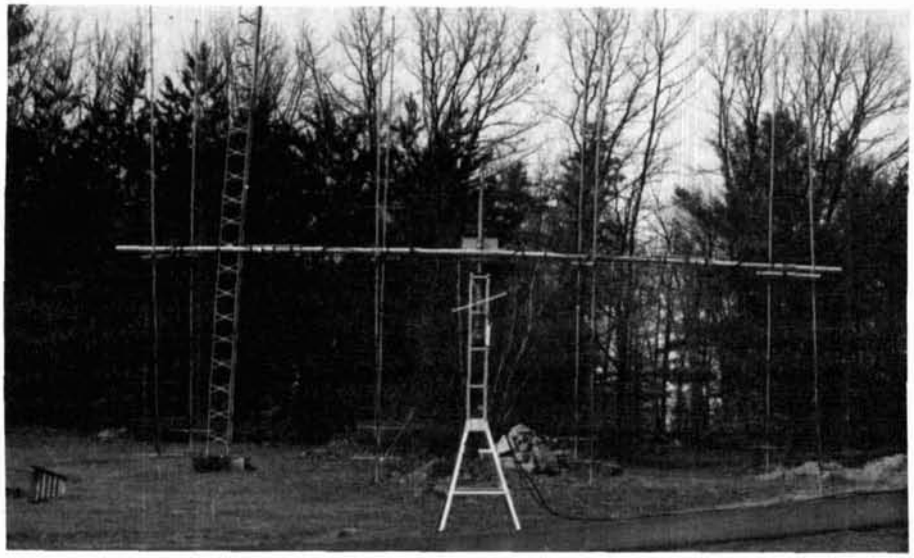

fig. 2. Portable EME antenna system used by W1JR. Eight 4.2λ NBS-type Yagis are mounted on an 11-foot (3.35 meter) high tower. Main boom is a 30-foot (9.15 meter), 3-inch (7.6 cm) diameter irrigation tube.

transmitters

Most 220 EMEers prefer to use an up-converter or transverter driven by a 28 or 50-MHz exciter. This provides the necessary accuracy, flexibility, and stability required for EME. As pointed out in the receiver section of this article, designs are available in references 12, 13, and 14. Commercial transverters such as the Microwave Modules MMT 220/28 and others are available.

The majority of high-power amplifiers used on 220 MHz require greater than 10 watts if full output is required. Most operators either build or buy a moderate power (25-60 watt) solid-state driver. Many circuits have been published and many are available commercially.

Until recently, 4CX250B-type tubes were used in either a modified push-pull plumber's delight with tubing and flapper plates[17] or in the parallel kilowatt unit similar to the K2RIW 70 cm design.[18] 8930 tubes can be substituted for the 4CX250Bs if greater power is required. 8874s[18] or the newly announced EIMAC 3CX800A7 tube should also work well in this design if the input matching network and the output tank circuit are redesigned accordingly, but they will require more drive (40-60 watts) than the 4CX250Bs.

One worthwhile amplifier to consider now available on the surplus market is the AM-6155. Listed as a 50-watt driver manufactured by ITT, it is available from Fair Radio Sales for approximately $150. Included is a coaxial cavity amplifier complete with a tube (8930 typical) and 115 VAC power supply. With a few simple modifications, it will deliver 500-600 watts of output power — not a big EME amplifier, but one to start with and one that's surely more than sufficient for other modes of operation.[19]

The recent (September 1, 1983) FCC change from measuring input to output power and the tantalizing possibility of running legally up to 1500 watts output power has had a profound effect on EME operations. No longer is efficiency a primary requirement. This has led to the use of slightly less efficient but higher output tubes.

In this regard the 8877 is now becoming the most popular tube. It works well using either the W6PO[20] or the ARRL Handbook circuit.[21] (I have been unable to obtain sufficient data from the ARRL to clarify the use of the design in reference 21.) W4WD, who has built it by scaling some of the missing information from the photographs shown, suggests that you extend the Teflon insulation on the plate tank to overlap at least 1/4 inch (6.35 mm) to prevent breakdown. He also experienced some regeneration, but cured it by using the input matching circuitry in the W6PO design. Both of these amplifiers will deliver 1500 watts of output at good efficiency, but require 50 to 60 watts of drive, considerably more than required by typical 4CX250B designs. Finally, most 220-MHz power amplifiers have harmonics that are typically only 25-30 dB below the fundamental. Therefore a harmonic filter such as a series-tuned circuit[18] or a 1/4 wave (at 220 MHz) shorted stub should be placed across the amplifier output connector.

feedlines

Suffice it to say that feedline losses should always be kept to a minimum, especially on EME. A 0.5 dB loss ahead of a 220-MHz preamplifier is acceptable if a very low noise GaAs FET preamp such as the one just described is used. The transmitter feedline loss should be no greater than 1 dB unless you are running the new legal power limit.

Feedline loss is not such a problem

on 220 MHz. Losses are only about 66 percent of those on 70 cm and about 33 percent greater than on 2 meters. Hence, RG-213 coax cable is still usable for phasing lines in a Yagi array. However, 1/2 inch (12.7 mm) or larger hardline is recommended for the transmitter line. Of course, Andrew Corporation Heliax™ is recommended for the ultimate in low loss. The newly announced Belden 9914 is similar to RG-213 with lower loss (approximately 2.5 dB per 100 feet or 30.5 meters at 220 MHz).[22] The Belden 9913 is even lower loss and is similar to RG-213 in size but uses an air dielectric. Either of these coax cables should be useable for phasing lines. A complete list of recommended feedlines is shown in **table 1** of reference 3. As stated above, the 200 MHz line loss is approximately 66 percent of the loss listed in the table and the power handling capability is approximately 150 percent of that shown for 70 cm, while the velocity factor remains the same.

system checkout

Assuming that your station is now complete, it's time to go through a checkout to see if all your gear is working properly. The first step is to check VSWR. If it isn't below 1.5:1, and hopefully closer to 1.2:1, it's back to the drawing board. Assuming an acceptable VSWR, the output power should be measured both at the transmitter (to verify FCC requirements) and at the antenna to see that the transmitter feedline loss is low enough. At this point I'll reiterate the necessity of doing power and VSWR tests with an appropriate instrument such as a Bird Electronics model 43 or equivalent. ***Warning: do not stand in front of your antenna with high power applied because your body may absorb hazardous levels of RF radiation.***

Next, check out the receiver. Depending on the noise figure and sky temperature, the audio output from your receiver should decrease from 1 to 2 dB as you elevate your EME antenna from the horizon to directly overhead. You may also move the overhead point several degrees one way or the other to find a "cold" spot which will yield the maximum drop in receiver output noise. Next, aim your antenna at the sun after noting the receiver output on the cold sky. The noise level should increase from 7-10 dB depending on your antenna size, noise figure, and the conditions on the sun at the time of measurement. Check with another EMEer to compare figures that are presently being measured. (This procedure is described in more detail in reference 3.)

Now you can check for echoes; don't get frustrated if you don't hear any. (The Faraday rotation may not be cooperating.) Remember that the round-trip path to the moon is just over 2.5 seconds, so long dahs or letters may be sent for test purposes. Also, doppler shift can be up to ±750 Hz on 220 MHz. The maximum will be up to +750 Hz at moonrise and −750 Hz near moonset, with little or no doppler when the moon is directly south of your QTH. If Faraday is uncooperative, wait 30 minutes to an hour and try again. Better yet, get another EMEer to either listen for you or transmit a test signal for you to listen for.

scheduling

220 MHz EME operation is usually conducted between 220.005 and 220.050 MHz with 220.020 MHz as the calling or CQ frequency. DXpeditions usually operate on 220.035 MHz and listen 5-10 kHz up. The activity is usually centered near perigee similar to the 70 cm EME weekend. To allow for those who work multiple bands, 220 MHz EME is usually conducted in the Saturday evening/Sunday morning time frame.

About a year ago, the 220 MHz EMEers decided to adopt the 70 cm scheduling and reporting system. Hence, the transmission/receiving periods are 2 1/2 minutes long, with the westernmost station (and DXpeditions) transmitting the first 2 1/2 minutes of each 5-minute block. A "T" report indicates signals or letters received. An "M" report means that positive identification (both call signs) has been received, and is therefore valid for a contact, while an "O" report signifies "Q5" copy. The usual acknowledgements both ways with "R" completes the exchange.

No formal 220 MHz scheduling is conducted as on 2 meters or 70 cm, so you will have to set up your own schedules until activity warrants more formal arrangements. However, the 70-cm EME net is often used to set up 220-MHz EME schedules. You can find this net between 1600-1700 UTC every Saturday and Sunday on 14.345 MHz. Many EMEers also meet to exchange schedules and information by using OSCAR 10 on a downlink frequency of 145.950 MHz when the satellite is in view.

summary

You too can join the fun on a frequency that in many ways is less critical or demanding than 2 meters or 70 cm yet still challenging. I have tried to sum up the state-of-the-art on 220 MHz and provide a recipe for simple EME success. Because 220-225 MHz antenna systems are often smaller than those used on 2 meters, the lower sky temperature and the availability of suitable designs or commercial equipment make 220 MHz an ideal band for conducting EME schedules and experiments. There is also the challenge of attaining WAS on a band where this feat has only been recently accomplished. Good luck — see you on 220 soon.

acknowledgements

As in past columns, I have had to rely on many persons to provide some of the material needed to put this column together. I'd particularly like to thank Lewis Collins, W1GXT; Fred Merry, W2GN; Ron Barlow, N4GJV; Russ Wicker, W4WD; Lee Fish, K5FF; Fred Fish, W5FF; Al Ward, WB5LUA; Ed Gray, WØSD; and Marc Thorson, WBØTEM for all the help and encouragement they gave me to make this month's column possible.

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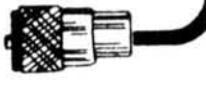
VHF/UHF coming events

September 8,9: *ARRL VHF QSO Party*
September 25: *EME perigee*

DX news note

The 23 cm (1296 MHz) tropo record was broken on June 24, 1984, at 0035 UTC. N6CA at 1100 feet (335 meters) on the Palos Verdes Peninsula in Torrance, California, running 150 watts output and one 44-element loop Yagi, worked KH6HME at 8200 feet (2500 meters) ASL on the eastern slope of Mauna Loa, Hawaii, running 20 watts output and four 25-element loop Yagis. The opening, while lasting several hours on 2 meters (where liason was conducted), lasted only about 10 minutes on 23 cm. This extends the DX record on this frequency to 2472 miles (3977 km).

ham radio



More Details? CHECK—OFF Page 150

improving amplifier ALC circuits: part 2

MLA-2500 input matching and tube protection circuits

The MLA-2500 has acquired a reputation as a tube eater, and it's no secret that the cost of replacing the final tubes in the MLA-2500 has risen from $75 to $520 in just ten years. This has left many MLA-2500 owners nervous about — if not fearful of — tube loss. The ALC and driver matching circuit described in this article should significantly decrease the possibility of tube loss due to overdrive.

One problem that has plagued many MLA-2500 owners is the lack of an input matching circuit. A Kenwood TS-430, for example, is almost unusable with the MLA-2500. The success of the E.T.O. "Alpha" amplifier series has allowed several design ideas to be field-proven. I adapted the broadband, untuned input circuitry used in the small E.T.O. amplifiers to cure the input mismatch problem. The matching circuit is simple to design and construct. Ten trifilar turns of No. 18 enameled wire are wound on a T94-2 core. An electric drill is used to twist three 15-inch lengths of wire together. (The completed coil is shown in **figs. 1** and **2**. **Fig. 3** shows the original input mounting around the input relay in an MLA-2500B. **Fig. 4** shows the proper mounting of the input toroid. The wirewound "Non-inductive" swamping resistor used in the MLA-2500 was found to be too reactive to be of use and was removed. I constructed a 50-ohm, 40-watt non-inductive resistor suitable for swamping use from twenty 1-kilohm, 2-watt carbon resistors. I tightly packed the resistors into two groups of 7 and 13 respectively (shown in **figs. 5** and **6**) and then mounted them as shown in **fig. 7**. The interconnection is shown schematically in **fig. 8**.

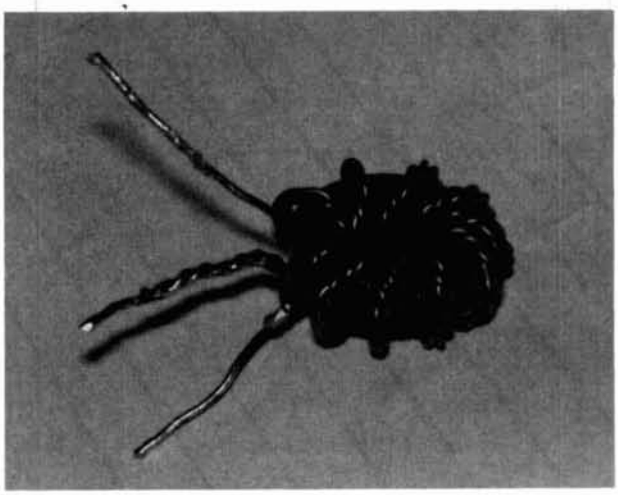


fig. 1. Toroid input transformer consists of 10 trifilar turns on a T94-2 core.

The next step in stabilizing the input impedance involved moving the cathode RF choke, RFC-4, from the ALC board, PC-1004, to the cathode area. Some older MLAs use an unbypassed RF choke, RFC-7, already installed in series with the cathode line to the ALC board. If no RFC-7 exists, remove RFC-4 from the ALC board and reconnect it between the cathode line common and an empty terminal on the barrier strip mounted between the tube sockets. Install a jumper between the ALC board terminals from which RFC-4 was removed. Move the cathode return line to the barrier strip terminal and add a 0.01 μF bypass capacitor to ground as shown in **fig. 8**. After installation, the MLA-2500 will present less than a 1.3:1 VSWR to the exciter on all bands from 80 to 10 meters; on 160 meters the VSWR is 1.3:1. Although some variation in the value of the compensating capacitor, C_c, may be required, 100 pF connected as shown in **fig. 2** has proven optimum in all retrofits completed to date. The use of different core material and/or core size is likely to necessitate some variation in the value finally selected and the connection terminal.

By J. Fred Riley, WA8AJN, 1721 Poplar Street, Kenova, West Virginia 25530

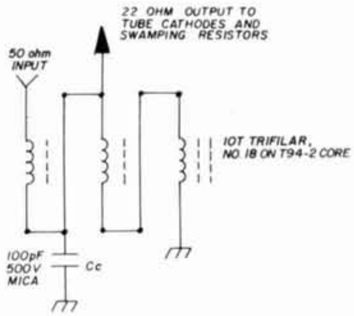


fig. 2. Toroid internal and external connections show position of compensating capacitor.

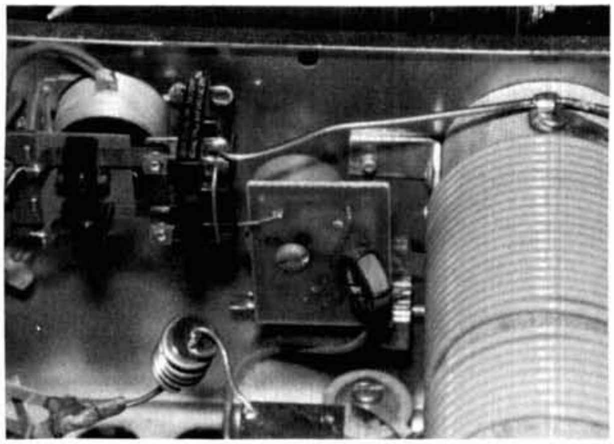


fig. 3. MLA-2500B input relay area before modification.

ALC

The final modification to the MLA-2500 may well be the most important and beneficial to improved performance. The technique employed is a modified version of the circuit used in the E.T.O. Alpha 77. It is a grid-current-derived ALC circuit that uses readily available Radio Shack parts. I could not use the original Alpha 77 circuit because it uses a positive sample voltage whereas negative is used in the MLA-2500. In installing the ALC circuit I also remounted the thermal sensor and increased the voltage to the cooling fan.

I remounted the thermal sensor, SW-3, shown in **fig. 9**, from behind the 40-meter loading padder, C42, to behind the 80-meter loading padder, C46. The final position is shown in **fig. 10**. Why the inside tube should run hotter is not obvious. Nevertheless, the inside tube *does* run hotter, and moving the thermal switch makes sense. Perhaps the bandswitch disturbs the airflow. You may wish to replace the cooling fan; after extensive evaluation of cooling fans, the Rotron WR2A1 "Whisper" is highly recommended. It is both quiet and efficient. I also removed R20, a 500-ohm, 10-watt resistor, from the thermal sensor circuit. When I removed R20 and rewired around it, I saved the thermal strip and remounted it to the bottom of the chassis below the 40-meter loading capacitor, C42, using C42's mounting screw. This terminal strip is used in the ALC circuit and is shown at the top center of **fig. 7**. Fifty milliamperes, the new maximum grid current, represents only one-twentieth scale on the original MLA-2500 meter. By replacing the grid shunt, R19, with a 10-ohm, 2-watt resistor and adding a 1-kilohm, 1/4-watt resistor in series with the grid meter line, the full-scale meter reading is increased to 100 mA. As a benefit, enough voltage is available across the new grid shunt to activate the new ALC circuit shown in **fig. 5** of part 1. (**Fig. 6** of Part One of this article shows the construction technique used and **fig. 7** of Part One shows the mounting to the pushbutton mounting nuts.)

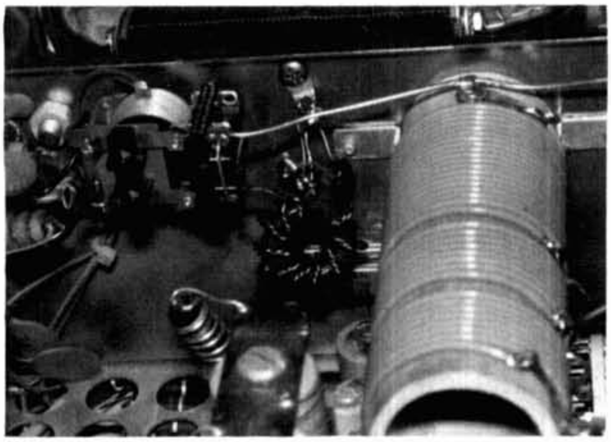


fig. 4. MLA-2500B input relay area shows toroid connections and mounting to ground lug and relay terminal. Compensating capacitor is visible at top of toroid.

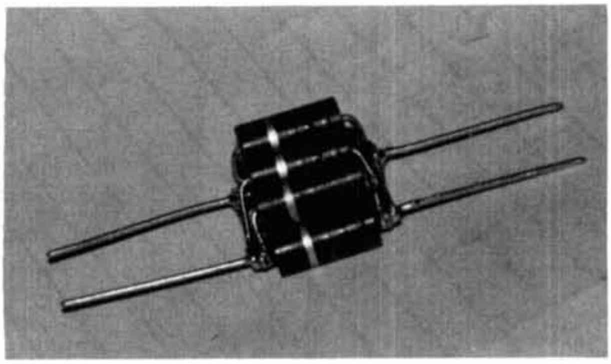


fig. 5. Construction technique for seven-resistor pack.

I used the ground lug on the remounted terminal strip to provide a ground for the new grid shunt, R19, and to provide a terminal point at which to connect

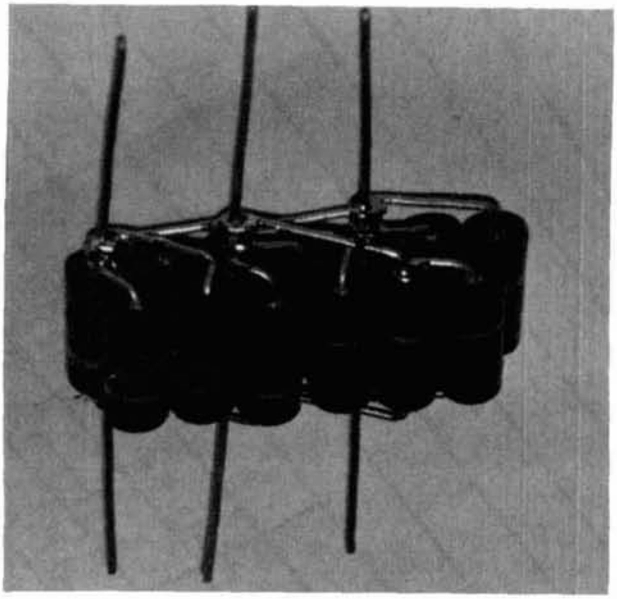


fig. 6. Construction technique used for thirteen-resistor pack.

the grid meter line to the new series metering resistor, a 1-kilohm, 1/4-watt resistor. A new wire was added inside the wiring harness from the grid line to the area of the function switch mounting nuts. Using terminal strips modified in Dentron fashion and discrete components I constructed the basic circuit shown before. The −18 VDC required was obtained by a simple modification to the power supply board, PC-1002. Later model MLA-2500s do not have the 120 VAC winding shown on the schematic. If your unit has a black wire connected to pin No. 3 on the bottom of power supply board, PC-1002, unsolder the wire and tape it back. If your unit has a C32 capacitor installed, remove it. Remove the line going to pin No. 1 bottom — if it exists — and pull it back to the ALC circuit construction area. If no line exists between the ALC and power supply boards, run an additional wire in the harness to connect the ALC board to the new ALC circuit.

On the power supply board, PE-1002, install the new C32 capacitor, observing polarity. Diode CR16 may or may not be present. Use the old CR16 or any general purpose power diode. It may be most convenient to tack solder CR16 in from the 1/T, 2/B (12 VAC) trace on the power supply board to the 1/B terminal trace to which C32 is soldered, refer to part 1, **Fig. 5** for schematic representation. Carefully locate the lines to the transmit light, X-2, and unsolder them from the power supply board. You may wish to use part of the excess wire connecting X-2 to the new ALC circuit for the new line connecting the 1/B (−18 VDC) terminal to the ALC circuit. After connecting X-2, the power supply board, and the new ALC circuit, only the ALC board, PC-1004, remains to be modified.

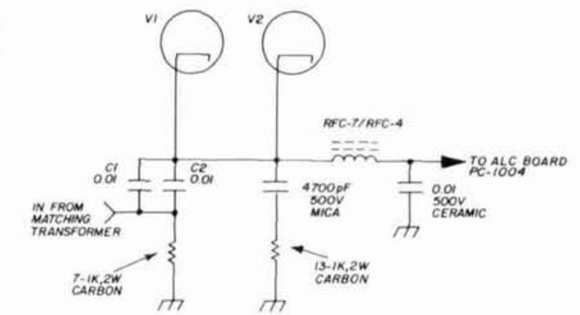


fig. 7. Schematic representation of connections from tube cathodes to new swamping resistor packs and remounted cathode choke.

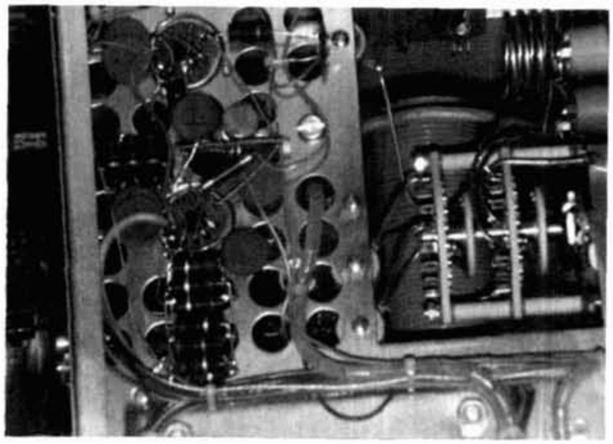


fig. 8. Installation of resistor packs clearly shown in spaces between tube sockets and wiring harness. Note remounted terminal strip for grid shunt and meter multiplier at top right of photograph.

fig. 9. Original mounting of thermal sensor.

modifying the ALC board

Remove C22, RFC3 (if present), and R10 from the ALC board, PC-1004. Replace R12 with a 1-kilohm,

fig. 10. Remounted thermal sensor positioning.

1/4-watt resistor. Tack solder the old R12, a 27-kilohm, 1/4-watt resistor, from the input, pin No. 2, trace to ground. Using R10's terminals, correctly remount CR18 in the circuit. This completes the modifications. Check the ALC circuit by insuring that the transmit light, X-2, comes on at 55-60 mA of grid current; −8 VDC should appear at the ALC jack simultaneously with X-2's illumination. The new ALC circuit provides protection from accidental or transient overdrive when connected to the exciter. The input swamping and matching circuit helps limit the maximum grid current available. The increased sensitivity of the grid meter and X-2's visual indication prove powerful tools in preventing accidental or transient overdrive. The ALC circuit should act in concert with the change in cooling to protect the tubes under almost any operating conditions.

"Inadequate warm-up time is something these modifications cannot protect against. Four or five minutes has been found to be a practical minimum. Internal tube arcing can occur even though Eimac's specification sheet calls for sixty second minimum and the MLA provides seventy-five seconds. Increasing the time for warm-up can unquestionably save your tubes."

acknowledgment

I wish to thank Tom Keadle, W8EII, for the photographs and Rodger Miller, KC8DA, for the use of his amplifier.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

shortwave circus

As time goes by, more and more modern HF transceivers come off the production line with the capability to receive the range of 100 kHz to 30 MHz built right in. This has opened up a whole new world to Amateurs who thought that the shortwave spectrum ended at the edges of the ham bands.

It's fun to tune the spectrum; no wonder the SWL hobby has grown so rapidly over the past few years. There are lots of interesting signals to hear in the HF range!

The most obvious signals come from the shortwave broadcast stations; there are plenty of them, and most of them are listed by frequency and operating hours in the *World Radio Handbook*.[1] Even the casual observer will find other signals: point-to-point transmissions, ship-to-shore, aircraft, military, RTTY, FAX, and so on. SWL magazines provide, on occasion, lists of these interesting transmissions.

In a few days' listening time, you can gain a good idea of what is going on outside the ham bands, as far as legal, recognized transmission goes. But an even more interesting field to explore is that category of transmissions that are undercover, clandestine, or modified in such a way that the casual listener cannot comprehend the transmitted information. And then, there are other signals . . .

things that go bump in the night

The shortwave spectrum is full of incomprehensible and confusing signals that whet the interest of the serious listener. Some of these signals are quite loud and easily found.

Sweepers. One of the most common "mystery" signals is the sweeper. This is an unsteady carrier, loud and rough. It "sweeps" through your receiver quite rapidly, as though someone had tuned a wobbly VFO across your listening frequency. These signals, most noticeable in the 14 and 26 MHz regions of the spectrum, are in fact emitted from large, industrial heat-treating machines used in the plastics industry, making water beds, furniture, dishes, and other sundries. These industrial RF oscillators run upwards of 100 kW and shift frequency as the manufacturing process advances. While they *should* be in the ISM (Industrial-Scientific and Medical) assignments at 13.56 MHz and 27 MHz, they seem to roam the spectrum at will.

I spoke to the operator of such an oscillator once. He told me that he was an avid CBer who made sure his oscillator never landed in the CB channels (that's a Goody Buddy, for you!).

Many other industrial RF oscillators exist for various purposes, and most of them radiate — sometimes badly. They're often operated by untrained personnel who have little concern for radiation. The minimal shielding on these machines is frequently removed to facilitate easy loading and unloading of the material they are designed to process.

Woodpeckers. Most hams are familiar with the obnoxious woodpecker signals that infest the Amateur bands. They exist in force too, on other frequencies. At least four such signals exist; they are over-the-horizon, high power backscatter radars operated by the Soviet Union. With the United States as the target, the radars search for telltale missile trails and other interesting reflections of military importance to the Soviet radar operators.

Repeated protests about the disruptive effects of these long-distance radars have been lodged with the USSR. The extreme power of these devices, plus the sharp wavefront, make them a pest to all users of the HF spectrum.

Five-letter "numbers" groups. It won't take you long to find the 5-letter mystery stations. These can be SSB, AM, or CW signals that transmit code groups at length, with no recognizable identification. On voice, the transmissions may be in English, Spanish, or German. The voice repeats 5-letter code groups of numbers or letters. The most numerous are the "numbers" stations. A typical message sounds like: "83457-90030-45089-10019-63345," and so on; often the message is repeated again and again. No station identification is ever given. Some stations repeat a series of letters in the phonetic alphabet instead of numbers, and others mix numbers and letters. Who are these stations? Where are they? And what are they doing?

"Spook" transmission. Harder to find are the two-way "spook" signals. (A good place to look for these is just above the 10 MHz Amateur assignment.) You'll hear two-way CW conversations at about 8 to 10 WPM (very poorly sent, by the way). A typical transmission will run: "AJ23 AJ23 DE 64Z QRK?" Then the other station will reply, "64Z DE AJ23 QRK 5 GA." Then the coded message will start. (Just after the 10 MHz assignment opened for Amateurs, I ran across a pair of spooks trying to work each other. They were both S7 but they had a terrible time, stumbling around, trying to make contact. I couldn't resist, and broke in with a "QRK 5 GA PSE." This *really* upset the spooks. They frantically signalled each other, and in a burst of poorly sent CW, moved out of the Amateur assignment.) Careful listening will reveal a myriad of these signals, many of them coming from Central America.

Scientific sounders. You'll find a lot of more routine signals, too. Ionospheric sounders run up and down the spectrum, sounding like a string of dots passing quickly across your listening frequency. Others are more sophisticated and have a more complex sound. An interesting trio of stations used to monitor potential earthquake activity in California can be found on 5.115 MHz, 3.395 MHz, and 10.163 MHz. Located along a major fault, each station transmits a steady carrier (without identification), and the signals are observed at a monitoring point in Utah. When an earthquake occurs, the ionosphere above the quake area is disturbed; by closely observing the signals, investigators can learn much about the relationship between earthquakes and the accompanying ionospheric disturbance.

In this same vein, certain obscure data is transmitted by some AM broadcast stations that employ a 20 Hz FSK on their carrier. One station that does this is KNX in Los Angeles (1070 kHz).

The single-letter beacons (SLB). Of great interest to some listeners are the so-called single-letter beacons, which have been on the air for up to 20 years with little publicity. One or two of these are in the ham bands.[2] On the west coast, in the early morning hours when conditions are good, the SLB on about 3979 kHz is quite loud. It simply sends the Morse letter K about every four seconds in FSK. It can be quite annoying to early-morning nets on this channel.

Many other SLBs exist across the HF spectrum. Some are on-off keyed, others are FSK. Many of the latter use the Eastern European shift of 1 kHz, which suggests Soviet origin. The SLBs send different individual letters, and sometimes will send a short burst of five number code groups at about 20 WPM, then return to the carrier or the keyed letter. A large number of beacons, fading in and out with the skip, have been logged in the United States.

One set of beacons is particularly interesting, since they are well received on the west coast. This set comprises a number of *K* beacons. The beacons are keyed FSK simultaneously and are on 9.043, 11.156, 12.152, 14.478, 14.968, 18.086, and 18.349 kHz (approximately). Signal arrival indicates that the beacon set is located in Siberia, possibly on the Kamchatka penisula.

There are plenty of SLBs on the air, as the footnote indicates, and they seem to be heard all over the world. What is their purpose? Where are they? What messages do they convey? And who are the recipients? Your guess is as good as mine.

"Cut-number" stations. Some unidentified CW stations, in addition to sending coded messages, encode the numbers in the message. The transmissions sound like letter groups when they are really number groups. For example, the digit 1 is sent as A. 2 as U, 3 as V, 5 as E, and so on. This can be quite confusing to the casual listener.

Spread-spectrum signals. Various forms of wideband transmissions can be logged in the HF spectrum. One subtle form sounds like "white noise" on a receiver. This hiss occupies about 100 to 200 kHz of spectrum space. For some time such a signal was apparent in the high frequency end of the 20-meter phone band, but nobody seemed to notice it. Along with the Swedish Amateur who first pointed it out to me, I ran a directional plot on it and found that it seemed to be coming from England, as far as we could determine. In recent years, the signal has moved out of the 20-meter band.

Another form of spread-spectrum transmission is noticed by the perceptive observer as bits and pieces of voice transmission that occasionally pop up on your receiver. Each burst is very short; only fractions of words can be heard. The signal is obviously jumping around at a very fast rate!

"Junk" signals. A few minutes listening to the HF spectrum reveals an amazing quantity of sloppy signals. It seems as if all the old World War II surplus transmitters must be on the air somewhere. For years Amateurs on the west coast were plagued by slurpy, burpy coded CW signals that jammed the 80-meter band during the early morning hours. Most of the transmissions were in Chinese. Some are still on the air. Many South and Central Americans use ham gear as telephone links between isolated locations. The 10-meter FM channels are occasionally blocked by Spanish-language signals carrying on telephone-type conversations.

A quiet scandal (seemingly ignored by the FCC) is the proliferation of illegal CB-type operations between 27 and 28 MHz. The casual listener will soon pick out loud signals, some of whom run kilowatts of SSB power into large beam antennas. Not long ago one such illegal operator boasted that he had worked over 90 countries with his illegal transmissions.

Another collection of "junk signals" exists just outside the low frequency end of the 160-meter band. These are the wireless telephones which transmit frequency modulated signals in the span of 1650 kHz to 1800 kHz. Some of them operate right up into the low end of the 160-meter Amateur assignment. With a good antenna in a quiet location, a wireless phone can be heard for up to 10 miles. I wonder if the users of these phones know that they are furnishing amusement to casual eavesdroppers?

"Free-radio" broadcasting. Do you like to play music on the air? Join the free-radio broadcasters and play hide-and-seek in the radio spectrum! One popular frequency for pirate broadcasters is 1605 kHz, just outside the top end of the broadcast band. Others pop up on various frequencies near the short wave broadcast bands, and a few operate in the 88-108 MHz FM band. Although pirate broadcasters are quite rare in the United States, many exist in Europe. Because they vary frequency and time of broadcast, they are difficult to pinpoint, but many send QSLs for reception reports! The FCC is quick to crack down on pirate broadcasters, and it is not easy to spot one operating in the United States.

Soviet jammers. One of the major occupants of the international broadcasting bands transmits only noise, in a deliberate attempt to prevent listeners from hearing the program material on certain frequencies. It has been estimated that there are more than 2,000 jamming transmitters, located principally in the USSR, Bulgaria, Czechoslovakia, and Poland, aimed at the local language broadcasts beamed behind the "Iron Curtain" from the west. Illegal or not, they are a reality. Some sound like a buzzsaw, others a rhythmic whine. Many are quite broad. The majority have identification signals, such as ZG or U7 which are sent in slow-speed Morse.

To make matters more interesting, Soviet broadcasts to China are jammed by the Chinese. Sometimes this jamming takes the form of taped music played backward! What next?

Illicit drug trade. Because HF radio is widely used by drug smugglers, the alert listener can occasionally run across transmissions dealing with this underground activity. These messages, mainly on SSB, are generally in English or Spanish. Nicknames are used instead of calls, and most of the traffic seems to occur between 4 MHz and 14.5 MHz, often just outside an Amateur band.

Good stuff, too! Aside from this long list of assorted follies and undesirables, there are many other interesting things to monitor outside the Amateur bands: point-to-point RTTY for the news services of the world, airline networks, weather broadcast, military, MARS (Military Affiliate Radio Stations), Coast Guard, and INTERPOL. The list goes on and on. The point is that there's plenty going on outside the Amateur bands.[3] Exploring these regions is a fascinating undertaking. You'll be suprised at what you can hear! Good listening!

references

1. J.M. Frost, Editor, *World Radio and TV Handbook*, 38th Edition, available from Ham Radio's Bookstore, Greenville, N. H. 03048 ($20 postpaid).
2. Observed frequencies of some of the SLBs heard on the west coast are (in MHz): 3.979, 4.006, 6.227, 7.512, 7.557, 8.138, 8.146, 8.646, 9.043, 9.058, 10.645, 11.156, 12.152, 12.185, 12.329, 13.329, 13.638, 14.478, 14.968, 17.016, 18.016, and 18.349 (all frequencies plus or minus 2 kHz).
3. For more information on activity in the radio spectrum, see *Popular Communications*, published monthly by Popular Communications Publishing Group, 76 North Broadway, Hicksville, New York 11801.

ham radio

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packet radio: the software approach

AX.25, 1200 baud packet on the TRS-80 Models I and III

There have been a number of excellent articles[1,2] published recently on the new Tucson Amateur Packet Radio (TAPR) AX.25 protocol terminal node controller (TNC). This TNC communicates with a host microcomputer over an RS-232C or parallel interface and includes its own 6809 microprocessor, 32K of EPROM, 8K dynamic RAM, an SDLC/HDLC controller, an RS-232 UART, and a number of ancillary support chips. It is, in essence, a complete dedicated packet microcomputer.*

There is yet another approach to 1200 baud synchronous packet using the AX.25 protocol: a software approach for the TRS-80 Model I or Model III that eliminates the TNC's dedicated 6809 microprocessor, SDLC/HDLC controller, 32K of EPROM, 8K of RAM, RS-232C UART, and all ancillary support chips.

Like the TAPR TNC, the software approach requires a 1200 baud modem using the EXAR 2206/2211 AFSK modulator/demodulator chips. It also requires a port zero encoder/decoder as an interface between the TRS-80 microcomputer and the outside world. Both the modem and port zero encoder/decoder may be homebrewed for a total cost for parts of approximately $25 to $30.

The balance of this article describes the three fundamental software subroutines used to do the following:

- convert the computer's parallel 8-bit byte to a 1200 baud synchronous serial data stream with real-time zero insertion where necessary during transmission.
- convert the 1200 baud incoming synchronous data stream to parallel 8-bit bytes with zero deletion in real-time during reception.
- virtual real-time cyclic redundancy checking (CRC) of incoming packet frames and CRC generation for transmitted packet frames.

1200 baud transmit parallel byte-to-serial bit conversion

This is illustrated in the relatively simple subroutine in **fig. 1**'s commented source code. All opening and closing flags are generated by **CALLing SN1A** with the unique 126 decimal flag byte in the 'A' register. Call SN1A at least 60 or 70 times for the first frame's opening flags, once for frame separator flags (in a multi-frame packet the closing flag for one frame serves as the opening flag for the next frame), and call it once for the entire packet's closing flag.

To transmit data between opening and closing flags that may require zero insertion, CALL SN1 with the data byte in the 'A' register. Either SN1A or SN1 must be called sequentially with a maximum delay between calls of about 40 microseconds so as not to disrupt the timing of the serial synchronous data stream.

1200 baud receive serial bit-to-parallel byte conversion

Figure 2's commented source code shows the subroutine that converts the incoming 1200 baud synchronous bit stream to parallel 8-bit data bytes with zero deletion where necessary. Most of the Z-80's regular and alternate registers are used by the IN1 routine (originally created by W2EUP). This routine is

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*Available in kit form from the TAPR group, $247 prepaid. The kit is of superb quality and workmanship and may be assembled by the average Radio Amateur with modest kit building experience in eight to ten hours. Contact Tucson Amateur Packet Radio, Inc., P.O. Box 22888, Tucson, Arizona 85734 for information.

fig. 1. 1200 baud SDLC/HDLC fundamental transmit subroutine.

```
00100 ;                        FIGURE 1
00110
00120 ; 1200 BAUD SDLC/HDLC FUNDAMENTAL TRANSMIT SUBROUTINE
00130
00140 ; FLAGS ARE TRANSMITTED BY CALLING SN1A WITH 126 IN
00150 ; THE 'A' REGISTER......NO ZERO INSERTION IS REQUIRED.
00160
00170 ; DATA BYTES THAT MAY REQUIRE ZERO INSERTION ARE TRANS-
00180 ; MITTED BY CALLING SN1 WITH THE DATA IN 'A' REGISTER.
00190
00200 ; LINE 1620 'SPEED' SHOULD = 98 DECIMAL FOR THE MODEL
00210 ; I AND 115 DECIMAL FOR THE MODEL III'S FASTER CLOCK.
00220
00230
00240 SN1     LD      D,A             ;BYTE VALUE TO TRANSMIT
00250         LD      E,8             ;NUMBER OF BITS PER BYTE
00260 SN2     LD      A,(LASONE)      ;1 = SPACE & 5 = MARK
00270         CP      1               ;WAS IT A SPACE ?
00280         JP      Z,LASTSP        ;IF SO, GOTO LAST SPACE
00290         BIT     0,D             ;SET Z FLAG FOR BIT ZERO
00300         CALL    NZ,MARK         ;IF NOT ZERO SEND MARK
00310         BIT     0,D             ;SET Z FLAG FOR BIT ZERO
00320         CALL    Z,SPACE         ;IF ZERO SEND SPACE
00330         NOP                     ;2 USEC TIMING ADJUST
00340         DEC     E               ;-1 FROM BIT COUNTER
00350         RET     Z               ;IF ZERO, GET NEXT BYTE
00360         RRC     D               ;RIGHT SHIFT ALL 1 BIT
00370         JP      SN2             ;GO BACK FOR NEXT BIT
00380 LASTSP  BIT     0,D             ;SET Z FLAG FOR BIT ZERO
00390         CALL    NZ,SPACE        ;IF NOT ZERO SEND SPACE
00400         BIT     0,D             ;SET Z FLAG FOR BIT ZERO
00410         CALL    Z,MARK          ;IF ZERO SEND MARK
00420         NOP                     ;2 USEC TIMING ADJUST
00430         DEC     E               ;-1 FROM BIT COUNTER
00440         RET     Z               ;IF ZERO, GET NEXT BYTE
00450         RRC     D               ;RIGHT SHIFT ALL 1 BIT
00460         JP      SN2             ;GO BACK FOR NEXT BIT
00470 SPACE   LD      A,5             ;SEND SPACE TONE
00480         OUT     (0),A           ;VIA PORT ZERO
00490         XOR     A               ;ZERO OUT 'A' REGISTER
00500         LD      (ZEROMK),A      ;AND ZERO MARK COUNTER
00510         LD      A,(SPEED)       ;COUNTDOWN VALUE
00520         LD      HL,SPACEA       ;RETURN MEM LOCATION
00530         PUSH    HL              ;PUSH ON TOP OF STACK
00540         LD      HL,DECSP        ;JP (HL) ADDRESS
00550 DECSP   DEC     A               ;-1 COUNTDOWN VALUE
00560         RET     Z               ;GOTO SPACEA WHEN ZERO
00570         JP      (HL)            ;JUMP TO DECSP
00580 SPACEA  LD      A,(LASONE)      ;PREVIOUS BIT SENT
00590         CP      5               ;WAS IT A MARK ?
00600         JP      Z,SPACEB        ;IF SO, DON'T COUNT IT
00610         LD      A,(ZEROSP)      ;SPACE COUNTER STASH
00620         INC     A               ;+1 TO SPACE COUNTER
00630         CP      5               ;5 SPACES IN A ROW ?
00640         JP      Z,SPACEC        ;IF SO, DO ZERO INSERTION
00650         LD      (ZEROSP),A      ;IF NOT, SAVE NEW VALUE
00660         NOP                     ;2 USEC TIMING ADJUST
00670         RET                     ;RETURN WHENCE U CAME +1
00680 SPACEB  LD      A,1             ;SINCE NOT SAME CHANGE IT
00690         LD      (LASONE),A      ;UPDATE LASTONE
00700         NOP                     ;EQUALIZING DELAY
00710         NOP                     ;EQUALIZING DELAY
00720         NOP                     ;EQUALIZING DELAY
00730         RET                     ;RETURN WHENCE U CAME +1
00740 SPACEC  LD      A,1             ;1 = SPACE & 5 = MARK
00750         LD      (LASONE),A      ;UPDATE LASTONE
00760         LD      BC,1            ;DELAY - NO SN2 ITERATION
00770         CALL    060H            ;APPROX. 30 MICROSECONDS
00780         CALL    MARK            ;DO ZERO INSERTION
00790         XOR     A               ;ZERO OUT 'A' REGISTER
00800         LD      (ZEROMK),A      ;AND ZERO MARK COUNTER
00810         RET                     ;RETURN WHENCE U CAME +1
00820 SPACE1  LD      A,5             ;SPACE1 ONLY FOR FLAG
00830         OUT     (0),A           ;SPACE TONE PORT ZERO
00840         LD      A,1             ;1 = SPACE & 5 = MARK
00850         LD      (LASONE),A      ;UPDATE LASTONE
00860         XOR     A               ;ZERO OUT 'A' REGISTER
00870         LD      (ZEROMK),A      ;AND ZERO MARK COUNTER
00880         LD      A,(SPEED)       ;COUNTDOWN VALUE
00890         LD      HL,DECSP1       ;JP (HL) ADDRESS
00900 DECSP1  DEC     A               ;-1 COUNTDOWN VALUE
00910         RET     Z               ;RETURN WHENCE U CAME +1
00920         JP      (HL)            ;JUMP TO DECSP1
00930 MARK    LD      A,1             ;SEND MARK TONE
00940         OUT     (0),A           ;VIA PORT ZERO
00950         XOR     A               ;ZERO OUT 'A' REGISTER
00960         LD      (ZEROSP),A      ;AND ZERO SPACE COUNTER
00970         LD      A,(SPEED)       ;COUNTDOWN VALUE
00980         LD      HL,MARKA        ;RETURN MEM LOCATION
00990         PUSH    HL              ;PUSH ON TOP OF STACK
01000         LD      HL,DECMK        ;JP (HL) ADDRESS
01010 DECMK   DEC     A               ;-1 COUNTDOWN VALUE
01020         RET     Z               ;GOTO MARKA WHEN ZERO
01030         JP      (HL)            ;JUMP TO DECMK
01040 MARKA   LD      A,(LASONE)      ;PREVIOUS BIT SENT
01050         CP      1               ;WAS IT A SPACE ?
01060         JP      Z,MARKB         ;IF SO, DON'T COUNT IT
01070         LD      A,(ZEROMK)      ;MARK COUNTER STASH
01080         INC     A               ;+1 TO MARK COUNTER
01090         CP      5               ;5 MARKS IN A ROW ?
01100         JP      Z,MARKC         ;IF SO, DO ZERO INSERTION
01110         LD      (ZEROMK),A      ;IF NOT, SAVE NEW VALUE
01120         NOP                     ;2 USEC TIMING ADJUST
01130         RET                     ;RETURN WHENCE U CAME +1
01140 MARKB   LD      A,5             ;SINCE NOT SAME CHANGE IT
01150         LD      (LASONE),A      ;UPDATE LASTONE
01160         NOP                     ;EQUALIZING DELAY
01170         NOP                     ;EQUALIZING DELAY
01180         NOP                     ;EQUALIZING DELAY
01190         RET                     ;RETURN WHENCE U CAME +1
01200 MARKC   LD      A,5             ;1 = SPACE & 5 = MARK
01210         LD      (LASONE),A      ;UPDATE LASTONE
01220         LD      BC,1            ;DELAY - NO SN2 ITERATION
01230         CALL    060H            ;APPROX. 30 MICROSECONDS
01240         CALL    SPACE           ;DO ZERO INSERTION
01250         XOR     A               ;ZERO OUT 'A' REGISTER
01260         LD      (ZEROSP),A      ;AND ZERO SPACE COUNTER
01270         RET                     ;RETURN WHENCE U CAME +1
01280 MARK1   LD      A,1             ;MARK1 ONLY FOR FLAG
01290         OUT     (0),A           ;SEND MARK TONE
01300         LD      A,5             ;1 = SPACE & 5 = MARK
01310         LD      (LASONE),A      ;UPDATE LASTONE
01320         XOR     A               ;ZERO OUT 'A' REGISTER
01330         LD      (ZEROSP),A      ;AND ZERO SPACE COUNTER
01340         LD      A,(SPEED)       ;COUNTDOWN VALUE
01350         LD      HL,DECMK1       ;JP (HL) ADDRESS
01360 DECMK1  DEC     A               ;-1 COUNTDOWN VALUE
01370         RET     Z               ;RETURN WHENCE U CAME +1
01380         JP      (HL)            ;JUMP TO DECMK1
01390 SN1A    LD      D,A             ;SN1A ONLY FOR FLAG
01400         LD      E,8             ;NUMBER OF BITS PER BYTE
01410 SN2A    LD      A,(LASONE)      ;1 = SPACE & 5 = MARK
01420         CP      1               ;WAS IT A SPACE ?
01430         JP      Z,LASSP         ;IF SO, GOTO LAST SPACE
01440         BIT     0,D             ;SET Z FLAG FOR BIT ZERO
01450         CALL    NZ,MARK1        ;IF NOT ZERO SEND MARK
01460         BIT     0,D             ;SET Z FLAG FOR BIT ZERO
01470         CALL    Z,SPACE1        ;IF ZERO SEND SPACE
01480         DEC     E               ;-1 FROM BIT COUNTER
01490         RET     Z               ;IF ZERO, GET NEXT BYTE
01500         RRC     D               ;RIGHT SHIFT ALL 1 BIT
01510         JP      SN2A            ;GO BACK FOR NEXT BIT
01520 LASSP   BIT     0,D             ;SET Z FLAG FOR BIT ZERO
01530         CALL    NZ,SPACE1       ;IF NOT ZERO SEND SPACE
01540         BIT     0,D             ;SET Z FLAG FOR BIT ZERO
01550         CALL    Z,MARK1         ;IF ZERO SEND MARK
01560         DEC     E               ;-1 FROM BIT COUNTER
01570         RET     Z               ;IF ZERO, GET NEXT BYTE
01580         RRC     D               ;RIGHT SHIFT ALL 1 BIT
01590         JP      SN2A            ;GO BACK FOR NEXT BIT
01600 ZEROSP  DEFB    0               ;SPACE COUNTER STASH
01610 ZEROMK  DEFB    0               ;MARK COUNTER STASH
01620 SPEED   DEFB    98              ;MODEL 3 USE 115 DECIMAL
01630 ; - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
01640 ; END OF FUNDAMENTAL 1200 BAUD TRANSMIT SYNC. CONVERSION
```

entered in line 560 with the first data byte in the 'A' register after the last opening flag was received.

The software digital phase locked loop in lines 980 through 1330 is the author's favorite and is the one used in Volume I of *Synchronous Packet Radio Using The Software Approach*. This DPLL accommodates 1200 baud signals whose timing is off about plus or minus 10 percent from the norm.

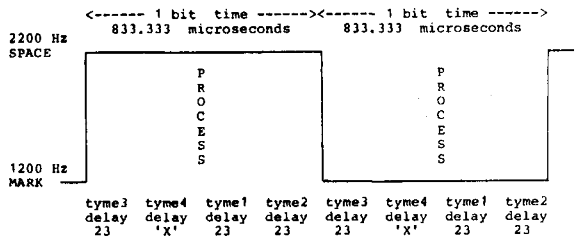
software digital phase-locked loop

Figure 3 shows two 1200 baud, bit time frames where the incoming signal has changed from a space to a mark. In SDLC/HDLC it is not the absolute value of a mark or space that counts. It is only the relative change from the previous bit that determines whether it is a logical 1 or logical zero.

The software digital phase-locked loop is divided into quadrants much like its hardware counterpart, the Intel 8273 synchronous data link controller chip. But it is somewhat different in that there is no "dead band" between tyme 2 and tyme 3. If the transition occurs during tyme 2, a bit early from the last PROCESSing, the countdown time delay from tyme 4 is decreased slightly so that the next PROCESSing between tyme 4 and tyme 1 will be closer to dead center. If the transition occurs during tyme 3, a bit late from the last PROCESSing, the countdown time delay for tyme 4 is increased slightly so that the next PROCESSing between tyme 4 and tyme 1 will be closer to dead center. Any transitions during tyme 1 or tyme 4 dramatically decrease or increase, respectively, the countdown time delay to quickly bring the software DPLL back into correct synchronization.

Ideally, the software DPLL countdown values for fig. 2. Receive mode real-time SDLC/HDLC serial synchronous date stream to parallel decimal byte conversion.

```
00100 ;                    FIGURE 2
00110
00120 ; RECEIVE MODE REAL-TIME SDLC/HDLC SERIAL SYNCHRONOUS
00130 ; DATA STREAM TO PARALLEL DECIMAL BYTE CONVERSION.
00140
00150 ; THE REGISTERS USED IN THIS RECEIVE MODE SUBROUTINE ARE:
00160
00170 ; REGULAR REGISTERS:
00180
00190 ; A = USED + NEW PORT ZERO VALUE IN EACH DPLL QUADRANT
00200 ; F = USED THROUGHOUT
00210 ; B = DPLL COUNTDOWN VALUE FOR FIRST 3 DPLL QUADRANTS
00220 ; C = 8 BITS PER BYTE COUNTER
00230 ; D = CALCULATED DPLL COUNTDOWN VALUE FOR 4TH QUADRANT
00240 ; E = LAST PORT ZERO VALUE
00250 ; HL= MEM LOCATION TO STORE ENDING FLAG ADDRESS
00260 ; IX= ONLY FOR EQUALIZING TIME DELAYS; INC IX & DEC IX
00270 ; IY= UNUSED
00280
00290 ; ALTERNATE REGISTERS:
00300
00310 ; A = UNUSED
00320 ; F = UNUSED
00330 ; B = RECEIVED PARALLEL BYTE WITH ZERO-DELETION
00340 ; C = RECEIVED PARALLEL BYTE WITHOUT ZERO-DELETION
00350 ; D = INCOMING BIT VALUE AT CENTER OF BIT TIME FRAME
00360 ; E = LAST BIT VALUE AT CENTER OF BIT TIME FRAME
00370 ; HL= MEM LOCATION TO STORE CONVERTED DECIMAL BYTE
00380
00390 ; THIS SUBROUTINE IS ENTERED IN LINE 700 WITH THE FIRST
00400 ; ASSEMBLED DATA BYTE IN 'A' REGISTER AFTER THE LAST
00410 ; OPENING FLAG HAS BEEN RECEIVED.
00420
00430 ; THE SOFTWARE DIGITAL PHASE LOCKED LOOP (DPLL) IS AT THE
00440 ; END OF THIS SUBROUTINE IN LINES 980 THROUGH 1330.
00450
00460 IN1     BIT     0,A             ;PACKET TONES DROPPED ?
00470         JP      Z,MOVEM+1       ;IF SO, PROCESS IT.
00480         EXX                     ;SWAP ALTERNATE REGISTERS
00490         LD      D,A             ;INCOMING BIT VALUE TO D
00500         XOR     E               ;COMPARE WITH LAST ONE
00510         LD      E,D             ;UPDATE E FOR NEXT TIME
00520         CPL                     ;DATA IN BIT 7
00530         RLCA                    ;SHIFT INTO CARRY
00540         RR      B               ;OUTPUT DATA -
00550         RRCA                    ;ACCUMULATES HERE.
00560         RR      C               ;INCOMING BIT PATTERN
00570         LD      A,C             ;TEST IT
00580         CP      126             ;FOR A CLOSING FLAG ?
00590         JP      Z,FL1           ;IF SO, GOTO LINE 760
00600         CP      254             ;PACKET TONES DROPPED ?
00610         JP      Z,MOVEM         ;IF SO, PROCESS IT
00620         AND     254             ;REMOVE BIT ZERO
00630         CP      124             ;0111110X PATTERN ?
00640         JP      Z,DELETE        ;IF SO, DO ZERO DELETION
00650         LD      A,B             ;BUILT UP DATA VALUE
00660         EXX                     ;RESTORE REG. REGISTERS
00670         DEC     C               ;DECREMENT BIT COUNTER
00680         JP      NZ,IN4          ;NOT ZERO, GET NEXT BIT
00690 IN1A    NOP                     ;DO NOTHING AT ALL
00700         EXX                     ;SWAP ALTERNATE REGISTERS
00710         INC     HL              ;CONVERTED BYTE LOCATION
00720 IN2     LD      (HL),A          ;STASH IT IN MEMORY
00730         LD      A,H             ;TOO LONG A PACKET ?
00740         CP      176             ;OVER 4096 BYTES LONG ?
00750         JP      Z,MOVEM-3       ;IF SO, PROCESS IT
00760 IN3     EXX                     ;RESTORE REG. REGISTERS
00770         LD      C,8             ;RESET BITS/BYTE COUNTER
00780 IN4     CALL    TYME            ;DIGITAL PHASE LOCK LOOP
00790         JP      IN1             ;CONVERT INCOMING BIT
00800 FL1     PUSH    HL              ;GOT A CLOSING FLAG
00810         EXX                     ;RESTORE REG. REGISTERS
00820         POP     BC              ;FLAG LOCATION MINUS ONE
00830         INC     BC              ;FLAG MEM LOCATION
00840         LD      (HL),C          ;STORE FLAG ADDRESS LSB
00850         INC     HL              ;NEXT STORE LOCATION
00860         LD      (HL),B          ;STORE FLAG ADDRESS MSB
00870         INC     HL              ;NEXT STORE LOCATION
00880         LD      A,144           ;OUT OF BOUNDS DUE TO -
00890         CP      H               ;RUN AWAY TNC ?
00900         JP      Z,MOVEM+1       ;IF SO, PROCESS IT
00910         JP      IN3+1           ;ELSE GO FOR NEXT ONE
00920 DELETE  RL      B               ;ZERO DELETION, SO -
00930         EXX                     ;BACKUP ALTERNATE B
00940         INC     (IX)            ;COMPENSATING TIME -
00950         DEC     (IX)            ;DELAY.
00960         CALL    TYME            ;DIGITAL PHASE LOCK LOOP
00970         JP      IN1             ;CONVERT NEXT BIT
00980 TYME    LD      A,(14400)       ;ESCAPE IS CLEAR KEY
00990         CP      2               ;IF PRESSED GOTO -
01000         JP      Z,MENU0-1       ;TRANSMIT MODE.
01010         LD      B,23            ;MODEL I COUNTDOWN VALUE
01020 TYME1   DJNZ    TYME1           ;1ST QUADRANT COUNTDOWN
01030         IN      A,(0)           ;PORT ZERO VALUE TO 'A'
01040         CP      E               ;ANY CHANGE FROM LAST ?
01050         JP      NZ,DEC2         ;IF SO, GOTO LINE 1180
01060         LD      B,23            ;MODEL I COUNDOWN VALUE
01070 TYME2   DJNZ    TYME2           ;2ND QUADRANT COUNTDOWN
01080         IN      A,(0)           ;PORT ZERO VALUE TO 'A'
01090         CP      E               ;ANY CHANGE FROM LAST ?
01100         JP      NZ,DEC1         ;IF SO, GOTO LINE 1210
01110         LD      B,23            ;MODEL I COUNTDOWN VALUE
01120 TYME3   DJNZ    TYME3           ;3RD QUADRANT COUNTDOWN
01130         IN      A,(0)           ;PORT ZERO VALUE TO 'A'
01140         CP      E               ;ANY CHANGE FROM LAST ?
01150         JP      NZ,INC1         ;IF SO, GOTO LINE 1240
01160         LD      B,D             ;ADJUSTED COUNTDOWN VALUE
01170 TYME4   DJNZ    TYME4           ;4TH QUADRANT COUNTDOWN
01180         IN      A,(0)           ;PORT ZERO VALUE TO 'A'
01190         CP      E               ;ANY CHANGE FROM LAST ?
01200         JP      NZ,INC2         ;IF SO, GOTO LINE 1270
01210         RET                     ;DPLL DONE. GO PROCESS IT
01220 DEC2    LD      E,A             ;SAVE NEW BIT IN 'E'
01230         LD      D,15            ;WAY TOO LATE, SO SHORT-
01240         JP      TYME2-2         ;EN LAST QUADRANT COUNT
01250 DEC1    LD      E,A             ;SAVE NEW BIT IN 'E'
01260         LD      D,20            ;TINY BIT TOO LATE, SO -
01270         JP      TYME3-2         ;SHORTEN LAST QUADRANT.
01280 INC1    LD      E,A             ;SAVE NEW BIT IN 'E'
01290         LD      D,24            ;TINY BIT TOO SOON, SO -
01300         JP      TYME4-2         ;LENGTHEN LAST QUADRANT.
01310 INC2    LD      E,A             ;SAVE NEW BIT IN 'E'
01320         LD      D,29            ;WAY TOO SOON, SO -
01330         RET                     ;LENGTHEN LAST QUADRANT.
01340 ; - - - - - - - - - - - - - - - - - - - - - - - - - - - -
01350 ; END OF 1200 BAUD RECEIVE MODE SUBROUTINE
01360
01370 ; IDEALLY THE DPLL WILL OSCILLATE BETWEEN DEC1 & INC1.
01380
01390 ; THE MODEL 3 NORMAL COUNTDOWN VALUE IS 28 FOR B REGISTER
01400 ; IN LINES 1010, 1060, AND 1110. ALL ELSE THE SAME.
```



Where 'X' is the countdown value calculated by the DPLL.

If a bit transition during quadrant 1 next tyme 4 = 15.
If a bit transition during quadrant 2 next tyme 4 = 20.
If a bit transition during quadrant 3 next tyme 4 = 24.
If a bit transition during quadrant 4 next tyme 4 = 29.

fig. 3. 1200 baud software digital phase-locked loop quadrants.

tyme 4 will oscillate between 20 and 24, which is exactly what this software DPLL accomplishes. With the Model 3's faster clock, register B in TYME, TYME1, and TYME2 is set to 28 decimal.

The PROCESSing time between tyme4 and tyme1 should be held to less than 10 percent of the total 1200 baud 833.333 microsecond bit time so as not to further complicate the software DPLL's job.

virtual real-time CRC generation and checking

Figure 4 is the AX.25 Volume 2 program's CRC subroutine with comments. It uses the 'byte-wise' look-up-table approach suggested by Aram Perez[4] and converted by the author to the CRC polynomial used by both the Vancouver and AX.25 protocols. It is *incredibly* fast. That is why we use the term 'virtual' to describe its almost real-time speed. It is exactly 27 times faster than the bit-by-bit CRC'ing described by the author in Volume 1 of *Synchronous Packet Radio Using the Software Approach*.

Unfortunately, there's no "free lunch." The price we have to pay for this lightning-fast speed is the 512 byte look-up table illustrated at the end of **fig. 4**. It is shown as a two-byte word table to conserve space. The label TABLE is in the upper left hand corner at

fig. 4. IBM SDLC CRC generation and CR checking subroutines.

```
00100 ;                    FIGURE 4
00110
00120 ; IBM SDLC CRC GENERATION AND CRC CHECKING SUBROUTINES
00130
00140 ; CRC1 AND CRC2 ARE FOR GENERATING THE 2 BYTE CRC VALUE
00150 ; FOR A FRAME OF (LENG1) BYTES IN LENGTH.  ADDREZ IS THE
00160 ; MEMORY LOCATION OF THE BEGINNING OF THE SINGLE FRAME
00170 ; PACKET TO BE TRANSMITTED.  MULTI-FRAME PACKETS USE A
00180 ; VARIABLE ADDREZ DEPENDING UPON WHERE EACH FRAME IS
00190 ; SEQUENTIALLY LOCATED IN MEMORY.
00200
00210 ; RCRC BEGINNING IN LINE 800 TESTS THE RECEIVED CRC VALUE
00220 ; OF A FRAME STARTING AT (BGINIT) IN MEMORY WITH A TOTAL
00230 ; LENGTH OF 'BC' REGISTER BYTES.  MULTI-FRAME PACKETS OF
00240 ; 1 TO 7 FRAMES/PACKET ARE ACCOMODATED.
00250
00260 ; TABLE BEGINNING AT LINE 970 IS THE LOOK-UP TABLE FOR
00270 ; THE BRILLIANT 'BYTE WISE' CRC SUBROUTINE SUGGESTED BY
00280 ; ARAM PEREZ IN THE THE JUNE '83 ISSUE OF I.E.E.E. MICRO.
00290
00300 CRCVAL  DEFW    0               ;RECEIVE CRC VALUE STASH
00310 ENDCRC  DEFW    0               ;XMIT CRC VALUE STASH
00320 CRC1    LD      HL,ADDREZ       ;BEGIN MESSAGE LOCATION
00330         LD      BC,(LENG1)      ;LENGTH OF FRAME IN BYTES
00340         LD      DE,65535        ;INTIALIZE DIVIDEND 1'S
00350         CALL    CRCT            ;GENERATE CRC LINE 470
00360         CALL    FINCRC          ;SORT/STUFF RIGHT ORDER
00370         LD      A,(SIGN2)       ;DISPLAY CRC VALUE -
00380         CP      1               ;ON VIDEO DISPLAY ?
00390         RET     Z               ;IF NOT, RETURN.
00400         LD      HL,(ENDCRC)     ;IF SO, THEN DISPLAY IT
00410         CALL    DZ              ;ON TOP LINE OF VIDEO.
00420 CRC2    LD      BC,960          ;= 15 LINES OF VIDEO
00430         LD      HL,ADDREZ       ;BEGIN PACKET ADDRESS
00440         LD      DE,15424        ;2ND LINE OF VIDEO
00450         LDIR                    ;DISPLAY MESSAGE SENT
00460         RET                     ;RETURN WHENCE U CAME +1
00470 CRCT    LD      A,(HL)          ;FIRST BYTE TO CRC
00480         INC     HL              ;INCREMENT FOR NEXT ONE
00490         PUSH    BC              ;SAVE BYTES TO CRC
00500         PUSH    HL              ;SAVE NEXT BYTE LOCATION
00510         XOR     E               ;XOR REMAINDER LSB W/'A'
00520         LD      C,A             ;SAVE RESULT IN 'C'
00530         LD      B,0             ;ZERO OUT 'B'
00540         LD      HL,TABLE        ;LOOKUP TABLE LOCATION
00550         ADD     HL,BC           ;ADD BC TO LOCATION
00560         ADD     HL,BC           ;ADD BC TO LOCATION
00570         LD      A,D             ;REMAINDER MSB TO 'A'
00580         XOR     (HL)            ;XOR WITH TABLE VALUE
00590         LD      E,A             ;SAVE RESULT IN 'E'
00600         INC     HL              ;NEXT TABLE LOCATION
00610         LD      D,(HL)          ;SAVE VALUE IN 'E'
00620         POP     HL              ;NEXT BYTE TO CRC MEM
00630         POP     BC              ;NUMBER BYTES TO CRC
00640         DEC     BC              ;LESS ONE
00650         LD      A,B             ;TEST FOR
00660         OR      C               ;ZERO
00670         JP      NZ,CRCT         ; IF NOT, CRC NEXT ONE
00680         RET                     ;ELSE ALL DONE. RETURN
00690 FINCRC  LD      A,E             ;DE = CRC 2 BYTE VALUE
00700         CPL                     ;COMPLEMENT IT
00710         LD      HL,(WHER4B)     ;END OF MESSAGE +1
00720         LD      (HL),A          ;LD 1ST CRC ON MESSAGE
00730         LD      (ENDCRC+1),A    ;AND SAVE IT HERE
00740         INC     HL              ;NEXT MESSAGE LOCATION
00750         LD      A,D             ;SECOND CRC BYTE
00760         CPL                     ;COMPLEMENT IT
00770         LD      (HL),A          ;LD 2ND CRC ON MESSAGE
00780         LD      (ENDCRC),A      ;AND SAVE IT HERE
00790         RET                     ;RETURN WHENCE U CAME +1
00800
00810 RCRC    LD      DE,65535        ;RECEIVE CRC CHECK
00820         LD      HL,(BGINIT)     ;BEGIN FRAME LOCATION
00830         CALL    CRCT            ;CRC ALL INCLUDING CRC
00840         LD      (CRCVAL),DE     ;SAVE REMAINDER IN MEM
00850         LD      HL,61624        ;COMPARE REMAINDER WITH
00860         RST     18H             ;61624 DECIMAL
00870         JP      NZ,BADCRC       ;NOT ZERO = BAD ONE
00880         RET                     ;OK, SO RETURN
00890 BADCRC  POP     AF              ;ADJUST STACK
00900         POP     AF              ;FOR 2 CALLS
00910         LD      IY,37692        ;<BAD CRC> MESSAGE
00920         CALL    SHOWIT          ;DISPLAY ON VIDEO
00930         JP      MODE1A          ;GO AWAIT NEXT PACKET
00940
00950 ; 512 BYTE LOOKUP TABLE FOR BYTE-WISE CRC SUBROUTINE
00960
00970 TABLE   DEFW    0
00980 ; - - - - - - - - - - - - - - - - - - - - - - - - - - -
00990
01000 ; SEE CRC LOOK-UP TABLE BELOW
```

location 1. The table resides sequentially in memory from location 1 through 256 anywhere you wish to put it.

adapting the software approach to non-TRS-80 computers

This is neither a simple nor impossible task if you are a professional assembly language programmer with access to a mini or mainframe computer with cross-assemblers for the more popular microprocessors. Many of the software houses now use this accessory. The alternative is to create your own software approach packet program for your own favorite microcomputer. Hopefully this short article will inspire you to do so.

```
FIGURE 4 CONTINUED
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

This is the 512 bvte CRC lookup table printed out as 256 two
byte words to save space.  The label TABLE is at location 1.

  1 DEFW     0    53 DEFW 30631   105 DEFW 61262   157 DEFW 24293   209 DEFW 54925
  2 DEFW  4489    54 DEFW 26158   106 DEFW 65223   158 DEFW 20332   210 DEFW 50948
  3 DEFW  8978    55 DEFW 21685   107 DEFW 52316   159 DEFW 32247   211 DEFW 62879
  4 DEFW 12955    56 DEFW 17724   108 DEFW 56789   160 DEFW 27774   212 DEFW 58390
  5 DEFW 17956    57 DEFW 48587   109 DEFW 43370   161 DEFW 42250   213 DEFW 37033
  6 DEFW 22445    58 DEFW 44098   110 DEFW 47331   162 DEFW 46211   214 DEFW 33056
  7 DEFW 25910    59 DEFW 40665   111 DEFW 35448   163 DEFW 34328   215 DEFW 46011
  8 DEFW 29887    60 DEFW 36688   112 DEFW 39921   164 DEFW 38801   216 DEFW 41522
  9 DEFW 35912    61 DEFW 64495   113 DEFW 29575   165 DEFW 58158   217 DEFW 23237
 10 DEFW 40385    62 DEFW 60006   114 DEFW 25102   166 DEFW 62119   218 DEFW 19276
 11 DEFW 44890    63 DEFW 55549   115 DEFW 20629   167 DEFW 49212   219 DEFW 31191
 12 DEFW 48851    64 DEFW 51572   116 DEFW 16668   168 DEFW 53685   220 DEFW 26718
 13 DEFW 51820    65 DEFW 16900   117 DEFW 13731   169 DEFW 10562   221 DEFW  7393
 14 DEFW 56293    66 DEFW 21389   118 DEFW  9258   170 DEFW 14539   222 DEFW  3432
 15 DEFW 59774    67 DEFW 24854   119 DEFW  5809   171 DEFW  2640   223 DEFW 16371
 16 DEFW 63735    68 DEFW 28831   120 DEFW  1848   172 DEFW  7129   224 DEFW 11898
 17 DEFW  4225    69 DEFW  1056   121 DEFW 65487   173 DEFW 28518   225 DEFW 59150
 18 DEFW   264    70 DEFW  5545   122 DEFW 60998   174 DEFW 32495   226 DEFW 63111
 19 DEFW 13203    71 DEFW 10034   123 DEFW 56541   175 DEFW 19572   227 DEFW 50204
 20 DEFW  8730    72 DEFW 14011   124 DEFW 52564   176 DEFW 24061   228 DEFW 54677
 21 DEFW 22181    73 DEFW 52812   125 DEFW 47595   177 DEFW 46475   229 DEFW 41258
 22 DEFW 18220    74 DEFW 57285   126 DEFW 43106   178 DEFW 41986   230 DEFW 45219
 23 DEFW 30135    75 DEFW 60766   127 DEFW 39673   179 DEFW 38553   231 DEFW 33336
 24 DEFW 25662    76 DEFW 64727   128 DEFW 35696   180 DEFW 34576   232 DEFW 37809
 25 DEFW 40137    77 DEFW 34920   129 DEFW 33800   181 DEFW 62383   233 DEFW 27462
 26 DEFW 36160    78 DEFW 39393   130 DEFW 38273   182 DEFW 57894   234 DEFW 31439
 27 DEFW 49115    79 DEFW 43898   131 DEFW 42778   183 DEFW 53437   235 DEFW 18516
 28 DEFW 44626    80 DEFW 47859   132 DEFW 46739   184 DEFW 49460   236 DEFW 23005
 29 DEFW 56045    81 DEFW 21125   133 DEFW 49708   185 DEFW 14787   237 DEFW 11618
 30 DEFW 52068    82 DEFW 17164   134 DEFW 54181   186 DEFW 10314   239 DEFW 15595
 31 DEFW 63999    83 DEFW 29079   135 DEFW 57662   187 DEFW  6865   239 DEFW  3696
 32 DEFW 59510    84 DEFW 24606   136 DEFW 61623   188 DEFW  2904   240 DEFW  8185
 33 DEFW  8450    85 DEFW  5281   137 DEFW  2112   189 DEFW 32743   241 DEFW 63375
 34 DEFW 12427    86 DEFW  1320   138 DEFW  6601   190 DEFW 28270   242 DEFW 58886
 35 DEFW   528    87 DEFW 14259   139 DEFW 11090   191 DEFW 23797   243 DEFW 54429
 36 DEFW  5017    88 DEFW  9786   140 DEFW 15067   192 DEFW 19836   244 DEFW 50452
 37 DEFW 26406    89 DEFW 57037   141 DEFW 20068   193 DEFW 50700   245 DEFW 45483
 38 DEFW 30383    90 DEFW 53060   142 DEFW 24557   194 DEFW 55173   246 DEFW 40994
 39 DEFW 17460    91 DEFW 64991   143 DEFW 28022   195 DEFW 58654   247 DEFW 37561
 40 DEFW 21949    92 DEFW 60502   144 DEFW 31999   196 DEFW 62615   248 DEFW 33584
 41 DEFW 44362    93 DEFW 39145   145 DEFW 38025   197 DEFW 32808   249 DEFW 31687
 42 DEFW 48323    94 DEFW 35168   146 DEFW 34048   198 DEFW 37281   250 DEFW 27214
 43 DEFW 36440    95 DEFW 48123   147 DEFW 47003   199 DEFW 41786   251 DEFW 22741
 44 DEFW 40913    96 DEFW 43634   148 DEFW 42514   200 DEFW 45747   252 DEFW 18780
 45 DEFW 60270    97 DEFW 25350   149 DEFW 53933   201 DEFW 19012   253 DEFW 15843
 46 DEFW 64231    98 DEFW 29327   150 DEFW 49956   202 DEFW 23501   254 DEFW 11370
 47 DEFW 51324    99 DEFW 16404   151 DEFW 61887   203 DEFW 26966   255 DEFW  7921
 48 DEFW 55797   100 DEFW 20893   152 DEFW 57398   204 DEFW 30943   256 DEFW  3960
 49 DEFW 12675   101 DEFW  9506   153 DEFW  6337   205 DEFW  3168
 50 DEFW  8202   102 DEFW 13483   154 DEFW  2376   206 DEFW  7657
 51 DEFW  4753   103 DEFW  1584   155 DEFW 15315   207 DEFW 12146
 52 DEFW   792   104 DEFW  6073   156 DEFW 10842   208 DEFW 16123
```

conclusion

Further information on the software approach can be found in *Synchronous Packet Radio Using The Software Approach — Volume II: AX.25 Protocol.*[3] This 253-page book is available for $22 postpaid (overseas, add $10 for airmail) from Richcraft Engineering Ltd., #1 Wahmeda Industrial Park, Chautauqua, New York 14722, or from Ham Radio's Bookstore, Greenville, N. H. 03048.

If you wish to forego the pleasure of typing in approximately 5000 lines of source code, the program is available (from Richcraft) on disk for the Model I or Model III TRS-80 (specify) for an additional $29, postpaid. If you wish to modify the program with your call letters or personalized prepared messages, you'll need a copy of the book, but no knowledge of assembly language, and no editor/assembler.

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3. Robert M. Richardson, W4UCH, *Synchronous Packet Radio Using The Software Approach*, Volumes I - III, Richcraft Engineering, Ltd., 1982.
4. Aram Perez, "Byte-wise CRC Calculations," *IEEE Micro Journal*, IEEE Computer Society (10662 Los Vaqueros Circle, Los Alamitos, California 90720), June, 1983, pages 41.50.

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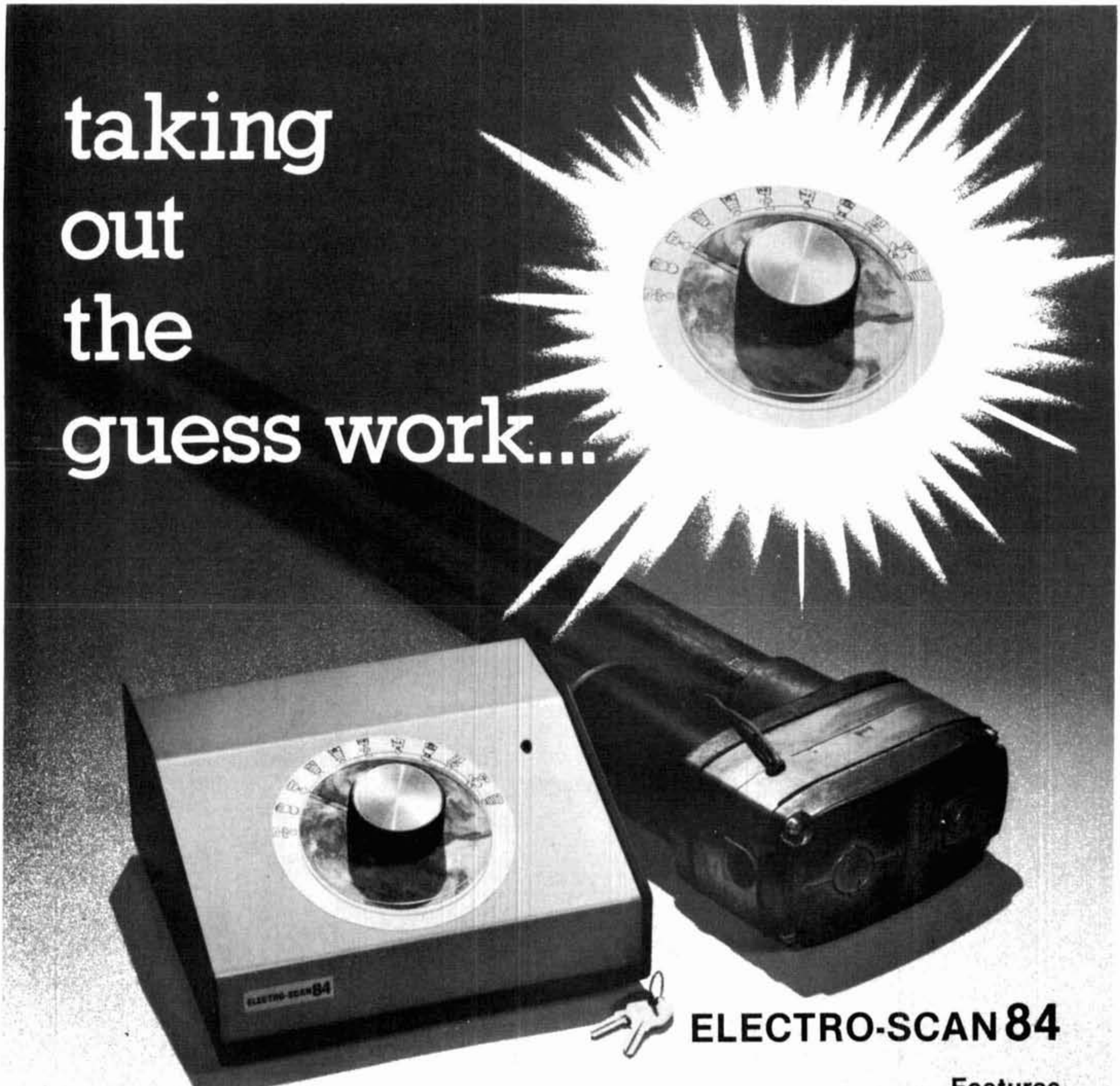

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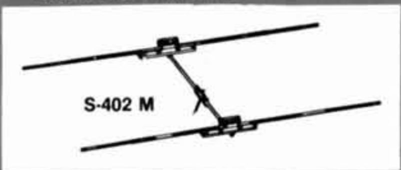

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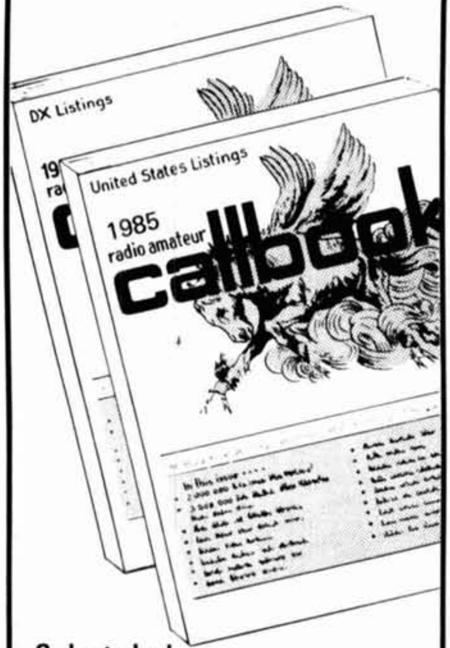

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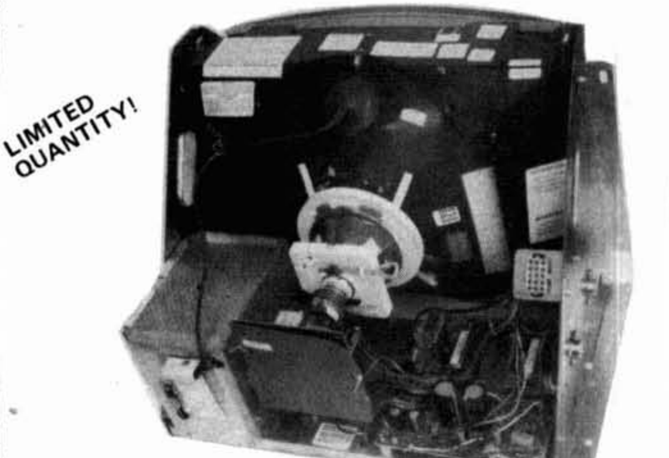

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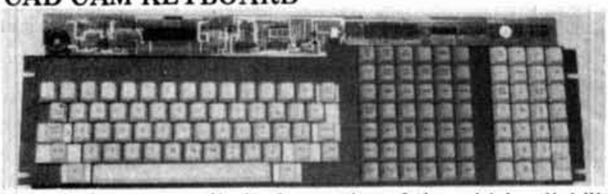
CAD CAM KEYBOARD



We only have a very limited quantity of these high reliability, beautifully layed out 8 bit, serial output keyboards. These were made by Keytronics for use in a Cad-Cam system. The board is made up of 3 sections. The typewriter format section has 2 control keys plus full upper and lower case alpha-numerics. The 42 keyswitch pad, when used with appropriate logic, allows extensive, precise manipulations of displayed data such as close up, moving information, sketching, etc. The third section consists of 27 keys which include a numeric scratch pad, 4 way cursor control plus some command keys. On board are 3 LSI's including an Intersil IM6402, INS8048, and NS2716 UV PROM which contains the programs for manipulating data, plus other circuitry and an alert beeper. The keyboard requires +5 V and −12 V. Each one will come with schematics. New and unused. Shpg. Wt. 4 Lbs. KYBRD No. 6 $45.00

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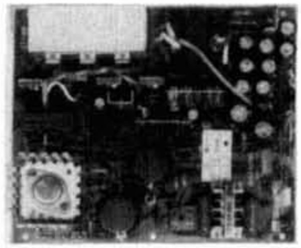
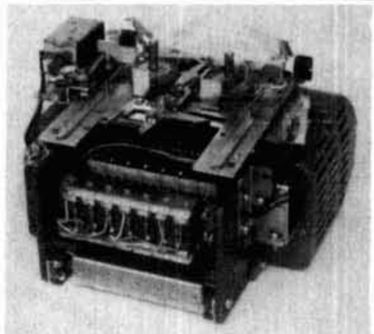


This regulated multi-voltage switching power supply board is made by KEPCO (their part no. MRM 174KF) and is still in production (. . . regular price $124.95). It was originally part of the Zorba portable PC. The four outputs are as follows: & +5 VDC @ 5 A, +12 VDC @ 2.8 A, +12 VDC @ 2 A, and −12 VDC @ .5 A. The +12 VDC @ 2 A is very heavily filtered so it could be used on a glitch free monitor. The −12 VDC @ .5 A can be changed to −5 VDC just by changing the onboard 7912 regulator chip to a 7905. The board's lightweight and small size should make it perfect for many projects. All new and provided with a schematic. The input is jumper selectable 110/220. New, unused.

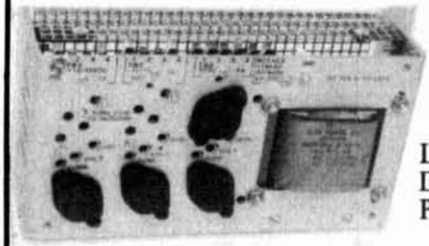
Quanity prices available. $49.95
Shpg. Wt. 2 Lbs. ea. SPL-471-33B 2/$90.00

EPSON PRINTERS



Two surplus printers made for the computer industry by Shimshu Seiki/ Epson. One prints alpha-numeric characters and the other prints numeric characters plus other symbols. These may have been intended for use in cash registers but other uses come to mind. Good enough to print program listings, using hard copy verification on timing devices or just for parts. Heck, the price is right. Runs on +5 V and 12 V. With pinout data. Shpg. Wt. 8 Lbs. (either printer).

Alpha numeric type	SPL-465-33A	$17.50
Numeric only	SPL-466-33A	$15.00



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More Details? CHECK—OFF Page 150

interrupt-driven RTTY reader

Receive RTTY on your Apple while other programs run

This is a 6502 machine language program written for an Apple II equipped with a 6522 Versatile Interface Adapter chip (VIA).* (It should be simple to convert the program to other 6502 computers.) The unusual feature of this program is that RTTY reception is accommodated during interrupts that occur at 1000 Hz intervals. Thus, this program can easily be extended without concern about timing. This program will not work well on the Apple IIe at 100 WPM because when the IIe does a scrolling operation, it turns off the interrupts! This is because the IIe allows the alternate 64K to bank-select over the ROMs, which contain the IRQ vector. (This confirms my hunch that Apple did not really have interrupts in mind when they designed the IIe.)

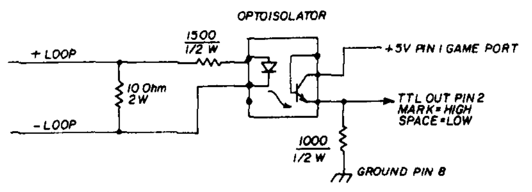

fig. 1. 170 volt current loop to TTL connector.

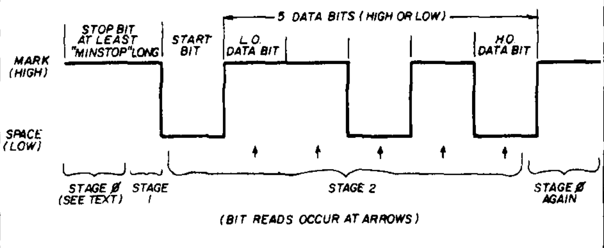

fig. 2. Program operation on a typical character.

*The 6522 is found on some accessory cards (John Bell and Mockingboard, for example) of which several thousand have been sold — **Editor**.

A *suitable terminal unit* (TU) must be used between the radio receiver and the Apple's game port. The input is switch 0 (pin 2 of the game port). Five volts, or TTL high, should be applied when the TU detects mark condition and zero volts, or TTL low when a space is detected. This is the same input that is commonly used with other programs available for the Apple. Many late-model terminal units have TTL compatible outputs; **fig. 1** shows a simple circuit to convert from current loop to TTL. Be careful with this circuit . . . you don't want to hook up the 170-volt loop to your Apple or to yourself! The circuit uses an opto-isolator that should protect your Apple from the high voltages.

The program listing is heavily commented. Here's how it works (see **fig. 2**):

STAGE 0. The program searches for a stop pulse, which is an uninterrupted mark at least as long as "MINSTOP."

STAGE 1. After finding a stop pulse, the program waits for a transition to space indicating a start pulse.

STAGE 2. The program reads in 5 data bits, waiting the proper amount of time between each bit.

Program operation is simple. Just assemble the program and 'BRUN' it from the disk. Values for different speeds are included in the listing. It supports 80-column display boards and printers as well; just type "PR#3" or "PR#1" to turn on the board or printer before running the program.

Many enhancements are possible — for example, creating a larger text buffer so that the main program can do other tasks while still receiving RTTY, or for later transfer of the received text to disk or printer. Some non-ham TTY stations broadcast using inversion of one or more bits of the five-level code; this could be decoded by "exclusive-or" with various values until readable copy appears. It should be possible to add enhancements in basic because interrupts are used. Of course, a transmit function could be added, and this program could even form the basis for a powerful "MSO," or bulletin board.

By Scott D. Schram, KN4L, 225 LaPrado Place, Homewood, Alabama 35209.

```
                 ********************************
                 *                              *
                 *     RTTY READER PROGRAM      *
                 *      BY SCOTT D. SCHRAM      *
                 *                              *
                 ********************************
                 *
                         ORG  $803
                 *
                 *    *** EQUATES ***
                 *
                 * RECIEVED CHARACTER BUFFER.
                 *
                 RECCHAR  =     $4000
                 *
                 COUT     =     $FDED       ;APPLE'S OUTPUT CHAR IN 'A' REG
                 IRQVEC   =     $3FE        ;APPLE'S IRQ VECTOR LOCATION
                 *
                 * RTTY INPUT IS APPLE SWITCH 0
                 *  MARK IS HIGH, MAKING RTTYIN NEGATIVE
                 *  SPACE IS LOW, MAKING RTTYIN POSITIVE
                 *
                 RTTYIN   =     $C061
                 *
                 * THE 6522 VERSATILE INTERFACE ADAPTER LOCATION
                 * (YOU NEED A VIA TO MAKE THIS PROGRAM WORK,
                 *  I USE THE JOHN BELL ENGINEERING BOARD.)
                 *  SOME OTHER PERIPHERAL CARDS HAVE A VIA AVAILABLE.
                 *  SOME OTHER COMPUTERS HAVE A VIA BUILT IN.
                 *
                 **** THE VIA MUST BE CONNECTED TO THE IRQ LINE
                 ****  SO IT CAN INTERRUPT THE PROCESSOR
                 *
                 * CHANGE THE VIA EQUATE TO YOUR VIA LOCATION
                 *
                 VIA      =     $C200       ;SLOT 2 VIA BASE LOCATION
                 ACR      =     VIA+11      ;VIA AUXILLIARY CONTROL REG.
                 IER      =     VIA+14      ;VIA INTERRUPT ENABLE REG.
                 IFR      =     VIA+13      ;VIA INTERRUPT FLAG REG.
                 T1L      =     VIA+4       ;VIA TIMER 1 LOW BYTE
                 T1H      =     VIA+5       ;VIA TIMER 1 HIGH BYTE
                 *
                 ********************************
                 *
                 *    *** MAIN FOREGROUND ROUTINES ***
                 *
0803: A9 00      START    LDA  #0           ;CLEAR RECIEVED CHARACTER
0805: 8D 49 08            STA  RECPNTA
0808: 8D 4A 08            STA  RECPNTB
                 *
080B: A9 00               LDA  #0
080D: 8D 4B 08            STA  STAGE        ;INIT INTERR. VARS.
0810: 8D 4C 08            STA  MARKCNT
0813: 8D 55 08            STA  SHIFT
                 *
0816: A9 5C               LDA  #<INTSVC     ;SETUP APPLE'S IRQ VECTOR
0818: 8D FE 03            STA  IRQVEC
081B: A9 08               LDA  #>INTSVC
081D: 8D FF 03            STA  IRQVEC+1
                 *
                 * SETUP THE VIA REGISTERS TO INTERRUPT
                 *  1000 TIMES PER SECOND.
                 *
0820: A9 40               LDA  #%01000000
0822: 8D 0B C2            STA  ACR          ;TIMER 1 FREE RUNNING
0825: A9 FF               LDA  #255
0827: 8D 04 C2            STA  T1L
082A: A9 03               LDA  #3
082C: 8D 05 C2            STA  T1H          ;1000 HZ INTERRUPTS
082F: A9 C0               LDA  #%11000000
0831: 8D 0E C2            STA  IER          ;ENABLE VIA INTERRUPTS
0834: 58                  CLI               ;ENABLE IRQ
                 *
                 * WAIT FOR CHARACTER TO BE RECIEVED BY INTERRUPT ROUTINE
                 *
0835: AE 49 08   WAIT     LDX  RECPNTA
0838: EC 4A 08            CPX  RECPNTB
083B: F0 F8               BEQ  WAIT         ;NONE YET.
083D: EE 49 08            INC  RECPNTA      ;MOVE PRINT POINTER UP ONE
0840: BD 00 40            LDA  RECCHAR,X    ;GET CHARACTER
0843: 20 ED FD            JSR  COUT         ;PRINT IT.
0846: 4C 35 08            JMP  WAIT         ;WAIT FOR MORE
                 *
                 ********************************
                 *
                 *    ***  VARIABLES ***
                 *
                 * IF THESE TWO POINTERS ARE UNEQUAL THEN
                 * AT LEAST ONE CHARACTER IS AVAILABLE FOR PRINTING
                 *
                 RECPNTA  DS   1
                 RECPNTB  DS   1
                 *
                 * STAGE=0, WAITING FOR STOP PULSE
                 * STAGE=1, FOUND STOP PULSE, NOW WAIT FOR START PULSE
                 * STAGE=2, READING SUCCESSIVE BITS
                 *
                 STAGE    DS   1
                 *
                 * MARKCNT IS USED WHEN STAGE=0 TO COUNT UP
                 *  DURATION OF THE STOP PULSE (WHICH IS A MARK)
                 *  AND SEE IF IT IS LONG ENOUGH.
                 *
                 MARKCNT  DS   1
                 *
                 * BITCNT IS USED WHEN STAGE=2 TO TELL WHICH BIT
                 *  IS TO BE READ NEXT. (RANGES FROM 0 TO 4)
                 *
                 BITCNT   DS   1
                 *
                 * BITWAIT IS USED WHEN STAGE=2 TO COUNT DOWN DELAYS
                 *  BETWEEN SUCCESSIVE BITS.
                 *
                 BITWAIT  DS   1
                 *
                 * BITS STORES THE 5 ACTUAL BIT VALUES READ DURING
                 *  STAGE TWO FOR ANALYSIS WHEN THE ENTIRE
                 *  CHARACTER HAS BEEN RECIEVED.
                 *
                 BITS     DS   5            ;BIT VALUES READ (L.O. FIRST)
                 *
                 * CHAR IS USED AS TEMPORARY WORK SPACE TO
                 *  BUILD UP THE BAUDOT VALUE FROM THE
                 *  INDIVIDUAL BITS READ.
                 *
                 CHAR     DS   1
                 *
                 * SHIFT SHOWS IF THE MACHINE IS RECIEVING LETTERS
                 *  OR NUMBERS. (AND WHICH TABLE TO LOOKUP IN.)
                 *      0 = LETTERS.
                 *  NON-0 = NUMBERS.
                 *
                 SHIFT    DS   1
                 *
                 *    *** CHANGE MINSTOP AND DELAYS FOR SPEED CHANGE ***
                 *
                 * MINIMUM ACCEPTABLE STOP PULSE LENGTH
                 *  (MUST REMAIN MARK FOR AT LEAST THIS LONG
                 *   TO BEGIN READING A CHARACTER)
                 *
                 * MINSTOP=30 FOR 60 WPM.
                 *         27 FOR 66 WPM.
                 *         16 FOR 100 WPM.
                 *
0856: 10         MINSTOP  DFB  16           ;(100 WPM)
                 *
                 * DELAYS FROM THE BEGINNING OF THE START PULSE
                 *  TO THE MIDDLE OF EACH DATA BIT.
                 *
                 * DELAYS ARE 33,22,22,22,22 FOR 60 WPM.
                 *            30,20,20,20,20 FOR 66 WPM.
                 *            20,13,14,13,14 FOR 100 WPM.
                 *
0857: 14 0D 0E   DELAYS   DFB  20,13,14,13,14 ;(100 WPM)
085A: 0D 0E
                 *
                 ********************************
                 *
                 *     *** INTERRUPT SERVICE ROUTINE ***
                 *
085C: 78         INTSVC   SEI               ;DISABLE IRQ
                 *
                 * SAVE REGISTERS
                 *  ('A' REGISTER WAS SAVED AT $45 BY APPLE MONITOR.
                 *   IF YOU USE INTERRUPTS DON'T USE $45!!!)
                 *
085D: 98                  TYA
085E: 48                  PHA               ;SAVE Y
085F: 8A                  TXA
0860: 48                  PHA               ;SAVE X
                 *
0861: 2C 04 C2            BIT  T1L          ;CLEAR TIMER INTERRUPT FLAG
                 *
0864: AD 4B 08            LDA  STAGE
0867: D0 1E               BNE  INTSVC1
                 *
                 * WAITING FOR STOP PULSE
                 *
0869: AD 61 C0            LDA  RTTYIN
086C: 30 03               BMI  IS0A         ;MARK?
086E: 4C C7 08            JMP  NEWCHAR      ;ENCOUNTERED SPACE TOO SOON
0871: EE 4C 08   IS0A     INC  MARKCNT      ;MARK RECIEVED
0874: AD 4C 08            LDA  MARKCNT
0877: CD 56 08            CMP  MINSTOP      ;MINIMUM STOP PULSE LENGTH
087A: B0 03               BGE  IS0B
087C: 4C CF 08            JMP  EXIT         ;NOT LONG ENOUGH YET
                 *
087F: A9 01      IS0B     LDA  #1           ;FOUND STOP PULSE,
0881: 8D 4B 08            STA  STAGE        ;NOW WAIT FOR START
0884: 4C CF 08            JMP  EXIT
                 *
0887: C9 01      INTSVC1  CMP  #1           ;SEE IF WAITING FOR START PULSE
0889: D0 15               BNE  INTSVC2      ;NO?
088B: AD 61 C0            LDA  RTTYIN
088E: 10 03               BPL  IS1A         ;SPACE FOUND!
0890: 4C CF 08            JMP  EXIT         ;NO START YET
0893: A9 02      IS1A     LDA  #2           ;BEGIN WAITING FOR DATA BITS
0895: 8D 4B 08            STA  STAGE
0898: A9 00               LDA  #0
089A: 8D 4D 08            STA  BITCNT
089D: 4C BB 08            JMP  DELSET
                 *
08A0: CE 4E 08   INTSVC2  DEC  BITWAIT      ;WAIT FOR NEXT DATA BIT
08A3: D0 2A               BNE  EXIT
08A5: AD 61 C0            LDA  RTTYIN       ;IT'S TIME, SO GET A BIT
08A8: AE 4D 08            LDX  BITCNT
08AB: 9D 4F 08            STA  BITS,X       ;AND SAVE IT FOR LATER ANALYSIS
08AE: EE 4D 08            INC  BITCNT
08B1: AD 4D 08            LDA  BITCNT
08B4: C9 05               CMP  #5           ;SEE IF WE HAVE GOTTEN 5
08B6: 90 03               BLT  DELSET       ;NO, SET NEXT DELAY
08B8: 4C D7 08            JMP  FNDCHAR      ;YES, FOUND CHARACTER.
                 *
08BB: AE 4D 08   DELSET   LDX  BITCNT
08BE: BD 57 08            LDA  DELAYS,X     ;GET DELAY TIME TO NEXT BIT
08C1: 8D 4E 08            STA  BITWAIT      ;AND PUT IN COUNTDOWN
08C4: 4C CF 08            JMP  EXIT
                 *
                 *
08C7: A9 00      NEWCHAR  LDA  #0           ;START READING A NEW CHAR
08C9: 8D 4B 08            STA  STAGE        ;PREPARE TO WAIT FOR STOP BIT
08CC: 8D 4C 08            STA  MARKCNT
                 *
                 * *** EXIT INTERRUPT ROUTINE ***
                 *
                 * RESTORE REGISTERS
                 *
08CF: 68         EXIT     PLA
08D0: AA                  TAX               ;RESTORE X
08D1: 68                  PLA
08D2: A8                  TAY               ;RESTORE Y
08D3: A5 45               LDA  $45          ;RESTORE A
08D5: 58                  CLI               ;RE-ENABLE IRQ
08D6: 40                  RTI               ;RETURN TO MAIN PROGRAM
                 *
                 *    *** ALL 5 BITS READ, PROCESS CHARACTER ***
                 *     (SUBROUTINE USED BY INTERRUPT PROCESSING)
                 *
                 * PUT THE BITS TOGETHER INTO A BAUDOT CHARACTER
                 *
08D7: A9 00      FNDCHAR  LDA  #0           ;CLEAR CHARACTER
08D9: 8D 54 08            STA  CHAR
08DC: A2 04               LDX  #4           ;DO ALL 5 BITS
08DE: BD 4F 08   FC0      LDA  BITS,X
08E1: 0A                  ASL               ;ROLL BIT INTO CARRY
08E2: 2E 54 08            ROL  CHAR         ;THEN OUT INTO CHARACTER
08E5: CA                  DEX
08E6: 10 F6               BPL  FC0          ;LOOP FOR ALL 5
                 *
                 * NOW, HAVE THE BAUDOT REPRESENTATION OF THE CHARACTER
                 *  DETERMINE WHAT TO DO WITH IT.
                 *
08E8: AE 54 08            LDX  CHAR
08EB: D0 03               BNE  FC1          ;TEST FOR 'BLANK'
08ED: 4C C7 08            JMP  NEWCHAR      ;IGNORE BLANK, JUST EXIT.
08F0: E0 08      FC1      CPX  #8           ;TEST FOR CARRIAGE RETURN
08F2: F0 0E               BEQ  UNSHIFT      ;IGNORE CR BUT UNSHIFT
08F4: E0 1B               CPX  #27          ;TEST FOR FIGURES
08F6: D0 06               BNE  FC3
08F8: 8E 55 08            STX  SHIFT        ;SHIFT TO FIGURES
08FB: 4C C7 08            JMP  NEWCHAR      ;AND EXIT
08FE: E0 1F      FC3      CPX  #31          ;TEST FOR LETTERS
0900: D0 08               BNE  FC4A
0902: A9 00      UNSHIFT  LDA  #0
0904: 8D 55 08            STA  SHIFT        ;LETTERS
0907: 4C C7 08            JMP  NEWCHAR
                 *
                 * UNSHIFT ON LF OR SPACE, THEN PRINT THEM
                 *
090A: E0 02      FC4A     CPX  #2           ;LF
090C: F0 04               BEQ  FC4B
090E: E0 04               CPX  #4           ;SPACE
0910: D0 05               BNE  FC4
0912: A9 00      FC4B     LDA  #0
0914: 8D 55 08            STA  SHIFT        ;UNSHIFT
                 *
                 * GET THE ASCII CHARACTER TO PRINT FROM THE
                 *  APPROPRIATE TABLE DEPENDING ON SHIFT.
                 *
0917: AD 55 08   FC4      LDA  SHIFT
091A: D0 06               BNE  FC5
091C: BD 31 09            LDA  LTRSTBL,X    ;IF LETTERS SHIFT
091F: 4C 25 09            JMP  FC6
0922: BD 51 09   FC5      LDA  FIGSTBL,X    ;IF FIGURES SHIFT
                 *
0925: AE 4A 08   FC6      LDX  RECPNTB
0928: 9D 00 40            STA  RECCHAR,X    ;STORE CHARACTER IN BUFFER
092B: EE 4A 08            INC  RECPNTB
092E: 4C C7 08            JMP  NEWCHAR
                 *
```

```
                 *   *** THE TABLES OF ASCII VALUES FOR BAUDOT CHARS. ***
                 *
0931: A0 C5      LTRSTBL  ASC  " E"
0933: 8D                  HEX  8D        ;LF
0934: C1 A0               ASC  "A "
0936: D3 C9 D5            ASC  "SIU D"
0939: A0 C4
093B: D2 CA CE            ASC  "RJNFC"
093E: C6 C3
0940: CB D4 DA            ASC  "KTZLW"
0943: CC D7
0945: C8 D9 D0            ASC  "HYPQO"
0948: D1 CF
094A: C2 C7 A0            ASC  "BG MX"
094D: CD D8
094F: D6 A0               ASC  "V "
                 *
0951: A0 B3      FIGSTBL  ASC  " 3"
0953: 8D                  HEX  8D
0954: AD A0               ASC  "- "
0956: 87                  HEX  87        ;BELL
0957: B8 B7 A0            ASC  "87 $4"
095A: A4 B4
095C: A7 AC A1            ASC  "',!:("
095F: BA A8
0961: B5                  ASC  "5"
0962: A2                  HEX  A2        ;DOUBLE QUOTE MARK
0963: A9 B2 A3            ASC  ")2#"
0966: B6 B0 B1            ASC  "6019?"
0969: B9 BF
096B: A6 A0 AE            ASC  "& ./; "
096E: AF BB A0
                 *
                 ********************************

--End assembly--

366 bytes

Errors: 0

Symbol table - alphabetical order:

   ACR      =$C20B     BITCNT   =$084D     BITS     =$084F     BITWAIT  =$084E
   CHAR     =$0854     COUT     =$FDED     DELAYS   =$0857     DELSET   =$08BB
   EXIT     =$08CF     FC0      =$08DE     FC1      =$08F0     FC3      =$08FE
   FC4      =$0917     FC4A     =$090A     FC4B     =$0912     FC5      =$0922
   FC6      =$0925     FIGSTBL  =$0951     FNDCHAR  =$08D7     IER      =$C20E
?  IFR      =$C20D     INTSVC   =$085C     INTSVC1  =$0887     INTSVC2  =$08A0
   IRQVEC   =$03FE     IS0A     =$0871     IS0B     =$087F     IS1A     =$0893
   LTRSTBL  =$0931     MARKCNT  =$084C     MINSTOP  =$0856     NEWCHAR  =$08C7
   RECCHAR  =$4000     RECPNTA  =$0849     RECPNTB  =$084A     RTTYIN   =$C061
   SHIFT    =$0855     STAGE    =$084B  ?  START    =$0803     T1H      =$C205
   T1L      =$C204     UNSHIFT  =$0902     VIA      =$C200     WAIT     =$0835


Symbol table - numerical order:

   IRQVEC   =$03FE  ?  START    =$0803     WAIT     =$0835     RECPNTA  =$0849
   RECPNTB  =$084A     STAGE    =$084B     MARKCNT  =$084C     BITCNT   =$084D
   BITWAIT  =$084E     BITS     =$084F     CHAR     =$0854     SHIFT    =$0855
   MINSTOP  =$0856     DELAYS   =$0857     INTSVC   =$085C     IS0A     =$0871
   IS0B     =$087F     INTSVC1  =$0887     IS1A     =$0893     INTSVC2  =$08A0
   DELSET   =$08BB     NEWCHAR  =$08C7     EXIT     =$08CF     FNDCHAR  =$08D7
   FC0      =$08DE     FC1      =$08F0     FC3      =$08FE     UNSHIFT  =$0902
   FC4A     =$090A     FC4B     =$0912     FC4      =$0917     FC5      =$0922
   FC6      =$0925     LTRSTBL  =$0931     FIGSTBL  =$0951     RECCHAR  =$4000
   RTTYIN   =$C061     VIA      =$C200     T1L      =$C204     T1H      =$C205
   ACR      =$C20B  ?  IFR      =$C20D     IER      =$C20E     COUT     =$FDED
```

ham radio

ICOM IC-730

Proven, Reliable HF Compact Transceiver

BUILT-IN SWR BRIDGE | **BUILT-IN RECEIVE PREAMP** | **ONE MEMORY PER BAND** | **DUAL VFOs** | **TUNING KNOB LOCK** | **LARGE RIT TUNING KNOB**

***ICOM's IC-730 go-anywhere* HF all-band SSB/CW/AM transceiver, the best value on the market, has a proven record of high performance, ease of operation and durability. Compact in size, yet full-featured, the IC-730 has gained an uncomparable reputation.**

Receiver Performance. Utilizing ICOM's DFM (Direct Feed Mixer), the IC-730 obtains a dynamic range of 100dB and an intercept point of 19.5dBm.

Superior front-end receiver performance, coupled with a switchable preamplifier and IF shift or passband tuning (optional), gives the IC-730 receiver flexibility yet allows it to be easy to operate.

Compact. The IC-730 is sized to be used mobile — either in a car, airplane or boat — to be carried in a suitcase, or to be used as a base station. Only 3.7 inches high by 9.5 inches wide by 10.8 inches deep, the IC-730 is a very compact package. Still the IC-730 sports a large tuning knob, large RIT knob, and large bandswitching knob to make mobile operation easy. The RIT control is conveniently located in the lower right corner to make access by touch easy while operating the unit mobile.

Convenience Features. The IC-730 has important features that make the unit easy to operate in a mobile environment. Two VFOs are easily accessed at the push of a button. Normal or split operation and three separate tuning rates for fast QSY or slow tuning are available. The dial lock deactivates the main tuning knob for rock-solid stability without the possibility of moving off frequency. One memory per band is provided to allow storage of net frequencies or favorite frequencies at the push of a button.

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✓ 156

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All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emissions.

7301283

More Details? CHECK—OFF Page 150

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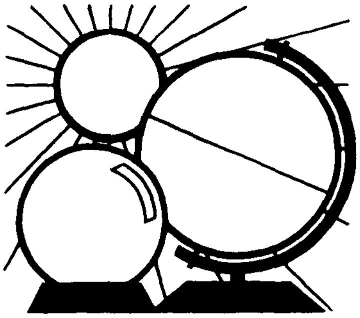

DX FORECASTER

Garth Stonehocker, KØRYW

September is a special season of the year for propagation, and therefore DX. The reason for this is that during the equinox, with its nights and days of equal length, the sun is directly overhead at noon on the geographic equator. This causes solar radiation to hit the earth broadside, and because the equatorial planes of the sun and earth nearly coincide at this time, particles from the sun's eruptions (flares) and coronal holes (thin places in the sun's gases) have a bull's-eye path to the earth. These charged particles, called the solar wind, enter the earth's atmosphere in the polar regions; they also build up in the Van Allen belts around the earth above the equatorial region. When full, the belts release these particles into the polar auroral zone, (on the Canadian-U.S. side after about 2200 local time), causing geomagnetic storms.

Geomagnetic storms affect propagation — and DX — in three ways. First, the particles entering the auroral zone ionospheric D and E regions increase signal absorption, resulting in weak east-west path signals and few signals across the poles. Second, the particles form a reflective curtain along the equatorial side of the auroral zone (south side for us in North America), enhancing VHF auroral scatter propagation. Third, the F region of the ionosphere, once again looking at the auroral zone, but further south, becomes depleted of electrons, forms an electron density trough in which the maximum usable frequency (MUF) for a particular path *through* this area decreases by 30 to 50 percent.

However, still further south at ±20 degrees from the geomagnetic equator, an equivalent-size enhancement of the F region occurs, resulting in evening TE (Trans-Equatorial) openings during the equinox and winter seasons. These three effects vary with time on a short to long basis (seconds through hours), causing what we experience as fading. These effects continue to occur each night for two to three days before ionospheric equilibrium is established. The closer to the equator these effects occur, the bigger the geomagnetic storm (higher K or A value).

Just as the particle density and speed of the solar wind vary, so do the characteristics of the geomagnetic field and ionosphere. Ionospheric variation causes signal focusing and defocusing, which simply means that the signals arriving at your QTH will vary in both strength and angle of arrival. Some directions and locations you haven't heard from in a long time may suddenly be workable, but this kind of surprise is what you can expect during the equinoxes.

last-minute forecast

The higher HF bands, 10 through 30 meters, are expected to be best just after the middle of the month as a result of high solar flux and activity on the sun. Some solar flares that may cause the earth's geomagnetic field to be disturbed for two to three days are possible. However, most of these disturbances will probably be the result of solar coronal hole activity during the extended periods of low solar flux during the first and second weeks of the month. These disturbances will occur on or near September 1, 5, 10, 14, 24, and 30. The highly disturbed period of the sunspot cycle will still be felt in 1984 and 1985. (The first peak of these disturbances occurred in September, 1982; a later peak of this cycle may occur this fall, (in September or October.) Despite these disturbances, DX *on the lower frequency bands* should be better than it was over the summer months, especially during the second week of September.

The full moon will be visible on the 9th and be at perigee on the 23rd. The autumnal equinox will occur on September 22nd at 2033 UT.

band-by-band summary

Ten and fifteen meters will provide many short-skip E_s openings and long skip openings during the high solar flux periods to most areas of the world during daylight. Some trans-equatorial openings associated with disturbed ionospheric conditions may occur in the evening hours.

Twenty, thirty, and forty meters will support propagation from most areas of the world during the daytime and into the evening hours almost every day, either long-skip to 2500 miles (4000 km) or short-skip E_s to 1250 miles (2000 km) per hop.

Thirty, forty, eighty, and one-sixty meters are all good for nighttime DX. However, on many nights 30 and 40 meters will be the only usable bands because of the effect of thunderstorm QRN on 80 and 160 meters. Signal strength via short-skip E_s may overcome the static when E_s is available, even though E_s propagation does become more scarce in September.

ham radio

SEPTEMBER

WESTERN USA

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

MID USA

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

EASTERN USA

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

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

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

More Details? CHECK—OFF Page 150 ✓ 153

ADM-10′

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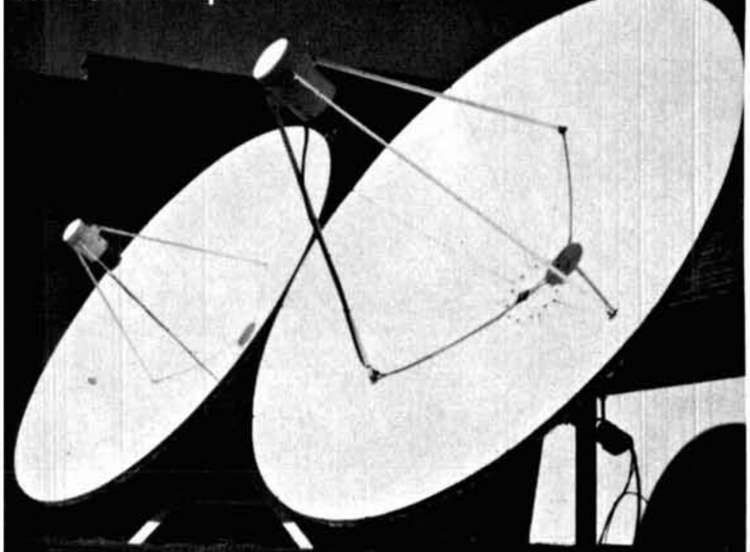

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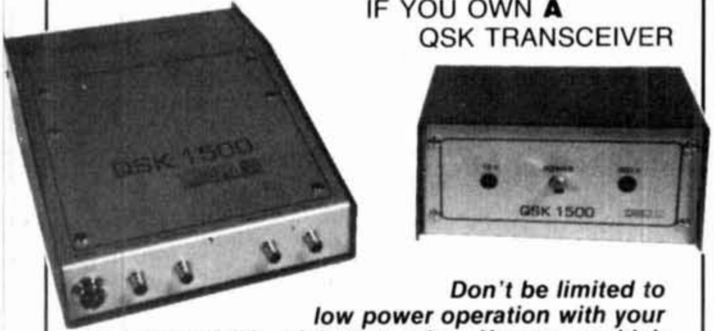

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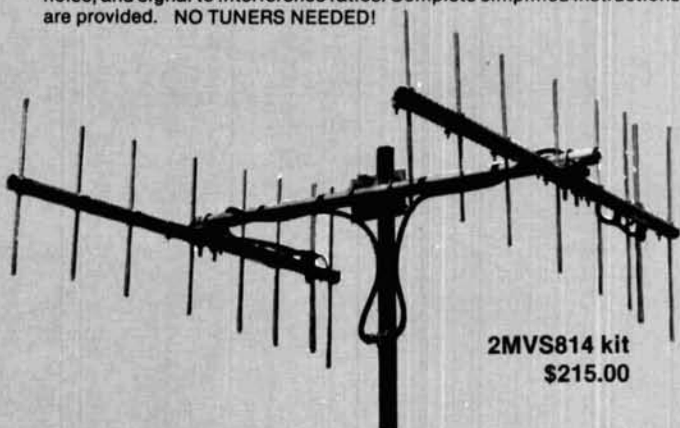

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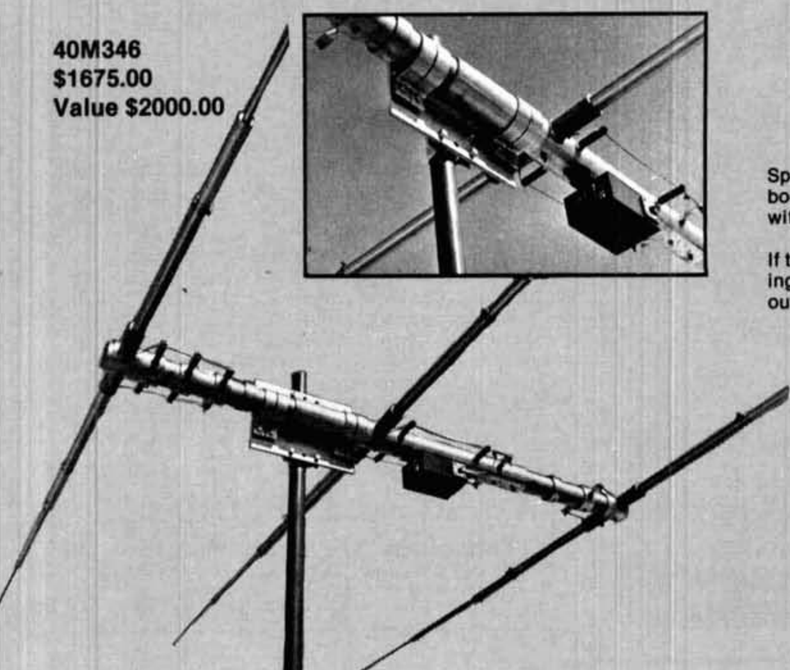

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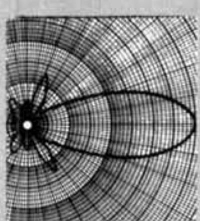
10M523	10 Meter 5 element	(13 DBD)	352.00	**295.00**
10M636	10 Meter 6 element	(14.6 DBD)	745.00	**625.00**
15M532	15 Meter 5 element	(13 DBD)	555.00	**465.00**
15M845	15 Meter 8 element	(15 DBD)	1120.00	**925.00**
20M536	20 Meter 5 element	(12 DBD)	660.00	**550.00**
20M646	20 Meter 6 element	(14 DBD)	1130.00	**945.00**
40M214	40 Meter 2 element	(5.6 DBD)	750.00	**625.00**
40M329	40 Meter 3 element	(8.3 DBD)	1145.00	**965.00**
40M346	40 Meter 3 element	(9 DBD)	2000.00	**1675.00**
TB4EC	10, 15, 20M Tri-Band	(5.5 DBD)	252.00	**215.00**
TB5ES	10, 15, 20M Tri-Band	(8.5 DBD)	408.00	**340.00**
TB6EM	10, 15, 20M Tri-Band	(10 DBD)	755.00	**580.00**



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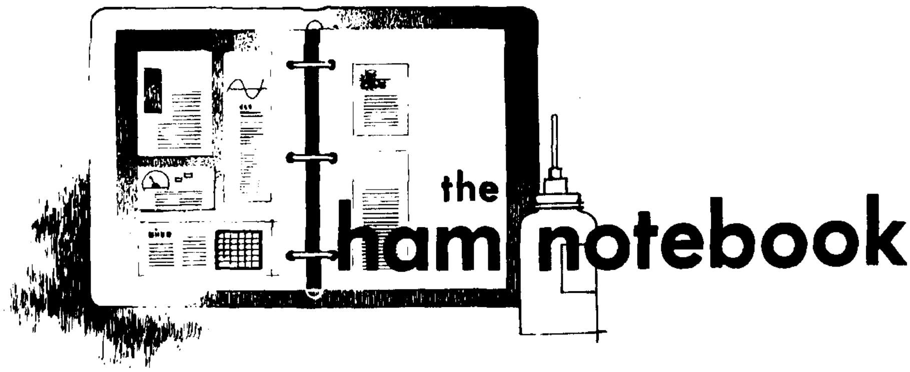


RTTY oscilloscope input using line transformers

Here's how to use line transformers ("ouncers") for inputting an RTTY signal to a monitor scope without using any active stages, yet still provide enough gain to produce a picture one and a half inches high.

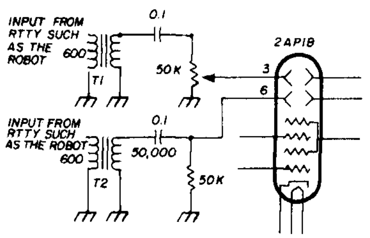


fig. 1. Small line transformers called "ouncers" provide sufficient amplification of RTTY signal to monitor scope input.

The lack of inexpensive monitor scopes for RTTY makes it worthwhile to modify some of the older one- and two-inch oscilloscopes. (Check the surplus market for bargains.) This circuit (**fig. 1**) was applied to an old Millen AM monitor scope. (Circuits for oscilloscopes can be found in the handbooks.[1])

reference

1. *ARRL Handbook*, American Radio Relay League, Newington, Connecticut, 1964, page 544.

Ed Marriner, W6XM

prerecorded messages help the hearing impaired

It's easy to devise a system that enables hearing-impaired persons to communicate with fire, police, ambulance, and other emergency services having TTY or TTY-type-equipment.

Using the TTY machine of the service to be addressed, and a portable cassette tape recorder, record the name, address, phone number, and nature of the emergency to be communicated. Record this data *at least twice* to ensure that all essential information will be transferred, and mark the tape and its container with the name of the emergency described: fire, burglary or assault, or medical emergency, and the phone number of the appropriate service. (If the individual has a particular medical condition, it might be a good idea to prepare an additional tape naming that condition, so that the service can be prepared to respond appropriately in the event of an emergency requiring specialized care.)

This is how it's done:

1. Enter the necessary data into the TTY machine at the headquarters of the emergency service.

2. Set your cassette recorder on "record" and dial the number of the telephone to which data from the TTY will be transmitted. (Do not use the telephone used on the TTY machine.)

3. Hold the microphone near the earphone of the telephone, or attach an inexpensive suction-cup pickup. Record the data from the TTY machine.

4. After recording, send the data back to the TTY machine. Be sure to verify successful transmission.

In an emergency, all the hearing-impaired person needs to do is dial the number, hold the tape recorder to the mouthpiece of the phone and push the "PLAY" button as soon as the call is answered. (To confirm that the phone has been answered, the individual places a fingertip on the diaphragm of the mouthpiece and feels the vibrations of the rings.)

In areas in which TTY facilities are not yet available, the same system can be applied, using prerecorded vocal messages instead of TTY transmissions.

J.W. Dates, W2QLI

modified Bobtail

A modification of the standard Bobtail curtain shown in **fig. 1A** provides good performance on four bands (75, 40, 20, and 15). Center fed with coax, it uses additional lengths of wire placed as shown in **fig. 1B**. The center 66-foot leg can be folded as required if the antenna is lower than 66 feet.

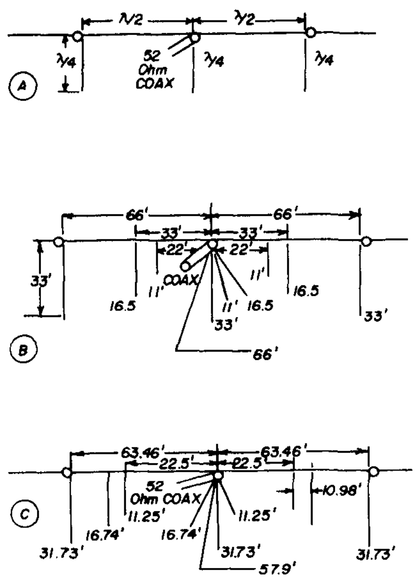


fig. 1. Modified Bobtail curtain.

A Navy MARS version of this same antenna is shown in **fig. 1C**. The design — for 4.04, 7.375, 13.975, and 20.8 MHz — requires a height of at least 40 feet above ground. The 57.9-foot radiator for 4.040 MHz, which must be folded at low heights, will require considerable adjustment to resonate on the desired frequency, with the folded portion supported just a few feet above ground level.

The advantage of this experimental antenna is a power gain much higher than a simple dipole on all frequencies above 75 meters, on which the 4.040 MHz radiator functions as a simple upside-down quarter-wave vertical. The center radiators must be kept separated to avoid excessive interaction. The center radiator is fed with 52-ohm coax, preferably through an antenna tuner.

Cliff Francis, W0MBP

fastening Trigon reflectors to VHF antennas

My EME array for two meters uses the method shown below to fasten the Trigon reflectors. It might be well to cut a small V in the rear of the main boom in areas subject to extreme winds. (This was not done on my antenna.) There is no indication of loosening after several windstorms.

The slots through which the hose clamp passes were cut with a saber saw; an ordinary hacksaw blade isn't quite thick enough to provide a slot wide enough to permit easy passage of the hose clamp.

George N. Chaney, W5JTL

VIC-20 printer

It's easy to build an inexpensive printer for the VIC-20 using an ASR-33 teletype machine and the interface illustrated in **figs. 1A** and **1B**.

The printer, which produces typewriter-quality text, won't do everything that an expensive printer will do, but it will allow data listing and, in general, enhance your ability to communicate with your VIC-20. ASR-33's can be found for as little as $50 to $75; other

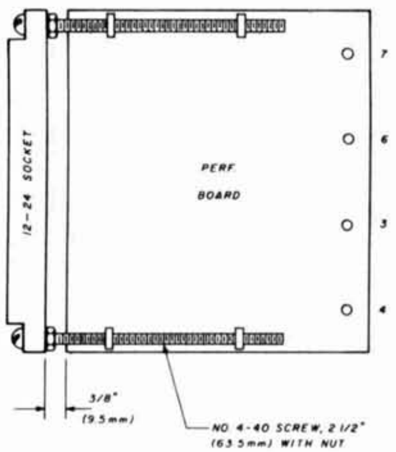
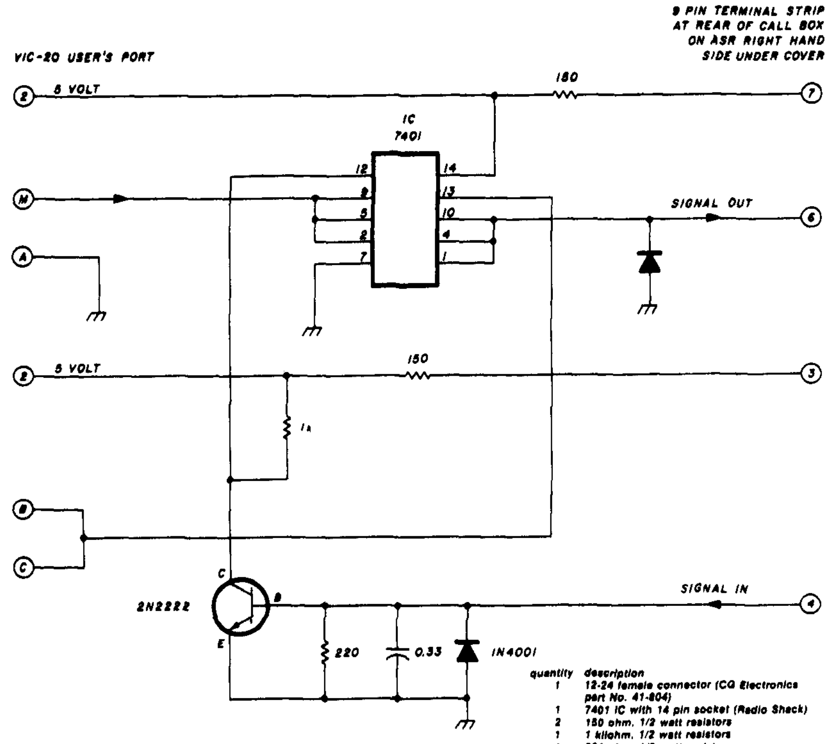


fig. 1A. Interface circuit uses multi-pin edge connector to match VIC-20 requirements.

materials can be found in your junkbox or acquired at little cost. The cost of the entire project should not exceed $100.00.

The interface is inserted into the user's port of the VIC-20, and joined to the ASR-33 by means of a four-wire cable. A simple program (**fig. 2**) provides instructions to the VIC-20.



quantity	description
1	12-24 female connector (CQ Electronics part No. 41-804)
1	7401 IC with 14 pin socket (Radio Shack)
2	150 ohm, 1/2 watt resistors
1	1 kilohm, 1/2 watt resistors
1	220 ohm, 1/2 watt resistors
1	0.33 μF capacitor
2	1N4001 diode
1	2N2222 transistor
1	piece of perforated board 2 x 2-1/2 inches 0.100 x 0.100 hole spacing
2	4-40 x 2-1/2 inch screws with nuts

fig. 1B. Interface circuit that ties a VIC-20 to an ASR-33.

```
10 REM ASR 33 TTY
15REM FILE#>128 FOR CR WITH LF
20REM 163=2 STOP,7 ASCII,110 BAUD
30REM 224=SPACE PARITY,FULL DUPLEX
100OPEN 129,2,3,CHR$(163)+CHR$(224)
110GET#129,A$
200REM MAIN LOOP
220IF B$<>"" THEN IF B$=CHR$(13)THEN
PRINT#129,B$;CHR$(10);CHR$(0);CHR$(
0);:GOTO230
225IF B$<>""THEN PRINT#129,B$;
230GET#129,C$:IF C$<>""THEN PRINT #129,C$;
240PRINT B$;C$;
250SR=ST:IFSR=0THEN200
300REM ERRORS
310PRINT "ERROR";
320IF SR AND 1 THEN PRINT"PARITY"
330IF SR AND 2 THEN PRINT"FRAME"
340IF SR AND 4 THEN PRINT"RCVR BUF FULL"
350IF SR AND 8 THEN PRINT"BREAK"
360IF(PEEK(37151)AND64)=1 THEN 360
370CLOSE 129:END
```

fig. 2. VIC-20/ASR-33 program listing.

J.W. Dates, W2QLI

ham radio

Adjust element spacings, lengths to improve gain, F/B, pattern, and bandwidth

applied Yagi antenna design part 5: additional optimization techniques

In the first four parts of this series, specific Yagi antenna designs were optimized for each of four VHF/UHF bands.[1-4] At a designated frequency in each band's weak signal area, computer iterations provided calculated maximas for forward gain and F/B. Three well-known Yagi antenna design approaches formed the bases for these iterations, with comparisons being presented in reference to a standardized fourth approach, the NBS Yagis.[5] For the same Yagi design approach at the same design frequency, some of the more significant findings from these iterations and comparisons include the following:

- Parasitic element lengths for maximum calculated forward gain and F/B are different, sometimes significantly so.
- Increasing the tapering of a given design approach requires a longer first director.
- Increases in tapering initially, but not always, result in some increase in calculated forward gain.
- Increased tapering almost always results in some increase in calculated F/B.
- Carefully selected arrangements of unequal director spacing result in more gain for a given boom length, as compared to carefully selected arrangements of equal director spacing, sometimes with fewer directors as well.

Before proceeding further with a general discussion of gain or F/B optimizing techniques, it should be useful to consider why a Yagi antenna produces peaks and/or nulls in both desired and undesired directions.

pattern generation

The Yagi antenna serves to form a traveling wave whose shaping is a function of the amplitude and phasing of the currents in the parasitic elements. These currents result from driving one or more elements with an RF voltage at a given design frequency. Phase relationships are determined by the self impedance of each element and the mutual impedances among the elements. Self impedance is a function of an element's length and diameter, and mutual impedance is a function of the spacing between elements. A Yagi antenna is essentially a system of dipole elements whose resulting radiation patterns are combined into a single pattern. This combining process can be represented in terms of vector quantities that are based on the current flowing in each element. As it is dipole patterns that are being combined, there is usually some resemblance between the resulting Yagi pattern and a single dipole pattern. Some of these resemblances are a peak at zero degrees, a sharp null at 90 degrees, and a lesser peak at 180 degrees. As Yagi patterns are generally symmetrical, a null also occurs at 270 degrees. The patterns in references 1-4 are typical examples.

Forward gain is a measurement of the sharpness of the definition of the main lobe (zero degree lobe). F/B

By **Stanley Jaffin, WB3BGU**, 800 Stonington Road, Silver Spring, Maryland 20902

table 1. Design parameters for a six-element Yagi whose gain is spacing optimized from 11.21 dBi to 12.87 dBi, with a 1.5 dB increase in F/B.

element	element length (λ)	initial spacing from previous element (λ)	optimized spacing from previous element (λ)
reflector	0.51	0.000	0.000
driven	0.50	0.250	0.250
director 1	0.43	0.310	0.336
director 2	0.43	0.310	0.398
director 3	0.43	0.310	0.310
director 4	0.43	0.310	0.407

table 2. Design parameters for a six-element Yagi whose gain is spacing optimized from 10.92 dBi to 12.89 dBi, with a 1.4 dB increase in F/B.

element	element length (λ)	initial spacing from previous element (λ)	optimized spacing from previous element (λ)
reflector	0.51	0.000	0.000
driven	0.50	0.280	0.250
director 1	0.43	0.310	0.352
director 2	0.43	0.310	0.355
director 3	0.43	0.310	0.354
director 4	0.43	0.310	0.373

table 3. Design parameters for a ten-element Yagi whose gain is spacing optimized from 13.07 dBi to 14.25 dBi.

element	element length (λ)	initial spacing from previous element (λ)	optimized spacing from previous element (λ)
reflector	0.51	0.000	0.000
driven	0.50	0.250	0.250
director 1	0.43	0.310	0.319
director 2	0.43	0.310	0.357
director 3	0.43	0.310	0.326
director 4	0.43	0.310	0.400
director 5	0.43	0.310	0.343
director 6	0.43	0.310	0.320
director 7	0.43	0.310	0.355
director 8	0.43	0.310	0.397

Note: While the text in the original source gives the director spacing as 0.310 wavelengths, a table provided in that article gives a dimension of 0.330 wavelengths for director spacing. It is apparent, however, that this Yagi was meant to be an extension of the prior Yagis, with the extra four directors serving merely to show how the model worked with longer Yagis.

is a ratio of the amplitude of this main lobe and the amplitude of the 180 degree lobe. F/B is more critically affected by even slight changes in element current than is forward gain. Variances of many decibels of F/B are often accompanied by forward gain changes that are fractions of a decibel. Overall pattern structure, however, is also materially affected. This explains why forward gain and F/B, while the most popular and perhaps the most significant measures of Yagi performance, do not always accurately reflect a single Yagi's performance or the comparative performances of two or more Yagis.

With three variables to determine current amplitudes and phases in the parasitic elements, it is possible to obtain virtually the same gain or F/B figures with different combinations of these variables. This explains why Yagis with what appear to be measurably different design approaches can have almost the same gain, F/B, or other measures of performance. It is also worth noting that element diameter is usually chosen for reasons of mechanical stability, and is therefore not iterated with the other variables.

Gain or F/B can be mathematically optimized by iterating a single variable, parasitic element length.[1-4] The same results can be calculated by holding parasitic element length constant and iterating parasitic element spacing. For a system of given element lengths, optimum spacings could be found. This could be either in terms of a given number of elements or a given boom length. Likewise, optimal performance values can be calculated for different element lengths when either of these two spacing parameters are held constant. When a given Yagi is described in the Amateur literature as "optimal," it is necessary to ask *what* has been optimized — gain or F/B? It also follows that whenever any of these parameters are changed, "optimal" must now be re-optimized. For example, a seven-element Yagi made by adding an element to an already "optimal" six-element Yagi is not an "optimal" seven element Yagi; the spacings of the other elements (and perhaps their lengths) need to be re-optimized. When two directors were added to the K2RIW Yagi, optimal director length (for gain) dropped from 11.75 to 11.50 inches.[3] Failure to do so would have cost 0.737 dB of gain and 8.784 dB of F/B. It is also necessary to determine if the new boom length might be better served with five (or eight) elements, and if the resulting F/B is available across the entire weak signal area or is a function of single frequency vectorial cancellation.

It would seem logical that if all of these variables could be optimized at the same time, a Yagi antenna with truly phenomenal performance parameters might be designed. The Lawson model used in references 1-4 can easily be adapted to perform these calculations. One series of articles in the professional literature reporting the results of using another model for this same purpose is summarized below.

continuous Yagi antenna performance parameter optimization

A series of computer programs for this purpose has been prepared and apparently successfully executed. An existing Yagi design approach is described in the programs in terms of element spacing, length, and diameter, as well as operating frequency. The program further iterates the design parameters to optimize the Yagi's gain. Cheng and Chen[6] provide a highly mathematical description of a Yagi element spacing optimization procedure, and give three examples of its use. In the first example (summarized in **table 1**) a six-element Yagi with an initial gain of 11.21 dBi is element space optimized to 12.87 dBi. In the second example (summarized in **table 2**) another six-element Yagi with an initial gain of 10.92 dBi is similarly optimized to 12.89 dBi. In the third example (summarized in **table 3**) a 10-element Yagi with an initial gain of 13.07 dBi is similarly optimized to 14.25 dBi.

For element length optimization, Chen and Cheng[7] provide a description of the process and two examples. In the first example, summarized in **table 4**, a six-element Yagi with an initial gain of 10.89 dBi is element length optimized to 12.15 dBi. In the second example, summarized in **table 5**, this same six-element Yagi is first space optimized to 12.83 dBi, and is then length optimized to 13.40 dBi. (Note: for the Yagis described in **tables 1-5**, element diameter is 0.006738 wavelengths and the booms are non-conductive. F/B calculations were not given, but this figure is derived from the plots provided in both articles.)

A combination of length and spacing optimization or a series of either of these individual optimizations can be continued. The rapid convergences described in both articles indicated that very little additional gain would be realized. If gain figures for various boom lengths are extrapolated from the NBS findings in reference 5, they can be used to arrive at very favorable comparisons with the Chen-Cheng results. Yagis whose gain figures were initially low for comparable NBS Yagis of equal boom lengths, were optimized to gain figures equal to or in excess of these same NBS figures. The accuracy of these results depends on a careful validation of the Chen-Cheng model against all of the NBS Yagis, or against some other equally validated reference. Unfortunately, this could not have been done because the NBS data was

table 4. Design parameters for a six-element Yagi whose gain is length optimized from 10.89 dBi to 12.15 dBi, with a 1.6 dB increase in F/B.

element	spacing from previous element (λ)	initial element length (λ)	optimized element length (λ)
reflector	0.000	0.510	0.472
driven	0.250	0.490	0.456
director 1	0.310	0.430	0.439
director 2	0.310	0.430	0.444
director 3	0.310	0.430	0.432
director 4	0.310	0.430	0.404

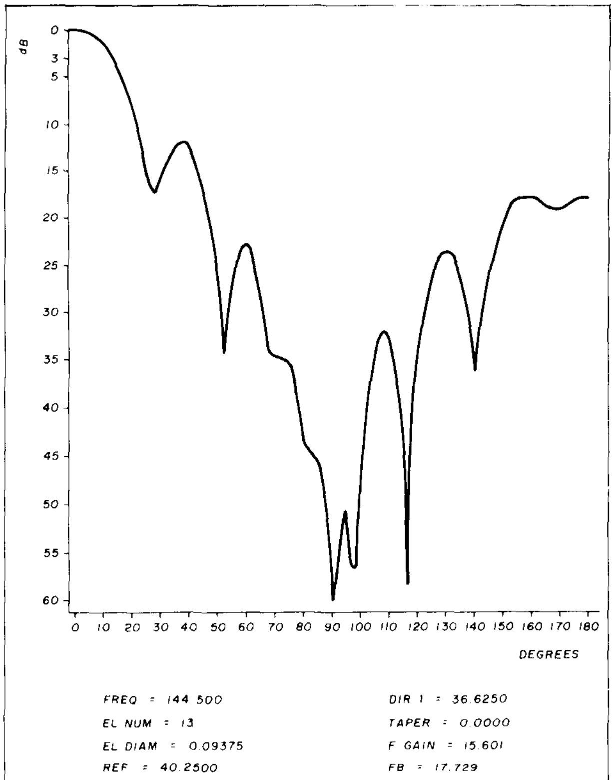


fig. 1. E-plane plot of the zero-taper, gain optimized Kmosko-Johnson Yagi antenna.

table 5. Design parameters for a six-element Yagi whose initial gain of 10.89 dBi is space optimized to 12.83 dBi and then length optimized to 13.40 dBi, with a 0.4 dB increase in F/B.

	initial design parameters		optimized design parameters	
element	spacing from previous element (λ)	element length (λ)	spacing from previous element (λ)	element length (λ)
reflector	0.000	0.510	0.000	0.476
driven	0.250	0.490	0.250	0.452
director 1	0.310	0.430	0.289	0.436
director 2	0.310	0.430	0.406	0.430
director 3	0.310	0.430	0.323	0.434
director 4	0.310	0.430	0.422	0.430

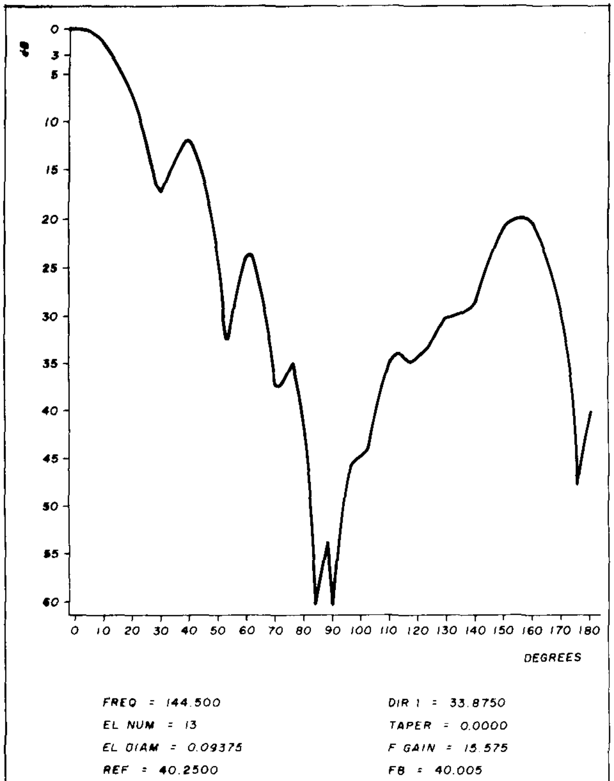


fig. 2. E-plane plot of the F/B maximized version of the zero-taper, gain optimized Kmosko-Johnson Yagi antenna.

not published until three years after Chen and Cheng's first article. Comparisons with the Lawson model on the Yagis contained in the two articles would not be a conclusive test. A Yagi model needs to be validated against a wide range of parasitic element numbers and spacings, not a select few that might fall through some mathematical "cracks."

Articles in the Amateur literature also describe techniques that have been shown to increase Yagi gain or F/B. These techniques involve adding another element or altering the length of an existing element. The following two examples given are from the sources cited in references 1-4.

F/B optimization for the Kmosko-Johnson Yagi

Reference 1 described an extensive analysis of the Kmosko-Johnson design approach for long Yagis. These computer iterations showed how increased director tapering resulting in increased gain and significantly increased F/B. Kmosko and Johnson's original article made mention of a rather unique method for increasing F/B,[8] in which the last director is made shorter than its tapering schedule would normally require, resulting in a higher F/B ratio. While Kmosko and Johnson mentioned a very slight decrease in this director's length, computer iterations were made over a wide range of such decreases.

The last director of each of four gain optimized Kmosko-Johnson Yagis was continually decremented by 0.0625 inch. These Yagis had director tapering schedules of 0.000, 0.0625, 0.125, and 0.1875 inch. The most dramatic results were obtained for the zero taper Yagi, giving further credence to these designers' belief (and the findings in reference 1) that their Yagi performed better with at least some degree of director tapering. **Table 6** presents the results for the zero taper gain optimized Yagi, with the initial gain optimized performance parameters followed by those measured at 0.25-inch decrements (every fourth 0.0625 decrement). **Table 7** and **8** present comparisons between the original Yagi and the Yagi optimized for F/B by this process. **Figs. 1** and **2** present the E-plane plots for these respective Yagis.

The newly optimized F/B derives from single frequency vectorial cancellation. There is nearly a 16 dB drop across the 144-MHz weak signal area. The gain remains nearly constant, but at a level below that of the original Yagi. The newly optimized Yagi has a different lobe structure in its second quadrant (90-180 degrees). The overall reduction of signal pick-up is greater than that of the original optimized Yagi, and from 160-180 degrees, the nearly 23 dB increase in F/B becomes readily apparent. As is usually the case with antennas, the selection of either of these Yagis is a matter of the station operator's personal preference. Reference 1 provides the potential user of Kmosko-Johnson Yagis with additional alternatives.

F/B optimization for the Tilton/Greenblum Yagi

References 2-4 described many Yagis based on this proven design. In Greenblum's first article, he mentions a method for increasing the F/B ratios of the Yagis described in his design tables.[9] This involves adding another director, but only after determining its position by moving it down the boom to find the F/B maxima. The Greenblum design is based on finding the gain maxima, as Greenblum was obviously concerned about F/B and the overall pattern.

The 0.000 taper gain optimized Yagi from reference 2 was selected for the computer iterations used to illustrate this technique. With tapered directors there would be the additional problem of controlling for a second variable, the taper of the new director. All iterations were made at the Yagi's design frequency of 220.5 MHz.

In order to avoid having this extra director coincide with any of the existing directors, an initial spacing from the reflector of 0.15 wavelengths was selected. Increments were in steps of 0.01 wavelengths, with the last positioning of this director being 3.20

table 6. The effects of decreasing the length of the last director on the performance parameters of the gain optimized zero taper Kmosko-Johnson Yagi.

length of last director (inches)	gain (dBi)	F/B (dB)
36.625	15.601	17.729
36.375	15.604	19.090
36.125	15.605	20.525
35.875	15.604	22.054
35.625	15.602	23.702
35.375	15.599	25.509
35.125	15.595	27.531
34.875	15.592	29.851
34.625	15.587	32.588
34.375	15.583	35.840
34.125	15.579	39.164
33.875	15.575	40.005
33.625	15.571	37.681
33.375	15.567	35.048
33.125	15.563	32.923
32.875	15.559	31.249
32.625	15.555	29.905
32.375	15.552	28.800
32.125	15.548	27.873

table 7. Frequency response parameters for the initial zero taper gain optimized Kmosko-Johnson Yagi.

frequency	gain (dBi)	F/B (dB)
142.5	15.259	11.162
143.0	15.344	12.022
143.5	15.440	13.266
144.0	15.537	15.126
144.5	15.601	17.729
145.0	15.524	18.591
145.5	15.082	13.846
146.0	13.920	8.321
146.5	11.736	3.390

table 8. Frequency response parameters for the initial zero taper gain optimized Kmosko-Johnson Yagi after maximizing F/B by reducing the length of the last director.

frequency	gain (dBi)	F/B (dB)
142.5	15.301	14.600
143.0	15.404	16.310
143.5	15.500	19.015
144.0	15.570	24.302
144.5	15.575	40.005
145.0	15.434	20.942
145.5	15.013	13.968
146.0	14.137	9.146
146.5	12.653	5.125

wavelengths from the reflector. A five-page listing, detailing many undulating cycles of both gain and F/B results, was produced. **Table 9** presents comparisons among the performance calculations for the original Yagi, a new gain optimized Yagi, and each of the Yagis at calculated F/B maximas. **Tables 10, 11,** and **12**

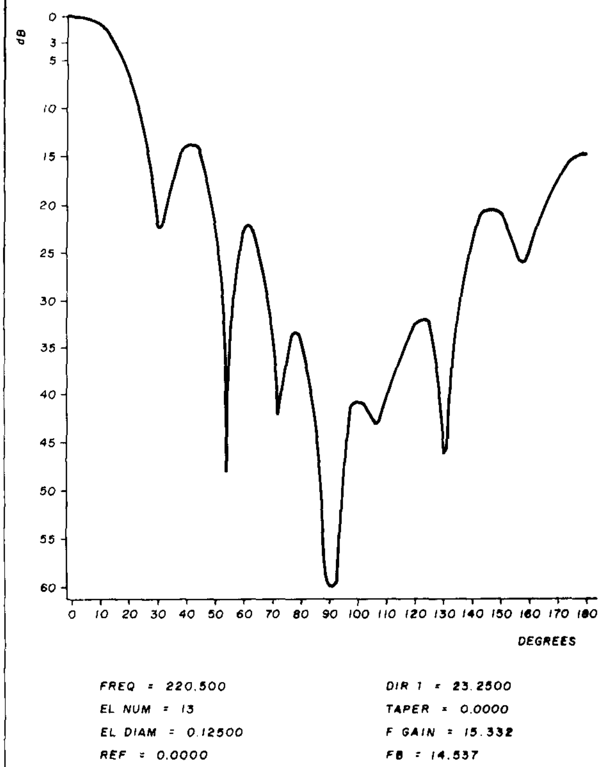


fig. 3. E-plane plot of the zero-taper, gain optimized Tilton-Greenblum Yagi antenna.

table 9. Performance parameter comparisons among various gain optimized zero taper Tilton/Greenblum Yagis as a function of placement of an additional director.

spacing of extra element from reflector (λ)	gain (dBi)	F/B (dB)	comments
---	15.332	14.537	original Yagi
0.28	15.476	16.030	local F/B maxima
0.35	15.576	13.614	new gain maxima
0.69	14.482	21.392	local F/B maxima
1.17	14.551	23.888	local F/B maxima
1.67	14.878	19.850	local F/B maxima
2.12	14.872	21.325	local F/B maxima
2.61	14.611	29.760	global F/B maxima
3.07	15.116	19.931	local F/B maxima

present the frequency response characteristics for the original Yagi, the new gain optimized Yagi, and the F/B optimized Yagi resulting from this process. **Figs. 3, 4,** and **5** present these antenna's respective E-plane plots.

With the exception of the amplitude of some of the minor lobes, there are no real differences between the original and the new gain optimized Yagis. The F/B optimized Yagi has the minor lobes with the greatest

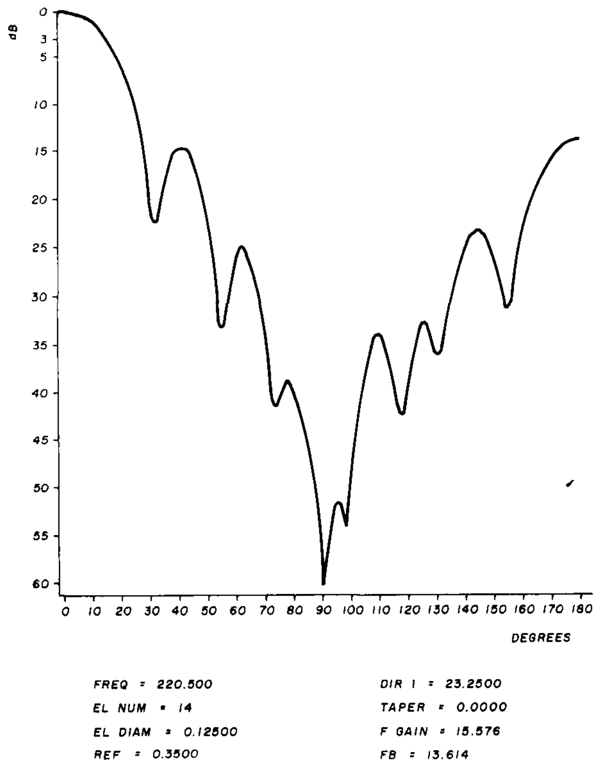


fig. 4. E-plane plot of the new zero-taper, gain optimized Tilton-Greenblum Yagi antenna.

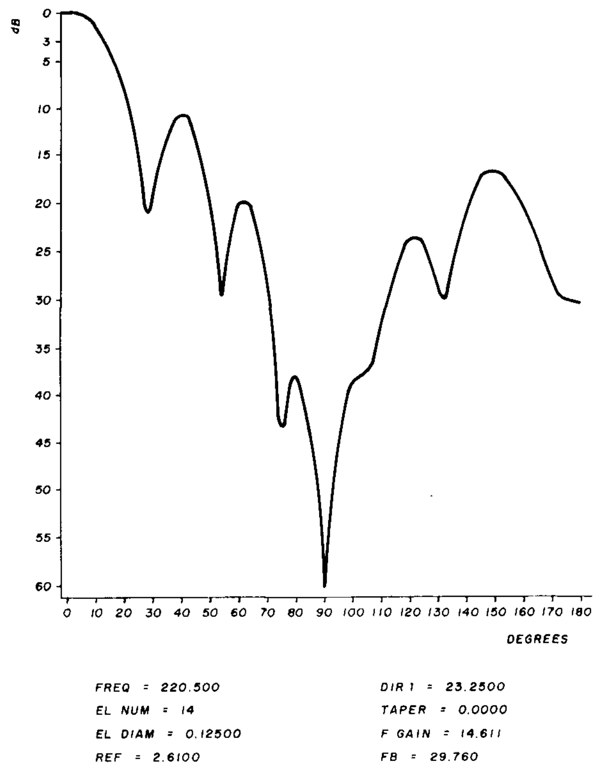


fig. 5. E-plane plot of the F/B maximized verison of the zero-taper, gain optimized Tilton-Greenblum Yagi antenna.

table 10. Frequency response parameters for the initial zero taper gain optimized Tilton/Greenblum Yagi.

frequency	gain (dBi)	F/B (dB)
216.5	14.737	16.075
217.5	15.007	16.472
218.5	15.194	16.169
219.5	15.301	15.425
220.5	15.332	14.537
221.5	15.295	13.695
222.5	15.201	13.003
223.5	15.065	12.515
224.5	14.903	12.266

amplitude, particularly from 100-160 degrees. It is only from 165-180 degrees that the reduced signal pick-up associated with a higher F/B is apparent. All three Yagis display an F/B that increases at frequencies higher than the design frequency, a characteristic of a Yagi inherently optimized for something other than F/B. Specially placing an element to optimize F/B has not changed this Yagi's basic performance characteristics. While individual preferences are generally an important factor in Yagi selection, the 220 MHz operator desiring a high F/B may be better served with those Yagis presented in reference 2.

concluding comments

Throughout this series I have emphasized the use of the digital computer as an antenna design tool capable of providing the VHF/UHF Radio Amateur with a wealth of accurate information in a relatively short time. Gone are the days of tedious and seemingly endless iterations of element lengths, spacings, and resulting pattern measurements on antenna test ranges, all with the inherent possiblity for significant human error. With the computer, several "lifetimes" of Yagi design iterations can be performed accurately and painlessly by using a model that starts with specific designs. More importantly, the VHF/UHF operator can estimate the expected performance of any design more closely than has been possible in the past.

This series has shown how to identify Yagis whose overall performance parameters — a well defined main lobe, reduced side lobes, and a reasonable F/B ratio — are most desirable in the VHF/UHF station. Once again, Reisert has restated and illustrated the importance of emphasing these parameters.[11] However, the operator with special needs, or with the age-old urge to tinker with antennas, can now do so with relative ease.

To further aid the knowledgeable antenna experimenter, the final article in this six-part series will pre-table 11. Frequency response parameters for the new gain optimized zero taper Tilton/Greenblum Yagi with an additional director 0.35 wavelengths from the reflector.

frequency	gain (dBi)	F/B (dB)
216.5	14.850	14.071
217.5	15.171	14.322
218.5	15.391	14.215
219.5	15.521	13.920
220.5	15.576	13.614
221.5	15.573	13.441
222.5	15.528	13.529
223.5	15.451	14.025
224.5	15.330	15.149

table 12. Frequency response parameters for the new F/B maxima on a gain optimized zero taper Tilton/Greenblum Yagi with an additional director 2.61 wavelengths from the reflector.

frequency	gain (dBi)	F/B (dB)
216.5	14.322	16.928
217.5	14.504	19.378
218.5	14.613	22.262
219.5	14.650	25.709
220.5	14.611	29.760
221.5	14.491	33.654
222.5	14.279	33.505
223.5	13.958	28.425
224.5	13.493	22.647

sent a detailed explanation of the FORTRAN program that enables the mathematical model to be iterated on a digital computer. An NBS Yagi will be used to illustrate the program's logic, and a copy of the FORTRAN program will be made available at that time.

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LS138	.60	LS367	.50
LS139	.60	LS368	.40
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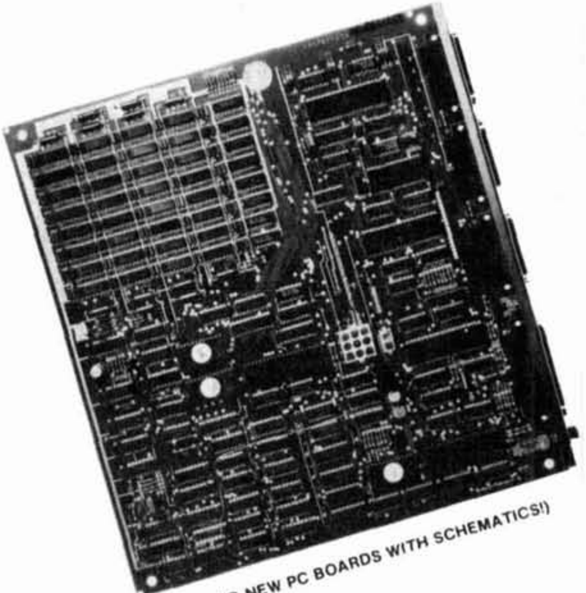

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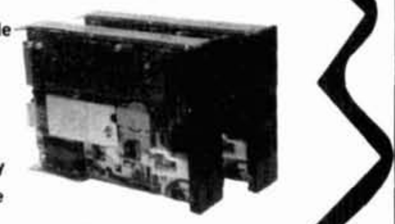

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The antenna measures 20 feet (6 meters) long, and its center is 14 feet (4.2 meters) above the ground. Input SWR is less than 1.15:1 from 3.5 to 4.0 MHz (160 meter data is comparable).

If the interest in small antennas is as widespread as it appears to be, and if the numerous popular designs are as inefficient as I believe them to be, then the story of the SEED antenna, whether useful, amusing, or controversial — might be worth telling. My design considerations, measurement techniques, performance data, and evaluation are included: if they were flawed in any way, experts are welcome to set the record straight, but the antenna *does* work . . . and it has advantages I've never seen in any other ham antenna, large or small.

initial design

The first task was to decide what features were considered most important, and what their order or priority should be. They were:

- operation in the 80 and 160-meter bands
- small size
- efficiency
- feed point impedance of 50 ohms
- simplicity of operation

The first two would be mandatory; optimizing the others would be the job at hand.

Since short radiators have low radiation resistance, good efficiency requires even lower loss resistance. The possibilities of a vertical monopole antenna operated against ground were not explored because an adequate radial system is not small and, without one, ground losses are excessive. Similarly, capacitive end loading structures, to be effective, would also be too big. A short dipole, fed at its center, would require loading inductance, which would necessarily have too much resistance to be acceptable.

However, when viewed from its ends, a short dipole exhibits inductive reactance. This can be resonated with capacitance, and the losses in capacitors can be quite small.

The efficiency of such a short antenna could also be enhanced if the radiation resistances were maximized. This could be done by causing more current to flow in a greater part of the length of the radiator. The end-fed design would provide maximum current in the full length of the radiator and maximum radiation resistance for the length available. The antenna would then be a short, efficient, end-fed dipole.

With these thoughts in mind, a 20-foot (6.1 m) piece of 1-inch (25.4 mm) copper pipe was selected for the radiating element corresponding to a length of 0.08 wavelength or 29 degrees at 3.950 MHz, and half that at 1.9 MHz. A tapered transmission line of two 20-foot pieces of 1/2-inch (12.7 mm) copper pipe are used to end feed the driven element while providing closely spaced points for connection of the other parts. This approximates an equilateral triangle, with the narrow end of the transmission line separated by only a few inches. At this point the reactance would still be highly inductive.

Air dielectric tuning capacitors from each side of the transmission line establish resonance. By placing a low

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reactance loading capacitor between them, the two connecting points provide a low impedance, balanced feed point. By proper selection of the loading capacitor value, this becomes a 200 ohm feedpoint, nonreactive when the system is tuned to resonance, and appropriate for a conventional 4:1 balun to match to 50-ohm coaxial cable.

Inherent in this design philosophy is the distinction between the radiator and the transmission line functions. The radiator is a linear elementary dipole in which current is essentially the same at all points along its length, and voltages at its ends are equal and opposite in phase.

The transmission line section consists of two adjacent, straight conductors in which current and voltage are equal and opposite. It is tapered, and therefore its characteristic impedance varies throughout its length. Its center line is perpendicular to the radiator, and all elements lie in the same plane.

If the radiator is mounted vertically, its intrinsic radiation will be vertically polarized and maximum toward the horizon, while the center line of the transmission line will be horizontal, as will the polarization of its radiation.

The inductive reactance present at the open end of the transmission line section is the combination of that at the ends of the radiator and the effects of the line itself. This total was considered the inductive component of the resonant circuit, and no attempt to separate the factors appeared to be necessary.

construction

The antenna assembly is illustrated in **fig. 1**. The pipe was joined using standard soldered plumbing fittings to minimize junction losses. The ends of the transmission line were connected with half inch silver plated braid to rather large feedthrough insulators on the box containing the other parts. A wooden "T" frame supports the pipe and box, and is mounted on a 14-foot (4.27 m) high wooden 4 × 4 inch (100 × 100 mm) pole. The copper pipe weighs about 18 pounds (8.16 kg) and is not self supporting.

A weatherproof box at the end of the transmission line houses the capacitors, balun, and selsyn. The circuit within the box is shown in simplified form in **fig. 2**.

The tuning capacitors, "ganged" by a shaft coupling, are controlled from the operating position by a pair of surplus selsyns connected by a multi-conductor cable. A small reversible, slow speed motor might have been a better choice. The loading capacitors are mounted and connected with copper strap and banana plugs.

The assembly is mounted with the radiating element vertical. The supporting boom is hinged at the top of the pole to allow it to be tilted 90 degrees to bring the control box down to shoulder level for substitution of capacitors during evaluation.

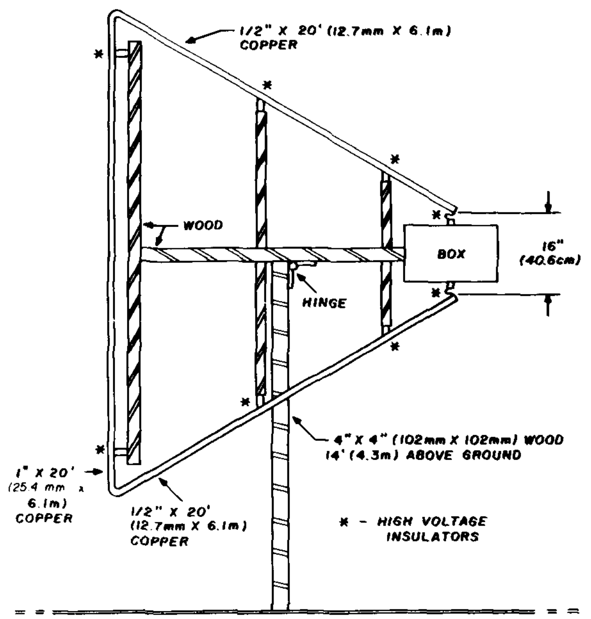

fig. 1. The structure of the SEED antenna and its mounting (not to scale).

After the initial selection, the loading capacitor does not require adjustment to provide a low SWR across a single band. However, a different value is required for each band. Because of the high current to be carried, use of relays or switches is avoided and plug-in units are substituted when changing bands.

circuit description

The basic circuit as originally envisioned is a parallel resonant circuit as shown schematically in **fig. 3A**. The series resonating capacitors, C_{S1} and C_{S2}, and the loading capacitor, C_L, all in series, are across the inductance of the pipe structure, L. There is also a significant distributed capacitance, C_D, across the inductor. This is the capacitance between the sides of the pipe structure plus the stray capacitance of leads to and within the component box. The inductance is 20 μH and the distributed capacitance is 19 pF. The resistance, R, is the sum of the radiation resistance and the loss resistance of the pipe (including joints) and capacitors.

Selection of the series resonating capacitors determines the operating frequency. The value required for the loading capacitor will depend, to some extent, on the physical characteristics of the antenna structure, its mounting and environment, and the adjacent ground. The balun is a standard commercial unit with a cylindrical core and an impedance ratio of 4:1, and is rated for full Amateur power.

The practical circuit now in use is shown in **fig. 3B**. C_{S1} and C_{S2} are, in fact, series or parallel connected assemblies of fixed units, as required by band selec-

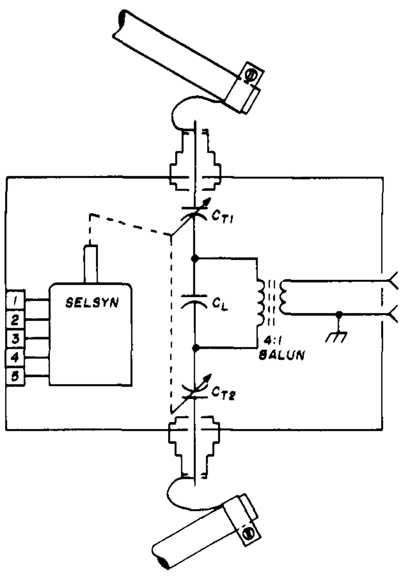

fig. 2. Simplified diagram of the contents of the control box on the boom of the antenna.

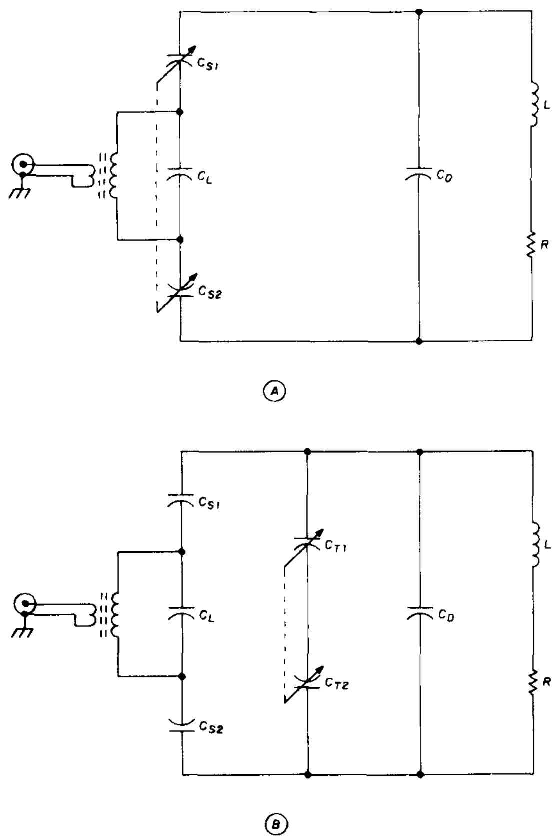

fig. 3. Circuit of the SEED antenna: (*A*) the elementary circuit originally envisioned, and (*B*) the practical circuit in use. (Component designations are explained in text.)

tion and parts availability. In early experiments, each of the variable tuning capacitors was connected in parallel with the related series resonating capacitor. This isolated the distributed capacitance, C_D, and facilitated its measurement. Under these conditions, SWR was 1.5:1 or less from 3.5 to 4.0 MHz. It later developed that connecting the tuning capacitors in series across the entire circuit, as shown, would significantly improve the SWR at the band edges.

Under operating conditions, the total resistance, R, also included the effects of ground and environment. This measured 0.64 ohms at 1.9 MHz and 2.21 ohms at 3.950 MHz.

The tuning capacitors are 10-100 pF, 4500 volt units. When each is paralleled with a fixed series capacitor of 680 pF at C_{S1} and C_{S2}, the circuit tunes from 1.813 to 1.907 MHz. The optimum value of C_L was 7450 pF, and maximum SWR was 1.3:1 in this range. Bandwidth for an SWR of 2:1 without retuning was 3.75 kHz with a loaded Q of about 370. At 200 watts to the antenna, the tuning capacitors each had 2000 volts, RMS, across them and the current in the circuit was 18 amperes, RMS. The benefits of the revised connection of the tuning capacitors had not yet been recognized when 160 meter tests were made.

Using the same tuning capacitors but in the revised circuit, and with fixed 100 pF units at C_{S1} and C_{S2}, the circuit could be tuned from 3.300 to 4.095 MHz. The optimum value of C_L was 1250 pF for an SWR of less than 1.15:1 from 3.5 to 4.0 MHz. The bandwidth for an SWR of 2:1 without retuning was 14 kHz, with a Q of about 225. At 200 watts to the antenna, each tuning capacitor had 2250 volts, RMS, across it, and current in the circuit was 9.5 amperes, RMS.

2-meter model

A 1:36 scale model of the design was made and operated in the 2-meter band in an effort to determine the free space radiating characteristics of the design. Under much less than ideal conditions, scans of 360 degrees of azimuth were made for both horizontally and vertically polarized radiation, with the antenna in three attitudes.

The most informative patterns occurred when the radiator was horizontal and the center line of the feedline section vertical, as shown in **fig. 4A**. This separated the horizontal radiation of the radiator from the vertical radiation of the feedline section, and facilitated consideration of each separately from the other. It emphasized that the maximum signal from the radiator was at right angles to it, whereas that from the feedline section was concentrated in the directions in the plane of the structure and perpendicular to its center line.

With the plane of the assembly horizontal, a plot of the horizontal radiation, as shown in **fig. 4B**, shows essentially a circular pattern, decreasing about 2 dB off the ends of the radiator. Radiation from the feedline section nearly fills in the nulls at the ends of the radiator. Vertical radiation was not detectable in any direction.

With the radiating element vertical, the vertical radiation pattern, as shown in **fig. 4C** shows lobes in directions in the plane of the antenna which were about 6 dB above the nulls at 90 degrees from them (broadside). There was no measureable horizontal radiation.

orientation

The model tests simulated operation of the SEED antenna in free space. To that information must be added the effects of the proximity of ground. Even though they could not be measured with available facilities, the nature and relative magnitude of the distortions to be expected could be estimated.

Mounted horizontally, the SEED design might be an excellent antenna if it were about 140 feet (42.67 m) above ground. At a height appropriate to its size, its radiation resistance would be reduced, decreasing efficiency. Very little low angle radiation would exist. Ground losses would be severe.

If it were mounted with the plane of the structure vertical and the radiator horizontal, the horizontal radiation would be degraded as described above. The feedline section would produce some vertically polarized radiation.

By mounting the SEED with the radiating element vertical, ground losses might be less and low angle radiation should be improved. Since selection of polarization could not be based on comparison of measurable losses, vertical polarization was chosen to favor lower vertical radiation angles.

initial observations

A unique feature of the SEED design is a feed point

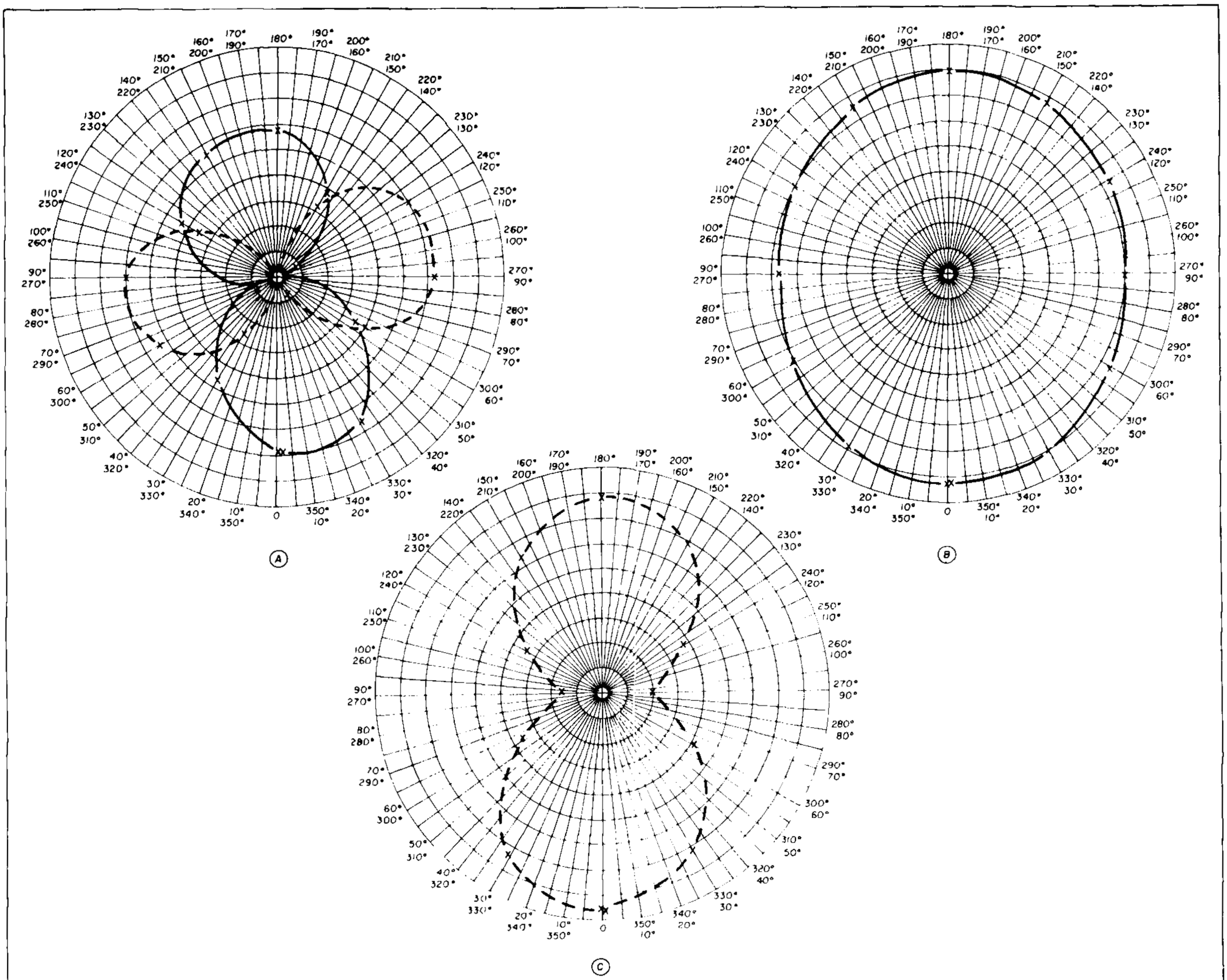

fig. 4. Free space radiation patterns of the 2-meter model SEED: (*A*) with plane of antenna vertical and radiator horizontal, (*B*) with plane of antenna horizontal, and (*C*) with radiating element vertical. Zero degrees in *A* is perpendicular to the plane of the antenna; in *B* and *C*, perpendicular to the radiator in the plane of the antenna, feed point at 180 degrees. Solid line shows horizontally polarized radiation, dashed line, vertical.

impedance of exactly 50 ohms, non-reactive. Other resistive or complex impedances may be obtained if desired. The resistive component is continuously variable by adjusting the value of the loading capacitor, and reactance may be introduced or eliminated by the main tuning control. With the loading capacitor optimized at mid-band, SWR did not exceed 1.15:1 from 3.5 to 4.0 MHz.

Since the loading capacitance is "set-and-forget," only one operating control is needed. A noise bridge or other low power indicator of resistance and reactance at the operating position will show when the antenna is resonant at the desired frequency, and causes no harmful interference. Under power, any device which will show maximum forward or minimum reflected power in the feed line will indicate proper tuning. But accurate tuning is critical to optimum antenna performance as well as feed point impedance. Error in tuning of 8 kHz at 3.950 MHz results in SWR of 2:1 and degrades efficiency, and at 160 meters much more care is necessary. CAUTION: A matching network or "antenna tuner" should not be used with the SEED antenna; neither it nor any controls in the transmitter can compensate for mis-adjustment of this antenna.

If a slow speed, reversible motor is used for remote tuning, a drive shaft speed of 1 RPM is a little too fast for convenience and accuracy, while a slower rate increases the time required for wide frequency excursions.

The very high loaded, operating Q of this circuit, 225 at 3.950 MHz and 370 at 1.900 MHz, probably attenuates harmonics and many other spurious emissions very effectively, but this effect could not be assessed. The resulting high current in the full length of the radiator is the good news. High current and voltage in the other parts of the circuit require special attention. Many hams may not be familiar with antenna parameters of 16,000 volts, peak, or 42 amperes of RF.

No inherent frequency limitations on the SEED design were observed. The 144 MHz model performed well, but both selection and adjustment of low loss, small capacitors were tedious. The total length of the radiator plus both elements of the feedline section should not exceed about 0.4 wavelength at the highest frequency to be used for fundamental operation.

At lower frequencies, through the broadcast band and below, it appears that a structure of this design, but still less than 0.1 wavelength long, would operate well and might have advantages. Elimination of the need for an extensive field of ground radials as an integral part of the circuit may be beneficial in some cases.

operational testing

The test site for the SEED is in a ravine nearly surrounded by ground 130 feet higher. The surface slopes about 8 degrees and is completely covered by trees. There are seven houses within a half wavelength of the antenna. A full length horizontal dipole 35 feet high and a 48-foot vertical are available for comparison. A single knob permits instant selection of any antenna and disabling of the others so they will not act as parasitic radiators. All antennas were matched to accept the same power. Most tests were conducted at frequencies near 3.950 MHz.

A lengthy effort was made to obtain dependable numerical comparative performance data, but results were inconclusive. Subjectively, less formal signal reports and innumerable listening tests over a three-year listening period were encouraging. At distances of less than 100 miles, the consistent superiority of the horizontal dipole confirmed the predominantly low-angle radiation of both the SEED and the vertical. At distances up to about 550 miles, the SEED and the horizontal dipole exceeded each other as conditions varied, while the vertical whip was consistently inferior. The immediate terrain prevents investigation of the probable superiority of the SEED and the vertical at greater distances, where predominantly low-angle radiation is most effective.

The antenna was resonated and matched in the 160 meter band and operated for about three weeks in early April. Power to the antenna was about 160 watts, PEP, on Single Sideband. Most contacts were made between 6 and 10 PM and at distances of 300 to 600 miles. No apology was offered for the size of the antenna and good reports were received. Those who asked and were told that the radiator was 20 feet long expressed surprise and curiosity.

The most frustrating aspect of these experiments was the inability to obtain satisfactory "on the air" performance data. It is hoped that someone with a suitable test site will investigate and report the low angle, long distance capability of the SEED which could not be determined at this location.

measurements

Several years of dredging at surplus outlets and hamfests had provided a supply of nondescript capacitors for this project. It soon became apparent that knowing the capacitance of those in the circuit would be necessary, and accuracy would be important. A Dynascan digital capacitance meter was obtained and used for measurements. A popular noise bridge was found to be inadequate for critical, repeatable, measurements. By modifying a published design, a noise bridge with suitable accuracy and resolution was made and calibrated. A secondary station receiver was dedicated to the project, and a signal generator and frequency counter provided signals of known amplitude and frequency.

One of the useful features of the SEED design is that it is a parallel resonant circuit with easily measurable

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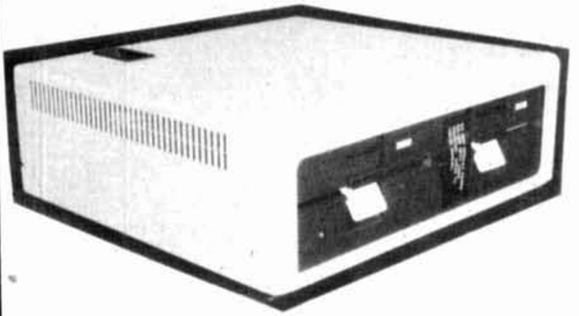

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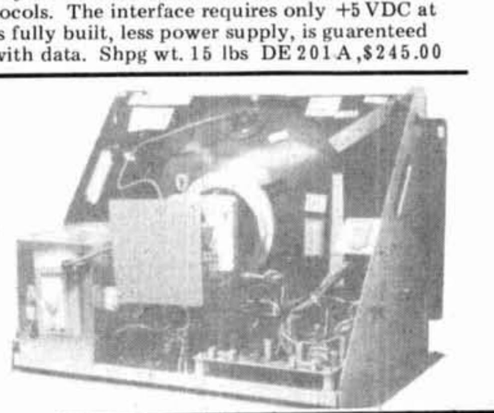

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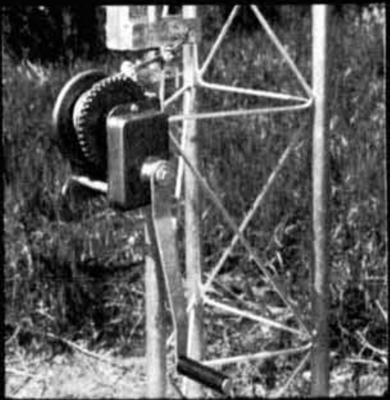

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components. The series, loading and tuning capacitors can be measured directly. The value of the distributed capacitance and the inductance of the structure, including the connecting leads, can be computed directly from these measurements and the frequency of resonance, as explained in **appendix A**.

With this data, it is possible to determine the series resistance of the antenna in position, as shown in **appendix B**. This is the sum of the radiation resistance, the loss resistance of the components, and the effects of absorption and reflection of adjacent ground and other objects. The loaded Q of the circuit can also be found, and measurement of the bandwidth for an SWR of 2:1 can be confirmed as in **appendix C**.

efficiency

The books say that the radiation resistance at 3.950 MHz of the SEED antenna in free space would be about 5 ohms. Loss resistance in the primary circuit has been determined to be about 0.1 ohm. Under these conditions, efficiency would be $\frac{5}{5 + 0.1} \times 100 = 98$ *percent*. This shows success in obtaining some of the design and construction goals, but usefulness of the figure is limited.

When the real secondary effects of ground and environment loss and reflection are added, the measured total resistance is 2.21 ohms at 3.950 MHz. Facilities were not available to divide this total between loss and radiation resistance, so a real efficiency percentage cannot be determined. However, the portion which represents total losses cannot exceed 2.21 ohms and must be somewhat less because useful radiation has been observed.

This justifies the original premise that even small amounts of loss resistance in the primary circuit could seriously degrade the output signal. As an example, substitution of No. 10 wire for the pipe which was used would increase primary resistance by 1.1 ohms and would just about double the total loss of the operating antenna. In other words, the increased resistance of the wire would be more or less equivalent to the power of the radiated signal.

evaluation

The initial design goals were all satisfactorily met or exceeded. A 20-foot radiator which can be operated without apology on either 160 or 80 meters is certainly small, and the SEED appears to be much more effective in use than would be expected. An SWR of less than 1.15:1 across the entire 3.5-4 MHz band may be one of the best solutions available for modern transceivers with transistor output stages. Elimination of the usual "antenna tuner" in the shack, and a single control to resonate the system, is operating convenience which approaches the ultimate (automatic sensing and resonating of the circuit could be provided).

However, CAB's Law is that "A problem solved is a problem created." At full legal Amateur power, a very short antenna must carry very high current, as do the associated capacitors. In the process of developing that current, high voltages are created. Ham-type handbooks and reference data available here provide very little theoretical or practical information about capacitors under conditions of high voltage, high current, high frequency, and high capacitance values.

The SEED antenna operates at 200 watts on either band with surplus capacitors that cost less than $25. The air variables are currently advertised at about twice that, but all others are obsolete and not now available. The capacitors in SEED Mk IV, a rather different version, are more than is needed, but they will take a full kilowatt without strain. They could be bought new, now, but for well over $1,000.

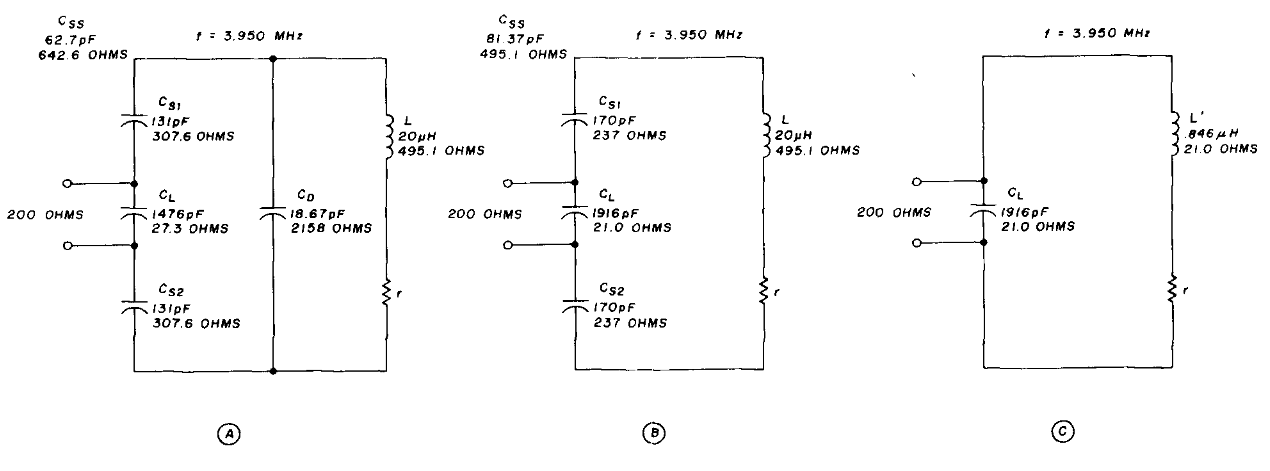

fig. 5. Transposition of the actual circuit of the SEED antenna (*A*); to the equivalent circuit (*B*); and to the simplified equivalent (*C*), as described in *appendix B*.

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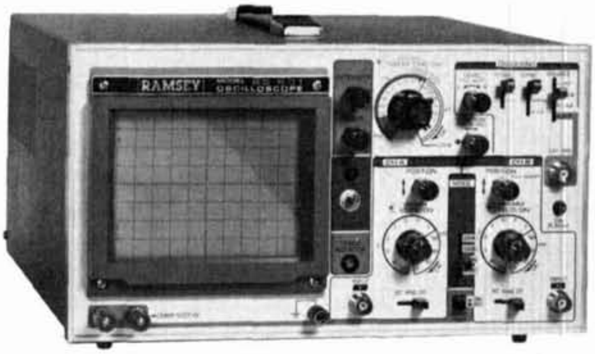

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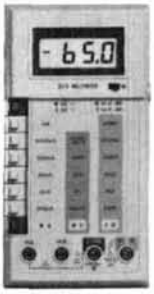

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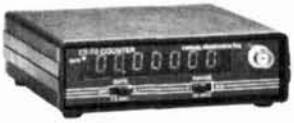

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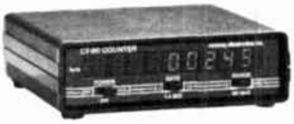

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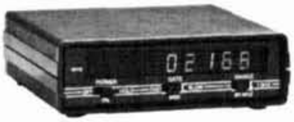

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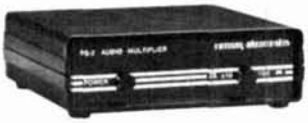

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appendix A

With reference to **fig. 3A**, the parallel tuned circuit consists of an inductance, L, a distributed capacitance, C_D, and a series combination of tuning and loading capacitors, C_{SS}. The values across C_{SS} were measured as follows:

1.900 MHz	333 pF
3.950 MHz	62.7 pF

In each case, the distributed capacity must be added to that measured to resonate with L.

The formula for resonance,

$$f = \frac{1}{2\pi\sqrt{LC}}$$

can be rewritten:

$$\frac{\left(\frac{1}{2\pi f}\right)^2}{C} = L$$

Substituting appropriate numbers,

$$\frac{\left(\frac{1}{6.28 \times 1.9 \times 10^6}\right)^2}{333 \times 10^{-12} + C_D} = L$$

$$= \frac{\left(\frac{1}{6.28 \times 3.95 \times 10^6}\right)^2}{62.7 \times 10^{-12} + C_D}$$

which can be solved for C_D (18.67 pF) and then for L:

At 1.900 MHz: $333\ pF + 18.67\ pF$
$= 351.67\ pF$ *or* $238.2\ ohms$
and $238.2\ ohms = 19.953\ \mu H$ *for* L
at 3.950 MHz: $62.7\ pF + 18.67\ pF$
$= 81.37\ pF$ *or* $495.2\ ohms$
and $495.2\ ohms = 19.952\ \mu H$ *for* L

appendix B

With the antenna resonant at 3.950 MHz, the value of the loading capacitor was adjusted for 50 + j0 ohms at the end of about a half wavelength of new RG 213/U cable. Subject to any imperfections in the balun, this indicated an impedance of 200 + j0 ohms across the loading capacitor. The measured value of this capacitor was 1476 pF for a reactance of 27.3 ohms. The reactance across the series combination of C_{S1}, C_{S2}, *and* C_L, or C_{SS}, was 643 ohms.

The ratio of X_{CSS} to X_{CL} is 643 to 27.3 or 23.553 to 1. The impedance ratio is the reactance squared, or 554.75 to 1. Therefore, the impedance across C_{SS}, at resonance, is the impedance across C_L, 200 ohms, multiplied by 554.75 or 110,950 ohms. This is the impedance across the parallel tuned circuit and, at resonance, it is purely resistive. Since the relationship of the series resistance, r, to the parallel resistance, R, is:

$$r = \frac{X^2}{R}$$

where X is the reactance of either the inductor or total capacitance of $C_{SS} + C_D$, or 495.1 ohms. Then

$$r = \frac{245,124}{110,950} = 2.2093\ ohms$$

or the total series resistance of the antenna is 2.21 ohms.

Alternatively, the circuit may be considered by transposing it as shown in **fig. 5**. The circuit was modified and measured at 3.950 MHz, as shown in **fig. 5A**. In the absence of C_D, the total of C_D and C_{SS} would need to be combined to resonate at the same frequency. Retaining the same ratio between C_S and C_L, the values can be computed and would be as given in **fig. 5B**.

It can then be seen that the net reactance of C_{S1}, L, C_{S2}, in series, is inductive and equal to the capacitive reactance of C_L. Considering this combination, L', the circuit can be redrawn as in **fig. 5C**. This is a simple parallel tuned circuit, and it is known that its parallel impedance at resonance is 200 + j0 ohms and may be expressed as R. Then, since the equivalent series resistance, r, is given by $r = \frac{X^2}{R}$ and X is the reactance of C_L, which is 21 ohms. Then $r = \frac{441}{200} = 2.205\ ohms$.

appendix C

The loaded Q of the antenna at 3.950 MHz can be found by dividing the reactance of L by the series resistance. Then $Q = \frac{495}{2.21} = 224$. It can be shown that for a Q of 224, the bandwidth for an SWR of 2:1, would be 13.225 kHz at this frequency.

Tests of the SEED at 3.800 kHz, where the coax was electrically a half wavelength long, measured the bandwidth for a SWR of 2:1 of 13.950 MHz. This tends to corroborate other tests and computations.

ham radio

electromagnetic interference
and the digital era

Component selection, grounding and shielding solve common problem of digital design

Whatever happened to the good old days when unwanted radiation consisted of RF on the microphone cord or key line and relative output power was measured by the length of the arc drawn from the final caps to chassis? A high wattage soldering iron and a handful of large disk capacitors was always enough to solve any floating RF problems and the pulsing of the gas filled tubes served only as an "on-the-air" indicator.

As more electronic consumer equipment entered the home, Amateurs found it necessary to clean up their signals by adding shielding and lowpass filters to prevent interference with home entertainment products. New terms such as radio frequency interference (RFI), electromagnetic compatibility (EMC), and television interference (TVI) became more common and Amateurs were forced to become knowledgeable about quarter-wave traps, hi-fi speaker bypassing, and other methods of preventing their signal from being received by their neighbor's equipment.

With the advent of home computers, the interference problem took a new turn. Now manufacturers were producing and mass marketing equipment capable of causing interference in radio and television reception. It didn't take the FCC long to determine that some new regulations were in order. The result of the FCC rulemaking was Docket 20780, which placed certain limits on both conducted and radiated interference, and Docket 80284, which outlined the testing requirements necessary to show compliance with 20780.

what are the requirements?

The FCC made two major decisions which set the schedule and defined technical requirements for industry. The first cutoff date, January 1, 1981, applied to personal computers and electronic games. All such equipment manufactured after this date was required to meet the new specifications. After October 1, 1981, all other subsequently produced computing equipment had to meet the new specifications, and after October 1, 1983, no devices could be sold, regardless of the date of manufacture, unless they were tested and certified to operate within the allowable interference limits.

Docket 20780 defines two different classes of equipment and specifies radiated and conducted limits for each. *Class A* includes commercial equipment, while *Class B* limits apply to home equipment. **Table 1** outlines the allowable limits for both classes in the two interference categories.

There are, obviously, some questions which the manufacturer must settle before he will know if the product he makes falls under the new regulations. First of all, just what is classified as computing equipment and what is not? According to the definition in Docket 20780, any device that generates or uses signals or pulses in excess of 10 kHz is designated a computing device. Secondly, if the manufacturer produces a device which is used in both residences and businesses, which specification must be met? I don't know the legal ramifications of this question, but if a sizable portion of the market is for home use, I suspect the Class B specifications will have to be met. So, is your new Hi-Tech DX transceiver covered by this regulation? Well, if it contains or uses digital circuitry with clock frequencies in excess of 10 kHz; memories, a CRT, or a switching power supply; disks, a tape-drive, printer, communications interface, or microprocessor, it probably *is*.

By F. Dale Williams, K3PUR, 1394 Old Quincy Lane, Reston, Virginia 22094

why the sudden interest?

Life in the analog lane was almost always predictable, with any interference problems easily isolated to a particular frequency and circuit. However, digital electronics has overwhelmed the RF environment with binary clocks that produce harmonics into the Gigahertz range, plastic equipment enclosures, wall plug power supplies, and unshielded ribbon cable that acts as an antenna to radiate both the signals it is meant to carry as well as any other signals near the circuit connection.

By the very nature of the binary format, digital pulses are rich in harmonics. As the signal switches from the minimum circuit value to the maximum, the potential interference at any frequency is dependent upon the waveform characteristics. **Fig. 1** shows the parameters for a typical pulse waveform. If we assign values to these parameters for purposes of illustration:

$A = 4$ *volts*

$t_r = 5$ *nanoseconds* $= 0.005$ *microseconds*

$t = 0.5$ *microseconds*

$T = 1$ *microsecond (PRF* $= 1$ *MHz; PRF* $= 1/T$*)*

PRF (Pulse Repetition Frequency) $= 1/T$

Then calculate:

$A(t + t_r) = 4(0.5 + 0.005) = 2.02$ *microsecond-volts*

$A/t_r = 4/0.005 = 800$ *volts per microsecond*

These values can then be plotted on a standard conducted interference graph for the particular waveform used. The resulting interference level for the above waveform parameters is shown in **fig. 2(A)**. Now let's increase the rise time by a factor of 100:

$t_r = 500$ *nanoseconds* $= 0.5$ *microseconds*

$A(t + t_r) = 4(0.5 + 0.5) = 4$ *microsecond-volts*

$A/t_r = 4/0.5 = 8$ *volts per microsecond*

table 1. Conducted and radiated interference limits.

conducted (MHz)	class A (μv)	class B (μV)
0.45 – 1.6	1000	250
1.6 – 30.0	3000	250
radiated (MHz)	**class A (μV/m)***	**class B (μV/m)****
30 – 88	30	100
88 – 216	50	150
216 – 1000	70	200

*measured at 30 meters
**measured at 3 meters

These values are plotted in **fig. 2(B)**. As a final test, let's change the repetition or clock rate to 500 kHz in the first example:

$T = 2$ *microseconds (PRF* $= 0.5$ *MHz; PRF* $= 1/T$*)*

$t = 1$ *microsecond*

$A(t + t_r) = 4(1 + 0.005) = 4.02$ *microsecond-volts*

These values are shown as curve *C* in **fig. 2**. From the interference plots, it is obvious that the lower clock frequency produces slightly greater amplitude, while a decrease in rise/fall time produces less interference at the higher frequency ranges. The points marked as f_1 denote the point where the envelope begins to drop

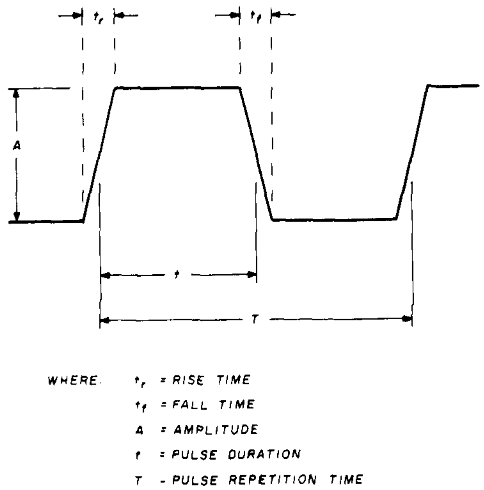

fig. 1. Pulse waveform parameters.

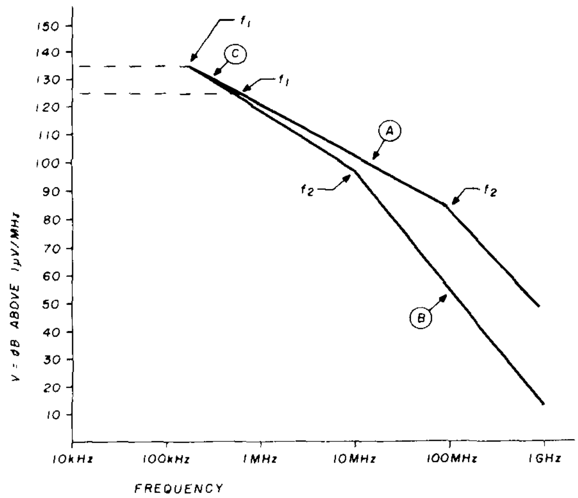

fig. 2. Conducted interference from symmetrical trapezoid.

off at the rate of 20 dB per decade. This point is determined by the pulse duration or period. Points shown as f_2 mark the frequency where the envelope drops off at a rate of 40 dB per decade. These points are determined by the rise and fall times. From this interference plot, it becomes clear that pulse shape, controlled by the rise and fall times, is the most important factor in reduction of the interference spectrum. This is further illustrated by **fig. 3**, which shows the relative interference levels of various waveshapes. It also becomes evident why operating a computer with poor electromagnetic interference protection precludes simultaneous use of everything from HF receivers and TV to the scanner.

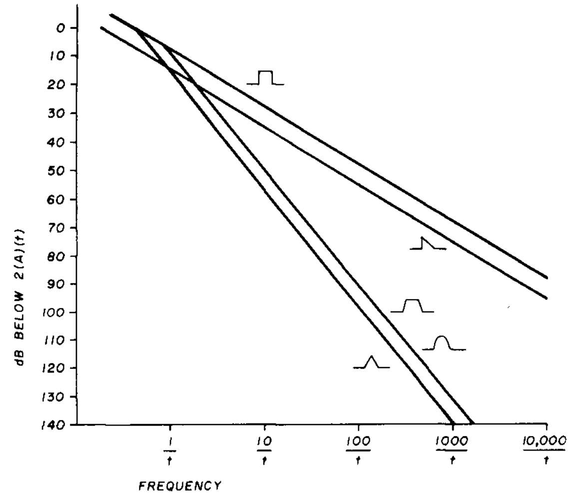

fig. 3. Interference levels for various waveforms.

conducted versus radiated interference

If we compare these two types of interference to a hot water heating system, the analogy may help us to understand the problem. The hot water radiator disperses heat to the room in proportion to the temperature of the water circulating through the system. If the water is not conducted to a particular radiator, no heat can be radiated from that radiator. Similarly, the interfering signals must be conducted from the source by means of circuit board traces, wiring, or components from which the interference can be radiated to a distance dependent upon signal strength.

Probably the only areas where conducted emissions are more important than radiated emissions are in the power line and grounding circuit. These areas become particularly important when switching type power supplies are used. With common power units, a multisection pi-type filter placed in a metal box, with *RF* continuity to the shielded equipment enclosure, will prevent any signals generated in the circuitry from reaching the power line. This procedure will also protect against interference radiation by the power cable. Conductive interference caused by ineffective grounding circuits is caused by an unintended resistive circuit ground connection to true ground. Such a connection will cause an offset signal level from true ground to be circulated to other points of the circuit which are also attached to the common bus.

Radiated interference commonly refers to any interfering signal propagated via an electromagnetic field. This definition includes radiation from wires or cables acting as transmitting antennas and coupling by mutual inductance or capacitance. The electromagnetic field propagates in normal fashion where the strength of the signal is inversely proportional to the distance from the source.

Interference contained on a signal cable between two pieces of equipment is not normally considered a potential radiated emission problem unless the conducted interference affects the operation of the unit to which it is connected.

design considerations

One of the worst jobs in the industry is trying to modify a piece of equipment manufactured without regard to EMC/RFI requirements to meet FCC regulations. In most cases, it is more economical to redesign, at least at the board or module level.

Good design practice dictates that EMI should be reduced as much as possible at every level. For circuit design, that means we must choose logic families with no greater bandwidth than necessary. For instance, CMOS has a lower bandwidth capability than other logic families. If a high speed clock is not required, use a lower speed clock instead of dividing down. Use waveforms with as long a rise and fall time and duration as possible within timing constraints.

When laying out the circuit board, use a minimum of one-eighth inch wide ground/common traces and place them at the edges of small boards, with additional traces down the center for larger boards. Ground traces should be connected at one end of the board only — the connector end. Ground returns should be as short as possible. If double-sided boards are used, interconnections between top and bottom surfaces should be frequent. Use of wiring to connect integrated circuits on different parts of the board should be avoided. When unavoidable, shielded cable, or at a minimum twisted pairs, should be used. Do not "float" any unused IC pins. Circuits employing clock frequencies on the order of 10 MHz and above are good candidates for double-sided boards. This procedure also acts to shield parallel boards in a vertical card slot configuration.

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106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286	298	310	322	334	346
107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311	323	335	347
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
109	121	133	145	157	169	181	193	205	217	229	241	253	265	277	289	301	313	325	337	349
110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314	326	338	350
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315	327	339	
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Liberal use of bypass capacitors will help minimize stray emissions. When strategically placed in the circuit, they will do the job even better. **Figure 4** shows the placement of various types and values of capacitors to suppress the complete range of frequencies.

Circuit board connectors present one of two locations where all signals are in close proximity to each other. If ribbon cable is used to parallel connectors, it should be mounted flat to the chassis and not run in close proximity and parallel to the component side of a circuit board. If various timing signals are to be carried on the same ribbon cable, alternate strands should be at ground potential. When using clock frequencies above 1 MHz, coaxial board connectors and cable should be considered.

The other location where the signal cables are in close proximity to each other is in the output connectors. If the output is a bus connection, it should be actively terminated rather than left to "float." This is one of the worst areas for emissions. If the outputs will not be continuously covered by an external connector, they must be covered by a shield (or metal shell) that prevents any leakage of RFI. External connectors must be metallic and use cables employing an overall shield that is continuous with the connector. For particularly bad cases, special chassis-mount connectors that incorporate filters as an integral part of each pin are manufactured. They operate much as DC feedthrough capacitors, as shown in **fig. 5**. Keep in mind that any filtering on signal lines will alter the waveform, much as a long length of cable would.

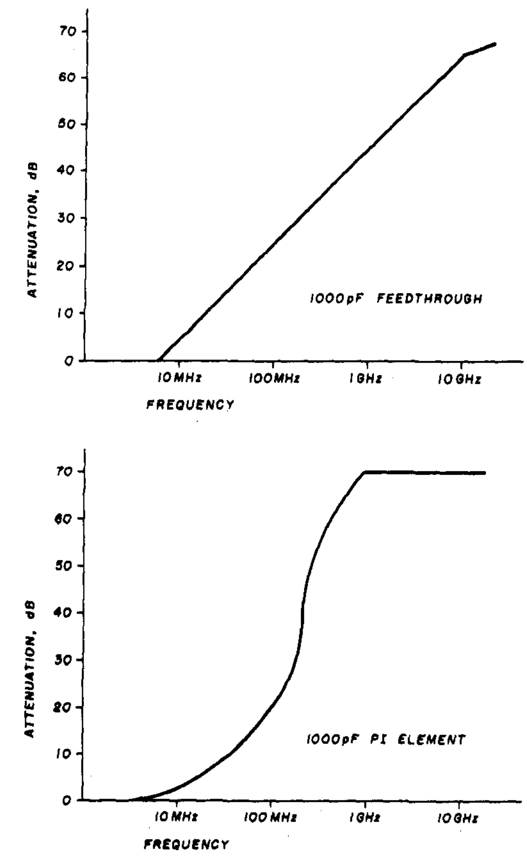

fig. 5. Typical attenuation for connector pin filters.

Therefore, if signal line filters are required, they must be selected by the effect they may have on the pulse shape, typically lengthening rise and fall times, but not necessarily by equal increments. If all else fails, fiber optics or optocouplers may be used.

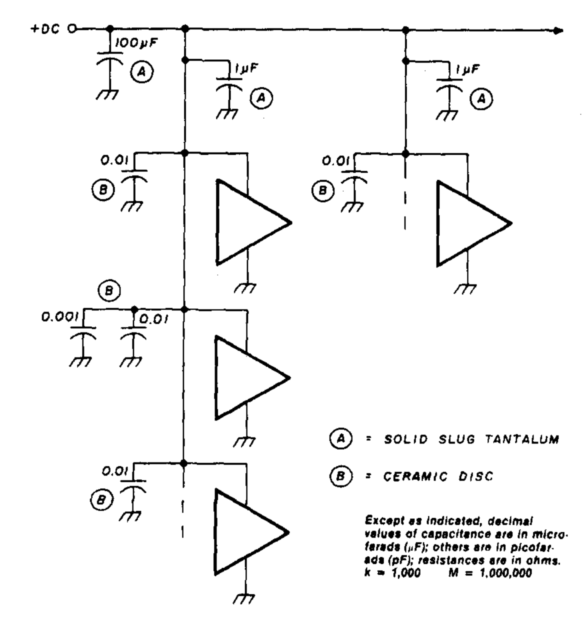

fig. 4. Bypassing for EMI suppression.

grounding

Although no guide to a perfect grounding system exists, practical experience has shown that following certain standard procedures is the first step in establishing an effective grounding system.

If you have control of that part of the ground system to which the equipment being designed will be connected (such as in a home or business environment), you should consider this as an integral part of the overall system. If a ground system is to act as a common voltage reference point, it is important that a single point, low potential, true ground location be established and that all branches feeding this point are low resistance/impedance paths. A typical system configuration is shown in **fig. 6.** Within each piece of equipment, all circuit boards/modules should have only one ground lead to the internal ground bus; if such a lead would be too long (over one-quarter wave-

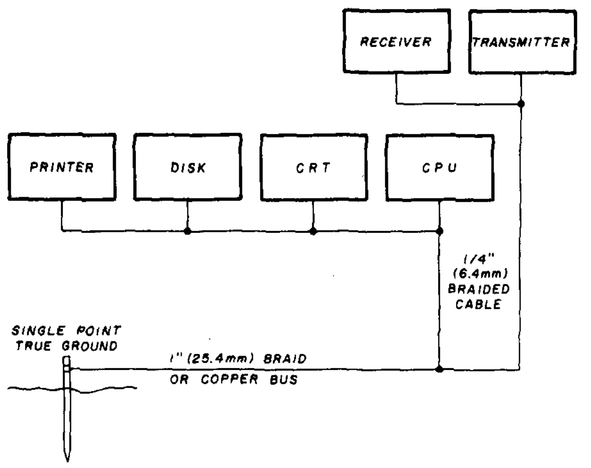

fig. 6. Representative single-point ground system.

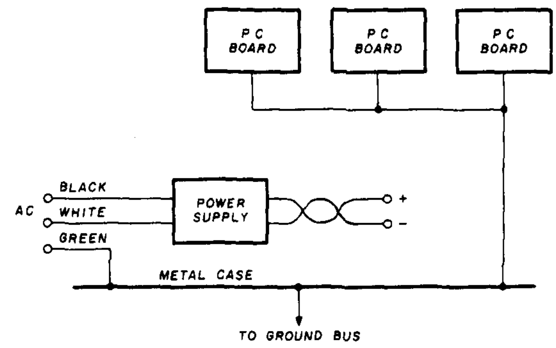

fig. 7. Internal equipment grounding.

length at the clock frequency), this lead may be connected directly to the chassis, as shown in **fig. 7**. Additional pieces of equipment comprising part of a system — i.e., CPU, disks, CRT, and printer — normally receive ground continuity via shielded cables and no additional ground wire connection between the chassis should be made.

shielding

Shielding refers to the use of an electromagnetic barrier to separate electric or magnetic fields. When implemented as an equipment enclosure, with appropriate measures to secure any openings against discontinuties, it functions to maintain all signals generated within the case as well as keeping potential external interfering signals from entering the enclosure. The enclosure material may be any one of various metals, a mixture of metal elements, or a plastic impregnated with metal bits or coated with metallic paint.*

table 2. Conductivity and permeability relative to copper.

metal	conductivity	permeability (150 kHz)	penetration loss dB/mil
copper	1.00	1	1.29
aluminum	0.61	1	1.01
brass	0.26	1	0.66
tin	0.15	1	0.50
steel (SAE1045)	0.10	1000	12.90

When the electromagnetic wave impinges upon the enclosure surface, it is not completely reflected. Although part of the energy is, in fact, reflected, the balance of the energy is transmitted through the material with the degree of attenuation (absorption) depending upon the type of enclosure material, thickness of the material, and frequency of the electromagnetic energy. (If we were to consider the shield as a plane of glass through which we are attempting to shine a light, perhaps this analogy would clarify the concept. The glass will reflect some of the light, depending upon the angle of the beam, but some will also be transmitted to the other side, with the amount transmitted dependent upon the thickness and color of the glass. In addition, there will be secondary and higher orders of reflections from each side of the glass plane of lower amplitude, as shown in **fig. 8**. For practical purposes, we may neglect the secondary and higher functions since they are mainly applicable to magnetic fields, and state that the shielding effectiveness is the sum of the reflection and absorption losses.)

In the selection of a suitable material for shielded enclosures, we must know the attenuation required, the frequency range of the potential interference, and the limits of thickness of the material (10 gauge steel

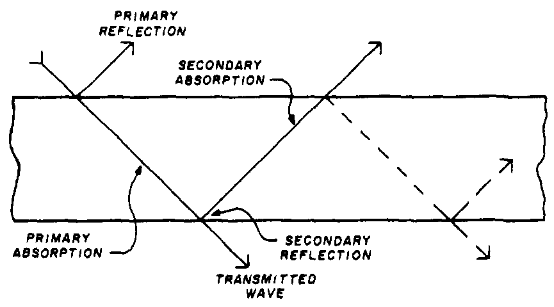

fig. 8. Reflection and absorption of electromagnetic wave.

*See Vaughn Martin's "EMI/RFI Shielding: New Techniques," *ham radio*, January and February, 1984.

table 3. Metal thickness required for 60 dB absorption loss at 1 MHz.

metal	thickness
copper	15 mils
aluminum	20 mils
brass	25 mils
tin	35 mils
steel	1 mil

table 4. Plane wave reflection loss at 1 MHz.

metal	reflection loss
copper	108 dB
aluminum	104 dB
brass	102 dB
tin	100 dB
steel	77 dB

does not lend itself to easy preparation). Generally speaking, ferrous metals are more effective shields at very low frequencies than nonferrous materials; sheet steel has medium effectiveness at these frequencies; nonferrous metals and steel are suitable at higher frequencies. The thickness of the shielding material is a function of permeability and can be found by:

$$t = \frac{A}{3.338 \times 10^{-3}\sqrt{fG\mu}} \text{ mils}$$

where A = required attentuation
f = frequency in Hertz of lowest interfering signal
G = conductivity of shielding material chosen compared to copper
μ = the relative permeability of the shielding material

Conductivity and permeability values for various metals are given in **table 2**. Choosing the wrong material may require a shield thickness that is impractical. The thickness required for various metals to provide 60 dB absorption attenuation at 1 MHz is shown in **table 3**. For reflection loss, **table 4** lists the plane wave attenuation for the same metals at a frequency of 1 MHz. A tradeoff of skin thickness versus attenuation required can be made in cases where one area of circuitry is producing the strongest interference. By installing a shield around the offending components on the circuit board, the requirements for enclosure shielding are lessened.

Holes in the case for ventilation, connectors, switches, etc., will materially decrease the shielding effectiveness. The larger the diameter of the hole and the higher the frequency, the greater the leakage. Ventilation openings may be covered with wire mesh, but it must be directly bonded to the case for maximum effectiveness. Preformed metal cases with hole patterns will decrease the attenuation in proportion to the hole diameter, depth, and size of the area containing the openings. Although the cutoff frequency of the openings can be determined from the diameter

$$f_c = \frac{6.92}{d}$$

$$f_c = 1 \times 10^6 = \frac{6.92}{d}$$

solving for d, we obtain $d = 0.000007 \text{ inches}$

the depth or thickness of the material must be three times the diameter of the hole to produce 100 dB attenuation.

Where parts of the shielding enclosure must be bolted together, the opportunity for leakage is great. For example, with perfectly flush, bare metal contact between two pieces of one-half inch, 0.09 inch thick aluminum, shielding effectiveness decreases by 25 dB when mounting hole spacing is increased from one inch to five inches. Using woven knitted wire mesh gasket material in these areas, as well as around connectors, will maintain the shielding integrity of the enclosure. As a general rule of thumb, where RF gasketing is not used, or the enclosure contains discontinuities such as corner bend strain relief openings, multiple bolt-together sections, openings for switches, fuses, etc., the maximum expected attenuation is about 30 dB.

The same type of rationale applies to the use of coax cable. Leakage through the braided shield depends on the material used, the number of strands used, and the spacing or turns per inch. Cable is available with various values of shielding effectiveness to 95 percent for double shielding. The shielding effectiveness of coax cable is *only as good as the connectors used at each end.* A double-shielded cable yielding 95 percent effectiveness with 60 dB connectors will not provide more than 60 dB attenuation.

conclusion

Although we can estimate the required shielding for a given attenuation specification, it is impossible to forecast the interference level of the circuitry in the design stage. Therefore, it is imperative that procedures to minimize RFI be implemented at the circuit board level to lessen the system shielding requirements.

Now that Amateurs are more involved in designing their own digital circuitry for use with their other station equipment, we must put appropriate EMC procedures into practice or risk operational degradation to the companion units or even loss of use of the complete station because of RFI.

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ham radio

solving the problems of RFI

A brief recollection of quirks and cures

Whenever there's an RFI problem with a piece of equipment, the instruction manual inevitably suggests connecting the equipment to a good ground. This is appropriate advice if the equipment is all in the basement, or at worst, on the first floor. But if your gear is spread around the house, obtaining a good ground at Amateur Radio frequencies may not be easy.

While some grounds *are* more effective than others, sometimes it's better not to use a ground at all, but to use other means — such as filters — instead. Those of you who've worked in broadcasting, and are familiar with the sensitive, low-level audio circuits found in studios close to the transmitting antenna, know that it's a common practice to ground only the shield at the input end of the audio circuit and leave the output end ungrounded. This prevents a ground loop that can aggravate a hum problem rather than alleviate it.

It's a mistake to tie everything to one ground lead. The more equipment connected to a ground lead, the greater the resulting current flow, creating more problems with interference. Better to keep all grounds, especially AC and RF grounds, separate. The feedthrough of RF power to the AC line will be much greater from a common junction than the AC line would pick up from direct radiation.

A classic case of RF power being fed through a common junction was a commercially built one-kilowatt RF amplifier designed for Amateur use. Probing around with an RF meter fitted with a figure-eight pickup loop showed plenty of RF current flowing in both the line cord and the house wiring. This was rather puzzling because the amplifier has a built-in AC line filter of good construction, consisting of sufficient turns of heavy wire on a half-inch ferrite rod, five inches long.

The amplifier had a built-in power supply with dual windings on the power transformer primary so that it could be operated from either a 115 volt or 230 volt power line. Finally the words, "the neutral (green) wire of the line cord should be connected to the chassis at all times" caught my attention.

That phrase gave me the answer — an answer that for some reason, escaped the attention of the design engineer. The direct connection of the neutral wire to the chassis and to the AC ground nullified any filtering action of the AC line filter. The cure was obvious.

If the amplifier had been operating on 230 volts, I would have had to wind a third coil over the line filter, or if that were too difficult, to wind a separate and suitable RF choke and connect it between the chassis and the neutral lead. Since I was operating the amplifier from the 115 volt line, all I had to do was to disconnect the neutral (green) lead from the chassis and tape it. This reduced the RF current flow in the cord and the house wiring to a barely noticeable flicker of the needle on the RF meter.

When bypassing flickering lights, "hot" outlet receptacles, transformers, and/or motors, instead of following the customary method of connecting a capacitor from each side to ground, I connect a capacitor across the line and then connect another capacitor from the hot side to ground.

This practice began when I installed a large fluorescent light above my workbench. It gave very good light but it also put out a lot of RF "hash," making it impossible to do any signal tracing or alignment work with the light on. The fixture had a ballast-type coil or transformer in the case and evidently connecting the bypass capacitors in the usual manner made the capacitors act like a voltage divider. Connecting the capacitors the second way cleared up the "hash."

This brings to mind a home-made power RF amplifier that was very unstable. Neutralizing it on 10 meters made it unstable on 20 or 40. The suggested cure for such a condition is to try to achieve a low impedance path from the filament to ground by adding capacitors in parallel, but doing so only made things worse. The cure was to *reverse* my efforts.

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Instead of loading more and more capacitors on the filament lead I removed all capacitors from the filament lugs and wired a small RF choke consisting of eight turns of No. 14 wire wound on a 2-watt 220-ohm carbon resistor in each filament lead directly at the socket. The other end of the choke that was connected to the filament transformer was bypassed with just one 0.001 μF capacitor.

The deliberate introduction of some negative feedback made the amplifier stable. The neutralization was effective on all bands. There was also a marked reduction in the amplitude of the harmonics coming out of the amplifier. The only change from normal was that the amplifier required a little more drive for full output on 10 meters.

When the interference cure you install does not provide the expected result, don't assume your idea wasn't good; perhaps the item or items you used simply failed to do the intended job. This was vividly demonstrated to me early in my struggle with television interference when I decided to feed all the television sets in the house through coaxial cable from a distribution amplifier. The results did not meet my expectations.

Noticing that some parts varied in performance, I made a deal with a helpful local distributor. He allowed me to charge out every *make* of *every item that* I'd need to do the job with the understanding that I could return for full credit anything I did not use. What a *revelation!*

Sometimes an item made by a well-known company gave very poor or even negative results, while the same item made by a lesser known company did a much better job. This applied to such items as distribution amplifiers, high-pass filters, matching transformers and AC line filters. So if your first choice doesn't work, don't give up; try using the same part, but from a different manufacturer.

In summary, remember that just because the wire is connected to earth ground doesn't mean that it's an effective ground at all frequencies. Run *another* ground lead even if it seems to be a needless duplication.

Keep AC ground and RF grounds separate. Also, if the cure you try doesn't work, don't remove it right away. Many times a combination of two or more remedies will be effective where the single cure is not.

It's been my observation that home-made AC line filters work better than the commercial variety because they can be made to fit the load and space. Low-pass filters never worked for me; they seemed to waste power, and if you cranked up the power, they went up in smoke. Use coax stubs cut for the affected channel.

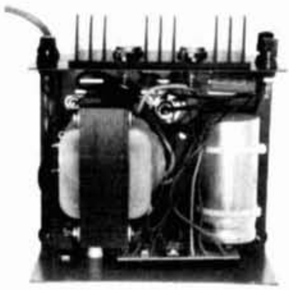
If matching transformers don't have insulated windings, modify them by rewinding.

ham radio

ASTRON CORPORATION

2852 Walnut Ave., Unit E
Tustin, CA 92680
(714) 832-7770

Canadian Distributor
Eastcom Industries, Ltd.
4511 Chesswood Dr.
Downsview, Ontario, Canada M3J 2V6
(416) 638-7995



INSIDE VIEW – RS-12A

ASTRON POWER SUPPLIES

• HEAVY DUTY • HIGH QUALITY • RUGGED • RELIABLE •

RS and VS SERIES

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-4A.
- 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)

MODEL RS-50A

MODEL RS-50M

MODEL VS-50M

RM-A Series

MODEL RM-35A

19" X 5¼ RACK MOUNT POWER SUPPLIES

Model	Continuous Duty (AMPS)	ICS* (AMPS)	Size (IN) HXWXD	Shipping Wt. (lbs.)
RM-35A	25	35	5¼ × 19 × 12½	38
RM-50A	37	50	5¼ × 19 × 12½	50

RS-A SERIES

MODEL RS-7A

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

RS-M SERIES

MODEL RS-35M

- Switchable volt and Amp meter

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

VS-M SERIES

MODEL VS-20M

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

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

RS-S SERIES

MODEL RS-12S

- Built in speaker

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

More Details? CHECK—OFF Page 150

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RF TRANSISTORS, MICROWAVE DIODES

TYPE	PRICE	TYPE	PRICE	TYPE	PRICE	TYPE	PRICE
2N1561	$ 25.00	2SC1678	$ 2.00	M1134	$ 16.90	MSC1821-3	$125.00
2N1562	25.00	2SC1729	20.00	M9579	7.95	MSC1821-10	225.00
2N1692	25.00	2SC1760	1.50	M9588	7.50	MSC2001	40.00
2N2957	1.55	2SC1909	4.00	M9622	7.95	MSC2223-10	200.00
2N2857JANTX	4.10	2SC1946	36.00	M9623	9.95	MSC3000	50.00
2N2857JANTXV	4.10	2SC1946A	40.00	M9624	11.95	MSC3001	50.00
2N2876	13.50	2SC1970	2.50	M9625	17.95	MSC73001	50.00
2N2947	18.35	2SC1974	4.00	M9630	18.00	MSC82001	40.00
2N2948	13.00	2SC2166	5.50	M9740	29.90	MSC82014	40.00
2N2949	15.50	2SC2237	32.00	M9741	29.90	MSC82020	40.00
2N3375	17.10	2SC2695	47.00	M9755	19.50	MSC82030	40.00
2N3553	1.55	A50-12	25.00	M9848	37.00	MSC83001	50.00
2N3632	15.50	A209	10.00	M9850	16.90	MSC83005	100.00
2N3733	11.00	A283	5.00	M9851	20.00	MT4150	14.40
2N3818	5.00	A283B	6.00	M9887	5.25	MT5126	POR
2N3866	1.30	AF102	2.50	MEL80091	25.00	MT5596/2N5596	99.00
2N3866JAN	2.20	AFY12	2.50	MM1550	10.00	MT5768/2N5768	95.00
2N3924	3.35	BF272A	2.50	MM1552	50.00	MT8762	POR
2N3927	17.25	BFR21	2.50	MM1553	50.00	NE02136	2.50
2N3950	25.00	BFR90	1.00	MM1614	10.00	NE13783	POR
2N4012	11.00	BFR91	1.65	MM1943/2N4072	1.80	NE21889	POR
2N4041	14.00	BFR99	2.50	MM2608	5.00	NE57835	5.70
2N4072	1.80	BFT12	2.50	MM3375A	17.10	NE73436	2.50
2N4080	4.53	BFW16A	2.50	MM4429	10.00	TRW	
2N4127	21.00	BFW17	2.50	MM8000	1.15	PRT8637	POR
2N4427	1.30	BFW92	1.50	MM8006	2.30	PT3190	POR
2N4428	1.85	BFX44	2.50	MM8011	25.00	PT3194	POR
2N4430	11.80	BFX48	2.50	MPF102	.45	PT3195	POR
2N4957	3.45	BFX65	2.50	MPSU31	1.01	PT3537	7.80
2N4959	2.30	BFX84	2.50	MRA2023-1.5	42.50	PT4166E	POR
2N5090	13.80	BFX85	2.50	MRF208	16.10	PT4176D	POR
2N5108	3.45	BFX86	2.50	MRF212	16.10	PT4186B	POR
2N5109	1.70	BFX89	1.00	MRF223	13.25	PT4209	POR
2N5160	3.45	BFY11	2.50	MRF224	15.50	PT4209C/5645	POR
2N5177	21.62	BFY18	2.50	MRF231	10.92	PT4556	24.60
2N5179	1.04	BFY19	2.50	MRF232	12.07	PT4570	7.50
2N5216	56.00	BFY39	2.50	MRF233	12.65	PT4577	POR
2N5583	3.45	BFY90	1.00	MRF237	3.15	PT4590	POR
2N5589	9.77	BLX67	15.24	MRF238	13.80	PT4612	POR
2N5590	10.92	BLX68C3	15.24	MRF239	17.25	PT4628	POR
2N5591	13.80	BLX93C3	22.21	MRF245	35.65	PT4640	POR
2N5637	15.50	BLY87A	8.94	MRF247	35.65	PT4642	POR
2N5641	12.42	BLY88C3	13.08	MRF304	43.45	PT5632	4.70
2N5642	14.03	BLY94C	21.30	MRF309	33.81	PT5749	POR
2N5643	15.50	BLY351	10.00	MRF314	28.52	PT6629	POR
2N5645	13.80	BLY568C/CF	30.00	MRF315	28.86	PT6709	POR
2N5646	20.70	C458-617	25.00	MRF316	POR	PT6720	POR
2N5651	11.05	C4005	20.00	MRF317	63.94	PT8510	POR
2N5691	18.00	CD1899	20.00	MRF420	20.00	PT8524	POR
2N5764	27.00	CD2188	18.00	MRF421	36.80	PT8609	POR
2N5836	3.45	CD2545	25.00	MRF422A	41.40	PT8633	POR
2N5842/MM1607	8.45	CTC3005	100.00	MRF427	17.25	PT8639	POR
2N5849	20.00	Dexcel GaAs FET		MRF428	46.00	PT8659	POR
2N5913	3.25	DXL3501A-P100F	49.30	MRF433	12.07	PT8679	POR
2N5916	36.00	Fujitsu GaAs FET		MRF449/A	12.65	PT8708	POR
2N5922	10.00	FSX52WF	58.00	MRF450/A	14.37	PT8709	POR
2N5923	25.00	GMO290A	2.50	MRF453/A	18.40	PT8727	29.00
2N5941	23.00	HEP76	4.95	MRF454/A	20.12	PT8731	POR
2N5942	40.00	HEPS3002	11.40	MRF455/A	16.00	PT8742	19.10
2N5944	10.35	HEPS3003	30.00	MRF458	20.70	PT8787	POR
2N5945	11.50	HEPS3005	10.00	MRF463	25.00	PT9783	16.50
2N5946	14.40	HEPS3006	19.90	MRF472	1.00	PT9784	32.70
2N6080	10.35	HEPS3007	25.00	MRF475	3.10	PT9790	56.00
2N6081	12.07	HEPS3010	11.34	MRF476	2.00	PT31962	POR
2N6082	12.65	Hewlett Packard		MRF477	14.95	PT31963	POR
2N6083	13.25	HFET2204	112.00	MRF492	23.00	PT31083	POR
2N6084	15.00	35821E	38.00	MRF502	1.04	PTX6680	POR
2N6094	11.00	35826B	32.00	MRF503	6.00	RCA	
2N6095	12.00	35826E	32.00	MRF504	7.00	40081	5.00
2N6096	16.10	35831E-H31	30.00	MRF509	5.00	40279	10.00
2N6097	20.70	35831E	30.00	MRF511	10.69	40280	4.62
2N6105	21.00	35832E	50.00	MRF515	2.00	40281	10.00
2N6136	21.85	35833E	50.00	MRF517	2.00	40282	20.00
2N6166	40.24	35853E	71.50	MRF559	2.05	40290	2.80
2N6201	50.00	35854E	75.00	MRF605	20.00	40292	13.05
2N6304	1.50	35866E	44.00	MRF618	25.00	40294	2.50
2N6459	18.00	HXTR3101	7.00	MRF628	8.65	40341	21.00
2N6567	10.06	HXTR3102	8.75	MRF629	3.45	40608	2.48
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2SC1251	12.00	JO4045	25.00	MRF961	2.30	S3031	5.00
2SC1306	2.90	Motorola Comm.		MRF8004	2.10	SCA3522	5.00
2SC1307	5.50	M1131	8.50	MS261F	POR	SCA3523	5.00
2SC1424	2.80	M1132	11.95	MSC1720-12	225.00	PRICE ON REQUEST = POR	

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MHz electronics

GaAs, TUNNEL DIODES, ETC.

* R F TRANSISTORS *

TYPE THOMSON CSF	PRICE	TYPE	PRICE	TYPE	PRICE	TYPE	PRICE
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SD1004	15.00	SD1127	3.50	SD1283	10.00	SD1477	48.00
SD1009	15.00	SD1133	14.00	SD1289-1	15.00	SD1478	21.00
SD1009-2	15.00	SD1133-1	14.00	SD1290-4	15.00	SD1480	60.00
SD1012	9.90	SD1134-1	3.00	SD1290-7	15.00	SD1484	1.50
SD1012-3	9.90	SD1135	8.00	SD1300	3.00	SD1484-5	1.50
SD1012-5	9.90	SD1136	15.00	SD1301-7	3.00	SD1484-6	1.50
SD1013-3	13.50	SD1136-2	15.00	SD1305	3.00	SD1484-7	1.50
SD1013-7	13.50	SD1143-1	12.00	SD1307	3.00	SD1488	39.00
SD1014	11.00	SD1143-3	17.00	SD1308	3.00	SD1488-1	28.00
SD1014-6	11.00	SD1144-1	3.00	SD1311	1.00	SD1488-7	27.00
SD1016	15.00	SD1146	15.00	SD1317	10.00	SD1488-8	28.00
SD1016-5	15.00	SD1147	15.00	SD1335	3.00	SD1499-1	39.00
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SD1018-6	15.00	SD1189	24.00	SD1365-1	2.50	SD1522-4	33.00
SD1018-7	15.00	SD1200	1.50	SD1365-5	2.50	SD1528-1	24.00
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SD1020-5	10.00	SD1202	10.00	SD1375-6	7.50	SD1530-2	38.00
SD1028	15.00	SD1212-11	4.00	SD1379	15.00	SD1536-1	41.00
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SD1043	12.00	SD1212-16	4.00	SD1380-3	1.00	SD1561	79.00
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SD1045	3.75	SD1214-11	5.00	SD1405	40.00	SK3048 RCA	5.00
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1N831	10.00	1N833	10.00	1N950	4.00	1N1084	2.00
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1N3717	14.00	1N3718	10.00	1N3721	14.00	1N3733	10.00
1N3747	21.00	1N4386	20.00	1N4396	15.00	1N4785	11.00
1N4812B	9.00	1N5139A/B	4.25	1N5140A/B	4.25	1N5141A/B	4.25
1N5142A/B	4.25	1N5143A/B	4.25	1N5144A/B	4.25	1N5145A/B	4.25
1N5146A/B	4.25	1N5147A/B	4.25	1N5148A/B	4.25	1N5167	5.50
1N5453	3.75	1N5465	7.65	1N5711	1.00	1N5711 JAN	2.00
1N5713	5.00	1N5767	2.00	1N6263	1.00	1S2199	15.00
1S2200	15.00	1S2208/9	1.00	8B1087/48R869558	65.00	8D3020	65.00
A2X116M Aertech	50.00	BB105B	1.00	BB105G	1.00	BD4/4JFBD4 G.E.	15.00
BL161 Bomac	5.00	CMD514AB C.M.	POR	D4060 Alpha	POR	D4159 Alpha	POR
D4233B Alpha	POR	D4900 Alpha	POR	D4959 Alpha	POR	D4987M Alpha	POR
D5047C Alpha	POR	D5147D Alpa	POR	D5503 Alpha	POR	D5506 Alpha	POR
DGB6158-98 Alpha	POR	DMD6022 Alpha	POR	DMD6460A Alpha	POR	DP20054 Crown	POR
GC1691-89 GHZ	31.35	GC1602-89 GHZ	31.35	GC1607-40 GHZ	31.35	GC2531-88 GHZ	37.40
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HP5082-1028	POR	HP5082-1332	POR	HP5082-2254	POR	HP5082-2302	10.70
HP5082-2303	5.20	HP5082-2696	POR	HP5082-2711	23.15	HP5082-2727	POR
HP5082-2800	1.00	HP5082-2805	4.45	HP5082-2835	1.00	HP5082-2884	POR
HP5082-3039	6.70	HP5082-3040	36.00	HP5082-3080	2.00	HP5082-3188	1.00
HP5082-3379	1.50	HP5082-6459	POR	HP5082-6462	POR	HP5082-6888	POR
HP5082-8016	POR	HP5082-8323	POR	K3A Kemtron	7.00	MA450A	POR
MA475	POR	MA40008	POR	MA41487	POR	MA41765	POR
MA41766	POR	MA43004	48.00	MA43589	POR	MA43622	POR
MA43636	POR	MA45104	27.00	MA47044	POR	MA47051	25.50
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3CW30000H7	1700.00	5768	125.00	8122	110.00
3X2500A3	473.00	5819	119.00	8134	470.00
3X3000F1	567.00	5836	232.50	8156	12.00
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4-250A/5D22	98.00	5867A	185.00	8295/PL172	500.00
4-400A/8438	98.00	5868/AX9902	270.00	8458	35.00
4-400B/7527	110.00	5876/A	42.00	8462	130.00
4-400C/6775	110.00	5881/6L6	8.00	8505A	95.00
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4CX250FG/8621	75.00	5894B/8737	54.00	8560AS	100.00
4CX250K/8245	125.00	5946	395.00	8608	38.00
4CX250R/7580W	90.00	6083/AZ9909	95.00	8624	100.00
4CX300A/8167	170.00	6146/6146A	8.50	8637	70.00
4CX350A/8321	110.00	6146B/8298	10.50	8643	83.00
4CX350F/8322	115.00	6146W/7212	17.95	8647	168.00
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4CX600J/8809	835.00	6159	13.85	8877	465.00
4CX1000A/8168	242.50*	6159B	23.50	8908	13.00
4CX1000A/8168	485.00	6161	325.00	8950	13.00
4CX1500B/8660	555.00	6280	42.50	8930	137.00
4CX5000A/8170	1100.00	6291	180.00	6L6 Metal	25.00
4CX10000D/8171	1255.00	6293	24.00	6L6GC	5.03
4CX15000A/8281	1500.00	6326	P.O.R.	6CA7/EL34	5.38
4CW800F	710.00	6360/A	5.75	6CL6	3.50
4D32	240.00	6399	540.00	6DJ8	2.50
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4PR60A	200.00	6883B/8032A/8552	10.00	6GF5	5.85
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NOTE * = USED TUBE NOTE P.O.R. = PRICE ON REQUEST

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More Details? CHECK—OFF Page 150

HEWLETT PACKARD SIGNAL GENERATORS

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606B	Same as above but has frequency control feature to allow operation with HP 8708A Synchronizer.	$1100.00
608C	10MHz to 480MHz,0-1uV-1V into 50 ohms,AM,CW,or pulse modulation, calibrated attenuator.	$ 500.00
608D/ TS510	10MHz to 420MHz, 0.1uV-0.5V into 50 ohms,+-0.5% accuracy, built-in crystal calibrator, AM-CW or pulse output.	$ 375.00
608E	Improved version of popular 608C.Up to 1V output.Improved stability,low residual FM.	$1450.00
608F	10MHz to 455MHz in 5 bands +-1% frequency accuracy with built-in crystal calibrator.Can be used with HP 8708A Synchronizer. Output continuously adjustable from .1uV to .5V into 50 ohms.	$1100.00
612A	450-1230MHz ,o.1uV-0.5V into 50 ohms,calibrated output.	$ 750.00
614A	900-2100MHz with many features including calibrated output and all modulation characteristics.	$ 500.00
616A/ TS403	Direct reading and direct control from 1.8 to 4.2GHz. The H.P.616A features +-1.5dB calibrated output accuracy from -3127dBm to -dBm.The output is directly calibrated in micro-volts and dBm with continuous monitoring. Simple operation frequency diad accuracy is +-1% and stability exceeds 0.005%-/ C change in ambient temperature. Calibrated attenuator is within +-1.5dB over entire output band. 50 ohm impedance unit has internal pulse modulation with rep rate variable from 40 Hz to 4KHz,variable pulsewidth(1 to 10usec)and variable pulse delay(3 to 300usec).External modulating inputs increas versatility.	$ 375.00
616B	Same as above but later model.	$ 600.00
618B	3.8 to 7.6GHz range,with calibrated output and selection of pulse-FM or square wave modulation.	$ 600.00
618C	Same as above but later model.	$2200.00
620A	7 to 11GHz range,with calibrated output and selection of pulse-FM or square wave modulation.	$ 750.00
620B	Same as above but later model.	$2200.00
626A	10 to 15GHz,10mw output power with calibrated output and pulse-square wave or FM modulation.	$4200.00
8708A	Synchronizer used with 606B,608F.The synchronizer is a phase-lock frequency stabilizer which provides crystal-oscillator frequency stability to 430MHz in the 608F signal generator.Phase locking eliminates microphonics and drift resulting in excellent frequency stability.The 8708A includes a vernier which can tune the reference oscillator over a range of +-0.25% permitting frequency settability to 2 parts in 10 to the seventh.Provides a very stable signal that satisfies many critical applications. (With HP 606B or 608F) / (Without)	$ 350.00 / $ 450.00
EMC-10	ELECTROMETRICS EMC-10 RFI/EMI RECEIVER Low frequency analyzer covering 20Hz to 50KHz frequency range.Extendable to 500 KHz in wideband mode.	$2500.00
NF-105F	Empire Devices Field Intensity Meter. Has NF-105/TA,NF-105/TX,NF-105/T1,NF-105/T2,NF-105/T3. Covers 14KHz to 1000MHz.	$2100.00

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DELIVERY: Orders are usually shipped the same day they are placed or the next business day, unless we are out of stock on an item. The customer will be notified by post card if we are going to backorder the item. Our normal shipping method is UPS or U.S. Mail depending on size or the weight of the package. Test Equipment is shipped only by air and is freight collect, unless prior arrangements have been made and approved.

FOREIGN ORDERS: All foreign orders must be prepaid with a Cashier's Check, or Money Order made out in U.S. FUNDS ONLY. We are sorry but C.O.D. is not available to foreign countries and letters of credit are unacceptable as a form of payment. Further information is available on request.

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INSURANCE: Please include 25¢ for each additional $100.00 over $100.00, UPS ONLY. All insured packages are shipped thru UPS only. If you wish to have it shipped through the post office there is a $5.00 fee which is additional to the shipping, handling and insurance.

OPEN ACCOUNTS: We regret that we do not issue open accounts.

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PRICES: Prices are subject to change without notice.

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RESTOCK CHARGES: If parts are returned to MHZ ELECTRONICS, INC. due to customer error, the customer will be held responsible for all fees incurred and will be charged a 15% RESTOCK CHARGE with the remainder in CREDIT ONLY. The following must accompany any return; A copy of our invoice, return authorization number which must be obtained prior to shipping the merchandise back. Returns must be done within 10 DAYS of receipt of parcel. Return authorization numbers can be obtained by calling (602) 242-8916 or notifying us by post card. Return authorizations will not be given out on our 800 number.

SALES TAX: ARIZONA residents must add 6% sales tax, unless a signed ARIZONA resale tax card is currently on file with us. All orders placed by persons outside of ARIZONA, but delivered to persons in ARIZONA are subject to the 6% sales tax.

SHORTAGE OR DAMAGE: All claims for shortages or damages must be made within 5 DAYS of receipt of parcel. Claims must include a copy of our invoice, along with a return authorization number which can be obtained by contacting us at (602) 242-8916 or sending a post card. Authorizations cannot be on our 800 number. All items must be properly packed. If items are not properly packed make sure to contact the carrier so that they can come out and inspect the package before it is returned to us. Customers which do not notify us within this time period will be held responsible for the entire order as we will consider the order complete.

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✓ 164

Clean up the radio/computer clutter.

For less than $250 you can make your investment in yourself pay off!

MICRO-OFFICE
WORK CENTER

Chances are you have spent a couple thousand dollars on setting up a computer system that gets a lot of your work done. But sometimes it gets to be work to work at it.

I know that when I have to move two program manuals and a pencil holder to boot up the disk drive, it is work. When there is an unlabeled floppy (that I am going to identify some day) on top of the monitor and the business checkbook is on top of the printer . . . and I will remember (I hope) before the next "report" comes through . . . that is work.

I found the annoyance of my own "computer clutter" was even worse than the extra work the disorder created. And that is when I started looking for some practical furniture for my computer set up. Since I had already spent a lot of money on the system itself, I was really dismayed when I found out how much it would cost to get a decent-looking desk or even a data table for my equipment. $400 . . . $500 . . . even more for a sleasy unit that looked like junk! In fact, it was junk! And it took a long time for me to find something that was really worth the money . . . and more.

A lot of my working day is spent with my computer, and I will bet a lot of your time is too. So I figure a "home" for my system—a housing that is good looking as well as efficient to work at—will pay off two ways:

1. Less work: an efficient and orderly layout will save me time and energy.
2. Personal satisfaction: good quality furnishings look better; they just plain feel better to work at too.

So imagine how good I felt to find the "Micro-Office" Work Center! These are fine pieces of computer system furniture that make my office-at-home as pleasant a place to work as it ought to be. And the biggest and best surprise is the low, low price for such good quality.

Here is what you get—all for only $249.50 plus shipping.

- Mar-resistant work surface. Your choice of oak or walnut grained. Work surface height is adjustable to your keyboard, your chair, your height.
- Two shelves plus work surface extender. Both shelves tilt to lock in position so that monitor faces you—in a position that does away with screen glare squinting and neck craning forever. Retainer bar keeps equipment from sliding off shelf. Snap-in bookends hold reference manuals and programs.
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- There is no risk in buying from us either. We will make a full refund of purchase price plus shipping charges if you return the workcenter within 30 days for any reason whatsoever. In addition, the product is warrantied for any defects in materials or construction for a full year from date of purchase. This is a no-risk investment in your own productivity and work efficiency that will pay off for years to come—even if you do not yet have a microcomputer of your own.
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book and product REVIEWS

Computer Programs for Amateur Radio

by Wayne Overbeck, N6NB, and James Steffan, KC6A

Amateur Radio is an "information intensive" avocation. Detailed and accurate records are imperative if you're working toward WAS, DXCC, or VUCC awards. Contesting, too, requires that accurate original and "dupe" logs be kept. And if you're a DXer, you also want to know such things as beam headings, distances to DX stations, sunrise and sunset times for grayline propagation, and much more. All this data can be stored in a home computer and retrieved with ease. But many hams use their home computers for nothing more than video games, RTTY, and Morse code applications because they don't have the programming skills to do more. No wonder — until now, there haven't been many programs available for Amateur Radio applications. Those that were available were usually written for just one machine and couldn't be used with others without extensive revision.

The authors of *Computer Programs for Amateur Radio* — who have over 50 years of Amateur Radio experience in all phases of operation, from contesting to electronic design — were aware of this phenomenon and set about the task of writing progams for just about every aspect of radio operation. The programs will work with most popular home computers.

Chapter One gives the reader an overview of the programs contained in the book. Programs were selected according to two basic criteria: first, that they be useful in the hamshack and fully tested, and second, that they be compatible with the most popular brands of home computers. They can be used with the Apple II, IBM PC, TRS-80, Commodore C-64, and any other CP/M and Microsoft BASIC unit. Owners of the VIC-20 and Timex/Sinclair or Sinclair units will find that a number of the programs will also run on their machines.

You'll need at least 48K of memory and a disk drive. A printer is optional but highly recommended. Chapter One also provides a listing and explanation for each program in the book. Programs include *Logbook, Radio Awards Data Base, Grid Locator, Worldwide "Catalog File," Sunrise Chart, Sunrise Calculator, Grayline, Beamheading Chart, DX Display, DX Checker, Dupe Checker, Dupe Print, Contest Logger, Generalized Logger, Field Day Logger, Sweepstakes Logger, Log Print, Antenna Scaler, Antenna Evaluator, Phased Vertical Pattern Plotter, EME System Analyzer, Moontracker,* and *Skylocator*.

Now that you know what you're going to get, are you ready to use it all? Anticipating that readers would need additional help, the authors devoted Chapters Two and Three to a discussion of microcomputers in general, including their evolution and associated hardware. Chapter Four provides an overview of some of the problems often encountered; it's not meant to discourage, but rather to prepare the user for the potential problems that can and will occur. Chapter Five is a rather complete discussion of BASIC (*B*eginners *A*ll-purpose *S*ymbolic *I*nstruction *C*ode) included for the purpose of providing a solid grounding in the most frequently used computer language. While BASIC is slower than assembly language, it is quite flexible and easy to write and revise. To illustrate how BASIC is used, the authors use a "Mini Logger" program as an example. A flow chart and full step-by-step description of the program assist the reader in learning the program.

The rest of the book, Chapters Six through Ten, are devoted specific programs. Each program is fully discussed, documented, and presented with hints to help the reader obtain maximum use of each.

The authors have gone to great lengths to provide all the information necessary to help readers get the most out of their home computers. Beginners and experts alike will find this book full of helpful information.

Computer Programs for Amateur Radio is available from Ham Radio's Bookstore, Greenville, New Hampshire 03048, for $16.95 plus $2.50 shipping and handling.

Circle #301 Reader Service Card.

NIACH

Clandestine Confidential

A new book published by Universal Electronics, Inc., covers the world of clandestine broadcasting yesterday and today. Subject areas covered include clandestine DX'ing, the history of clandestines, a listing of 30 active countries with their frequencies, discussion of where new clandestines may surface in the future, and clandestine QSLing. A list of clandestine station addresses is also provided.

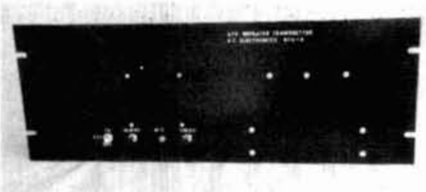
The retail price of *Clandestine Confidential* is $8.95 plus $1.75 shipping and handling in the U.S. and Canada.

For further information, contact Universal Electronics, Inc., 4555 Groves Road, Suite 3, Columbus, Ohio 43232.

Circle #321 on Reader Service Card.

ATV repeater transmitter

A new 40-watt PEP ATV repeater transmitter is available from P.C. Electronics. The 7 × 19-inch rack panel RTX-4 transmitter comes crystalled for the normal ATV repeater output frequency of 421.25 MHz, but can be ordered for any other frequency in the 70 cm Amateur band between 420 and 440 MHz for transmitting weather watch or other emergency service bulletins, NASA space shuttle video, or even beacon and base station use.



The transmitter accepts the normal 1-volt composite video, either color or black and white, and mike or line audio. Besides the video output from a color TV/monitor normally used in the repeater application, any device with a composite video output, such as a camera, VCR, computer, TVRO, etc., can simply be plugged into the front panel jacks and transmitted.

The RTX-4 contains the VOR (video operated relay) module, which keys the transmitter on only when a video signal containing the normal horizontal sync frequency around 15.75 kHz is sensed at its video input. This prevents false keying from military radars, commercial radio positioning, and other Amateur modes that may be sharing the repeater input frequency range.

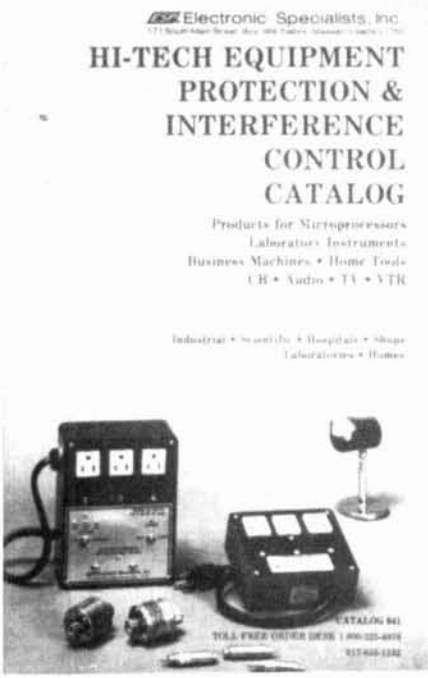
Power requirements are a regulated 13.8 VDC at 8 amperes and 120 VAC at 0.1 ampere for operation. Notes on how to successfully assemble a complete basic ATV repeater system for under $2000 and the technical considerations unique to ATV are included.

For more information on this ATV transmitter and other ATV products, contact P.C. Electronics, 2522 S. Paxson Lane, Arcadia, California 91006.

Circle #302 on Reader Service Card.

ham gear protection

The new 40-page catalog from Electronic Specialists includes a line of protection and interference control products designed to prevent costly damage from lightning or power line spikes and disruptions or interference from power line carried EMI and RFI. Protective devices include AC line voltage regulators and conditioners, modem and phone line surge suppressors as well as equipment isolators and filter/suppressors.



Typical protection and interference problems are described in the text, together with suggested solutions for various Amateur and other communications installations, as well as numerous applications for hi-tech equipment protection and interference control.

For more information, contact Electronic Specialists, Inc., 171 South Main Street, P.O. Box 389, Natick, Massachusetts 01760.

Circle #303 on Reader Service Card.

DMM/DCM

MCM Electronics has introduced the Temma Combination DMM/DCM meter with hFe transistor gain tester. The unit measures voltage, current, resistance, capacitance and hFe on the clear 1/2-inch, 3-1/2 digit LCD display.

A capacitance measuring socket gives direct measurements of capacitors, along with a transistor hFe. The color-coded panel allows users easy identification of function and range settings.

Safety features include input overload protection, single fusing (with a spare fuse inside), and stress relief test leads. The Temma Combination DMM/DCM meter comes in a convenient carrying case, with alligator clip hFe leads and has

NEW products

a one-year warranty. Battery operated, the LCD display indicates low battery condition. The price is $74.95.

For more information, contact MCM Electronics, Centerville, Ohio 45459.

Circle #304 on Reader Service Card.

ShackMaster™

A new product from Advanced Computer Controls, Inc., allows remote control of your shack and effective communication with family members over your home equipment.

ShackMaster's™ crossband linking capability allows you to access your high performance home station from VHF/UHF, either by simplex or through repeaters. Telephone access permits remote control of your home station from any Touch-Tone telephone, and BSR X-10 shack control offers Touch-Tone remote control of 120-volt devices with Touch-Tone commands, over the air or over the phone.

The ShackPatch™ feature, a remotely controlled intercom, permits remote control of your home equipment, allowing third parties to participate. Based on the same principles as an autopatch, it leaves you in complete control of your station at all times. An electronic mailbox permits you and your family to leave messages for each other, to be retrieved when convenient. Finally, a simplex autopatch is available when it's necessary to make a phone call.

Based on ACC's proven repeater control technology, ShackMaster™ includes electronic synthesized speech with a custom vocabulary, making it easy for anyone to use. It interfaces to up to three transceivers, the phone line, a local speaker, and microphone.

For more information, contact Advanced Computer Controls, Inc., 10816 Northridge Square, Cupertino, California 95014.

Circle #305 on Reader Service Card.

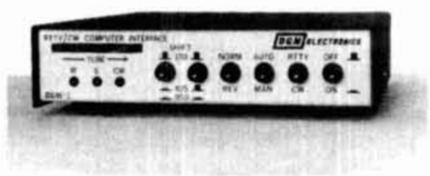
RTTY/CW computer interface

DGM Electronics, Inc., has introduced their new DGM-1 RTTY/CW computer interface, which simply connects between any transceiver and computer and works with almost any RTTY/CW software on the market because of its versatile I/O circuitry.

The RTTY demodulator provides strong performance even on the weakest, noisest signals that can be found. This is because of the sensitive mark and space active filter demodulator, rather than a phase-locked loop, as found in other low cost interfaces. This unit copies both the mark and space tones, not just the space tone. The demodulator section is preceded by a bandpass filter to provide excellent adjacent signal rejection. A three-pole post detection filter provides optimum signal-to-noise reception of the RTTY signal. The 170, 425, and 850 Hz shift selector provides fast and accurate shift selection; shift can also be reversed with the use of a front panel pushbutton. An LED bargraph and mark/space LED indicators provide positive tuning indication. Scope outputs are also provided for the ellipse tuning. A function generator chip is used to provide a stable, sinewave AFSK output to your transmitter. This interface will also key your FSK input. Automatic or manual PTT control can also be selected by a front panel pushbutton.

The CW demodulator, centered around 800 Hz, includes bandpass filtering to reject nearby signals. Both positive and negative CW keyed outputs are provided on the rear panel.

The rear panel contains a standard 5-pin I/O connector for TTL level interfacing. These signals can be inverted so that just about any software can be used with the interface. An RS 232 connection is also included for use with computers requiring these voltage levels.



The DGM-1 RTTY/CW computer interface is housed in a compact 1-1/2 × 7 × 7 inch aluminum enclosure to provide excellent RF immunity. The unit is powered by a 120 VAC wall transformer, included with the interface. The price of the DGM-1 is $149.00.

For more information, contact DGM Electronics, Inc., 787 Briar Lane, Beloit, Wisconsin 53511.

Circle #306 on Reader Service Card.

coax checker

North American SOAR Corp.'s Model 1500 coaxial cable length checker was designed to meet the needs of cable manufacturers, users, and installers.

The length of coax and its termination — whether on a reel or strung out — is essential information for anyone who works with it. Using the Model 1500 coax checker, damaged cable in plenum, conduit or in free air can be checked for shorts or opens. The device provides numerical indication to the short or open in feet or meters and indicates the state — either short or open — on a 4-digit LCD readout. This unit can measure all types of coaxial cable in lengths ranging from 10 feet to 6500 feet. The pulse reflection technique used as its measuring method allows for fast cable length indication.

Totally portable, the unit measures only 7-3/8 × 2-1/4 × 7 inches and weighs only 3 pounds with batteries. Priced at $499 in small quantities, it is supplied with 6 Ni-Cad rechargeable batteries, a battery recharger/AC adaptor and a car/truck cigarette lighter adaptor.

For more information, contact North American Soar Corp., 1126 Cornell Avenue, Cherry Hill, New Jersey 08002.

Circle #307 on Reader Service Card.

Triplett hand-size tester

The new Model 310-T5 hand-held V-O-M just introduced by Triplett Corporation offers an extended AC/DC voltage range up to 1200 volts for extra versatility in making laboratory or in-field measurements on industrial, commercial, or consumer electronic/electrical equipment.

The tester has a sealed range switch for improved resistance to contaminants and new, safety-designed test leads to provide optimum user safety. The drop-resistant case is high-impact thermoplastic to endure rugged use.

Only 2-3/4 × 1-5/16 × 4-1/4 inches, the Model 310-T5 has an easy-reading, 2-1/8-inch scale meter which is self-shielding and is protected against overload. Full scale accuracy is ±3 percent DC and ±4 percent AC.

Ranges include: 0-1200 VDC and VAC in 5 ranges; 0-200 megohms in 4 ranges; 0-600 DC milliamperes in 4 ranges with a 0-600 microampere (250 mV) range. A convenient single range selector switch is provided.

Tester sensitivity is 20,000 ohms/volt DC and 5,000 ohms/volt AC.

Priced at only $70, the one-year warranteed Model 310-T5 tester is furnished complete with 42 inch safety test leads, screw-on alligator test clips, batteries and a comprehensive instruction manual. Optional accessories include the Model-10 clamp-on AC ammeter, Model 101 line

NEW products

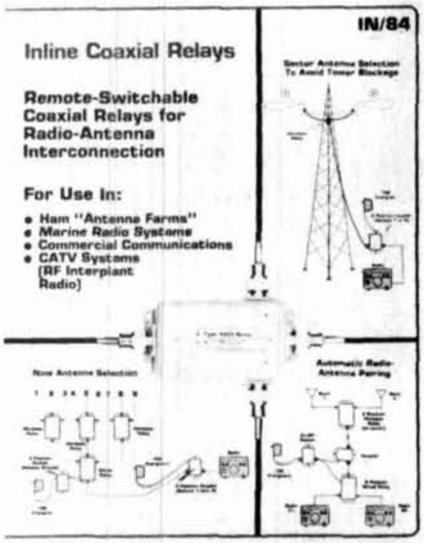
separator, carrying cases and replacement test leads.

For additional information, contact Triplett Corporation, One Triplett Drive, Bluffton, Ohio 45817.

Circle #308 Reader Service Card.

In-line coax relays

In-line coaxial relays can remotely select from up to nine antennas using a single coaxial cable to the radio.



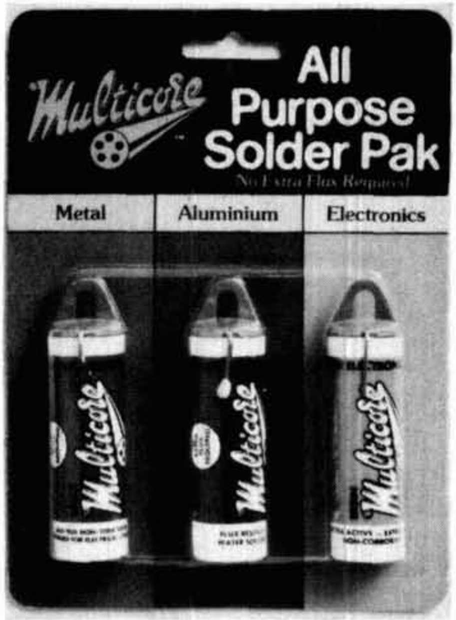
The two and three-output relays can be arranged in systems to select from among multiple antennas, pair different antenna-radio combinations, or connect a series of radios to a single broadband antenna. The various relays cover some part of the 0-900 MHz range, and feature high power handling, long life, and weatherization. These systems as relays, together with ancillary couplers, switches, and power supplies are described in catalog IN/84. They range in price from $40 to $66, depending on configuration.

For more information, contact Microwave Filter Company, Inc., 6743 Kinne Street, East Syracuse, New York 13057.

Circle #311 on Reader Service Card.

solder kit

A new selection of solders for virtually any type of soldering job — including metal, aluminum, and electrical wiring — is available from Multicore Solders. The "All Purpose Solder Pak" contains an assortment of multiple-core construction wire solder for self-fluxing action. The



correct flux formulation and alloy composition provide the ideal combination for different soldering jobs: metal, aluminum, or electrical/electronic. No pre-cleaning of surface is necessary. Each plastic dispenser has a convenient hook-eye cap for bench-top storage.

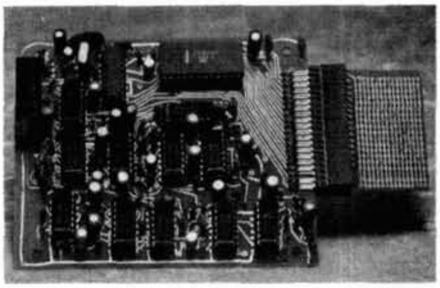
Included in the selection are Arax Solder for general metal repair, Alu-Sol Solder for aluminum, and Ersin Solder for electrical/electronic connections.

For complete information, contact Multicore Solders, Cantiague Rock Road, Westbury, New York 11590.

Circle #310 on Reader Service Card.

Touch-Tone remote control board

TTC300, is a new DTMF (Touch-Tone) Controller Board that provides remote DTMF control of virtually any ON/OFF function via a radio or any type of link with audio output, such as wireline or phoneline. Typical applications include remote control of functions at a repeater site or any location with a radio link.



The controller uses a new high quality crystal controlled decoder IC, with high immunity to falsing, decodes all 16 digits, and features 3 ON/OFF functions per main card. Easily expandable to any number of functions with expansion cards, the board can be field programmed using plug-in coded cards.

Its transistor switch outputs can directly trigger solid-state circuitry or relays for any type of control function.

For more details, contact Spectrum Communications Corp., 1055 W. Germantown Parkway, Norristown, Pennsylvania 19401-9616.

Circle #312 on Reader Service Card.

code teacher program

Cynwyn now offers MC-10 owners Morse Code Teacher, a program requiring 4K RAM. Available on cassette for $15 plus $2 shipping and handling, Morse Code Teacher is designed for the beginner. It features three different practice routines that promote familiarity with the code and can increase copying speed up to 5 WPM. In the introductory routine, whenever any letter or number on the computer keyboard is pressed, the program responds with the equivalent character in Morse Code. The second routine generates and sends characters one at a time from pre-determined letter/number groups and displays them on the screen for checking. In the final routine, random letters and numbers are sent at either 3 or 5 WPM for copying sessions of one minute and displayed on the screen at the end of each session.

For more information, contact Cynwyn, 4791 Broadway, Suite 2F, New York, New York 10034.

Circle #313 on Reader Service Card.

CW keyboard

The HD-8999 UltraPro CW Keyboard is a third-generation code computer designed to minimize keying errors and increase the ease and accuracy of sending high-speed CW. A 64-character "type ahead" buffer permits typing faster than the keyboard is sending. Ten variable length buffers

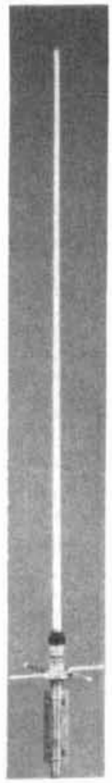
eliminate waste when storing text, and messages stored in the buffers can be compiled, corrected, or transmitted with no more than one to three keystrokes. A large, four-digit LED display indicates many functions including speed, spacing, weighting, serial number, remaining message character space, input error, tune mode, sidetone on/off, keyclick and individual buffer protection. An 8-segment bar graph indicates buffer protection. An 8-segment bar graph indicates fullness of the type-ahead buffer. Parameters are easily set from the keyboard,

NEW products

and battery back-up of the CMOS memory retains buffer contents and last-used parameters in the event of power failure or the keyboard's being turned off. Three different, four-level code practice modes are built in, as are turn-on circuit diagnostics, a sidetone oscillator, and speaker.

For more details, contact Heath Company, Benton Harbor, Michigan 49022.

Circle #309 on Reader Service Card.



UHF fixed station antenna

The new G6-440 UHF antenna for fixed station or repeater use was recently announced by Hustler.

Based on the popular G7-144 VHF antenna, the new UHF antenna delivers 6 dBd gain through the use of stacked 5/8-wave brass radiator sections, series phased, and sealed in an ultralight, tapered fiberglass radome.

Mechanical integrity is assured with the use of aluminum and stainless steel components. Coaxial cable termination is accomplished through the use of a hub-mounted, moisture resistant, "N" type connector.

The antenna is factory tuned at 440 MHz, with a typical VSWR of 1.15:1, and exhibits an 18 MHz bandwidth under 2:1. Its overall height is 88 inches, with a wind survival rating of 120 MPH.

For further information, contact Hustler, Inc., 3275 North B Avenue, Kissimmee, Florida 32758.

Circle #315 on Reader Service Card.

Touch-Tone decoder and encoder/decoder

Midian Electronics, Inc. has introduced the TTD-3 and TTC-3. The TTD-3 is priced at $59.95, and the TTC-3 is priced at $85. The TTD-3 is a 1 to 4-digit diode snip programmable anti-falsing DTMF decoder. It can decode, A,B,D,D,*,#, 1-0. It has a 2400-Hz ring tone, momentary horn output, latchng call light, and positive or negative squelch output. The unit measures 1.17 × 1.15 × 0.3 inches.

The TTC-3 is a combination encoder/decoder with all the features of the TTD-3 plus push-to-talk, sidetone audio to the speaker and adjustable audio output, and all the 16 standard Bell System touch tones.

For additional information, contact Midian Electronics, Inc., 2302 East 22nd Street, Tucson Arizona 85713.

Circle #314 on Reader Service Card.

code and theory tapes — in stereo

Gordon West's Radio School offers over 30 individual 1-1/2 hour long code speed-building courses on stereo cassettes. There are also over 20 individual tapes covering theory for examination preparation, and 10 tapes dealing with Amateur Radio equipment installation techniques.

West's stereo technique allows students to play the tapes in a variety of ways to satisfy their individual learning requirements. Any tape player with a balance control can be used to fade out the voice channel as needed. Played on a monaural tape recorder, the student hears both channels.

Radio School also offers complete 4-cassette theory courses covering the new FCC questions from Novice to Extra class. These theory courses feature the "live sounds" of Amateur Radio operating to assist the student in recognizing some of the topics discussed on the tape.

All Gordon West Radio School tapes are available directly from Radio School, 2414 College Drive, Costa Mesa, California 92626.

Circle #316 on Reader Service Card.

all-plastic potentiometers

Mouser Electronics has announced the release of a new hi-rel potentiometer said to have been designed for safety.

The 31N series pots are suitable for applications requiring both high voltage and high insulation resistance. Both body and shaft are made of flame-retardant nylon with a conductive plastic element. These pots can handle a working voltage up to 315 VAC (630 VAC peak) with a minimum insulation resistance of 1000 megohms.

They are linear taper and are power rated at 1/4 watts at 20 degrees C. Resistance tolerance is 20 percent and terminal resistance is a maximum of 5 ohms. Insulation voltage is 450 VDC. The pots measure 0.79 × 0.6 × 0.68 inch shaft.

Production quantities are available from stock in values from 1 K to 1 M and come complete

NEW products

with hardware. Prices are as low as 99 cents in quantities of 500.

For further information, contact Mouser Electronics, 11433 Woodside Avenue, Santee, California 92071.

Circle #317 on Reader Service Card.

receiver guard

Design Electronics Ohio (DEO) has announced the Receiver Guard 2000, a solid-state, RF-triggered protection device that prevents high power RF from damaging modern solid-state front ends.

The unit may be installed in any receiver antenna line, or with slight modifications, in the transverter jack of several popular transceivers. Once installed, the unit is totally passive until RF voltage on the antenna exceeds 1 volt (1000 millivolts). At this threshold voltage, the unit begins to activate, shunting excess voltage to ground while automatically increasing the resistance in the line to the receiver. This automatic increase in receiver line resistance continues until a fusible link inside the Receiver Guard 2000 opens.

Many Amateur Radio applications are possible. This unit is suited for use in the multi-transmitter contest station where great amounts of RF on several frequencies are present. The Radio Amateur who lives near a fellow ham operating at the 1500-watt level will find the Receiver Guard 2000 to be a great insurance policy. Field day operators can now use their own rigs without fear of losing their front ends. Those Amateurs who use listening antennas (loops, beverages, etc.) can install the unit in the coax line from the listening antennas without fear of destroying the front end of their own radio when transmitting.

SWL'ers, who as a rule use very low Q antennas, need also to protect their expensive receiver front ends. With the ever-increasing density of RF signals, SWLers who do not protect their receivers from high power RF transmitters are clearly at risk.

The Receiver Guard 2000 has less than 0.3 dB insertion loss between 1.8 and 300 MHz. The unit is attractively packaged in a black die-cast aluminum RF-tight box measuring 3.5 × 1.25 × 1.5 inches. Three models are available: Model P, the standard protection unit with RCA type phono plugs, is priced at $29.95. Model U, the standard protection unit with UHF (SO-239) fittings, is also priced at $29.95. Model CTT, the standard protection unit (Model U) with the addition of an Alpha Delta Transi-Trap™ LT Lightning Protector is available only with UHF fittings, at $49.95. (Add $4 for shipping and handling to all prices.)

For further information, contact Design Electronics Ohio, 4925 South Hamilton Road, Groveport, Ohio 34125.

Circle #318 on Reader Service Card.

multimode transceiver

ICOM has announced the IC-471H 430-450 MHz transceiver with 75-watt transmitter and extremely low-noise PLL circuitry.

Standard features include 430-450 MHz coverage; 75 watts RF output; FM, SSB, CW modes; 32 full-function tunable memories storing frequency, offset, offset direction and tones; and 32 built-in subaudible tones, all front-panel selectable. 10 Hz tuning increments, 1 MHz up/down buttons, scanning of memories, memory modes, or band, and all-mode squelch are all also standard. The compact unit features an easy-to-read fluorescent display.

The IC-471H uses 12 volt DC power and may be supplied from an external source (IC-PS15 or IC-PS30, optional) or from an optional internal AC power supply (IC-PS35). Other optional features include an IC-AG35 switchable mast-mounted preamplifier, UT15S encoder/decoder (PL encoder is standard), IC-CT10 computer interface, IC-EX309 computer interface connector and IC-EX310 voice synthesizer. The suggested retail price is $1099.

For more information, contact ICOM, 2112 116th Ave., N.E., Bellevue, Washington 98004.

Circle #319 on Reader Service Card.

digital VOM

The new Model 3550-A hand-held, push-button operated, digital VOM just introduced by Triplett Corporation offers ±0.25 percent accuracy on all DC ranges, plus 10 amp test capability and audible continuity tone. Designed for 2000 hours of battery life, the Model 3550-A is suited for in-field measurements on industrial, commercial or consumer electronic/electrical equipment.

MISSOURI RADIO CENTER 1-800-821-7323

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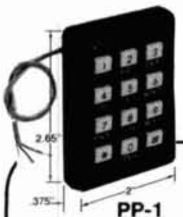

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installs easily between the antenna and receiver input. When RF voltage to the receiver line exceeds 1 volt, the unit activates by shunting the over voltage to ground and increasing the resistance in the receiver line. If over voltage exceeds design parameters, an internal fuse lamp opens (easy to replace). Perfect for contest stations, field day operations, areas saturated with broadcast services and those who use separate transmit and receive antennas. Less than .3 dB insertion loss between 1.8 and 30 MHz.

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3 Models available

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U	(with SO-239)	$29.95
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NEW products

The tester features a new 2 amp, 600 volt fuse arrangement plus safety-designed test leads for optimum user protection.

Measuring only 3-1/2 × 6-3/4 × 1-1/2 inches and weighing only 10 ounces, the Model 3550-A has a half-inch, 3-1/2 digit LCD with polarity and low battery indication. The new 2 amp, 600-volt fuse arrangement prevents nuisance fuse blows in volt and ohm ranges. Overrange and auto-polarity are included.

Handy pushbuttons permit rapid selection of 6 tester functions. Ranges include: 0-1000 VDC in five ranges; 0-750 VAC in five ranges; 0-10 amps DC or AC current in six ranges including a 200 microamp range; 0-20 megohms in six ranges. Pushbutton selectable, hi-low power ohms and resistance diode check is included. Audible continuity is available on the 200 ohm range in the HIV mode of ohms operation.

The molded black, high-impact thermoplastic case has a sure-grip "finger tread" surface finish. An optional tilt stand facilitates bench use and easy external battery and fuse access. Other optional accessories include vinyl carrying case, battery cover, high-voltage probe, external shunt, temperature probe, clamp-on AC ammeter and line separator.

Priced at $85.00, the new Model 3550-A is warranteed for one year and is furnished complete with 9 volt (NEDA 1604) battery, 42 inch test leads, screw-on alligator clips, and a comprehensive instruction manual.

For further information, contact Triplett Corporation, One Triplett Drive, Bluffton, Ohio 45817.

Circle #320 on Reader Service Card.

flea market

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"KT5S" Super DX sloper 80-10M only $59.95. "KT5B" Multiband dipole 160-10M only $59.95 2-KW roller inductor (28uh) $47.50. Weather boot kit (PL-259) $8.95 pp. Much more! Info available Kilo-Tec, PO Box 1001, Oakview, CA 93022. Tel: 805-646-9645.

IBM-PC RTTY ASCII/BAUDOT/CW send and receive. Split screen, buffers and features beaucoup. SASE to: E. Alline, 773 Rosa, Metairie, LA 70005.

WANTED: Old RCA, Western Electric, tubes, speakers, amps. (713) 728-4343, Corb, 11122 Atwell, Houston, Texas 77096.

ENJOY SATELLITE TELEVISION. Save money with easy, guaranteed, *do-it-yourself antenna plans/kits. Electronic* knowledge not necessary. Send $1.00 for catalog or $8.95 for "Consumer Guide to Satellite Television". GFI-41, Box 9808, Missoula, MT 59807.

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FOR SALE: Swan 350 transceiver w/ps $250. SA2040 antenna tuner $125. QF-1A audio filter $50. Kantronics CW/RTTY interface for Vic-20 with programs board + cables $135. Shipping included. Send money order. Package price $500. Write Jim Howell, KA4EBW, 18 Dan St., Salisbury, NC 28144. (704) 637-0313 evenings.

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NATIONAL RADIO CO equipment manuals price list SASE. Dust covers, NCX 3 or NCX 5 plus NCX A, pair $8.95 PP. Maximilian Fuchs, 11 Plymouth Lane, Swampscott, MA 01907.

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SELL: 1850A Iconoscope, B.O. Filament, Radiotron 201A, brass ring base with short prongs. Raytheon 01A (1934). Heath model IM5238 AC voltmeter. Hallicrafters S38-C, G.E. table radio — M-63 mfd. by RCA. W.E. 417A, 418 and other tubes. Stan, W5TPS. (501) 636-6404.

$$$$ SUPER SAVINGS on electronics parts, components, supplies, and computer accessories. Free 40-page catalog for SASE. Get on our mailing list. BCD Electro, PO Box 830119, Richardson, TX 75083. Or call (214) 690-1102.

RCA Volt-Ohmyst WV-97A $30. WV-77C $20. Old HRO coil set $70. Beckman PH meter $25. K6KZT, 2255 Alexander, Los Osos, CA 93402.

WANTED: Old microphones, remote mixers other mic related items. All pre-1935. Box Paquette, 107 E. National Avenue, Milwaukee, WI 53204.

PORTABLE 2-meter Quads and J-Verticals. Write Radio Engineers, 3941 Mt. Brundage Avenue, San Diego, CA 92111.

RECONDITIONED TEST EQUIPMENT *$1.00 for catalog.* Walter, 2697 Nickel, San Pablo, CA 94806.

FOX-TANGO Newsletters — Since 1972, the prime source of modifications, improvements, and repair of Yaesu gear, free to Club members. Calendar year dues still only $8 U.S., $9 *Canada, $12 elsewhere. Includes five year cumulative index by model numbers, or send $1 for index and sample Newslet*ter. Fox Tango Club, Box 15944, W. Palm Beach, FL 33416.

RTTY-EXCLUSIVELY for the Amateur Teleprinter. One year $7.00. Beginners RTTY Handbook $8.00 includes journal index. P.O. Box RY, Cardiff, CA 92007.

IMRA International Mission Radio Assn. helps missioners — equipment loaned; weekday net, 14.280 MHz, 2-3 PM Eastern. Br. Frey, 1 Pryer Manor Rd., Larchmont, NY 10538.

"HAMS FOR CHRIST." Reach other Hams with a gospel tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

TENNATEST — Antenna noise bridge — out-performs others, accurate, costs less, satisfaction guaranteed, $41.00. Send stamp for details, W8URR, 1025 Wildwood Road, Quincy, MI 49082.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

VERY in-ter-est-ing! Next 4 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60189.

Coming Events

ACTIVITIES

"Places to go..."

RADIO EXPO '84 sponsored by the Chicago FM Club, Saturday and Sunday, September 22 and 23, Lake County Fairgrounds, Rt. 120 & 45, Grayslake, IL. Major manufacturers and gigantic outdoor flea market. Flea market opens 6 AM. Exhibits 9 AM. *Free parking and overnight camping.* Reserved indoor flea market $5/day. Tickets $3.00 advance, $4.00 at gate, good for both days. Seminars, technical talks and ladies' programs. Talk in on 146.16/76. SASE to Radio Expo '84, Box 1532, Evanston, IL 60204 or (312) 582-6923.

ONTARIO, CANADA: The Radio Society of Ontario's 16th annual Convention, October 5, 6 and 7, Westin Hotel, Ottawa. Friday night eyeball and dance. Saturday and Sunday technical sessions, demonstrations and commercial exhibits. Saturday night banquet and dance. For information: RSO Convention Committee, PO Box 15806 Station "F", Ottawa, Ontario K2C 3S7.

MARYLAND: The Columbia Amateur Radio Association's 8th annual Hamfest, Howard County Fairgrounds, Sunday, October 7, 8 AM to 3:30 PM. Admission $3.00. XYLs and children *free. Reserved tables $6.00 by September 30. $8.00 after* September 30. Outdoor tailgating $3.00. Indoor tailgating $6.00. *Food available.* Talk in on 147.735/135, 146.52/52. For tables and information: Mike Vore, W3CCV, 9098 Lambskin Lane, Columbia, MD 21045. 992-4953.

INDIANA: The 5th annual Grant County ARC Hamfest, Saturday, September 8, McCarthy Hall, St. Paul's Catholic Church, Marion. Doors open 8 AM. Donation $2.00 advance, $3.00 gate. Refreshments, free parking. 8 ft. tables $2.00. Talk in on 146.19/79 and 146.52 simplex. For information/tickets SASE to: WD9EOI, Jim Allman, 1108 Spencer Avenue, Marion, IN 46952.

PENNSYLVANIA: The Mt. Airy VHF ARC (Pack Rats) invites all Amateurs and friends to the 8th annual Mid-Atlantic VHF Conference, Saturday, October 6, Warrington Motor Lodge, Rt. 611, Warrington. And the 13th Pack Rat Hamarama, Sunday, October 7, Bucks County Drive-in Theater, Rt. 611, Warrington. Flea Market admission $3.00. Selling spaces $5.00 each. Gates open 6 AM. Rain or Shine. Bring your own tables.

Advance registration for the Conference including Hamarama admission $4.00. Send to Hamarama '84, P.O. Box 311, Southampton, PA 18966 or Lee A. Cohen, K3MXM (215) 635-4942.

NEW YORK: The Elmira Amateur Radio Association's 9th annual International Hamfest, Saturday, September 29, Chemung County Fairgrounds. Gates open at 6 AM until 5 PM. Outdoor flea market. Indoor dealer displays of new equipment. Breakfast and lunch available on premises. Tickets available at the gate or in advance from Steve Zolkosky, 118 East 8th St., Elmira Heights, NY 14903.

GEORGIA: The 11th annual Lanierland ARC Hamfest, Sunday, September 23, 9 AM in the Holiday Hall of Holiday Inn, Gainesville. Flea market, left foot CW contest and many other activities. Free tables and inside display area for dealers reserving in advance. Doors open 8 AM for setup. Talk in on 146.07/.67. For information: Phil Loveless, KC4UC, 3574 Thompson Bend, Gainesville, GA 30506. (404) 532-9160.

TEXAS: Tornado Alley Hamfest, sponsored by the Wichita Amateur Radio Society, September 22 and 23, National Guard Armory, Wichita Falls. Saturday 9 to 5; Sunday 9 to 2. Dealer displays and demonstrations. Large inside flea market. Ladies' activities. Nearby museums, art center and shopping. Pre-registration $4.00. $5.00 at the door. Air Force MARS, QCWA meeting, QLF contest, homebrew contest and more. Talk in on 146.34/94, 147.75/15, 449.30/444.30 and 449.20/444.20. For information: Wichita Amateur Radio Society, P.O. Box 4363, Wichita Falls, TX 76308.

GEORGIA: The Amateur Radio Club of Augusta'a annual Hamfest, Sunday, September 16, Julian Smith Casino Park. Refreshments, Bar-B-Q, entertainment. Dealers welcome. Flea Market. Tickets $1.00; 6/$5.00; 13/$10.00. Talk in on 145.49-600. Hospitality room Saturday evening, Ramada Inn West, Washington Road, Rm. 108-110. For information SASE to: D.F. Miller, 4505 Shawnee Rd., Martinez, GA 30907. (404) 860-3700.

PENNSYLVANIA: The Skyview Radio Society's annual Hamfest, Sunday, September 16, noon to 4 PM, Club Grounds, Turkey Ridge Road, New Kensington. Registration $2.00. Vendors $4.00.

NEW MEXICO: Northern New Mexico Hamfest, Sunday, October 7, 8 AM to 3 PM, Terrero Group Shelter along the Pecos River east of Santa Fe. Tailgate flea market, meetings, fishing, picnicking, family fun. Admission $3. Children $1.50 includes hot dogs, chips and free Saturday night camping. Talk in on local repeaters and 52 simplex. For information SASE to: Northern New Mexico ARC, c/o Bob, N5EPA, Rt. 3, Box 95-15, Santa Fe, NM 87501 or call on 3.939 MHz at 0100 UTC.

ILLINOIS: The Peoria Area Amateur Radio Club's Superfest '84, September 15 and 16, Exposition Gardens, W. Northmoore Rd., Peoria. Gates open 6 AM, Commercial Building at 9 AM. Admission $3.00 advance, $4.00 gate. Children under 12 free. Amateur Radio and computer displays, huge flea market, free bus to Northwoods Mall on Sunday. Full camping facilities on grounds. Saturday night informal get-together at Heritage House Smorgasboard, 8209 N. Mt. Hawley Rd., Peoria. Talk in W9UVI on 146.16/76. For information and reservations SASE to Superfest '84, P.O. Box 3461, Peoria, IL 61614.

NEW YORK: Electronics Fair and Giant Flea Market, sponsored by the Yonkers ARC, Sunday, October 7, 9 AM to 4 PM, rain or shine, Yonkers Municipal Parking Garage, Corner of Nepperhan Avenue and New Main Street. All day demonstrations; Amateur Radio, computers, electric car, satellite TV, SSTV and more. Giant auction 2 PM. Refreshments, free parking, facilities. Free coffee all day. Admission $2.00. Children under 12 free. Sellers $6.00 per space admits one. Bring tables. For information: YARC, 53 Hayward Street, Yonkers, NY 10704. (914) 969-1053. Talk in on 146.265T-146865-R or 52 direct. CB channel 4.

VIRGINIA: ARRL Roanoke Division Convention and 9th annual Amateur Radio-Computer Fair, Saturday and Sunday, September 22 and 23, Virginia Beach Pavilion. 9 AM to 5 PM. Displays, forums, computer equipment, giant flea market, ladies' activities, movies for the kids. Admission $4.00 advance (good for both days). $5.00 at door. Flea market tables $5.00 one day, $8.00 both days. Plan a family vacation at beautiful Virginia Beach. Visit the Waterside Festival Marketplace in Norfolk with its specialty shops and restaurants. For information/tickets: Jim Harrison, N4NV, 1234 Little Bay Avenue, Norfolk, VA 23503. (804) 587-1695.

CONNECTICUT: The Natchaug Amateur Radio Association's annual Giant Flea Market. September 23, Elks Home, 198 Pleasant Street, Willimantic. Starts 9 AM. Dealers 8 AM. Admission $2.00. Under 16 free. Advanced reserved tables $5.00. $7.00 at door. Plenty of food and drink. Talk in on 52 direct and 147.30/90 repeater. For information: Ed Sadeski, KA1HR, 49 Circle Drive, Willimantic, CT 06226. (203) 456-7029 after 4 PM.

NEW HAMPSHIRE: The Connecticut Valley FM Association's 8th annual Hamfest and Flea Market, September 16, King Ridge Ski Area, Sutton. 9 AM to 5 PM, rain or shine. Admission $2.00. Dealers and flea market $3.00 per tailgate or table. Food available on premises. Overnight camping for self-contained units only. No hookups. Talk in on 146.16/76 or 146.52 simplex.

KENTUCKY: The 14th annual Greater Louisville Hamfest and Great Lakes Division Convention, Saturday and Sunday, September 29 and 30, Kentucky Fair and Exposition Center. 8 AM to 5 PM both days. Air-conditioned indoor exhibitors' area and flea market. Meetings and forums. Hotels across from Hamfest site. Camping available on grounds. For information: Greater Louisville Hamfest Association, P.O. Box 34444, Louisville, KY 40232. (502) 368-6657.

ALABAMA: Hospitality Hamfest sponsored by the Mobile ARC, September 15 and 16, Texas Street Recreation Center off I-10, Mobile. Doors open 9 AM. Admission free. Activities for ladies, swap tables, parking, good food and fellowship. Talk in on 146.22/82. For information: Porter Chambers, KI4FE, 3320 Emelye Drive, Mobile, AL 36609. Call 661-1160.

TENNESSEE: The fourth annual Tri-Cities Hamfest, sponsored by the Johnson City, Kingsport and Bristol Amateur Radio Clubs, Saturday, October 20, Appalachian Fairgrounds, Gray. Forums, dealers, flea market and RV hookups. For information: Tri-Cities Hamfest, PO Box 3648 CRS, Johnson City, TN 37601.

NEW YORK: Ham-O-Rama and Computerfest '84, Friday evening, September 7, 6 PM to 9 PM and Saturday, September 8, 7 AM to 5 PM, Erie County Fairgrounds, Buffalo Raceway, south of Buffalo. Indoor/outdoor flea markets, new equipment and video displays, computer demonstrations, tech and non-tech programs. Chicken barbeque, awards and more. Admission $3.50 advance. After August 24 and at gate $4.50. Outside flea market $3.00; inside $10.00. Talk in via W2EUP/R 146.31/91 and 146.52. For information: Nelson Oldfield, 126 Greenway Blvd., Cheektowaga, NY 14225.

CALIFORNIA: The Sonoma County Radio Amateur's second annual Ham Radio Flea Market, Saturday, September 15, 8 AM to 2 PM, Sebastopol Community Center, 390 Morris St., Sebastopol, 5 miles west of Santa Rosa. Admission and parking free. Tables $6 at door or $5 advance. Vendor set up 7 AM. Radio clinic, exhibits, refreshments, auction at noon. Talk in on 146.13/73. For tickets/information: SCRA, Box 116, Santa Rosa, CA 95404.

TENNESSEE: Memphis Hamfest, sponsored by the Mid South Amateur Radio Association, Delta Radio Club and Memphis Radio Relay Club, October 13 and 14, Pipkin Building, Memphis Fairgrounds. 8 AM to 4 PM Saturday, 9 AM to 2 PM Sunday. Forums, ladies' activities and large flea market all inside in air-conditioned comfort. Flea market tables $5.00 each per day. Trailer hookups available. For information: Clayton Elam, K4FZJ, 28 No. Cooper, Memphis, TN 38104. (901) 274-4418 Days. (901) 743-6714 Nights.

NEBRASKA: 8th annual 3900 Club Hamboree and Iowa State Convention, October 12 and 13, Marina Inn, South Sioux City. Sponsored by the 3900 Club and Siouxland Amateur Radio Repeater Association. Flea market, exhibits, ladies' programs, Air Force MARS, QCWA, UHF/VHF, ARRL, DX session, Novice session and QSL Bureau. Friday night get-together. Saturday night banquet, Dr. Beverly Mead, speaker. Flea market and convention $6.00. Banquet $10.00 ($12.00 at the door). Flea market tables $4.00 each. All indoor facility. Talk in on 146.37/146.97. For advance reservations: Dick Pitner, 2931 Pierce, Sioux City, IA. Advance flea market reservations: Al Smith, 3529 Douglas, Sioux City, IA.

MASSACHUSETTS: The 1979 Amateur Radio Association is sponsoring Novice and Technician/General classes starting September 18 at the Chelsea High School, Chelsea, MA. Admittance is free. Student pays cost of materials. For more information: Frank, K1BPN, 1979 ARA, P.O. Box 171, Chelsea, MA 02150.

NEW ENGLAND: Hosstraders' Fall Tailgate Swapfest, Saturday, October 6, sunrise to sunset at Deerfield, NH Fairgrounds. Admission $2 including tailgaters. Friday night camping at nominal fee after 4 PM. No reservations. Profits benefit Boston Burns Unit of Shriners Hospital. Last Spring's donation $5,813.00. For map to northeast's biggest ham flea market SASE to Norm, WA1IVB, RFD Box 57, West Baldwin, ME 04091.

OPERATING EVENTS

"Things to do..."

SEPTEMBER 8: The Mark Twain ARA will operate W0KEM from 1400Z to 2300Z, Sept. 8 and 9 to celebrate the dedication of the 20,000 acre Mark Twain Lake and Clarence Canon Dam in East Central Missouri. Phone: lower 25 kHz of 40, 20 and 15 meter General band. Novice operation in 40 meter band. For a certificate send legal SASE to Mark Twain ARA, P.O. Box 56, Center, MO 63436.

SEPTEMBER 8 AND 9: "WE TALK SO THEY CAN WALK." The Ararat Shrine Radio Club of Kansas City, MO, will hold a talk in to benefit the crippled children's hospitals. We will host a multi-band, multi-operator talk in from 10 AM to 6 PM each day. First 10 kcs of general portion of ham bands and first 10 kcs of 40 meter Novice band. For any contact with club station, WA0NQA, you will receive a two-color certificate with name and call. Send $1.00, QSL card and large SASE to: J.V. Foust, KA0GBK, 5240 N. Palmer, Kansas City, MO 64119. All monies will go to the crippled children's hospitals. Your QSL card will be displayed in the Kansas City Shrine Temple Radio room.

SEPTEMBER 8 AND 9: The Radio Association of Erie (W3GV) will commemorate Admiral Perry's victory at the Battle of Lake Erie during the War of 1812. 1200Z to 0100Z Saturday and 1200Z to 2100Z Sunday. 7.235, 14.235 MHz (phone) and 7.090, 14.090 MHz (CW/RTTY). Special QSL and historical date on the flagship Niagara via W3GV, 4572 Southern Dr., Erie, PA 16506 or W3 QSL Bureau for DX stations. Please enclose business SASE.

SEPTEMBER 15: The McHenry County Wireless Association will sponsor the 2nd annual DXpedition to Cedar Island, Fox Lake, Illinois. Operation begins at 10000 CDT on lower 20 kHz of phone portion of 40 and 15 meters. An atrractive QSL card will be supplied for all confirmed contacts.

SEPTEMBER 22: The Paul Bunyan Wireless Association and the Brainerd Area Amateur Radio Club will sponsor a special event station from the site of the Paul Bunyan Festival near Brainerd, MN, from 1800Z on September 22 to 2100Z on September 23. Lower portion of the General class phone portion of 40-10 meters. Send QSL and SASE to KC0YG for a commemorative QSL.

SEPTEMBER 22: The Alford Memorial Radio Club of Stone Mountain, Georgia, will sponsor its first annual Pig Out from 0400 to 2200Z. SSB phone and CW, 10 kHz above bottom of General portion of 80-10 meters. For a commemorative QSL and special certificate for contact, SASE with information to: Alford Memorial Radio Club, P.O. Box 1282, Stone Mountain, GA 30086.

OCTOBER 13 AND 14: Columbus Day International DX Contest in commemoration of Columbus Day, sponsored by the Miami Havana Lions Club. From 1200 GMT Saturday to 2400 GMT Sunday. Any Amateur station making five contacts with official Radio Club DX member operator during the 2 days will be eligible to apply for the Miami Havana Lions Club QSL award. Exchange RS(T) and QTH. For this special award, send QSL's or log and $2.00 U.S. funds or 6 IRC's to: Miami Havana Lions Club, Box 674, Miami, FL 33135. At the start of the contest, October 13, 1200 GMT, members of the Contest Committee will read the names and assigned numbers of the official operators in the following frequencies: 28.915, 21.250, 14.250, 7.230 phone.

A FAR NET AWARD CERTIFICATE offered by the Armored Force Amateur Radio Net. Non-member stations qualification requirements: For basic award, non-member stations must establish 2-way contact with a minimum of 15 different A FAR NET member stations. For endorsements, non-member stations must contact ten or thirty-five additional members, any band, any mode. Confirmation of required contacts through copy of log certified by two other Amateur radio operators. Send application with 50¢ minimum for postage, etc. to: Alfred G. Beutler, K2DWI, A FAR NET Certificate Manager, 36 Manchester Road, East Aurora, NY 14052.

SPACE SHUTTLE COMMENTARY VIA OSCAR SATELLITE. The Spaceport Amateur Repeater Club (SPARC) has been authorized by AMSAT to transmit Space Shuttle mission commentary for all missions on Special Services channel H2, 145.963 MHz of AMSAT-OSCAR 10. All Amateur Radio operators are invited to submit reception reports to: SPARC, P.O. Box 672, Merritt Island, FL 32952.

AUGUST 31 AND SEPTEMBER 1: The Wireless Institute of New Orleans (W.I.N.O.) will operate K5WF from the Louisiana World Exposition — World's Fair. 10 AM to 10 PM CDT daily on HF bands, all modes and 40 meters, LSB about 7.240 MHz. Also 75 and 20 meters, propagation allowing. A special commemorative QSL/Certificate confirming contacts will be available for a SASE: W.I.N.O., Box 6541, New Orleans, LA 70174.

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FRONT COVER: 70 Years of SSB

An early single sideband receiver, designed by James Lamb in 1937, included provisions for duplex operation on 4 MHz and used the filter method of SSB generation. Shown within the schematic for Lamb's receiver is a state-of-the-art SSB receiver. Developed by RCA Corporation Government Communications Systems under the guidance of Dr. Ulrich L. Rohde, business area director of radio systems, the unit is a highly software-based experimental transceiver with frequency-hopping capabilities. It contains a special receiving system for noise blanking and uses a delay line to enable processing. The transceiver covers 1.5 to 30 MHz in transmit and 10 kHz to 30 MHz in receive in 100 Hz steps. Modes of operation include AM, CW, SSB, FSK, and frequency hopping. Particular software features are automatic FFT (Fast Fourier Transform) analysis of signals and tuning of SSB with an error of less than 1 Hz, frequency and memory scanning, real-time clock operation, and storage of 100 frequencies with all signal parameters. It utilizes a second alphanumeric display with a self-help feature that tells the user how to activate and use the software-based function. It has an intercept point of greater than +30 dBm and an SSB phase noise of −140 dB at 25 kHz to −160 dB at 100 kHz, indicating dynamic performance. AGC is 0.2 microvolts to 1 volt, with a 4 dB audio change and linearized S-meter look-up table in ROM.

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79.7 SP	103.5 1A	136.5 4Z	179.9 6B
82.5 YZ	107.2 1B	141.3 4A	186.2 7Z
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600	697	1209	1600	1850	2150	2400
1000	770	1336	1650	1900	2200	2450
1500	852	1477	1700	1950	2250	2500
2175	941	1633	1750	2000	2300	2550
2805			1800	2100	2350	

- Frequency accuracy, ± 1 Hz maximum - 40°C to + 85°C
- Tone length approximately 300 ms. May be lengthened, shortened or eliminated by changing value of resistor

Model TE-64 **$79.95**

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TS-430S "Digital DX-terity!"

TS-430S

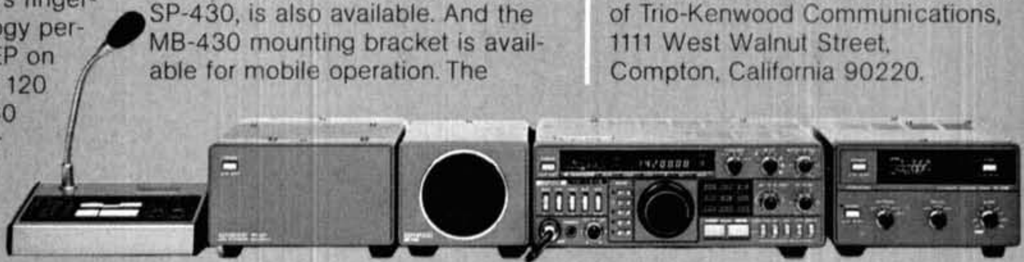
Digital DX-terity...that outstanding attribute built into every KENWOOD TS-430S that lets you QSY from band to band, frequency to frequency, and from mode to mode with the speed and ease that will give you a dominant position in DX operations.

KENWOOD'S TS-430S, a revolutionary, ultra-compact, HF transceiver has already won the hearts of radio Amateurs the world over. It covers 160-10 meters, including the new WARC bands (easily modified for HF MARS). Its high dynamic range receiver tunes from 150 kHz-30 MHz. It utilizes an innovative UP conversion PLL circuit for superior frequency stability and accuracy. Two digital VFO's allow fast split-frequency operations. A choice of USB, LSB, CW, or AM, with FM optional, are at the operators fingertips. All Solid-state technology permits inputs of 250 watts PEP on SSB, 200 watts DC on CW, 120 watts on FM (optional), or 60 watts on AM. Final amplifier protection circuits and a cooling fan are built-in.

Eight memories store frequency, mode, and band data, with Lithium battery memory back-up. Memory scan and programmable automatic band scan help speed up operations. An IF shift circuit, a tuneable notch filter, and a Narrow-Wide switch for IF filter selection help eliminate QRM. It has a built-in speech processor. A fluorescent tube digital display makes tuning easy and fast. An all-mode squelch circuit, a noise blanker, and an RF attenuator control help clean up the signal. And there's a VOX circuit, plus semi-break-in, with side-tone. All-in-all, it just could be that the expression "Digital DX-terity" is a bit of an understatement.

TS-430S Optional Accessories:
In typical KENWOOD fashion, there are plenty of optional accessories for this great HF transceiver. There is a special power supply, the PS-430. An external speaker, the SP-430, is also available. And the MB-430 mounting bracket is available for mobile operation. The AT-250 automatic antenna tuner was designed primarily with the TS-430S in mind, and for those who prefer to "roll their own," the AT-130 antenna tuner is available. The FM-430 FM unit is available for FM operations. The YK-88C (500 Hz) or YK-88CN (270 Hz) CW filters, the YK-88SN SSB filter, and the YK-88A AM filter may be easily installed for serious DX-ing. An MC-60A deluxe desk microphone, MC-80 and MC-85 communications microphones, an MC-42S mobile hand mic., and an MC-55 8-pin mobile microphone, are available, depending on your requirements. TL-922A linear amplifier (not for CW QSK), SM-220 station monitor, PC-1A phone patch, SW-2000 SWR/power meter 160 ~ 6 meter, SW100A SWR/power/volt meter 160-2m, HS-4, HS-5, HS-6, HS-7 headphones, are also available.

More information on the TS-430S is available from authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.



Specifications and prices are subject to change without notice or obligation.