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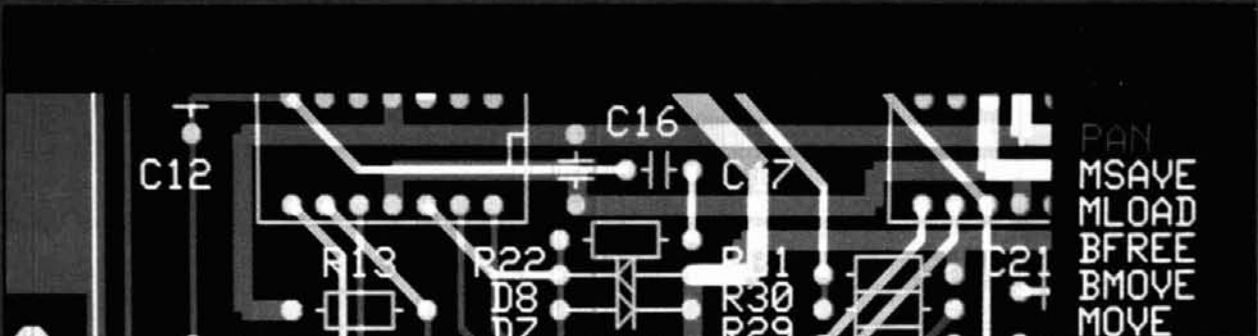
ham radio magazine

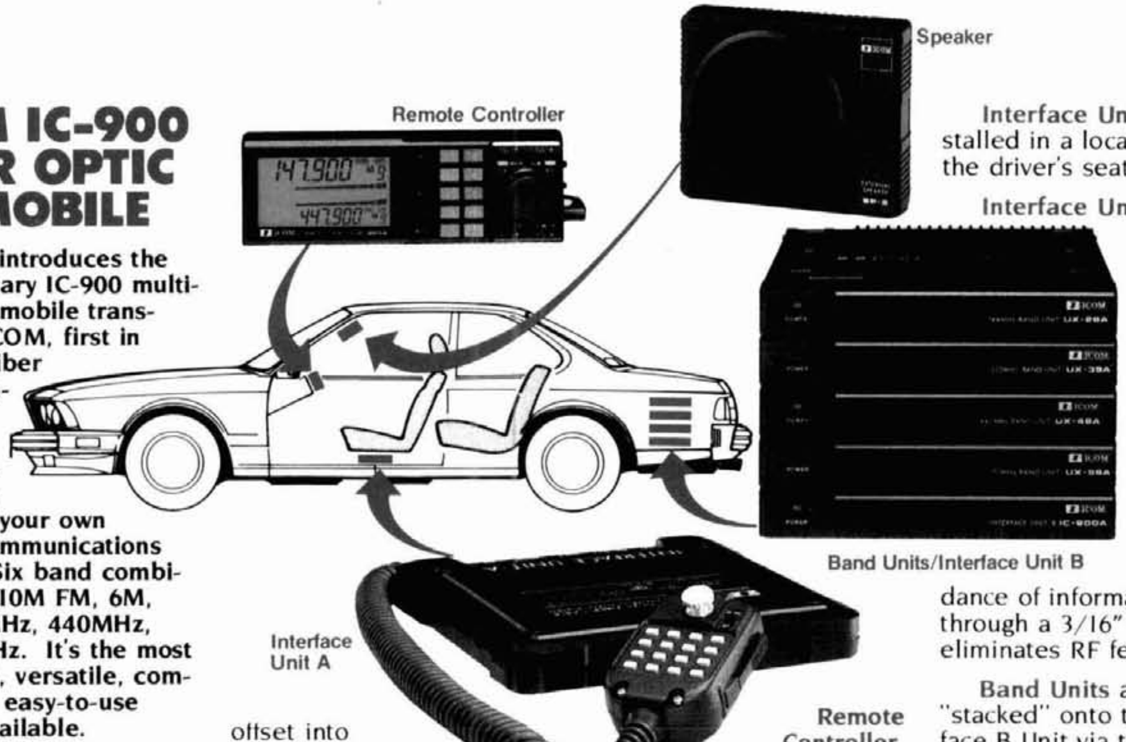


professional layout software for amateur radio applications

focus on communications technology

NEW

ICOM IC-900
Six Bands in One Mobile!



ICOM IC-900 FIBER OPTIC FM MOBILE

ICOM introduces the revolutionary IC-900 multi-band FM mobile transceiver. ICOM, first in utilizing fiber optic technology in amateur radio, enables you to create your own mobile communications system. Six band combinations... 10M FM, 6M, 2M, 220MHz, 440MHz, and 1.2GHz. It's the most advanced, versatile, compact, and easy-to-use mobile available.

Features Galore. The IC-900 is an operator's dream... Listen on two bands simultaneously or transmit on one band and receive on a different band when using a second speaker (**true full duplex crossband operation**), 10 memories per band, independent PL tones and offset into each memory, memory and programmable band scan, and all subaudible tones in actual Hz readout.

The IC-900 includes an ultra compact remote controller, an Interface A unit, Interface B unit, SP-8 speaker, HM-14 up/down DTMF mic, **fiber optic** and controller cables.

Remote Controller. Measuring only 2 inches high by 5.7 inches wide by 1 inch deep, the remote controller can be installed on your car's dash or sun visor with the supplied velcro. And, if you want, take the controller with you when you leave your car. The controller features a super large, highly visible LCD.

Interface Unit A is installed in a location near the driver's seat.

Interface Unit B controls the six band units and can be installed in your car's trunk. A **fiber optic** cable runs from Interface A to Interface B, which transports an abundance of information through a 3/16" cable and eliminates RF feedback.

Band Units are "stacked" onto the Interface B Unit via the supplied mounting bracket. Optional band units available are:

Band Unit	Power Output	Frequency
UX-19A	10W/1W	28-30MHz
UX-29A	25W/5W	138-174MHz Rx; 140.1-150MHz Tx
UX-29H	45W/5W	138-174MHz Rx; 140.1-150MHz Tx
UX-39A	25W/5W	216-236MHz Rx; 220-225MHz Tx
UX-49A	25W/5W	440-450MHz
UX-59A	10W/1W	50-54MHz
UX-129A	10W/1W	1240-1300MHz

✓ 110

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First Again!

TW-4100A

2 m/70 cm FM Dual Bander

A Kenwood original just got better! Kenwood was the first to develop a 2 m/70 cm mobile radio in a single, compact package. Since then, other companies have imitated the concept, but still have not done it the "Kenwood way." The all-new TW-4100A is more compact, more powerful, and packed with more features than ever before! With many new features and accessories, and backed by Kenwood's experience, the all-new Kenwood Dual Bander is light years ahead of the rest!

- **Selectable full duplex cross band ("telephone style") operation.** Remote base or cross band repeater function possible (a control operator is needed for remote or repeater operation*).
- **45 watts on 2 m. 35 watts on 70 cm.** 5 watts (adjustable) low.
- **Frequency coverage: 142-149 MHz (allows operation on certain MARS and CAP frequencies) and 440-449.995 MHz.**
- **New compact size!** Only 5.9" W x 1.97" H x 7.87" D and weighs less than 4 pounds!
- **Proven high performance Kenwood GaAs FET front end receiver.**
- **Easy to operate!** Only 3 knobs and 8 keys on the front panel.
- **Separate antenna ports for VHF and UHF.** Minimizes loss and increases reliability and performance!
- **10 memory channels.** Lithium battery backs up memory. Store frequency, offset, subtone. Two channels store the transmit and receive frequencies independently **for odd split or cross band operation.**
- **Front panel-selectable CTCSS tone (when optional TU-7 is installed.)**
- **Non-volatile operating system.** Even after memory back up cell dies, all operating features remain intact! No re-programming or "board-swapping" necessary!
- **Programmable band scan and memory scan with memory channel lock-out.**
- **Large, illuminated LCD display and main knob.** For excellent visibility in direct sunlight or darkness.
- **Selectable frequency step for quick and easy QSY.**
- **Voice synthesizer VS-2 option.**

Optional accessories:
- **PS-50/PS-430** DC power supplies
- **MU-1** DCL modem unit
- **TU-7** CTCSS encoder
- **VS-2** Voice synthesizer
- **SW-100B** SWR/Power/Volt meter 140-450 MHz for mobile use
- **SW-200B** SWR/Power meter for base station use 140-450 MHz. 0-200 W in 2 ranges
- **SWT-1/SWT-2** 2 m and 70 cm antenna tuner
- **SP-40** Compact speaker
- **SP-50B** Mobile speaker
- **PG-2N** Extra DC cable
- **PG-3B** DC noise filter
- **MC-60A, MC-80, MC-85** Base station mics.
- **MC-55** (8-pin) Mobile microphone
- **MA-4000** Dual band mobile antenna with duplexer (shown)**
- **MB-11** Extra mobile mount

- **Digital Channel Link (DCL) option.**

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P.O. Box 22745, Long Beach, CA 90801-5745

*Please check FCC regulations on repeater operation.
**Mag mount is not Kenwood supplied.
Minor modification necessary for repeater operation.
Specifications and prices subject to change without notice or obligation.
Complete service manuals are available for all Kenwood transceivers and most accessories.

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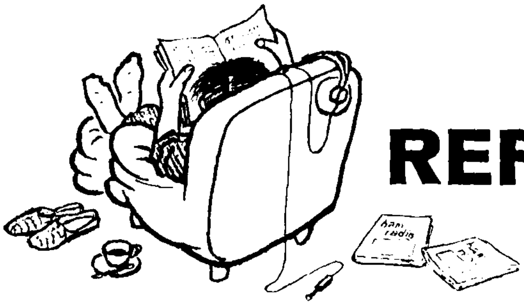

REFLECTIONS

the possessed

During the anything-goes sixties, while attending City College, I shared an apartment with two roommates on the upper west side of Manhattan. This editorial is dedicated to one of them. Without naming names (let's just call him "Mr. A"), this roommate was the antithesis of what most of us Radio Amateurs have become.

We're like magnets. Anything we see that might be remotely useful, even in the far-distant future, will come to us to be saved for that eventuality. Now, I'm not talking about just nuts and bolts. I'm talking real quantity and diversity.

Look around your shack, which in some cases might be considered the entire house. If you're like me, you've probably spread out all over.

What was that sound? The one just before that awful grinding noise and the smell of burning motor? Was it that 1-percent precision, 141.7-ohm resistor you've been looking for since Labor Day — the part you needed to finish your super-deluxe noise bridge — being sucked up into the vacuum cleaner? Well, it's history now. The vacuum cleaner has claimed another victim.

"Just a darn minute!" you exclaim. *"That resistor was carefully placed on the dining room table!"*

Come on. Follow me. Starting from the shack, let's take a quick walk – in our mind's eye — around the house. It's probably impossible, even dangerous, to walk around any other way because of the overcrowding or perhaps because of those three 6-foot racks of tube equipment you've built over the years. All those dangling jumper cables (control, audio, digital, and rf) seem to want to reach out and trip people. Come on, don't let me hear that argument you give your spouse about how keeping all that equipment going helps keep the house warm, thereby cutting the the fuel bill, and hasn't she noticed how nice and dry it is down in the basement when all those pretty tubes are lit? I've heard all those justifications before. In fact, I've used some of them myself.

As painful as it may be, let's leave the shack and move on. No point stopping at the kitchen or dining room tables; we all know what we'll find there.

If you're at all like me, you have many different interests and probably subscribe to a number of magazines that address those interests. Are the magazines all neatly stacked on a bookshelf in the radio room — just as pictured in any of the operating manuals that show what the typical ham station looks like? Naah. Who are you kidding? Those magazines are strewn all over the place – scattered atop the TV and on side tables and even chairs, heaped in piles in corners, in the attic, in the hallway, the bathroom, the garage, and, of course, on the floor. Did you ever consider the possibility that your spouse might consider this an encroachment on *her* living space?

Speaking of the garage, that's a story in itself. It's amazing to consider how seven sections of Rohn 45 can fit in there so nicely. But the XYL's car? Well, that's a different matter. Maybe winter won't be so bad after all.

I won't even mention those drums of surplus wire, cable, or whatnot that you picked up at that flea market in 1979. What a deal! Heck, you're going to help her shovel the snow off the car this winter anyway, right?

Moving outside, did you know that the great outdoors offers almost unlimited storage capability? Of course you do. Why, there's the evidence: more rusting tower sections, some sturdy anchors, a hundred feet of guy line, and a 6-foot dish! Too good to sell, give away, or discard, they're also too big for the garage. But they're not too big for the great outdoors!

"All right!," you protest. *"Maybe there's some truth to what you've been saying. But what's the point?"*

This is it: perhaps October's the time to take another look at what we possess, or more appropriately, what possesses us. Maybe this is the time to go through the entire house, gather all our treasures together, and decide what's really important, what we *really* want to keep. Let's sell the rest, or better yet, donate it to a worthy cause like that Novice down the block. After all, we've gotta start 'em right on this acquisition madness, don't we?

I hope you appreciate the gravity of the chance I'm taking by writing this editorial. If my XYL ever reads this, I might have to practice what I preach. As a friend of mine is wont to say: *"End of message."*

And what about the legendary Mr. A, to whom this editorial is dedicated? Well, Mr. A owned exactly two shirts and two pairs of shoes, pants, and socks – and barely anything else. When the time came to move, I had to rent a trailer to cart my possessions. Mr. A put everything he owned into his attache case and walked away.

Rich Rosen, K2RR
Editor-in-Chief

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Kenwood brings you the greatest hand-held transceiver ever! More than just "big rig performance," the new TH-215A for 2 m, TH-315A for 220 MHz, and TH-415A for 70 cm pack the most features and the best performance in a handy size. And our full line of accessories will let you go from hamshack to portable to mobile with the greatest of ease!

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- **5, 2.5, or 1.5 W output, depending on the power source.** Supplied battery pack (PB-2) provides 2.5 W output. Optional NiCd packs for extended operation or higher RF output available.
- **CTCSS encoder built-in.** TSU-4 CTCSS **decoder** optional.
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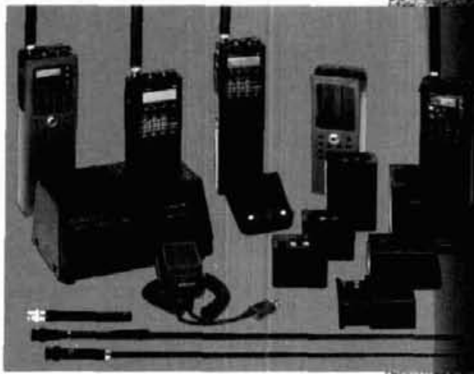
- **Nine types of scanning!** Including new **"seek scan" and priority alert.** Also memory channel lock-out.
- **Intelligent 2-way battery saver circuit extends battery life.** Two battery-saver modes to choose, with power saver ratio selection.
- **Easy memory recall.** Simply press the channel number!
- **12 VDC input terminal for direct mobile or base station supply operation.** When 12 volts applied, *RF output is 5 W! (Cable supplied!)*
- **New Twist-Lok Positive-Connect locking battery case.**
- **Priority alert function.**
- **Monitor switch to defeat squelch.** Used to check the frequency when CTCSS encode/decode is used or when squelch is on.
- **Large, easy-to-read multi-function LCD display with night light.**
- **Audible beeper to confirm keypad operation.** The beeper has a unique tone for each key. DTMF monitor also included.
- **Supplied accessories:** Belt hook, rubber flex antenna, PB-2 standard NiCd battery pack (for 2.5 W operation), wall charger, DC cable, dust caps.



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

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comments

ground plane antennas

Dear HR:

I was rather taken aback at a recent ham club meeting when a couple of friends informed me that according to a letter to the editor in *ham radio*, my "offset drooper" ("The Offset Drooper: An Improved Ground Plane," January, 1986, page 43), had been invented years ago by a Frenchman.

DJ0TR/OE8AK's letter in the June, 1987 issue, in which he discusses the origins of the venerable ground plane antenna, states, immediately following his reference to my article, "This VHF/UHF antenna was invented several years before in France . . . ."

A careful reading of the letter, however, makes it quite clear from the context that the statement "This VHF/UHF antenna was invented several years before . . ." applies to the earlier mentioned classic ground plane credited to Dr. George Brown. But apparently, if one hurriedly skims the letter, the remark can be mistakenly applied to the "offset drooper" version of the ground plane antenna.

While on the subject of originality, I'm surprised that the matter of French prior art pertaining to ground plane type antennas has taken 50 years to surface. I do know that I certainly am not in a position to pass judgement as to worldwide prior art. My information was taken from the article, "The Ground Plane Antenna: Its History and Development," by Harold Vance, Sr., W2FF (now deceased), which appeared in the January, 1977 issue of *ham radio*.

George Brown and Harold Vance were both highly respected VIPs at RCA during World War II. As section head and project officer on some new USMC electronic equipment under development, I used to visit Harold Vance and his crew of key engineers at the RCA Camden plant frequently. He was a fine gentleman, with exceptional electronics savvy and management know-how. I regret I didn't get a chance to meet George Brown, who, I believe, was at RCA Labs (elsewhere) at the time.

In hindsight, my offset drooper article could have been more accurately titled "An Improved Drooping Ground Plane." For over three decades, drooping radials have been widely used by the ham fraternity to permit direct connection of 50-ohm coax. However, this aggravates antenna effect. The Offset Drooper configuration provides a substantial reduction in antenna effect without adding a detuning sleeve or an extra set of radials, while still maintaining a 50-ohm match.

Woody Smith, W6BCX
Anaheim, California 92804

is nothing sacred?

Dear HR:

With this rather untimely heading ["Is Nothing Sacred?" — Ed.], The New York Times recently reported slight changes in more than 100 of the fundamental constants used in science. These changes represent a consensus of scientific opinion by the world's leading measurements laboratories, including those in the Soviet bloc and our National Bureau of Standards as well.

It is gratifying to learn that the speed of light hasn't changed, and remains at 299,792,458 meters per second. I shall leave it to some computer whiz to translate that into feet and inches; my hand calculator is inadequate.

However, whereas this number was previously termed "approximate," it is now defined as "exact," and the second is considered constant. The meter is then defined in terms of the velcity of light and the second — a nice Catch-22! Greater accuracy will be achieved with future improvements in measurement.

The meter, as originally proposed by a French vicar in 1670, was defined as 1 ten-millionth of the distance between the equator and the North Pole. It was subsequently translated into two scratches on a platinum bar kept at 23 degreees C. (Now that we deal in subatomic distances, this is gross measurement indeed.) Thus the scientists have defined the meter as the distance that light will travel in 1/299,792,458 second!

Obviously, you won't have to throw away your tape measure when you put up that new beam!

Josef Darmento, W4SXK
Merritt Island, Florida 32952

bird chaser

Dear HR:

Noticed the letter from Bernard Kirschner in the May issue ("Comments," page 6).

He's having troubles using an owl as a bird chaser, is he? Perhaps he should use one of those inflatable snakes from the local garden shop instead. Tie one end of it about halfway out along the boom and the other end on the pole so it looks like it's just climbing onto the boom. Those things would scare me off — as well as all manner of feathered creatures.

Charles Chrestien
Sunnyvale, California 94086

neighborly gesture

Dear HR:

There's a very useful technique for dealing with neighbors who complain of TVI. Instead of making critical comments about their television receivers, try lending them a table model color receiver fitted with the proper filters. Then ask them to help you perform a simple test.

Three or four days later they'll ask you to tell them how they can fix *their* receivers. Amazingly, even the most formerly rabid neighbor will approach you in a very friendly and reasonable frame of mind.

As proof of the effectiveness of this method, how many Amateurs do you know who have ground radial systems covering not only their yards, but a side neighbor's yard and the yard of the neighbor in the back as well?

John Labaj, W2YW
Elsmere, New York 12054

New MFJ-1274 lets you work VHF and HF packet with built-in tuning indicator for $169.95 . . .

. . . you get MFJ's latest clone of TAPR's TNC-2, TAPR's VHF/HF modem and built-in tuning indicator that features 20 LEDs for easy precise tuning

MFJ-1274
$169^95^

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Now you can join the exciting world of packet radio on both VHF and HF bands with a precision tuning indicator . . . for an incredible $169.95!

You get MFJ's top quality clone of the highly acclaimed industry standard TAPR TNC-2. We've made TAPR's modem selectable for both VHF and HF operation, added their precision 20 segment LED tuning indicator, a TTL serial port, an easily replaceable lithium battery for memory back-up and put it all in a new cabinet.

If you don't need the tuning indicator or the convenience of a switchable VHF/HF modem, choose the affordable MFJ-1270 for $139.95.

All you need to operate packet radio is a MFJ-1274 or MFJ-1270, your rig, and any home computer with a RS-232 serial port and terminal program.

If you have a Commodore 64, 128, or VIC 20 you can use MFJ's optional Starter Pack to get on the air immediately. The Starter Pack includes interfacing cable, terminal software on disk or tape and complete instructions . . .everything you need to get on packet radio. Order MFJ-1282 (disk) or MFJ-1283 (tape), $19.95.

Unlike machine specific TNCs you never have to worry about your MFJ-1274 or MFJ-1270 becoming obsolete because you change computers or because packet radio standards change. You can use any computer with an RS-232 serial port with an apropriate terminal program. If packet radio standards change, software updates will be made available as TAPR releases them.

Also speeds in excess of 56K bauds are possible with a suitable external modem! Try that with a machine specific TNC or one without hardware HDLC as higher speeds come into widespread use.

You can also use the MFJ-1274 or MFJ-1270 as an excellent but inexpensive digipeater to link other packet stations.

Both feature AX.25 Level 2 Version 2 software, hardware HDLC for full duplex, true Data Carrier Detect for HF, multiple connects, 256K EPROM, 16K RAM (expandable to 32K with optional EPROM), simple operation, socketed ICs plus much more.

You get an easy-to-read manual, a cable to connect your transceiver (you have to add a connector for your particular radio), a connector for the TTL serial port and a power supply for 110 VAC operation (you can use 12 VDC for portable, remote or mobile operation).

Help make history! Join the packet radio revolution now and help spread this exciting network throughout the world. Order the top quality and affordable MFJ-1274 or MFJ-1270 today.

MFJ-1273, $49.95

Now you can tune in HF, OSCAR and other non-FM packet stations fast!

This MFJ clone of the TAPR tuning indicator makes tuning natural and easy - - it shows you which direction to tune. All you have to do is to center a single LED and you're precisely tuned in to within 10 Hz. 20 LEDs give high resolution and wide frequency coverage.

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

Order any product from MFJ and try it -- no obligation. If not satisfied return within 30 days for prompt refund (less shipping).
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Reader Service CHECK – OFF Page 106

✓ 112

low-cost pc board layout software

The price *has* dropped — but watch out for those options!

The price of sophisticated printed circuit board layout packages has plummeted. For less than $1000 — often *much* less — you can buy an easy-to-use package that can handle almost any board layout. Even if you've never used computer-aided design (CAD), you can master any of these packages quickly.

Until recently, pc board designers had to choose between sending their designs to pc board service bureaus or using expensive layout packages that ran on dedicated work stations. CAD packages priced at less than $1000 were drafting tools at best. But all that's changed; today's relatively low-cost pc board layout software packages provide almost the same features as work station-based systems. What's more, they run on personal computers, which means they're now within reach of clubs and individual Amateurs.

All packages aren't equally suited for all applications, however. For analog designs, a package should provide an area-fill capability, which you'll need for constructing irregularly shaped ground planes. Some packages are tailored for digital designs and consequently don't provide a way to create copper planes of arbitrary shape.

Most of the low-cost packages, however, offer tools for filling in copper areas. For example, area fill is a standard feature of Accel Technologies' *Tango-PCB*® program for IBM PCs and compatible personal computers. Together with the package's 1-mil grid, the area-fill command enables you to create copper areas and thick tracks for microstrips and ground planes. Its $495 price includes software, documentation, a function key overlay, a sample pc board, and a 30-day money-back guarantee.

Procad xtra®, from Interactive CAD Systems, features filled areas for ground planes and lets you select up to seven fill patterns and styles of lines. Complex symbols such as standard power-supply layouts or memory bus structures can be stored in the program's library for repeated use. Procad xtra costs $695; it runs on IBM PCs and on Digital Equipment Corporation's VAX minicomputers.

Similar features are found in QTech's *Qwik Tek*® package. That's not too surprising — they were developed by the same programmers. Like Procad xtra, Qwik Tek runs on IBM PCs and on DEC VAXs; the base price of Qwik Tek is $695.

automatic layout software

Qwik Tek and Procad xtra aren't alike in all respects. Procad xtra is a purely interactive system, which is all you'll need for most analog applications. But for designs with large numbers of components, you'd need a program that could position them on a layout and draw interconnections among them. A $7900 version of Qwik Tek includes these capabilities, offering a schematic editor, interactive layout, automatic placement, and an autorouter.

An autorouter interconnects the components on a layout automatically. The sophistication of the autorouters in low-cost pc board layout packages approaches that of autorouters in the most advanced work stations and mainframe-based layout systems. Yet the price of an IBM PC-based autorouter can be relatively low. For $750, CAD Software's *Pads-Route*® autorouter provides three routers: power-and-ground, memory, and maze. The power-and-ground and memory routers specialize in power supply and RAM interconnections; the maze router interconnects all other digital and analog components.

By Eva Freeman, 108 Trapelo Road, Lincoln, Massachusetts 01773

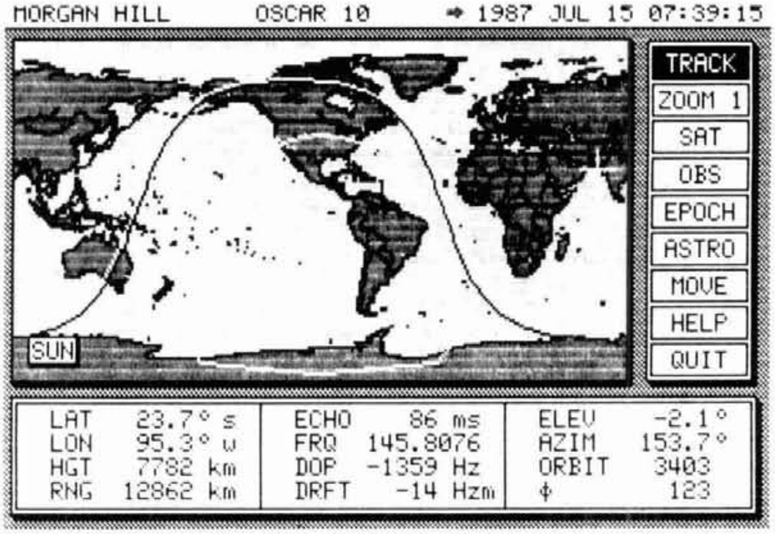
Table 1. Low-cost pc board layout packages.

Company	Product	Base price	Required hardware	Operating system	Auto-router	Auto-router price	Auto-placement	Compatible net lists	Max. no. of colors	Max. no. of traces	Max. no. of components	Max no. of layers
Abacus Software Box 7219 Grand Rapids, MI 49510 (616) 241-5510	PC Board Designer	$195	Atari 520ST or 1040ST	Gem	X				2	1100 lines	250	2
Accel Technologies Inc. 7358 Trade St. San Diego, CA 92121 (619) 695-2000	Tango-PCB	$495	IBM PC or compatible	MS-DOS	X			Accel; Omation; Orcad	16	26,000 lines	1000	9
Advanced Microcomputer Sys. 2780 SW 14th St. Pompano Beach, FL 33069 (305) 975-9515	PC-PRO	$250	IBM PC or compatible	MS-DOS	X	$250		AMS FutureNet Racal-Redac	16			256
B & C Microsystems 355 West Olive Sunnyvale, CA 94086 (408) 730-5511	PCB/DE	$395	IBM PC or compatible	MS-DOS and AutoCAD				B & C Microsystems	16			
CAD Software Inc. Box 1142 Littleton, MA 01460 (617) 486-9521	Pads-PCB	$975	IBM PC or compatible	MS-DOS	X	$750	X	FutureNet	16	4511 nets	764	30
Dasoft Design Systems 1827B Fifth St. Berkeley, CA 94710 (415) 486-0822	Project: PCB	$950	IBM PC or compatible	MS-DOS	X			Dasoft	6			4
Design Computation Inc. 10 Frederick Ave. Neptune, NJ 07753 (201) 922-4111	Draftsman-EE	$749	IBM PC or compatible	MS-DOS	X	$2450	X		16	4000 nets	300	20
Douglas Electronics 718 Marina Blvd. San Leandro, CA 94577 (415) 483-8770	Douglas CAD/CAM	$95	Apple Macintosh	Macintosh					2			
Interactive CAD Systems 2352 Rambo Court Santa Clara, CA 95050 (408) 970-0852	Procad Xtra	$695	IBM PC or compatible	MS-DOS				ICS	16	2000 nets		50
QTech Inc. 256 E. Hamilton Ave. Campbell, CA 95008 (408) 370-3910	Qwik Tek	$695	IBM PC or compatible	MS-DOS	X	$7205	X	QTech	16	1500 nets		50
Softcircuits Inc. 401 SW 75th Terrace North Lauderdale, FL 33068 (305) 721-2707	PCLO	$500	Commodore Amiga 1000	Amigados	X				16			
Vamp Inc 6753 Selma Ave. Los Angeles, CA 90028 (213) 466-5533	McCAD	$395	Apple Macintosh	Macintosh	X	$995	X	Vamp	2	32,000 lines	32,000	6
Visionics Corp. 1284 Geneva Dr. Sunnyvale, CA 94089 (408) 745-1551	EE Designer	$975	IBM PC or compatible	MS-DOS	X	$975	X		16		999	26
Wintek Corp. 1801 South St. Lafayette, IN 47904 (317) 742-8428	Smartwork	$895	IBM PC or compatible	MS-DOS	X			Wintek	3			6

It's not reasonable to expect too much of pc board autorouters priced at under $1000. They can't match the speed of mainframe or work station-based autorouters, nor can they consistently route all boards to completion, as can some mainframe or work station-based autorouters.

Though these packages are certainly more than adequate for typical Amateur projects, you shouldn't expect, for example, to use a PC-based package to design an eight-layer, 500-IC board. Although several of the PC-based layout programs listed in **table 1** do permit eight layers and 500 components, their autorouters just can't route boards of such complexity. If you do find your designs limited, they'll be limited not by the maximum number of components or layers, but instead by the maximum number of traces your software package will allow.

Table 1 lists the maximum number of traces each package can handle. Note that vendors differ in the way they specify this capability. Some specify a maximum number of nets; others, a maximum number of lines. A net links all pins that are to be connected to-



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VSWR	1.5:1
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BEAMWIDTH	60°
FEED IMP	50 ohm
BALUN	4:1 coax

MECHANICAL:

ELEMENT LENGTH	13½" max.
BOOM LENGTH	28"
TURN RADIUS	28"
WINDLOAD	.2 sq. ft.
WEIGHT	1 lb.
MAST	1½" o.d.
MOUNT	Rear

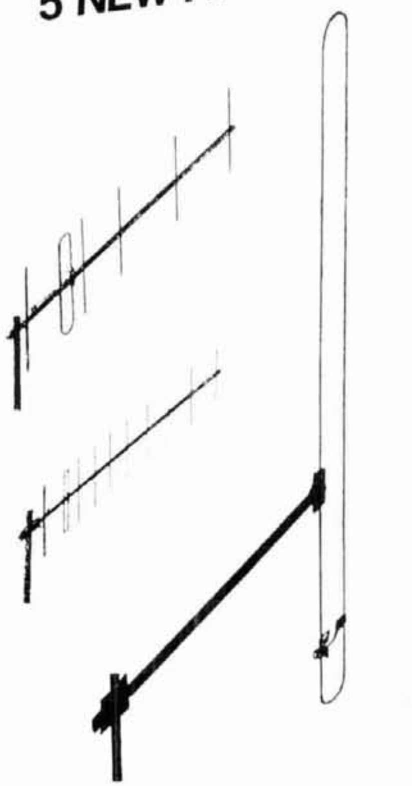
440-10X

ELECTRICAL:

BANDWIDTH	420-460 MHz
GAIN	11.2 dBd
VSWR	1.5:1
F/B	20 dB
BEAMWIDTH	48°
FEED IMP	50 ohm
BALUN	4:1 coax

MECHANICAL:

ELEMENT LENGTH	13½" max.
BOOM LENGTH	64"
TURN RADIUS	64"
WINDLOAD	.4 sq. ft.
WEIGHT	1½ lbs.
MAST	1½" o.d.
MOUNT	Rear



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VSWR	1.5:1
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MECHANICAL:

HEIGHT	61"
WEIGHT	2½ lbs.
MAST	1½" o.d.

CJ220

ELECTRICAL:

BANDWIDTH	220-224 MHz
GAIN	1.8 dBd
VSWR	1.5:1
FEED IMP	50 ohms

NO GROUND PLANE REQUIRED

MECHANICAL:

HEIGHT	40"
WEIGHT	2 lbs.
MAST	1½" o.d.

CJ440

ELECTRICAL:

BANDWIDTH	420-470 MHz
GAIN	1.8 dBd
VSWR	1.5:1
FEED IMP	50 ohms

NO GROUND PLANE REQUIRED

MECHANICAL:

HEIGHT	19¼"
WEIGHT	1 lb.
MAST	1½" o.d.

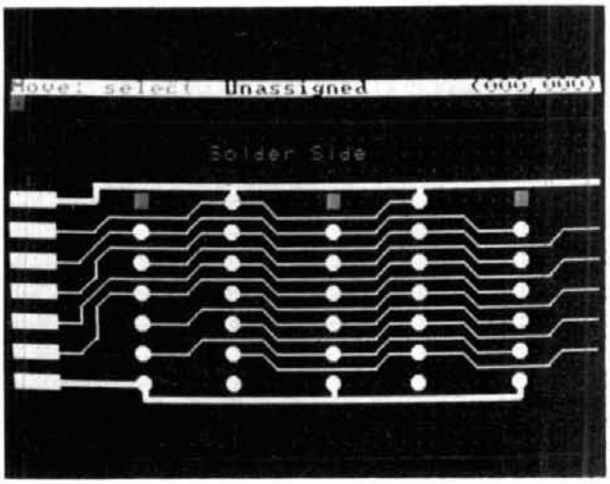

fig. 1. *PC Pro*, a $250 pc-board layout program from Advanced Microcomputer Systems, accepts schematic designs from either the package's own schematic editor or from Future-Net's IBM PC-based schematic-capture program.

gether; a line simply connects two points. A line doesn't even necessarily connect two components; if a connection includes a 90-degree bend, some vendors consider the connection to be two lines. A typical design contains roughly five lines per net. Thus, it's safe to assume that a package that specifies a 2000-net maximum is equivalent to one that specs a 10,000-line maximum.

Caution: the specifications provided in **table 1** can be misleading. Although a package might permit 1000 nets, 300 components, and 50 layers, it's best to stay away from the specified limits, because as a design approaches the limits of a package, the software starts to run more slowly and the autorouter generally fails to complete all the interconnections.

Any limitations of the low-cost packages are largely attributable to the limitations of the computers on which they run. The MS-DOS operating system used by the IBM PC, for example, can address only 640K of memory. Thus low-cost packages that run on IBM PCs and compatible personal computers can't handle databases of greater size.

Those working in especially demanding applications can add an extended-memory board to overcome this limitation. Although most PC-based layout packages can't yet take advantage of extended memory, CAD Software's programs can: their $250 Pads-Large-SW option increases the maximum number of components from 539 to 764, and increases the number of connections from 2711 to 4511. This package is the first to use extended memory, but you'll soon be seeing other layout programs that use it.

It's possible to accelerate IBM PC-based layout packages by running them on 80286 or 80386-based personal computers. Most vendors of PC-based layout packages have written their software to run on most compatible PCs (see **table 1** for details).

Whether routed manually or automatically, a layout can be only as good as component placement permits. If you don't optimize the placement of components on your board, your board will have more "vias" (plated-through holes) and longer interconnections than should be necessary. In many cases, the autorouter will simply fail to route the board completely. In all cases, pc board fabrication costs will be higher and system speed will be lower than they might be.

Even if you don't use an autorouter, you'll find that pc board layout packages can assist you in interconnecting components. Most of the packages include a rat's-nest utility that displays straight-line connections between components. With it, you can shift components on your layout to minimize the length of interconnections.

the bottom line: price, practicality

For Amateurs, the most important feature of a pc board layout system is likely to be its price. The least expensive package available for the IBM PC is Advanced Microcomputer Systems' $250 *PC PRO*® (**fig. 1**). This program gives users extensive control over designs; for example, it offers trace widths from 0.001 to 0.255 inches, and a single net can include a combination of trace widths. Similarly flexible, the symbol library includes footprints for standard ICs, connectors, and discrete components — and offers tools for creating new pad shapes.

Some of the less expensive packages were designed for computers other than the IBM PC. **Table 1** lists four such programs. The $195 *PCBoard Designer*® from Abacus Software (**fig. 2**) provides pc board layout tools for Atari users. The package offers component rotation in 90-degree increments and a choice of 45- or 90-degree routing paths; output is configured for Epson dot-matrix printers.

Softcircuits' $500 *PCLO*® package for the Commodore Amiga provides pan capabilities and fast screen redraws to keep the overall layout coherent while you're working. Ten work-area memories provide instant movement among disjoint areas.

Apple Macintosh users can choose between two programs: Vamp's *McCAD*® and Douglas Electronics' *Douglas CAD/CAM*.® The graphics-manipulation capabilities of the Macintosh are particularly attractive for analog applications; the line-and-pad-array generators in McCAD, for example, cut down on the time you need to create ground planes.

You can buy a Douglas CAD/CAM for as little as $95, but it won't provide automatic layout features or schematic capture. The basic package doesn't include interfaces to pen plotters or photoplotters; you have to send your layout to Douglas and have them fabri-

cate your pc board* — or make it yourself from the image you see on the screen. You can buy a pen-plotting option or a combined pen-plotting and photo-plotting option, but they'll cost you $300 and $500, respectively.

Although the least expensive package runs on the Macintosh, most low-cost layout programs were designed to run on the IBM PC. One vendor, B&C Microsystems, has held down the cost of its IBM PC-based *PCB/DE*® program by linking the software to Autodesk's *AutoCAD*® drafting package. Strictly speaking, the total package costs more than $1000 because you must purchase AutoCAD; but if you already own AutoCAD, you'll find that the $395 program provides more features than comparable packages that include drafting software.

Most PC-based packages don't require AutoCAD or any other additional drafting software; it's included with the pc board software. Wintek's $895 *Smartwork*® program, for example, includes all the graphics tools you need for pc board layouts. Though the program doesn't have an autorouter, it does offer an interactive router that finds the best possible connection between each successive pair of interconnections. Besides its layout package, the company offers an $895 schematic-capture program and is introducing an automatic router.

Visionics has recently added a $975 automatic router to its $975 *EE Designer*® pc board layout package (**fig. 3**). The autorouter can route not only two-layer boards but surface-mount devices and multilayer boards as well.

what options do you need?

Each one of these low-cost pc board layout packages comes with a "catch." The least expensive product that most vendors sell is the basic program; the optional programs and hardware dramatically increase the total cost. Like automobile manufacturers, vendors of low-cost pc board layout software often derive their profits not from the basic package, but from the options that accompany it.

Unfortunately, these "optional" programs aren't always optional. For example, Design Computation's basic *Draftsman-EE*® provides only a graphics editor, a component library, and bill of materials and parts list utilities. To generate a rat's nest display and to check for design rule violations, you'll have to purchase the optional *DC/Check*® program. An autorouter is yet another option. Often, these options are necessary.

Draftsman-EE is priced at $749, DC/Check costs $398, and the autorouter lists for $2450. For about $4000 you can purchase all of these tools, as well as

*Estimated price for 3 1/2 × 4 1/2-inch board, 250 holes, no gold: $193 for setup, $7.80 per board in small quantities. Price decreases for larger quantities.

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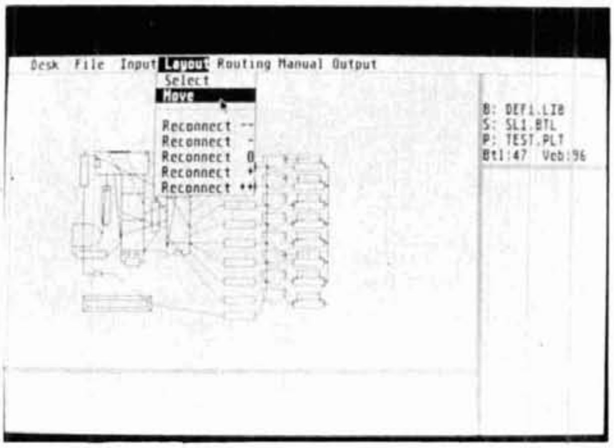

fig. 2. This rat's nest display shows direct connections among all components. Using the rat's nest display in Abacus Software's *PCBoard Designer*, you can interactively complete any one- or two-sided pc board.

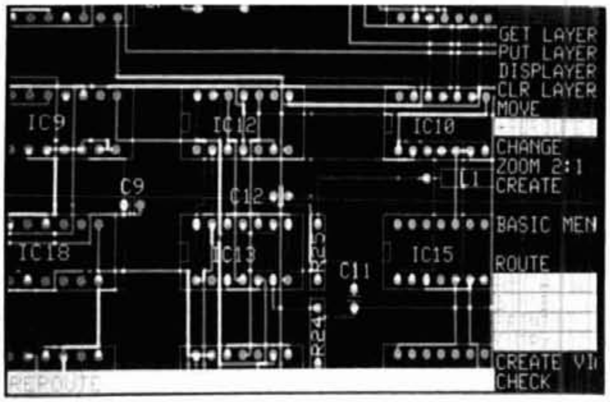

fig. 3. Even inexpensive packages can handle mixed analog and digital designs. *EE Designer*, from Visionics, routed an 88-component analog/digital board with 269 interconnections to 100-percent completion in six minutes.

12 months of telephone assistance; while it's a modest price for a complete professional pc board layout system, it's still more than five times the cost of the basic program alone — and far more than most Amateurs would probably be willing to spend.

Even though these options, especially for packages that list for less than $1000, greatly increase the cost of pc board software, the total cost — in professional applications — is still far less than the cost of using pc board service bureaus or work station-based layout systems. In considering the purchase of pc board layout software for Amateur applications, then, it's probably best to keep in mind the advice of the United States Postal Service: "If an offer sounds too good to be true, it probably is."

reference

1. Eva Freeman, "Low-cost pc board layout software," *EDN*, March 18, 1987, page 138.

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antenna relay sequencing

Use one basic protection circuit for normal switching or full break-in

Antenna relays are very expensive, and while bargains can sometimes be found on the surplus market and at swap meets, it takes time to find them.

Running 1500 watts into 50-ohm coax means that more than 5 amperes of rf current flows at almost 300 volts. Coax relays, with their contacts and spacing kept relatively small to preserve the impedance match, are definitely not designed to hot-switch this kind of rf power. If you try using them for this, you'll burn out the contacts; in fact, Murphy's Law ensures that transmit contacts will burn out completely just as you hear the rare DX country or VHF grid square you've been looking for.

Another form of antenna relay failure that's as common as burning out the contacts is arcing from the transmitter connector to the relay shell. This is caused by abnormally high rf voltage output from a high-power amplifier under open-circuit conditions.

A power amplifier also needs protection from any open-circuit condition, even for just a fraction of a millisecond. If a tube-type amplifier sees an open load at any time, either at the beginning or the end of a transmission, plate circuit arcing and damage to the components may occur. In solid-state amplifiers, an open load can destroy the transistors instantly.

The need for sequencing a mast-mounted VHF preamplifier is well known. GaAsFETs certainly aren't designed to handle several hundred watts, even for the few milliseconds it takes for a relay to switch.

This article discusses the most common case of a power amplifier and an ordinary coaxial antenna relay. The same basic circuit is used for full break-in with vacuum relays; in such a situation, the delay periods will simply be shorter. The same circuit can also be used to sequence mast-mounted VHF preamplifiers, together with an interface circuit to delay the exciter.

design criteria

To protect the relay and amplifier when the push-to-talk (PTT) line is closed, the amplifier turn-on should be delayed long enough for the relay contacts to close — and, most important, to have settled down after bouncing. To protect the relay and amplifier when the PTT line is opened, the relay contacts should be held in long enough for the amplifier output to have dropped to zero.

Each unit should, as much as possible, "take care of itself." This means, for example, that the relay should not depend upon a certain capacitor in the exciter or amplifier for a delay. Because you might want to use a different exciter or amplifier later on, the sequencing circuit should be treated as an integral part of the antenna switching mechanism.

circuit specifications

The timing functions of amplifier hold-off at the beginning of a transmission and relay hold-in at the end of a transmission are separated, greatly simplifying the selection of timing capacitors.

The control line for the circuit conforms to the following standards, which I've adopted for all the equipment in my shack: the open-circuit voltage on the control line is negative, and does not exceed −1 volt; the closed-circuit current on the control line does not exceed 1 mA; and the control line is diode-isolated. The first two standards ensure that the control line may be easily controlled by other such circuits, using inexpensive, easily obtainable, low-voltage PNP transistors, without the need for complicated interface circuits or relays. The result is that everything in the shack (except the antenna and other rf circuits) is controlled by solid-state switching. The final standard al-

By Mark Mandelkern, KN5S, 5259 Singer Road, Las Cruces, New Mexico 88005

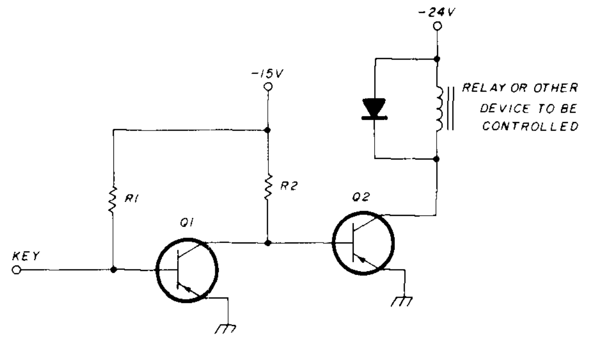

fig. 1. Basic two-transistor PNP switch.

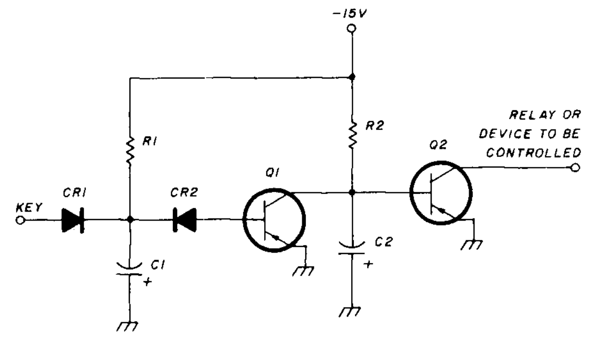

fig. 2. Basic switch with diode isolation and timing capacitors added.

lows the control lines of any number of such relay circuits, power amplifiers, drivers, transverters, preamplifiers, or other items to be tied in parallel, with no interaction. If the exciter's PTT line conforms to these standards, or is fitted with an appropriate interface circuit so that it does conform, it may be tied in parallel with the control lines of any number of other pieces of equipment, along with the PTT switch on the mike stand and the foot switch. A master band switch on the operating bench allows you to select which amplifiers, transverters, or antennas are to be tied in at the same time.

Since my exciter has a negative voltage on the PTT line, and my tetrode amplifiers use negative bias standby switching, I've used negative relay supplies and PNP switches for everything in the shack. However, this circuit can also be used with positive supplies by merely substituting NPN transistors and flipping over all the electrolytic capacitors.

A basic two-transistor PNP switch is illustrated in **fig. 1**. I use dozens of these switches in my shack. Most of the transistors are available for about ten cents. The relay drivers (which must handle high current) and the tetrode amplifier bias switches (which must handle high voltage) cost a bit more. I've used this circuit to convert all the gear I've built with relays over the last 40 years to solid-state switching; none has ever failed.

circuit description

The switching operation shown in **fig. 1** is very simple. Were it not for Q1, resistor R2 would supply enough base current to saturate Q2. This lowers the collector voltage to a very low value, which energizes the relay and enables the amplifier or other circuits. In the unkeyed state, resistor R1 supplies enough base current to saturate Q1, lowering the voltage at the collector of Q1 to about −0.1 volts, much lower than the − 0.6 volts needed at the base of Q2 to turn it on. Thus, in the normal state, Q1 is on and Q2 is off. Now what happens when the key is closed?* Keying the circuit grounds the base of Q1, turning it off. This removes the grounding (by the collector of Q1) from the base of Q2, allowing R2 to turn it on. Now the collector of Q2 drops to about −0.1 volts, enabling the relay or other device. Having the top of the relay coil always hot is one clue to the simplicity of this circuit. The transistors all have their emitters grounded and are either on or off, so their collectors either present a ground to the next stage or do not. Everything in the shack is enabled by simply grounding a terminal. There's no need for making two-wire connections when you want to apply a voltage to something.

The basic circuit shown in **fig. 1** needs only diode isolation and timing to become a full working device. These features have been added in **fig. 2**.

diodes provide isolation

Diode isolation is provided by inserting CR1 in the key line. If two or more of these switches have their key lines all tied together, the diodes CR1 in each switch will prevent any current flow between switching circuits. There's only one problem: with CR1 in the key line, closing the key reduces the voltage at the low end of R1 only to the forward voltage drop of the diode, which is just about the same as the −0.6 volts required to turn on the base-emitter junction of Q1. Thus, Q1 may or may not turn off, depending on the characteristics of the diodes and transistors, the temperature, and other such details. Diode CR2 saves the day by producing a 0.6-volt drop between the low end of R1 and the base of Q1. Now the voltage at the low end of R1 must be about −1.2 volts to turn on Q1. Closing the key drops it to −0.6 volts, and Q1 goes off with absolute certainty. Thus CR2 fixes the problem caused by the isolating diode, CR1.

*"Key" is a generic term used here for the point in any solid-state switch, relay circuit, exciter, or amplifier which is grounded in order to enable the device. Only in a CW keying circuit would "key" indicate a real telegraph key, and even then we'd usually be referring to the output of an electronic keyer. In this antenna relay sequencing circuit, the PTT line connects to the "key" terminal of the switch.

Figure 2 shows the general form of the switch, with two timing capacitors, although we use only one capacitor in each of the separate antenna relay and amplifier switching circuits. (Both capacitors could be used in certain applications, when both turn-on and turn-off delays are desired.) Capacitor C2 provides a turn-on delay (which we will use for the amplifier), while capacitor C1 provides a turn-off delay (which we will use for the relay). When the key is closed, C1 discharges immediately through CR1, and Q1 turns off. This allows R2 to turn on Q2, but not instantaneously. It must charge C2 up to about −0.6 volts, and this takes a bit of time. Thus C2 provides a turn-on delay, but C1 doesn't affect the turn-on. Now when the key is let up, this allows R1 to turn on Q1 — but, again, not instantaneously. It must charge C1 up to about −1.2 volts, and this provides the turn-off delay. As soon as Q1 turns on, its collector discharges C2 immediately, so C2 doesn't affect the turn-off time.

separate relay and amplifier switching

It's the clean separation of functions between C1 and C2 that makes the use of two separate switching circuits — for relay and amplifier — well worth the few extra parts. In the relay switching circuit, there's no C2 and the turn-off delay capacitor C1 doesn't delay the turn-on. In the amplifier switch, there's no C1 and the turn-on delay capacitor C2 doesn't delay the turn-off. Although there may be circuits that will do all this with one transistor, the adjustment of turn-on and turn-off times is much more complicated, there's no isolation (so key lines can't be tied together), and hot two-wire connections are often required. The sequencing could also be done with timer ICs, but this circuit seems simpler and may be less susceptible to rf pickup problems. Instead of comparators and timer thresholds, this circuit simply uses the base-emitter junctions of the transistors, which have sharp thresholds at about 0.6 volts with hard turn-on currents, resulting in a very sharp positive action. Timer IC circuits would still need the timing capacitors, transistors for relay drivers, and transistors or relays in interface circuits to match PTT lines and amplifier control lines.

selection of bias resistors

The basic switching circuit shown in **fig. 1** doesn't show the values of the bias resistors R1 and R2. These depend on the load current to be switched. Take first an antenna relay switch. A typical 24-Vdc antenna relay draws about 80 mA — let's say no more than 100 mA. We don't need the exact relay coil current, but rather just an upper limit for design purposes; our circuit will work well with any relay drawing less than this limit. To ensure that Q2 turns on hard at this collector current, a good rule of thumb is to provide a base current of about 10 percent of the collector current. This is like asking the transistor to have a gain of 10; the transistors we'll be using have typical gains in the 50 to 200 range, so this is quite a conservative rule. For Q2 to turn on hard means that with the 100-mA collector current, the collector voltage should drop quite low, to about 0.1 or 0.2 volts. This is not to ensure that the relay coil will get the full 24 volts (it will probably work fine at only 20 volts), but instead to keep the Q2 collector dissipation low. At 0.2 volts this will be only 0.02 watts, but if Q2 doesn't turn on hard, and the collector voltage drops only to 4 volts, the dissipation will be 0.4 watts, more than the rating of a typical ten-cent transistor. So for a 100-mA collector current, we'll provide a base current of 10 mA. The bias resistor R2 should then have the value $R = E/I = 15/0.01 = 1500$ ohms. The power in R2 will be $P = I^2R = (0.01)^2 \cdot 1500 = 0.15$ watts, so a 1/2-watt resistor will be satisfactory.

Q1 has to sink the 10-mA current in R2 in order to keep Q2 off until we push the PTT button. The collector voltage of Q1 should be as low as 0.1 to 0.2 volts, well below the 0.6 volts required by the base of Q2, so that Q2 will stay off. We apply the same rule of thumb as before; Q1 needs only 1-mA base current in order to sink 10 mA in the collector circuit. Thus for R1 we need a value of $R = 15/0.001 = 15$ k. Of course, the voltage across R1 isn't the full 15 volts, because of the small voltage drop in CR1 and the base-emitter junction of Q1. But there's no need here for mathematical precision. The power in R1 will be only 0.015 watts, so we'll use a 1/4-watt resistor. (Whenever the required current comes out less than 1 mA, I always provide 1 mA anyway; this avoids unusually low currents, thereby lessening any possibility of problems from leakage in the PTT line or rf pickup, and ensures that the output transistor in any switch, even if built to switch only another 1-mA line, will sink at least 10 mA, and will thus switch several 1-mA lines simultaneously if necessary.)

The current gain of the two transistors together is the product of the individual gains. Thus, to be safe, we assume a combined gain of 100, although 10,000 would be a more typical value. It's this gain of at least 100 that allows the 100 mA relay coil to be controlled with only 1 mA on the PTT line.

The amplifier switch bias resistors are even easier to select. If the amplifier bias switching circuit follows the standards listed above, you'll need to sink only 1 mA on the amplifier control line. So 15-k, 1/4-watt resistors will be acceptable for both R1 and R2. We'll leave the bias switching problem to the amplifier itself. This will keep the bias, up to −300 volts, off our control lines and out of our station band switch. The bias switch will be discussed below.

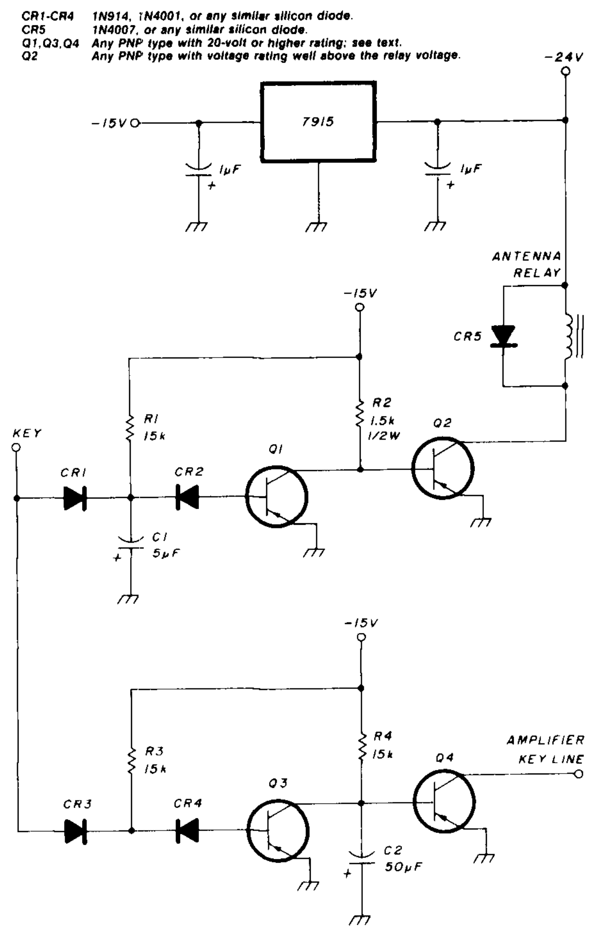

fig. 3. Complete sequencing circuits. Component values shown are for a typical 24-volt antenna relay; for other relays, see text. Not shown is rf filtering on all lines that lead outside the box, and disc ceramic bypass capacitors from base to emitter of each transistor. This filtering with rf chokes and bypass capacitors follows standard practice; actual values of the components will depend upon the frequency of operation.

selecting the timing capacitors

Figure 3 shows a typical complete sequencing circuit — in this case, for a 24-volt relay. The −24 volt relay supply is further dropped to −15 volts for the timing circuits. Since the voltage used affects the timing, this ensures that if the relay is changed to one with a different coil voltage, the timing circuits need not be readjusted.

Because of variations in the actuating time of different relays, it won't be sufficient to merely provide component values; the method of calculation must be explained. The time constant formula T = RC is usually used to choose circuit values in an R-C timing circuit, as in **fig. 4**. The units are seconds, ohms, and farads, but if kilohms and microfarads are used for R and C, the formula conveniently gives the time, T, in milliseconds (ms). The time constant, T, is the time required to charge the capacitor to about 63 percent of the applied voltage, V. In the circuit used here, however, the capacitors never charge beyond about −0.6 or −1.2 volts. To find the exact time to reach this voltage requires a complicated exponential-growth formula. But in this situation the level of charge is less than 10 percent of the applied voltage, so a much simpler formula will suffice:

$$v \approx \frac{t}{T} V \qquad (1)$$

This is a straight-line approximation to the exact voltage. Here, *V* is the applied voltage, *v* is the voltage reached after time *t*, and *T* is the time constant. The formula indicates a simple proportionality between the time and the voltage. Thus, in a circuit with a time constant, T = 500 ms, and an applied voltage of V = 15 volts, the capacitor will charge to about v = −0.6 volts (4 percent of the applied voltage) in about t = 20 ms (4 percent of the time constant). For a 10-ms antenna relay, this delay would be enough to hold off the amplifier while the relay closes.

Once we have the required time constant, it's easy to find the value of the capacitor needed in each bias circuit. With a 20-ms relay, we may wish to delay the amplifier for 30 ms, in order to allow for contact bounce. Using the relationship

$$t \approx \frac{v}{V} T \qquad (3)$$

with the values v = 0.6 volts and V = 15 volts, we find we need a time constant of

$$T \approx \frac{15}{0.6} \cdot 30 = 750 \ ms \qquad (3)$$

The delay capacitor C2 is on the base of Q4. If the switching circuit in the amplifier follows the standards

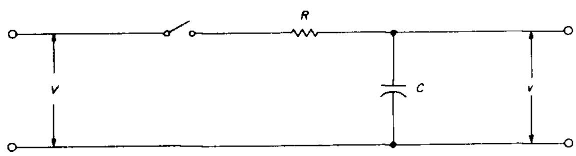

fig. 4. RC timing circuit. The time constant of this circuit is defined by T = RC, which is the time required for the voltage v on capacitor C to reach about 63 percent of the applied voltage V. The exact time required for the voltage on capacitor C to reach a specified voltage v is given by t = −T ln (1 − v/V). However, it is not necessary to use such a precise formula. The approximate time required for the voltage on capacitor C to reach a low specified voltage v is given by: $t = \left(\frac{v}{V}\right) \cdot T$. This approximation is within 6 percent of the exact time, as long as v is less than 10 percent of the applied voltage V.

CR1,CR2	1N914, 1N4001, or any similar silicon diode.
R2	For higher R3 current drain, the value of R2 is lowered, as described in the text.
R3	Bias adjustment potentiometer in existing amplifier.
R4,R5	Voltage divider to provide about – 15 volts to the switching transistors. The current required depends on the value of R2. R4 can be the bleeder resistor in the existing bias supply. The lower end of R4 is lifted from ground and R5 is inserted.
Q1	Any PNP type with 40 V or higher rating; see text.
Q2	Any PNP type with 300 V or higher rating, see text.

(part of fig. 7)

CR1,CR2	1N914, 1N4001, or any similar silicon diode.
Q1	2N4401 or any similar NPN type.

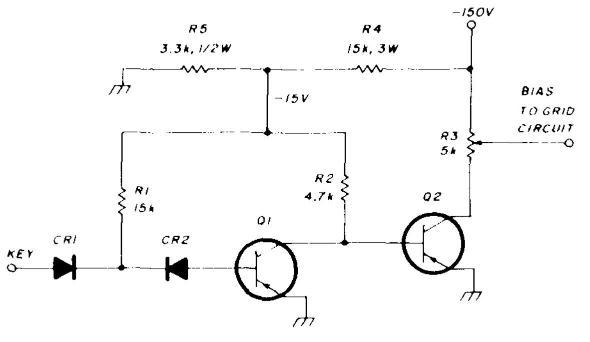

fig. 5. Tetrode amplifier bias switch. Values shown are typical for an amplifier of about – 150 volts standby bias, such as a 4CX1000A. Rf filtering should be added, as noted in fig. 3.

listed above (for example, the circuit shown in **fig. 5**), the bias resistor R4 will have the value 15 k. Thus, we obtain

$$C = \frac{T}{R} = \frac{750\ ms}{15\ k} = 50\ \mu F \qquad (4)$$

Although one could calculate all this precisely, the final adjustment is best made empirically with an oscilloscope, as described below.

Now that we have the amplifier delay timing capacitor chosen, we can work on the antenna relay hold-in timing. On voice, one usually stops talking a fraction of a second before letting up the PTT switch. The delay is provided by our human reaction time, which is pretty slow compared to the speed of the electrons we're pushing up to the antenna. Still, one might release the PTT button in the middle of the last syllable, or take the foot off the foot switch while keying, and we have to provide for any such possibility. A good exciter continues to transmit for 3 to 5 milliseconds after the key is let up; this allows gradual decay of the keying waveform and prevents key clicks. If the antenna relay opens during this time, arcing will result, and in the case of QSK operation, key clicks will be generated.

For these reasons we provide a short delay in opening of the antenna relay when the PTT line is opened. In **fig. 3**, this is done with C1 at the base of Q1 in the relay switching circuit. When the PTT line is opened, Q1 won't turn on until C1 charges through R1 up to about – 1.2 volts. This is 8 percent of the applied – 15 volts, so we need a time constant T = RC about 12.5 times the required delay. For a 6-ms relay hold-in time, T = 75 ms will be about right. If R1 is 15 k, C1 will need a value of C = T/R = 75 ms/15 k = 5 μF.

antenna relays

Since the best bargains for coaxial relays on the surplus market, or at swap meets, are 24-volt dc types, **fig. 3** shows the circuit for these. The dc relays offer the advantages of quiet operation, solid-state control, and the convenience of using the relay supply to power the sequencing circuit. However, the circuit is easily adapted for an ac antenna relay by adding a small reed relay as shown in **fig. 6**. The reed relay switching time is quite small compared to that of the coax relay. We can add a few milliseconds to our computations, or just let it be absorbed in the final scope test.

Because of the high cost of antenna relays, I've followed the old-fashioned custom of using only one relay, at the amplifier output, with the receiver antenna line running to a separate jack on the exciter. This minimizes losses on VHF and alleviates the need for double

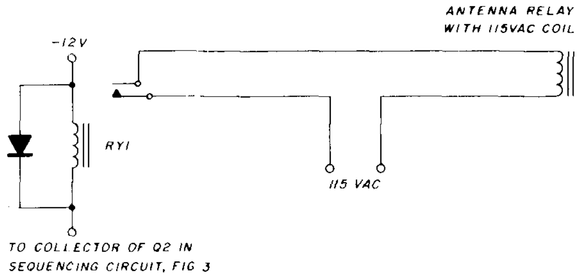

fig. 6. Interface for ac-operated antenna relay. RY1 is a 12-volt reed relay; other coil voltages may also be used.

relays on every preamplifier, attenuator, transverter, and driver down the line. This method is also highly recommended by some GaAsFET preamplifier manufacturers for safest operation. However, if you want to use two relays, switching the input and output simultaneously, just connect the coils in series or parallel, depending on the operating voltage available.

In the complete sequencing circuit shown in **fig. 3**, both the relay switch and amplifier switch are limited to 1-mA closed-circuit current, but the circuit as a whole requires the PTT line to sink 2 mA. The design standards can be implemented a bit loosely; in fact, the 1-mA limit was chosen for just this reason. If each individual circuit conforms to this limit, then any reasonable number of such circuits can be tied in parallel, and the total current will remain small.

In one of my relay sequencing circuits, extra protection is provided by inserting one set of the coax relay auxiliary contacts at the input to the amplifier delay circuit at the base of Q3 in **fig. 3**, and the other set at the output at the collector of Q4. This keeps the amplifier disabled in the event of failures such as an open relay coil or a shorted or open transistor. This also provides some mechanical delay so that C1 need provide delay only during the bounce time. However, this mechanical method doesn't eliminate the need for the amplifier sequencing circuit. Oscilloscope tests on typical antenna relays show considerable antenna contact bounce times, continuing long after the auxiliary contacts close. Incidentally, the "hot-shot" method (providing double the coil voltage for about 50 ms) often seems to make the bounce worse!

amplifier switching

For tetrode amplifiers with negative grid bias standby switching, amplifier switching is done with a separate switching circuit installed in the amplifier, as shown in **fig. 5**. In principle, the amplifier bias adjustment control could be connected directly to the collector of Q2 in the sequencing circuit of **fig. 3**, but this would have several disadvantages. The voltage rating of Q4 would have to be high enough to handle the full standby bias of the amplifier, as high as −300 volts or more. This high voltage would be on the cable between the amplifier and the sequencing circuit, violating the standards set forth at the opening of this article. If the control lines of both the driver and final amplifier are tied together at Q4, the −300 volts from the amplifier would appear at the driver switching circuit and in the station band switch. The isolating diodes would have to be the high-voltage type and there would be dangerous voltages in unexpected places. I much prefer to have the bias switching circuit inside the amplifier, even though it may seem a bit strange to find four transistors between the PTT switch and the amplifier bias circuit. All but the last one — a required high-voltage type — are inexpensive.

For amplifiers with screen voltage standby switching, a small reed relay with a solid-state driver can be installed in the amplifier. For zero-bias triode amplifiers, the solid-state interface circuit shown in **fig. 7** may be used.

connection to the exciter

The PTT jack on the sequencer can be connected in parallel with the PTT line of the exciter if the exciter PTT line is also negative and isolated. If the exciter PTT line is negative but not isolated, isolation can be easily provided by using the basic circuit of **fig. 2**, with no timing capacitors. If the exciter PTT line is positive, and you want to use negative switching for most gear in the shack, the interface circuit shown in **fig. 7** can be used. For full break-in, the exciter can be delayed using another two-transistor switching circuit.

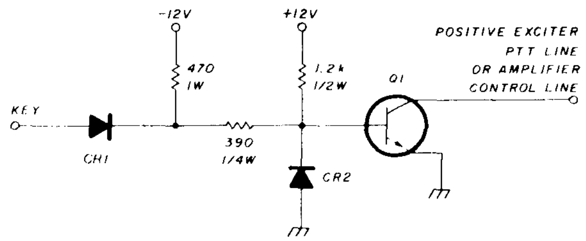

fig. 7. Interface for positive switching. This circuit will enable the negative switching sequencing circuit to control a positively-switched triode amplifier bias standby circuit, an exciter positive PTT circuit, or a relay energized with a positive voltage. It will sink more than 100 mA. Rf filtering should be added as noted in the caption for fig. 3. To reduce the current and voltage on the keyline, to conform with the standards suggested in the text, insert the basic circuit of fig. 2, without timing capacitors, in place of diode CR1.

testing and adjustment

The antenna relay can be tested to determine the actuating and bounce time before building the sequencing circuit, but it's easier to build the circuit using estimates of the delays required and then test the whole system afterwards. An amplifier delay of 50 ms and a relay hold-in time of 10 ms would be good figures to start with.

One possible test setup using a dual-trace triggered scope is shown in **fig. 8**. Although this illustration shows a battery, any available voltages from test supplies can be used. The antenna relay is controlled by the sequencing circuit, but the amplifier isn't used for the test. The external scope trigger connection, connected to the PTT line, is used. Thus the left edge of the scope trace represents closing of the PTT line. A foot switch, straight key, or push-button on the PTT line is convenient for repeated, manually triggered tests. The closing and opening transitions can be observed separately by changing the trigger polarity. One trace is used for the antenna relay contacts, and the other for the amplifier switching circuit. The testing is done with very small voltages and currents, so no damage results while you try different timing capacitors or parallel combinations of whatever capacitors are on hand in an effort to obtain the desired delays.

The timing capacitors should be selected so that the amplifier switch doesn't turn on until about 5 ms after the relay contacts cease bouncing and the contacts remain closed until about 10 ms after the amplifier shuts down. After initial adjustment, the antenna relay contact test current can be increased to several amperes; more bounce sometimes appears.

A single-trace scope can be used to see what's happening at two or more different places simultaneous-

ly, although it requires the special test circuit shown in **fig. 9**. A triggered sweep is still needed. The battery and the resistors establish various voltages, which the relay contacts and the amplifier switching circuit alter in such a way that can be observed on the scope. With the PTT line open, −9 volts will be seen on the scope. It stays at −9 volts while the relay contacts close. As soon as the relay closes, it climbs to −6 volts, then to −3.6 volts when the amplifier switching circuit turns on. If the amplifier switch turns on before the antenna relay closes, the trace will climb to −4.5 volts without going through the −6 volt stage, indicating that more amplifier delay is needed. *Contact bounce before the amplifier switch turns on* is seen on the scope as a fluctuation between −9 and −6 volts. Contact bounce after the amplifier switch turns on (to be avoided!) is seen on the scope as a fluctuation between −3.6 and −4.5 volts. Now when the PTT line opens, the amplifier switching circuit turns off instantly; the trace drops to −6 volts and stays there while the relay holds in, then drops back to the full −9 volts.

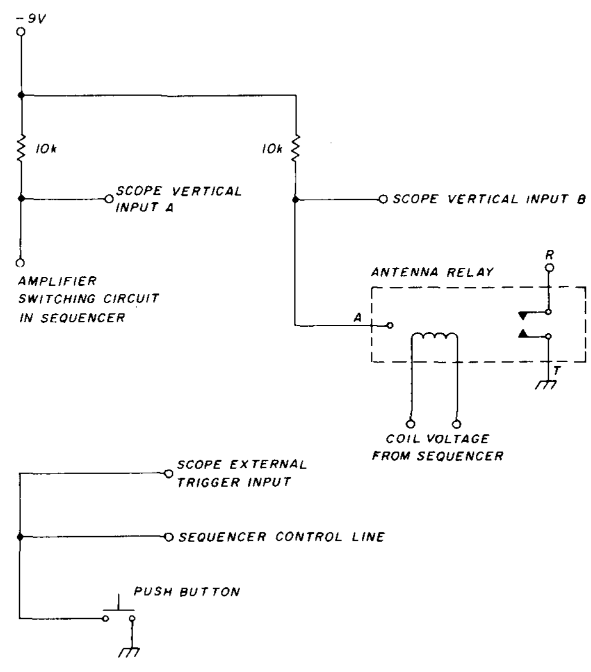

fig. 8. Test setup with a dual-trace scope.

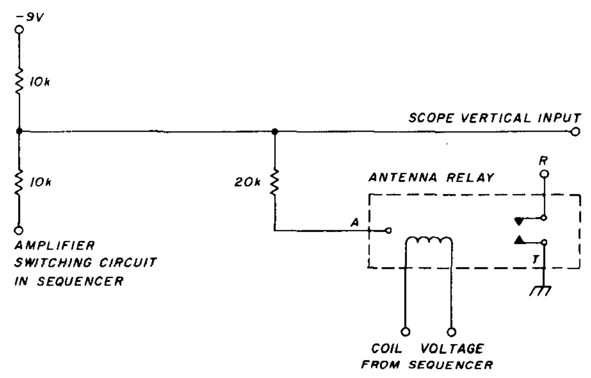

fig. 9. Test setup with a single-trace scope. Not shown is the trigger and PTT connection, which is the same as shown in fig. 8.

obtaining components

Inexpensive PNP transistors are available from the suppliers listed below.** For most circuit positions the 40-volt, 200-mA 2N3905 will do well. A good 24-volt relay driver is the slightly more expensive 120-volt 2N5400. Rated at 600-mA collector current, it will handle a 100-mA relay coil current with a nice safety factor. For higher coil current, such as we'd have with relays in parallel or 6-volt relays, the MPS-U57 (rated for 2 amperes) can be used. For tetrode amplifier bias switching in the circuit shown in **fig. 5**, the 300-volt MPS-A92 is available from BCD Electro.** These choices of transistor types are quite arbitrary; any available PNP types can be used as long as you check the manufacturer's ratings and compare these with the circuit voltage and current requirements.

For the timing capacitors, it's essential to use only tantalum electrolytics rather than ordinary filtering types. Tantalum will remain stable, with negligible leakage, over a very long time. Tantalum electrolytics usually have a 10 percent tolerance, which is satisfactory for sequencing purposes. On the other hand, the ordinary aluminum types often have tolerance ratings such as −20 percent to +100 percent. Because of this, and their leakage and unreliability, they are unusable in this application. Notice that in these circuits the capacitors never see more than 1.2 volts, so inexpensive 6-volt units may be used. One source for tantalum electrolytics is, again, BCD Electro.**

performance

For several years I've used two of these units with two homebrew amplifiers. One uses a 4CX1000A on 1.8 through 50 MHz; the other uses push-pull 4-400A's at 144 MHz. There's no arcing at the contacts, and I believe the antenna relays will last a long time.

Many antenna relays have an inspection port at one end, with a snap-in cover, for checking the contacts and connectors, which can be cleaned or replaced if necessary. It's interesting to remove this cover, turn off the shack lights, and watch for arcing. Without the sequencing circuit, the arcing can be seen clearly

** BCD Electro, P.O. Box 830119, Richardson, Texas 75083. Parts also available from Circuit Specialists, P.O. Box 3047, Scottsdale, AZ 85257.

every time you push or let up the PTT button. (For this test I ran low power to avoid burning the contacts too badly.) The dark-shack visual method provides a good final check on the sequencing circuit; this was how I found out how important it was to allow for the contact bounce time.

The sequencing circuit will protect the relay against contact arcing as long as there's a proper load on the antenna terminal. If a proper load is absent because of high SWR, antenna failure, feedline failure, or parasitics, the rf voltage could reach a high level and arcing could result between the transmit contact and the grounded relay shell. To protect against this, rf voltage limiting can be used with the circuit shown in reference 1. This circuit senses the rf voltage from the relay terminal to ground and uses the exciter ALC system to keep the amplifier output level below the arcing point. If the relay and sequencing circuit are built into the amplifier, all these protection circuits can be combined on one circuit board with an ALC circuit from reference 2 or 3.

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ham radio

VHF/UHF WORLD

Joe Reisert W1JR

impedance-matching techniques

Because hardly a month goes by that I don't receive at least one question about impedance matching, this month's column will first address the subject generally and then describe some specific techniques.

impedance matching in general

When impedance matching is discussed, it usually refers to matching to an antenna. Often the only question is "How do I get a low VSWR?"

For years Amateurs have had the notion that if the VSWR isn't close to unity (1:1), valuable power is being lost. They seldom consider the insertion loss of the transmission line, the accuracy of the measurement gear, or the mismatch loss (if any).

It's true that if the VSWR on a transmission line isn't 1:1, there's an additional line loss over and above that of the insertion loss of the feed line.[1] This is often referred to as "mismatch loss." For many years a graph published in several Amateur journals and the ARRL's *Antenna Book* has shown how to estimate the mismatch loss if the VSWR at the load and the nominal insertion loss of a transmission line are known.[2] Because I didn't know how precise it was, and because using it involves a two-step addition process (another possible source of error), and because it doesn't include low transmission line losses such as typically encountered at EME, I haven't had much confidence in it.

Thanks to Dick Turrin, W2IMU, I now have the mismatch loss mathe-

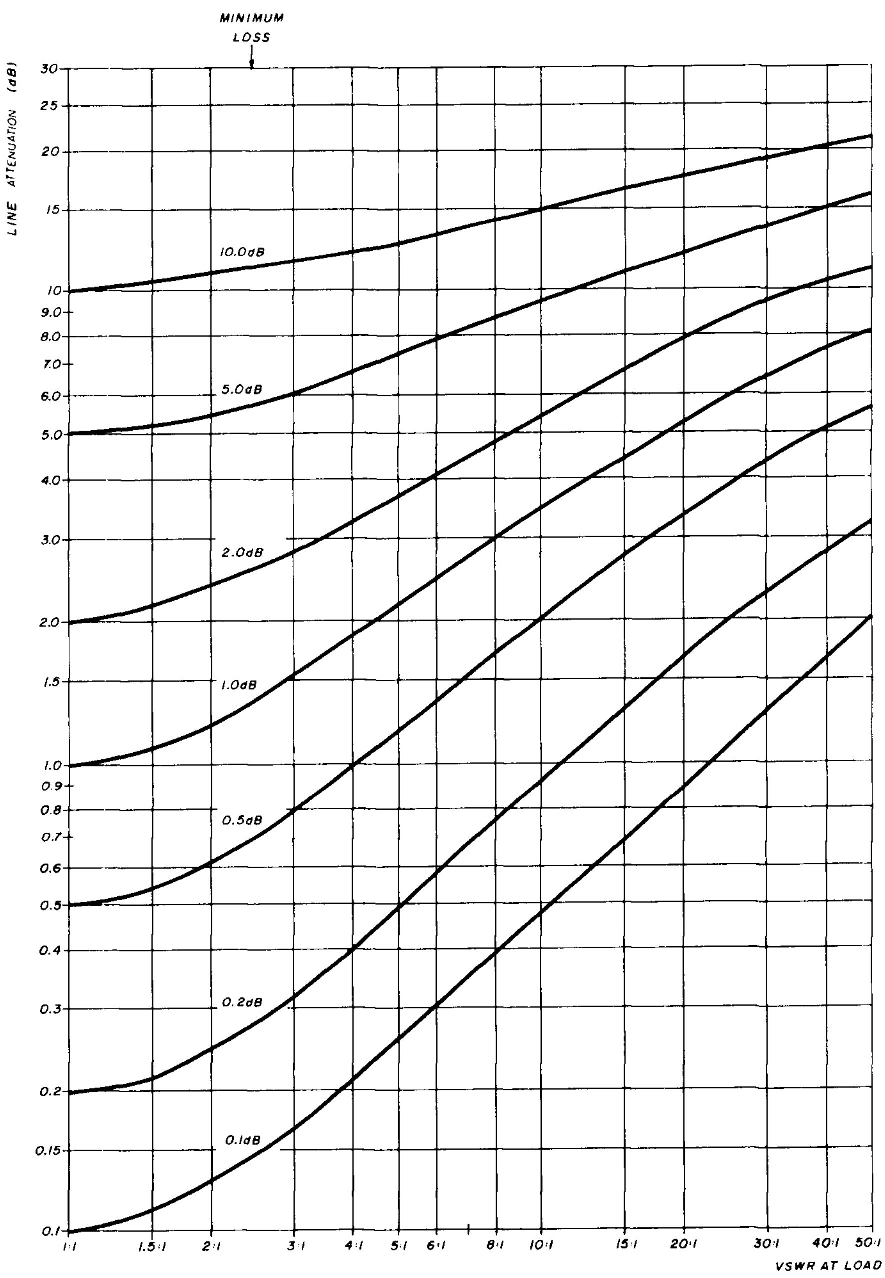

fig. 1. Total insertion loss in a transmission line terminated in a mismatch (see text).

matical equations, but they are lengthy. Dick pointed out to me that a mismatch loss graph using a different format was published in the 1940s.[3] Sure enough, I'd had the information in my files all these years and hadn't noticed it!

I've verified the math. The older and, in my opinion, more useful graph for mismatch loss is shown in **fig. 1**. Note that this graph stands alone, in that the loss indicated is the total loss, not just an incremental amount which then has to be added to the nominal insertion loss. As with the former graph, you still have to know the VSWR at the load as well as the nominal insertion loss of the transmission line. The latter quantity, however, is readily available.[1,2]

For example, using **fig. 1**, if the VSWR at the load is 5:1 and the nominal transmission line insertion loss is 0.2 dB, the total insertion loss — including the mismatch loss — will be 0.5 dB. Furthermore, if the VSWR at the load is 3:1 and the nominal insertion loss of the line is 5 dB, the total insertion loss will be 6 dB. I feel that **fig. 1** is easier to use and more realistic than the graph most Amateurs are presently using.

Impedance matching is especially important nowadays because of the proliferation of solid-state power amplifiers that will shut down or decrease power in the presence of VSWR above 1.5 or 2:1. However, the subject of impedance matching extends beyond antenna systems, since impedance matching can also refer to matching into or out of a low-noise, medium, or high power amplifier. Impedance matching can be narrowband as well as broadband and between resistive or reactive loads.

categories of impedance matching

Before we go any further, we should discuss what I feel are the three major categories of impedance matching: nonreflective, conjugate, and optimum source. Nonreflective matching is probably the most common type. In this scheme, an impedance matching network or "antenna tuner" is placed somewhere in the line between the source and load. This network is then tuned for minimum VSWR looking into the load. In a worst-case scenario, a large attenuator could be placed between the source and load to yield a good impedance match. (More on this shortly.)

Conjugate matching is often used in the design of solid-state power amplifiers where gains are typically low and therefore losses must be kept at a minimum, both in the input matching network and in the components involved.[4] In order to accomplish a conjugate match, all reactive components must be cancelled and the resistive component of the load made equal to the input line impedance.[5] Conjugate matching is often used in applications where wider bandwidth or no tuning is desired.

Optimum source matching usually refers to providing the impedance required for best operation of the load. In the case of a vacuum tube power amplifier, if a conjugate output match is used, at least one-half of the rf output power generated would have to be dissipated in the tube — a very inefficient condition.[5] Therefore, conjugate matching is usually not used in high-power amplifier designs.

In a similar manner, the input circuit of a low-noise preamplifier is often tuned to an impedance that produces the lowest noise figure, which seldom yields a good impedance match. Therefore a device or circuit that requires optimum source matching will usually have a moderate to poor input and/or output VSWR.

simple impedance-matching techniques

There are many ways to perform impedance matching. Resistors, transformers, reactive elements, transmission lines, and stubs are some commonly used VHF/UHF/SHF techniques. The optimum choice depends on whether the load is resistive or reactive, whether any insertion loss is allowable, and how broadband the match must be.

If loss isn't a problem, the load is resistive and doesn't have to see an impedance match looking back at the source; a simple resistor or resistor network is all that's necessary for a wideband impedance match. Several examples of resistor matching are shown in **fig. 2**.

In **fig. 2A**, the impedance of the amplifier must be resistive and less than the source impedance. The matching resistor, R, will be the difference between the source and load impedance. For example, if you want to match a source of 50 ohms and the load is 40 ohms, R should be 10 ohms.

If the load impedance is higher than the source, use a shunt resistance as shown in **fig. 2B**. With a load of 75 ohms, the shunt R will have to be 150 ohms to provide a match to a 50-ohm source. In either case, the matching resistor will dissipate power and decrease overall gain. Furthermore, the source will see a good impedance match but the load looking back toward the source will see a mismatch. The larger the impedance difference between the source and load, the larger the insertion loss and the lower the gain.

Sometimes it's desirable to have both the source and load see a good impedance match. In this case, the so-called "minimum loss pad" can be used for impedance matching (see **figs. 2C** and **2D**). This type of impedance matching provides a match looking both ways but has a higher insertion loss than the single resistor matching shown in **figs. 2A** and **2B**.

For example, using **fig. 2C** with a source impedance of 50 ohms and a load of 40 ohms, R1 should be 22.4 ohms and R2 89.4 ohms. The overall insertion loss will be 4.2 dB. If the load impedance is higher than the source, use the circuit in **fig. 2D**. With a source impedance of 50 ohms and the load at 75 ohms, R1 will be 86.6 ohms and R2 43.3 ohms. The overall insertion loss will be 5.7 dB.

If gain is of no consequence, typical "T" or "PI" attenuator pads can be used for impedance matching as shown in **figs. 2E** and **2F**. If the at-

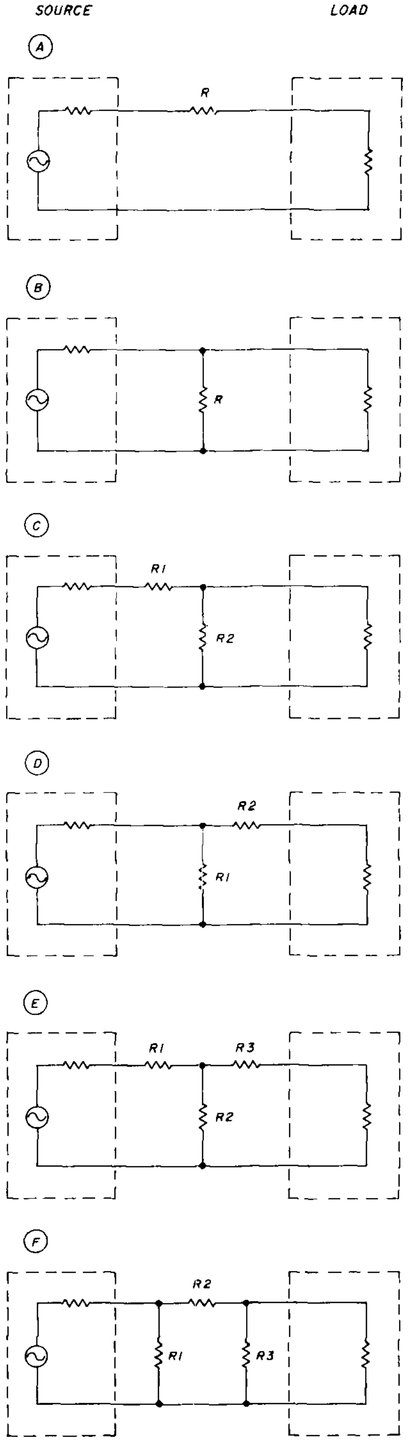

fig. 2. Different types of resistor matching for cases in which the source and load impedance are resistive: (A) source impedance is higher than load; (B) load impedance is higher than source; (C) minimum loss pad with source impedance higher than load; (D) minimum loss pad with load impedance higher than source; (E) typical symmetrical "T" pad attenuator; (F) typical symmetrical "PI" pad.

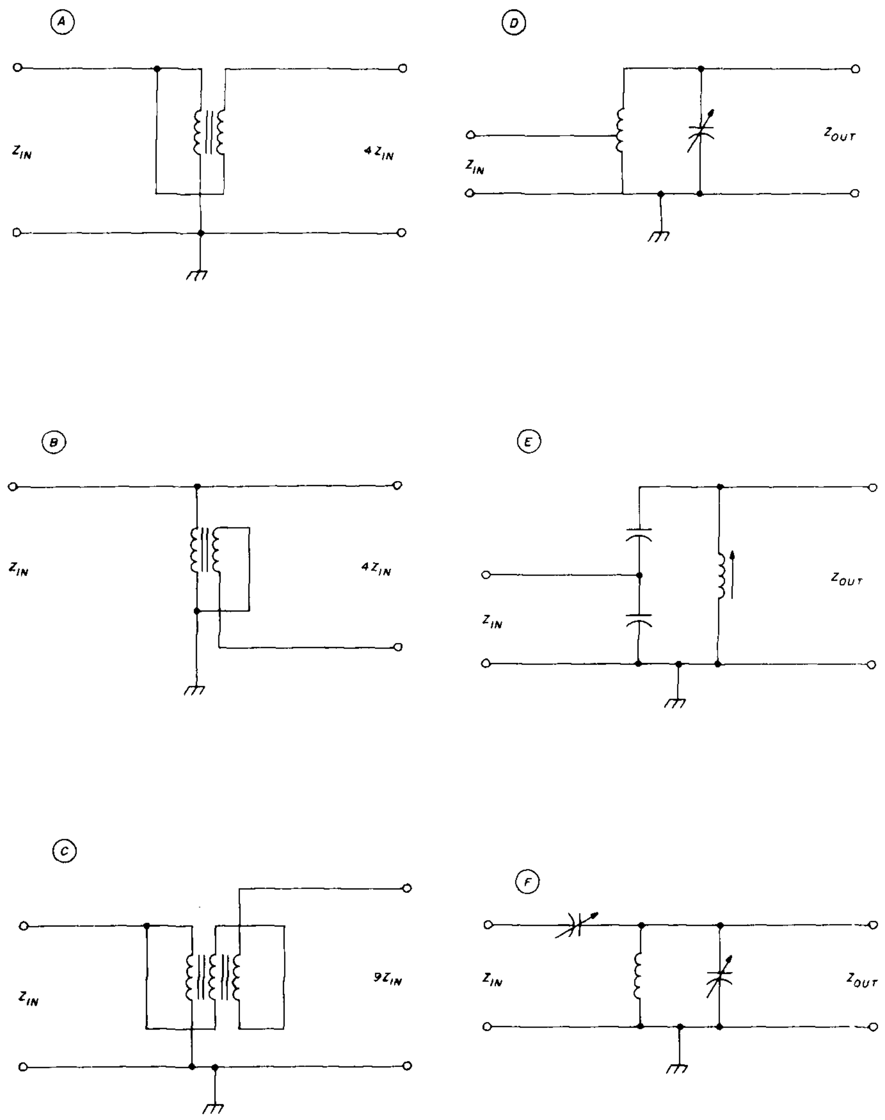

fig. 3. Typical transformer matching techniques: (A) simple 4:1 bifilar wound transformer; (B) typical 4:1 balun transformer; (C) trifilar wound 9:1 transformer; (D) typical resonant step-up/step-down transformer; (E) step-up/step-down transformer using tapped capacitor configuration; (F) variable tap transformer.

tenuation of the pad is high enough, for example 10 dB, the source and load will typically see a VSWR equal to or better than 1.2:1. Values for a 10-dB pad are 26, 35, and 26 ohms for R1, R2, and R3, respectively, in **fig. 2(E)** and 96, 71, and 96 ohms, respectively, in **fig. 2(F)**.

Finally, even lossy coax cable can act as an attenuator. For example, RG-58A/U coax has a loss of approximately 11 dB per 100 feet at 400 MHz. Therefore, about 90 feet of RG-58A/U would make an excellent 10-dB attenuator for the 70-cm (432 MHz) band with a power rating of 85 watts to boot.[1] Equations for designing minimum loss and matched attenuator pads are available in most design handbooks.[6] Typical computer programs are also available.[7]

transformer matching

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SWR SENSITIVITY	8 W	4W	S1:2W S2:3W	S1:2W/S2:3-4W
MEASURABLE FUNCTIONS	FWD POWER REF POWER PEP MONITOR SWR	FWD POWER REF POWER PEP MONITOR SWR	FWD POWER REF POWER PEP MONITOR SWR	FWD POWER REF POWER PEP MONITOR SWR
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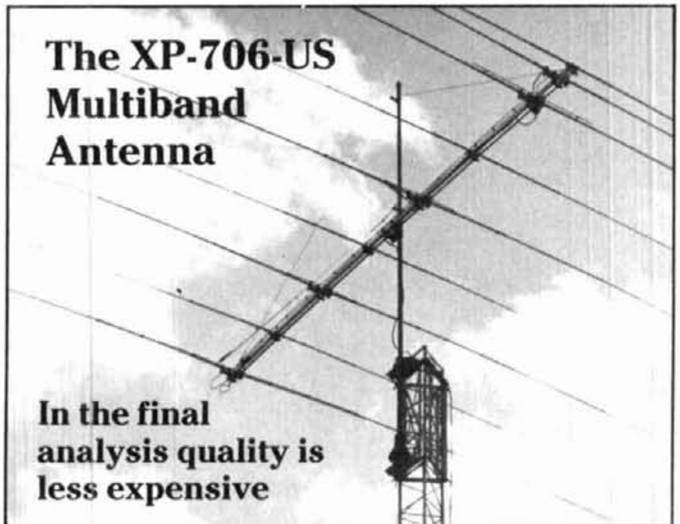

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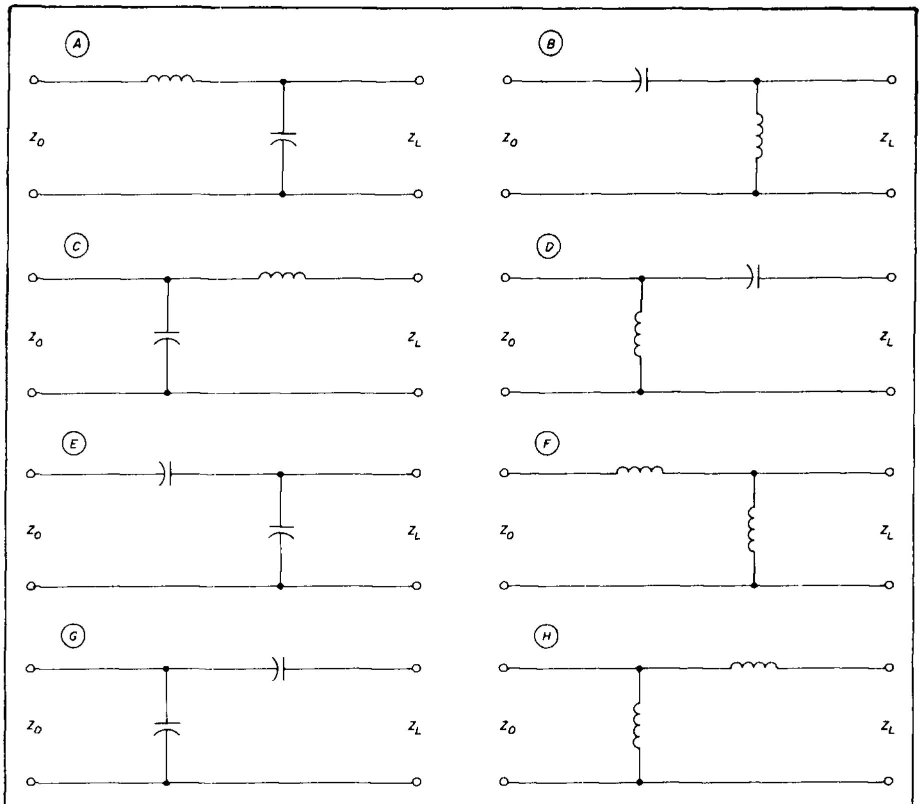


fig. 4. These eight "L" networks can be used to match any impedance to any other impedance (see reference 9).

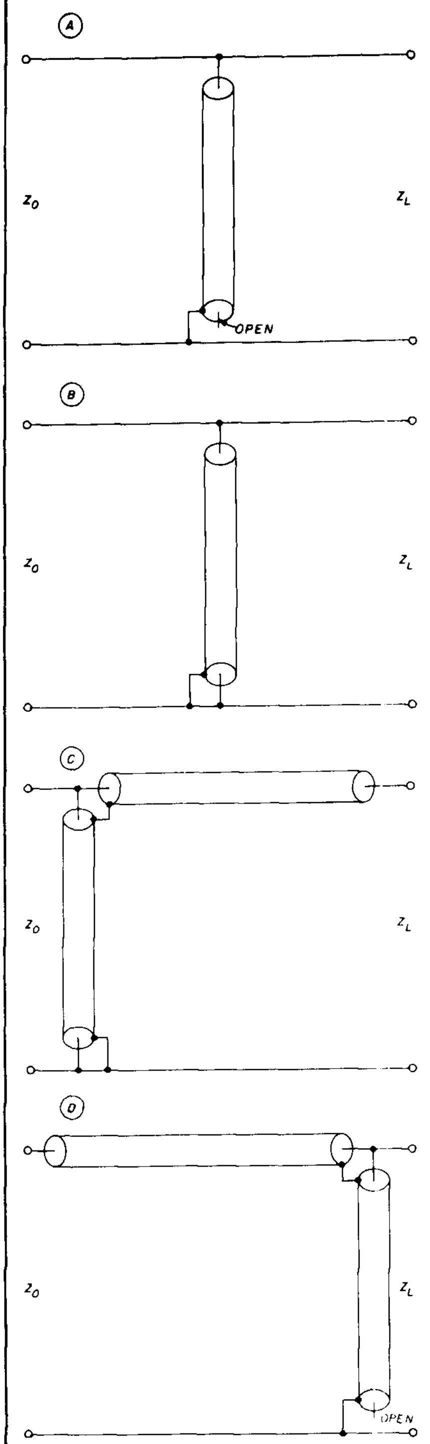


fig. 5. Typical stub impedance matching networks: (A) open shunt stub; (B) shorted shunt stub; (C) shorted shunt and series transformer; (D) series transformer and open shunt stub.

matching is through the use of transformers. The 4:1 transformer is particularly popular with Amateurs. It will conveniently match a resistive source to a resistive load that is four times the impedance. A bifilar wound transformer is often used, as shown in **fig. 3A**. This technique was recently suggested by Bob Sutherland, W6PO, for matching out of GaAsFET amplifiers.[8] Bifilar wound transformers are also very popular for toroidal baluns (**fig. 3B**). Trifilar wound transformers can also be used to match resistive impedances that are a ratio of nine times (**fig. 3C**).

Another popular form of transformer is the resonant step-up/step-down type that is often used at the input of low-noise receivers. It has many forms, but those shown in **figs. 3D** and **3E** are the most popular. **Figure 3F** is a somewhat simpler but more obscure transformer configuration that's popular where the goal is to optimize the impedance in the circuit without changing taps or components. Resonant transformers are often used in reverse to match the output of a high-impedance small signal amplifier to a lower impedance. Other types of transformers using coaxial techniques will be discussed shortly.

reactive impedance matching

So far I've been discussing mostly resistive matching networks. At the lower VHF/UHF frequencies, especially when low-loss impedance matching is required over only a narrow bandwidth, simple "L" networks using inductors and capacitors are often used, especially when the load impedance is reactive.

This is probably the time to mention the venerable "Smith Chart," a tool used mainly by professionals to impedance match from any one impedance to any other impedance if the impedances of the source, load, and reactive components are known.[9] Smith points out in Chapter 10 of his book that any resistive impedance, Zo, can be matched to any complex impedance, Z1, using a simple L-network. The eight required circuit topologies are shown in **fig. 4**. Smith shows the recommended network based on the portion of the Smith Chart where the load is present.

stub matching

Impedance matching can also be accomplished using coaxial stubs. The most common configurations are the open (**fig. 5A**) and the shorted (**fig. 5B**) shunt types. In most cases the stub is less than one-quarter wavelength. If a shunt stub isn't sufficient to complete the match, a tandem transmission line, also usually less than one-quarter wavelength, may be added ahead of or behind the shunt stub as shown in **figs. 5C** and **5D**. The Smith Chart is particularly useful for performing stub matching.

Use of the Smith Chart has been described many times in the Amateur literature[10,11,12] so I won't dwell on it here. Instead, I'll refer you to these references and use the rest of this month's column to show simple impedance-matching techniques that can be easily implemented by Amateurs.

coaxial transformers

Probably one of the most widely used impedance matching techniques in the VHF/UHF spectrum is the "quarter-wavelength transformer" as shown in **fig. 6A**. In its simplest form it can match virtually any two resistive impedances. The impedance of the line is the geometric mean between the input and output impedances as shown below:

$$Z_t = \sqrt{Z_{in} Z_{out}} \qquad \textbf{eqn. 1}$$

Where Z_t is the impedance of the quarter-wavelength transformer, Z_{in} is the input impedance, and Z_{out} is the output impedance, all in ohms. For example, let's say that we want to match a 50-ohm resistive line to a 75-ohm resistive line. Using equation 1, the optimum impedance of the quarter-wavelength transformer, Z_t, is 61.24 ohms.

The length, as stated above, must be one-quarter wavelength at the operating frequency. This can be determined using equation 2:

$$L = \epsilon_r (2951/f) \qquad \textbf{eqn. 2}$$

Where L is the length in inches, ϵ_r is the dielectric constant, 1.0 for air, and f is the frequency in MHz. Therefore a quarter-wavelength transmission line at 432 MHz using air dielectric is approximately 6.83 inches long.

Now all you have to do is to build a coaxial line section one-quarter wavelength long that has a characteristic impedance of 61.24 ohms. The impedance can be determined using equation 3:

$$Z = 138 \log (D2/D1) \qquad \textbf{eqn. 3}$$

Where Z is the impedance of a coaxial line, D1 is the outer diameter of the inner tubing, and D2 is the inner diameter of the outer tubing (see **fig. 6B**). For an impedance of 61.2 ohms, the ratio of D2/D1 is approximately 2.78:1.

A suitable coaxial transmission line can be made using hobby shop brass or copper tubing.[13] Half-inch household plumbing uses copper tubing that has an approximate inside diameter of 0.532 inches. Therefore, a 3/16-inch outside diameter tube, such as you'll find in hobby shops, would make a good match for the inside tube in this particular application.

Yet another transformer matching scheme — the "non-synchronous" transformer — is an outgrowth of the work of Frank Reiger, OD5CG[14,15,16,17] offering similar matching properties. **Figure 6C** shows a particularly fine example of this kind of transformer using two lengths of coax of the same impedance as that to be matched but inverted. No longer is there a need for an "oddball" line impedance. The overall length is 0.1628 wavelengths, which is 35 percent shorter than an equivalent quarter-wave transformer.

Another trick is to parallel coax. For instance, if two identical pieces of coax are paralleled, the new impedance is half the individual value (**fig. 6D**).

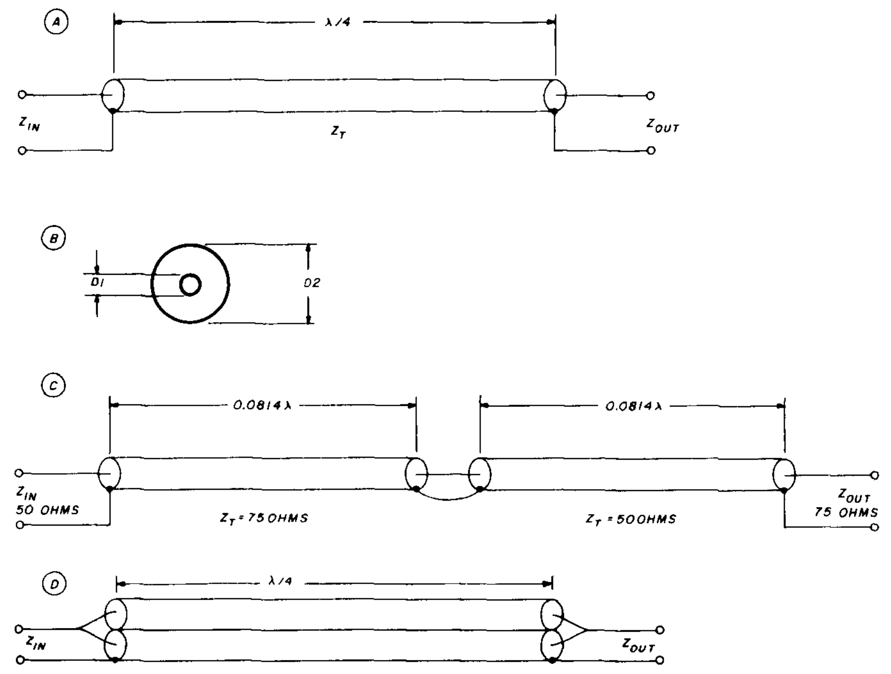


fig. 6. Typical coaxial transformers: (A) quarter-wavelength transformer; (B) elements of the physical properties of a coaxial line; (C) example of a 50- to 75-ohm non-synchronous transformer. (D) Coaxial cables can be paralleled to half the nominal impedance.

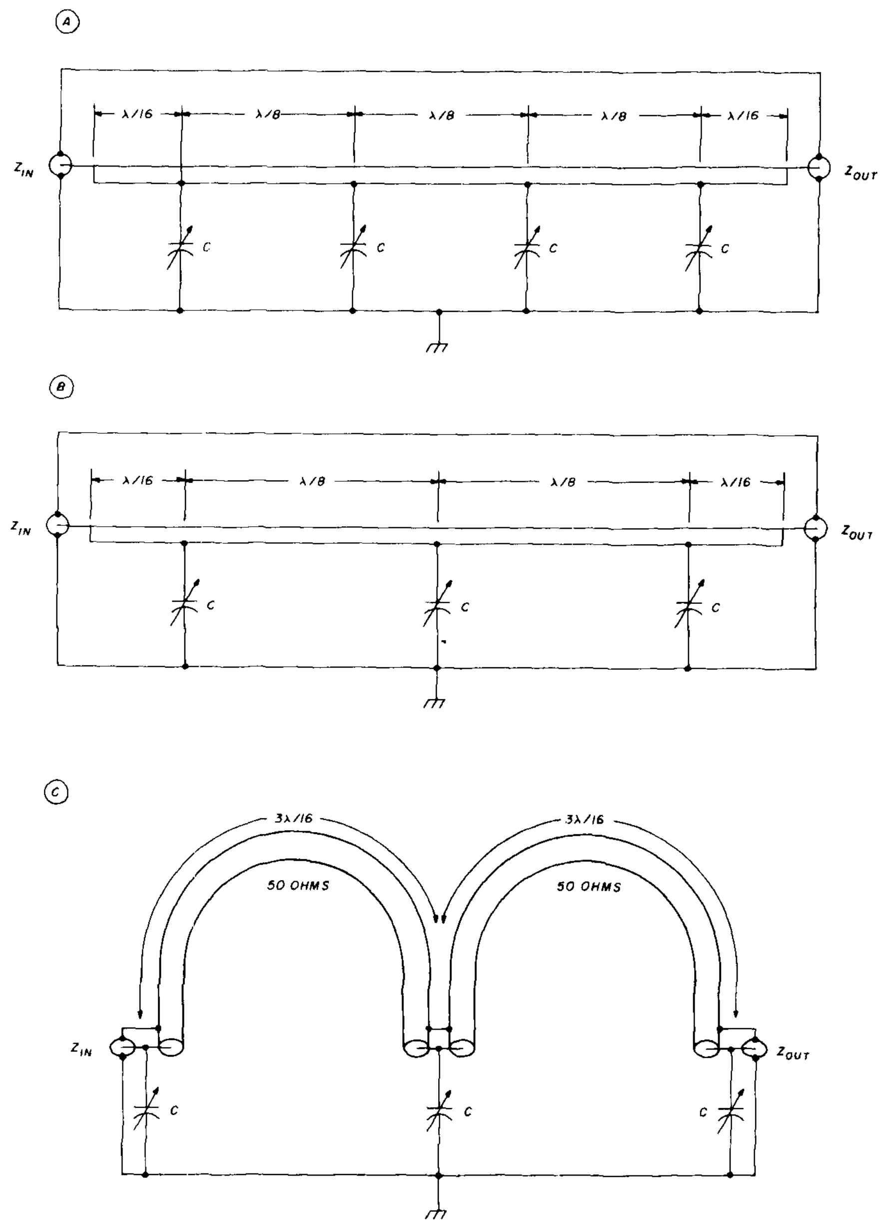


fig. 7. Examples of coaxial type antenna tuners: (A) half-wavelength adjustable transformer; (B) three-eighths wavelength adjustable transformer; (C) three-eighths wavelength adjustable transformer using coaxial cable.

Therefore, two quarter-wavelength pieces of 70-ohm coax in parallel would equal 35 ohms and could be used to match 25 ohms to a 50-ohm line. Likewise, two quarter-wavelength pieces of 50-ohm coax in parallel would have an impedance of 25 ohms and would be good for matching from 50 to 12.5 ohms.

variable impedance matchers

Some of the matching techniques just described are fine, especially when the impedances to be matched are resistive. But what do you do when you want to impedance match to a reactive load? The answer is that you need some sort of antenna tuner. At VHF/UHF/SHF frequencies this doesn't have to be the coil and variable capacitor type typically used at hf. Instead, you can build a very simple tuner using a section of coaxial line with a few small variable capacitors properly spaced along the line and shunted to ground.

Figure 7 shows some recommended types of coaxial line impedance matchers. The first, **fig. 7A**, is the most complex.[18] Basically speaking, a half wavelength of 50-ohm line is constructed in a trough, enclosure, or even in a microstrip line. Four variable capacitors are shunted to ground along the line at specific wavelength intervals as shown. **Figure 7B** shows a slightly simpler three-eighths wavelength matching scheme that probably has a little less tuning range.[19]

Figure 7(C) shows another scheme developed by one of my former colleagues, Dick Thurston. It originally used standard coax cable, so it has slightly higher loss than the schemes just described, but it's inexpensive and easy to construct. If standard coax is used, the line sections must also be shortened because of the dielectric constant of the line. At lower frequencies the coax can be coiled up. Thus a very compact, inexpensive impedance-matching transformer is possible.

The typical maximum capacitance required for the tuners shown in **fig. 7** can be determined empirically or by using equation 4 below:

$$C_{max} = 9,000/f \qquad \textbf{eqn. 4}$$

Where C_{max} is in pF and f is in MHz. For example, 60 pF and 20 pF are typical maximum values for 144 and 432 MHz, respectively. In any case, the minimum capacitance should be no greater than 10 percent of C_{max} or 6 and 2 pF, respectively.

In all of these coaxial type tuners, the capacitors must be physically small, have low inductance, and have very short leads. Mica compression trimmers similar to the types used in transistor power amplifiers are quite suitable. Air variables such as the E. F. Johnson type "U" or piston trimmers made by Johanson and others are excellent for low-power applications, especially at UHF frequencies.

On 220 MHz, I have a cathode-driven final that has a moderate input VSWR. Normally this wouldn't require any attention, but my solid-state driver doesn't care for the input mismatch. Hence a tuner similar to the one in **fig. 7C** is now used with three 4- to 40-pF mica compression trimmers and two pieces of RG-58A/U coax, each 6-1/2 inches long. This tuner now provides a good input VSWR to my final.

All that's necessary to adjust this kind of tuner is to connect it in the line with a VSWR bridge (**fig. 8A**). First set all capacitors at minimum capacitance. Then tune one capacitor at a time, starting with the one closest to the load, alternating combinations until a satisfactory match is obtained. It probably takes less time to do than explain it!

One final thought on coaxial tuners. As I pointed out earlier, additional mismatch loss will be incurred if a transmission line has even a moderate (2:1 or higher) VSWR. However, if a tuner is placed close to or at the load instead of the source, the mismatch loss may be entirely eliminated — a double bonus!

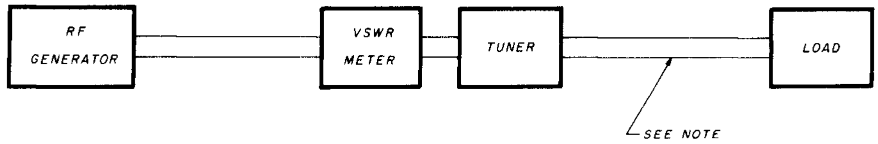


fig. 8. Typical VSWR test setup. Note that it's preferable to mount the tuner as close to the load as possible in order to decrease mismatch losses, as discussed in text.

UHF/SHF tuners

When you go higher in frequency, capacitors become inductive; consequently, the tuners mentioned above are probably usable only to about 1.3 GHz, provided that care is taken to select a good capacitor type. Above 1 GHz, impedance matching is often accomplished using variable shorted (or open) stubs, "line stretchers," and dielectric slug tuners.

Figure 9A shows the simplest type of stub tuner, usually fitted with a connector so that it can be easily inserted into a coaxial line, perhaps via a "T" fitting. If the stub won't decrease the VSWR sufficiently, a line stretcher (**fig. 9B**) may be inserted between the load and the stub so that the distance of the stub tuner from the load can be varied (**fig. 9C**).

Another common type of impedance matcher is the double-stub tuner (**fig. 9D**), which consists of two variable-length shorted (or open) stubs typically adjustable up to one-half wavelength and separated by the distance, D, one-eighth to three-eighths of a wavelength at the operating frequency. Double-stub tuners can match impedances only over a limited frequency range.

The triple-stub tuner shown in **fig. 9E** is more complex to use because it has more independent variables than the double-stub tuner. However, it will virtually match any impedance to any other impedance. It has one major drawback in that some settings will incur very high losses, so use it accordingly.

Stub tuners are in wide use, particularly where a quick impedance match is desired until a final circuit can be configured. However, most stub tuners employ some type of mechanical short circuit. This short sometimes increases insertion loss or causes intermittents due to high circulating currents, especially after extended tuner use. The construction of a suitable double-stub tuner is described in reference 20. Both double and triple stub tuners are manufactured by many companies, so they often turn up at flea markets.

Because of the mechanical problems associated with stub tuners as just described, dielectric slug tuners are sometimes used. A typical slug tuner is shown in **fig. 9F**. It usually consists of a 50-ohm air-type transmission line with electrical quarter-wavelength pieces of low-loss dielectric (such as PTFE/Teflon RTM) or metal slugs (covered with a low-loss insulating dielectric) placed along the line. Slug tuners don't have the tuning range of a stub tuner, but they will fit most applications and are usually easier to construct and use. Some recommended construction techniques for slug tuners are described in reference 21.

A variation on the slug tuner is the "multi-screw" tuner, which may be used in coax (**fig. 9G**) but is especially useful in waveguide (**fig. 9H**). It works on the same principle of operation as the coaxial tuner. The greater the number of screws available, the greater the tuning range. Brass or silver-plated screws are recommended, with appropriate nuts soldered to the housing for low-impedance, low-loss rf contacts. Some recommended construction techniques are described in reference 22.

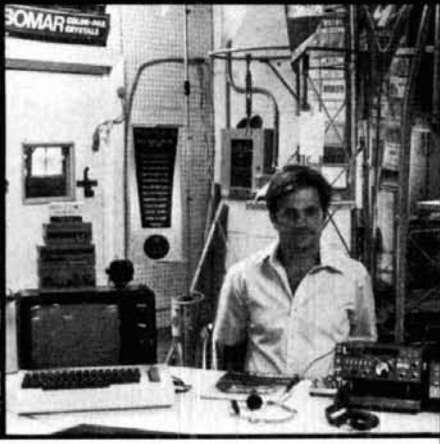
Most of you are probably familiar with microstrip transmission lines which are very popular, especially above 1 GHz. Microstrip is often used where impedance matching is required. The quarter-wavelength transformer (**fig. 10A**) or shorted and open stubs (**fig. 10B**) are easily implemented. Microstrip is great for production equipment. However, it does require a thorough knowledge of the circuit elements and much tweaking with expensive test equipment before optimum performance can be achieved.

This explains the recent popularity — particularly above 2 GHz — of what I call the "empirical matching tuner." **Figure 10C** shows a typical configuration. A 50-ohm microstrip transmission line perhaps one-half wavelength long is etched on the pc board either ahead of or behind the device to be matched. Then thin narrow strips (0.1 to 0.5 inches wide) of brass or copper shim stock perhaps 0.05 to 0.25 wavelength long are slid along the line until an optimum match occurs.

When using this empirical technique, sometimes the size and/or shape of the metal strip has to be altered many times. Often more than

Rob, WA3QLS

Katherine, KA3IYO



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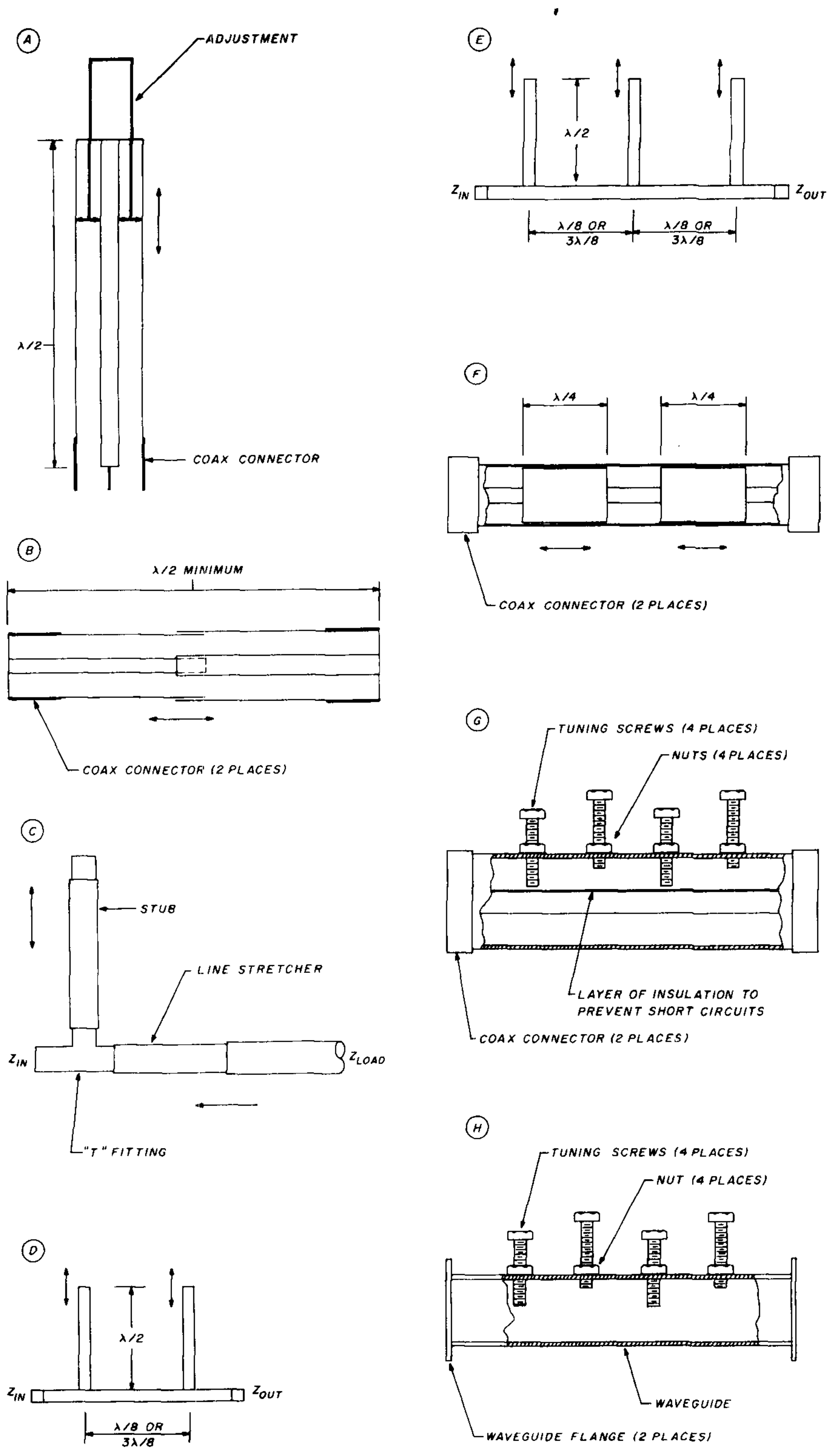

fig. 9. Examples of UHF/SHF tuners: (A) variable shorted (or open) shunt stub tuner; (B) typical line stretcher; (C) combination variable shunt stub and line stretcher; (D) typical double-stub tuner; (E) typical triple-stub tuner; (F) typical dielectric slug tuner; (G) multiple screw tuner; (H) screw tuner in waveguide.

one strip is required. These "tuners" can be slid along the main line with a small-diameter insulated material such as a wooden dowel from a cotton swab. When the optimum spot is located on the line, the strips are soldered in place and perhaps glued to the pc board so that they won't move. This approach is simple and inexpensive and can be quite effective.

wideband matching techniques

So far I've mentioned mostly narrowband matching techniques, since they're usually all that Amateurs need. Most wideband techniques require more hardware, several matching sections in cascade (rather than a single section, as previously discussed) and often have higher insertion loss.

Other wideband techniques involve the use of hybrid couplers, ferrite isolators, and circulators, but these usually aren't necessary in Amateur applications and are therefore beyond the scope of this month's column. For those interested, I'd recommend references 23 and 24 for some wideband impedance-matching transformers.

antenna impedance matching

By now you're probably wondering why I haven't covered any information directly related to antennas. The subject of antenna matching has been addressed many times in the literature. References 13 and 26 describe not only recommended techniques but also typical test equipment.

Basically, matching an antenna is largely a matter of setting up a measurement system similar to the setup in **fig. 8**. Then the length, spacings, and diameters of the driven element and matching section are adjusted until an optimum impedance match is obtained. If you have any specific questions about antenna impedance-matching techniques, let me know and they can be covered in a future column.

summary

The subject of impedance-matching techniques has been widely addressed in Amateur literature. New techniques — some simple, some complex — are constantly being presented. The material presented in this month's column reflects a summary of some of the information that should be most useful for Amateurs, especially those interested in the VHF/UHF/SHF frequencies. I hope I've described some new or interesting technique that will be of help to newcomers and oldtimers alike.

acknowledgments

I'd like to particularly thank Dick Turrin, W2IMU, for deriving the formulas necessary for me to calculate mismatch loss, and for providing appropriate references.

new records

Just as I completed this column, an important milestone in radio propagation occurred: the first two-way contact via sporadic E propagation on the 135-cm (220 MHz) Amateur band. As I've mentioned before, this has been a big plum, with at least two prior one-ways. (Yes, I was on one end of one of them!)

All that changed during the June ARRL VHF QSO Party, when sporadic E propagation was super on 6 and 2 meters in the southern portions of the United States. Finally, after a few unsuccessful attempts, on June 14, 1987, Bill Duval, K5UGM, of Irving, Texas (EM12MS) completed a two-way contact with John Moore, W5HUQ/4, of Orange Park, Florida (EM90GC), on 220.1 MHz — for a record 932 miles (1499 km). Both CW and SSB were used, and signals were much greater than S9. Congratulations to Bill and John. Another Amateur Radio propagation first! Now that it's been done, let's see how long it takes to do it again!

During this same contest, apparent double-hop sporadic E contacts took place on 2 meters. However, some of them that have been reported to me so far either were short of the present North American record (1891 miles or 3043 km) or were incomplete contacts. I would particularly like to hear from anyone who can better the existing record.

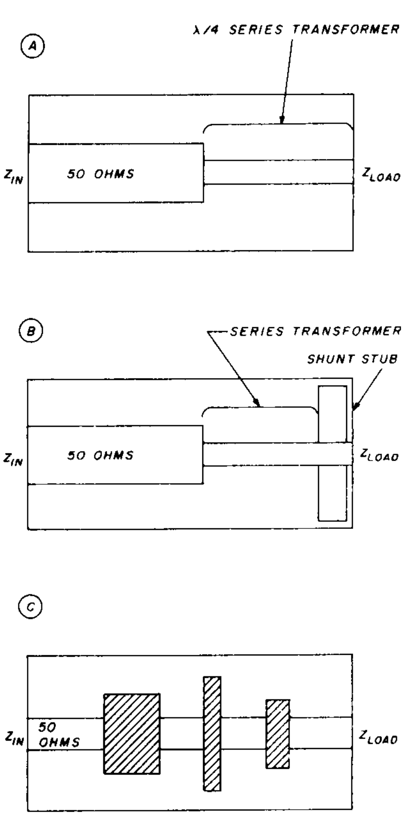

fig. 10. Examples of typical microstrip matching techniques: (A) series quarter-wavelength transformer; (B) series and shunt stubs; (C) empirical matching tuner.

important VHF/UHF events:

October 3-4	*International Region 1 UHF/SHF Contest, 70 cm and up*
October 4	*EME perigee*
October 9	*Predicted peak of the Draconids meteor shower at 0900 UTC*
October 10-11	*Mid-Atlantic States VHF Conference Warminster, Pennsylvania (Contact WA2OMY)*
October 17-18	*ARRL EME Contest, first weekend*
October 21	*Predicted peak of the Orionids meteor shower at 0830 UTC*
October 30	*EME perigee*
November 3	*Predicted peak of the Taurids meteor shower at 2200 UTC*
November 3	*Predicted peak of the Cassiopids meteor shower at 2100 UTC*

November 14-15 *ARRL EME Contest, second weekend*
November 17 *Predicted peak of the Leonids meteor shower at 1500 UTC*
November 24 *EME perigee*

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ham radio

return of the
360-degree propagation prediction

Improved coding combines 24-hour MUF and point-to-point programs

My February, 1987, article, "360-degree MINIMUF Propagation Prediction"[1] described a computer program for producing a 360-degree propagation prediction for any stated hour of the day. That article generated considerable interest in the program; unfortunately, there was a fault in the program for locations other than North Carolina, and that fault brought lots of mail from those interested in using the program but mystified as to why it would crash at the 180-degree computation of their latitude/longitude.

Several Alaskan hams, particularly AL7HU, discovered a problem in the computation of the longitude at zero bearing in that northern latitude, and others (WA1WPJ, VK1BGG, and Glenn Skaggs of the Naval Research Laboratories in Washington, DC) explained an apparent anomaly at certain MUF computations in southerly directions.

The main problem was the syntax error that occurs when you try to compute the latitude and longitude at the 180-degree bearing. I knew that the equations don't permit computations along the line of equal longitude, and therefore included an IF statement to make the 180-degree bearing "your home longitude + .1". That statement was useless. Interestingly enough, however, the problem doesn't occur for all latitude/longitude computations. The quick fix was to insert two additional lines:

105 IF H = 180 THEN H = 182
106 IF H = 192 THEN H = 190

While that addition made the program work, the cause of the problem was still in question.

I added a temporary line to the program asking for the printout of the "Y" computation of **line 180** (see **table 1** of the original article). The test was done using the latitude/longitude for Lodi, California, the QTH of WA6FKM, one of several readers having trouble with the program.

As the bearing approaches 180 degrees, the computation for Y approaches 1. At 180 degrees the value of Y is 1.00000599. The next line, **190**, computes the longitude and has a term using 1-Y*Y. When Y is greater than 1, a negative term results and the computer can't take the square root of a negative number, so that produces the syntax error. A better way of handling the problem is to delete **lines 105** and **106** and insert the following statement instead.

185 IF ABS(Y) => 1-1E-9 THEN Y = .999999

This will *always* work! If **line 185** is added, then **lines 105**, **106**, and **205** through **207** may be omitted.

The problem occurring at the high latitudes is that the zero-bearing 4000-km distance from Anchorage, Alaska, for example, is over the North Pole and down on the other side of the world. An IF statement at **line 200** says:

IF H = 0 THEN PRINT # . . . "HOME LONG. + .1"

Thus, the actual distance by a calculator is 2161 km. When I eliminated the **HOME LONG. + .1** statement and let the computer do its own thing, I discovered that it computed and printed the correct answer. So **lines 199** through **201** should be deleted.

The anomaly of the lower MUFs at certain southern bearings was explained by the fact that the MINIMUF program goes into a two-hop mode at ranges slightly greater than 4000 km. In my program

By **Henry Elwell, N4UH,** Route 2, Box 20G, Cleveland, North Carolina 27013

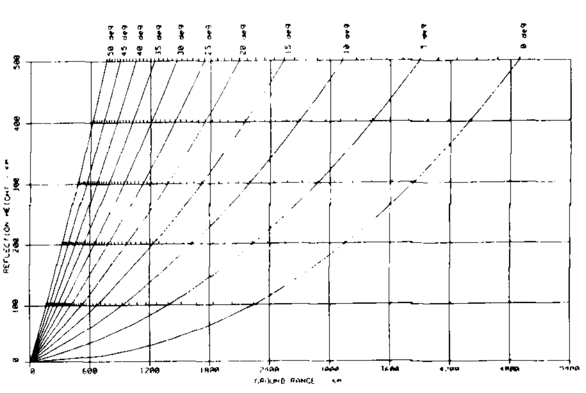

fig. 1. One-hop takeoff angle versus range and height.

it's attributable to a lack of precision (only one decimal point) in the results of the latitude/longitude program generation of the 4000-km periphery. Also, the 4000-km periphery for the first hop isn't practical for all stations because it's based on a vertical propagation angle of about 5 degrees or less. It's very practical for those with antennas producing such low angles of vertical radiation.

However, the average ham with, say, a tribander at 60 feet, has a takeoff angle of about 12 degrees on 20 mete's. Thus a first-hop distance would be no more than 3000 km, depending upon the reflection height of the ionosphere. **Figure 1** shows the relation of one-hop takeoff angles vs. range and ionosphere height. Using the 3000-km first-hop great circle periphery requires substituting the following lines for **lines 110** and **180**:

110 L2 = .0022617638*cos(L1*.01745) *cos(H*.01745) + (-.9999974422)*sin(L1*.01745)
180 Y = (-.9999974422)-(sinL1*.01745* [same as original to its end]

Any other distance may be used and the sin and cos values of D/60 substituted, but remember that D is in nautical miles and is found from kilometers by dividing the km by 1.852. Of course, if you want to reach way out, leave the 4000-km computation as is.

combining programs

In my original article I said that it should be easy to combine the point-to-point prediction with the 360-degree prediction because both methods employ the basic MINIMUF program. Because I'd found that at times I wanted to know the 24-hour prediction from North Carolina to somewhere else while I was still in the 360-degree program, I went ahead and combined the two.

One of the first steps was to combine the latitude/longitude program with the main program; with only 10 to 11 lines required, it was an obvious thing to do. I often felt the need to use a different transmitter location than the one built into the program as DATA, and it was a nuisance to write it in for different locations all the time.

The new program permits the user to select any first-hop distance. The program then sets up a latitude array and a longitude array, both of which are tied in with the bearing (heading). It's interesting to see how the MUF retreats as you decrease the length of the first hop to less than 4000 km. You can see how a range of 900 km, for example, would restrict you to the 40-meter band or lower if there were no other layers, because the F2 layer doesn't support higher frequency transmissions for those distances under all circumstances. *Note that the MINIMUF program is based only on the F2 layer.*

This would be a good place to mention some of the factors upon which the MINIMUF program is based, as detailed in the technical report (TR-186) referenced by K6GKU in his article in *QST*,[2] which Glenn Skaggs duplicated and sent to me.

The MUF is principally controlled by the critical frequency of the F2 layer of the ionosphere. The critical frequency is that frequency which will be reflected from the ionosphere when a signal is transmitted vertically. Unlike propagation from the E and F1 layers, which can be modeled as a function of the angle of the sun from the zenith, F2 propagation prediction is more complex. The F2 layer has diurnal (day/night), seasonal, and geographical variations. It also has so-called anomalies: the MUF can be higher in midday in winter than in summer, although in the Northern Hemisphere the summer sun is further north and suggests higher ionization; also, the MUF can peak in the late afternoon rather than at midday on certain days.

Figure 2 shows the E-layer 2000-km MUF in megacycles for a particular day. The horizontal scale is local time, and the vertical scale is latitude. Note that for your latitude, the MUF starts out very low, peaks at noontime, and decreases as the day continues. Thus, you can predict E-layer MUF by the angle of the sun from its zenith. TR-186 says let's start from there, using the zenith angle as a forcing function to "drive" a semi-empirical model; we'll use a single-lag linear system such as an RC circuit as the model. Allowing the lag time constant to be long (about ten hours in the summer) and short (one hour in winter) at middle and equatorial latitudes, one could then at least partially reproduce both the seasonal and diurnal anomalies. The lag time constant during the day is a function of the midday solar zenith angle. The time constant at night is two hours, regardless of season or geographical location.

All this adds up to an equation which the authors of the article called the ionosphere as foF2:

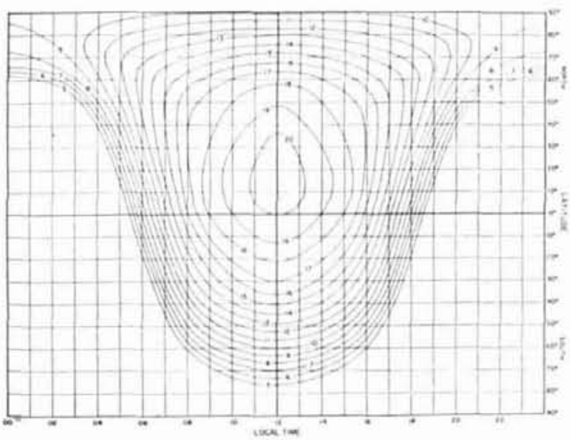

fig. 2. E-layer, 2000 MUF (predicted for June, 1947).

$$f_oF2 = \left[(1 + R/R_o)\sqrt{A_o + A_1(\sqrt{cosX_{eff}})} \right]$$

where: R = sunspot number, $cosX_{eff}$ is the cos of the effective solar zenith angle, and Ro, Ao and A1 are constants independent of geographic location and time.

Of course the technical report includes pages of equations for calculating those seemingly simple symbols which consider sunsets, sunrise, relaxation time, daytime duration, calculations of local noon, sunrise and sunset times, and the noon value of the solar zenith angle. Then we have to compute control points and two-hop paths if a 4000-km distance is exceeded. There's an M-factor that considers the ionosphere height of 290 km (which must change from winter to summer) and includes a factor for transequatorial paths, which increases MUF, a factor regarding increases in F2 layer heights observed at high northern latitudes during the summer, and others.

I chose MINIMUF 3.5 for the 360-degree propagation prediction because compared with advanced programs of its kind, it's very simple. I recommend that those who have more advanced prediction programs substitute them for MICROMUF 3.5. The subroutine for the MICROMUF program goes from **line 1140** to **2060**. When I first considered doing this revision, I thought a complete renumbering of the program would be neater and more desirable; however, recalling previous efforts, I decided to leave the numbering as it appeared in the orginal article for the benefit of others who may want to update their copies of the program.

I've eliminated a lot of unnecessary material in the new program. It starts out with a menu that asks whether you want a 360-degree or a point-to-point pre-

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HOUR=10Z DAY=6 MONTH=JUN SF= 74
35.75 DEG 80.75 DEG 1ST HOP= 4000 KM

BEARING	MUF	BEARING	MUF
0	14.9	180	11.1
10	15.4	190	11.1
20	15.5	200	11.2
30	15.6	210	11.3
40	15.2	220	11.5
50*	14.7	230	11.7
60	17.7	240	11.9
70	17.0	250	12.1
80	16.3	260	12.3
90	15.6	270	12.6
100	14.9	280	12.8
110	14.3	290	13.2
120	13.7	300	13.7
130	13.1	310	11.5
140	12.5	320	12
150	11.9	330	13
160	11.2	340	14.5
170	11.1	350	14.5

PRESS P PRINT:Q QUIT:T TRY AGAIN

*Note: the approximate 50-degree 1000 UTC MUF is slightly higher as a one-hop prediction than the 1000 UTC MUF to England because of the greater number of hops needed.

DATE:DAY 6 MONTH JUN
TRANSMITTER LOCATION:
LATITUDE 35.75 LONGITUDE 80.75
RECEIVER LOCATION:
LATITUDE 52 LONGITUDE 1
DISTANCE = 6298 KM
SUNSPOT NUMBER = 13

HOUR	MUF	HOUR	MUF
0	15.5	12	16.1
1	14.4	13	16.8
2	13	14	17.5
3	11.8	15	18
4	11.7	16	18.4
5	11.7	17	18.7
6	11.1	18	18.5
7	11	19	18.3
8	11	20	18
9	12.7	21	17.6
10*	14	22	17.1
11	15.1	23	16.4

PRESS P PRINT: Q QUIT: T TRY AGAIN

fig. 3. Compare (A), the 360-degree propagation values, to (B), the predicted point-to-point conditions to England over the same period of time as shown in (A).

diction. It also displays a note stating that MUFs will be lower if the WWV K-factor is greater than 1. Most predictions, including MINIMUF, ignore the geomagnetic field activity (K>1).

If you select a 360-degree prediction, you're asked whether you want your home coordinates. If so, you get them — provided, of course, that you've put them into **line 41**; mine are there now. If you want some other QTH, you're asked for that latitude and longitude; this is a good feature because you may want to see what's happening somewhere else or give information to a friend. Of course, you're also asked for the month, day, solar flux number, and the hour.

Once these decisions are made, the latitude/longitude computation takes place and is stored in memory to be used if you want to make other runs. It takes about 30 seconds for the computer to set up the information, but the screen tells you to wait. The screen also tells you to turn up the volume control of the monitor so you can be alerted by an automatic tone when the prediction is completed. You may then exit the program, run it again, or select a printout. If you want a prediction for another QTH, you must exit and start the program again so the new coordinates can be computed.

If you select the point-to-point prediction mode, you have similar decisions to make and enter into the computer as it requests them. There's also a tone to indicate completion of the prediction, but no notice of it beforehand, as in the 360-degree prediction.

In projects such as this, you reach the point at which you have to say "Enough!" and leave further development up to users; such is the case of a polar coordinate display, which is much more realistic than the same data presented in tabular form. WA1WPJ has devised a nice polar display for the C-128 and has offered to correspond with others who'd like more information; I appreciate his willingness to share his talents.

Figure 3 shows a comparison of the two printouts. The point-to-point prediction is from North Carolina to England, which has a bearing of approximately 50 degrees. Compare the two printouts for a time of 10Z, the time used for the 360-degree prediction, and you'll see that the one-hop MUF of the 360-degree prediction is 14.7 MHz, while the point-to-point prediction is 14 MHz. This difference is attributable to the fact that a two-hop mode is being used in the prediction, which lowers the MUF slightly when distances greater than 4000 km are used.

For those who wish to substitute another prediction in place of the MINIMUF 3.5 **lines 1140** to **2060**, an entrance and exit line has been inserted to change the transmitter latitude/longitude to radians and then back to degrees to facilitate printing degrees on the screen. There's also a short subroutine (**lines 2640** to

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- **160-10m/General Coverage Receiver**
- **Passband Tuning plus IF Shift**
- **QSK up to 60 WPM**

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fig. 4. N4UH program provides MINIMUF 3.5 propagation predictions for any hour and point-to-point predictions for 24-hour periods.

```
1 REM THIS PROGRAM PROVIDES A MINIMUF PROPAGATION PREDICTION FOR 360 DEGREES
2 REM FOR A SPECIFIED TIME FROM 0 TO 23 HOURS GMT AS WELL AS A PT-TO-PT PRED.
4 REM IT HAS BEEN MODIFIED BY HENRY ELWELL N4UH TO DO THAT FROM AN EARLIER
5 REM PROGRAM BY ALAN MEMLEY, KE6UY
6 REM THE REVISED PROGRAM IS DATED 20 MAY 1987
10 PRINT CHR$(147)
11 A$=CHR$(17):REM CURSOR DOWN
12 B$=CHR$(18):REM REVERSE ON
13 C$=CHR$(19):REM HOME
14 D$=CHR$(29):REM CURSOR RIGHT
15 E$=CHR$(145):REM CURSOR UP
16 F$=CHR$(147):PRINTF$:REM CLEAR/HOME
17 G$=CHR$(158):PRINTG$:REM CONTROL-YELLOW
18 H$="****************************************"
19 QC=0:QD=0:OG=0:G=0:REM SEE LINE 4000 FOR EXPLANATION
20 DIMM$(37),A$(4),M(12),H(40),L2(360).W2(360)
21 DATA31,28,31,30,31,30,31,31,30,31,30,31
22 FORX=1TO12:READM(X):NEXT
23 M$="JANFEBMARAPRMAYJUNJULAUGSEPOCTNOVDEC"
24 PRINTA$A$H$
25 PRINT"*  THIS PROGRAM USES MINIMUF 3.5 FOR   *"
26 PRINT"*  TWO PROPAGATION PREDICTIONS:         *"
27 PRINT"*      1.FOR 360 DEGREES ANY GIVEN HOUR *"
28 PRINT"*      2.FOR POINT-TO-POINT FOR 24 HOURS*"
29 PRINT"* SELECT EITHER MODE BY PRESSING 1 OR 2*"
30 PRINTA$H$A$A$"NOTE:MUF WILL BE LOWER AS WWV K INDEX EXCEEDS 1"
31 GETI$:IF I$="" THEN 31
32 IF I$="2" THEN QC=1:GOTO35
33 IF I$="1" THEN GOTO35
34 GOTO 31
35 :
36 PRINTA$A$"USE HOME LAT/LONG (Y/N)?":I$
37 GETI$:IF I$ = "" THEN 37
38 IF I$<> "Y" THEN GOTO50
40 QD = 1 :REM USING HOME LAT/LONG
41 L1= 35.75: W1 = 80.75
50 :
200 POKE 53280.14
210 POKE 53281.6
230 PRINT F$
285 PI = 3.14159265
290 R0=PI/180
300 P1=2*PI
310 R1=180/PI
320 P0=PI/2
330 PRINT F$
337 IF QD = 1 THEN 343
340 PRINTA$:INPUT"WHAT IS THE TX LATITUDE":L1
342 PRINTA$:INPUT"WHAT IS THE TX LONGITUDE":W1
343 PRINT:INPUT"DATE (DAY,MONTH):":D6,MO
344 IFMO<=12THEN370
350 PRINT "INVALID MONTH. MUST BE IN RANGE 1-12"
360 GOTO343
370 IFM(MO)-D6<0THEN390
375 J$=MID$(M$.3*MO-2.3):REM PROVIDES A 3-LETTER ABBREVIATION FOR MONTH
380 GOTO410
390 PRINT "INVALID DAY"
400 GOTO343
410 PRINT:INPUT"SOLAR FLUX NUMBER:":SF
420 IFSF<70THENPRINT"DO NOT USE SF < 70":GOTO410
425 IF QC=1 THEN GOTO600:REM QC USED FOR PT-TO-PT. PREDICTION
428 IFOG=1THEN GOTO450
430 PRINTA$:INPUT"GIVE DISTANCE TO 1ST HOP IN KM":K
440 NA=K/1.852: REM CONVERTS FROM KM TO NAUTICLA MILES
450 PRINT:INPUT"WHAT GMT DESIRED: 0-23 HOURS ONLY ":TG
460 IFTG>23THENPRINT"USE HOURS 0 TO 23 ONLY":GOTO450
470 IFOG=1 THEN GOTO540
480 PRINT:PRINT"TURN UP AUDIO GAIN TO HEAR END OF RUN     SIGNAL"
490 PRINT"THERE IS A 30 SECOND WAIT WHILE"
495 PRINT"COMPILING THE"K   "KM LAT/LONG INFO"
500 FOR H=0TO350 STEP 10
504 V=SIN((NA/60)*R0)*COS(L1*R0)*COS(H*R0)+COS((NA/60)*R0)*SIN(L1*R0)
508 L2=ATN(V/SQR(1-V*V))*57.2957795: REM LAT. OF DISTANT POINT
510 L2(H)=L2:REM ARRAY FOR 4000 KM LATITUDE CIRCUMFERENCE
512 O=(COS((NA/60)*R0)-(SIN(L1*R0)*SIN(L2(H)*R0)))/(COS(L1*R0)*COS(L2(H)*R0))
514 IF ABS(O)=>1-1E-9 THEN O = .999999
516 W2=(PI/2-ATN(O/SQR(1-O*O)))*57.296: REM S IS THE ARCOS CONVERSION TO DEGREES
518 IF H=<180 THENW2=-(W2-W1)
520 IF H> 180 THEN W2=W2+W1
522 W2(H)=W2:REM ARRAY FOR 4000 KM LONGITUDE CIRCUMFERENCE
524 NEXT H
540 S9=(SQR(.52998-.00356*(63.75-SF))-.728)/.00178
550 S9=INT(S9):REM SUNSPOT NUMBER
552 IF QC=1 THEN GOSUB2640
555 IFQC=1 THEN 700
560 FOR H=0 TO 350 STEP 10
570 IFG=1 GOTO950
580 PRINTF$:PRINT A$"HOUR="TG"Z DAY="D6"MONTH= "J$" SF="SF
```


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```
585 PRINTL1"DEG";W1"DEG";" 1ST HOP=";K"KM"
590 PRINTTAB(4)"BEARING";TAB(15)"MUF";TAB(21)"BEARING";TAB(33)"MUF"
595 GOTO 950
600 PRINTA$:INPUT"RECEIVER LAT, LONG";L2,W2
602 IF L<-90 THEN 608
604 IF L2>90 THEN 608
606 GOTO 614
608 PRINT"INVALID LATITUDE. MUST BE IN RANGE"
610 PRINT"OF -90 TO 90 DEGREES"
612 GOTO 600
614 IF W2 < -360 THEN 620
616 IF W2> 360 THEN 620
618 GOTO540
620 PRINT"INVALID LONGITUDE. MUST BE IN RANGE -360 TO 360"
622 GOTO 600
700 PRINTF$A$:"DATE:":"DAY"D6 ;"MONTH "J$
710 PRINT"  TRANSMITTER LOCATION:"
720 PRINTTAB(7)"LATITUDE";L1;TAB(22);"LONGITUDE";W1
730 PRINT"  RECEIVER LOCATION:"
740 PRINTTAB(7)"LATITUDE";L2;TAB(22);"LONGITUDE";W2
750 PRINT"  DISTANCE ="DX;"KM"
760 PRINT"  SUNSPOT NUMBER = ";S9
770 PRINT
780 PRINTTAB(4)"HOUR";TAB(11)"MUF";TAB(21)"HOUR";TAB(28)"MUF
945 IF QC=1 THEN GOTO 955
950 T5=TG:GOTO 970 :REM HOLDS TIME CONSTANT FOR 360' PREDICTION
955 FOR T5= 0 TO 24
960 IF T5>23 THENGOSUB3050:GOTO 2950
970 GOSUB1140
980 J9=J9*10
990 J9=INT(J9)
1000 J9=J9/10
1005 PRINTE$
1010 IFQC=1ANDT5=12THENE=12:FORI=1TOE:PRINTE$;:NEXTI:PRINTTAB(21)T5:TAB(27)J9:NE
XTT5
1015 IFQC=1 AND T5> 12 THEN PRINT TAB(21)T5:TAB(27) J9:NEXT T5
1020 PRINTE$:IFQC=1 THEN PRINTTAB(4)T5;TAB(10)J9:NEXT T5
1021 IFH=180THENE=18:FORI=1TOE:PRINTE$;:NEXTI:PRINTTAB(22)H;TAB(32)J9:NEXTH
1022 IFH>180THENPRINT TAB(22)H;TAB(32)J9:NEXT H
1023 IFH=360 THENGOTO1040
1030 PRINT   TAB(4)H;TAB(13)J9
1040 IFH=360THEN GOSUB3050:PRINTB$"PRESS P-PRINT:Q-QUIT:T-TRY AGAIN":GOTO3000
1041 NEXT H
1049 IF QC=1 THENPRINTE$E$:PRINTTAB(21)T5;TAB(27)J9:GOTO1060
1050 PRINTE$E$:PRINTTAB(21)H;TAB(27)J9
1060 :
1065 NEXT H
1140 REM MINIMUF 3.5
1141 L1=L1*RO:W1=W1*RO
1145 IFQC=1THEN K7=SIN(L1)*SIN(L2*RO)+COS(L1)*COS(L2*RO)*COS(W2*RO-W1):GOTO1160
1150 K7=SIN(L1)*SIN(L2(H)*RO)+COS(L1)*COS(L2(H)*RO)*COS(W2(H)*RO-W1)
1160 IFK7=>-1THEN1190[redacted]"
1170 K7=-1
1180 GOTO1210
1190 IFK7<=1THEN1210
1200 K7=1
1210 G1=-ATN(K7/SQR(-K7*K7+1))+PI/2
1220 K6=1.59*G1
1230 IFK6>=1THEN1250
1240 K6=1
1250 K5=1/K6
1260 J9=100
1270 FORK1=1/(2*K6)TO1-1/(2*K6)STEP0.9999-1/K6
1280 IFK5=1THEN1295
1290 K5=0.5
1295 IF QC=1 THEN P=SIN(L2*RO):GOTO1305
1300 P=SIN(L2(H)*RO)
1305 IF QC=1 THEN Q=COS(L2*RO):GOTO1320
1310 Q=COS(L2(H)*RO)
1320 A=(SIN(L1)-P*COS(G1))/(Q*SIN(G1))
1330 B=G1*K1
1340 C=P*COS(B)+Q*SIN(B)*A
1350 D=(COS(B)-C*P)/(Q*SQR(1-C^2))
1360 IFD>=-1THEN1390
1370 D=-1
1380 GOTO1410
1390 IFD<=1THEN1410
1400 D=1
1410 D=-ATN(D/SQR(-D*D+1))+PI/2
1415 IF QC=1THEN WO=W2*RO+SGN(SIN(W1-W2*RO))*D:GOTO1430
1420 WO=W2(H)*RO+SGN(SIN(W1-W2(H)*RO))*D
1430 IFWO=>0THEN1450
1440 WO=WO+P1
1450 IFWO<P1THEN1470
1460 WO=WO-P1
1470 IFC=>-1THEN1500
1480 C=-1
1490 GOTO1520
1500 IFC<=1THEN1520
1510 C=1
1520 LO=PO-(-ATN(C/SQR(-C*C+1))+PI/2)
1530 Y1=0.0172*(10+(MO-1)*30.4+D6)
1540 Y2=0.409*COS(Y1)
```

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```
1550 K8=3.82*W0+12+0.13*(SIN(Y1)+1.2*SIN(2*Y1))
1560 K8=K8-12*(1+SGN(K8-24))*SGN(ABS(K8-24))
1570 IFCOS(L0+Y2)>-0.26THEN1660
1580 K9=0
1590 G0=0
1600 M9=2.5*G1*K5
1610 IFM9<=P0THEN1630
1620 M9=P0
1630 M9=SIN(M9)
1640 M9=1+2.5*M9*SQR(M9)
1650 GOTO1910
1660 K9=(-0.26+SIN(Y2)*SIN(L0))/(COS(Y2)*COS(L0)+1.0E-3)
1670 K9=12-ATN(K9/SQR(ABS(1-K9*K9)))*7.639437
1680 T=K8-K9/2+12*(1-SGN(K8-K9/2))*SGN(ABS(K8-K9/2))
1690 T4=K8+K9/2-12*(1+SGN(K8+K9/2-24))*SGN(ABS(K8+K9/2-24))
1700 C0=ABS(COS(L0+Y2))
1710 T9=9.7*C0^9.6
1720 IFT9>0.1THEN1740
1730 T9=0.1
1740 M9=2.5*G1*K5
1750 IFM9<=P0THEN1770
1760 M9=P0
1770 M9=SIN(M9)
1780 M9=1+2.5*M9*SQR(M9)
1790 IFT4<TTHEN1820
1800 IF(T5-T)*(T4-T5)>0THEN1830
1810 GOTO1960
1820 IF(T5-T4)*(T-T5)>0THEN1960
1830 T6=T5+12*(1+SGN(T-T5))*SGN(ABS(T-T5))
1840 G9=PI*(T6-T)/K9
1850 G8=PI*T9/K9
1860 U=(T-T6)/T9
1870 G0=C0*(SIN(G9)+G8*(EXP(U)-COS(G9)))/(1+G8*G8)
1880 G7=C0*(G8*(EXP(-K9/T9)+1))*EXP((K9-24)/2)/(1+G8*G8)
1890 IFG0=>G7THEN1910
1900 G0=G7
1910 G2=(1+S9/250)*M9*SQR(6+58*SQR(G0))
1920 G2=G2*(1-0.1*EXP((K9-24)/3))
1930 G2=G2*(1+(1-SGN(L1)*SGN(L2))*0.1)
1940 G2=G2*(1-0.1*(1+SGN(ABS(SIN(L0))-COS(L0))))
1950 GOTO2020
1960 T6=T5+12*(1+SGN(T4-T5))*SGN(ABS(T4-T5))
1970 G8=PI*T9/K9
1980 U=(T4-T6)/2
1990 U1=-K9/T9
2000 G0=C0*(G8*(EXP(U1)+1))*EXP(U)/(1+G8*G8)
2010 GOTO1910
2020 IFG2>J9THEN2040
2030 J9=G2
2040 NEXTK1
2050 J9=.93*J9
2060 G=1:L1=L1*R1:W1=W1*R1:RETURN
2640 DY=SIN(L1*R0)*SIN(L2*R0)+COS(L1*R0)*COS(L2*R0)*COS(W1*R0-W2*R0)
2650 DX=60*(P0-ATN(DY/SQR(1-DY*DY)))*57.296:REM DISTANCE IN NAUTICAL MILES
2670 DX=DX*1.852:REM CONVERTS FROM NAUTICAL MILES TO KM
2680 DX=INT(DX):RETURN
2950 PRINTB$A$"PRESS P-PRINT:Q-QUIT:T-TRY AGAIN
3000 GETAN$:IFAN$=""THEN3000
3010 IFAN$="P"GOTO3200
3020 IFAN$="Q"THENPRINTF$A$A$D$D$D$"ENJOY YOUR RADIO!":END
3030 IFAN$="T"THEN PRINTF$:OG=1:G=0:GOTO343
3035 GOTO3000
3050 : REM TONE TO TELL WHEN SCREEN PRINT COMPLETE
3052 FOR AC=54272TO54296:POKEAC,0:NEXT
3054 POKE54296,15
3056 POKE54277,0
3058 POKE 54278,248
3060 POKE54273,35:POKE54272,134
3062 POKE54276,17
3064 FORT=1 TO 1000 :NEXT
3066 POKE54276,16:RETURN
3199 REM SCREEN DUMP
3200 OPEN3,3:OPEN4,4:PRINTC$:FORI=1TO1000:GET#3,A$:PRINT#4,A$;:NEXT:CLOSE3
3210 CLOSE4
3220 END
4000 REM QC= FLAG TO SELECT PREDICTION OPTION 2
4001 REM QD= FLAG SELECTS HOME LAT/LONG OF LINE 41
4002 REM OG= FLAG TO SKIP 1ST HOP COORDINATES FOR THE "TRY AGAIN"
4003 REM G= FLAG SKIPS REPRINTING 360 DEGREE TABLE TITLE
60000 OPEN15,8,15,"S0:360/PTP MUF":CLOSE15:SAVE"0:360/PTP MUF",8

READY.
```

2680) for computing the distance between the transmitter and receiver for the point-to-point prediction. That distance, used only for information to the screen, replaces several lines in the original program which had not been used.

The equation for S9, the sunspot number in **line 540**, has been changed in response to a suggestion from Glenn Skaggs. The original equation produces sunspot numbers slightly low at low flux numbers and slightly high at high flux numbers. The new equation gives a closer fit when converting flux to sunspot number.

The original article generated letters asking if I would copy the program to readers' disks. If you'll send me a disk with return postage (or a dollar bill if that's easier), I'll copy the program shown in **fig. 4** to your disk and return it.

acknowledgments

Besides those already mentioned herein, I want to thank Bob Brown, NA7M, for educating me about the more advanced programs he enjoys.

references

1. Henry G. Elwell, Jr., N4UH, "360-degree MINIMUF Propagation Prediction," *ham radio*, February, 1987, page 25.
2. Robert B. Rose, K6GKU, "MINIMUF: A Simplified MUF-prediction Program for Microcomputers," *QST*, December, 1982, page 36.

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PRACTICALLY SPEAKING ... Joe Carr K4IPV

try an oscilloscope for troubleshooting dc power supplies

It is something of a truism that the first place to look for trouble in a piece of malfunctioning electronic equipment is the dc power supply. Almost everyone who keeps records of equipment failure will report that a large percentage of repair actions involve the low-voltage dc power supply. This problem is so commonplace, and such a logistics cost driver, that the United States Navy now has a power supply standard that, among other things, limits the maximum junction temperature of semiconductor devices to 110 degrees C, and also limits the power-per-unit-of-volume (watts/cubic inch).

The typical low-voltage dc power supply will have a transformer to step down the 120-VAC line voltage to some lower voltage. The exact value of the transformer secondary voltage, of course, depends upon the dc output potential of the supply. The output of the transformer will be a sine wave or near-sine wave (**fig. 1A**). The transformer voltage ratings sometimes yield some confusing results for the troubleshooter. For example, let's consider the standard 12.6-VAC transformer (**fig. 1B**). The rated voltage of a transformer is the RMS potential across the entire secondary, unless otherwise specified.

If you use a reasonably good quality ac voltmeter, the reading will be 12.6-VAC across points A-B — right?

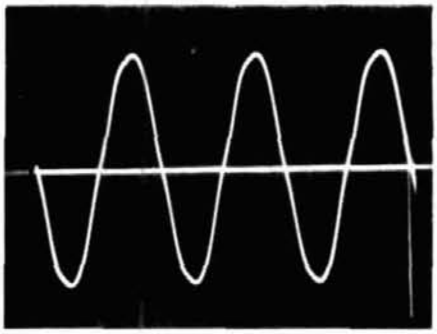

fig. 1A. Output of a typical low-voltage dc power supply transformer is a sine wave or near-sine wave.

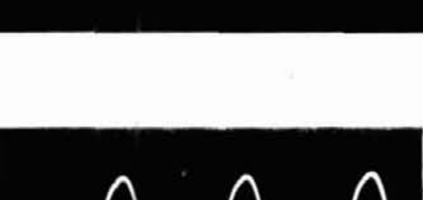

fig. 1B. Standard 12.6-VAC center-tapped transformer.

Not necessarily! First, it should go without saying that the input voltage will vary somewhat, and that in turn reflects variation in the secondary voltage. Measurements I made in preparation of this article showed a line voltage of 123-VAC RMS at my QTH, while at other times it has been as low as 102-VAC RMS.

Second, the rated voltage of a transformer assumes a minimum load current being drawn. If you measure a transformer with no load, you can expect a higher voltage than the rated potential. Some transformers are worse than others in this respect, but all will demonstrate this phenomenon to some extent. The problem lies in the internal resistance of the secondary windings. I've seen a 12.6-VAC @20-ampere transformer show a 22-VAC "RMS" on a digital ac voltmeter of good quality until a 500-mA load was placed across the secondary. The load reduced the secondary potential to 12.6-VAC RMS ± line fluctuation.

If the transformer is center-tapped, as in **fig. 1B**, then the rating of the secondary must be scrutinized to determine the actual voltage. For example, "12.6 VAC C.T." means that 12.6 VAC appears across A-B, while the potential readings from CT to A and CT to B will be 6.3-VAC RMS each.

Another point of confusion is found when measuring the voltage across the transformer secondary with an oscilloscope. Most ac meters are RMS-reading devices (or nearly so) for sine waves, unless they're specifically designed for peak-to-peak or peak-reading applications. But the oscilloscope is inherently a peak-to-peak reading instrument. In **fig. 1A**, the horizontal line denotes the zero-volts baseline, while the positive excursions are above the line and negative excursions are below the line (following the standard convention). The peak voltage is the potential between the zero baseline and either peak, while the

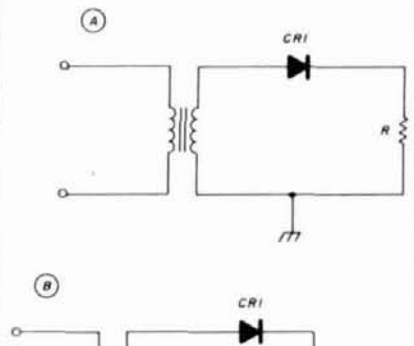

fig. 2. Forms of rectifiers: (A) half-wave; (B) conventional full-wave; (C) full-wave bridge.

peak-to-peak voltage is the reading between a negative peak and the adjacent positive peak. The peak voltage *is 1.414 times RMS voltage, while the* peak-to-peak voltage is 2.83 times the RMS voltage. On the oscilloscope and meter readings, we need to divide the *peak-to-peak reading obtained on the* oscilloscope by 2.83. Similarly, multiplying the RMS reading on the meter by 2.83 gives us the approximate peak-to-peak voltage to expect on the oscilloscope screen.

Because the ac voltage provided by the transformer is useless for most electronic circuits, we provide a rectifier to convert bipolar ac to unipolar pulsating dc. **Figure 2** shows the various forms of rectifiers, while **figs. 3A** and **3B** show the waveforms that the scope will show when connected across load resistor R. The device in **fig. 2A** is the half-wave rectifier, and it produces the waveform shown in **fig. 3A**. Note that only the positive half of the applied ac sine wave is applied, which causes a certain amount of inefficiency in this form of power supply. The other two rectifiers are both full-wave types, and they produce the waveform shown in **fig. 3B**. The rectifier shown in **fig. 2B** is a conventional full-wave rectifier, and depends upon the center-tap of the transformer secondary winding in order *to provide a ground reference.*

The rectifier in **fig. 2C** is a full-wave bridge. It does not require a center-tapped transformer, but instead uses *a node of the bridge to provide the* ground reference. This article is based on the bridge rectifier, by far the most commonly used rectifier in modern *equipment.* **Fig. 4** *shows the circuit of* the dc power supply that was used in making the measurements and waveform photographs. The transformer *was an* 8.5-VAC *@1-ampere transformer*, while the rectifiers (CR1-CR4) were 1N400x-series devices.

Figures 5A and **5B** show the *normal waveform* expected when the oscilloscope probe is applied to points A and B in **fig. 4**. Each waveform is half-wave rectified, but each is 180 degrees out of phase with the other. This phasing reflects the fact that the bridge rectifier is full-wave, and therefore uses the entire 360 degrees of the input ac waveform. Even with a single-trace oscilloscope, you can tell that the circuit

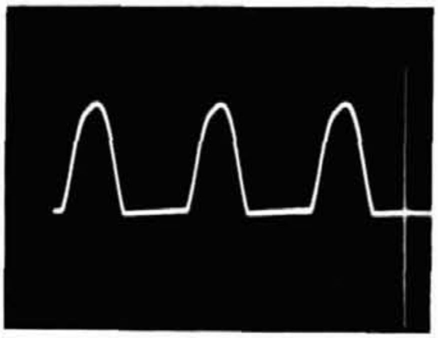

fig. 3A. Waveform produced by half-wave rectifiers.

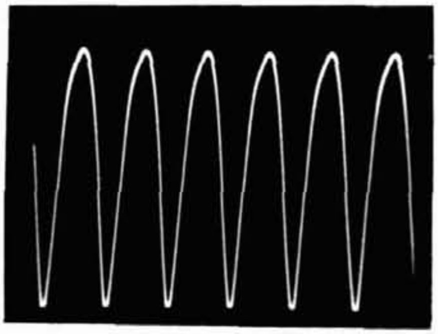

fig. 3B. Waveform produced by full-wave rectifiers.

is working correctly by the half-wave trace. **Figure 5B**, on the other hand, shows an anomaly. I once saw this waveform in a piece of equipment in which the printed circuit trace from the + terminal of the bridge rectifier was cracked, and that effectively removed the load from the rectifier. If you see a sine wave or near-sine wave at the ac nodes of the bridge (points A and B in **fig. 4**,) you should suspect that the load is somehow disconnected.

The full-wave pulsating dc wave-

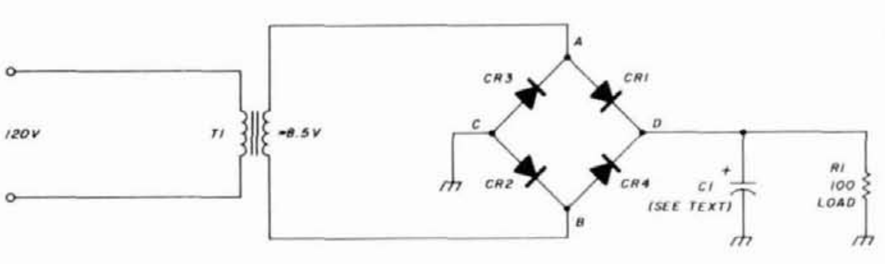

fig. 4. Circuit of low-voltage dc power supply used in making measurements and photographs for this article.

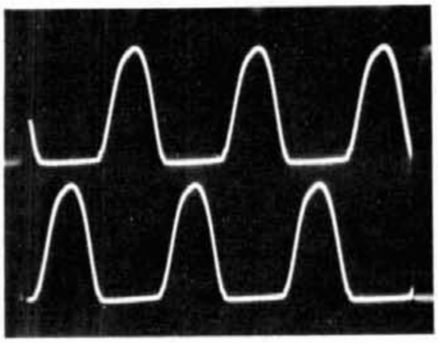

fig. 5A. Normal waveform generated when oscilloscope probe is applied to points A and B in fig. 4.

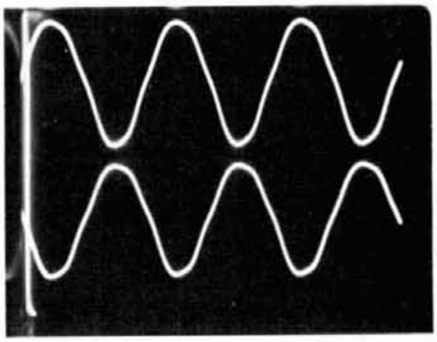

fig. 5B. Anomalous waveform indicates defective circuit.

form of **fig. 3B** is almost as useless for electronic equipment as ac, so circuit designers supply a filter capacitor such as C1 in **fig. 4. Figure 6** shows two cases of a filtered pulsating dc output from the low-voltage power supply of **fig. 4**. In both **figs. 6A** and **6B** the horizontal white line was placed at the zero-volts line in order to provide a frame of reference. The line was made by adjusting the position control for channel 2 of the oscilloscope, and keeping the input selector in the grounded position. The waveform of **fig. 6A** represents the case in which 500 μF of filter capacitance was used; in this situation, the digital voltmeter read 12.03 Vdc, while the measurements on the oscilloscope screen showed 10.8 volts between the zero-volts baseline and the bottom of the ripple waveform, and 12.4 volts to the peak of the ripple waveform (resulting in a ripple amplitude of 1.6 volts). In **fig. 6B**, the filter capacitor is increased to 2700 μF. The DVM read 12.01 Vdc,

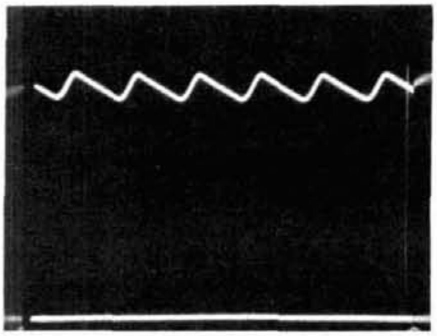

fig. 6A. Filtered pulsating dc output from the low-voltage power supply shown in fig. 4; 500 μF of filter capacitance results in ripple amplitude of 1.6 volts.

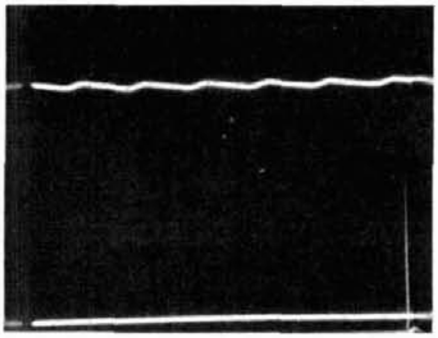

fig. 6B. With filter capacitance increased to 2700 μF, ripple amplitude drops to 0.25 volts.

while the oscilloscope showed 12.0 volts between zero and the bottom of the ripple waveform. The ripple amplitude in **fig. 6B** is 0.25 volts, or 15.6 percent of the case where 500 μF was used for the filter. Obviously, the greater the capacitance, the less the ripple. The general rule of thumb for the value of capacitance needed in a full-wave supply is:

$$C = \frac{1,000,000}{416 \cdot R_L \cdot RF}$$

where:

C is the capacitance in microfarads

R_L is the load resistance (Vo/Io)

RF is the required ripple factor

If the filter capacitor is open — a common fault — then you should expect to see the pulsating dc waveform of **fig. 3B** across the load resistor, instead of the distinctive waveforms of **fig. 6**. A certain amount of judgment and experience is needed, however, in the case where the filter capacitance is reduced significantly. This fault occurs occasionally in aluminum electrolytics, especially in equipment that has been unused for a while. Some service literature will show you the peak-to-peak readings to expect across the filters; in other cases, only experience or hunches will aid the troubleshooter.

Figures 7A and **7B** show a pair of ripple waveforms found in another situation. Both waveforms were made with the oscilloscope's vertical input ac-coupled because we are specifically looking at ripple, rather than at the ripple + dc component. The top waveform **(fig. 7A)** shows a filtered pulsating dc waveform in a normally operating dc power supply. In a full-wave rectified supply, the ripple frequency is twice the line frequency, or 120 Hz in the United States. But **fig.** 7B shows the same power supply with one leg of the bridge (CR4 of **fig. 4**) open-circuited. The ripple amplitude is up — a fact that could also be attributed to a weak filter capacitor — but the ripple frequency is one-half the expected frequency. On the oscilloscope timebase (horizontal) line, you'll find that the ripple waveform on a full-wave circuit will have a period of 1/120 Hz, or about 8.3 milliseconds. The half-wave rectified ripple waveform resulting when a diode is opened produced a period of 16.7 milliseconds on the oscilloscope.

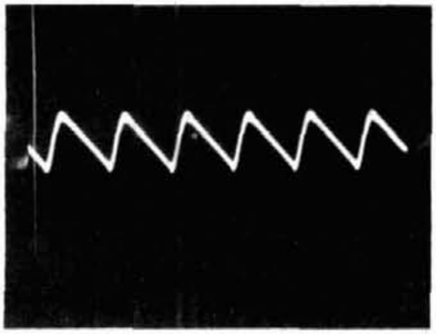

fig. 7A. Ripple waveform of filtered pulsating waveform in a dc power supply operating normally.

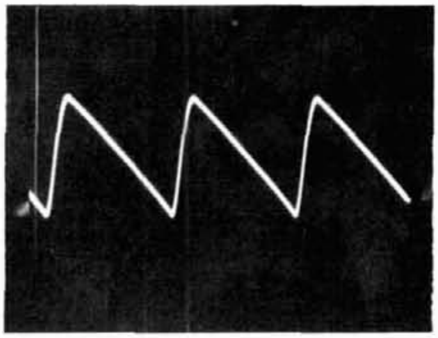

fig. 7B. Ripple waveform of power supply operating with one leg of the bridge open-circuited.

A lesson to be learned from this example is to examine not just the amplitude of the waveform, but also its period/frequency. Also, if its shape is wrong, then suspect a fault (again, examine the difference between **figs. 5A** and **5B**).

regulated power supplies

Most Amateur equipment uses voltage-regulated dc power supplies. This fact is due, in part, to the nature of modern solid-state circuits, which simply work better when the power supply is voltage regulated. It's also attributable in large part to the fact that IC voltage regulators are widely available today. In past times, because it was expensive to regulate supplies, many manufacturers used unregulated supplies. **Figure 8** shows a basic IC voltage regulator circuit based on the three-terminal IC regulator devices. In making the measurements for this article I used a 7805 device, which — for our purposes — is the same as the LM-309 and LM-340T-05 devices, all of which produce 5 volts output for TTL digital circuits. Similar devices are available in output voltages to 24 Vdc, both positive and negative.

One effect of the voltage regulator is to greatly reduce the ripple of the power supply. In fact, in 1964 a manufacturer of test equipment marketing a new regulated bench supply (then a rarity) bragged that it had the "equivalent of 1 Farad of filtering." The voltage regulator produced a reduction in ripple equivalent to what would be obtained with 1,000,000 μF of filter capacitance! This effect is shown in **fig. 9**. The upper trace, A, is taken at point "A" in **fig. 8**, and represents the

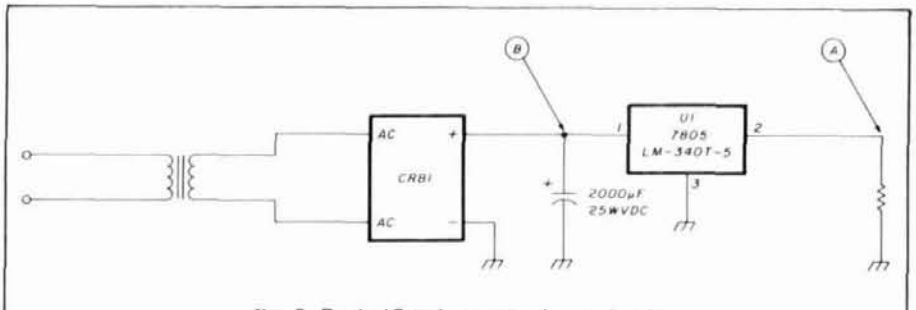

fig. 8. Basic IC voltage regulator circuit.

output waveform from the regulator. The bottom trace is the filtered pulsating dc at the input of the regulator device (point "B" in **fig. 8**). Both trace photos were taken with the oscilloscope's vertical attenuator set to 0.1 volts/cm. The bottom trace shows 160 mV of ripple, while the upper trace shows no discernible ripple. In fact, the oscilloscope showed no discernible ripple on all settings of the attenuator except at the 5-mV/cm (most sensitive) position. A defective regulator will show a high ripple on the output as well as an incorrect voltage.

WARNING: Defective regulators can produce a higher than normal voltage at the output of the supply! That potential can damage electronic circuits, so immediately turn off the equipment if this result is found. If the regulator is a simple IC type, then it can be replaced and the circuit inspected for damage.

I use a current-limited bench power supply to troubleshoot equipment of this sort. Disconnect the regulator, set the bench output voltage to the same potential the regulator is supposed to produce, set the current-limiting control to the rated value produced by the regulator, and then connect the bench supply across the equipment circuits. If the circuits are undamaged, they will function correctly. Next, place a load resistor across the output of the regulator (the equipment circuits are still disconnected). It should draw a current of 25 to 100 percent the normal load for that particular supply. Measure the output voltage and examine the waveform across the load resistor. If the regulator is operating correctly, you may reconnect the circuits to the replaced or repaired regulator.

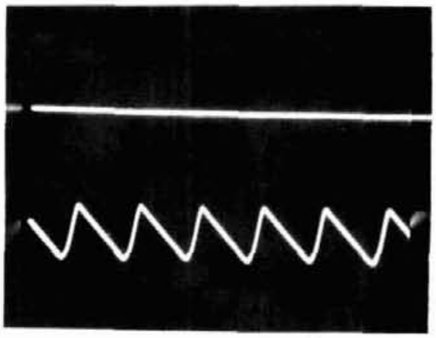

fig. 9. Voltage regulator greatly reduces ripple of power supply. Upper trace (A) was taken at point "A" in fig. 8; lower trace (B) is filtered pulsating dc at input of regulator (point "B" in fig. 8).

conclusion

Although professional servicers almost invariably prefer troubleshooting with oscilloscopes, many people still mistakenly believe that the dc voltmeter is the only instrument useful for troubleshooting dc supplies. In this article we've seen that the oscilloscope is also useful for this job — which strengthens my conviction that all technically inclined Amateurs ought to obtain good oscilloscopes for their workshops.

WARNING: *techniques presented in this article are for low-voltage dc power supplies only. Do not attempt to use them on a high-voltage supply unless a suitable high-voltage probe is provided. Otherwise, damage to the oscilloscope may result, and the high voltage present may also be dangerous to you.*

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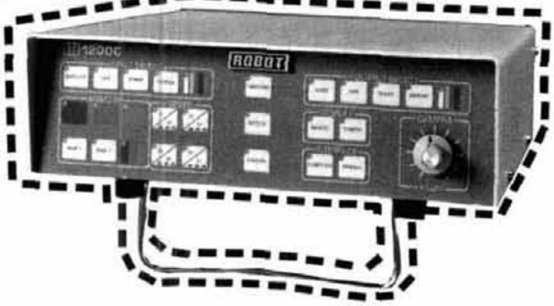

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While a number of different types of dc-to-dc converter circuits can be used, this article deals exclusively with the pulse width modulated (PWM) type. A wide variety of PWM ICs are available from a number of suppliers such as National, RCA, Fairchild, Motorola, Silicon General, Unitrode and others.

buck or forward converter

The first type examined will be the buck or forward converter used to supply a voltage lower than the input. Referring to **fig. 1**, note that the basic buck converter consists of a switch (S), a diode, an inductor, a capacitor, and a load resistor. In a practical converter, the switch is replaced by a transistor or FET driven by pulses supplied from a PWM chip.

When the switch is closed, current starts to build up gradually as the inductor opposes a rapid change in current flow. The capacitor begins to charge, and an EMF appears across the load. As the current increases, a magnetic field builds up in and about the inductor. The switch then opens, and forward current flow ceases. At this point the magnetic field collapses, inducing a voltage in the inductor of opposite polarity.

The energy induced in the inductor flows through the diode to the capacitor and load. Energy is supplied to the load from that stored in the inductor. The ratio of the time on (switch closed) to time off (switch open) determines the total energy delivered to the load, and therefore the output voltage. The PWM chip will monitor the output via the feedback resistor in a practical circuit, compare it with the internal reference voltage of the chip, and precisely control the ratio of on time to off time to maintain a constant output voltage. As the load is increased, the on time increases; as the load is decreased, the on time decreases. This circuit can be used to obtain an output voltage lower than the input by at least 2 volts or more.

flyback converter

Figure 2 shows a basic flyback converter with the same five basic components arranged in a different manner. In this circuit, when the switch is closed, energy is stored in the inductor because it cannot flow to the capacitor and load because of the diode. When the switch is open, the energy stored in the inductor is transferred to the capacitor and load because the diode is now forward biased. With this circuit, you can obtain a supply of reverse polarity greater than, less than, or equal to the input voltage.

boost or step-up converter

Figure 3 illustrates a basic boost or step-up circuit. In this circuit, we see the same five components arranged differently. When the switch is closed, the inductor is connected in parallel with the input, and energy is once again stored in the inductor.

By William R. Hennigan, W3CZ, 975 Clopper Road, Apartment A2, Gaithersburg, Maryland 20878

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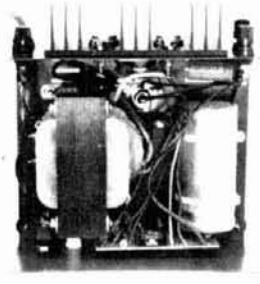

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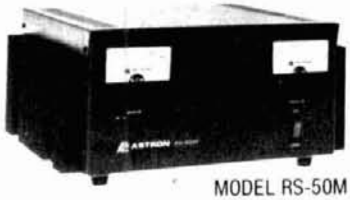

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RS-7A	5	7	3¾ × 6½ × 9	9
RS-7B	5	7	4 × 7½ × 10¾	10
RS-10A	7.5	10	4 × 7½ × 10¾	11
RS-12A	9	12	4½ × 8 × 9	13
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*ICS—Intermittent Communication Service (50% Duty Cycle 5min. on 5 min. off)

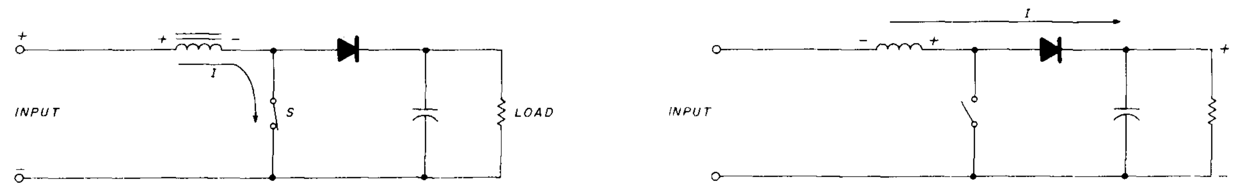

fig. 1. Buck or forward converter supplies an output voltage lower than its input — i.e., $E_{IN} > E_{OUT}$.

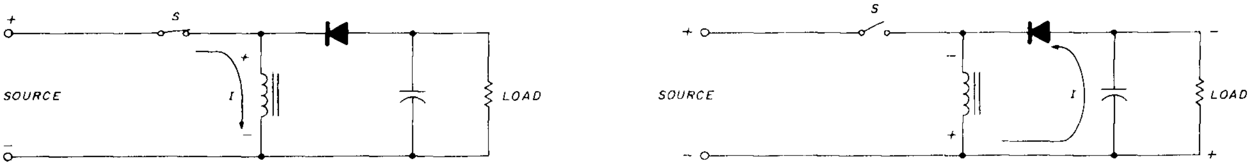

fig. 2. Flyback converter provides a reverse polarity output that is greater than, equal to, or less than the input voltage in magnitude.

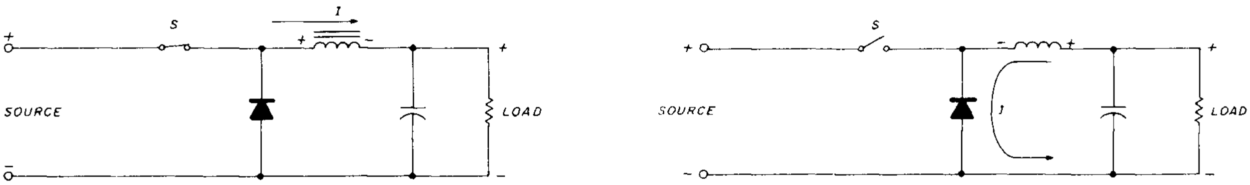

fig. 3. In this boost circuit the output is the sum of the input voltage and the voltage across inductor, i.e. $V_{OUT} > V_{IN}$.

When the switch is open, the energy in the inductor is transferred to the load and this voltage is now connected in series with the input; thus the output is the sum of the input voltage and the voltage across the inductor. This circuit can be used only as a step-up or boost circuit. It does suffer from one fault, however, which I'll explain later.

buck or step-down converter

A practical buck or step-down forward converter can be constructed using a 3524 IC, a chip that's readily available from a number of suppliers. **Figure 4** shows a schematic of an 8-volt regulated supply with an input of 12 volts. I built this circuit several years ago; the 8-volt output was loaded from 150 to 500 mA with a measured efficiency that varied from 83 to 85 percent.

Note that the internal reference at pin 16 is divided down to 2.5 volts at pin 2. This is necessary because the comparator in the chip is powered off the 5-volt reference and has a common mode input of 1.8 to 3.4 volts (see **fig. 5** for the internal circuitry of the chip). The Unitrode UC1524 family of chips has a higher common mode input because the comparators are powered off the input voltage of the chip; if they're used in this circuit — with 12-volt input — the reference could be applied directly to pin 2 by means of a resistor. The current limit comparator (pins 4 and 5) also has the same common mode input limitations with the LM3524, so the current limit resistor is in the negative lead in the circuit shown. The resistor value of RCL can be tailored to fit the need. A 1-ohm resistor will current limit at about 200 mA, a 0.2-ohm resistor at about 1 ampere, and a 0.4-ohm resistor at about 500 mA. The current limit value is the value of a resistor whose voltage drop equals 0.2 volts. If current limiting isn't necessary, it can be omitted and the leads connected together at this point, forming a jumper between point A and B.

L1 and L3, wound on toroids, consist of 45 turns of No. 25 wire on Micrometals T68-26A cores. These plus C6 can also be omitted if the ripple from the supply at both the 12-volt input and 8-volt output is acceptable.

Any of the 1524, 2524, 3524 chips will operate in the circuit shown in **fig. 4**. The operating frequency

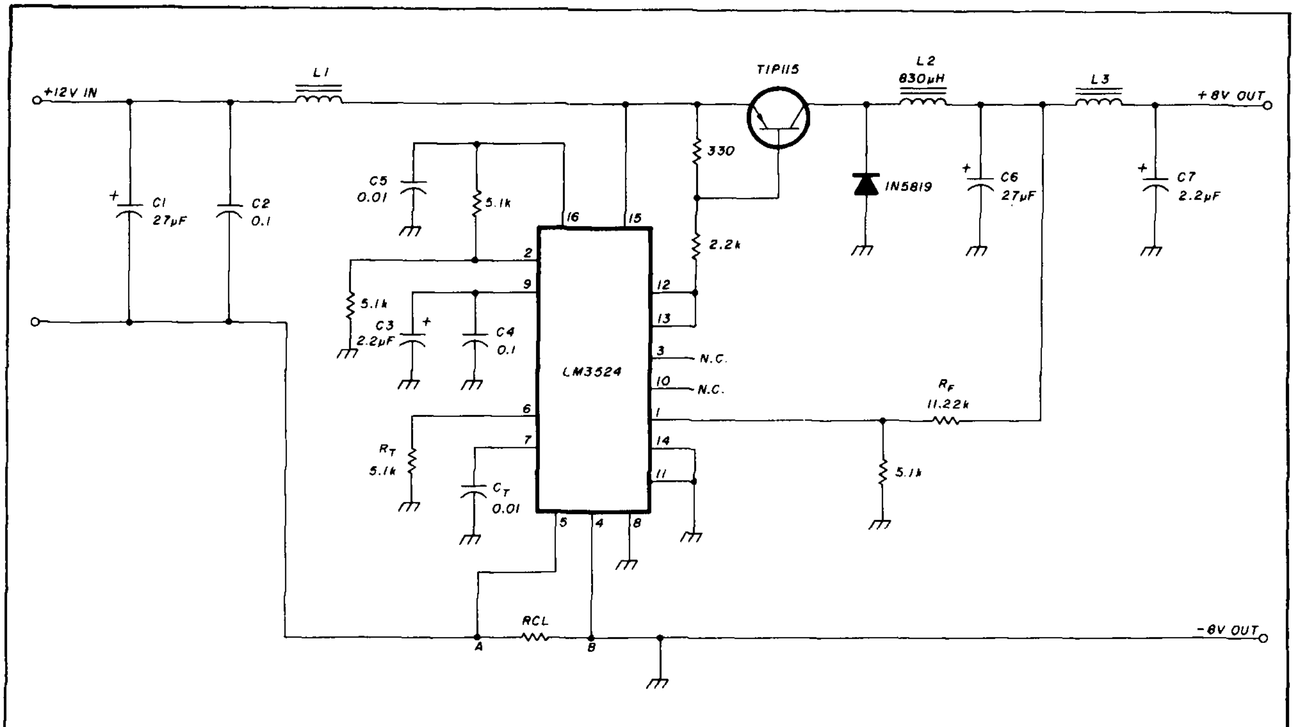

fig. 4. Step-down forward converter provides 8 volts out with 12 volts applied to the input.

of this converter, approximately 20 kHz, is determined by the value of R_t and C_t. The frequency is about equal to 1 over the product of the timing Resistor R_t here and timing Capacitor C_t or:

$$f = \frac{1}{R_t\, C_t} \tag{1}$$

The inductor L2, the heart of the unit, has an inductance of 830 μH, and consists of 72 turns of No. 26 wire wound on an 1811F1D bobbin mounted on a set of Ferroxcube® gapped cup cores (part No. 1811PA1603B9).* Though the inductor could just as well be wound on a toroid, I chose cup cores because they were available and because they're much easier to wind than toroids. I bolted them together with a nylon screw, but any nonmagnetic material, such as brass, would have been appropriate.

This supply will operate equally well with a 15, 18, or 24-volt input. To convert to a 5-volt output, change the feedback resistor R_f to 5.1 k; to fine-tune the voltage, use a 4.7-k resistor in series with a 500-ohm pot. To adjust this 8-volt supply, use a 10-k resistor in series with a 2-k pot instead of the 11.22-k resistor shown, because it isn't a standard value and would have to be made up of several resistors in series.

The feedback resistor for the circuit shown in **fig. 4** can be calculated as follows:

$$R_f = 5100\left(\frac{V_o}{2.5} - 1\right) \tag{2}$$

V_o being the desired output voltage from the supply.

The switching transistor TIP 115 should be heat sinked to keep it from overheating. In my supply it was bolted, with a mica washer, to the circuit board upon which the supply was built to keep it from shorting to the copper foil of the circuit board.

If the output current is increased to 1.0 ampere, the value of the inductor should be decreased to 300 to 500 μH or so. In all cases, the diode should be a fast-recovery type; for maximum efficiency in low-voltage supplies of 5 to 10 volts output, a Schottky type (for example, a 1N5819) is preferred. In any event, don't use 1N4000-type diodes, which will overheat.

The value of the inductor, L2, can be calculated as follows:

$$L = \frac{2.5\, V_o\, (V_{in} - V_o)}{I_o\, V_{in}\, f_{osc}} \tag{3}$$

V_o = output voltage
V_{in} = input voltage
I_o = output current
f_{osc} = oscillator frequency

inverted supply

Figure 6 shows a converter that gives us an inverted supply or a −15-volt supply from a positive source.

*The cup cores are available from Ferroxcube. Toroids were made by Micrometals; toroids from FairRite, Arnold Engineering, Magnetics, and other manufacturers may be used instead.

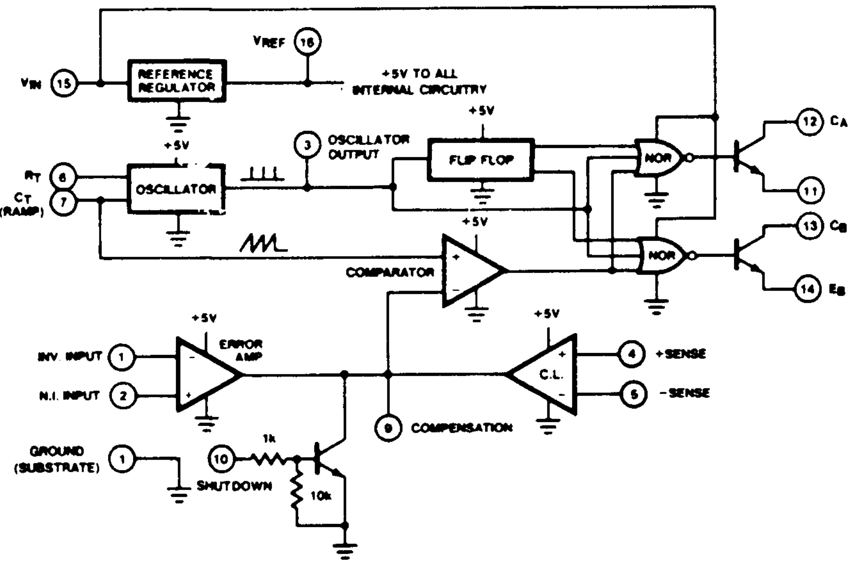

fig. 5A. Unitrode No. UC1524 series of ICs: equivalent internal block diagram.

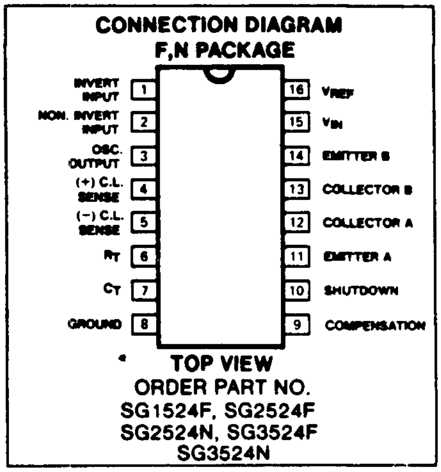

fig. 5B. UC1524 series pin configuration.

This circuit provided an efficiency of 76 percent loaded to 250 mA. The inductor measured 525 μH and consisted of 70 turns of No. 29 wire wound on a Ferroxcube cup core set of No. 1408PA1003B7 gapped cores. This is a smaller core than the one used in the buck converter shown in **fig. 4**. The frequency of this oscillator was measured at 21.2 kHz.

Do not operate any of these dc-to-dc converters without some load; if you do, the capacitor can charge up to the peak pulses applied to the inductor. One way to prevent this from happening is to modify the feedback resistor and 5.1-k resistor to ground to lower values, in order to provide some loading to the supply if you want to be able to remove the load while the supply is operating, or want to apply the load while it's operating. In this circuit, I used a Schottky diode (1N5819) with a snubber consisting of a 3.3-k resistor and a 1000-pF capacitor in series across the diode. If a fast-recovery type such as a 1N4935, 1N4936, or 1N4937 were used, the snubber could be deleted.

Since the 35.7-k feedback resistor isn't a standard value, a good substitute would be a 33-k resistor in series with a 5-k pot; with this arrangement, you'd be able to adjust the output to exactly 15 volts. The output voltage can be changed by merely changing the value of the feedback resistor.

The value of the feedback in this supply or circuit can be calculated as follows:

$$R_f = \frac{OV + 2.5}{2.5} \times 5100 \qquad (4)$$

This supply will operate just as well with an input voltage of from +12 to +24 volts. In fact, it will probably operate with an input as high as 40 volts, the maximum for the LM3524, but be sure to use a fast-recovery diode rather than a Schottky type.

boost converter

The boost converter shown in the next circuit (**fig. 7**) uses the internal switching transistors in the 3524 chip because the load was only 40 mA. The efficiency of this circuit, with an output of 24 volts at 40 mA, and an input of 12 volts, was measured at 78.6 percent. The 600-μH inductor consists of 80 turns of No.

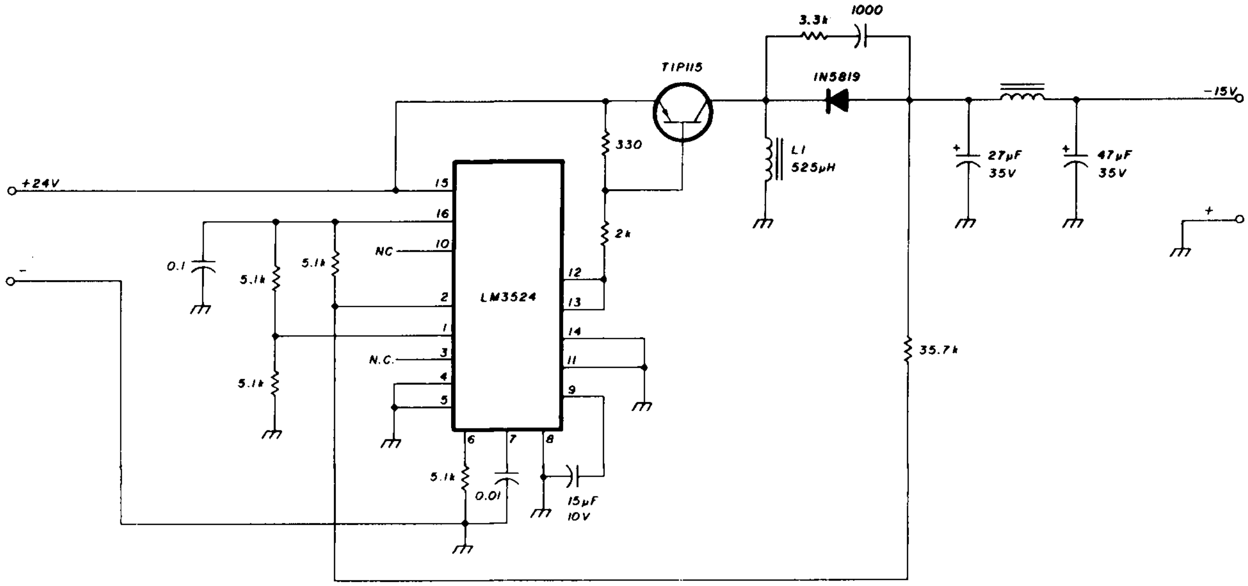

fig. 6. Inverting converter provides −15-volt output for positive input.

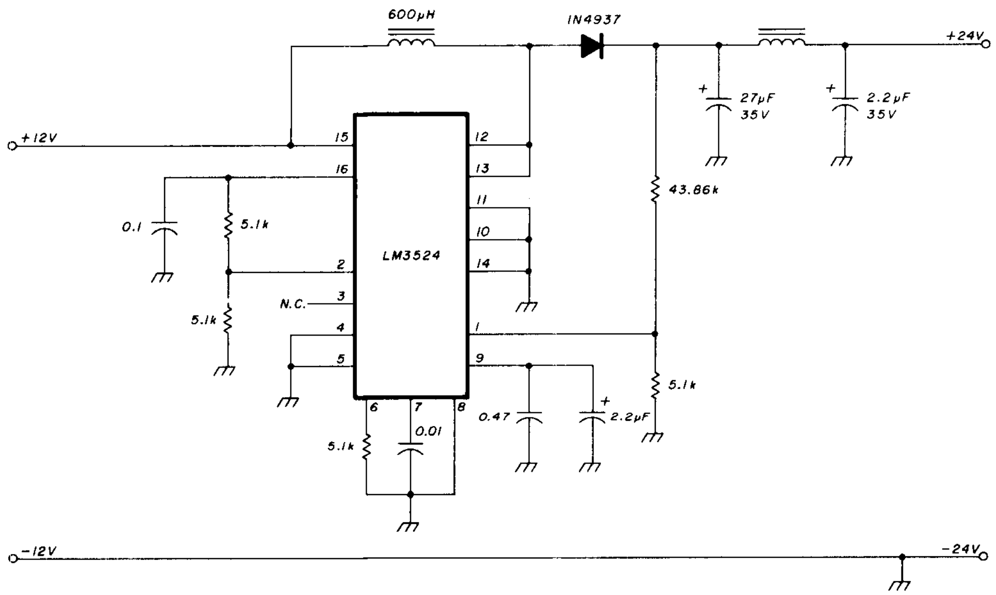

fig. 7. Boost converter is able to use the LM3524 internal switching transistors because of low-current operation.

32 wire wound on a Ferroxcube core (No. 1107PA1003B7), which is smaller than those used in the other circuits. In all cases, when you use cup cores, be sure to adjust the wire size to fill the bobbin completely for the inductance required. Toroids can also be used in these circuits.

The component values of a large part of the circuitry are similar to the other circuits used in **figs. 4** and **6.** Earlier I mentioned a problem with the basic boost circuit given that there's no easy way to current limit it when the switching transistor isn't connected between the input and output. In any of the circuits where the switching transistor is connected between the input and output, the current limit comparator at pins 4 and 5 can be connected across a limit resistor as shown in **fig. 4.** In the inverting supply, the resistor can be

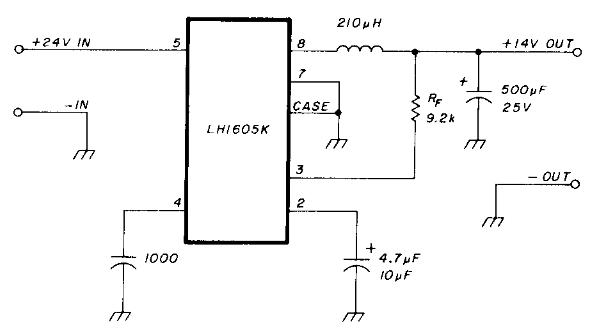

fig. 8A. Circuit diagram of simple buck converter using National LH1605K IC.

placed in series with the diode and ground, with the ends of the resistor connected to pins 4 and 5; be careful to observe the correct polarity.

simple buck converter

A rather simple buck converter can be built around the National LH1605K, a device with eight leads, contained in a TO3 package.* The internal schematic and complete circuit diagram are shown in **fig. 8**. The switching transistor and diode are contained in the same package, so the entire circuit consists of three capacitors, one resistor, and one inductor in addition to the IC. The internal transistor and diode combination is capable of supplying an output current of 5 amps. Needless to say, it's necessary to use some form of heat sink. The maximum input voltage, 35 volts, will supply an output voltage as low as 3 volts and as high as 30. The feedback resistor can be calculated as follows:

$$\frac{2 \times 10^3 (V_O - 2.5)}{2.5} \quad \textbf{(5)}$$

If a 15-volt output is desired, then R_f would be 10 k; for a 5-volt output, it would be 2 k. With a 12-volt input and a 5-volt output, I measured an efficiency of 68 to 69.5 percent with a 5-volt load of 600 mA to 1 ampere. With a 24-volt input and a 14-volt output, the efficiency varied from 73.5 percent to 79 percent because the load was varied from 300 mA to 2 amperes. If a step-down regulator is required, this chip would surely be appropriate. The inductor in my unit measured 210 μH and consisted of 35.5 turns of No. 20 wire wound on a Ferroxcube cup core set (No. 2616PA170368) held together by a nylon screw, which also was used to mount it. This chip can be used only as a buck converter. In my unit, R_f was a pot that could be set for any output voltage as long as it was several volts less than the input.

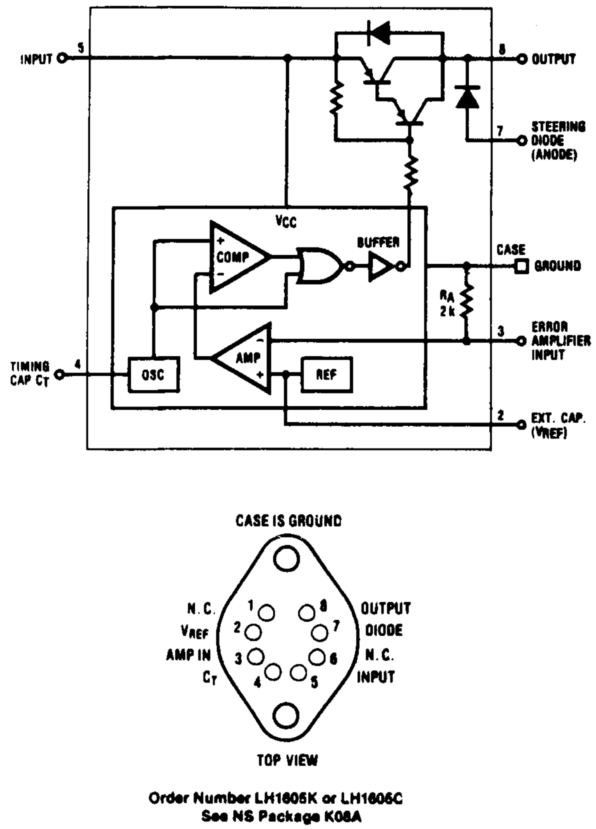

fig. 8B. National LH1605K IC: internal diagram and pin configuration.

other possibilities

Lambda's 6300 series of PWM regulators come in the same TO3 package with eight leads. These units can be used in a number of circuits — buck, boost, or inverting.

It's possible to build multiple output supplies using PWM chips. If the supplies require that all the outputs need to be regulated rather closely under varying load conditions, then you could probably build, as I have, several regulated supplies with all chips running at the same frequency. One chip uses R_t and C_t connected to the appropriate pins. Tie pin 3 of all chips together, and pin 7 of all chips together.

You can obtain a ± supply from one buck regulator which will track quite well even though one supply or output is sampled via the feedback resistor. It works best if the - supply is loaded to only 10 to 25 percent of the load on the + supply (see **fig. 9**). If the load on the + supply is removed with a load on

*The National LH1605K chip, most of the diodes, and the switching transistors used in these circuits are available from Digi-Key Corporation, P.O. Box 677, Thief River Falls, Minnesota 56701.

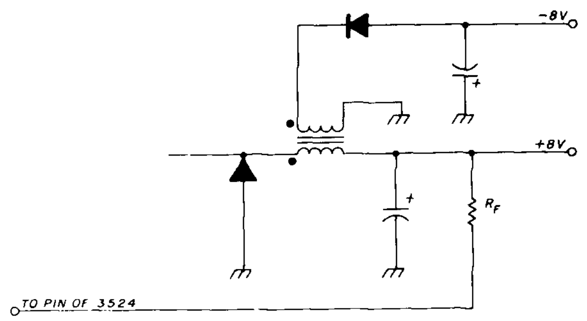

fig. 9. Dual-voltage supply uses single buck regulator.

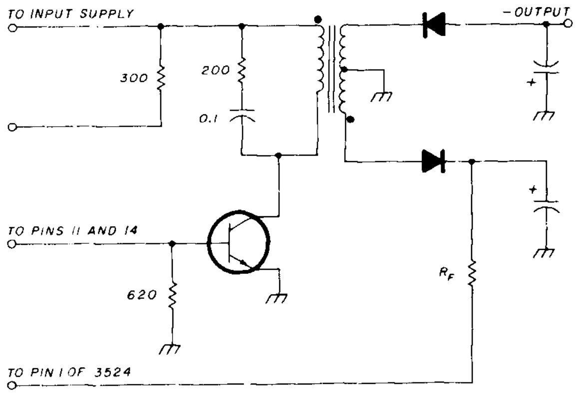

fig. 10. Dual-voltage supply uses center tapped transformer.

the - supply connected, the - voltage will drop considerably because the pulse width will be reduced severely — but with loads on both supplies, the voltages will track quite well. The inductor in this circuit was wound with 76 turns of bifilar No. 30 wire.

Another way to obtain a dual supply is to use a center-tapped transformer, as shown in **fig. 10**.

conclusion

In closing I might mention that since these supplies run at 20 kHz, good low-frequency rf practices should be followed in wiring. It would be best if pin 10 of the chip were grounded; when a supply I built with some new chips operated erratically, I found that pin 10 was picking up some hash from the circuitry and tending to shut down the regulator.

If you don't have a large assortment of wire sizes, you can vary the wire size to fit what you have on hand. The exact inductance of the inductors in the circuits isn't critical; a ± 15 to 20 percent variation from the detailed values would probably work just as well.

ham radio

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ham radio TECHNIQUES

Bill Orr W6SAI

"white noise" revisited

In my January and June, 1987, columns I discussed the interesting phenomenon known as "white noise" or "reciprocal mixing" (see these columns for background information). It's interesting to note that *Radio Communication*, the monthly publication of the Radio Society of Great Britain, discusses this subject in detail in their equipment review column, but little is said about this subject in Amateur Radio magazine equipment review columns in United States publications. My opinion is that the subject won't go away if you ignore it!

The RSGB reviews indicate transmitter noise sideband performance at 10 kHz off-tune as the "standard of performance" they measure, but they also provide reciprocal noise measurements at 2, 3, 5, 10, 20, 30, 50 and 100 kHz off tune. This is very useful information, and it's a pity that more of it isn't available on this side of the pond. I'm sure that as time goes on, the data will be available for general consumption. While publications other than this one may be oblivious to the fact, the readers of this column are not, judging from my mail on the subject.

In this regard, the November, 1986, issue of *rf Design* magazine[1] included an article entitled "Broadband Noise Improvement in RF Power Amplifiers" by Franke and DeLeon of the ECI Division of E-Systems, Inc. In brief, the authors maintained that operation of a high power transmitter in the vicinity of a sensitive receiver can result in the degradation of the receiver due to broadband transmitter noise.

This is nothing new. I remember back in 1935, when I first got on 20-meter phone, a local DXer had great, hissing sidebands on his a-m transmitter. Everyone objected. The DXer, who was an engineer, literally tore his rig apart trying to find the cause of the noise. He never found it, and the cause remained a mystery. The noise wasn't caused by a phase-lock loop circuit, either — they hadn't been invented yet!

In their article, Franke and DeLeon pointed out that the level of white noise is greatest close to the carrier frequency of the transmitter, and drops off gradually as the observation frequency departs from the carrier frequency (**fig. 1**). Unfortunately, the noise can't be filtered out at the receiver. They noted that the presence of close-in broadband noise isn't unexpected, considering the shape of the gain response of a bipolar transistor (**fig. 2**), which exhibits greater gain at frequencies lower than the normal operating region. This indicates to me that such amplifier stages are "wide open" to pass any close-in noise generated in the earlier stages of the transmitter.

Franke and DeLeon attacked this problem by using low frequency loading in the amplifier stages to reduce low frequency gain without sacrificing high frequency gain. In their example, the amplifier stages worked above 200 MHz, and they set about to lower stage gain at frequencies below 50 MHz. A sample of this design technique is shown in **fig. 3**.

In the base circuit of Q1, the rf choke (L1) is the normal one for the operating frequency. Choke L2 presents a high impedance down to very low frequencies and the low frequency (noise) energy flows through load resistor R1, which is in the range of 5 to 10 ohms. The base circuit, then, is loaded by R1 at low frequencies where power gain is high.

A similar scheme is used in the collector circuit. Choke L3 is normal for the operating frequency. However, L3 and hf bypass capacitor C1 form an L-network that transforms the value of resistor R2 to a value that will heavily load the collector at the lower frequencies. At the operating frequency, L4 appears as an open circuit and capacitor C2 provides a very low impedance, which results in the collector feedback network shown in the small illustration. Below the normal operating range of the amplifier the input impedance to the network looks resistive, approaching the value of R2, which is typically 10 to 20 ohms.

The authors provided "before and after" illustrations of broadband noise density with and without low frequency load resistance. In addition, they point out that FETs (Field Effect Transistors) have 10 to 15 dB lower broad-

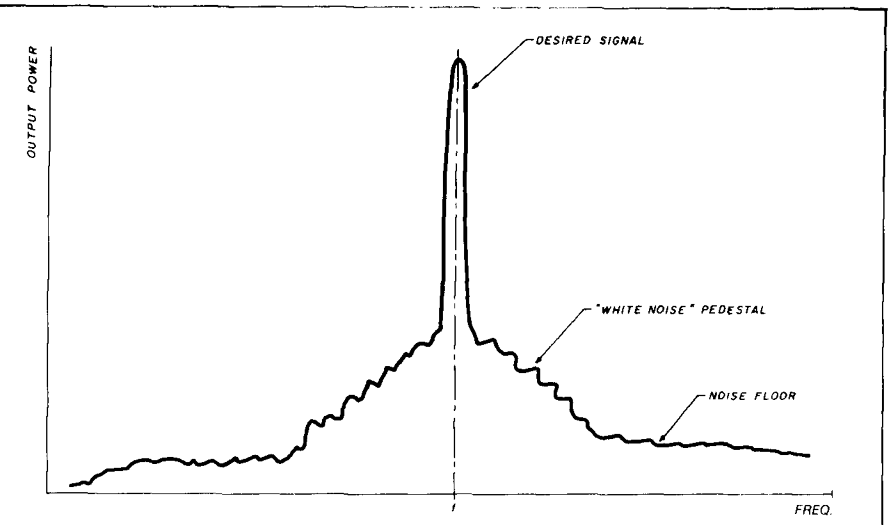

fig. 1. Level of white noise, greatest close to the carrier frequency of the transmitter, drops off gradually as the observation frequency departs from the carrier frequency.

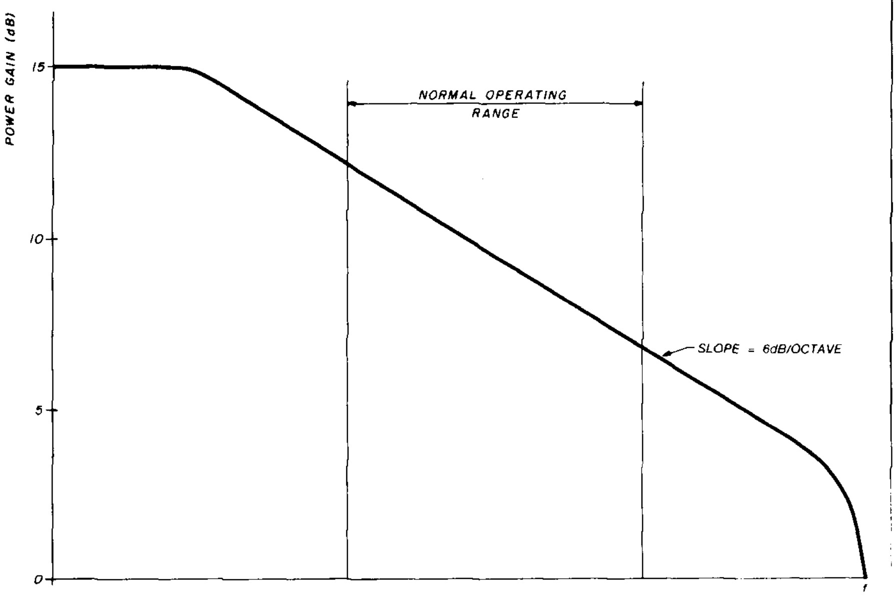

fig. 2. Bipolar transistor exhibits greater gain at frequencies lower than the normal operating range. Broadband noise power is predominantly low-frequency noise.

band noise than a comparable bipolar power transistor. It appears that this technique is worth considering in the continuing battle against the white noise problem.

It's obvious that progress is being made in this important area. Dealing with the problem of broadband noise (as far as ham equipment goes) is in about the same stage of development that receiver overload was 15 years ago. The latter problem has been solved, and I'm confident that this one is on the edge of being solved. Time will tell!

more on telephone interference

The following information was provided by W6BIP ("Bip"):

With regard to telephone interference caused by an Amateur station, recent editions of the ***ARRL Handbook*** *and other publications have suggested that compensation networks that are RFI-free can be obtained from the telephone companies for installation in an RFI-prone instrument. Unfortunately, the compensation networks discussed have been discontinued and deleted from the AT&T inventory. Bad news!*

W6BIP reports, however, that the new replacement line filter module Z-100A does the job in most cases. It consists of two 7.2-mH (8 ohms dc resistance) rf chokes wound on small ferrite cores. Contained in a plastic box that has matching connectors to place in series with the line, it can be bought at AT&T company phone stores or ordered by phone from the AT&T National Service Center in St. Louis, Missouri (800 222-3111). The stock number of the line filter is SKU-57210. A second line filter (model Z-101A), stock number SKU-57293, is available for use with wall-mounted phones.

W6BIP mentions that in addition to the line filter module, some phones may require additional rf filters in the form of a 0.01-μF ceramic capacitor placed across the microphone and a second one across the earphone. Experience has shown that the 3/16-inch diameter capacitors are superior in RFI reduction to the common 3/8-inch diameter capacitors. The value of 0.01 μF is not critical; values between 0.001 and 0.047 μF can be tried. When used in conjunction with the Z-100A filter module, they substantially reduce interference.

From experience, W6BIP says this combination of capacitors and filter module should work for those Amateurs using 1 kW input, or less, with their horizontal antennas at least 25 feet above and away from the affected telephones. For those using vertical antennas with radials on the roof, or slopers or end-fed antennas close to the roof, so much rf seems to enter the house wiring and indoor telephone lines that the filtering described may be inadequate.

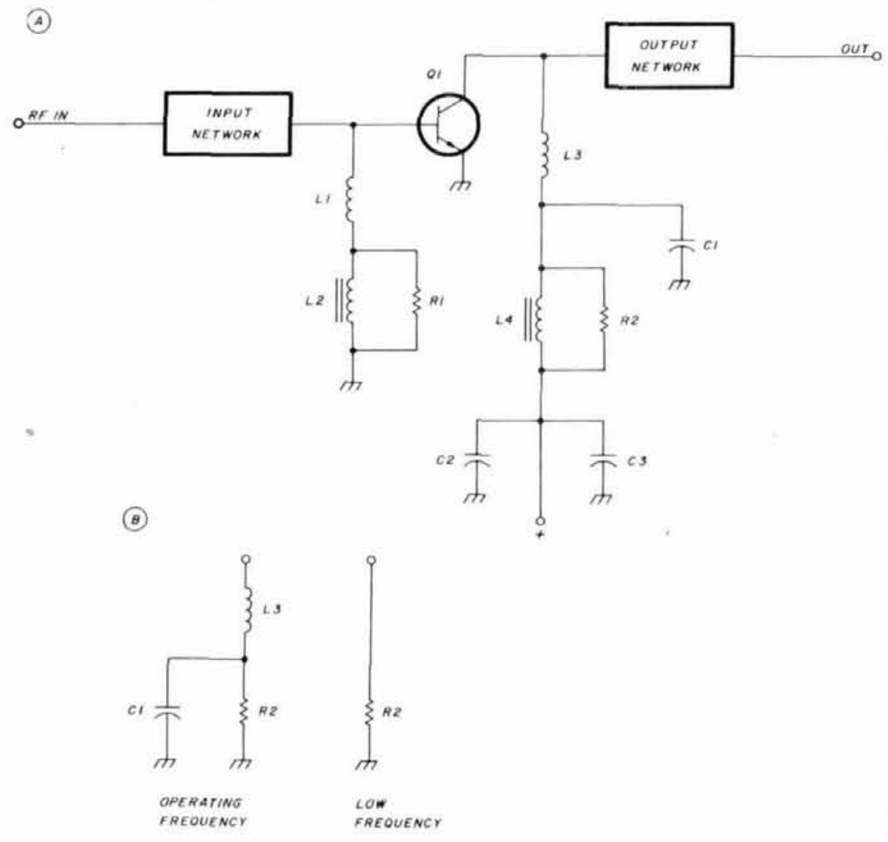

fig. 3. Design technique for low-frequency loading.

the "wideband dipole" — a different approach

Eighty-meter operators have been continually frustrated by the problem of getting an antenna that will show a low value of SWR across the whole band (3.5 to 4.0 MHz). Many modern transceivers require a feed line SWR of less than 2:1 to function properly.

A conventional dipole, cut to mid-band and fed with a 50-ohm coax line has an operational bandwidth of 170 to 190 kHz between the 2:1 SWR points, depending upon the height above ground. This means that such an antenna, cut for the high end of the band (phone) is useless at the low end of the band (CW).

Bill McLeod, VK3MI, has an interesting approach to this problem, as shown in **fig. 4**. His antenna design appeared in the April, 1986, issue of the *Journal of the Wireless Institute of Australia*. His idea consists of using a quarter-wave 73-ohm transformer made of RG-59/U coax plus a reactance compensation capacitor to introduce a deliberate mismatch at the antenna. The result is a poorer SWR level at the resonant frequency of the antenna, but a flatter SWR response across the band of interest.

Using a dipole cut for 3.7 MHz, Bill measured an SWR value of less than 2:1 over a bandwidth of 420 kHz, as shown in the illustration.

It seems to me that with the dipole cut for a slightly higher frequency (say, 3750 kHz) and with adjustment of the reactance capacitor, it may be possible to "stretch" the 2:1 operating bandwidth to cover the complete 80-meter band.

The capacitor should be a high-voltage mica type, or it may be made from a length of coax line open at the far end. The capacitive stub can be taped to the feed line, if desired.

One trick for achieving better bandwidth is to use this scheme with a

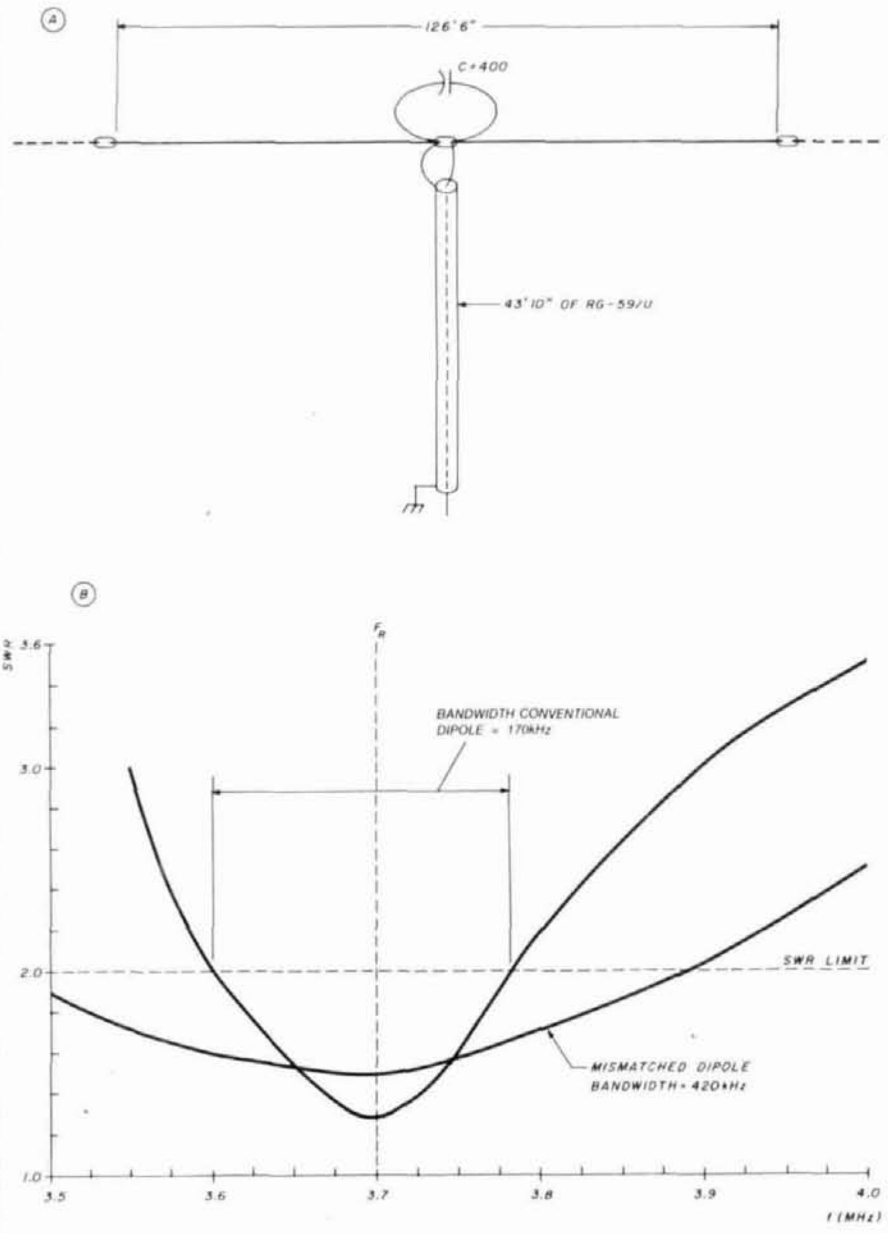

fig. 4. (A) VK3MI wideband dipole for 80 meters; (B) bandwidth of VK3MI and conventional dipole.

"fat" dipole. If the dipole halves were made of 300-ohm transmitting twin-lead, with the wires shorted together at the ends, the additional conductor area might achieve substantially better bandwidth response. In any event, this looks like a good idea to experiment with.

EME directory

The 144-MHz EME (moonbounce) directory is available again. For a copy, send five first-class stamps or five IRCs to me (no envelope required) at Box 7508, Menlo Park, California 94025. The directory is a 36-page list of EME operators, their QTHs, and the equipment they use.

reference

1. Franke and DeLeon, "Broadband Noise Improvement in rf Power Amplifiers," *rf Design*, November, 1986 (*rf Design*, 6530 South Yosemite Street, Englewood, Colorado 80111).

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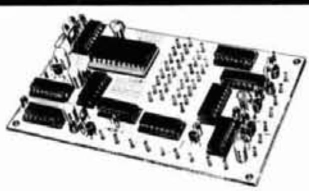

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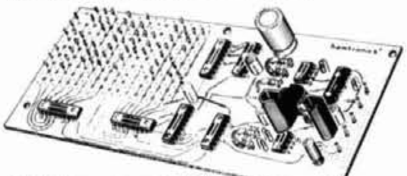

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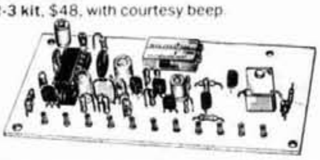

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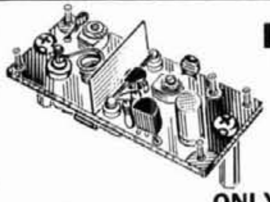

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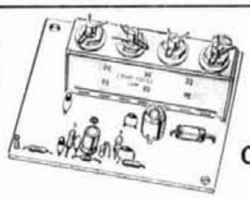

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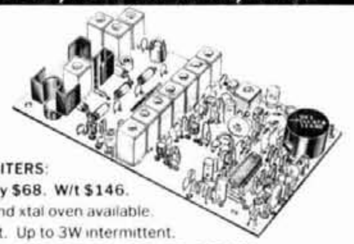

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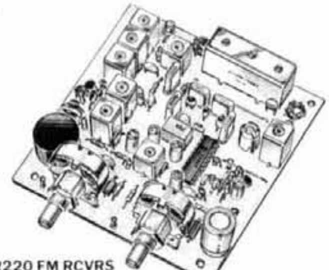

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		Antenna Input Range	Receiver Output
VHF MODELS		28-32	144-148
		50-52	28-30
		50-54	144-148
		144-146	28-30
Kit with Case	$49	145-147	28-30
		144-144.4	27-27.4
Kit less Case	$39	146-148	28-30
		220-222	28-30
Wired w/case	$69	220-224	50-54
		222-224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

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

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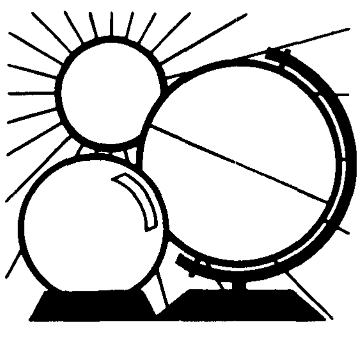


DX FORECASTER

Garth Stonehocker, K0RYW

equinox season DX

Sunspot minimum appears to be over until nearly eleven years hence. Even though a year or so will pass before momentum helps the new cycle to build up to its maximum rate, the return of the 27-day cycle (each solar rotation) has increased the number and size of solar flares and has solar flux energy topping 100 units again. This is expected to continue, gradually increasing in 27-day cycle activity until a sunspot region comes around at least three or four times before dying away. In the meantime, the geomagnetic disturbances will continue to be mainly variations in the solar wind from coronal holes, with an occasional flare-induced geomagnetic event. In either case, the disturbances affect DX fun adversely.

Geomagnetic disturbances, or storms, affect propagation — and DX — in four ways. First, particles from the sun entering the auroral zone at 50 to 70 degrees North and South latitudes come down into the ionospheric D and E regions, increasing signal absorption. This results in weak east-west path signals and few transpolar signals.

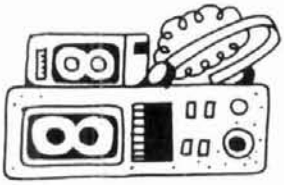
Second, the F region of the ionosphere (for stations in the United States, this is south of the auroral zone) has a depleted area of electrons that forms an electron density trough. The maximum usable frequency (MUF) for paths through this area decreases by 30 to 40 percent (see the January, 1986, *DX Forecaster* for tables of MUF statistics).

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

Fourth, the particles form a reflective curtain along the equatorial side of the auroral zone (for those of us in North America, this is south), enhancing VHF auroral scatter propagation. Six-meter openings to Europe are one result of this phenomenon. Just as the particle density and speed of the solar wind vary, so do the characteristics of the geomagnetic field and ionosphere. Ionospheric variations cause signal reflection focusing and defocusing, which simply means that the signals arriving at your QTH will vary in both strength and angle of arrival from all four directions. Some locations you haven't heard from in a long time may suddenly be workable.

last-minute forecast

The higher-level 27-day activity may push up the maximum usable frequencies (MUF) during the first and second weeks of October, giving better 10-, 12-, and 15-meter DX. Transequatorial one-long-hop propagation is expected to be underway again, especially around the 5th, 15th and 23rd of the month. This is because of a higher probability of geomagnetic disturbance at those times. During those same disturbed periods, the lower band's MUFs should decrease by 15 to 25 percent for



a couple of days at a time. This will be particularly noticeable on east-west paths, and with noticeable QSB. Otherwise, the lower bands should be best during the last two weeks of the month because of higher signal strengths.

The Orionids meteor shower will be visible from the 15th to 24th of October, with a maximum rate of between 10 to 20 per hour on the 20th to 21st of the month. The moon is full on the 7th, and perigee occurs on the 4th and 30th. A penumbra eclipse of the moon occurs on October 7.

band-by-band summary

Ten, twelve, fifteen, and twenty meters will be open from morning to early evening almost every day, and to most areas of the world. The openings on the higher of these bands will be shorter and will occur closer to local noon. Transequatorial propagation on these bands will more likely occur toward evening during conditions of higher solar flux and a disturbed geomagnetic field.

Thirty and forty meters will be useful almost 24 hours a day. Daytime conditions will resemble those on 20 meters. Skip distances and signal strength may decrease during midday of those days that coincide with the higher solar flux values. Nighttime DX will be good except after days of high MUF conditions and geomagnetic disturbances. Look for DX from unusual places on east, north, and west paths during this time. The usable distance is expected to be somewhat less than that on 20 meters in daytime and greater than that on 80 meters at night.

Eighty and one-sixty meters will exhibit short-skip propagation during the daylight hours and lengthen for DX at dusk. These bands follow the darkness path, opening to the east just before your sunset, swinging more to the south near midnight, and ending up in the Pacific areas during the hour or so before dawn. The 160-meter band opens later and ends earlier than 80.

ham radio

OCTOBER

WESTERN USA

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

MID USA

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

EASTERN USA

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

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

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

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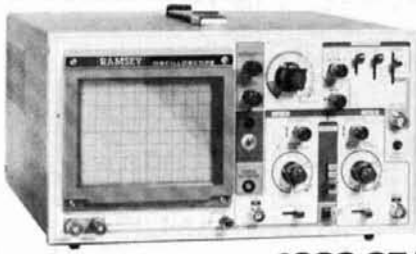

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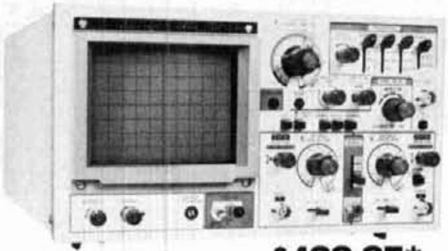

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MODEL	BAND WIDTH	# TRACES	CRT SIZE	VERTICAL SENSITIVITY	MAXIMUM TRIG FREQ	USEABLE MAXIMUM BANDWIDTH
2200	20 MHz	(2)	8x10CM	5 mV per div	35 MHz	30 MHz
2500	15 MHz	(2)	3.5 inch	2 mV per div	30 MHz	25 MHz
3500	35 MHz	(2)	8x10CM	1 mV per div	50 MHz	60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

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

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CT-90 9 DIGIT 600 MHz

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CT-50 8 DIGIT 600 MHz

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CT-125 9 DIGIT 1.2 GHz

$189.95 WIRED INCLUDES AC ADAPTER

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

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test leads and battery included

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

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RAMSEY D-5100 HANDHELD DIGITAL AUTORANGING METER

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

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

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PS-2 kit **$49.95**

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Complete kit, TD-1 **$5.95**

40 WATT 2 mtr PWR AMP
Simple Class C power amp features 8 times power gain 1 W in for 8 out, 2 W in for 15 out, 5 W in for 40 W out. Max output of 50 W, incredible value, complete with all parts, less case and T-R relay.
PA-1, 40 W pwr amp kit **$22.95**
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ML-1 Kit, **$8.95**

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

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Alternately flashes 2 jumbo LEDs. Use for name badges, buttons, warning panel lights. Runs on 3 to 15 volts.
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UT-5 Kit **$5.95**

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

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

SIREN
Produces upward and downward wail. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.
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A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker.
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locator field list

Do you like challenges? If the widespread acceptance of the DXCC, WAZ, and sundry other operating awards proudly displayed by Amateurs throughout the world is any indication, I'm sure you do.

Folke Rosvall, SM5AGM, has taken it upon himself to compile, on a per-band basis, the total number of fields worked by individuals. His list appears in *ham radio* four times a year (see page 75 of the July issue for the first list published in these pages).

"But," you ask, "What's a field?" Glad you asked. According to the Maidenhead locator system, the world is divided into 324 fields or areas, each 20 degrees wide in longitude and 10 degrees wide in latitude. Though most encompass land masses, quite a few do not; this means no countries, no islands, no reefs — just water. So even *if you've worked every country in the world and* your name is at the top of the honor roll, you still probably haven't worked all the fields. For example, *I'm very active on 80 meters*, yet I've been able to snag only 148 out of 324 fields. I can think of a number of other 80-meter operators who are even more active than I am.

Have I tickled your competitive spirit? Think of the ultimate challenge: *work all fields on all 19 bands on one specific mode.* Some quick calculating shows that to be . . . uh . . . 6156 contacts. That'll keep you off the streets (but probably get you into trouble with your family, your employer, etc.). Seriously, it's *all* for fun, and you'll learn a little more geography in the process.

All the necessary details are included on the *accompanying chart. Folke would be very glad* to hear from you. Please send your tabulations directly to him (his address at the bottom of the chart) — not to *ham radio.*

See you on 80!

Rich Rosen, K2RR

AJ | BJ | CJ | DJ | OJ | PJ | QJ | RJ
AI | BI | CI | DI | OI | PI | QI | RI

LOCATOR FIELD LIST

1987-06-30. COMPILED BY SM5AGM (JO99DK). WHO WILL BE THE FIRST RADIO AMATEUR TO WORK ALL 324 FIELDS ON THE SAME BAND?

Band	Station	Field	Fields/Date	Station	Field	Fields/Date	Station	Field	Fields/Date	Station	Field	Fields/Date	Station	Field	Fields/Date
1.8 MHZ	1 W1JR	FN	68 870501	3 SM6CTQ	JO	33 850127	5 SM0LH	JO	5 860322	7 SM0NZB	JO	2 870630			
	2 SM3CWE	JP	54 870630	4 OK1DKS	JO	9 870615	6 SM4JXG	JO	3 861231	8 SK6AW	JO	1 870630			
3.5 MHZ	1 K2RR	FN	148 870630	4 SM0CCE	JO	79 850122	7 SK6AW	JO	58 870630	10 OK1DKS	JO	23 870615	13 SM0LH	JO	8 860322
	2 SM3CWE	JP	130 870630	5 SM7WT	JO	68 850129	8 SM5CAK	JO	56 860921	11 SM3CVM	JP	19 861012	14 SM4JXG	JO	7 861231
	3 W1JR	FN	102 870501	6 SM0HTO	JO	64 851230	9 SM6INC	JO	29 870630	12 KC9RG	EN	10 870630			
7 MHZ	1 SM3CWE	JP	142 870630	5 SM7PKK	JO	88 870322	9 SM3CVM	JP	43 861012	13 SM5CAK	JO	11 860921			
	2 SM0CCE	JO	138 850122	6 SM6INC	JO	76 870630	10 OK1DKS	JO	19 870615	SM4JXG	JO	11 861231			
	3 W1JR	FN	119 870501	7 SK6AW	JO	67 870630	11 SM0LH	JO	15 860209	KC9RG	EN	11 870630			
	4 SM7WT	JO	97 850129	8 SM0HTO	JO	47 851230	12 9V1RH	OJ	14 870610	16 SM0NZB	JO	5 870630			
10 MHZ	1 W1JR	FN	43 870501	4 SM5FUG	JO	21 860912	7 SM6MSG	JO	10 850930	10 SM0HTO	JO	7 851230	13 SM5CAK	JO	3 860921
	2 9M2FP	OJ	31 861220	5 SM5ACQ	JO	17 870625	8 SM0LH	JO	9 860322	11 SM7BDB	JO	5 850922	SM0NZB	JO	3 870630
	3 SM6INC	JO	23 870630	6 SM3CWE	JP	13 870630	SM4JXG	JO	9 861231	12 SM5PAX	JO	4 850930	15 KC9RG	EN	1 870630
14 MHZ	1 SM3CWE	JP	222 870630	W1JR	FN	192 870501	7 W6DU	CM	147 860526	10 OK1DKS	JO	85 870615	13 SM5FBL	JO	44 850126
	2 SM7WT	JO	201 850331	5 SM0CCE	JO	186 850122	8 SM6INC	JO	131 870630	11 SM5CAK	JO	73 860921	14 KC9RG	EN	40 870630
	3 SM0HTO	JO	192 851231	6 SK6AW	JO	157 870630	9 SM5ACQ	JO	122 850930	12 SM0LH	JO	57 860212	15 SM4JXG	JO	37 861231
18 MHZ	1 SM6INC	JO	18 870630	3 SM7BDB	JO	8 850922	5 SM0LH	JO	5 860322	SM0HTO	JO	3 851230	9 9V1RH	OJ	1 870610
	2 SM5ACQ	JO	12 870331	4 SM4JXG	JO	7 861231	6 SM5PAX	JO	3 850930	8 SM3CWE	JP	2 870630			
21 MHZ	1 SM3CWE	JP	158 870630	4 SK6AW	JO	116 870630	7 OK1DKS	JO	68 870615	10 SM4JXG	JO	38 861231	13 W1JR	FN	17 870501
	2 SM0CCE	JO	153 850122	5 SM6INC	JO	109 870630	8 SM0HTO	JO	52 851230	11 KC9RG	EN	26 870630	14 SM5CAK	JO	10 860921
	3 SM7WT	JO	131 850129	6 SM5ACQ	JO	95 850930	9 SM0LH	JO	44 860209	12 SM3CVM	JP	24 861012			
24 MHZ	1 W1JR	FN	27 870501	3 SM0HTO	JO	5 851230	SM5ACQ	JO	5 870508	7 SM7BDB	JO	2 850922	9V1RH	OJ	1 870610
	2 SM6INC	JO	12 870630	SM4JXG	JO	5 861231	6 KC9RG	EN	3 870630	8 SM0LH	JO	1 860209	SM3CWE	JP	1 870630
28 MHZ	1 DF2NJ	JO	159 851111	5 SM0CCE	JO	126 850122	9 SM0HJV	JO	93 860917	13 W1JR	FN	29 870501	17 SM4JXG	JO	12 861231
	2 SM6LIF	JO	143 850909	6 SM3CWE	JP	123 870630	10 SK6AW	JO	90 870630	14 SM0JXA	JO	21 861101	18 SM5CAK	JO	9 860921
	3 SM0HTO	JO	139 851230	7 SM6INC	JO	111 870630	11 SM5ACQ	JO	53 850930	15 OK1DKS	JO	20 870615	19 SM3CVM	JP	5 861012
	4 SM7LXV	JO	127 850630	8 SM7WT	JO	108 850129	12 SM0LH	JO	32 860212	16 KC9RG	EN	17 870630	SM0NZB	JO	5 870630
50 MHZ	1 WA1OUB	FN	46 860801	W1JR	FN	41 870501	5 W6RXQ	CM	15 870630	7 JQ1GTC	QM	5 861212			
	2 N0LL	EM	41 861106	4 KA9MGR	EN	16 860331	6 KI3W	FN	14 870630	KC9RG	EN	5 870630			
144 MHZ	1 SM7BAE	JO	45 870214	5 SM2GGF	KP	37 850622	9 YU3ZV	JN	32 831231	OZ1EME	JO	31 841224	17 OH7PI	KP	28 831231
	2 VE7BQH	CN	42 870113	6 Y22ME	JO	36 861231	WA1JXN	DN	32 840508	14 SM4IVE	JO	30 840609	W5UN	DM	28 840428
	3 DL8DAT	JO	41 870620	7 YU3WV	JN	35 870331	F6CJG	JN	32 850110	WA4NJP	EM	30 840903	KD8SI	EM	28 850116
	4 K1WHS	FN	38 840930	8 SM4GVF	JO	34 860930	12 F6BSJ	JN	31 840903	16 KB7Q	DN	29 851231	OK1MS	JO	28 850331
220 MHZ	1 W1JR	FN	10 870501	2 KA9MGR	EN	4 860331	3 W6RXQ	CM	3 870630						
432 MHZ	1 K2UYH	FN	33 850331	5 WB5LUA	EM	28 840428	9 VE4MA	EN	23 830331	13 K1FO	FN	19 850318	17 DF9CY	JO	10 830627
	DL9KR	JO	33 861001	6 W7GBI	DM	27 840505	10 SM6CKU	JO	21 821231	Y22ME	JO	19 861231	18 OZ3ZW	JO	7 850630
	3 YU1AW	KN	30 860407	7 OK1KIR	JN	26 850221	SO1MN	JO	21 860617	15 SM0DJW	JO	18 851231	SM6FYU	JO	7 860331
	4 W1JR	FN	29 870501	SM3AKW	JP	26 861231	12 OH6NU	KP	20 821231	16 W7HAH	DN	12 860314	20 SM0BYC	JO	6 841231
902 MHZ	1 W1JR	FN	2 870501												
1.3 GHZ	1 K2UYH	FN	20 850331	W7GBI	DM	13 840505	OE9FKI	JN	7 850331	SM0DJW	JO	5 851231	W1JR	FN	4 870501
	2 OK1KIR	JN	17 850221	6 SM6CKU	JO	12 821231	OZ3ZW	JO	7 850630	SM3AKW	JP	5 861231	18 K1FO	FN	3 850318
	3 OE9XXI	JN	16 850331	7 YU1AW	KN	11 860407	11 DL7YC	JO	6 840411	15 SM0PYP	JO	4 830331	SK5EW	JO	3 850331
	4 WB5LUA	EM	13 840428	8 W6YFK	CM	7 840506	12 SM6HYG	JO	5 821231	SM4AXY	JO	4 831231	SM6NJC	JO	3 850630
2.3 GHZ	1 W4HHK	EM	4 850304	W6YFK	CM	3 840506	OK1DKS	JO	2 870615	WA4HGN	EM	1 840505			
	OE9XXI	JN	4 850331	5 OK1KIR	JN	2 850221	8 PA0SSB	JO	1 821231	OZ1CFO	JO	1 850826			
	3 SM6HYG	JO	3 830331	W1JR	FN	2 870501	WB5LUA	EM	1 840428	W6RXQ	CM	1 870630			
3.4 GHZ	1 SM6HYG	JO	1 850914												
5.7 GHZ	1 SM6HYG	JO	1 850914	OZ1CFO	JO	1 850930									
10 GHZ	1 SM0DJW	JO	2 850630	W6RXQ	CM	2 870630	SM7ECM	JO	1 860930						
	YU1AW	KN	2 860205	4 SM6HYG	JO	1 850914	W1JR	FN	1 870501						

This list shows the number of fields worked according to the Maidenhead Locator system. A field is a block of 20° (longitude) × 10° (latitude). Rules: 1. All fields must have been worked via passive reflectors. 2. All stations involved must be on the earth's surface. 3. QSL cards are not required if you are sure that the other station considers the QSO complete. 4. All QSO's must have been worked from points within a circle of 1000 km radius. 5. There is no starting time for contacts to be eligible. A world map showing the 324 fields can be found in "The Radio Amateur's World (Locator) Atlas", that normally should be available at your national amateur radio society.

Compiled quarterly since 1982, the list shows the situation on March 31, June 30, September 30 and December 31 at 2400 UT. Please send your info as soon as possible after each date to SM5AGM, Folke Rosvall, Vastenskarsringen 50, S-184 00 Akersberga, Sweden. Tel. 0764-27638.

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

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by John Devoldere, ON4UN, for Apple IIe/c, MS-DOS, Commodore C-128 Apple Macintosh and Kaypro CPM Computers

Here's a collection of 30 super programs written by ON4UN. Just about every interest or need is covered—from antenna design and optimization to general operating programs. Antenna programs include: shunt and series input L network design, feedline transformer, shunt network design, SWR calculation, plus 11 more! General Ham programs include: sunrise/sunset, great circle distances, grayline, vertical antenna design program, sunrise calendar plus 9 more! Phew. When you sit down to use these programs you'll be amazed at what you have. The best value in computer software available today. © 1986.

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by John Devoldere ON4UN

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NEW products

personal packet mailbox

The Kantronics Personal Packet Mailbox is an inexpensive — $39.95 — firmware option that allows your Kantronics packet communicator (the KPC-1, KPC-2, KPC 2400 and the KAM) to function as a self-contained personal mailbox system.

Until now, most popular packet mailbox systems relied on personal computers such as the Xerox 820 or IBM XT using special packet bulletin-board software written by W0RLI or W7MBL. The Kantronics personal mailbox eliminates the need to tie up (and run continuously) your expensive PC for simple mailbox operations.

As with other Kantronics firmware updates, installation is as simple as installing a new EPROM. After installation you'll have to perform a hard reset of the TNC, which involves simply moving one jumper for the first power-up. The procedure is amply covered in the documentation; several pages of instructions accompany the mailbox to supplement your original owner's manual.

The NULLS command has been deleted and eight other commands have been slightly changed. If you didn't already have the 2.3 version software, you'll benefit from the six new commands from that update built into the mailbox software.

One of the more interesting and useful of these is the LLIST (Lid LIST) command. When it's turned on, the calls entered as SUPCALLS are ignored: they can't digipeat through your station, don't show on the MHEARD list, won't receive a (DM) if they try to connect to you, and can't use your mailbox. As far as your TNC is concerned, these stations just don't exist!

Another useful command is MBEACON; when it's off, packets sent as beacons or ID's aren't monitored.

Once the mailbox is installed and operating, you must enter your call. If you don't, the CMD: prompt won't appear. Once your call is "permed" into memory, you'll come up in the command mode immediately.

On the air the mailbox responds to users' commands similar to those found on many popular W0RLI-type packet bulletin boards (LIST, READ, SEND, KILL, and BYE). At your end, you'll use seven others to enter, list, or delete messages on your mailbox, and to set some mailbox parameters. For instance, PBBS N is used to allocate the amount of TNC RAM, in 1K blocks, to be made available for the mailbox storage area. Up to 22K may be allocated providing the TNC has 32K of memory. MYPBBS is used to enter the unique callsign for the mailbox, which should be different from the call used for MYCALL. For instance, if K1ZJH were used for MYCALL, K1ZJH-1 would be acceptable for the mailbox call.

One of the nicest features of this mailbox is its transparent operation with normal packet operations from your station. You can carry on a packet QSO while another station is using the mailbox in your TNC, and by entering the command mode, you can access the mailbox even if someone is connected to you or to your mailbox.

While W0RLI-type PBBSs can forward mail to your mailbox, the Kantronics mailbox has no provisions for forwarding itself. Mail sent to your mailbox is treated as "private"; unless it's addressed to the connecting station or to "ALL," it can't be LISTed, READ or KILLed by that station. Upon connecting, stations are informed of any unanswered mail.

Since messages in the mailbox are stored in volatile RAM, even momentary power outages will trash its contents unless battery backup is supplied to the TNC. As its name implies, this mailbox is intended as a "personal mailbox," either for individual use, or as a small club bulletin board for limited general-interest bulletins. Due to its limited RAM allocation, the number and size of the messages that can be stored are necessarily limited (although impressive, considering the limitations). Once the memory limit is reached, future messages are lost.

Several friends and I have been using Kantronics' personal mailbox for months with no problems. Apparently the software was well written and very carefully debugged before the first versions were released. The documentation is concise and explains operation and all of the commands except for the PBBS N command, whose parameters were somewhat ambiguous. For marks, the Kantronics' personal mailbox rates an A+; we can fully expect this product to have a significant positive impact on packet operations.

For more info contact: Kantronics, 1202 E. 23rd St., Lawrence, KS 66046.

K1ZJH

Circle #307 on Reader Service Card.

updated fm dual-bander

The new 2-meter/70 cm Dual Bander from Kenwood puts out 45 watts on 2 meters and 35 watts on 70 cm. Features include compact size (5.9 x 1.97 x 7.87 inches), and light weight (less than 4 pounds). With only three knobs and eight keys on the front panel, it's easy to operate.

The large LCD display and main knob provide excellent visibility in direct sunlight or darkness. Full duplex crossband operation via repeater is possible (assuming, of course, that a control operator is available).

The new Dual Bander offers programmable band scan and memory scan with memory channel lock-out. A lithium battery provides

NEW products

backup for ten memory channels that store frequency, offset, and subtone. For odd split or crossband operation, two channels store transmit and receive frequencies independently. Thanks to a nonvolatile operating system, all operating features remain intact — even after the memory backup cell dies. No reprogramming or board-swapping is ever necessary.

Separate antenna ports for VHF and UHF are provided. Optional features and accessories are available. For more information, contact Kenwood Communications and Test Equipment Group, 2201 E. Dominquez Street, Long Beach, California 90810.

new compact amplifier

The HL-37V from Tokyo High Power Labs is a compact amplifier designed for 144-MHz fm/SSB hand-helds and portable transceivers. The unit has a built-in variable gain RX pre-amp which uses a low noise GaAs FET.

The unit features an LED power level indicator and front panel with a smoked polycarbonate sub-panel so that LED lights can be recognized only when they're lit. Combined with a hand-held transceiver, the HL-37V boosts power from 2 or 3 watts to 30; rf driving input between 0.5 and 5 watts is accepted. A built-in RX GaAs FET preamp allows clearer reception of noisy or weak signals. Gain is continuously variable from −20 to +14 dB; an effective low-pass filter minimizes spurs.

Priced at $99.95, the HL-37V also features the fm/SSB mode select switch on the rear panel. A 1-second delay during changeover from RX to TX prevents relay chatter.

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

Circle #304 on Reader Service Card.

RFI-free choke kit

MFJ Enterprises, Inc. offers the MFJ-701 RFI-free choke kit that eliminates RFI problems that affect TVs, radios, stereos, telephones, VCRs, computers, PA systems, burglar and fire alarms, test equipment, modems, monitors and other electronic devices.

Although winding an offending cable or wire around a ferrite toriod generally eliminates RFI, it's often difficult to find a toroid with the proper characteristics that has a large enough hole through which the end of a power cord, ac adapter, microphone cord, or speaker leads will fit. Priced at $14.95, the new MFJ-701 kit, however, gives you a package of four RFI-eliminating toroids (with complete instructions) which not only have the right properties for eliminating RFI, but separate into halves, making it easy to wind nearly any kind of wire or cable around the toriod. The toriod halves then mount in a snap-together plastic frame.

The individual toroids also snap together into a stack, increasing their effectiveness for large diameter wires when only a few turns can be wound around the toriod.

For additional information on the MFJ-701 RFI-free choke kit, contact MFJ Enterprises, Inc., 921 Louisville Road, Starkville, Mississippi 39759.

Circle #303 on Reader Service Card.

rack-mounted paging encoder

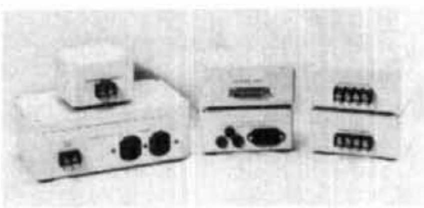
The PE-1000RMA, a rack-mounted version of Communications Specialists, Inc.'s PE-1000 Paging Encoder can be mounted in a standard 19-inch rack. Like the desktop PE-1000, the PE-1000RM is capable of 100- or 1000-call paging capacity in the two-tone sequential signaling formats. Five-tone sequential and REACH formats are also available. Programmable features include code plan and group selection, group call, duration of tone and delay timing, choice of alert tones, and automatic page. A non-volatile memory retains the programming if a power loss occurs. All standard Motorola and General Electric groups are included in every unit; non-standard tones from 250.0 Hz to 4000.0 Hz may be special-ordered. An output for printing a hard copy record of all paging activity is provided, and an automatic self-test is run each time the encoder is powered up. The price is $324.95.

For furter details or a free catalog, contact Communications Specialists, Inc., 426 West Taft Avenue, Orange, California 92665-4296.

Circle #302 on Reader Service Card.

overvoltage protection devices

CSE Technologies has introduced a comprehensive line of Surgeguard devices that provide virtually unconditional overvoltage protection for computing, control, communications, measuring, and home entertainment equipment.



Surgeguard devices include the LSA® Line Surge Absorber, which protects against overvoltage originating from signal/data/telephone lines; the Interguard®, which protects the CCITT V.24 digital interface of terminals, computers, and modems from overvoltages originating from

NEW products

interface cable; the Powerguard®, which provides protection for equipment connected to AC mains supply; Comguard®, which protects terminal-and-modem remote data stations; Termiguard®, which protects remote terminals, and Modemguard®, which renders modems immune to overvoltage damage.

A number of different Surgeguard models can be fitted in the same enclosure. Enclosures can be stand-alone, rack-mount, or plug-in modules for circuit boards. For more information, contact CSE Technologies, P.O. Box 308, New London, Minnesota 56273.

Circle #306 on Reader Service Card.

IC-900 mobile transceiver

ICOM's new IC-900 mobile transceiver is the first fiber optic multiband mobile transceiver that allows you to operate up to six bands ranging from 10 meters to 1.2 GHz with one controller.

The IC-900 includes an ultra-compact remote controller for remote mounting, an Interface A unit, an Interface B unit, an SP-8 speaker, an HM-14 up/down DTMF microphone, plus fiber optic and controller cables.

Measuring only 1 × 2 × 5.7 inches, the remote control display can be installed on your car's dash or sun visor with supplied Velcro® strips. Simple to operate, it's equipped with a large LCD for easy viewing.

The IC-900 allows the operator to listen on two bands simultaneously or transmit on one band while receiving on another band (for true full duplex crossband operation.) All subaudible tones are built in, and the actual subaudible frequency is displayed. Ten memories are available for each band, with individual PL tone and offset programming capability.

Two scanning systems are available: programmable band scan and memory scan. Fiber optic technology enables a 3/16-inch cable to transport all data between Interface A (installed near the driver's seat) and Interface B (installed in trunk or rear of vehicle). Fiber optic cable also eliminates rf feedback.

Separate rf modules will be available for 10, 6, and 2 meters, and 135, 75, and 25 cm.

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

Circle #305 on Reader Service Card.

repeater controller upgrades

ACC has announced two new upgrades for the RC-85 repeater controller.

Version 3 Firmware nearly triples the synthesized speech vocabulary to almost 500 words, making it easier to remotely program useful ID, tail, and bulletin board messages. A Kenwood TS-711A or TS-811A transceiver may now function as a synthesized remote base transceiver, with control through its serial port; support of these transceivers simplifies adding a remote base to the repeater system.

Many additional enhancements such as patch redial, more macro sets, zero hang time mode are included. The price is $125.00.

The AD-1 Audio Delay Line board provides a 75-ms audio delay from the repeater receiver to the transmitter. The benefits are squelch tail muting and complete touchtone muting through the repeater, resulting in pleasing repeater audio. The audio delay feature, an innovation ACC introduced in the RC-850 controller, is now available as an option for the RC85, priced at $150.00.

For additional information, contact Advanced Computer Controls, Inc., 2356 Walsh Avenue, Santa Clara, California 95051.

Circle #308 on Reader Service Card.

multimode TNC

The new Heathkit HK-232 Pack-Kit™ Multi-Mode TNC kit — a versatile addition to Heath's expanding Amateur Radio line — takes the hassle out of getting into RTTY, lets users run CW at speeds from 5 to 99 wpm and works on AMTOR, ASCII, hf, and VHF Packet. It decodes Weather Facsimile pictures onto Epson-compatible printers. The Multi-Mode TNC works Packet in both HF (300 baud) and VHF (1200 baud or up to 9600 baud, with an external modem.)

Adding the HK-232 to a radio and computer lets the Amateur get on the air in every mode. It connects to the radio's PTT line, speaker output, and microphone input for interchangeable VHF and HF operation. The same connections work for all other modes including CW.

Amateurs can connect both their hf and VHF rigs at the same time, to allow switching between VHF Packet and copying a WIAW RTTY bulletin on 40 meters with just the push of a button.

A unique "SIGNAL" command causes the Pack-Kit to determine the correct RTTY, ASCII, or AMTOR mode for the signal the Amateur is listening to. It also presets baud rate and mode and will invert the signal if necessary. All the user does is type "OK."

The HK-232 even handles American Standard Baudot (Western Union), Japanese Katakana Morse, Cyrillic (Russian) Morse, and translated versions of Cyrillic and Katakana.

The Pack-Kit will copy signals that seemingly baffle other units. The HK-232 features an eight-pole audio bypass filter followed by a limiter discriminator with automatic threshold correction.

No special software is required to operate the HK-232 Pack-Kit TNC. It can be used with any modem communication package you may already have or an optional program written specifically for the HK-232 and a Heathkit/Zenith PC or PC-compatible computer. It connects to a terminal or computer through a standard RS-232 serial port at baud rates from 300 to 9600. A step-by-step, easy-to-understand Operation Manual is included.

For more information, send for a free copy of the Heathkit Catalog; contact Heath Company, Department 150-945, Benton Harbor, Michigan 49022. (In Canada, contact Heath Company, 1020 Islington Avenue, Department 3100, Toronto, Ontario, M8Z 5Z3.

Circle #301 on Reader Service Card.

trap antennas

Spi-Ro Manufacturing offers a complete line of both dipole and vertical "sloper" multi-band trap antennas that cover all Amateur bands from 10 through 160 meters.

The lightweight, sealed, and weatherproofed traps feature rustproof solid brass terminals that require no soldering or jumper wires. Easy to install in the field, they handle full power, and allow users to work multiple bands with a single antenna. They're suitable for all transmitters, transceivers, and receivers, and are fed with coax via a standard PL-259 connector.

For more information, contact Spi-Ro Manufacturing, Inc., P.O. Box 1538, Hendersonville, North Carolina 28793.

Circle #309 on Reader Service Card.

flea market

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

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

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

DEADLINE 15th of second preceding month.

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

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

TEST EQUIPMENT WANTED. Don't wait we'll pay cash for LATE MODEL HP, Tek, etc. Call Glenn, N7EPK, at Skagitronics Co. (800) 356-TRON.

"HAMLOG" COMPUTER PROGRAMS. 17 modules auto-logs, sorts 7-band WAS/DXCC. Full features. Apple $19.95, IBM or CP/M $24.95. KA1AWH, POB 2015, Peabody, MA 01960.

RV OPERATORS are invited to check in Sun 2 PMC, 14.240 + 5. Tues, Thurs 8 PMC 3.880 + 5. Good Sam RV Net. Info SASE KJ4RO.

FREE HAM CATALOG. SASE. Bahr, 2549-H6 Temple, Palm bay, FL 32905.

HOMEBREW PROJECTS. SASE. WB2EUF, Box 708, East Hampton, NY 11937.

YAESU FT-727-R COMPUTER INTERFACE. For info write Gerald Hogsett Consulting, 1581 Woodland, Palo Alto, CA 94303.

TEN-TEC CORSAIR Model 560 with 280 power supply additional 2nd 8 pole 2.4 KC filter plus 1.8 KC and 500 Hz filters $845 w/shipping. AEA PK-64 w/HF modem, w/shipping $130. MFJ Versa Tuner V Mod 989, 3 KW w/shipping $145. All items mint condition Richard B. Stevens, W1QWJ, POB 118, Ashuelot, NH 03441 (603) 239-6079.

EIMAC 8877 less than 10 hours use with filament transformer $330, shipped. Richard B. Stevens, W1QSJ, POB 118, Ashuelot, NH 03441.

COMMODORE REPAIR. We are the largest/oldest Authorized Service Center in the country. (ex. C64-$39.95). 72 hour turnaround. Call Toll Free 1-800-642-7634 (outside NY) 914 356-3131. Kasara Microsystems, Inc., 33 Murray Hill Drive, Spring Valley, NY 10977.

COMMODORE CUSTOM CHIPS for C64/128 Computer Peripherals at low prices, 24-hour delivery #6510-$9.55*6526-$9.95*, #6567-$14.75, #6581 $12.85, PLA-$10.95, 901 ROMS at $10.95 each, C128 ROMS-$39.95 (set of 3) and many others"THE COMMODORE DIAGNOSTICIAN". A complete diagnostic reference chart for fixing Commodore computers, etc. An absolute must for those who want to fix their own computers and save money and down time. $6.95 plus postage...HD Power Supply for C64-$27.95...Send for complete chips/parts catalog. Kasara Microsystems, Inc., 33 Murray Hill Drive, Spring Valley, NY 10977. 800-248-2983 (outside NY) or 914-356-3131.

CODE PROGRAMS. APPLE/C-64. 37 modes. LARESCO, POB 2018, 1200 Ring Road, Calumet City, IL 60409. 1-312-891-3279.

FREE SELL-WANT LIST. WA6GER, 3241 Eastwood Rd, Sacramento, CA 95821.

FOR SALE: Yaesu FT-101EE, CW filter, desk mic, cover, manual, original box, excellent condition. Upgrading. $550. Matt Tyszka, 129 West Rd, Collinsville, CT 06022. (203) 693-0468. (WA1HRE).

WANTED: External Frequency Display YC-7B for Yaesu FT7B. W4YKH "Bill". Call collect (703) 533-0359.

DENTRON RADIO COMPANY—*The New Dentron Radio Company.* Replacement parts, technical information, new products. We will service any Dentron Radio products. Models Clipperton L, MLA 2500, Gla1000 series, MT3000A, MLA1200, DTR2000, DTR1200L, MT2000A or any Dentron Radio product. Please call or write. We will do our best to serve you. Dentron Radio Company, Inc, PO Box H, East Rockaway, New York 11518. Call (516) 536-2620.

23CM FM TV. Full line of modules. Tactical Electronics, PO Box 1743, Melbourne, FL 32902.

IBM-PC RTTY/CW. New CompRtty II is the complete RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in screen editor! Adjustable split screen display. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS-232C TU. $65. Send call letters (including MARS) with order. David A. Rice, KC2HO, 25 Village View Bluff, Ballston Lake, NY 12019.

SLEP SPECIALS: Jennings UCSL-1000 vacuum variable capacitors 10 thru 1000 MMFD at 5000V with gear drive train and mounting bracket. Ideal for that linear amplifier or tuner $69.50. Plate transformers Gonset P/N 271-107 for models 903, 913A 2/6M VHF linear amplifier using 4X150A, 4CX250B, 1650 VDC at 400 MA size inches 5-1/4L x 4-1/2W x 4-1/4H for replacement or amplifier construction $37.00. HP805B slotted line 500 MHz thru 4 GHz $275.00, HP8640B 500 kHz–1024 MHz $5,500.00. Tektronix 545B oscilloscope with CA dual trace plug-in $375.00. TS-510A signal generator 10 MHz-420 MHz, military version of HP608D $275.00, HP606A signal generator 50 kHz thru 65 MHz $375.00. Have quantity all items, satisfaction guaranteed. VISA, M/C or check. Add shipping. Phone Bill Slep (704) 524-7519. Slep Electronics Company, Highway 441, Otto, NC 28763.

MEASURE VSWR, antenna patters, match circuit impedances from 100 kHz to 2 GHz with portable scalar network analyzers. Write for details. Direct Conversion Technique, 3132 North Lowell Avenue, Chicago, Illinois 60641. (312) 283-1690.

CHASSIS, CABINET KITS. SASE. K3IWK, 5120 Harmony Grove Road, Dover, PA 17315.

TELEVISION SETS made before 1946, early TV parts, literature wanted for substantial cash. Especially interested in "mirror in the lid" and spinning disc tv's. Finder's fee paid for leads. Arnold Chase, 9 Rushleigh Road, West Hartford, Conn 06117. (203) 521-5280.

ENGINEERS request free catalog of Electronics Software. Circuit analysis, filter design, graphics, etc. BV Engineering, 2200 Business Way, Suite 207, Riverside, CA 92501 (714) 781-0252.

REMEMBER TROLLEY CARS? *Trolley Treasures: The Wartime Years in New Jersey* (1939-1947), a 4-volume photodocumentary history, includes 1600 unpublished, original photographs plus extensive historical notes. Volume I, *The Compromise Roof Cars of Public Service Coordinated Transport,* ready now. SASE for details. To order, contact Trolley Themes, A.W. Mankoff, 2237-3 Woodside Lane, Sacramento, CA 95825. ($14.95 plus $1.50 S&H).

$$$$$SUPER SAVINGS on electronic 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.

RTTY JOURNAL—Now in our 35th year. Join the circle of RTTY friends from all over the world. Year's subscription to RTTY JOURNAL, $10.00, foreign $15.00. Send to: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

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

WANTED Manuals and Cables for type RBM-3 Rcvr, June 1942 and CCT 20086 power unit. D. Palmer, W6PHF, 638 Benvenue Avenue, Los Altos, CA 94022.

BACK ISSUES HR Magazine from Vol. 1 No. 1 thru1986, except 2 issues. $150for all postpaid. Also PopTronics, RE, 73 back to 1961. $15.00/full year. Write with your needs. Bill Fossman, 632 Wetmore, Everett, WA 98201.

CANTENNA NEW $20.00 1 kw, Ham Keyer model HK5A new $40.00. Roller inductors, Johnson and B.W. $20.00 each. M.C. Jones power meter 1 kw with coupler $2000, new 813 transmitting tubes $20.00 each. C.E. 100V exciter $170.00, 75S3 receiver $175.00, Collins Brown Simpson MK 75 memory electronic keyer $125.00 mint. Near new Gonset GSB 100 $125.00, Eldico 100F exciter $150.00, miniature tubes $1.00 each, octals loctals $2.00 each. Levy, W5QJT, 2833 Junction Hwy No. 15, Kerrville, TX 78028 (512) 367-4741.

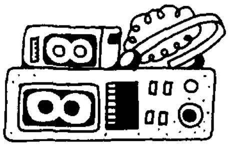
MARCO: Medical Amateur Radio Council, Ltd, operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc) invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

RUBBER STAMPS: 3 lines $4.50 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

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

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

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



COMING EVENTS

Activities — "Places to go . . ."

SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC, ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD BE GREATLY APPRECIATED BY OUR BROTHER/SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

CONNECTICUT: November 15. SCARA Indoor Ham Radio and Computer Flea Market, N. Haven Park and Recreation Center, 7 Linsley St, N. Haven. Sellers admitted at 7 AM; buyers from 9 AM to 3 PM. Tables are $10 in advance, $15 at the door. General admission $2 per person. Talkin on 146.61 MHz. Reservations for tables must be prepaid by November 4, 1987and no reservation by phone. For information or reservations SASE to: *SCARA, POB 81, N. Haven, CT 06473 or call Brad at (203)* 265-6478 between 7 PM and 10PM.

INDIANA: November 8. The Allen County Amateur radio Technical society presents its 16th annual Fort Wayne Hamfest, Allen County Memorial Coliseum, Coliseum Blvd. 8 AM to 4 PM. General admission $3.50/advance; $4.00/door. Chilcren 11 and under free. VE exams November 7 by advance registration only. Forums. Other activities. Nearby motels and restaurants. For more information or reservations contact AC ARTS Hamfest, POB 10342, Fort Wayne, IN 46851. For information ONLY Bernie Holm, K9JDF, Hamfest Chairman (219) 485-0164, 6 to 10 PM EST.

OKLAHOMA: October 4. Salt Plains ARC Eyeball QSO Party *south side of Salt Plains Lake, North Central Oklahoma. Talk* in on 147.30/90 or call Gary Gerber, KB0HH (316) 842 5079 or 842-5155.

ILLINOIS: October 31 and November 1. The Fox River Radio League is sponsoring the ARRL's Central Division Convention as part of a Hamtastic Weekend. Norris Sports Center of Rt 64 in St. Charles, about 35 miles west of Chicago. 8 AM to 2 PM both days. Tickets $3.00/advance; $4.00 door good for both days. Indoor flea market, forums, seminars and tech demos. Exams for all license classes. For advance tickets or information on tables or exams contact Phil Fors, N9FXO, 104 May Street, West Chicago, IL 60185 (312) 231-8841. SASE appreciated. Talk in on 145.47 (-600) and 145.21 (-600).

ILLINOIS: November 1. The Waukegan CAP will hold its 7th annual Hamfest, Lake County Fairgrounds, Rts 120 and 45, Grayslake. 7 Am to 5 PM. Large indoor flea market, cafeteria, free parking. Tables $5.00. Donation $3.00. For information and reservations SASE to CAP, 637 Emerald Street, Mundelein, IL 60060.

MINNESOTA: October 31. The third annual Hamfest Minnesota and Computer Expo, sponsored by the Twin City FM Club, Hennepin Technical Center, North Campus, 9000 Brooklyn Blvd, Brooklyn Park. 7:30 AM to 3:00 PM. Admission $3.50/advance; $4.50/door. Guest speakers Tony England, W0ORE and Doug Clapp. New CW contest, FCC exams, giant indoor flea market and much more! Talk in on 16/76. For information or registration SASE to Hamfest Minnesota and Computer Expo, Box 726, St. Louis Park, MN 55426.

NEW YORK: October 17. The Radio Amateurs of Greater Syracuse will hold their 32nd Hamfest, Arts and Home Center, New York State Fairgrounds. Giant indoor Flea Market, tech talks, contests, entertainment. Programs for non hams. Tailgating area

$3.00/car. Indoor flea market table $6.00 furnished. General admission $4.00. Under 12 free. FCC walk in exams start 12 noon. Novice through Extra. Talk in on 146.31/91 and 147.90/30. For information call Ed Swiatlowski, WA2URK (315) 487-3417 of Viv Douglas, WA2PUU (315) 469-0590 or write RAGS, POB ;88, Liverpool, NY 13088.

OHIO: October 25. The Marion ARC will hold its 13th annual Heart of Ohio Ham Fiesta, Marion County Fairgrounds Coliseum. 0800 to 1600 hours. Tickets $3/advance; $4/door. Tables $5. Check in on 146.52 or 147.90/30. For information, tickets or tables contact Ed Margraff, KD8OC, 1989 Weiss Avenue, Marion, Ohio 43302 (614) 382-2608.

ARIZONA: October 3. The Cochise ARA will hold its annual Swapmeet at the Club's Training Facility on Moson Road, Sierra Vista. Talk in on 146.16/.76. No charge for tailgaters. Refreshments available. For information: Jacquie Kelly, KD7DZ (602) 458-4107 or write CARA, POB 1855, Sierra Vista, AZ 85636.

OKLAHOMA: October 24-25. Texoma Hamarama '87, Lake Texoma Lodge, Catfish Bay, east of Kingston. ARRL programs, non-ham programs, Amateur exams, indoor/outdoor flea markets and more. Banquet, entertainment and dancing. For additional information contact: Texoma Hamarama Association, POB 610892, DFW Airport, TX 75261.

NEW YORK: October 18. Raindate October 25. NYC Largest Hamfest sponsored by the Hall of Science ARC, Hall of Science parking lot, 47th Avenue and 111th Street, Flushing Meadow Park, Queens. 9 AM to 3 PM. Buyers donation $3.00; Sellers $5.00. Computers, Amateur Radio, ARRL info, dealers. Visit the newly reopened Hall of Science museum and HOSARC's ARA WB2JSM. For more information call evenings only Steve Greenbaum, WB2KDG (718) 898-5599 or Arnie Schiffman, WB2YXB (718) 343-0172

TENNESSEE: October 24-25. The 9th annual Chattanooga Amateur Radio and Computer Convention, Grand Central Station at Chattanooga Choo-Choo complex. Amateur exams Saturday and Sunday. All forms should be sent to Hamfest Chattanooga, POB 3377, Chattanooga, TN 37404 by October 20. 8' flea market tables $10/day or $15/weekend. Talk in on 146.19/79. For further information write Hamfest Chattanooga, POB 3377, Chattanooga, TN 37404. Exhibitor info call WA4RMC (615) 892-8889. Flea Market info call KB4RTM (615) 622-8467 after 6 PM or W4ECW (615) 698-2147.

OHIO: October 11. NOARC (Northwest Ohio ARC) will hold their annual Allen County Hamfest, Allen Cluty Fairgrounds, Lima. Tickets $3.00/advance, $3.50/door. Tables $6.00 full; $3.50 half. License exams. Free camping available. Elec. $7.00. Talk in on 146.67 and 146.52. For info about exams W8TY, NOARC, Box 211, Lima OH 45802.

TENNESSEE: October 17. The 7th annual Tri-Cities Hamfest, Appalachian Fairgrounds, Gray. Indoor/outdoor flea market. Forums, dealers, RV hookups. Talk in on 146.37/97 and 146/01/61. For information write Tri-Cities Hamfest, POB 3682 CRS, Johnson City, TN 37602

MASSACHUSETTS: October 25. The Framingham Amateur Radio Association's annual Fall Flea Market and Exams, Framingham Civic League Building, 214 Concord Street, Downtown Framingham. Doors open 10 AM. Sellers setup 8:30. Admission $2.00. Tables $10 includes one admission. Talk in on 75/15 repeater. For tables Jon Weiner, K1VVC, 52 Overlook Drive, Framingham, MA 01701 (617) 877-7166. For exams send Form 610, copy of license and $4.35 check to FARA, POB 3005, Framingham, MA 01701.

PENNSYLVANIA: November 1. The RF Hill ARC's 1987 Hamfest, Pennsylvania National Guard Armory, PA Rt 152, Sellersville. Doors open 6 AM for sellers, 8 Am for general public. Entry $4.00, accompanying spouse and kids free. 6'x 8' indoor space $8. Outdoors $6. Talk in on repeaters at 145.31, 145.19, 146.88 and 146.52. To reserve space write Hamfest Chairman, 523 Vine street, Perkasie, PA 18944.

MICHIGAN: October 25. The Southwest Michigan AR Team and the Kalamazoo ARC are sponsoring the 5th annual Kalamazoo Hamfest. New larger location - Kalamazoo Central High School, 2432 N. Drake Road. 8 AM to 4 PM. Walk in VE testing. Admission $2/advance, $3/door. Tables $6. Send requests and check with SASE by September 28 to Jim Hastings, Kalamazoo Hamfest, 1813 Greenbriar Drive, Kalamazoo, MI 49008.

OPERATING EVENTS

"Things to do . . ."

October 17-18: 30th Scout Jamboree on the Air. Active Scouts, former Scouts, Amateur Radio Operators; any and all who are interested in doing a good turn for Scouting and Amateur Radio.

October 4. The Fresno ARC emergency communications van will operate from the City of Clovis to help celebrate their Octoberfest Crafts Fair - Pioneers' Day. 1500Z Oct. 3 to 0100Z Oct. 4. Listen for W6TO, the Diamond Jubilee Special Event Station. For certificate, QSL, large SASE to W6TO F.A.R.C., POB 783, Fresno, CA 93712-0783.

October 10-11: The South TexasAmateur Repeater Society (STARS) will operate N5CAF, 1400Z-2300Z to commemorate the annual Confederate Air Force Airshow held in Harlingen, TX. For special certificate QSL and SASE to Dr. David Woolweaver, K5RAV, 2210 S. 77 Sunshine Strip, Harlingen, TX 78550.

October 17-18: The Edmond ARS, a Special Service Club, will operate W5ERY from 1700Z to 1700Z in celebration of its 30th anniversary as an Amateur Radio club. Members will operate from the shores of beautiful Lake Arcadia. For a certificate send 9x12 SASE, 39 cents postage, to Edith Vaughn, KA5YPX, 1020 Juno Circle, Edmond, OK 73034.

HAM EXAMS: The MIT UFH Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday October 21, 7 PM, MIT Room 1-150, 77 Mass Ave, Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann at (617) 646-1641. Exam fee $4.25. Bring a copy of your current license (if any), two forms of picture ID, and a completed form 610 available from the FCC in Quincy, MA (617) 770-4023.

short circuits

high-performance Yagis

In **fig. 11** of K1FO's July, 1987, article, "High Performance Yagis for 432 MHz," a dimension is incorrectly placed. In the upper right hand part of the figure, the dimension "2 5/16" should be moved to the right, to indicate the distance between the end of the T-match section and the end of the driven element.

ladder networks

The following information was omitted from **fig. 2** of W3NQN's article, "BASIC Program Analyzes Simple Ladder Networks" (August, 1987, page 34):

RS = RL = 50 ohms
C1 = C5 = 1100 pF
C3 = 560 pF
L2 = L4 = 1.75 μH

Fco = 3.37 MHz
F 3 dB = 2.74 MHz
F 20 dB = 1.97 MHz
F 40 dB = 1.32 MHz

wrong call

In **table 3** of W1JR's column in the July, 1987 issue, the call "WA5CIW/5," listed under 5760 MHz, should be corrected to read "WA5ICW/5."

SSTV with C-64

The address of the Journal of the Environmental Satellite Users' Group was shown incorrectly in the October article, "Get on SSTV with the C-64" (page 43). The correct address is 2512 Arch Street, Tampa, Florida 33607. (Tnx WD4MRJ)

Yaesu FRG9600 modification

A complete kit — or circuit boards alone — for the modification described in W6MGI's article, *"Add General Coverage to Yaesu's Latest VHF/UHF Receiver"* (October, 1985, page 67) is available from Radiokit, P.O. Box 411H, Greenville, NH 03048. The kit is priced at $89.95 plus $3.00 shipping and handling; the boards only, at $7.00 plus $1.25 shipping and handling.

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ELMER'S NOTEBOOK

Tom McMullen, W1SL

packet communications

The answer is "definitely *not*!"

The question is "Is this guy hung up on digital stuff, or what?"

Hung up on digital stuff? No. But enthused? Absolutely! You see, I'm a follower of the old adage that there's no such thing as too much knowledge. I've never learned anything that I haven't found useful at one time or another, so I'm all for grabbing any knowledge I'm capable of absorbing. (And it's surprising how much you retain, even when you think you're in over your head.)

At the same time, however, I realize that not everyone shares my enthusiasm for "all things, great and small." Hence my opening answer to questions that might come up about subjects covered in pursuit of the goals of this column. As stated originally (June, 1987), the purpose of Elmer's Notebook is, first, to address the immediate needs of Elmers, Novices, and anyone else coping with the "Novice Enhancement" rules change; and second, to continue with as many subjects as needed to help Novices (or anyone else, for that matter) upgrade to a higher class of license or simply enjoy Amateur Radio more.

Along these lines, I'll cover whatever topics I think will be useful. (I'm certainly open to suggestions.) So if a particular column doesn't fit into your concept of what Amateur Radio means to you, read it anyway so you'll have something filed away as "Maybe Useful — Someday." Hang in there — I'll get to your favorite subject sometime, especially if you'll tell me what it is! Now, let's take a look at packet radio.

what's a packet?

According to some dictionaries, a packet is "a small package that contains anything. . . ."[1] An electronics dictionary defines a packet as "a group of binary digits, including data and control elements, which is switched and transmitted as a composite whole."[2]

Though both definitions apply to Amateur packet radio in a general way, let's see if we can be more specific without letting the technicalities overwhelm us. Describing a packet as "a package that contains data and control elements" sounds good, but isn't that what RTTY, voice, and CW messages are? After all, they include the information to be transferred (the message), the control information (the address for delivery, the identification of the sender, and a word count for checking accuracy). The answer, then, is "Yes, but. . . ."

The rapid growth of packet radio began with a coincidence of timing that placed the newly popular personal computer within reach of many enthusiasts and the relaxing or rewriting of Amateur rules to allow data communications of greater bandwidths on the VHF and UHF bands (increased bandwidths allow higher speed communications). It doesn't really matter which mode you're using if you're limited to a top speed of 100 baud or so on the hf bands; RTTY, AMTOR, and ASCII can handle that speed with ease. The higher speeds permitted on 2 meters and above were attractive, but the need for something better than the digital modes used on the lower bands was obvious. For one thing, RTTY and its cousins had no provision for rapid automatic relaying of data if there wasn't a direct path between the originator and the destination. The instructions required to do this (called "overhead") could end up longer than the text that was to be sent.

In their search for better means of transferring data between computers at scattered locations, commercial developers devised systems that provide fast, accurate transfer of data via telephone links, cable systems, and/or microwave or satellite relays. They're not only accurate and fast; they're *transparent* to the user — i.e., you feed your message into the system, and the system does the rest. Networks and repeaters are also accommodated in the language of these systems.

Such systems and languages are called *protocols*. "Protocol" means the same thing in packet radio as it does in any other context; it's a set of prearranged operating procedures, signals, and language that make sure you understand precisely how I'm going to say something, what I mean when I say it that way, and how you should respond when I say it. As long as we both stick to the protocol, the chance for misunderstanding (i.e., errors) is small.

One very successful digital protocol

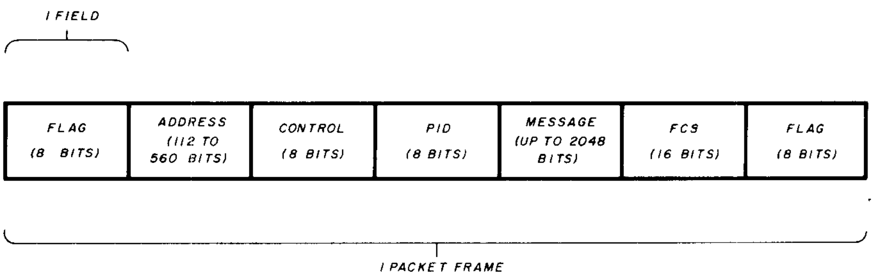


fig. 1. The AX.25 packet protocol frame is made up of several fields, each with a specific number of bits that convey special information about operation. This is an information frame. Supervisory frames, used to control links or repeaters, are similar but do not contain the message field.

is called High-level Data Link Control, or HDLC. Obviously, you don't have to know all about HDLC or the other protocols used to enjoy packet radio, but a basic understanding will help you see how it all fits together. (Beside, sooner or later you'll start wondering, "How do they do that?")

HDLC is part of a broader protocol called X.25, which covers several "layers" of packet radio, from the local level up through several types of networks. I'll not go into the history of how Amateurs got packet radio going, except to say that several individuals and organizations realized that a standard was needed if packet was to become more than a curiosity. As a result of a series of conferences, the X.25 protocol was adopted, with some minor modifications, as AX.25 (the A is for Amateur, obviously). Predictably, once a standard was established, the mode — and the equipment industry to supply it — mushroomed. (If you're interested in more information about the birth and development of growth of packet radio, see "for further reading," at the end of this column.)

The Amateur packet radio protocol isn't really very complex (see **fig. 1**). Each packet frame is made up of well-defined sections called *fields*. Each has a specific job to do, as defined by the protocol.

The first field is a *flag*. In digital language, a flag is an arrangement of bits that attract the attention of the data-processing equipment. In AX.25, the protocol tells the sending equipment, "When you want to get the other guy's attention, send eight bits arranged in this manner (01111110)." The receiving station has been told, "Every time you see eight bits arranged in this particular pattern, pay attention!"

The rest of the packet is checked to make sure that this pattern never occurs anywhere except at the start or end of a packet. What the first flag says, in essence, then, is "This is the start of a packet."

Next is an *address field*, which contains both the identification of the originator and the destination. One of the nice features of AX.25 is that it recognizes Amateur call signs as proper addresses.

The third field presents *control information*. Control information can vary, depending upon the job it has to perform, but the most common types in this field include information for the user, supervisory information for controlling data flow, and "unnumbered" information for controlling the link (if any).

Next is a *protocol identifier field* (PID) that identifies the network-layer protocol being used (if any).

Then comes the *information or message field*. This is where your "Having a great time, wish you were here" message goes. There's room for 2048 bits in this field, but you don't have to use all of them. Most of the packets I've seen consist of two to three lines of text on a normal computer screen. Each line requires approximately 640 bits for an 80-character-wide screen, so a three-line packet message would use up to 1920 bits.

The field following the message is a *frame check sequence* (FCS). (Didn't I warn you that packet radio was loaded with "alphabet soup"?) The FCS tests the message for accuracy. It doesn't care if you misspelled or mistyped a word; it simply checks to confirm that it received everything that was sent. This is done by a formula that I won't go into here, but the microprocessor in your TNC (terminal node controller)* knows all about it. Basically, the sending station calculates and sends a number and the receiving station performs the same calculation to see if it gets the same number. If it does, the receiving station sends an acknowledgment, or "ack"; if it doesn't, no acknowledgment is sent, and the sending station repeats the packet, saying, in essence, "I'm going to keep on doing this until you get it right!"

The last field is a flag that signifies "The End."

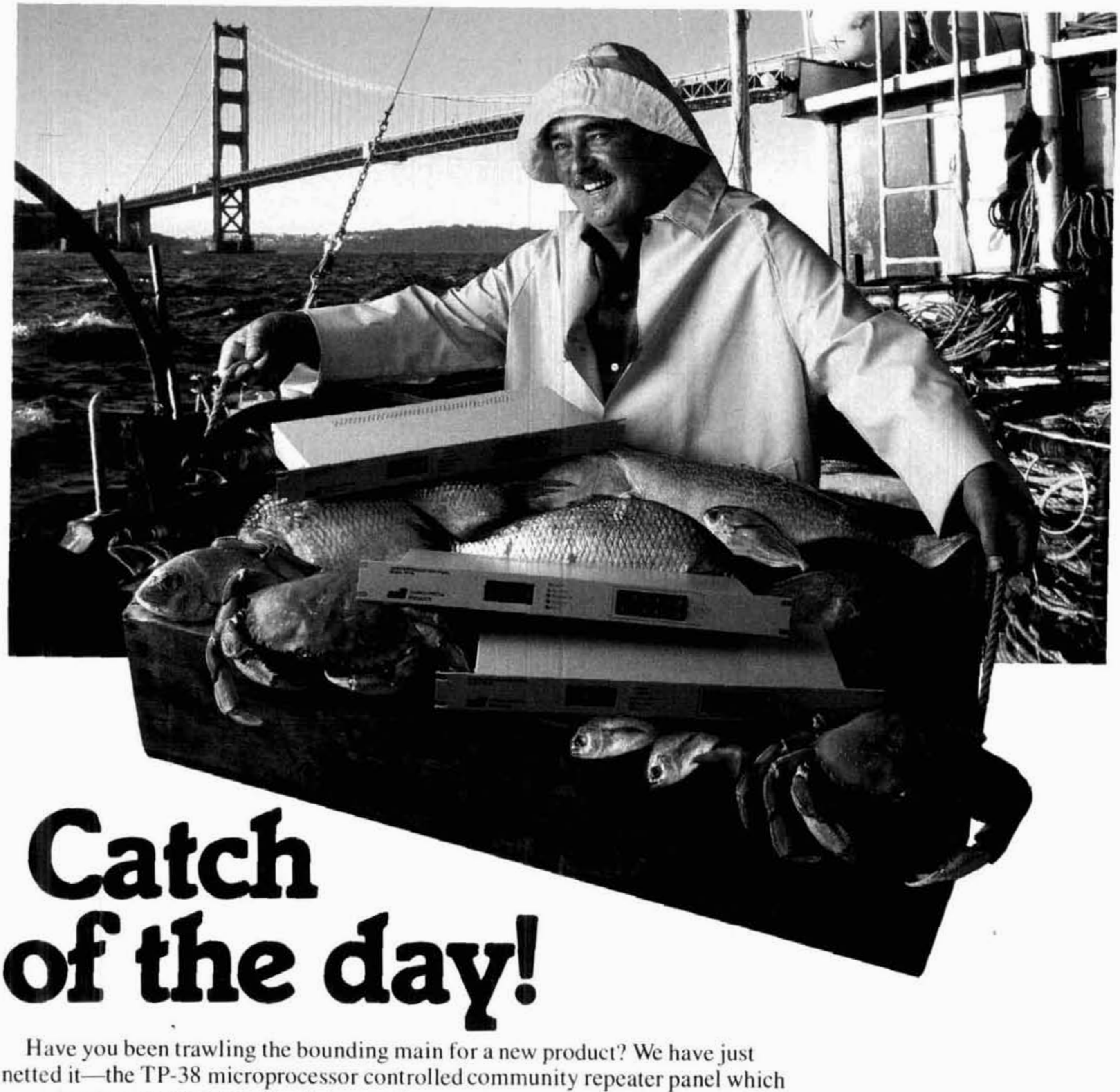
This sounds like heavy stuff, but the microprocessor handles it so fast that you don't even know it's happening. A packet passed between two Amateurs chatting via their keyboards can be sent and acknowledged in less than 1/4 second.

hooking it up

The output from the TNC is in the form of audio tones, which are applied to the modulator in the transmitter just as any other audio would be. The output from the receiver is also audio tones, which the TNC processes to provide binary digits (pulses) for the microprocessor.

Commercially available TNCs come equipped with instructions for connection to your computer, and cables

*A *terminal* is your keyboard and screen; a *node* is a connection point to a network or circuit; and the *controller* does just that — it controls the data flow by putting information into packets according to the protocol in use.



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may or may not be supplied. If they're not, you can make or perhaps buy some that will do the job. Hookup is frequently just as simple as plugging the cable into the serial port of the computer and using software that makes your computer act like a dumb terminal.

On the radio end, it's as simple as applying audio and push-to-talk (PTT) connections to the microphone (or auxiliary) input for the transmitter, and then plugging a connector into the external speaker plug on the receiver. Connectors vary in size, so you may have to shop for the right size to fit your radio. Many packet controllers use a nine-pin connector for the audio output/input to and from the radio, so you'll have to connect the wires from the microphone input and speaker output to this connector. It's a good idea to provide a termination for the radio's speaker to provide impedance matching and prevent distortion. **Figure 2** shows one way of doing this.

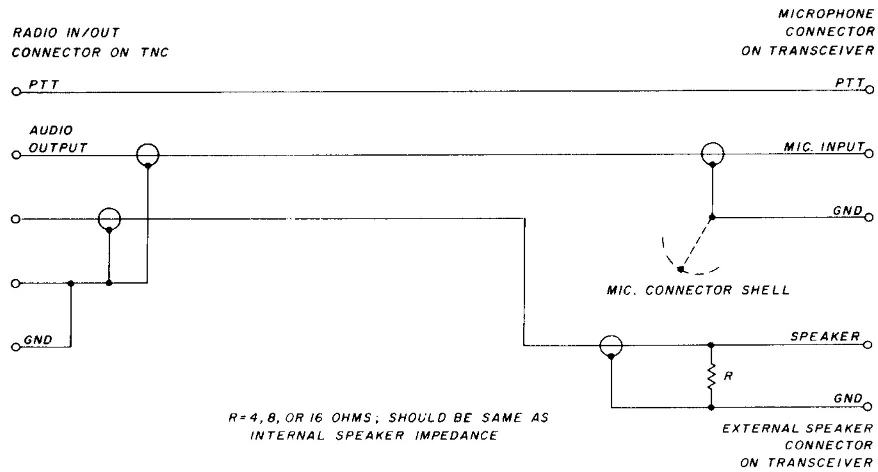

fig. 2. Typical connections between the TNC and radio equipment. Consult your TNC owner's manual for exact connector types and pin numbers to use.

what can I do with packet?

Packet is the fastest-growing mode of Amateur communication today, and more uses for it emerge all the time. In addition to just chatting with your nearby friends, you can send packets over *digipeaters* (digital repeaters) to distant stations (up to eight repeats can be handled by the packet protocol). You can perform public service at events or in emergencies; packet radio was used in the 1984 Summer Olympics in Los Angeles, in the field at forest fires in California, and in innumerable emergencies and emergency-preparedness drills nationwide. There are hundreds of packet bulletin boards (PBBS) throughout the country, and stations called "Gateways" that provide access to satellites and to UHF repeaters that increase the baud rate and allow rapid transfer of packet information over vast distances. Packet will also handle graphics, which opens even more possibilities!

what frequencies?

Like other digitial modes, packet can be used on 10 meters between 28.1 and 28.3 MHz. Novices can *listen*, but not operate, on several frequencies used on 2 meters; 145.01 MHz is the most popular, with 145.03, 145.05, 145.07, and 145.09 not far behind.

Several frequencies (223.42 to 223.90 MHz) on the 220-MHz band have been suggested for Novice packet operation. 223.30 has been suggested as a national packet simplex frequency (unless it's in use by a local repeater). Note that 223.50 is the national simplex frequency for voice fm, so don't use packet on that one.

Parts of the 220-MHz band have been used for developing experimental high-speed (9600 baud or higher) packet networking.

With Novice privileges now including packet on 220 MHz, the number of digipeaters and voice repeaters should increase, and local activity should grow rapidly. Check with local clubs for new activity in your area.

Here's a helpful tip for when you get your TNC hooked up and want to see things happening on your screen: set the Monitor Mode to ON. This will let you "read the mail" on the bands on which you can't transmit. Your instruction book will tell you how to do this — it's usually as simple as entering a command (usually MONON or MALL) from the keyboard.

This has been a thumbnail sketch of what makes packet radio an effective and entertaining mode. There's much left to tell, however, and I'll do that in a future column.

for further reading

The Amateur magazines have featured many excellent articles on packet radio. The following books contain a wealth of information about the development, operating techniques, and the future possibilities of this mode. All but *The Digital Novice*, which addresses several digital modes, are dedicated to packet radio; the first two are ideal for beginners in packet radio, regardless of license class. All are available from *ham radio's* Bookstore, Greenville, New Hampshire 03048.

The Packet Radio Handbook, by Jonathan L. Mayo, KR3T.

*Get ***CONNECTED to Packet Radio*, by Jim Grubbs, K9EI.

The Digital Novice, by Jim Grubbs, K9EI.

ARRL Computer Networking Conferences 1-4: Pioneer Papers on Packet Radio 1981-1985.

ARRL Fifth Computer Networking Conference Papers, 1986.

references

1. *The Random House Dictionary of the English Language*, College Edition, 1969.
2. *IEEE Standard Dictionary of Electrical and Electronics Terms*, IEEE Centennial Edition, 1984.

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