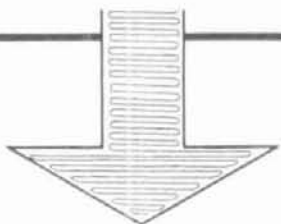
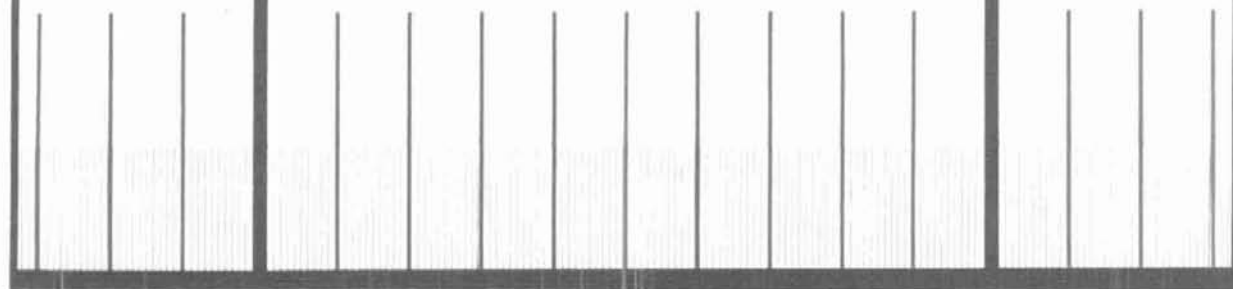


ham *radio* magazine

**the HF/VHF
decade frequency marker**



that does it all



— f —>

ICOM HF Transceiver

IC-751



The Standard of Excellence in HF Base Stations

The IC-751 is the most advanced transceiver available today. It's a competition grade ham receiver, a 100KHz to 30MHz continuous tuning general coverage receiver AND a full-featured all mode solid-state ham band transmitter. The IC-751 also covers the new WARC bands, MARS frequencies, and is AMTOR compatible.

Important Standard Features. Compare these important standard features in this "top of the line" base station:

- 100KHz - 30MHz Receiver
- 105dB dynamic range
- QSK — full break-in CW (nominal speed 20WPM)

- FM Mode Standard
- High-grade FL-44A 455KHz SSB filter
- 32 tunable Memories with lithium battery backup
- 100% Duty Cycle Transmitter
- Passband Tuning
- 12V DC operation
- Adjustable AGC
- Adjustable Noise Blanker
- RIT/XIT with separate readout
- IC-HM12 Microphone with Up/Down Scan
- Continuously adjustable transmit power

Options. IC-EX310 speech synthesizer, internal IC-PS35 power supply, external IC-PS15 or IC-PS30 system supply, IC-SM8 two-cable desk mic,

IC-SM6 desk mic, RC-10 external controller, and a variety of filters.

FILTER SPECIFICATIONS

Filter	Model	Center Freq. [KHz]	-6dB Width
STANDARD FILTERS			
AM Ceramic	CFW 455 IT	455	6.0
SSB (PBT) XTAL	FL-30	9011.5	2.3
FM Filter	9M15A	9011.5	15 (-3dB)
SSB Narrow (Hygrade Crystal)	FL-44A	455	2.4
OPTIONAL FILTERS			
CW Narrow	FL-52A	455	0.500
CW Narrow	FL-53A	455	0.250
SSB Wide	FL-70	9011.5	2.8
CW Narrow	FL-32	9010.6	0.500
CW Narrow	FL-63	9010.6	0.250
AM	FL-33	9010.0	6.0

Operating From 12V, the IC-751 is also available with an optional internal AC power supply, the IC-PS35...for the winning edge in field day competition.



Shown with IC-PS35

The IC-751 provides superior performance for all amateur radio operators...from novice to extra class. See the IC-7 at your local ICOM dealer.

Now with a ONE YEAR Warranty!

ICOM

First in Communication

What To Look For In A Home Patch

The best way to decide what patch is right for you is to first decide what a patch should do. A patch should:

Give complete control to the mobile, allowing full break in operation.

Not interfere with the normal operation of your base station. It should not require you to connect and disconnect cables (or flip switches!) every time you wish to use your radio as a normal base station.

Not depend on volume or squelch settings of your radio. It should work the same regardless of what you do with these controls.

You should be able to hear your base station speaker with the patch installed. Remember, you have a base station because there are mobiles. **ONE OF THEM MIGHT NEED HELP.**

The patch should have standard features at no extra cost. These should include programmable toll restrict (dip switches), tone or rotary dialing, programmable patch and activity timers, and front panel indicators of channel and patch status.

ONLY SMART PATCH HAS ALL OF THE ABOVE.

How Mobile Operators Can Enjoy An Affordable Personal Phone Patch...

Without an expensive repeater.


Using any FM transceiver as a base station.

The secret is a SIMPLEX autopatch. The **SMART PATCH**.

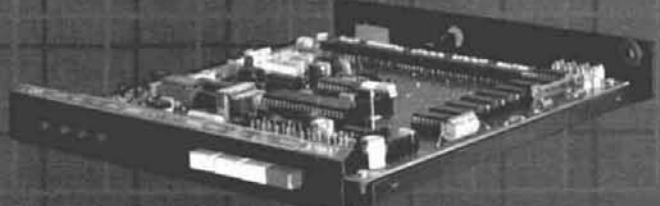
SMART PATCH is Easy To Install

To install **SMART PATCH**, connect the multicolored computer style ribbon cable to mic audio, receiver discriminator, PTT, and power. A modular phone cord is provided for connection to your phone system. Sound simple? ... YES!

With SMART PATCH You are in CONTROL

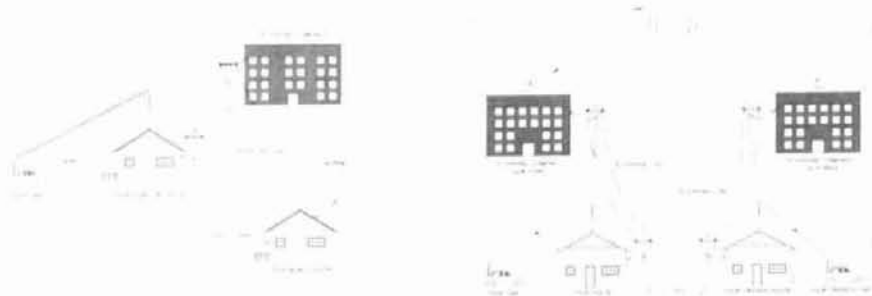


With CES 510SA Simplex Autopatch, there's no waiting for VOX circuits to drop. Simply key your transmitter to take control.



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

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



How To Use SMART PATCH

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

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

Use **SMART PATCH** for:

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

WARRANTY?

YES, 180 days of warranty protection. You simply can't go wrong. An FCC type accepted coupler is available for **SMART PATCH**.



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

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Accessories



TL-922A 160-15 m 2 kW PEP/1 kW DC Input Linear Amplifier. Pair of EIMAC 3-500Z tubes and excellent IMD characteristics. Perfect safety protection with blower turn-off delay circuit.



SM-220 Station monitor/10 MHz oscilloscope. Pan display capability with optional BS-8 (for TS-940S, TS-830S). Monitor transmitted waveforms and/or received signal waveforms. Built-in 2-tone generator.

Not Shown:

MC-50 Desk-top microphone. Hi/Lo Z. 4-pin connector.

MC-80 Desk-top microphone. 700 Ω unidirectional electret element with flexible boom. Built-in mic. pre-amp and UP/DOWN switch, with lock. (8-pin)

MC-48 Hand microphone with 16-key DTMF pad and UP/DOWN switches. (8-pin)

MC-46 As above, but with 6-pin connector.

MC-42S Hand microphone with UP/DOWN switches. (8-pin)

MC-35S Noise cancelling hand microphone. 50 k Ω (4-pin)

MC-30S As above, but 500 Ω .

PG-4A Microphone cable for MC-60A. Converts MC-60A to 4-pin connector.

PG-4B As above, but 6-pin.

PG-4C As above, but 8-pin, as supplied with MC-60A.

PG-4D Extra 4-pin cable for MC-85

PG-4E As above, but 6-pin.

PG-4F As above, but 8-pin.

HS-7 Micro-headphones.

KPS-7A 13.8 V DC, 7.5 A intermittent DC power supply.

RA-3 2 m, $\frac{1}{4}$ λ telescoping antenna with BNC connector.

RA-5 2 m $\frac{1}{4}$ λ / 70 cm $\frac{1}{4}$ λ telescoping antenna with BNC connector.

RA-8B 2 m StubbyDuk[®] with BNC connector

RA-9B As above, for 220 MHz

RA-10B As above, for 440 MHz

RD-20 Dummy load, 50 Ω DC: 500 MHz 20 W continuous, 50 W intermittent.

PG-3A DC line filter for mobile use.

Service manuals are available for all Kenwood transceivers and most accessories.



PC-1A Phone Patch (FCC Part 68 registered).

MA-5 80/40/20/15/10 meter mobile antenna. All resonators supplied. 200 W PEP max., VSWR 1.5:1 or less. Easily adjustable for center frequencies.

VP-1 Bumper mount for above.



VB-2530 25 W RF Power Amplifier (for TR-2600A). BNC-BNC cable, and mounting bracket supplied



HS-5 Deluxe headphones.

HS-6 Lightweight headphones.



LF-30A Low pass filter, 1 kW, 50 Ω . Insertion loss: less than 0.5dB at 30 MHz.

MA-4000 2 m/70 cm dual band mobile gain antenna. Duplexer supplied. Ideal for use with the TW-4000A "Dual Bander" and TM-211A/TM-411A. (Mount not supplied.)

AL-2 Lightning and static arrester. 1 kW, 50 Ω .



MC-85 (8-pin) Multi-function desk-top microphone (8-pin) 700 Ω unidirectional electret condenser mic. Built-in audio level compensation with output and tone control, meter, and UP/DOWN switch. Selector switch for up to three transceivers (Additional 4, 6, or 8-pin cables optional.)



MC-60A (8-pin) Deluxe desk-top microphone. Pre-amp built-in, PTT, LOCK and UP/DOWN switches. Hi/Lo Z selector switch.



SP-40 Compact mobile speaker

SP-50 Mobile speaker

Specifications and prices subject to change without notice or obligation

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TRIO-KENWOOD COMMUNICATIONS
1111 West Walnut Street
Compton, California 90220

ham radio

magazine

JANUARY 1986

volume 19, number 1

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

subscription rates

United States:
one year, \$22.95; two years, \$38.95; three years, \$49.95
Canada and other countries (via surface mail):
one year, \$31.00; two years, \$55.00; three years, \$74.00
Europe, Japan, Africa (via Air Forwarding Service): one year, \$37.00
All subscription orders payable in U.S. funds, via international
postal money order or check drawn on U.S. bank

international subscription agents: page 120

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

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

Copyright 1985 by Communications Technology, Inc.
Title registered at U.S. Patent Office

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

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



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REFLECTIONS REFLECTIONS

before you panic, get the facts

Picture yourself in a quiet restaurant with your spouse or friend. Without warning, the peaceful atmosphere is disturbed by a loud discussion — its content quite private in nature — from across the room. It gets your attention and you find yourself listening. But suddenly you're jolted by an authoritative voice directed at *you*, informing you that you've just broken the law. Your offense: *listening to a private conversation*.

That scenario, half-jokingly told to me by Joe Schroeder, W9JUV (see *Presstop*), has a remnant of truth in an analogous situation. There are presently in the works two bills (HR-3378 in the House of Representatives and S-1667 in the Senate) that could make it a federal crime to listen in on certain conversations received over the airwaves.

Before you panic, listen to the following facts. Several voice and data-handling organizations — specifically the Cellular Telecommunications Industry Association (CTIA), the Electronic Mail Association, Teletocator, paging, and video conferencing industries — do not want their communications intercepted. Sounds reasonable enough. The problem, as I see it, is in their methods. These groups are lobbying (quite strongly, I might add) for Congress to pass what is now known as the Electronic Communications Privacy Act of 1985, which would prohibit anyone in the United States who has a general coverage receiver or similar type device from listening to transmissions at will. If, for example, you inadvertently tuned your receiver or scanner across a cellular phone conversation and *continued* to listen, you'd be breaking the law.

The problem is not the desire of these industries to protect their customers' privacy, but their assumption that the general public should be asked to forfeit its right to listen to radio transmissions without restriction.

What about us Radio Amateurs? Aren't we excluded from this situation? Yes and no. In preliminary hearings, six broad categories — including Amateur Radio — were considered. But when the subject of Amateur autopatches came up, an initial response from one of the subcommittee members was that since the telephone is involved, reception of these types of transmissions might not be part of the exclusion.

Keep in mind that both the House and Senate subcommittees drafting this act — which, incidentally, may turn out to be the single most important piece of legislation affecting us since the 1934 Geneva Radio Convention accords — are still in the preliminary phases of the project. *This* is the time to let your senators and representatives know that you're very interested in these bills even before they come out of the Senate and House subcommittees.* You want your representatives to acquire the facts and understand your concern about potential encroachment on and abridgement of your operating privileges. It might not hurt for you to remind them of the helpful services Radio Amateurs have provided and will continue to provide to the public in emergencies — without desire for or expectation of recompense. It would be nice to leave them with some positive suggestions that they could take to the subcommittees drafting the legislation.

The problem, as mentioned before, is one of fear: people in the commercial communications industries are concerned about possible interception of their signals. But as foolish and unworkable as it would be for the "authorities" to tell all the clients in the hypothetical restaurant scene to close their ears, so would it be for the government to tell radio owners what kinds of transmissions they should or should not listen to.

What would make more sense would be for the cellular and other voice and data-handling organizations to utilize some form of encryption — be it non-standard forms of modulation, tone insertion, inversion, or coding. The necessary technology exists, and one application of it is in daily use in police departments across the country. Otherwise, just imagine a scene in a penitentiary, wherein one pathetic soul is asked by his cellmate, a thrice-convicted murderer, what *his* crime was. . . and the poor soul replies, with great timidity, that he was caught listening to a radio transmission.

Rich Rosen, K2RR
Editor-in-Chief

*In the House of Representatives, the Subcommittee on Courts, Civil Liberties, and the Administration of Justice; in the Senate, the Subcommittee on Patents, Copyrights, and Trademarks.

KENWOOD

...pacesetter in Amateur radio

Incredible Flexibility!

TM211A/411A

The TM-211A 2 m and the TM-411A 70 cm transceivers combine ultra-compact size with an impressive array of features to give you maximum flexibility in mobile operations. The TM-211A and the TM-411A may be stacked for even more operating flexibility!

• External speaker.

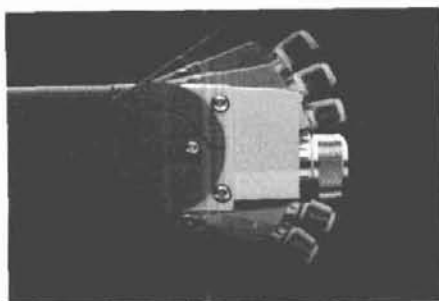
A high-quality external communications speaker is provided for the best sound quality.

• 5-channel memory with multiple scanning functions.

The transceiver can scan the memory channels or can be programmed to scan all or a portion of the band.

• 25 watts high power.

5 (adjustable to approx. 15 watts) low.



• 7-position, tilting control panel.

The unique control panel is designed to increase operating and installation ease. The panel may be moved to provide the best viewing angle and handiest access to controls.

• DCS—Digital Code Squelch.

Program your transceiver to respond only to a specific digital code—much more secure than CTCSS.

• Priority Watch.

The "Priority Watch" mode lets you keep an eye on an important channel when monitoring other frequencies.

• Extended frequency coverage on 2 m.

TM-211A covers 142-149 MHz—includes most MARS and CAP frequencies.

TM-411A covers 438-450 MHz

Optional accessories:

- CD-10 call sign display
- PS-430 DC power supply
- KPS-7A power supply
- MC-42S regular UP/DOWN hand microphone
- MC-55 (8-pin) mobile microphone with time-out timer
- MA-4000 dual band mobile antenna with duplexer
- SWT-1/2 2 m/70 cm 100 W antenna tuners
- SW-100A/B SWR/power meters
- PG-3A noise filter
- MB-201 extra mobile mount
- SP-40 compact mobile speaker



CD-10 DCS call sign display

CD-10 maximizes your use of Kenwood's new signalling concept, Digital Code Squelch. DCS uses a data string to open squelch on a receiver that has been programmed to accept the transmitted code. The transmitting station's call is programmed in ASCII. The CD-10 displays the station's call sign, and stores it in memory. Twenty calls may be stored. The CD-10 may be used with **any** receiver to display calls heard.



More product information is available from authorized Kenwood dealers.

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TRIO-KENWOOD COMMUNICATIONS
1111 West Walnut Street
Compton, California 90220

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

A SERIOUS POTENTIAL THREAT TO ESTABLISHED AMATEUR RADIO PRACTICES may be developing as the "Electronic Communications Privacy Act of 1985" moves toward consideration by both the U.S. Senate and House of Representatives. The two bills, HR-3378 in the House and S-1667 in the Senate, were initially intended to simply make earlier Congressional action against wiretapping apply to radio-relayed data transfer. They provided an opportunity that was quickly seized by the cellular telephone industry, already deeply concerned about the security of its 800 MHz communications as scanners move into the microwave region.

Although Amateur Radio Is One Service Specifically Exempted, along with fire, police, and several others, from the bills' prohibitions against unauthorized "interception," its unrelenting "protectionist" character could drastically change, if not prohibit, some popular Amateur services. For example, the bills' drafters would apparently characterize any "interception" of a radio-relayed telephone conversation by anyone except those actually participating as a federal crime -- with possibly no exception for Amateur autopatches or phone patching! One subcommittee staff member has even been quoted as feeling that all Amateur interconnection with the telephone system is possibly illegal.

Though the Premise -- Privacy For Radio-Carried Personal Communications -- is a worthy one, the bills could, in effect, result in a case of classic overkill. In its present form, the proposed legislation could, for example, declare vast portions of the RF spectrum, including most of the short and long wave bands, illegal territory for the SWL or other radio hobbyist -- not to mention the tens of millions of scanner owners in the U.S. Thus far the League's position has been one of "wait and see," in apparent belief that Amateur Radio's "exemption" will be sufficient to stave off any negative effects. However, in the absence of strong Amateur representation in protection of current Amateur privileges and practices, the bills' impact on Amateur Radio could actually be quite severe.

Amateurs Should Contact Their Senators and Representatives and advise them of their deep concern for the potential effects of these bills on both Amateur Radio and other citizens' activities. Offers of technical expertise as to the legislation's effects might be welcomed by the legislators as well. Be sure to insist that they keep you advised as to progress and significant changes as the bills move toward passage.

RADIOLOCATION HAS BEEN ASSIGNED THE 1900-2000 KHZ BAND, the FCC announced in early November. Amateur Radio will, however, continue to share that portion of 160 meters on a Secondary basis. Impetus for the shift was WARC '79, which expanded the AM broadcast band upward into Radiolocation's former 1605-1705 kHz slot. Though a "Secondary" status means Amateur operators must take pains to avoid interfering with operations of the Primary users, the net effect on Amateurs should be negligible.

Users Of Wideband Radiolocation Systems Could Be Licensed on 160 as early as December, 1985, but no large-scale movement to their new band is expected until mid-1987 -- and even then usage is still likely to be light and mostly in limited geographical areas.

A CONFERENCE TO DISCUSS PROGRESS AND PROBLEMS OF THE VOLUNTEER EXAMINER PROGRAM is being planned during the Orlando Hamfest, March 7-9, 1986. Sponsored by CARE (Council for Amateur Radio Examining), the session will be open to all VECs, VEs, and other interested parties whether CARE members or not. Contact CARE for further details.

CARE Membership Rates Have Now Been Set, and all who've requested information on the new national VEC organization should have received membership information by now. Dues for a VEC organization are \$25 per year, while General members (VEs accredited by a member VEC) must pay \$10 annually. Dues for At-Large members (VEs with accreditation from a non-CARE member) and Associates (anyone else) are \$15.

CARE Now Has A Permanent Mailing Address: P.O. Box 866, Glenview, Illinois 60025.

AMATEURS WHO'VE LOST THEIR LICENSES MAY NOT USE ANOTHER AMATEUR'S STATION for any further Amateur operation, the Commissioners decided in a Report and Order on PR Docket 85-51. The question had arisen in the case of a former West Coast Amateur whose license had been revoked for various violations and who wanted to remain active using friends' stations. The ban pertains to any Amateur licensee whose license has been revoked or suspended for all or part of the license term, who has surrendered his license for cancellation in connection with an action against him, or who is subject to a "Cease and Desist" order that relates to his Amateur Radio activities.

EXTENSIVE RESTRUCTURING OF CANADA'S AMATEUR LICENSING has been proposed by Canada's Department of Communications. The new no-code entry-level license would provide full privileges above 30 MHz (250 watts maximum) using only commercial transmitting equipment; the exam would cover only station installation and operation, very basic theory, antennas, and rules. Moving to the second level would require only a 12-WPM code exam and would extend the same privileges below 30 MHz. Top level would require passing an exam on "advanced electronic theory," then permit using home-built equipment and up to a kilowatt.

KENWOOD

...pacesetter in Amateur radio

Handy Handful...

TR-2600A/3600A

Kenwood's TR-2600A and TR-3600A feature DCS (Digital Code Squelch), a new signalling concept developed by Kenwood. DCS allows each station to have its own "private call" code or to respond to a "group call" or "common call" code. There are 100,000 different DCS combinations possible.



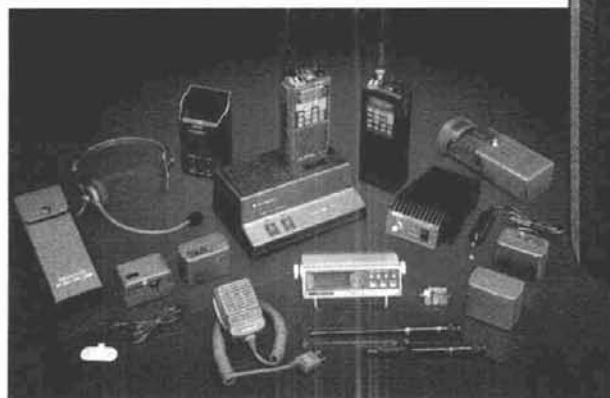
- **Simple to operate**
Functional design is "user friendly." Built-in 16-key autopatch encoder, TX STOP switch, REVERSE switch, KEYBOARD LOCK switch, high efficiency speaker.
- **Large LCD**
Easy to read in direct sunlight or in the dark with convenient dial light that also illuminates the top panel S-meter.
- **Extended frequency coverage**
Allows operation on most MARS and CAP frequencies. Receive frequency range is 140-160 MHz. (TR-3600A covers 440-450 MHz.)
- **Programmable scan**
Channel scan or band scan, search for open or busy channels.
- **SLIDE-LOC battery case**
- **10 Channels**
10 memories, one for non-standard repeater offsets.
- **2.5 watts high power, 350 mW low**
TR-3600A has 1.5 watts high or 300 mW low.

The Kenwood TR-2600A and the TR-3600A pack "big rig" features into the palm of your hand. It's really a "handy handful"!

Optional accessories:

- TU-35B built-in programmable sub-tone encoder
- VB-2530 2-m 25 W RF power amp.
- ST-2 base stand/charger
- MS-1 mobile stand/charger
- PB-26 Ni-Cd battery
- DC-26 DC-DC converter
- HMC-1 headset with VOX
- SMC-30 speaker microphone
- LH-3 deluxe leather case
- SC-9 soft case with belt hook
- BT-3 AA manganese/alkaline battery case
- EB-3 external C manganese/alkaline battery case
- RA-3 2-m telescoping antenna
- RA-5 2-m/70-cm telescoping antenna
- AX-2 shoulder strap w/ant. base
- CD-10 call sign display
- BH-2A belt hook

More TR-2600A and TR-3600A information is available from authorized Kenwood dealers.



KENWOOD

TR-2600A shown. TR-3600A is available for 70 cm operation.
Complete service manuals are available for all Trio-Kenwood transceivers and most accessories.
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Compton, California 90220

AFFORDABLE PACKET RADIO FROM MFJ

An identical TAPR TNC 2 clone with a new cabinet and added features ... for an incredible \$129.95.

MFJ-1270 **\$129.95**



Join the exciting packet radio revolution and enjoy error-free communications ... for an incredible \$129.95.

MFJ brings together efficient manufacturing and TAPR's (Tucson Amateur Packet Radio) leading edge technology to bring you affordable packet radio. You get a nearly identical clone of the widely acclaimed TAPR TNC 2 with identical software and hardware. It's in a new cabinet and includes a TTL serial port for extra versatility.

All you need is your rig, home computer with a RS-232 serial port and a 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. You get interfacing cable, terminal software on tape or disk and complete instructions ... everything you need to get on packet radio. Order MFJ-1282 (disk) or MFJ-1283 (tape), \$19.95 each.

Unlike machine specific TNCs, you never have to worry about your MFJ-1270 being obsolete because you change computers or because packet radio standards change. You can use any computer with an RS-232 serial port and an appropriate 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-1270 as an inexpensive digipeater.

It features the latest AX.25 Version 2.0 software, hardware HDLC for full duplex, true Data Carrier Detect for HF, 16K RAM, simple operation plus more. Join the packet radio revolution now and help make history. Order the MFJ-1270 today.

Here are MFJ's latest and hottest products for improving your station's performance.

SUPER KEYBOARD

MFJ-496
\$169.95



Price slashed 50% to \$169.95! Get a full feature Super Keyboard that sends CW/RTTY/ASCII for the price of a good memory keyer.

You get the convenience of a dedicated keyboard—no program to load—no interface to connect—just turn it on and it's ready to use.

This 5 mode Super Keyboard lets you send CW, Baudot, ASCII, use it as a memory keyer and for Morse Code practice. You get text buffer, programmable and automatic message memories, error deletion, buffer preload, buffer hold.

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comments

Novice Privileges

Dear HR:

With reference to T. Dillingham's (KA0DOE) comments concerning Novice privileges, ("Comments," September, 1985, page 15), it seems KA0DOE wants a "reward" for being a Novice for six years. This is itself a reward, as originally the license was a one-year, non-renewable affair, and before that, of course, did not exist at all.

I can't believe that anyone who aspires to increased operating privileges can't master the skills necessary to pursue their interests in a six-year period.

The tone of this letter suggests that, for some at least, adding any additional benefits would only make them more complacent, thus defeating the purpose.

Ray Cunningham, W3YBF
Ambler, Pennsylvania

Dear HR:

We are in sorry shape, I fear. A casual chat with our Section Manager revealed that many Amateurs in Nebraska are against the ARRL's enhanced Novice Privileges Proposal

— some adamantly so. If this is true throughout the United States, I think we have big problems in that I believe this is just the attitude that will be the death of our hobby. Look at the numbers on page 9 of the August, 1985, issue of *QST*. The numbers are *still* not in our favor.

One of the favorite arguments seems to be that the bands are crowded enough already. Oh, really? Has anyone tried operating the HF bands on a weekday mid-morning? People who work nights should be made a target of our efforts if there is a general feeling that the bands are too crowded. The bands certainly are not overpopulated most weekdays.

Some repeater operators are concerned about losing 220 MHz to Novices because they may have to find new territory for their control links. Yes, there are lots of repeaters...probably more than we need in many areas, although not in Nebraska. But if they could take away band privileges by state they could easily revoke 220 here since the control links wouldn't even occupy a space of several kHz, let alone 5 MHz. We are not going to keep the band if we just use it for control links. We must get more people on the band one way or another. A space can be reserved for the control links by band plan as is done now. Novices can respect band plans, too: they must on the HF bands, and do.

As one who acquired Novice privileges when phone operation was permitted on 2 meters, I see no problem in once again permitting Novices to operate phone. This, as has been stated in League literature on the subject, is even less of a problem now since the Novice license is renewable. During my term as a Novice, the phone privileges were taken away. I have often wondered whether this was a contributing factor to the seemingly low numbers of hams my own age (32) and other hams licensed about that time (1966) on-the-air.

It's time to wake up, folks. There will still be plenty of room for those of us who like to tinker and prefer CW and SSB ragchews. But we have a dual problem: lack of population on the ham frequencies will lead to their loss, and ultimately to the loss of the hobby; the lack of population will become worse if would-be newcomers are not interested in joining our ranks. This is the only real stab at a solution yet proposed and it appears to be one which has been given much forethought. Hams spoke out against no-code. Here is a compromise. Let's put away petty differences and get behind it for the continuance of our hobby.

Michael S. Lennen, KD0EV
Omaha, Nebraska

to key or not to key?

Dear HR:

Print this if you like. It's just for fun.

To Key or Not To Key

*To key or not to key
— that is the question.
Should we drop the code exam?
Dismiss the simple switch
Or retain the day when ability
was reckoned by the fist?*

*To master the key
is to be
a radioman.
To scorn the key
is not
to be.*

*2001 — a CW odyssey.
What a sci-fi mode!
For each Jedi knight,
a practice oscillator
was dutifully stowed.
Even on the Enterprise
Uhura copied code.
Does the future hold
digital radio?
Eighty-meter beams on
a chip?
Or will we turn 'round
to see
Digital radio
to be
the key?*

Bob Zavrel, W7SX
Sunnyvale, California

a frequency and level standard

A little black box
and some digital pulse magic
produce a frequency-stable,
high-level generator

A good RF signal generator needs an effective electrical shield around its generating circuit. Without such a shield, it would not be possible to guarantee an accurately determined output level over a wide range of frequencies. In other words, the output attenuator would lose its credibility.*

Shielding an RF circuit requires more than just placing the components behind a metal wall. Leakage and radiation will occur from almost anything electrical that happens to protrude from the circuit enclosure. Sometimes a rather sophisticated filter system is required for stopping the interference that would otherwise spoil the output-level calibration, particularly at low levels and at high frequencies.

This shielding requirement is only one reason a good RF signal generator is usually an expensive piece of test equipment, and difficult to build yourself. For me, it was *the* reason behind the rather unusual design of the *frequency and level standard*, which, of course, is just another name for a signal generator.

design concept

In principle, the idea is simple. A circuit contained in a hermetically sealed box can't have any filter problems if there's nothing to filter in the first place. That's why I thought of designing a signal source without external controls, power cable, tuning, or level meter — just a box with an output connector. Everything except the output is kept inside.

*That is to say, RF from a poorly shielded generator could combine with a highly attenuated signal and provide erroneous results — Ed.

Thinking a bit further, putting such a drastic principle into practice was not as easy as it sounds, and a few concessions were unavoidable here and there. For example, it's difficult to tune an oscillator and to have its frequency displayed through a solid shield. Consequently, I had to restrict the output signal to cover only a certain number of predetermined frequencies.

The simplest way to obtain many fixed frequencies simultaneously is by adopting the frequency-marker principle; that is, by deriving harmonics from a crystal oscillator. This also guarantees good frequency stability. To keep the many signals separate from each other they must be labelled; I gave them, therefore, different amplitudes, making them clearly distinguishable. This was done with the help of a very elementary digital processing circuit.

A simple action — such as flipping a switch — could pose a problem if it had to be done through a metal shield. But this is also no problem: mercury switches mounted inside the circuit can be actuated simply by turning the box to a different position.

The part that needs most switching, the variable output attenuator, is kept outside the shielded enclosure. This allows the signal generator to produce a uniform, but accurate, signal level over a wide frequency range. In fact, it turns out that it's not only the generator itself, but also the variable attenuator that determines the eventual level accuracy at higher frequencies. And the outboard attenuator can be easily replaced by an improved version at a later date.

The cost of the active components (six ICs, including the voltage regulator) should come to not much more than \$3.00. To sum it up, at least for many applications, the box-with-plug idea works the way I hoped it would: as a good signal generator that is neither expensive nor difficult to build.

synthesizer

Many people who've tried to calibrate a receiver frequency scale using a frequency marker have had the experience of being confused by the different, but

By Hans Evers, PA0CX, Am Stockberg 15,
D-5165, Hürtgenwald, West Germany

look-alike, signals. It is therefore an advantage to introduce signals that belong to a different order in the spectrum hierarchy. First the 1-MHz markers, for instance, then the 100-kHz markers, and so on. Usually this is done by turning a switch.

To avoid using such a switch, I tried a different method. The coarse markers were labelled by emphasizing their amplitudes (fig. 1). After frequency division of a 1-MHz crystal-oscillator signal, pulses of

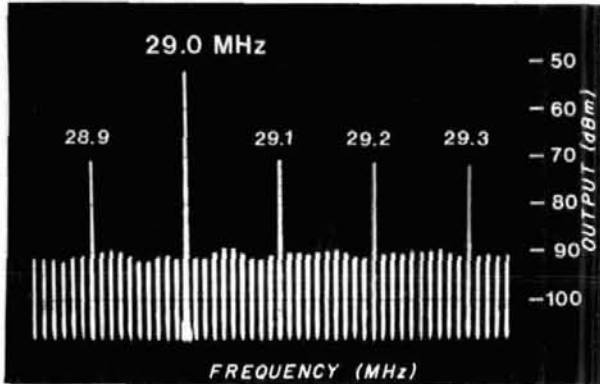


fig. 1. Typical output display spectrum as seen on a frequency-spectrum analyzer. Multiples of 100 kHz harmonics have signal strengths corresponding to the standard S9. The MHz markers are about 20 dB stronger; the 10-kHz markers are 20 dB weaker.

different lengths arrive at the NAND gates. The product is used to interrupt the stream of 1-MHz oscillator-output pulses at regular intervals by longer or shorter spaces (fig. 2).

The underlying mechanism that produces the different phenomena may be easier to understand when you realize what the pulse sequence would look like if the polarity had been reversed. Tuned circuits in a receiver recognize certain patterns in the stream passing by and therefore respond to certain rhythms. Thus, for example, the one-pulse space in the otherwise steady flow of 1- μ s (1-MHz) pulses represents, in fact, a pulse of relatively longer duration. If such an event occurs regularly every 10 μ s, it is capable of causing a response in a circuit tuned to a multiple of 100 kHz (being the repetition rate of the space).

The reason amplitudes of the 1-MHz markers stand out from the rest is not difficult to see. The train of 1- μ s pulses with each 10th pulse removed produces more energy in a circuit tuned to a 1-MHz multiple than to one tuned to a 0.1-MHz multiple (where, at the same time, the circuit has to manage with only one out of ten pulses).

The two-pulse spaces responsible for the 10-kHz markers (occurring every 100 μ s) produce energy that must be shared over 100 times as many signals in the frequency spectrum. This explains why the 10-kHz markers are so much weaker than the others. Of

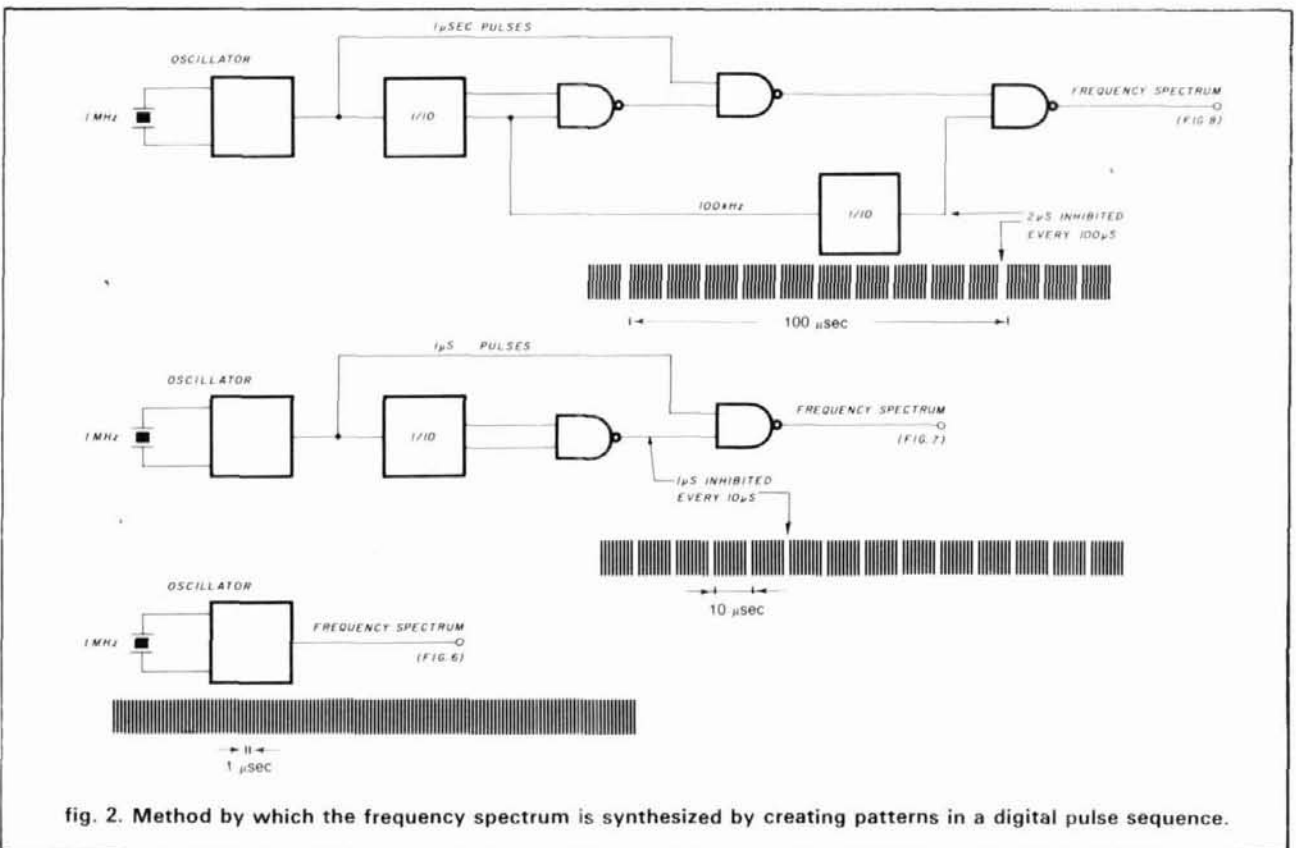


fig. 2. Method by which the frequency spectrum is synthesized by creating patterns in a digital pulse sequence.

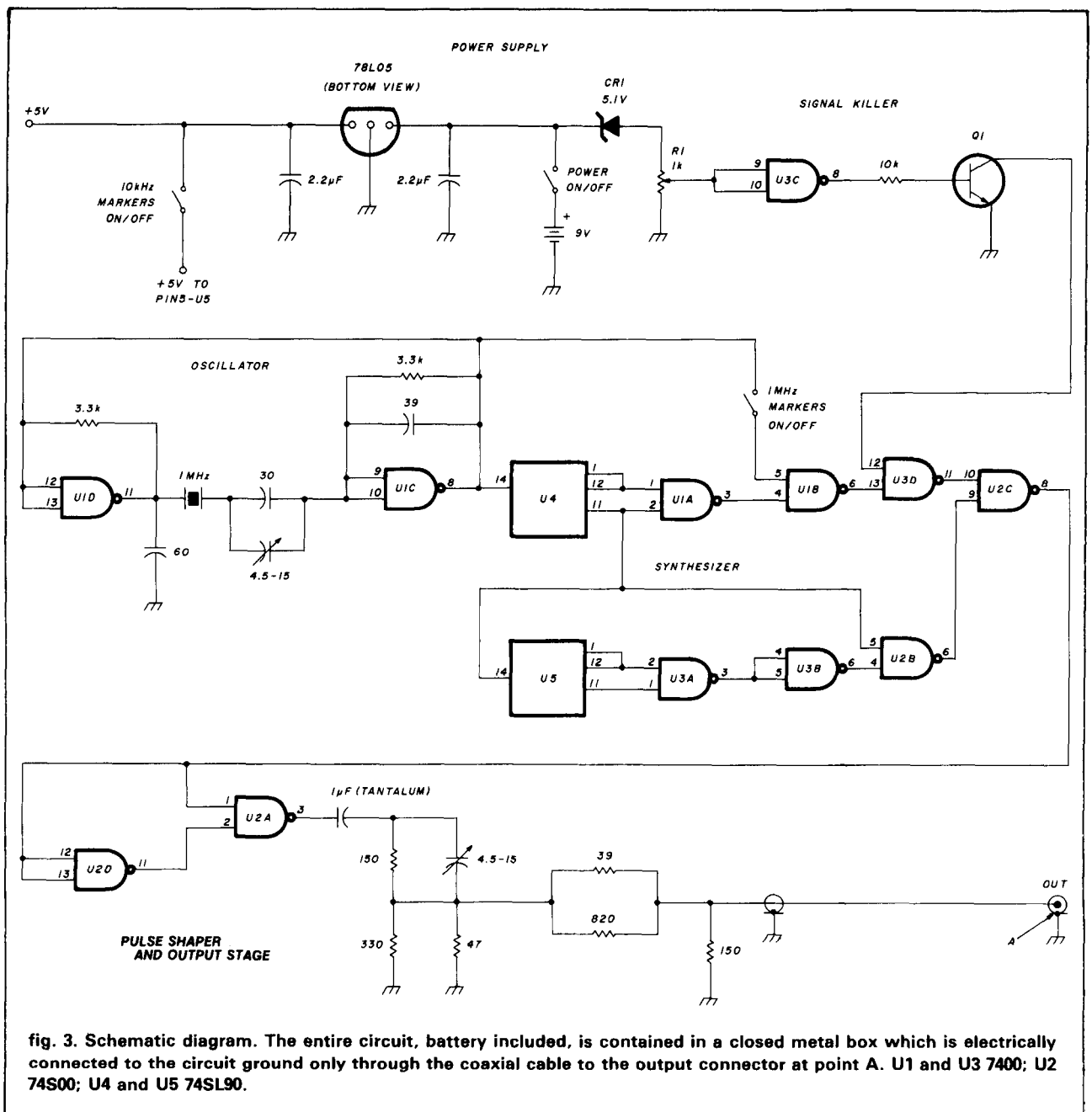


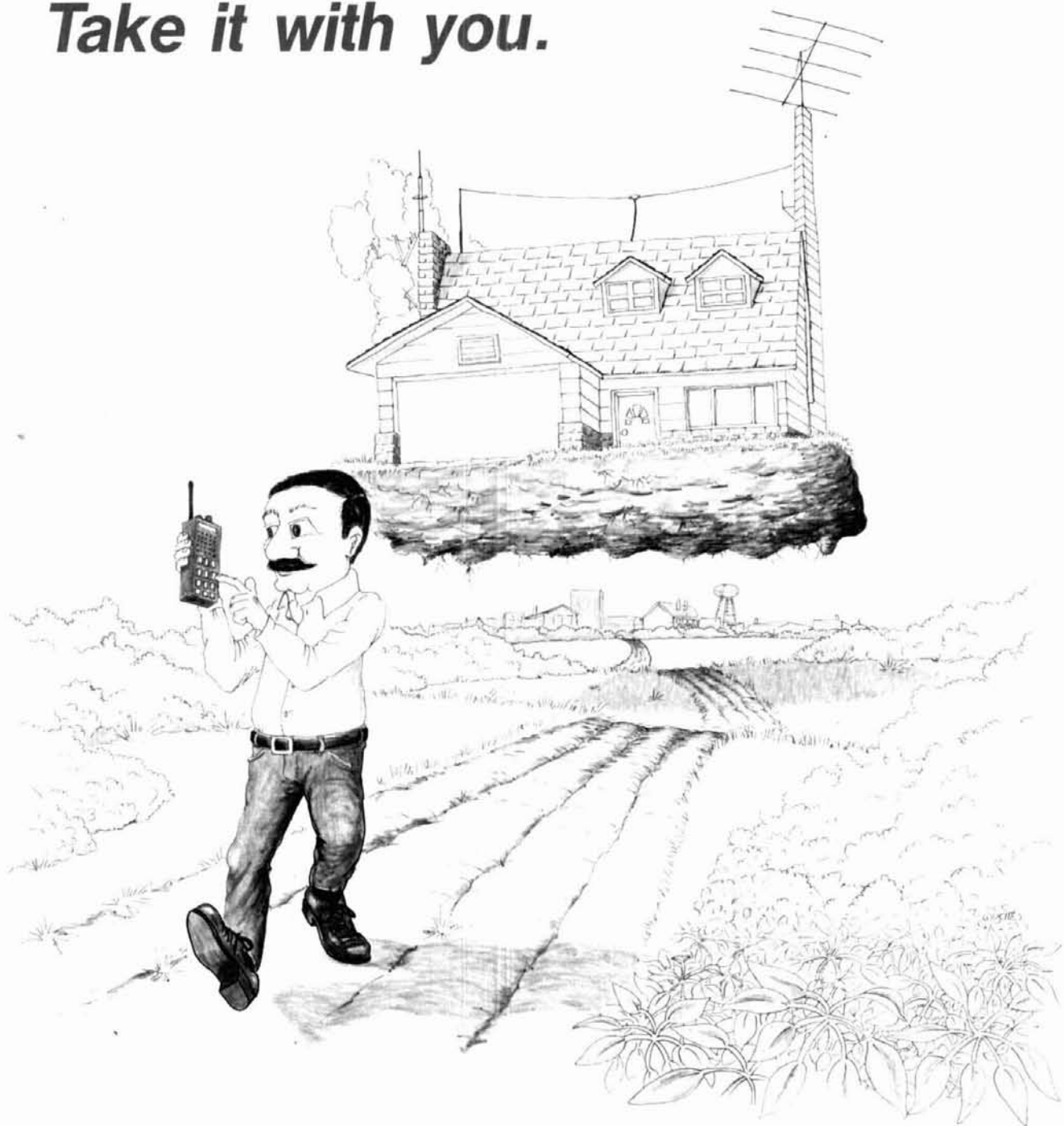
fig. 3. Schematic diagram. The entire circuit, battery included, is contained in a closed metal box which is electrically connected to the circuit ground only through the coaxial cable to the output connector at point A. U1 and U3 7400; U2 74S00; U4 and U5 74SL90.

course, all this tampering with pulses makes the total architecture rather complex. It is, therefore, not surprising to find that there's a practical limit to where the results remain acceptable, and where further refinements would create a less orderly spectrum. What happens is that if the mixture of pulses and spaces in between gets too complex, less-wanted patterns become recognizable. This results in poorly determined amplitudes. Therefore only the 100 kHz position (only multiples, all with identical amplitudes) should be used as a level standard. The spectrum-analyzer pictures show how the amplitudes tend to become irregular as the frequency spectrum becomes more complex.

Thus the imperfection is not so much the result of what a typical analog thinker (as many Radio Amateurs appear to be) might suspect: the wiring. Digital circuits are remarkably tolerant of construction-related problems such as breakthrough or crosstalk — and, for that matter, of poor layout, messy wiring, and horrible-looking breadboard creations. What is also appreciable is that from the synthesizer output onward, only the absolute amplitude may change. The amplitude ratios between the different orders of frequency, once they have been encoded into a digital pattern, are not likely to be changed by following wave-shapers, amplifiers, or other analog circuits.

Figure 3 shows the circuit as it was eventually

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adopted; **fig. 4** shows the socket connections of the ICs. Note that an electrolytic capacitor is provided at each individual IC for additional voltage protection.

Figure 5 shows an oscilloscope display of a detail from the synthesizer output pattern showing some 1-pulse spaces (indicated by A) responsible for the 100-kHz signals, as well as the 2-pulse spacing (B) that produces the 10-kHz markers. **Figures 6, 7, and 8** show the different frequency spectra that are created by the pulse patterns given in **fig. 2**.

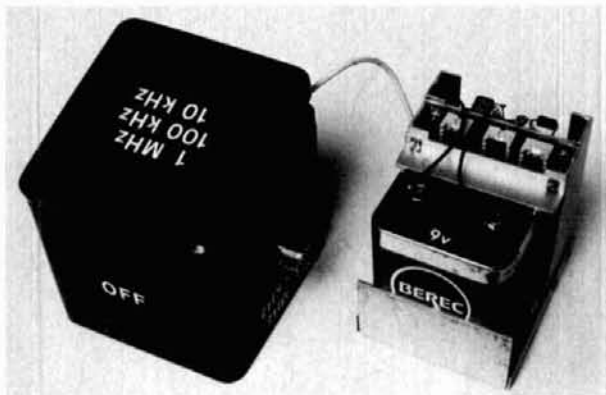
output stage

The output stage consists mainly of a pulse shaper, or "harmonic producer," based on the fact that the shorter the pulse duration, the more frequencies are produced, and consequently the frequency spectrum will be wider and the harmonic amplitudes more uniform, though lower.

How short should the pulse duration be for obtaining a reasonable compromise between frequency range and output level? For lack of more specific information in the otherwise plentiful literature on frequency markers, I investigated a few circuits I found in Amateur Radio publications.

The output of a 7400-type NAND gate turns out to have an impedance of about a few hundred ohms and could, if necessary, be safely connected to a 50-ohm load. (The IC would even survive a full DC short from its output terminal to ground, if it ever came to that.) However, to permit a proper match into a 50-ohm device, such as an attenuator, a small network is inserted. This also permits an increase in frequency response at the high-frequency end of the spectrum.

Figure 9 illustrates some of the networks that I tried. Note the important improvement by the one shot in **fig. 9B**. This simple circuit turns out very short pulses indeed. In this circuit, the last NAND gate receives the pulse directly at its top input. The pulse is inverted at



The frequency and level standard outside its enclosure. Normally the entire circuit, power supply, and all control elements are inside the black metal box; thus all RF leakage is eliminated without the need for any filtering.

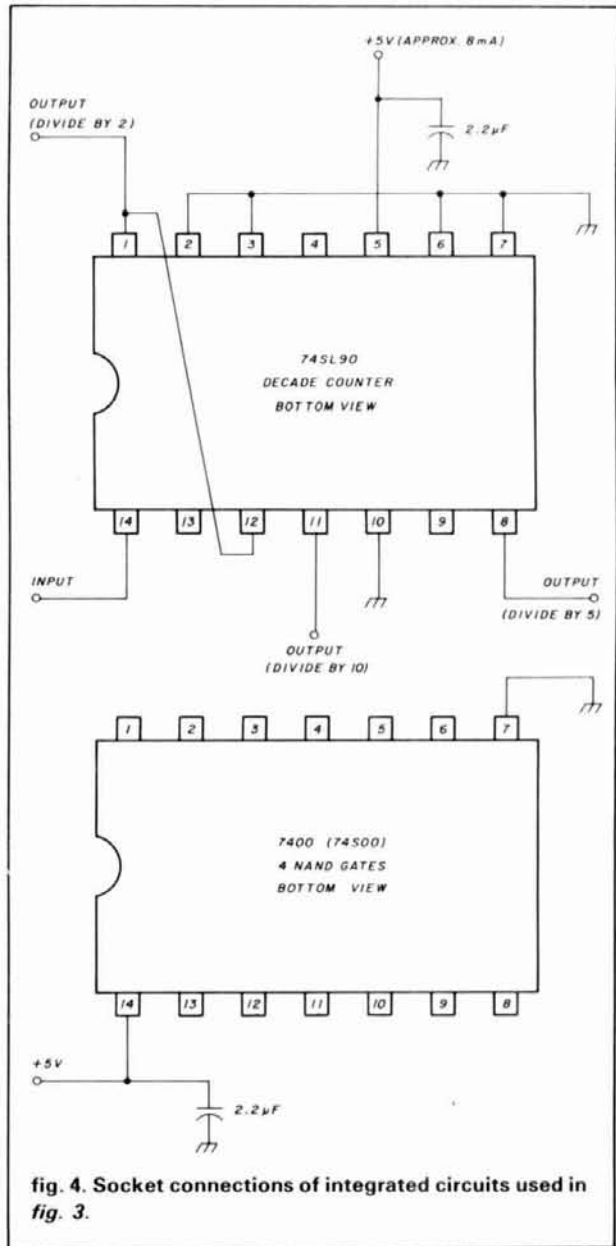


fig. 4. Socket connections of integrated circuits used in **fig. 3**.

the bottom input, and is delayed only by another NAND which acts as the inverter. As the output of a NAND gate is low only if both inputs are high, the total effect could perhaps be compared with letting a signal rush through the circuit, and immediately slam the gate shut behind it, chopping its tail. Thus, using an ordinary 7400, all output pulses have a duration that can't be longer than about 10 nanoseconds, the delay time of the inverter. The circuit produces adequately short pulses for creating a reasonably flat frequency response that covers all HF bands, requiring only a slight correction.

The 7400 also exists in a more than three-times-as-fast Schottky version, the 74S00. This device produces even shorter pulses and makes it possible, at least with

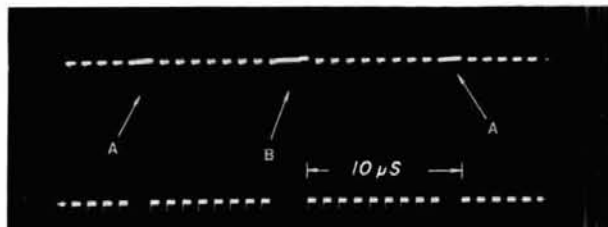


fig. 5. Synthesizer output signal as displayed on oscilloscope. At *A* one pulse is inhibited, repetition rate 10 μ s. At *B* two successive pulses are inhibited, repetition rate 100 μ s.

some correction again, to create a flat response that comfortably includes the 2-meter band. At the time the spectrum (which starts to roll off at 160 MHz) reaches 400 MHz, the amplitudes have dropped by about 15 dB. This would still make a good frequency marker for the 70-cm band.

In the final circuit (fig. 3) an extra 50-ohm, 6-dB attenuator is inserted. This puts the output level at -73 dBm and provides isolation between the frequency-correcting network and a possible capacitive load at the output connector.

The -73 dBm level was chosen for a good reason. It allows sufficient compensation of the frequency response for including the 2-meter band. It also corresponds with the IARU-recommended S9 level at HF bands. By leaving the output unterminated, the open-circuit output voltage produced by every multiple of 100 kHz (100 kHz position) is 100 μ V, or S9 at the high-impedance input terminal of an HF receiver. Terminated into a 50-ohm receiver antenna input, the voltage drops to the IARU-recommended 50 μ V.

Once the receiver S-meter has been calibrated for this level, the other S-points are easy to determine by halving the voltage for each lower S-point on the scale. To put it more practically, each S-point change in level corresponds to 6 dB. Just a few examples: S8 = -79 dBm, S3 = -109 dBm.

Somewhere in the last NAND lies the borderline between the digital and analog sections of the circuit. From this point onward, carefree wiring concepts are better abandoned. The resistor network between the NAND and output connector requires careful layout consistent with good VHF practice. The resistors are best mounted free from each other and from other components, and with their wires as short as possible. Printed-circuit technique is not recommended here.

The shield box is electrically insulated from the circuit ground except at the output connector, through the coaxial cable.

oscillator

Experimenting with ICs of the 7400 series, one may find that the different blocks, with their low input and

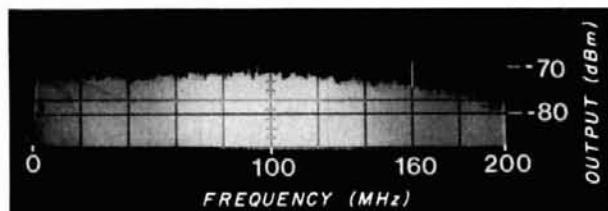
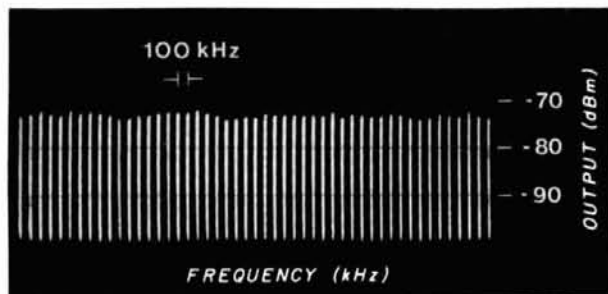


fig. 6. 100 kHz position. Top: typical segment of output frequency spectrum as displayed on spectrum analyzer. Each signal frequency is a multiple of 100 kHz and has a level of -73 dBm \pm 1.5 dB, up to at least 30 MHz. Bottom: spectrum displayed over full usable frequency range. Although signals are no longer individually distinguishable, the display shows signal levels within \pm 2 dB up to 160 MHz.

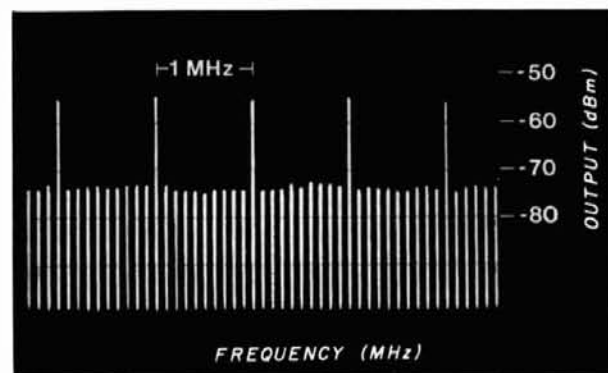
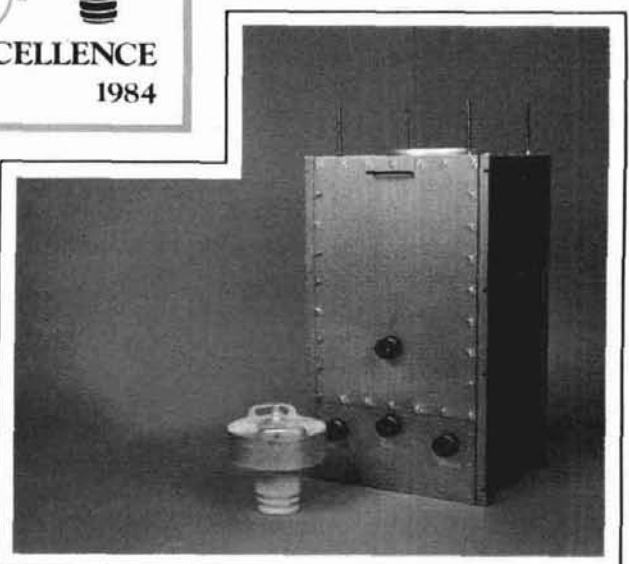
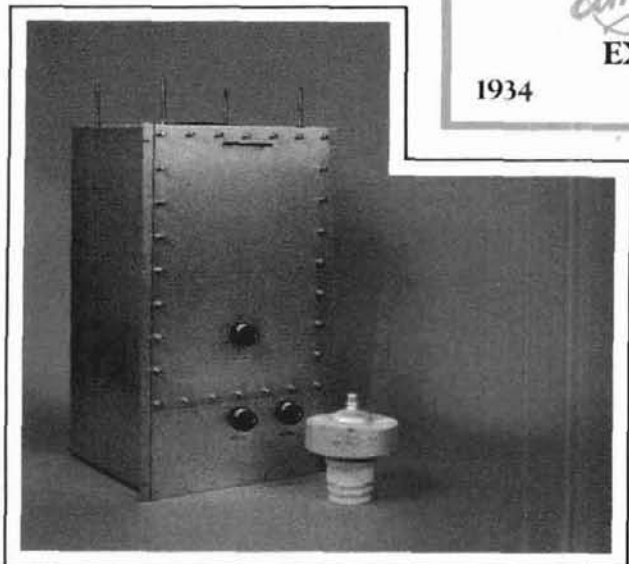
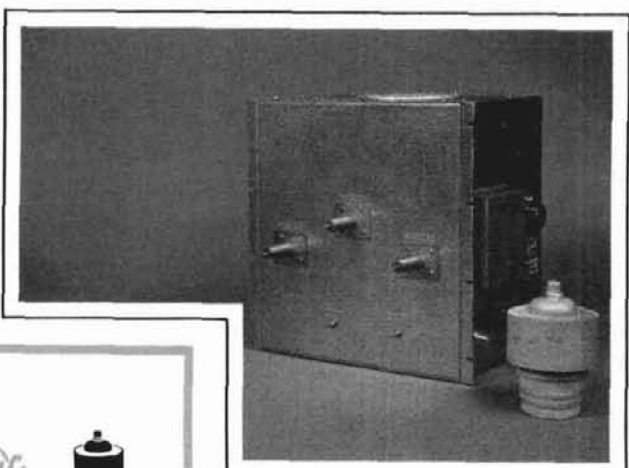
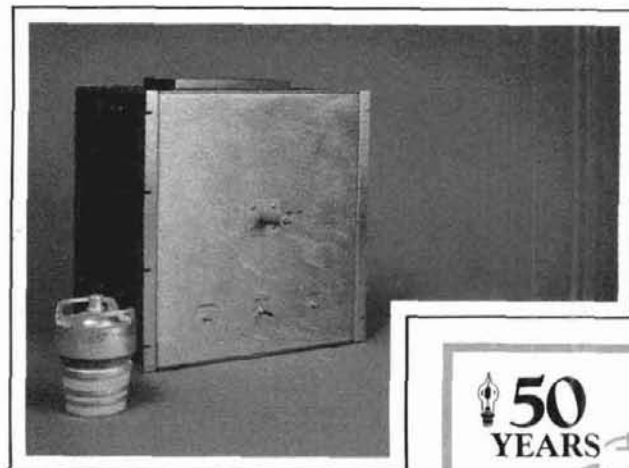


fig. 7. Position: 1 MHz + 100 kHz. Spectrum of 100-kHz marker signals, with 1-MHz marker amplitudes emphasized by approximately 20 dB.

output impedances, aren't the ideal elements for building a crystal oscillator. If the crystal isn't very active, the oscillator won't work. Nevertheless, the reason for using this circuit is that the NANDs — four of them combined in one IC — happened to be available, and they draw supply current whether they are used or not.

If the circuit doesn't work, it may well be possible to wake up a lethargic crystal by using different values for the resistors and capacitors in the oscillator circuit. However, it's also possible to overdo it, causing the oscillator to produce parasitics. In case of persistent recalcitrance, any other oscillator using one or two discrete transistors may do the job just as well, consuming only a few milliamperes of extra current.



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15 kW	CV-2210	4CX12,000A
10 kW	CV-2228	4CX7500A
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1.5 kW	CV-2220	3CX1500A7
150 W	AM-2215A	Solid State



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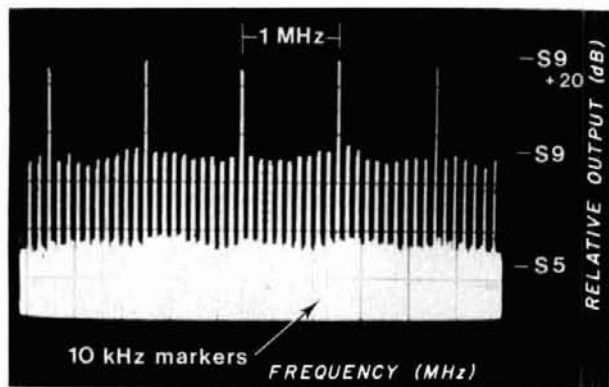


fig. 8. Position: 1 MHz + 100 kHz + 10 kHz. Spectrum is shown with all markers in operation.

power supply

One disadvantage of the closed-box technique may be that it doesn't leave much opportunity for monitoring the battery-supply voltage. That's why a voltage regulator, supplied by a battery that has some voltage to spare, is incorporated. The 9-volt battery can be drained to the point at which its actual voltage drops to 6.4 volts before the regulator gets in trouble trying to keep up its 5-volt output (that is to say, this is what I found; the 78L05 specifications state a minimum input voltage of 7 volts). As soon as the regulator output becomes affected, the RF output level of the total circuit becomes unreliable. Responsibility for this is mainly the last NAND in the output stage, producing pulses with lower amplitude and consequently less energy.

The problem of the aging battery is solved by applying a form of euthanasia. The "signal killer" circuit is based on the principle that it is better to have no signal at all than one on which you cannot rely. As soon as the battery drops below 6.4 volts, the RF output signal is cut off abruptly (fig. 10), before it can cause incorrect test results. This is done by blocking a NAND in the main signal path through a NAND inverter and a transistor.

When the appropriate moment arrives, the act is performed swiftly, even in case of a very slowly deteriorating battery voltage. The threshold is set by potentiometer R1 (fig. 3) to make the RF output signal disappear just before a reduction in amplitude occurs.

Because an output signal that suddenly disappears can be disconcerting, I found it useful to provide a means of alerting the user to the imminent demise of the battery. If the box fails to deliver its output signal, just turn it to the position 1 MHz + 100 kHz + 10 kHz. If only the 10-kHz markers are still present, this is a sign that the malfunction of the generator is the result of too-low battery voltage, and that there's no reason to expect anything worse than having to replace the battery.

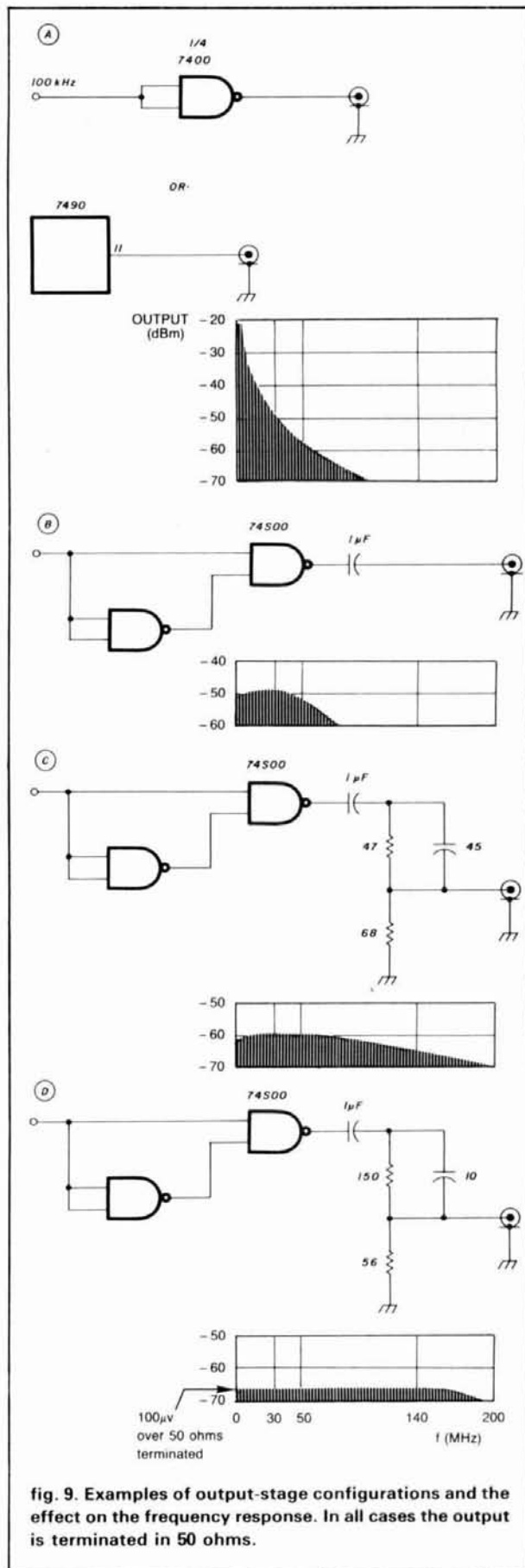


fig. 9. Examples of output-stage configurations and the effect on the frequency response. In all cases the output is terminated in 50 ohms.

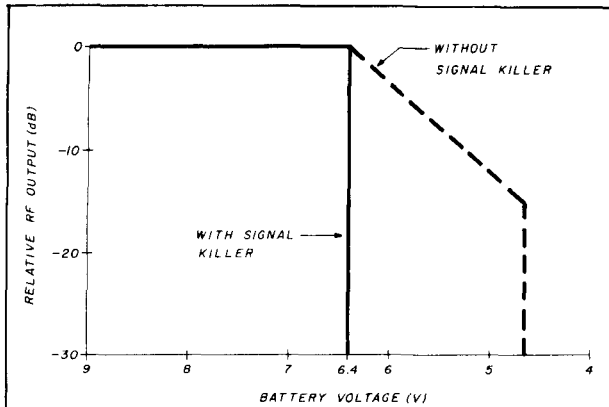


fig. 10. RF output as a function of battery voltage. An unnoticed drop in RF output level, resulting from an exhausted battery, is made impossible by the action of a "signal killer."

The battery is normally switched on and off by a mercury switch, a miniature glass bulb in which a droplet of mercury makes contact between two wires, depending on the position of the device. With some three-dimensional imagination, it's not difficult to see how, using a switch, a circuit can stay switched on at a maximum of three different positions of the box. This is done by mounting the switch in the circuit wiring at an oblique angle with respect to the three axes of the box. Similar switches are used for switching the 1-MHz and 10-kHz markers.

If mercury switches are difficult to obtain, it shouldn't be difficult to think of something else, such as one or more reed switches and a movable magnet, for example. Another method would be to use a steel ball (a ball bearing, for example) that can roll around inside a little plastic box with contact wires, or in a little box made of printed-circuit board (fig. 11).

The total battery consumption at 9 volts is about 43 mA with all markers operational, or about 36 mA in the 100 kHz position.

attenuator

The type of outboard step attenuator shown in the photograph has been described already in many Amateur publications. In this case, miniature toggle switches and 1/4-watt carbon resistors are used. The resistors are mounted on the solder lugs of the switches, with their leads kept as short as possible. For the rest of the wiring, copper braid (taken from thin coaxial cable) is used, soldered over the full length of the solder lugs. Braid is not essential insofar that it doesn't seem to extend the flat portion of the frequency response; however, I found that it can give a considerably smoother result at VHF.

Production tolerances in the resistor-manufacturing industry appear to have greatly improved over the last

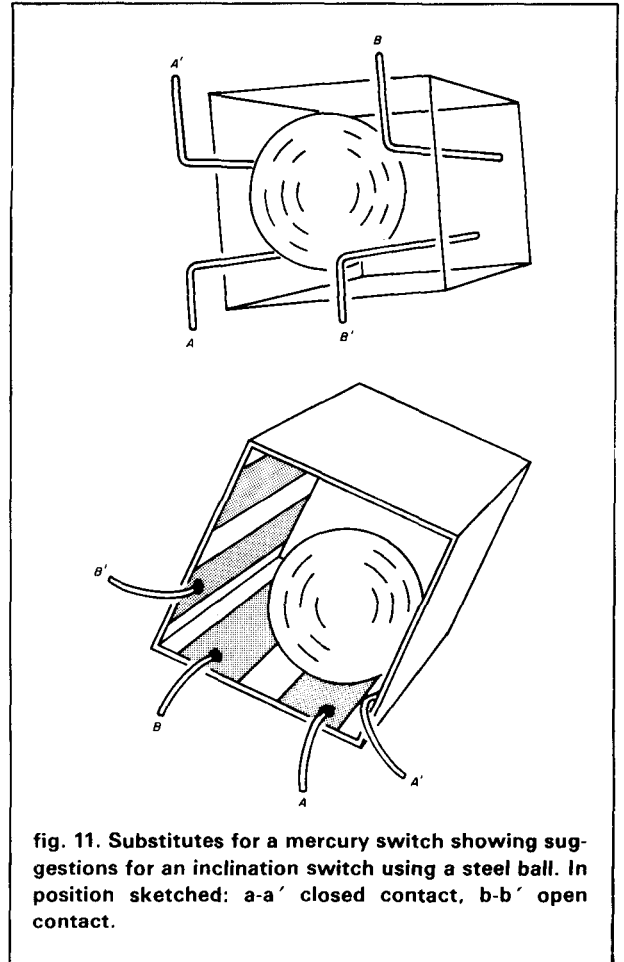


fig. 11. Substitutes for a mercury switch showing suggestions for an inclination switch using a steel ball. In position sketched: a-a' closed contact, b-b' open contact.

decade. At one time, a 10-percent resistor was almost bound to show a tolerance between 5 and 10 percent.

Today it's not unusual to find that ordinary 10-percent resistors are in fact not much more than 2 percent off the mark. And as more accurate ohmmeters become available to Radio Amateurs, it's no longer difficult to obtain reasonably precise resistors.

The required values for the attenuator are obtained by parallel combinations. In each combination it is mainly the lower-value resistor that is critical and which should preferably be within 1 to 2 percent. (Tolerances of resistors are like those of voltages, and the same rule-of-thumb applies: for small variations, each percent corresponds to 0.1 dB.) Alternatively, each combination should be brought as close as possible to the ideal value by selection and trial and error, using an accurate (digital) ohmmeter (fig. 12).

Most descriptions of this type of step attenuator remain rather vague about the performance, particularly at higher frequencies. Therefore, fig. 13 may be of interest, because it shows the test results of this home made attenuator, built with no particular care other than ordinary construction techniques. The device is accurate within 1/10 of a dB or thereabouts,

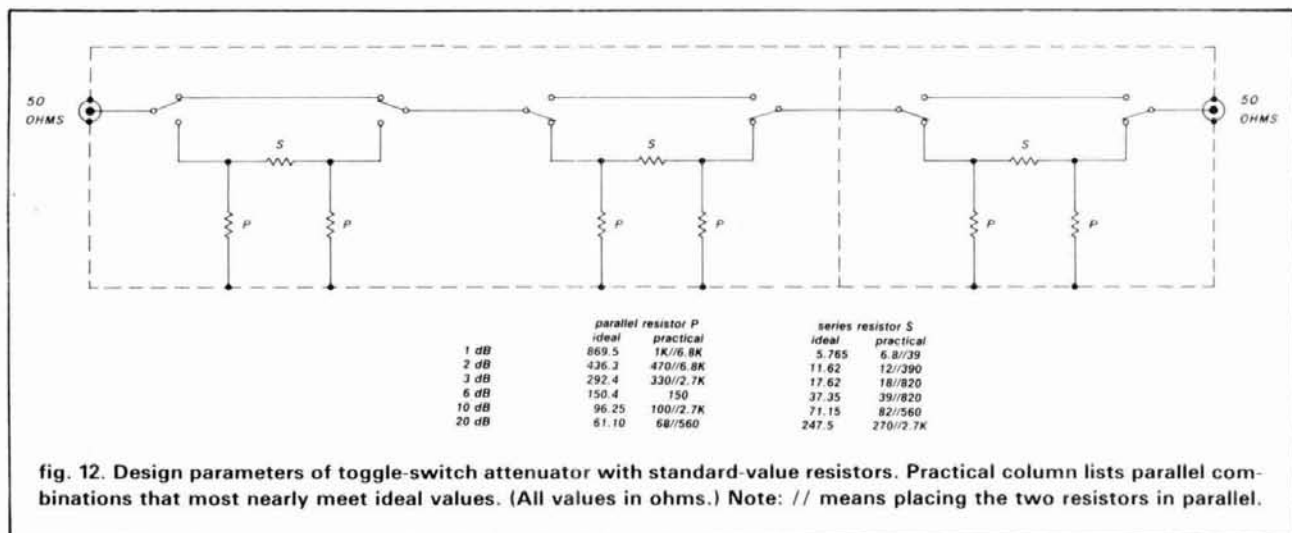


fig. 12. Design parameters of toggle-switch attenuator with standard-value resistors. Practical column lists parallel combinations that most nearly meet ideal values. (All values in ohms.) Note: // means placing the two resistors in parallel.

up to 65 MHz; that is, as accurate as the resistors could be selected with the available DC ohmmeter.

Figure 13 also shows the reason for the apparent reluctance to publish test results: at VHF precision tends to become questionable. Nevertheless, the general performance is still within the tolerance of the signal generator, about ± 1 dB uncertainty at 144 MHz.

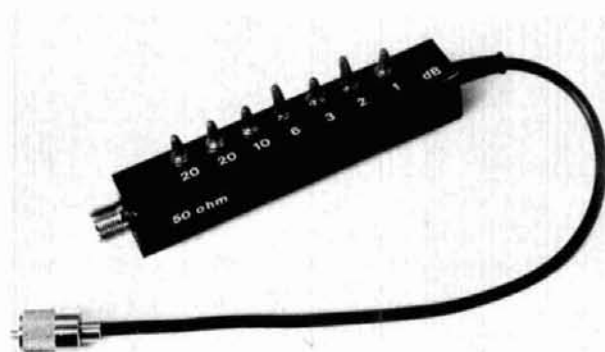
That the discrepancies are mainly the result of the many twists and turns in the signal path through the switches is also clearly demonstrated. Even with all attenuators in the *OUT* position (0 dB), the wavy character of the curve remains. This gives hope; it's not impossible that (cheaper) slide switches and N-type coaxial connectors would make an improvement on VHF.

calibration

The accuracy of the frequency can be checked and corrected by adjusting the oscillator trimmer while comparing a signal with one of the short-wave standard signals such as WWV in the USA, or GDF in Europe. Because the circuit doesn't contain any variables in the form of tuned circuits, the output level of -73 dBm should be fairly easily reproducible for HF by using the components as described. Up to, say 30 or 40 MHz, the frequency response should remain flat within reasonable limits, even if the output trimmer is simply replaced by a 10 pF fixed capacitor.

In the multitude of standard-size 100-kHz harmonics there appear to be two exceptions where the amplitude seems to behave a bit freakishly: at 100 kHz itself and at 1MHz. I found relative levels of -4 dB and -10 dB, respectively. As yet I have no fully satisfactory explanation to offer for the phenomenon; it's difficult to speculate to what extent these findings may be typical for the circuit.

The output can be calibrated by comparing the level



Toggle-switch attenuator.

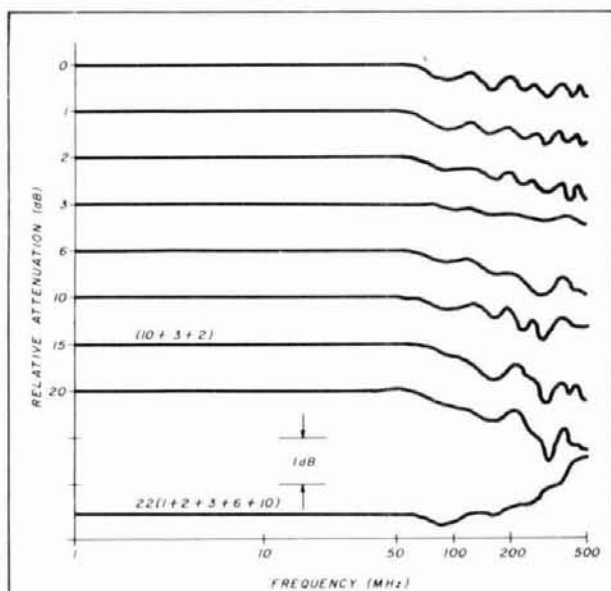
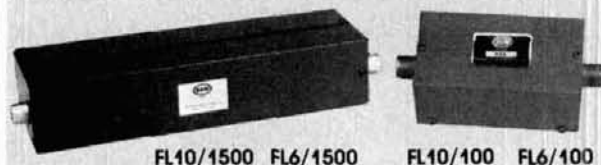


fig. 13. Test results of home made attenuator. Frequency response is shown at each setting, as well as at some combinations. Note absence of any appreciable discrepancies up to 65 MHz.

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of one of the 100-kHz harmonics (except at 100 kHz and at 1 MHz) with that of a signal from an RF generator with a reliable output attenuator, using a radio receiver as a frequency-selective balance detector. A signal-strength meter is not absolutely essential. By comparing two beat tones, one immediately after the other, providing that they both have the same pitch, one should be able to match levels well within 1 dB.

However, a professional RF signal generator could be difficult to procure, and for the average Radio Amateur a more common audio generator might be more easily available. Audio levels are more accurately determined using an audio voltmeter or an oscilloscope. Most audio generators cover 200 kHz, and a level comparison could be made on a long-wave radio receiver, using an audio meter or the human ear. After all, the 200-kHz harmonic is just as strong as any other harmonic in the entire HF spectrum of the generator and, even if it sits at an extreme end of the range, it provides a perfectly typical specimen upon which to base the level calibration.

In case level corrections appear to be necessary, the resistors in the attenuator between output trimmer and coaxial cable can be replaced to change the 6-dB attenuation into a different value. Figure 13 supplies the data.

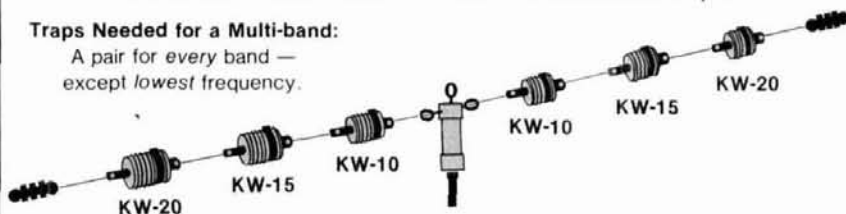
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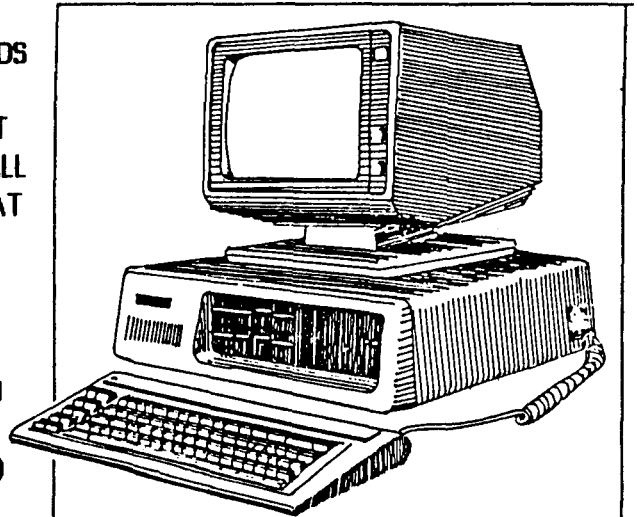
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a calibrated S-meter

Meaningful signal
reports are possible
— here's how

Long ago a wonderful idea emerged that would make signal reporting, gain measurements, antenna comparisons, and propagation studies as easy as reading, reporting, and comparing meter values. This idea came to be known as the S-unit system of signal reporting. Sometime later an S-unit "standard" was set, in which each S-unit change represented a level change of 6dB and S9 was referenced to 50 microvolts rms in a 50 ohm system. This standard was straightforward and simple. S1 was 48 dB below 50 microvolts, near the practical lower limit of receiver sensitivity and noise floor. This standard offered the Amateur community a method of quantifying signal reporting and other useful measurements. **Tables 1 and 2** are included to illustrate the nearly 180 dB of dynamic range common in Amateur Radio equipment and show where the S-unit scale fits in at the threshold of receiver sensitivity.*

Nearly half a century has passed with very little conformation to this or any other level standard. For practical purposes, the RST system as practiced today is a farce — yet it's the most common exchange between stations. Consequently, meaningless guesstimates echo endlessly through the ether, apparently for lack of something more meaningful to say. This ironic state of affairs is especially troublesome in light of the advantages standardization and conformation could afford.

By nature, Amateur Radio is a quantitative hobby embracing the technology and science of multiple disciplines. Why, then, is the basic RST number abused?

* From minimum discernible signal at the receiver to maximum legal output from a linear — Ed.

The more cynical among us might suggest that we're simply locked into a bad habit, or that you must give S9 signal reports to get rare QSL cards. There's probably some truth to the first notion; the second, even if true, is a poor reason for general abuse. After careful investigation, however, more subtle reasons emerge. The basic problem is simply that modern receivers generally do not have calibrated S-meters. Standards differ drastically from one manufacturer to another and from one unit to another. Most Amateurs know their S-meters are probably not calibrated and consequently give politely inflated signal reports.

Receiver manufacturers will respond only to customer demand; this is reflected by the multitude of "bells and whistles," compact size, and sleek styling found in modern Amateur equipment. Because Amateurs appear not to care, important specs have actually declined over the past several years. Dynamic range, on the other hand, has been improved because it has received much attention in the literature. Amateurs have become aware of this important phenomenon and now often ask equipment dealers embarrassing questions. I hope this signals a trend toward increased consumer demand for improved radio performance rather than for superficial enhancements that may have little or no effect on actual performance.

To be fair, lack of concern from the Amateur community is not the only reason that receiver manufacturers have not offered calibrated S-meters. There are real technical problems inherent in doing so. Providing consistent front end mixer gain over many frequency bands, for example, is a major problem. All amplifiers and attenuators ahead of the S-meter circuit must have identical gain on all bands and frequencies within these bands to assure consistent readings. Furthermore, most S-meter voltage sources are derived from the AGC circuit, and the response of these circuits varies widely — not only among receiver model types, but among individual units of similar types as

By Robert J. Zavrel, Jr., W7SX, P.O. Box 24845, San Jose, California 95154

well. **Table 3** shows the extent of this deviation among popular receiver types.^{1,2,3} This unpredictable deviation from receiver to receiver of the AGC voltage versus received signal strength represents the most difficult obstacle to setting an S-meter standard. The first problem can now be solved by broadbanding front ends, using flat response mixers, and employing modern RF components and layout techniques. The second problem has been alleviated with the introduction of the Signetics NE604, an FM RF integrated circuit designed primarily for the cellular radio market (fig. 1 and 2).

Receivers for cellular radio systems require a received signal strength indicator (RSSI) function. The response of this required logarithmic measurement must conform to 3 dB accuracy over an 80 dB dynamic range. This function represents an ideal signal source for S-meters and other RF measurement equipment

table 1. Power and voltage levels common to Amateur equipment.

dBm	power (watts)	volts (50 ohms)
+70	10 kW	707.0 V
+60	1 kW	223.0 V
+50	100 W	70.7 V
+40	10 W	22.3 V
+30	1 W	7.07 V
+20	100 mW	2.23 V
+10	10 mW	707.0 mV
0	1 mW	223.0 mV
-10	100 μ W	70.7 mV
-20	10 μ W	22.3 mV
-30	1 μ W	7.07 mV
-40	100 nW	2.23 mV
-50	10 nW	707.0 μ V
-60	1 nW	223.0 μ V
-70	100 pW	70.7 μ V
-80	10 pW	22.3 μ V
-90	1 pW	7.07 μ V
-100	100 fW	2.23 μ V
-110	10 fW	707.0 nV
-120	1 fW	223.0 nV

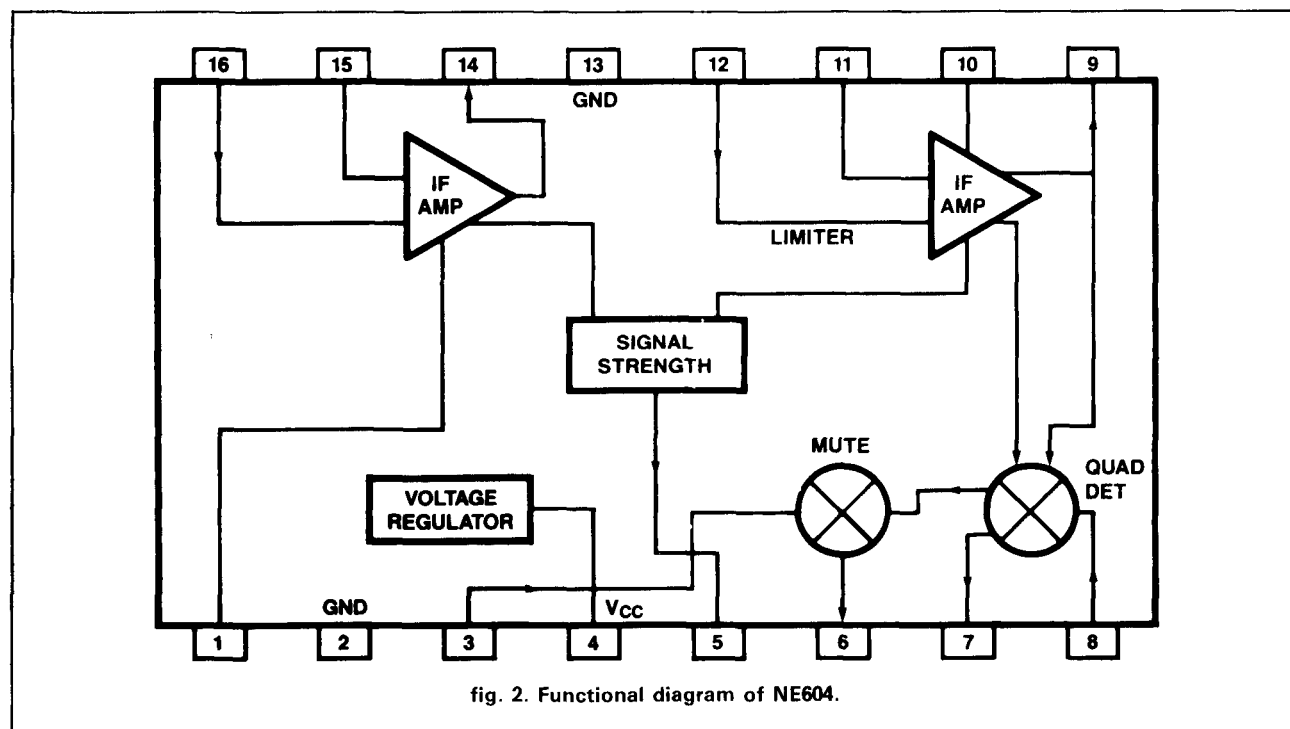
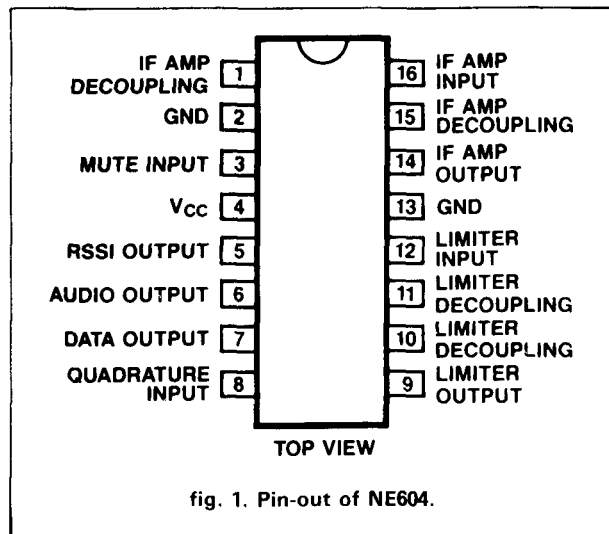


table 2. Power and voltage levels for the nine S-units.

S-unit	dBm	volts (50 ohms)
S9	-73	50.0 μ V
S8	-79	25.0 μ V
S7	-85	12.6 μ V
S6	-91	6.3 μ V
S5	-97	3.2 μ V
S4	-103	1.6 μ V
S3	-109	792.0 nV
S2	-115	397.0 nV
S1	-121	199.0 nV

such as field strength meters. The NE604 performs this function by providing a current source which is typically sunk through a 100 kilohm resistor (fig. 3). The high impedance voltage produced at pin 5 is then buffered by an op amp (NE532) to drive a linear analog voltmeter or other suitable display. The DC voltage output is plotted against RF level input in fig. 4. Responses for unattenuated and attenuated inputs are given.

The RF input to the NE604 can be taken off an IF amplifier stage operating up to 15 MHz. The higher RF levels associated with the later IF stages make them more attractive as drivers for the 604. Very light coupling can be employed (3 pF) with these stages to prevent any undesirable loading to the receiver IF amplifier. Figure 4 shows that the unattenuated amplitude input range for the 604 is about -90 to -10 dBm. The effect of the fig. 3 input isolation circuit is to move the effective range up about 20 dB. Because the RSSI function is mode independent, the S-meter will function for CW, AM, SSB, or FM.

A simple LC filter should be placed between the IF and limiter stages (pins 12 and 14) to reduce broadband noise. Optimum performance of the 604 occurs with a 6-volt power supply, but will work over a 4 to 8 volt range. Supply current is only about 2.5 mA suggesting battery powered operation for both Amateur receivers and accurate field strength meters.

building an S-meter circuit

As stated earlier, each S-unit represents a 6 dB change in RF signal strength. For each 10 dB change in RF input, the 604 circuit output will change about 1/2 volt. If S1 is referenced to the lower limit of the 604's dynamic range (about 0.3 volts output), then S9 will be 48 dB higher (about 2.7 volts output.) Each S-unit will represent 0.3 volt of output meter calibration. A standard linear 0-5 volt meter can be calibrated for S-units and "dB over S9." With an 80 dB dynamic range and 48 dB difference between S1 and S9, 32 dB remains for the "dB over S9" calibration. Furthermore, the S-meter can also be calibrated in dBm and/or RF

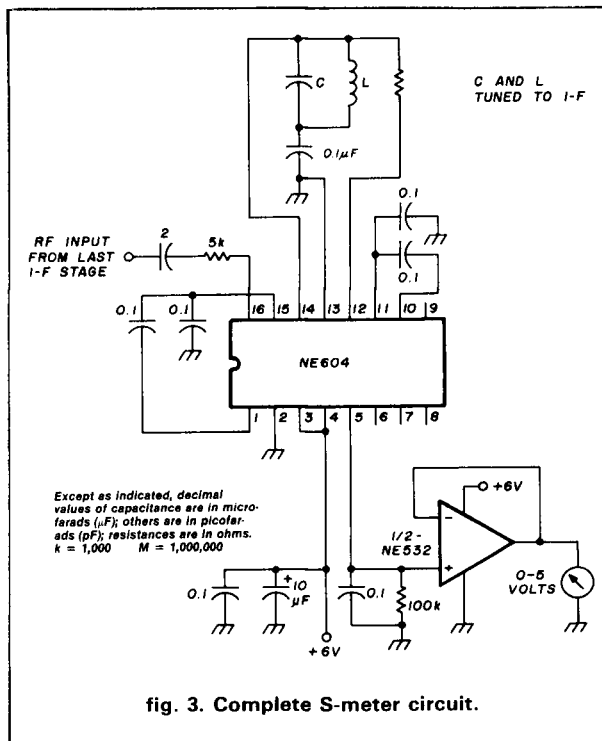


fig. 3. Complete S-meter circuit.

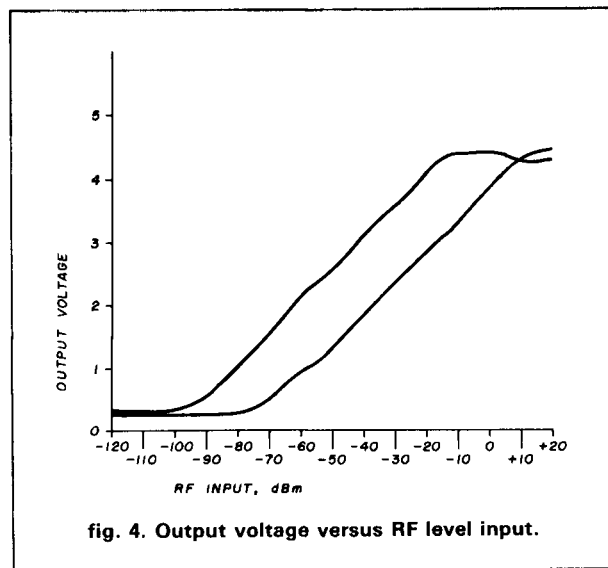


fig. 4. Output voltage versus RF level input.

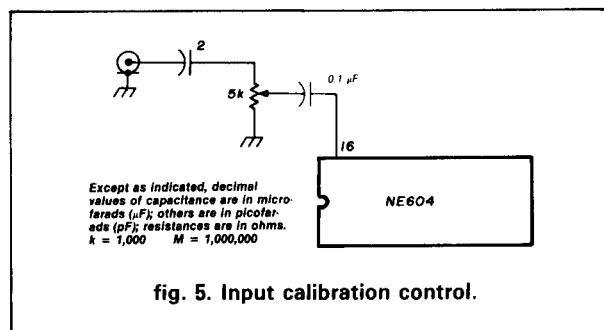


fig. 5. Input calibration control.

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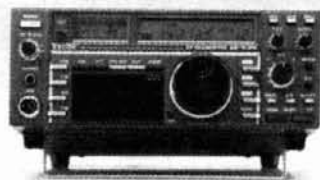
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volts. The receiver has now evolved into a valuable RF test instrument.

Because it might overshoot the actual peaks of signal intensity, an underdamped meter is not recommended for S-meters; critically or slightly overdamped meter movement is preferred instead. An LED or LCD bar graph would also make a suitable display. Digital readout displays are not recommended for S-meters because of their inferior peak reading response.

The RF input impedance at pin 16 is about 1500 ohms. Other capacitor and resistor values can be set for a given IF signal level range, including a potentiometer for a calibration adjustment (fig. 5). Calibration consists of placing a 50 microvolt signal at the antenna terminal, peaking the response by fine tuning the VFO, and adjusting the pot for S9. Correct meter tracking will now be automatic.

This circuit will provide an accurate S-meter reading if certain precautions are taken. Most S-meters use the AGC voltage as the control voltage. Although the RSSI generated voltage would also be ideal for the AGC voltage source, the S-meter linearity would require the AGC function to be disabled. Alternatively, the meter can be calibrated with the AGC "on". Either way, the NE604 will also allow you to know exactly the

table 3. Tested S9 μV sensitivity for some popular rigs.

radio	S9 (μV)	radio	S9 (μV)
FT901	50	Omni D	36
TS-820	200	Triton IV	20
SB104	265	Atlas 350 XL	150
FT301	95	FT901	8
TS-520	110	Argonaut	10
FT7	180	TS-820	110
TS-120V	180	FT301S	30
TR7	20	SB303	70
75S3B	250	KWM2	60
IC701	20	FT101E	10

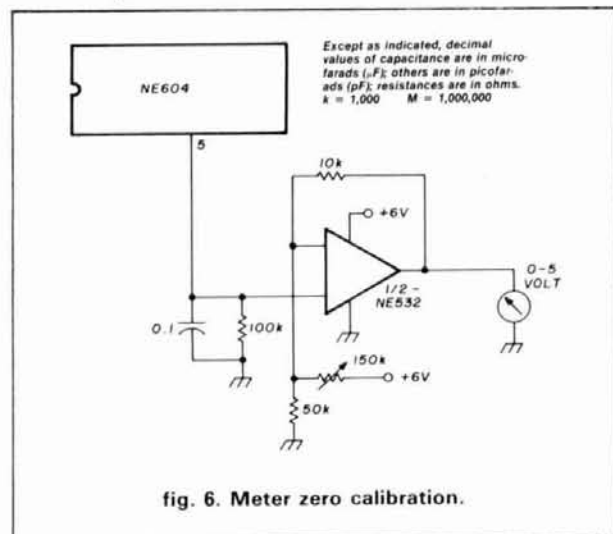


fig. 6. Meter zero calibration.

amount of gain limiting present at any time by comparing the S-meter readings with and without AGC. When not using the AGC, any RF or IF gain controls must have a "calibrated" position. Furthermore, if gain varies with frequency, as in older receiver designs, any array of trim pots controlled by the bandswitch could be the answer.

An important feature of this circuit is that relative dB measurements will be very accurate even if the absolute reading is not calibrated. This is a useful practical on-the-air feature for accurate antenna gain comparisons.

Figure 4 shows that the output voltage never goes to zero. A meter zeroing control should be easy to build with the addition of a few more op amps and standard DC offset techniques (fig. 6).

This is a simple project that can transform your receiver into a field strength and RF voltmeter. More importantly, it can transform meaningless numbers into valuable measurements.

references

1. *CQDL*, December, 1980, pages 550-555.
2. Sidney Kaiser, WB6CTW, "Measuring Receiver Dynamic Range," *ham radio*, November, 1979, page 56.
3. Doug DeMaw, W1FB, and Wes Hayward, W7ZOI, "Modern Receivers and Transceivers: What Ails Them?" *QST*, January, 1983, page 11.

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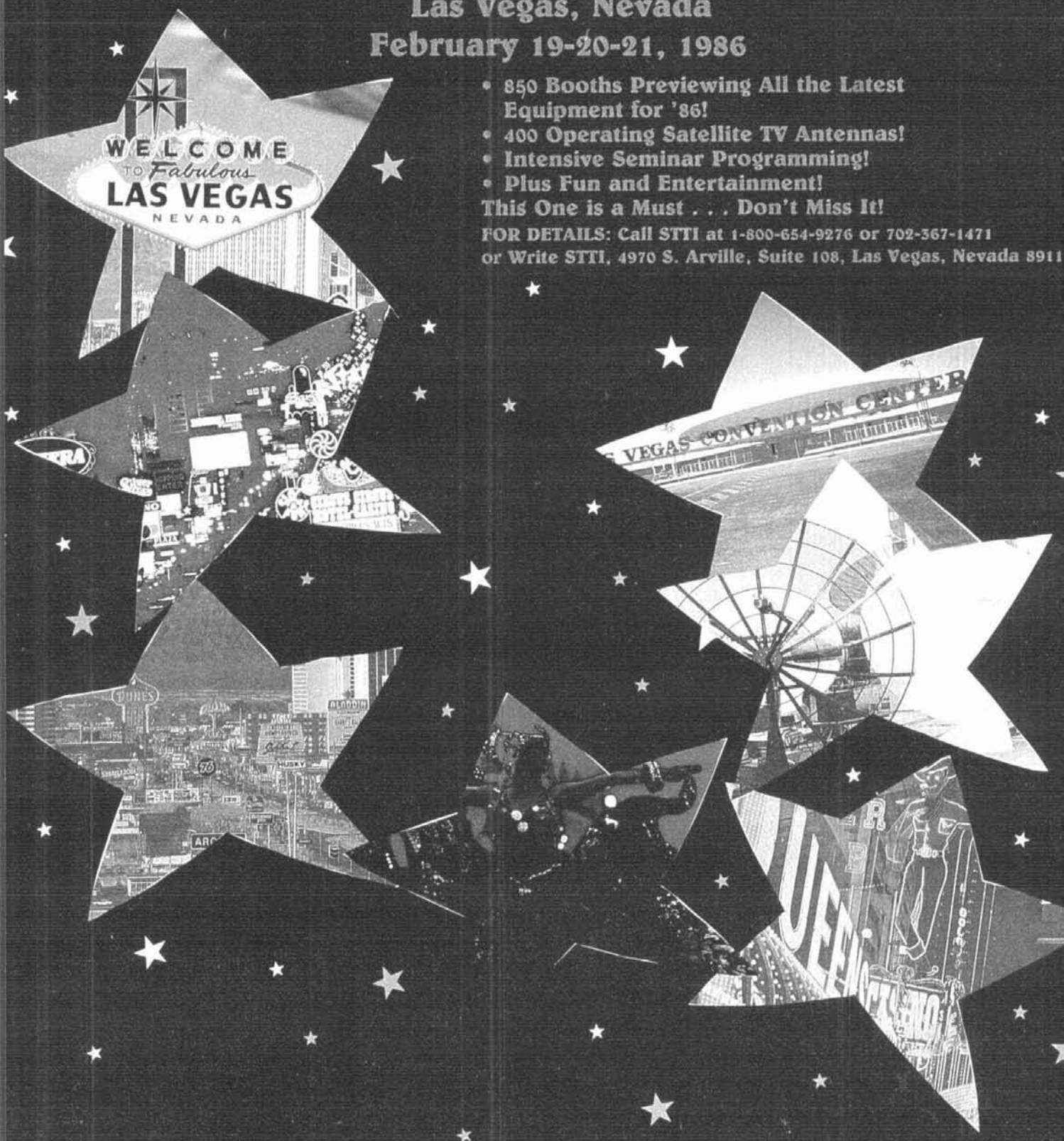
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passive audio filter design

part 3: attenuation equalizers and driving, terminating audio filters

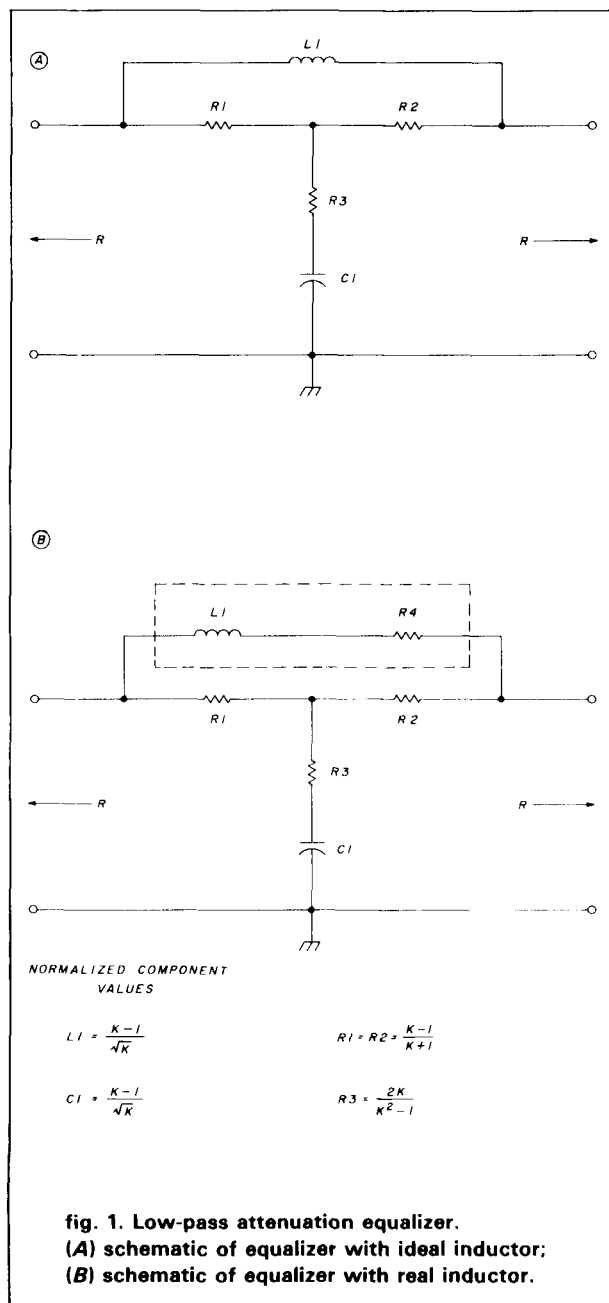
Improving the response of filters constructed with low- Q inductors

In parts 1 and 2^{1,2} of this series, it was shown that two effects of using low- Q inductors in a filter are a general decrease of the passband response as frequency increases and a roundoff near the theoretical cutoff frequency. These effects are most noticeable with the responses of sharp cutoff filters, such as the elliptic low-pass filters described earlier. To a certain extent, these effects can be reduced by adding a high-pass filter in series with the low-pass, giving a band-pass response.

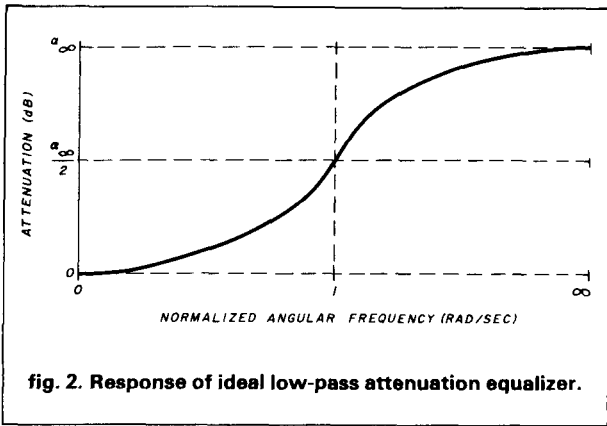
The classical method of correcting this roundoff of the amplitude response (other than by using higher- Q inductors) is by using an attenuation equalizer. Do not be put off by the name; equalizers are very simple and can produce a dramatic improvement in filters with low- Q inductors. I will now outline the design of these equalizers and show the effect they can produce on some of the filters already described.

low-pass attenuation equalizers

The schematic of an ideal low-pass attenuation equalizer is shown in fig. 1(A), along with equations



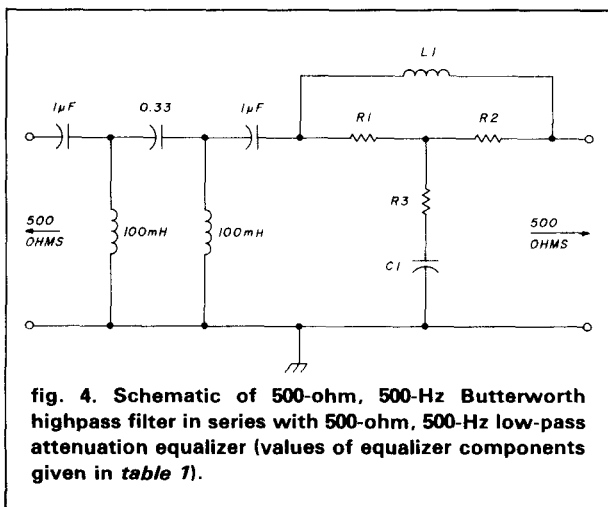
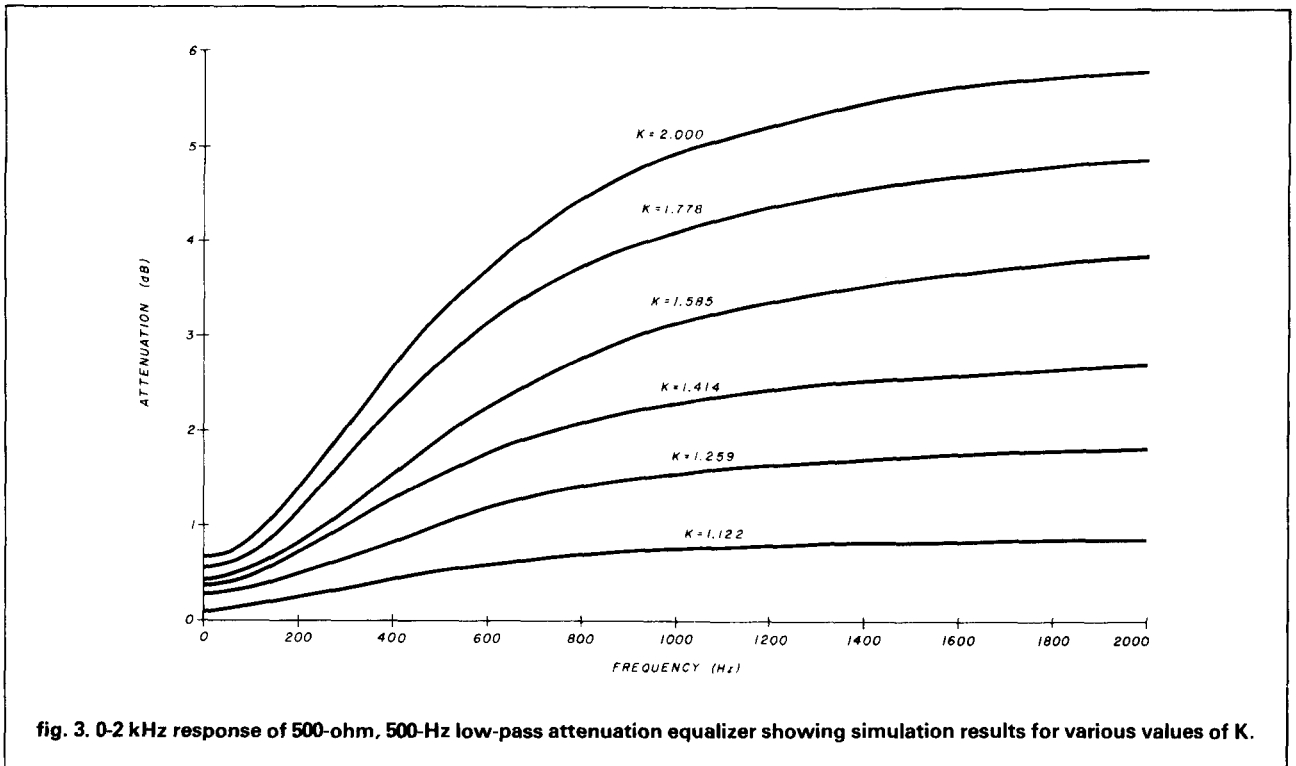
By Stefan Niewiadomski, 29 Mackinley Avenue, Stapleford, Nottingham, NG9 8HU, England



that define the normalized (1-ohm, 1-rad/sec) component values in terms of a constant, K .³ **Figure 1(B)** shows the equalizer with a resistor, R_4 , added in series with L_1 to simulate the low Q of the inductor used in the actual equalizer. The theoretical response of the ideal network is shown in **fig. 2**.

At zero frequency, the equalizer has no loss. As frequency increases, the attenuation increases, asymptotically approaching a finite value of α_∞ dB at infinite frequency. The value of α_∞ is given by:

$$\alpha_\infty = 20 \log K$$



where K is the constant used to calculate the component values. At the normalized angular frequency of 1 rad/sec, the attenuation is $\alpha_\infty/2$.

A low-pass equalizer is intended for use with a high-pass filter, constructed with low- Q inductors, to correct its response near its cutoff frequency. I will use the Butterworth 500-ohm, 500-Hz highpass filter described previously to illustrate the effects of a low-pass equalizer. The normalized equalizer component values must therefore be scaled to 500 ohms to match the highpass filter. The scaled equalizer will then present an impedance at its terminals which is purely resistive and equal to 500 ohms at all frequencies. The half-attenuation frequency of the equalizer does not necessarily have to be equal to the filter cutoff frequency, but this represents a good starting point. The final,

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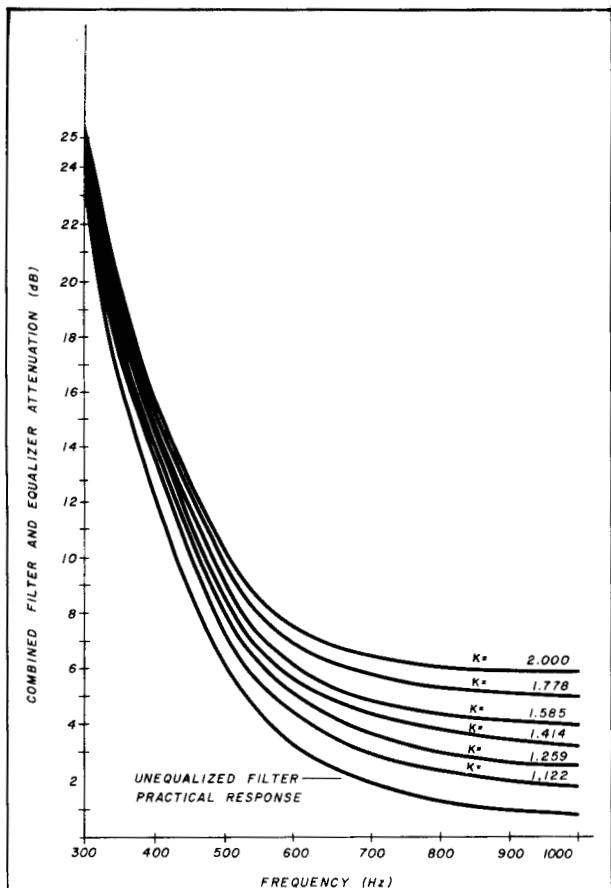


fig. 5. 300-1000 Hz response of 500-Hz Butterworth highpass filter with 500-ohm, 500-Hz lowpass equalizer for various values of K, showing simulation and practical results (original highpass filter practical response also shown for comparison).

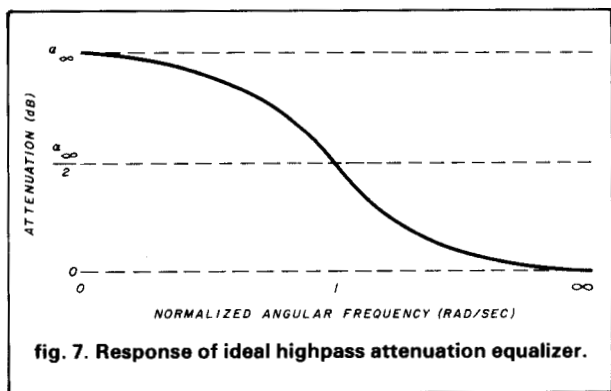


fig. 7. Response of ideal highpass attenuation equalizer.

scaled values of the equalizer are therefore set for 500 ohms and 500 Hz.

Table 1 shows, for six values of K, the 1-ohm, 1-rad/sec component values; the exact 500-ohm, 500-Hz values assuming an ideal inductor; and rounded values with a value entered for R4 to model the real inductor, L1. These six K's give values of α_{∞} of 1, 2,

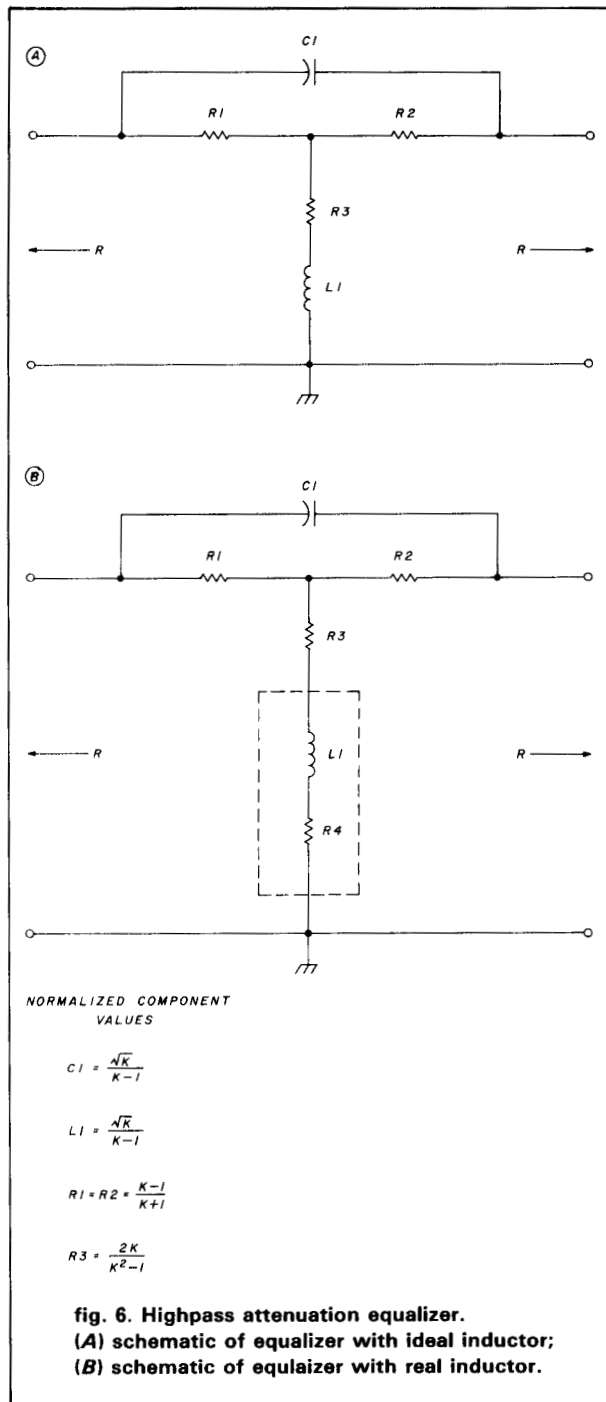


fig. 6. Highpass attenuation equalizer. (A) schematic of equalizer with ideal inductor; (B) schematic of equalizer with real inductor.

3, 4, 5, and 6 dB, respectively, and attenuations at 500 Hz (for the scaled values) of 0.5, 1, 1.5, 2, 2.5, and 3 dB. Component values for the scaled impedance and half-attenuation frequency are obtained in the same way as for filters,* so the normalized values in table 1 can be used to obtain practical values for any impedance and half-attenuation frequency.

Figure 3 shows the simulated response of the

*See part 1, September, 1985, page 30.

500-ohm, 500-Hz equalizer with the rounded values and real inductor. Curves are plotted for the six values of K tabulated in table 1. For K = 1.122, 1.259, 1.414, and 1.585, good agreement with theory was found, the half-attenuation values being 0.5, 1, 1.55, and 1.95 dB, respectively. At the maximum frequency plotted,

2 kHz, the responses flatten out and approach the maximum attenuation of 1, 2, 3, and 4 dB. The curves for K = 1.778 and 2.000 show more deviation from the theoretical responses, having half-attenuation values of 2.7 and 3.25 dB. However, at 2 kHz the maximum attenuations of 5 and 6 dB are approached.

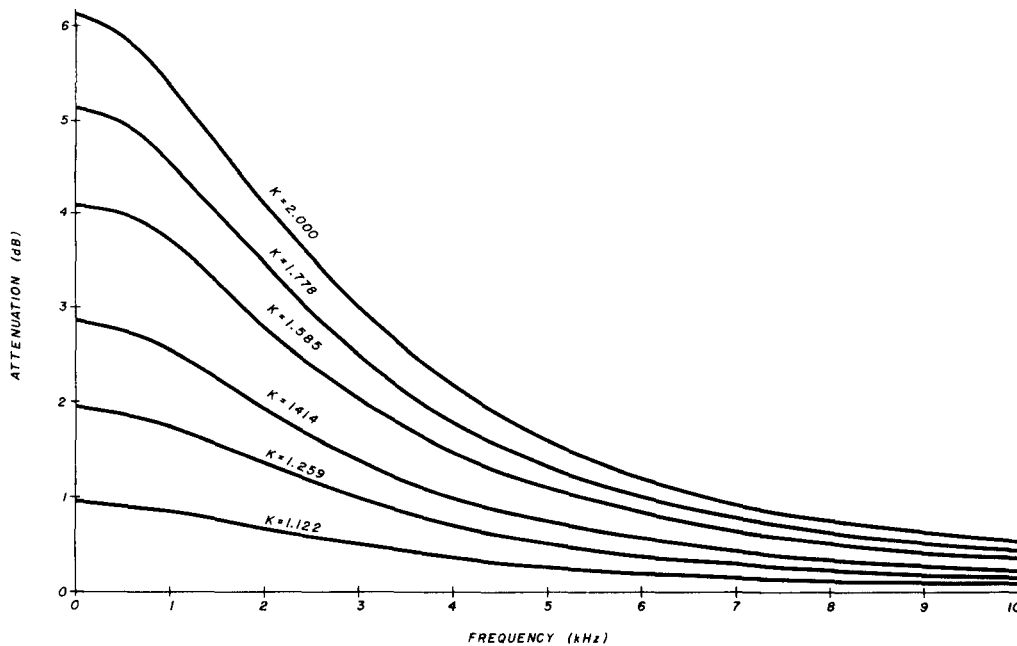


fig. 8. 0-10 kHz response of 500-ohm, 3-kHz highpass attenuation equalizer showing simulation results for various values of K.

table 1. Low-pass attenuation equalizer component values.

component	1 ohm, 1 rad/sec value	500 ohm, 3 kHz theoretical value ideal inductor	500 ohm, 3 kHz rounded value real inductor	1 ohm, 1 rad/sec value	500 ohm, 3 kHz theoretical value ideal inductor	500 ohm, 3 kHz rounded value real inductor
K = 1.122						
C1	0.1152 F	0.0733	0.068	0.2308 F	0.1469	0.15
L1	0.1152 H	18.33 mH	18 mH	0.2308 H	36.73 mH	39 mH
R1,R2	0.0575	28.75	27	0.1147	57.35	56
R3	8.668	4334	4700	4.304	2152	2200
R4	—	0	17	—	0	45
K = 1.259						
C1	0.3482 F	0.2217	0.22	0.4647 F	0.2958	0.27
L1	0.3482 H	55.42 mH	56 mH	0.4647 H	73.96 mH	68 mH
R1,R2	0.1715	85.75	82	0.2263	113.15	120
R3	2.830	1415	1500	2.0962	1048	1000
R4	—	0	58	—	0	66
K = 1.414						
C1	0.5835 F	0.3715	0.39	0.7071 F	0.4502	0.47
L1	0.5835 H	92.87 mH	100 mH	0.7071 H	112.54 mH	120 mH
R1,R2	0.2801	140.1	150	0.3333	166.67	180
R3	1.6453	822.7	820	1.3333	666.67	680
R4	—	0	82	—	0	97
K = 1.585						
C1	0.5835 F	0.3715	0.39	0.7071 F	0.4502	0.47
L1	0.5835 H	92.87 mH	100 mH	0.7071 H	112.54 mH	120 mH
R1,R2	0.2801	140.1	150	0.3333	166.67	180
R3	1.6453	822.7	820	1.3333	666.67	680
R4	—	0	82	—	0	97
K = 1.778						
C1	0.5835 F	0.3715	0.39	0.7071 F	0.4502	0.47
L1	0.5835 H	92.87 mH	100 mH	0.7071 H	112.54 mH	120 mH
R1,R2	0.2801	140.1	150	0.3333	166.67	180
R3	1.6453	822.7	820	1.3333	666.67	680
R4	—	0	82	—	0	97
K = 2.000						
C1	0.5835 F	0.3715	0.39	0.7071 F	0.4502	0.47
L1	0.5835 H	92.87 mH	100 mH	0.7071 H	112.54 mH	120 mH
R1,R2	0.2801	140.1	150	0.3333	166.67	180
R3	1.6453	822.7	820	1.3333	666.67	680
R4	—	0	82	—	0	97

Having shown by simulation that low-pass equalizers can be built with practical, preferred-value components, the effect on the Butterworth 500-ohm, 500 Hz filter will now be shown.

The schematic of the Butterworth filter combined with the low-pass equalizer is shown in **fig. 4**. **Figure 5** shows the simulated response of the Butterworth highpass filter in series with the 500-ohm, 500 Hz equalizer. Again, the responses for six values of K are shown, as well as the practical response of the original filter. How much improvement in the response has occurred?

If we take the difference in attenuation between 1 kHz and 500 Hz (which should, in theory, be very close to 3 dB) as a measure of quality, the improvement can be assessed. For the unequalized filter, this figure is about 5.5 dB; for the filter with the equalizer of $K = 1.122$ it is about 5.7 dB; with $K = 1.414$, it is about 5.3 dB; and with $K = 2.000$, it is about 4.3 dB. There has been a gradual improvement in the response as K increases, but of course the price to be paid is a corresponding increase in the 1-kHz (and beyond) insertion loss. This loss can be compensated by increasing the gain of the active devices in the audio path. With this particular example, however, it is doubtful whether the fairly marginal improvement in response is worth the extra components required and the extra insertion loss suffered.

highpass attenuation equalizers

The schematic of an ideal highpass attenuation equalizer is shown in **fig. 6A** with equations for the

normalized component values. This equalizer has been obtained by an identical transformation to that applied to a lowpass filter to transform it into a highpass filter.

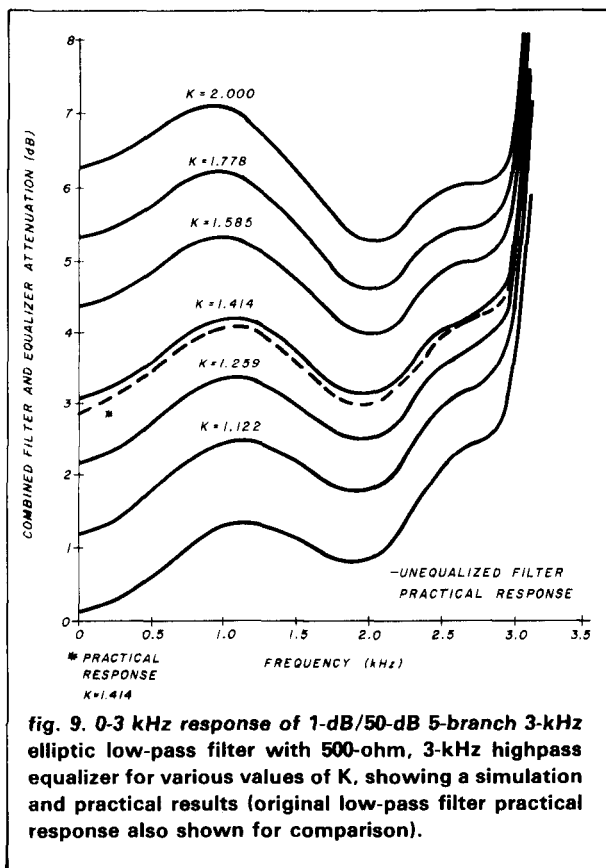


fig. 9. 0-3 kHz response of 1-dB/50-dB 5-branch 3-kHz elliptic low-pass filter with 500-ohm, 3-kHz highpass equalizer for various values of K, showing a simulation and practical results (original low-pass filter practical response also shown for comparison).

table 2. Highpass attenuation equalizer component values.

component	1 ohm, 1 rad/sec value	500 ohm, 3 kHz theoretical value ideal inductor	500 ohm, 3 kHz rounded value real inductor	1 ohm, 1 rad/sec value	500 ohm, 3 kHz theoretical value ideal inductor	500 ohm, 3 kHz rounded value real inductor
K = 1.122						
C1	8.681 F	0.921	1 μ F	4.333 F	0.460	0.47
L1	8.681 H	220.3 mH	220 mH	4.333 H	114.95 mH	120 mH
R1,R2	0.0575	28.75	27	0.1147	57.35	56
R3	8.668	4334	4700	4.304	2152	2200
R4	—	0	95	—	0	97
K = 1.414						
C1	2.872 F	0.3047	0.33	2.152 F	0.2283	0.22
L1	2.872 H	76.19	82 mH	2.152 H	57.09 mH	56
R1,R2	0.1715	85.75	82	0.2263	113.15	120
R3	2.830	1415	1500	2.0962	1048	1000
R4	—	0	71	—	0	58
K = 1.778						
C1	1.714 F	0.1819	0.18	1.4142 F	0.1500	0.15
L1	1.714 H	45.47 mH	47 mH	1.4142 H	37.52 mH	39 mH
R1,R2	0.2801	140.1	150	0.3333	166.67	180
R3	1.6453	822.7	820	1.3333	666.67	680
R4	—	0	52	—	0	45
K = 2.000						

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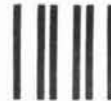
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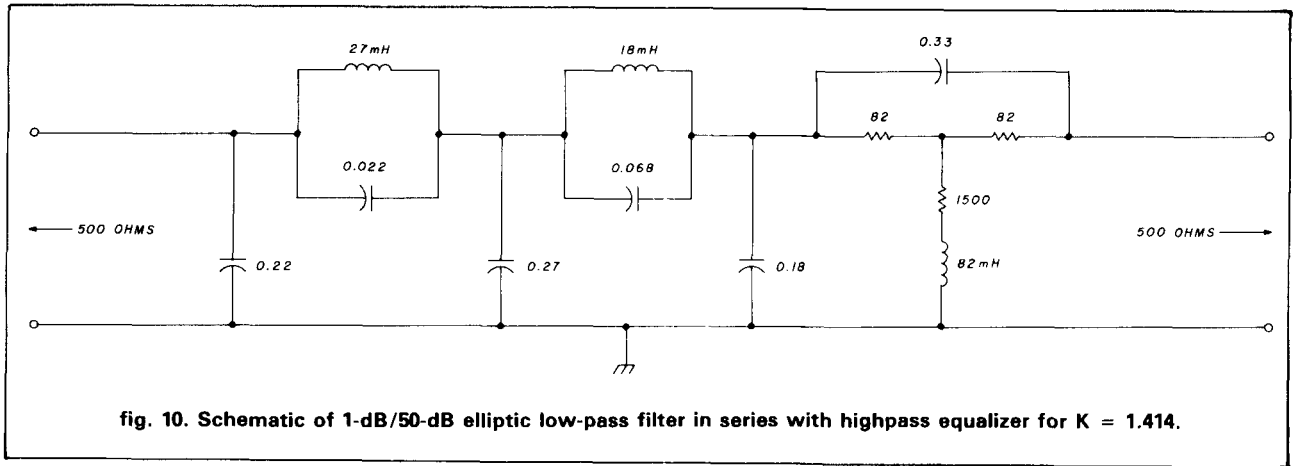


fig. 10. Schematic of 1-dB/50-dB elliptic low-pass filter in series with highpass equalizer for $K = 1.414$.

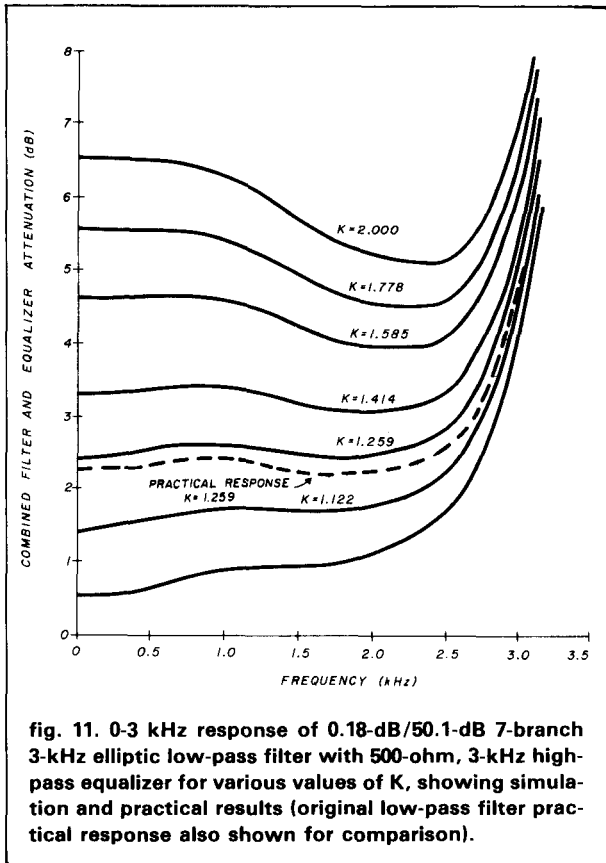


fig. 11. 0-3 kHz response of 0.18-dB/50.1-dB 7-branch 3-kHz elliptic low-pass filter with 500-ohm, 3-kHz high-pass equalizer for various values of K , showing simulation and practical results (original low-pass filter practical response also shown for comparison).

That is, the inductor has been transformed into a capacitor, the capacitor into an inductor, and their values are the inverse of the original values. **Figure 6B** shows resistor $R4$ added in series with $L1$, as before. The theoretical response of the ideal network is shown in **fig. 7**. This response is the inverse of that of the low-pass equalizer.

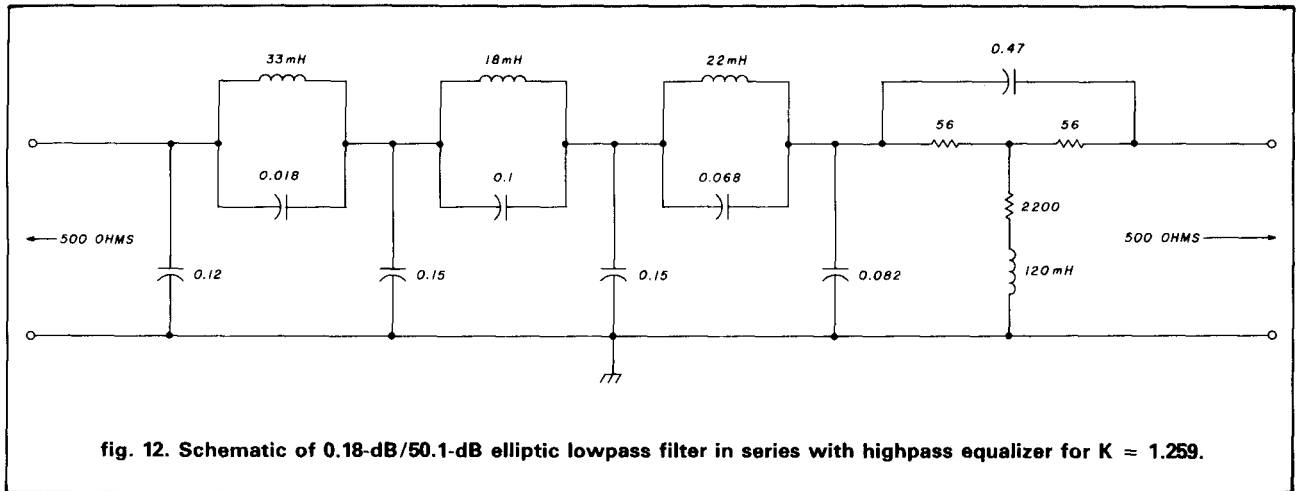
The method of calculating α_∞ is identical to the low-pass case, and again the half-attenuation angular frequency is 1 rad/sec.

Table 2 shows the component values obtained for the same six values of K as before. This time, however, the values have been scaled to 500 ohms, 3 kHz to make the equalizers compatible with the 1-dB/50-dB and 0.18-dB/50.1-dB low-pass elliptic filters described previously.

Figure 8 shows the simulated response of the 500-ohm, 3-kHz equalizer with the rounded values and real inductor. Curves for the six values of K are plotted. The simulations show good agreement with theory, having half-attenuation values close to the theoretical values at 3 kHz. For $K = 1.122, 1.259,$ and 1.414 , the curves approach 1, 2, and 3 dB respectively, as expected. However, for $K = 1.585, 1.778,$ and 2.000 , the asymptotic values are a little above those expected.

Figure 9 shows the simulated response of the 1-dB/50-dB elliptic low-pass filter in series with the highpass equalizers of **table 2** for the six values of K . For these simulations, the equalizer was inserted after the filter, but which comes first is not important. The practical response of the filter with no equalization is also shown, and the progressive effect of increasing the value of K for the equalizer can be seen. Only the responses up to 3100 Hz are shown, because above this frequency they are almost indistinguishable. The difference in minimum stopband attenuation between the unequalized filter and the filter with the $K = 2.000$ equalizer is only about 1 dB.

As shown in **figure 9**, the smoothest passband response is obtained for $K = 1.414$. The passband ripple up to 260 Hz now meets the design specification of 1 dB, with approximately 1.5 dB more loss before the design cutoff frequency of 3 kHz is reached. The total attenuation difference between 100 Hz and 3 kHz is therefore approximately 2.5 dB, compared with approximately 3.6 dB for the unequalized filter. The penalty paid is a decrease in the differential between the minimum passband and minimum stopband attenuations from approximately 53 dB to approximately 50 dB.



To verify the simulation results, the equalizer with $K = 1.414$ was built and connected to the output of the practical 1-dB/50-dB filter. The schematic of the combined network is shown in fig. 10. The results are plotted in fig. 9 for comparison with the simulated response. Very close agreement with the simulated response was obtained. In practice, slightly less insertion loss is seen at all frequencies than in the simulated response.

The way in which the highpass equalizer modifies the 0.18-dB/50.1-dB elliptic low-pass filter is shown in fig. 11. The equalizer component values are those shown in table 2. A flattening of the passband response can be seen, particularly for $K = 1.259$. The equalizer for this value of K was built, placed in series with the 0.18-dB/50.1-dB filter and the combined response measured. The schematic of the combined networks is shown in fig. 12, and the practical results are plotted in fig. 11 for comparison with the simulated response. Again, good agreement with the simulated response was found. The real insertion loss is slightly less than expected at all frequencies.

Ripple in the practical response for the combination with $K = 1.259$ is now less than 0.4 dB up to 2.5 kHz. Although this is still more than the theoretical maximum for the ideal low-pass filter, it is a considerable improvement on the unequalized response (approximately 1.5 dB).

driving and terminating audio filters

Whether passive audio filters are incorporated into existing equipment or included in new designs, correct source and termination impedances must be used if predictable results are to be obtained. Figure 13 shows some methods commonly used to interface these filters.

Figure 13A shows a common emitter amplifier that uses Q1, which can be almost any commonly available

transistor. The output impedance of this amplifier is equal to the collector resistor, R_S , so this should be chosen to be the same as the source impedance of the filter. The base and emitter resistors should be chosen to set the DC voltage at the collector of Q1 at a value that allows an AC swing compatible with the signal level being handled. The output buffer amplifier, Q2, is an emitter follower. The input impedance of the transistor in this configuration is very high, so the termination seen by the filter is the parallel combination of R1 and R2. R1 and R2 should therefore be chosen to terminate the filter correctly and set the DC operating conditions of Q2. If a DC path exists from the input of the filter to ground or to the output, then the input DC blocking capacitor, C_1 , will be required. If a DC path exists from the output of the filter to ground, then C_O will be required. The RC network in the supply line prevents any signal coupling from input to output through the buss, which would degrade filter performance.

Transistor Q2 can be replaced by an FET stage. The termination impedance for the filter will then be provided by a resistor from the gate of the FET to ground.

Figure 13B shows an operational amplifier circuit. Because the output impedance of an operational amplifier with feedback is very low, the source impedance for the filter has to be provided by resistor R_S . The termination for the filter is provided by R_T . The feedback resistors for the operational amplifiers can be chosen to provide any reasonable value of gain for these stages. Of course, the techniques of figs. 13A and 13B can be combined, and the final configuration can be chosen to make the best use of available components.

You may have noticed that the source and termination impedances for all the filters previously described is 500 ohms, which, of course, is a non-preferred value. The importance of providing the correct impedances is often stressed, so how critical is

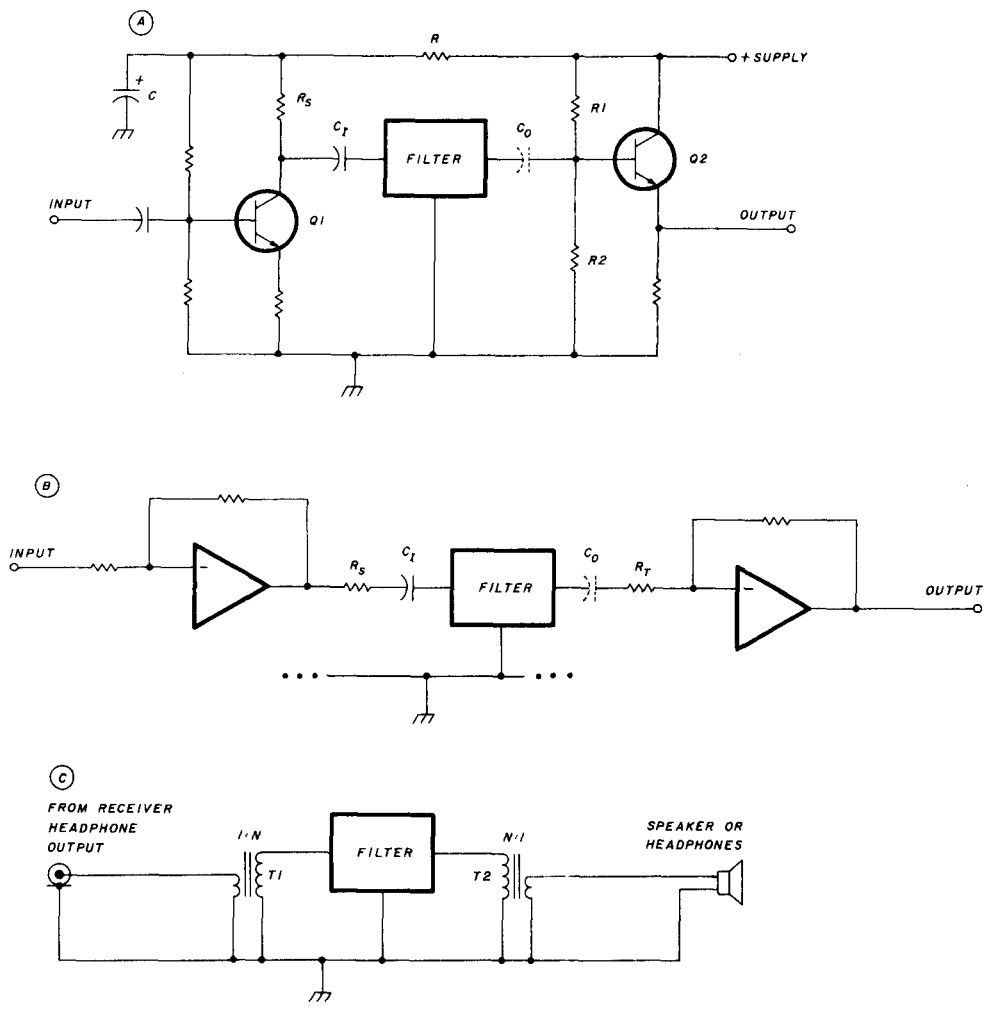


fig. 13. Various methods of connecting an audio filter into the audio path: (A) transistor circuit; (B) op-amp circuit; and (C) transformer-coupled circuit.

this matching? My own experiments have shown that the E12 values* of 470 and 560 will give slightly increased passband ripple, but not enough to be noticeable in practice. One interesting point is that an increase in passband ripple, even if it is caused by mismatching a filter, tends to give an increase in stopband attenuation (though this is not recommended as a method of obtaining better stopband performance.)

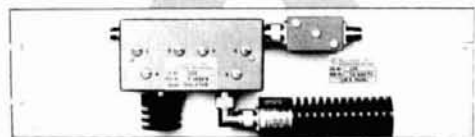
Often the simplest way of adding an audio filter is in the low-impedance headphone output of a receiver. A method used to couple the comparatively high-impedance filter (typically 500 ohms) to the much lower impedance audio output is shown in fig. 13C. Transformers T1 and T2 have a turns ratio equal to the square root of the ratio of the filter and speaker or phone impedances. One low-power transformer

suitable for matching an 8-ohm phone output to 500-ohm filters is the Mouser Electronics No. 42TU400, (8/500 ohm c-t) transformer with PC leads (\$1.67 each).

mismatched sources

Though transformer coupling is the easiest method of incorporating an audio filter into an existing design, it is also the most likely to result in filter mismatches. One source of mismatch is that the headphone output of a receiver may come directly from the audio power amplifier, which will have a very low output impedance — typically less than 1 ohm. The filter input is therefore most likely to be driven by a too low source impedance. This can be alleviated to a certain extent by inserting a low value resistor in series with the connection to the low-impedance winding of T1. A loss in signal will result, but it can be compensated for by

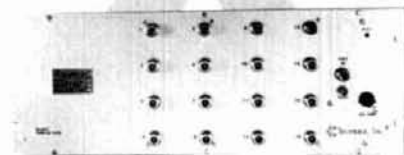
*See Niewiadomski, part 1, September, 1985, page 17.



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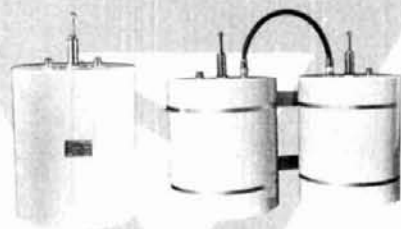


Receiver Multicoupling

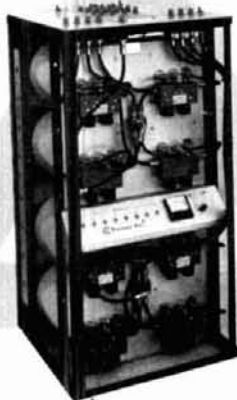
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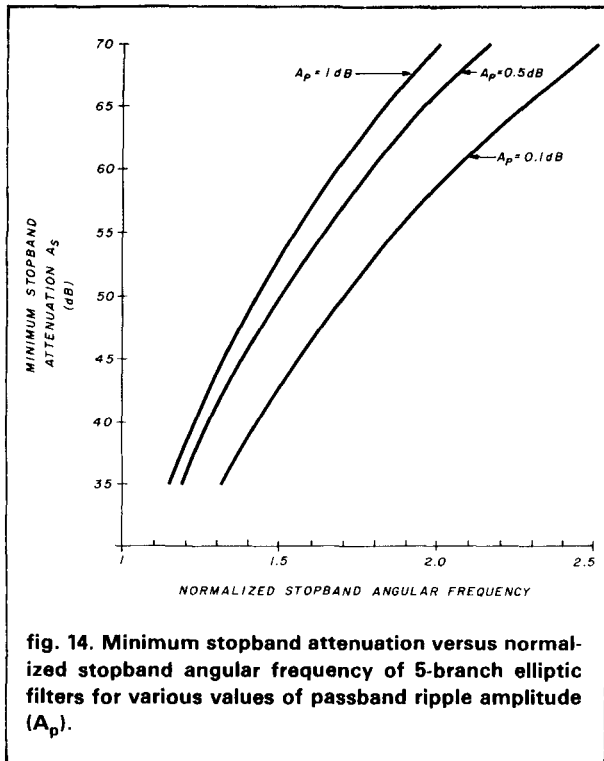
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increasing the volume level of the receiver. Another source of mismatch is the speaker or headphones themselves, which can often have an impedance which varies with frequency, thereby mismatching the output of the filter. Additional losses and mismatches can occur in the transformers. Despite these problems, a filter connected into the output of the average receiver will result in a considerable reduction in hiss and hum as well as unwanted shifted frequency SSB signals, thereby providing a corresponding increase in intelligibility.

significance of passband ripple

One notable effect on the performance of a filter using rounded component values and low- Q inductors is an increase in passband ripple. The question that has to be asked, therefore, is whether this is a significant effect in practice for a filter used in a radio receiver? I will try to answer this question by looking for other sources of audio ripple in a receiver and assessing what amplitude this ripple might typically be.

The first element which may introduce any significant ripple is the IF SSB filter. Although these filters are usually of very high quality (and expensive), they typically have a passband ripple of 1-3 dB. This ripple value may effectively be doubled if you are communicating with someone using the same model of transceiver as yours, since the peaks in ripple produced in the other station's transmit IF filter will tend to be at the same frequencies as in your receive IF filter, and vice versa.

Probably the biggest source of ripple in a receiver is the loudspeaker, which inherently has a nonlinear electrical power input to sound pressure output characteristic. Typically, a 4-inch loudspeaker in free air exhibits a 9-dB ripple from 1 kHz to 3 kHz in its sound pressure output.⁴ When mounted in a metal case, with many cavities formed by metal dividers and printed circuit boards behind it, even more ripple may be produced.

Another source of ripple is the response of the human ear. Experiments performed to measure the thresholds of audibility for pure tones⁵ indicate that the ear exhibits approximately 8 dB variation in the range 1 kHz to 3 kHz, being more sensitive at high frequencies.

A similar effect to that caused by the loudspeaker response will also be caused by the microphone at the transmitting end. I do not have any typical figures for this ripple, but it could be similar to the loudspeaker value.

These factors tend to negate attempts to minimize the passband ripple of an audio filter in a receiver. In this context, I believe that the passband ripple found in the filters described here is insignificant for most practical applications. Since in many cases increased passband ripple can be traded for rapid rolloff and/or greater stopband attenuation, advantage should be taken of the relative insignificance of passband ripple. This trade-off can be seen from fig. 14, in which curves of minimum stopband attenuation (A_S) are plotted against normalized ripple cutoff frequency for 5-branch elliptic filters of 0.1, 0.5, and 1-dB passband ripple.³ It can be seen that for a normalized start of stopband angular frequency of 1.5 rad/sec, an extra 10 dB of stopband attenuation can be obtained by using the 1-dB rather than the 0.1-dB filter. Alternatively, the 50-dB stopband attenuation figure can be achieved at 1.42 rad/sec rather than at 1.7 rad/sec by using the 1-dB rather than the 0.1-dB filter. Another approach is to use a lower-order filter with a higher amplitude of ripple for a given application to achieve an attenuation comparable to a higher-order filter with a lower amplitude of ripple, thereby saving components and cost.

Considerable opportunity for experimentation remains on this question of passband ripple amplitude, specifically in regard to the point at which the ripple amplitude becomes both noticeable and objectionable, as well as values produced by modern receivers and transceivers.

summary

In this series of three articles, it has been shown, using simulation results, that rounding each component of an audio filter to the nearest preferred value does not result in a drastic change in performance.

Though the results obtained are not as good as with the exact component values, they would be indistinguishable for most practical purposes. This result in itself can considerably simplify the construction of filters using high- Q inductors, as exact values of capacitors and inductors do not have to be obtained or selected.

When low- Q inductors are used in filter designs, further degradation in performance takes place, but again acceptable results are obtained. Toko 10RB inductors were used in the experiments described here. Very small and inexpensive, they allow complex filters to be built compactly and inexpensively.

Several designs of elliptic low-pass filters and one Butterworth highpass filter have been described. All have been tested and shown to be thoroughly practical. Construction details have also been provided. The results obtained suggest that tables of normalized filter designs (which have for many years been used only by professionals) can now be used by Amateurs with the confidence that near-to-theoretical responses can be obtained. It has also been shown that these passive filters can be cascaded to form bandpass filters; construction details have been provided.

Attenuation equalizers have been shown to be a practical method of improving the response of filters constructed of low- Q inductors. These fairly simple networks, whose design procedure has been described, can be cascaded with the filters described here. Simulation and practical results have been presented to show the improvements obtained.

Computer simulation of filters and other networks has been shown to be a powerful design aid. As well as showing the effects of varying component values, simulation also shows that calculations such as scaling to the final cutoff frequency and impedance values can be confirmed before any components are bought.

Some methods of driving and terminating audio filters have been described, ensuring that the correct

source and termination impedances for the filter are provided.

Finally, some of the factors that affect the ripple amplitude in the audio passband of a receiver were discussed. This indicated that efforts to minimize the passband ripple of an audio filter can be negated by other factors. Therefore, it can be more advantageous to trade increased passband ripple for better stopband performance at the design stage to obtain improved overall performance.

The experiments have been carried out entirely with Toko 10RB inductors, which are very compact and inexpensive. Other inductors, such as those manufactured by Dale or Miller, may also be suitable for audio filter applications.

I hope this series of articles has convinced experimenters and builders that audio filters can be constructed easily, either by using the designs presented here or by selecting other designs from tables of normalized component values. With passive designs, performance far superior to that obtainable from active designs can be obtained; perhaps passive designs will become popular again in Amateur equipment.

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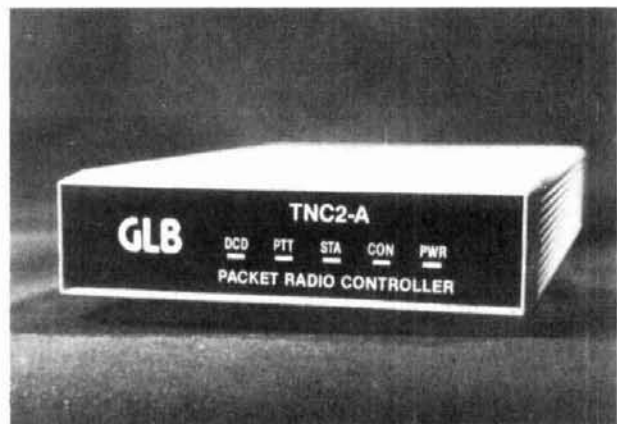
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Amateur microwave bands

My dictionary defines microwaves as the frequency range between 1 millimeter and 1 meter, the region between infrared and short-wave radio frequencies. Most Amateurs, however, consider the microwave bands those Amateur frequencies allocations above 450 MHz.

In the United States, we are presently allocated over 23,000 MHz — not counting all the frequencies above 1 mm (300 GHz). This is a huge resource. Compare this with less than 50 MHz below the microwave frequencies, of which 10 MHz are currently under attack (420-430 MHz), where greater than 99 percent of all Amateur operation takes place. For comparison, I've listed the Amateur frequency allocations above 450 MHz in the microwave bands in **table 1**.

As stated in last month's column, I haven't written much about the microwave bands because I felt I had to first establish a solid base at the VHF/UHF frequencies.¹ With the past 24 columns in this series behind us, that base is now in place. With this in mind, I hope now to devote some of my columns specifically to the microwave frequencies. Therefore, this month's column will serve as sort of an introduction to the microwave bands, frequencies in use, and activities thereon.

a look back

First, let's take a glance at the past. Amateurs have really only operated on the microwave frequencies since World War II.² Most microwave operation in North America has been conducted on the 23 cm (1215-1300 MHz), 13 cm (2300-2450 MHz), and 3 cm (10-10.5 GHz) bands with a little

table 1. Major worldwide Amateur microwave frequency allocations. Many countries share the same frequency bands, although the frequencies may be shifted slightly.

band	frequency	notes
33 cm	902-928 MHz	Available in USA since Sep. 28 1985. Canada has same but on A3/F3 only.
23 cm	1215-1300 MHz	1215-1240 still available in Canada, but recently withdrawn in USA. Some countries in Region 1 do not have the full assignment. Others have power or EIRP restrictions.
13 cm	2300-2450 MHz	2310-2390 was removed from USA use on November 6, 1984. Many Europeans cannot operate below 2320. Japan has only 2400-2450.
9 cm	3300-3500 MHz	Some area restrictions apply. UK and West Germany have 3400-3475.
6 cm	5650-5925 MHz	Some area restrictions apply. UK and West Germany have 5650-5850.
3 cm	10.0-10.5 GHz	
12 mm	24-24.25 GHz	24-24.05 in West Germany
6 mm	47-50 GHz	47-47.2 in West Germany, 48-50 in USA.
4 mm	71-76 GHz	75.5-76 in West Germany
2 mm	142-170 GHz	165-170 GHz in USA, 142-144 GHz in West Germany.
1.2 mm	240-250 GHz	248-250 in West Germany
1 mm	300 GHz and above	No restrictions in USA.

activity on 9 cm (3300-3500 MHz), 6 cm (5650-5925 MHz), 12 mm (24-25.25 GHz) and 6 mm (47-50 GHz) thrown in. In fact, the only reported North American Amateur contacts above 50 GHz are in the optical frequency bands, those frequencies above 300 GHz!³ I've updated the DX record table and the latest records (as of this date) are shown in **tables 2, 3 and 4**.

During World War II, the military classified frequencies by assigning let-

ter designations to the various bands. Some of those designations are still in use today, especially in reference to older surplus gear. **Table 5** shows these designations. However, tri-Service designations have now changed to a more orderly list; the more recent band designators are shown in **table 6**.

Until recently, most Amateur gear used on the microwave bands was commercial or surplus equipment that

table 2. Worldwide claimed microwave terrestrial DX records.

frequency	record holder	date of QSO	prop mode	dx miles (km)
1296 MHz	KH6HME-N6CA	6/24/84	Tropoducting	2472 (3977)
2.3 GHz	VK5QR-VK6WG	2/17/78	Tropoducting	1170 (1883)
3.3 GHz	G3LQR-SM6HYG	7/11/83	Ducting	576 (927)
5.7 GHz	G3ZEZ-SM6HYG	7/12/83	Ducting	610 (981)
10 GHz	I0SNY/EA9- I0YLI/IE9	7/08/83	Ducting	1032 (1660)
24 GHz	I3SOY/3, IW3EHQ/3- I4BER/6, I4CHY/6	4/25/84	LOS	180 (289)
47 GHz	HB9AMH/P-HB9 MIN/P	6/11/84	LOS	33 (53)
474 GHz	K6MEP-WA6EJO	6/09/79	LOS	15 (24)

table 3. North American claimed microwave DX records by propagation modes. The records are listed alphabetically by mode. Ducting is suspected where the paths are mostly over water. No efforts are made to separate ducting on overland paths, so they're grouped under "tropo".

frequency	record holder	date	prop mode	dx miles (km)
1296 MHz	KH6HME-N6CA	6/24/84	Ducting	2472 (3977)
	K2UYH-VK5MC	12/06/81	EME	10,562 (16995)
	W4WSR-WA5TKU	6/03/85	Tropo	1112 (1790)
2.3 GHz	PA0SSB-W6YFK	4/5/81	EME	5491 (8836)
	W4HHK-W8YIO	7/28/83	Tropo	583 (938)
3.3 GHz	K6HIJ/6-W6IFE/6	6/18/70	LOS	214 (344)
5.6 GHz	K5FUD-K5PJR	9/20/77	Tropo	267 (430)
10 GHz	WA4GHK/4- WD4NGG	8/07/84	Ducting	297 (478)
	W7JIP/7- W7LHL/7	7/31/60	LOS	265 (426)
24 GHz	KX00/0, W0MXY/0- NK0P/0, WA0VSL/0	8/24/85	LOS	74 (119)
48 GHz	W2SZ/1- WA2AAU/1	9/08/84	LOS	0.3 (.5)
71-250 GHz	None reported			
Above 300 GHz	K6MEP-WA6EJO	6/09/79	LOS	15 (24)

table 4. Worldwide claimed EME Microwave DX records.

frequency	record holder	date of QSO	prop mode	dx miles (km)
1296 MHz	PA0SSB-ZL3AAD	6/13/83	EME	11595 (18657)
2304 MHz	PA0SSB-W6YFK	4/05/85	EME	5491 (8836)
3300 MHz and above:	None reported.			

was often borrowed or modified by Amateurs for their use. The primary modes of communication were often wideband FM and pulse.²

The San Bernadino Microwave Society (SBMS) was an early supporter of the microwave bands with their "polaplexers."⁴ This scheme uses

only one oscillator at each end of the path that is modulated for transmitting and provides the LO for receiving. This LO was often a klystron; in more recent designs, it's often a Gunn diode oscillator.

Polaplexers were primarily used to set DX records between mountain tops using portable gear — with "portable" meaning gear that could be carried by two men and a boy! Indeed, the SBMS 9 cm record for North America still stands (table 3). The polaplexer's days seem to be numbered, and the gunplexer is rapidly replacing it on the 3 cm and 12 mm bands.⁵

looking forward

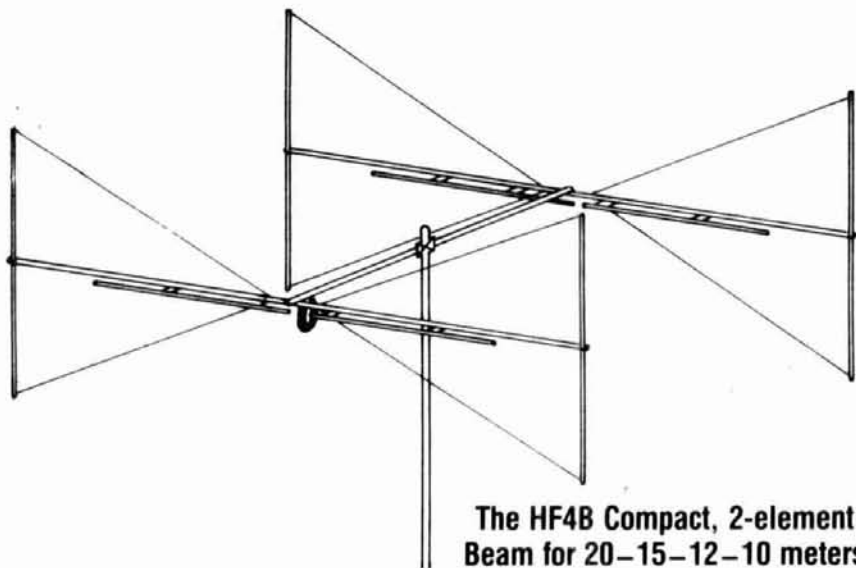
Before 1970, many of the microwave records were held by North Americans. Then the British and Germans started to take on the challenge. Before long, many of the European countries were there in great numbers. When you look at the worldwide DX records in table 2 and compare these with the North American records in table 3, you must conclude that there's plenty of room for challenging DX records. Furthermore, I'm not aware of any successful Amateur EME activity above the 13 cm band (table 4).

At the present time, narrow-band modes such as CW and SSB are starting to take hold even on 3 cm, a hotbed of activity in the UK. The state of the art advances rapidly. Needless to say, the Europeans have a good track record. So let's get in on the ground floor and see what we in North America can do!

Unless you're a radio astronomer, it's no fun to listen to white noise. Activity on the microwave bands, especially above 13 cm, will be successful only if individuals band together and concentrate their efforts. We have the technology — all we need to do is spend the time and make the effort.

The FCC has finally allocated the 33 cm or 902-928 MHz band to radio Amateurs in the USA on a secondary basis. Canadian Amateurs already

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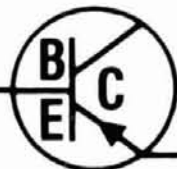


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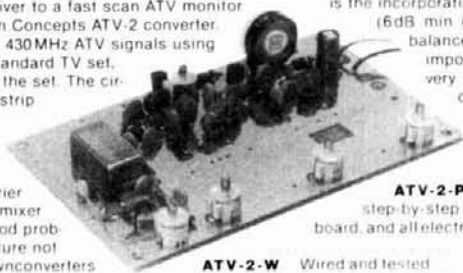
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microwave frequencies and modes

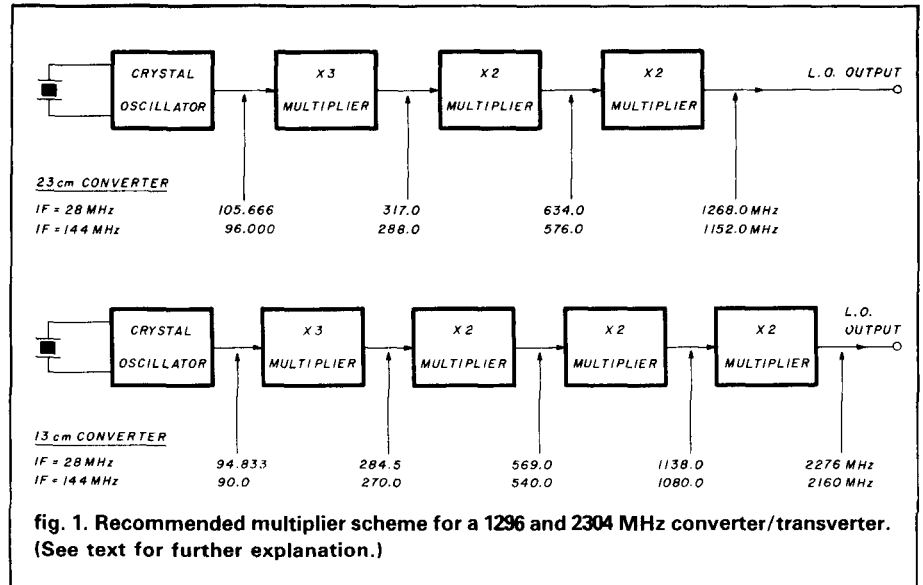
Most of the North American activity below 9 cm is now on CW and SSB. Many years ago weak signal operators used multipliers from 144 MHz to go to the 70 cm and higher bands. As a result, the weak signal frequencies of 432.0 MHz (144 X 3), 1296 MHz (144 X 9), 2304 MHz (144 X 16), 3456 MHz (144 X 24), 5760 MHz (144 X 40), and 10368 MHz (144 X 72) became established and are still recognized worldwide.

Because CW and especially SSB will probably become widely used, the transmitters and receivers presently employed must be upgraded. Some Gunnplexer operation on 3 cm and 12 mm will undoubtedly continue. But these units will probably be upgraded with frequency/phase locking, improving frequency stability and hence weak signal operation.

The prime weak signal calling frequencies on the lower microwave bands have mostly shifted to 1296.1 and 2304.1 MHz to allow EME exclusively between 1296.0-1296.05 and 2304.0-2304.05 MHz. EME on the 13 cm band will be somewhat fragmented since many European Amateurs can no longer operate below 2320 MHz, and the FCC has removed 2310-2390 MHz in the USA. Therefore, cross-band operation (2304.0 to 2320.15 MHz) is now in use. The ARRL VUAC has recommended 903.1 MHz as the weak signal calling frequency on 33 cm, with EME between 903.0 and 903.05 MHz.

propagation

Radio propagation on the microwave bands is somewhat different than on the VHF/UHF bands. Aurora, while theoretically possible, has yet to be reported. Meteor scatter, sporadic E, F2, and FAI are theoretically impossible on these frequencies.



The most common modes of microwave propagation will probably be line-of-sight (LOS), tropospheric bending, tropospheric ducting, scatter, and EME. Scatter will undoubtedly become more popular for DX since it's very prevalent at microwave frequencies. Large stationary objects (buildings, hills, mountains, and such) as well as aircraft and lightning make excellent scattering media.³ Scatter is often overlooked, but even local operation may be enhanced between stations that have obstructed paths if each station aims at some large hill, building, TV tower, or other structure that they can both "see."

The biggest impediments to DX on microwaves will be foliage/evergreen attenuation, feedline losses, low transmitter power, and narrow antenna beamwidths. The latter problems can all be improved with continued development in state-of-the-art equipment (see below).

Therefore, with the exception of EME, the DX records on the microwave bands will probably be shorter than the VHF/UHF records until better equipment becomes available and activity increases. For more information on the subject of propagation, refer to references 3 and 6.

receiving equipment

Almost all microwave weak signal

operation now uses crystal controlled converters, with 28 and 144 MHz IFs most popular. This permits most of the weak signal types of emissions to be used.

Adequate RF filtering, especially at the image frequency, is required for low-noise operation. Allowing other RF frequencies outside the band of interest to enter the receiver lowers performance, especially if the signals are strong. If a 28 MHz IF is used, filtering is more critical.

However, simple filter designs such as the interdigital type are now available to Amateurs.^{7,8} These filters are particularly easy to design using computer programs that can change the mechanical and electrical specifications at will. Construction is not beyond the hand tool level.

The present state-of-the-art permits noise figures below 3 dB up to 25 GHz. Only a few years ago this would have been unheard of except with the use of parametric amplifiers and masers, both out of the reach of most Radio Amateurs.

Microwave bipolar transistors are now inexpensive and can deliver 1 to 3 dB noise figures through 4 GHz. Affordable (less than \$25) GaAs FETs can now provide less than 2 dB noise figures through 3 cm.⁹ The lower noise figure high mobility electron transistors (HMETs) are coming.¹⁰ Although they

presently cost around \$150.00 (if they can be obtained at all), they reportedly will eventually be less expensive than GaAsFETs since they're easier to manufacture.

The local oscillator (LO) of a microwave converter is very important. As I've stated in previous columns, the basic oscillator for VHF/UHF and above should be an overtone crystal type in the 90-120 MHz region.^{11,12} Not only will this reduce phase noise, but it will improve stability, generate fewer spurs, and require less multiplication.¹³ As a result, there will be fewer birdies and fewer LO products to be filtered out.

Multipliers should also be clean. I recommend that doublers be used if possible since they're more easily filtered and more efficient. If triplers are used, they should be limited to about 400 MHz on the output. Some recommended combinations for 1296 and 2304 MHz are shown in **fig. 1**. Many types of mixers have been used over the years. The through-line single-diode type was commonly used on microwave frequencies in the early days.² More recently, interdigital mixers and the anti-parallel harmonically pumped mixers have been used, since they require a lower frequency LO at a sub-harmonic of the desired frequency.^{14,15,16}

However, I prefer the balanced mixer types.^{11,12} They're usually broadband and represent 50 ohms at all three ports (LO, RF, and IF). Hence they're easy to work with, especially in a modular converter. The double-balanced (DBM) type with four diodes is preferred, and are becoming quite easy to obtain and are reasonable priced (usually \$10-40 for 1-4.5 GHz), with the MDS and TVRO market paving the way for the 2-5 GHz spectrum. The DBM usually requires about 5 milliwatts of LO power.

Finally, the post amplifier (the one following the mixer) should have a low (1 to 2 dB) noise figure to lessen the preamplifier gain requirements. A suitably low noise figure bipolar preamplifier that will cover any IF from 14-150 MHz is described in references 12 and

17. Other low noise circuits are also acceptable, especially those with good input VSWR.

transmitters

Multipliers are fine for the microwave bands. As mentioned before, 144 MHz transmitters used to be multiplied all the way up to the desired microwave band. However, their frequency stability left something to be desired.

If you decide to use a multiplier scheme, there's a preferred method that has been used by many microwave and contest stations.^{18,19} Basically, it uses a 96 MHz oscillator which is multiplied up to 1152 MHz. This is a convenient frequency since its second, third, fifth, and ninth harmonics allow operation on 2304, 3456, 5760, and 10368 MHz respectively, as shown in **fig. 2**. Coincidentally, 1152 mixed with 144 MHz yields 1296 MHz as a bonus!

However, the transverter is rapidly becoming the most popular scheme for getting on the microwave bands. Since only one LO is required per band, it significantly lowers the cost and reduces complexity, not to mention construction time. Properly built, it will have excellent frequency stability. In addition, a transverter allows CW as well as SSB operation at the flip of a switch on the exciter.

The only problem with a transverter is that a separate oscillator is required for each microwave band, unlike the 1152 MHz transmitter scheme just mentioned. Many simple two- or three-band schemes have been proposed to lower the number of required oscillators.

Recently a more or less universal microwave scheme was proposed using a single oscillator.²⁰ Although it may at first seem complicated, it would make a dandy add-on type of building block, since once the first block is in place, bands can be readily added. The disadvantage of the scheme is that a separate converter is required at 288 MHz. However, that frequency is a snap to work with and will be high enough to make image

table 5. Major microwave band designations used during and after World War II. Note that there are some overlaps to add to the confusion.

frequency (GHz)	designation
0.10 - 0.225	G
0.225 - 0.390	P
0.390 - 1.55	L
1.55 - 5.2	S
3.9 - 6.2	C
5.2 - 10.9	X
10.9 - 36	K
12.9 - 18	Ku
26.5 - 40	Ka
36 - 46	Q
46 - 56	V

table 6. Modern Tri-Service microwave band designations in present use.

frequency (GHz)	designation
0 - 0.25	A
0.25 - 0.5	B
0.5 - 1	C
1 - 2	D
2 - 3	E
3 - 4	F
4 - 6	G
6 - 8	H
8 - 10	I
10 - 20	J
20 - 40	K
40 - 60	L
60 - 100	M

rejection a trivial problem. The basic scheme is shown in **fig. 3**.

obtaining power

Power amplifiers aren't always required on the microwave bands. If solid-state multipliers are used, up to several watts can be generated on the lower microwave bands.

Solid-state bipolar transistors can generate several watts of power up through 6 GHz. Power MOSFETs that generate several watts at 1 GHz have been demonstrated. Power GaAs FETS that can deliver 5 to 10 watts of output through 10 GHz are also available.

Until recently, the 2C39/7289 has been the king of transmitting tubes on the lower microwave bands. Single, two, four, six and even eight-tube

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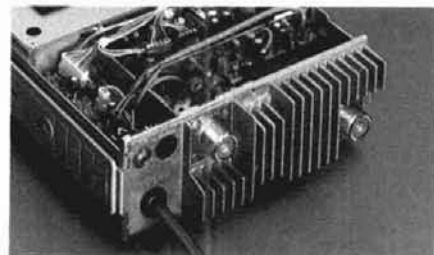
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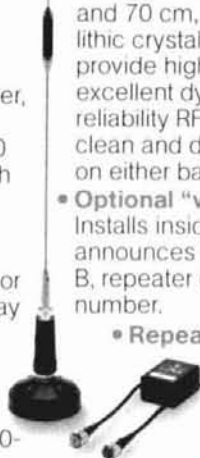
transmit frequencies independently for odd repeater offsets, or cross-band (2 m/70 cm) operation.



- **Rugged die-cast chassis.**
- **Two separate antenna ports.** Use of separate antennas is recommended. This simplifies antenna matching and minimizes loss. However, mobile installations may require a single antenna. The optional MA-4000 dual band mobile antenna comes with an external duplexer.
- **Programmable memory scan with channel lock-out.** Programmable to scan all memories, or only 2 m or 70 cm memories. Also may be programmed to skip channels.
- **Band scan in selected 1-MHz segments.** Scans within the chosen 1-MHz segment (i.e., 144,000-144,995 or 440,000-440,995, etc.). The scanning direction

may be reversed by pressing either the “UP” or “DOWN” buttons on the microphone.

- **Priority watch function.** Unit switches to memory 1 for 1 second every 10 seconds, to monitor the activity on the priority channel.
- **Common channel scan.** Memories 8 and 9 are alternately scanned every 5 seconds. Either channel may be recalled instantly.
- **High performance receiver/transmitter.** GaAs FET RF amplifiers on both 2 m and 70 cm, high performance monolithic crystal filters in the 1st IF section, provide high receive sensitivity and excellent dynamic range. The high reliability RF power modules assure clean and dependable transmissions on either band.
- **Optional “voice synthesizer unit!”** Installs inside the TW-4000A. Voice announces frequency, band, VFO A or B, repeater offset, and memory channel number.
- **Repeater reverse switch.**



More TW-4000A information is available from authorized Kenwood dealers.



Optional accessories:

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- TU-4C two-frequency CTCSS tone encoder
- PS-430 DC power supply
- KPS-7A fixed station power supply
- MA-4000 dual band mobile antenna with duplexer
- SP-40 compact mobile speaker
- SP-50 mobile speaker
- MC-42 UP/DOWN microphone
- MC-55 8-pin mobile mic. with time-out timer
- SW-100B SWR/power meter
- SW-200B SWR/power meter
- SWT-1/SWT-2 2 m/70 cm antenna tuners
- PG-3A noise filter
- MB-4000 extra mounting bracket

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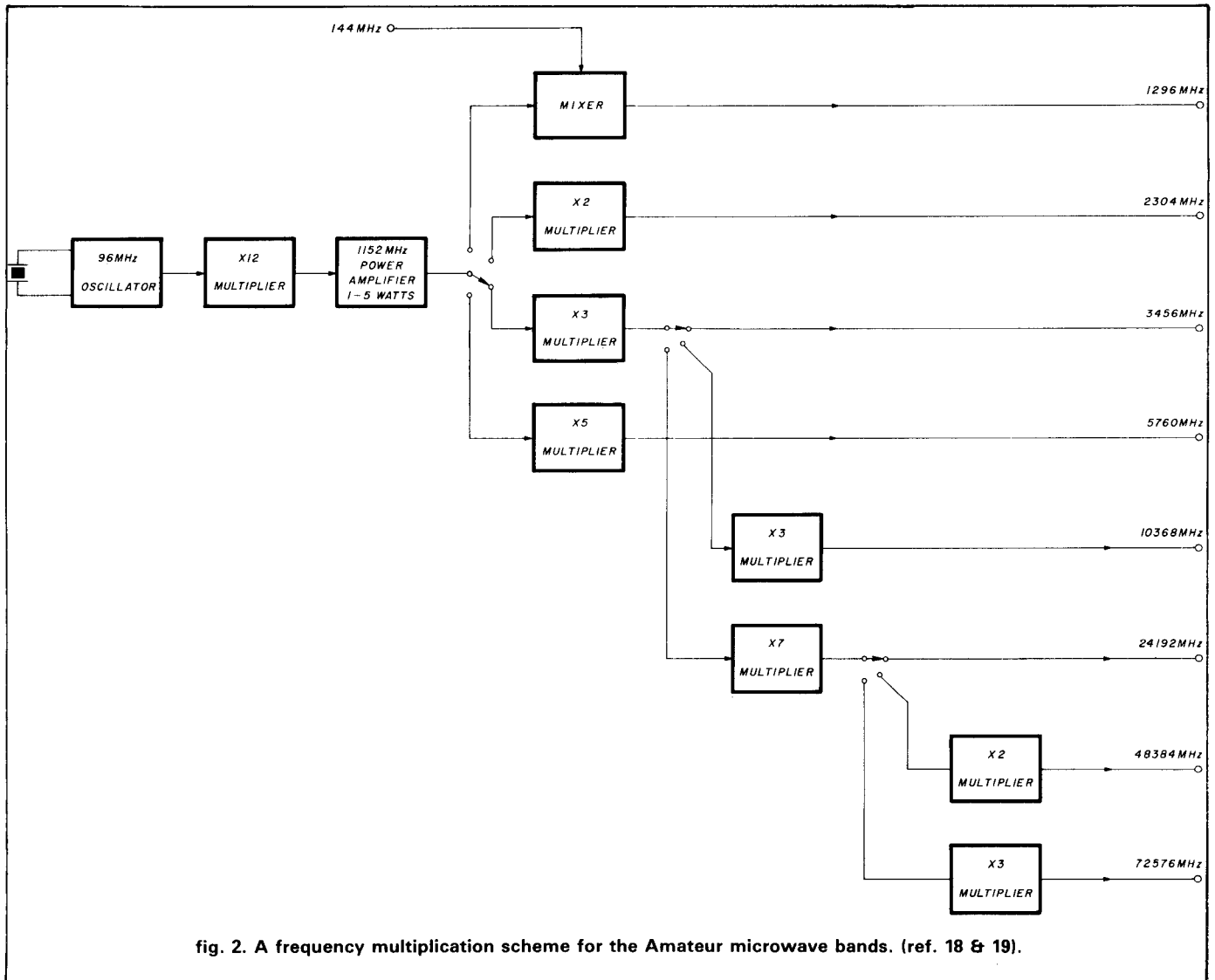
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amplifiers have been used through 2304 MHz.²¹⁻²⁵ The eight-tube amplifier design described in reference 24, however, is not recommended, because this design offers very low efficiency (30-40 percent).

Recently a new single-tube 23-cm amplifier design using a UHF TV tube was introduced. It will reportedly deliver over 400 watts with a 10 dB gain.²⁶ Other tubes and designs are available. Traveling wave tubes (TWT) will deliver up to 100 watts at microwave frequencies, although those above 10 watts are rare in Amateur circles. The outstanding properties of the TWT are that it is broadband (typically one octave), has good linearity, and 25 to 35 dB of gain is typical!

Amateurs are also using high-power klystrons, but they're difficult to obtain and quite high in price. Like TWTs, they frequently have gains of over 30 dB. Magnetrons are another possibility. If someone can find out how to use the type presently so common in microwave ovens, we could have a readily available, low-cost high power amplifier source for 13 cm!

antennas

The principal types of antennas used on the microwave bands are the Yagi, loop Yagi, horn, and the parabolic dish. Because of the critical dimensional requirements, the Yagi will probably not be widely used except below 1300 MHz. But the loop Yagi, with its

unique mounting and matching methods, should be a good performer where 19 to 21 dBi of gain is required with low wind resistance up through at least 3500 MHz.^{27, 28} The microwave horn has only moderate gain (10 to 20 dBi), but is widely used on 3-cm gunplexers and as a feed system for parabolic dishes where low gain or controlled beamwidth is required. The parabolic dish, with its high gain, will probably remain the standard antenna for the microwave bands because it's easily designed, has predictable gain, and is easy to feed.²⁹

feedlines

The microwave bands are a transitional region for feedlines.³⁰ Coaxial

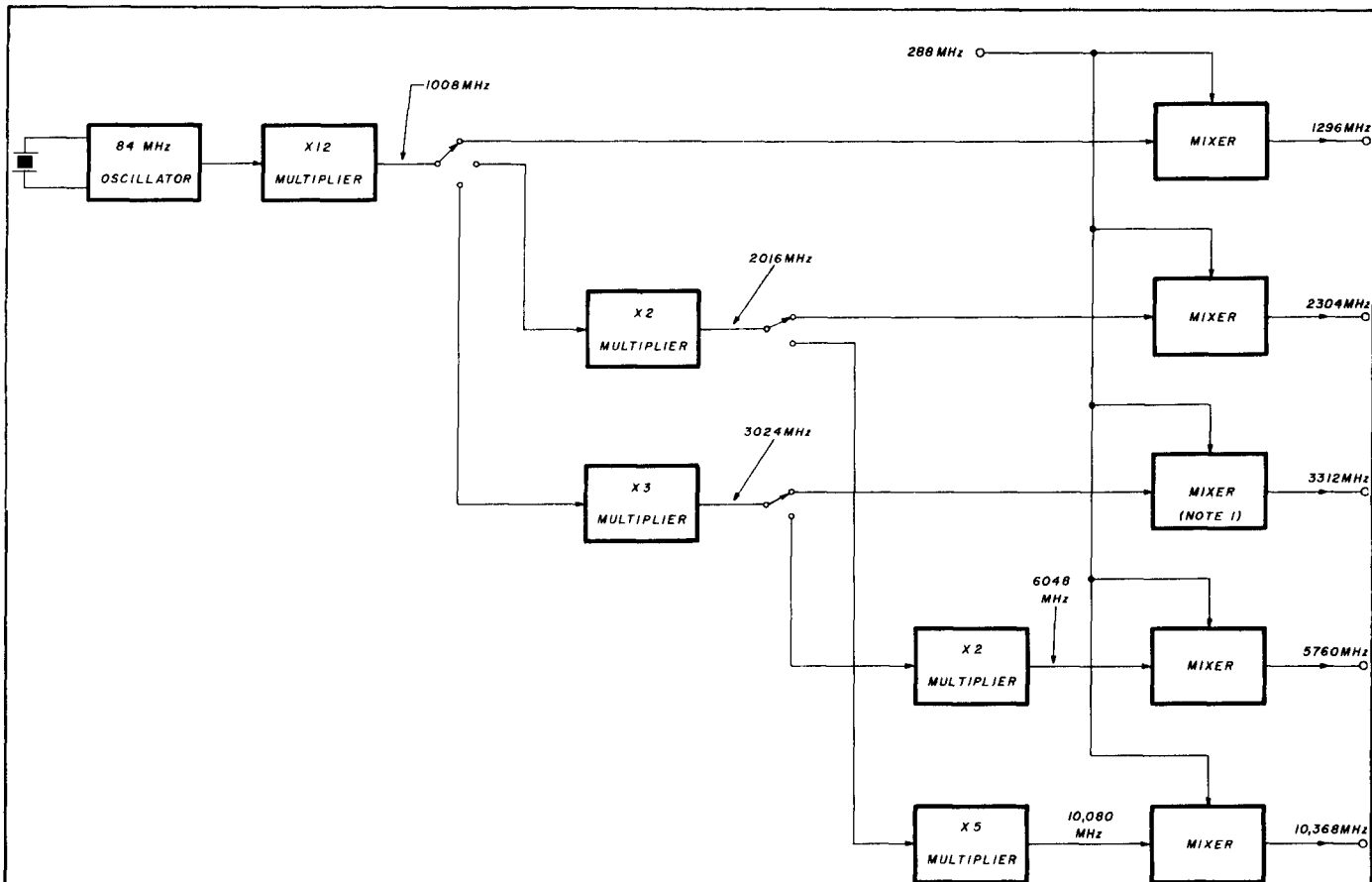


fig. 3. A universal frequency conversion scheme for many of the lower Amateur microwave bands. (ref. 20). Note 1: If 432 MHz is injected instead of 288 MHz, the output will be on 3456 MHz, the standard weak signal frequency.

cable is improving all the time; it's easy to work with, especially where bends or flexibility are required. It will probably remain the most popular line at the lower microwave frequencies and slowly move up in frequency as the state-of-the-art improves. In this regard, the air dielectric types of coax such as Heliac™ are preferred.

Waveguide will probably remain the most common type of transmission line on the microwave bands above 10 GHz. It's readily available as surplus and has very low insertion loss. Don't overlook the possibilities of "G-line," which has the potential for low loss at a very moderate cost — and you can "roll your own."³⁰

commercial gear

Those who know me well are aware that I prefer to build my own gear from scratch because it allows me flexibil-

ity in choosing features as well as the ability to make modifications and improvements without the fear of lowering resale value. It also yields a great sense of accomplishment when everything works!

However, there's now a fair amount of microwave gear available not only from Amateur suppliers, but from commercial suppliers, too. Furthermore, because the state-of-the-art in commercial equipment is moving ahead so rapidly, there's a lot of surplus equipment available to the Amateur. Check the Amateur magazines for further information. The microwave bands are no longer the exclusive territory of the homebrewer!

reference material

There's plenty of material about the microwave bands available if you know where to look.³¹ Of particular note are

the RSGB's *VHF/UHF Manual*, *The Microwave Newsletter Technical Collection*, *The Gunnplexer Cookbook*, *VHF Communications*, *DUBUS*, *IEEE Microwave Theory Transactions*, and *The UHF Compendium*, for example. (For information on how to obtain any of these, see reference 31.) Bibliographies are also available.^{32, 33, 34}

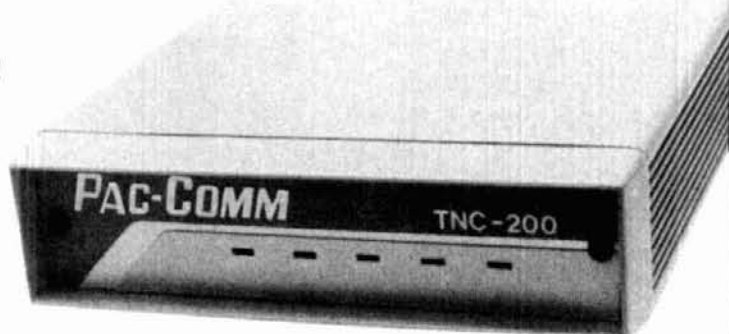
Finally, numerous trade magazines are available for those engaged in the electronics field.³¹ The material is available, but you'll have to take the initiative!

summary

In this month's column, I've tried to provide an introduction to the microwave bands. Because complete examination of the topic would obviously be beyond the scope of this column, I strongly advise you to refer to the references cited.

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important VHF/UHF events:

- January 3: *Peak of Quadrantids Meteor Shower predicted at 2300 UTC*
- January 8: *EME perigee*
- January 11-12: *ARRL VHF Sweepstakes Contest*
- February 4: *EME perigee*

ham radio

short circuit

VHF/UHF world

In the September, 1985 column, "VHF/UHF World" (page 45), the 2 7/8-inch dimension shown in fig. 2C should be changed to $\pm 2 1/2$ inches. This is the height of the loop (from top to bottom), not the diameter, and will cause the loop to appear somewhat oval rather than round.

During final adjustment, the loop Yagi should be tested for minimum VSWR. If it is not below 1.2:1 (after adjusting the spacings between the first director and the reflector, as explained in the text) adjust the loop height carefully to obtain the best match. After adjustment, the junction point where the driven element connects to the brass bolt and the transmission line should be thoroughly soldered together.

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FEATURING: Annual receiver issue, preamp, pulsewidth noise discriminator, IMD of cascaded stages, double conversion portable SW receiver, modular 2m receiver, receiving signals from outer space, receiver alignment system.

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FEATURING: Adjustable power supply, low cost UHF tower, trap antenna design, the "smart" frequency counter, top loaded vertical, power dividers, compact keyer, Part 6 VHF Yagi design.

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FEATURING: History of SSB, audio AGC, MLA-2500 modifications, software packet radio approach, SEED antenna, EMI and digital radio, RFI solutions, OSCAR on your HT, Part 5 VHF Yagi design.

August 1984

FEATURING: 3CX800A7 linear amplifier, How to Buy and recycle surplus parts, ALC circuits, Part 2 cooling semiconductors, grayline fundamentals, computer DX'ing, Part 4 VHF Yagi design.

July 1984

FEATURING: Intro to VHF/UHF propagation, Part 1 cooling semiconductors, wideband VCO design, ground rod resistance, Part 3 VHF Yagi design.

June 1984

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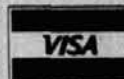
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troubleshooting I: signal tracing/injection

SCENE: It's one of those evenings when you can't determine whether the band has just died a little earlier in the evening than usual or somebody's stuck a pin through your antenna coax. Wise Old Elmer (WOE) is leisurely tuning across 15 meters when the doorbell rings. He opens the door. Standing there, looking more than a

little crestfallen, is Young Squirt (YS), a novice who has only recently upgraded to General Class.

"Hiya, Young Squirt — what's the matter, a truck run into your tower?" Young Squirt replies, "Almost. My \$800 Super Band-Buster Single Sideband (SBBSSB) transceiver died on receive — think ya' can help?"

Now, WOE is one of those old-fashioned people who believes that if you give someone a fish then they eat for today, but if you teach them how to fish, then you feed them for a lifetime. "Well, Squirt, I reckon I could fix it —

after all, you bought the shop manual and I got a workshop full of test equipment. But what good does it do if I fix it?"

WOE pauses, knowing YS's objection because he remembers a scene like that, oh, so many years ago, back when he thought the QCWA met in the local nursing home.

"Well, answers YS, ...it'd get me back on the air."

"Young Squirt," says WOE, assuming a fatherly tone, "you just passed a community college course in radio and nearly aced the General class

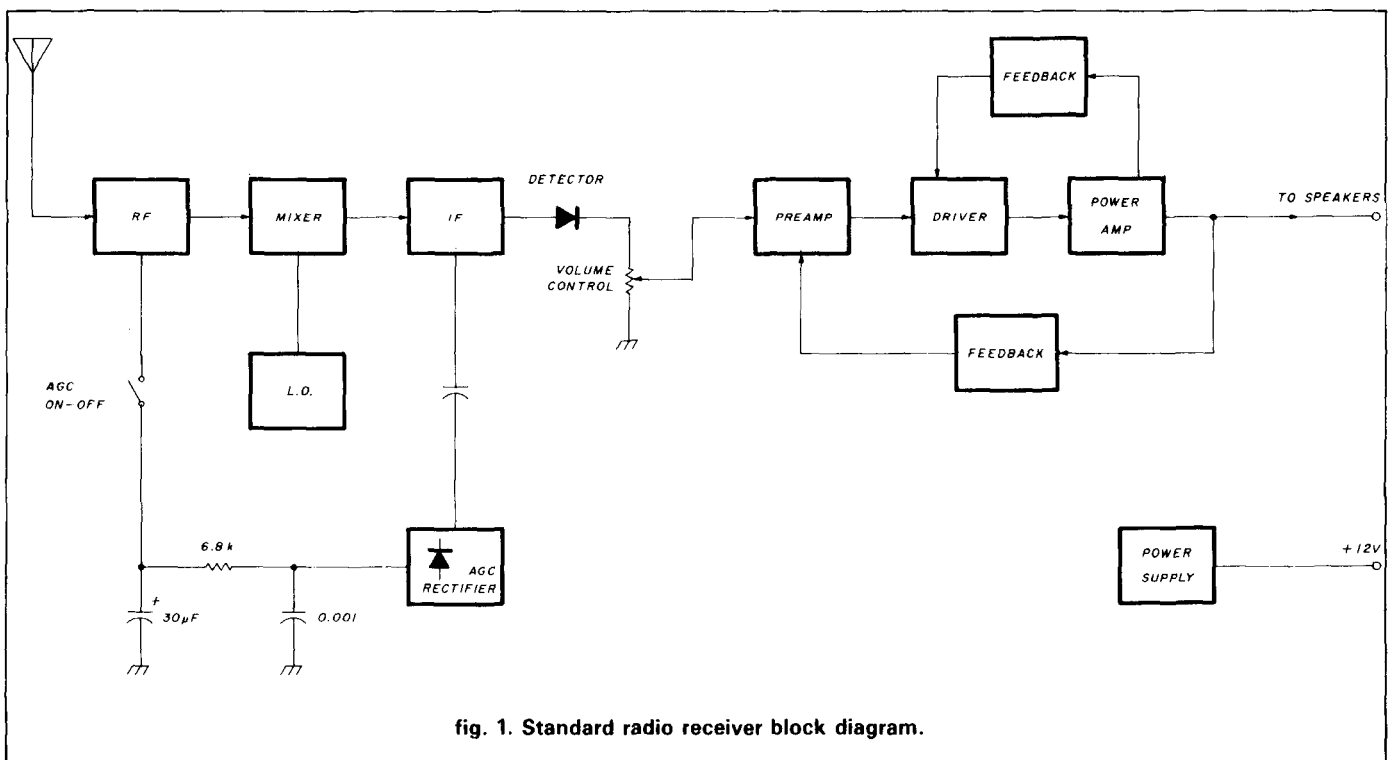


fig. 1. Standard radio receiver block diagram.

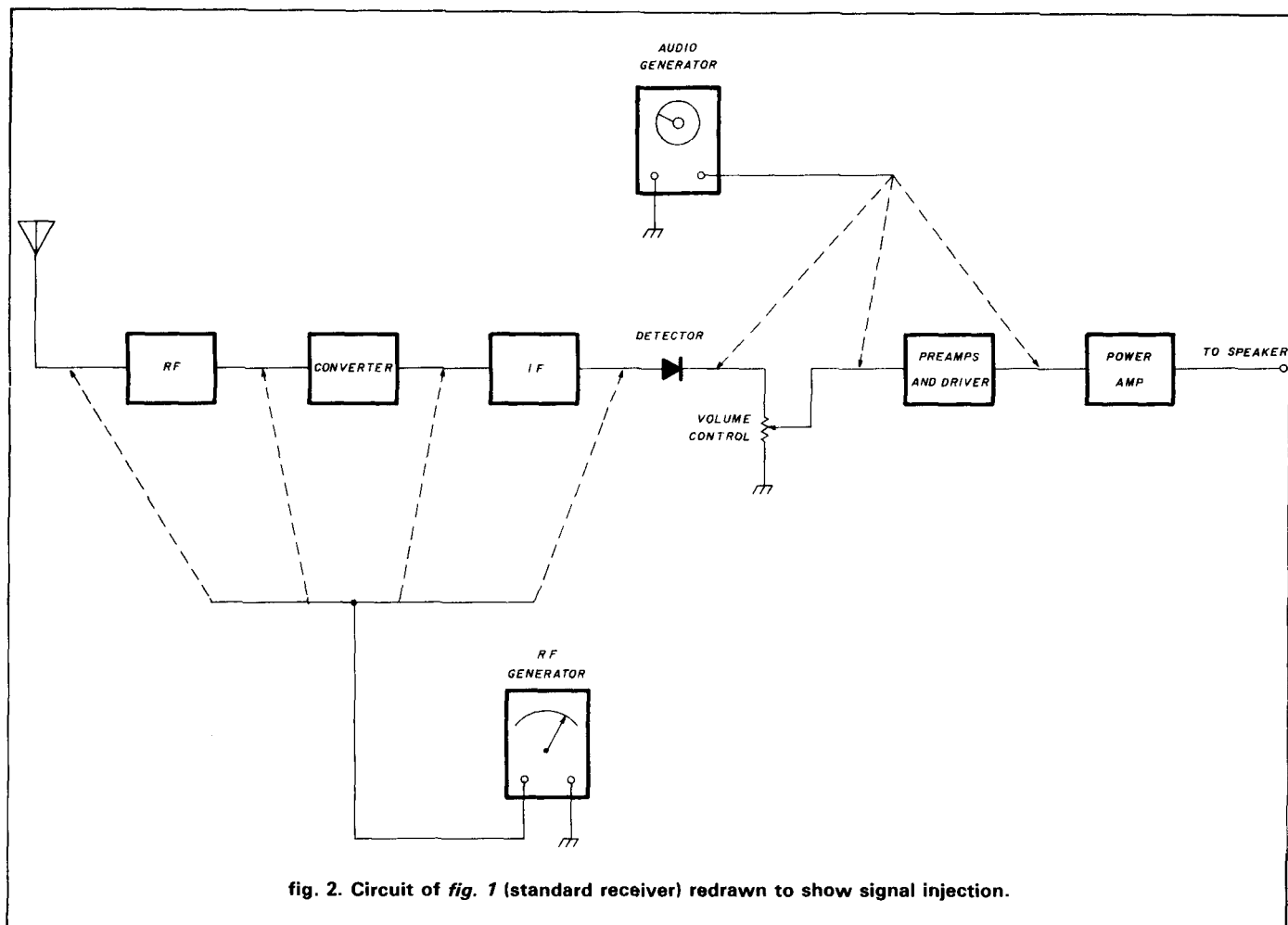


fig. 2. Circuit of fig. 1 (standard receiver) redrawn to show signal injection.

license exam. Why don't I show you how to troubleshoot that rig of yours, and see if you can learn a thing or two?"

YS is startled at the suggestion. Elated, but still questioning his own ability, he admits that WOE knows a lot more than he does, so puts his anxiety on hold. But when WOE heads over to the workbench — muttering something about getting out his fishing pole — the anxiety returns.

With the transceiver on the workbench, WOE directs YS to remove the top and bottom covers according to instructions in the service manual. Taking out a piece of paper and a stubby No. 2 pencil, he draws a block diagram of a standard radio receiver (fig. 1).

"Take a look at this picture, Squirt. Note the various stages. We have an RF amplifier tuned to the incoming sig-

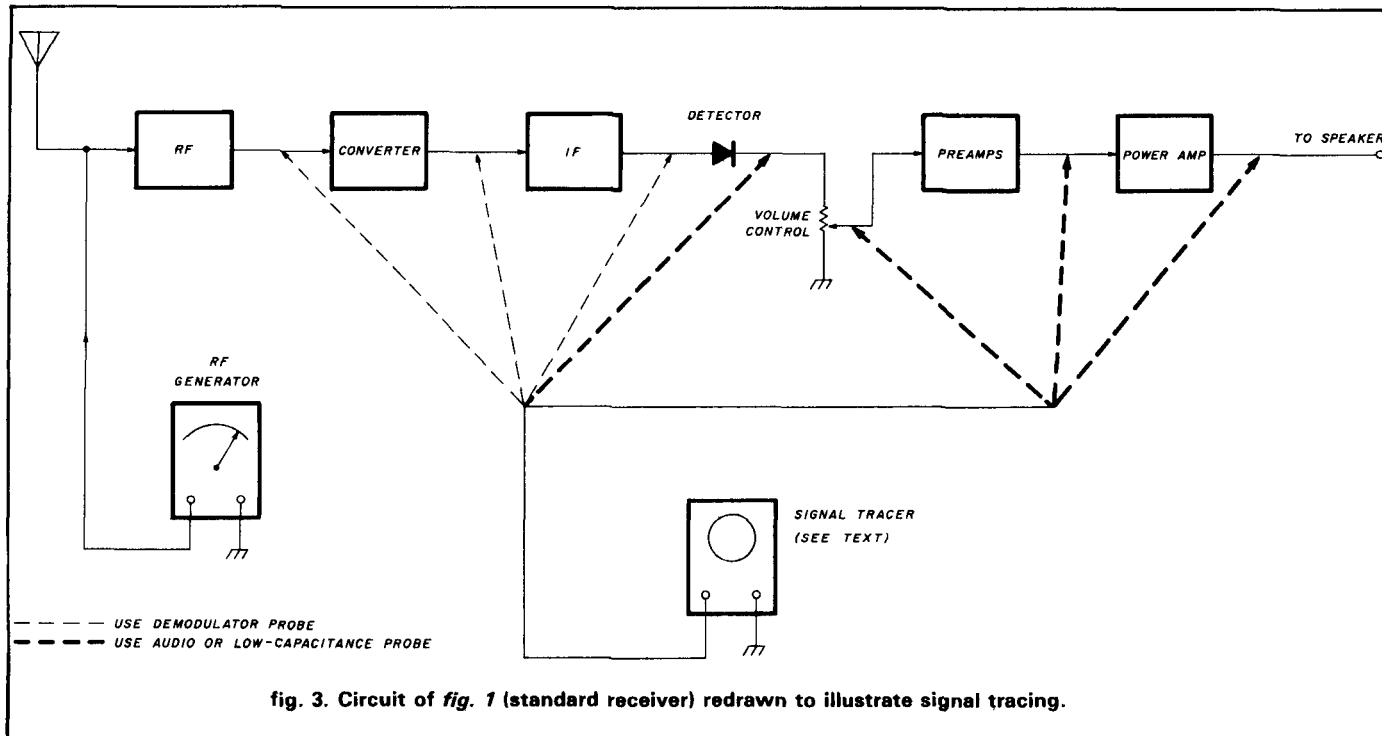
nal, a converter or mixer/local-oscillator stage that converts the RF signal to the IF frequency, an IF amplifier where most of the gain and selectivity are placed, a detector — let me draw a simple AM envelope detector, just for the sake of argument — and an audio amplifier chain. There might be various feedback loops in the audio, but we can leave them out for now. There might also be an automatic gain control (AGC) circuit. This circuit is simple compared with the SBBSSB receiver section, but it serves to show you how to bait your hook."

"Huh? Bait my hook?"

WOE smirks. "Let's talk a little about troubleshooting philosophy, YS," he says. "It'll help us think this process through. *The vast majority of electronic troubleshooting problems involve either losing a desired path for current or gaining an undesired path*

for current." That certainly sounds simple, so Squirt figures WOE just might know a thing or two. "Furthermore," WOE continues, "there is, in each stage, an AC path for current and a DC path for current. Although there are cases in which examining the DC path in each stage will allow us to isolate the defective section of the receiver, it's more often the case that the signal path — an AC path — is the best way to attack the problem."

"DC path, AC path?" YS asks, "that sounds familiar. I talked to Sally Solderburn last week, and she told me about using those ideas to troubleshoot solid-state circuits." (Sally only recently obtained an Amateur license, but had been the Chief Engineer of the local National Public Radio FM station in their town for several years. She'd also spent several years repairing CB and taxicab two-way radios.)



"Yeah, Sally showed me a thing or two about troubleshooting solid-state circuits," replies WOE, "but let's get to that in a moment. The first job is to isolate the dead stage. There are two methods we can use: signal tracing or signal injection."

Taking out another sheet of paper, WOE redraws the circuit of fig. 1 in the form of fig. 2. "In signal injection we use a signal generator to insert a signal into the various stages of the receiver, while monitoring the output signal on the speaker or a pair of headphones."

"In the textbook case — I use that term because, practically speaking, there are telling indications that allow us to cut the process short — we'll first use an audio generator at the input of the audio output stage. If this signal creates an appropriate response in the output — that is, a tone in the speaker — then we move the signal generator back to the input of the AF preamps or the volume control. If the audio stages prove out OK, then we have to switch to an RF signal generator. At first, set the RF sig gen to the IF frequency. Inject the signal into the input of each IF stage (there are three

stages, you know) and the output of the converter (or mixer, if that system is used). Finally, if all these stages prove out, as indicated by the signal getting all the way through to the output, switch the sig gen frequency to the RF frequency. This step's a little tricky, in some cases, because the receiver and sig gen aren't tuned to the same frequency; the dials are way off from each other. Rock either the receiver or signal generator dial back and forth to find the signal. The last stage is the RF amplifier."

YS marvels at the simple logic of stage isolation, but now wonders what "signal tracing" is: "Tell me, Wise Old Elmer," he asks, "you mentioned signal tracing a couple minutes ago — what's that?" WOE reaches for his old Heathkit signal tracer and shows it to YS. "Well, Squirt," he begins, "the signal tracer is merely a high gain audio amplifier with a loudspeaker output. The input is a switchable probe. In one switch position the probe acts like a simple low-capacitance probe, while in the other it's a demodulator probe. This latter position will demodulate an AM signal." Turning the now well-used piece of paper over, WOE again

draws the simplified block diagram of a radio receiver (fig.3) and shows Squirt how to signal trace.

"Remember how in signal injection we started at the audio output stage and worked backward toward the RF amplifier?" he asks. "In signal tracing, we work in the *opposite* direction — from the RF amplifier toward the AF stages. It's important to have the receiver tuned to some reasonably strong signal that will stay on the air for a little while. On some Amateur bands there are enough signals so that this is not a problem — 75 meters after 6 PM for example — but in other cases, we'll have to supply a signal. In our area, WWV on 10 MHz is usually strong, so we can use the WWV mode of the receiver. Otherwise, simply connect a signal generator to the antenna terminals. Set the output frequency to the same frequency as the receiver dial.

"Use the signal tracer in the 'demodulator' mode (also called the 'RF' mode on some instruments). Look for the signal first at the output of the RF stage, then at the converter (or mixer), at each IF stage in succession, and finally at the input of the

detector. If the bad stage is not found, then switch to the AF mode on the signal tracer, and continue to the detector and each of the audio stages in succession."

"The process of stage isolation," WOE continues, "is used to limit the problem area to a single bad stage. Once we determine which stage is dead, then we can use other methods to figure out which component is defective."

YS is impressed. "Darn!" he exclaims, "that's simple, WOE. Why didn't I think of that?"

"Hmmm..." thinks WOE, "that's a good question."

"WOE," asks YS, "you mentioned some shortcuts...what were you talking about?"

"Well, I don't mean to imply that the process isn't valid, because it works in almost all cases — in fact, it's never failed for me. But a little experience shows us that some indications allow

us to eliminate certain stages. You know, professional technicians often make more money from merely observing sets than from testing them. People like your friend Sally make their living by fixing as many sets per working hour as possible, so they're deeper in the bucks if an educated guess shortens the process."

Squirt is now almost breathless — but whether from a desire to impress Sally or from the technical wisdom he's gaining isn't clear. "What kind of shortcuts are there?" he asks.

"Well, let's take a quick look at your rig and see." WOE makes sure the rig is turned off and in the receive mode. He plugs in the AC power cord and turns on the power switch. "Run the AF gain control up and down through its range several times, YS," he directs. "Hear that scratching? Very few volume controls are perfectly clean potentiometers. Almost all of 'em have enough scratching to let you know whether or not the AF stages are working."

YS turns the control several more times, and sure enough, the speaker emits a rough scratching sound as the control is adjusted.

"That scratching tells us that the AF amplifiers are probably OK," WOE explains. "Now set the AF gain at or near maximum and turn the RF gain control all the way up. Notice that the set is all but dead — there's only a small hissing sound. That tells us that the problem is probably in the detector, IF, or mixer/oscillator (or converter) stages. If the mixer/oscillator and all following stages are working, and the problem is in the RF amplifier, then we'd hear a loud hiss amplified by the high gain IF amplifier. This hiss is a combination of thermal noise in the stages plus a certain amount of noise created by the heterodyning process. Listening to the receiver with the antenna disconnected is nearly the same sound."

WOE takes out another sheet of paper, brushes away some instant coffee crystals, and makes a list for his young friend. He titles it "common faults and their indications, especially

for AM/SSB radios" and begins to write

1. With all gain controls turned up, a loud hiss indicates a lot of gain is present, so the problem is closer to the front-end.

2. Picking up only a few stations in a normally crowded band (not 15 meters at 10 PM) could indicate a sensitivity problem. If there's not a lot of hiss, then look in the IF amplifiers (especially the early stages). The fact that the signals are there, in the right place, exonerates the mixer/oscillator.

3. A lot of signals, but with low volume, usually indicates that one of the latter IF stages, the detector, or one of the AF stages is faulty. If the volume control scratch is normal, then the AF stages are probably OK.

4. Tune the radio across a busy band while watching the S-meter. If there are periodic deflections — indicating that the receiver tuned across a signal — but there's still no output signal, then the dead stage is between the S-metered stage and the output.

5. A constant — or nearly constant — indication on the S-meter might indicate an oscillating IF amplifier or other stage.

"Well, there you have it, Squirt. Think you can show me which stage is bad?"

YS, who by now has had both his consciousness and confidence raised, mutters, "I expect so."


next month

This month we used a little "Elmer Scenario" to illustrate a little lesson in troubleshooting. Next month we'll return to our usual format and tell you what Sally Solderburn taught YS about troubleshooting.

have a question for Joe Carr?

Send your question to Joe Carr, *ham radio*, Greenville, New Hampshire 03048. While not every letter can be answered personally, he will try to answer as many as possible in this column.

—Ed.



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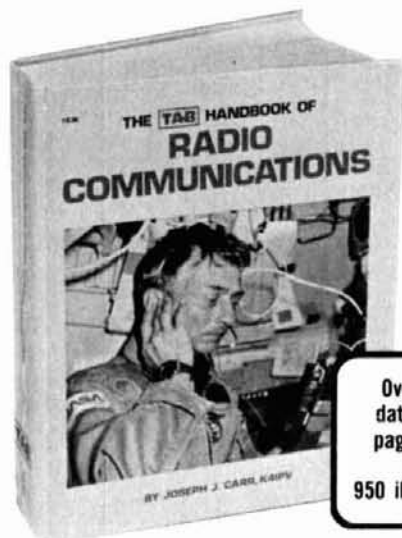
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short circuit K1BQT transceiver

The following corrections should be made to K1BQT's November article, "A Compact 75-meter Monoband Transceiver":

AUDIO AMPLIFIER/AGC MODULE: Schematic omitted 1N914 in line from audio output to gate of Q1. Also, AGC delay may be too long with 2.5 μ F on gate of Q1. If so, substitute 1 or 1.5 μ F.

DRIVER/BPF MODULE: Q3 gate No. 1, resistor value should be 10k. Schematic omitted 0.01 between L4 and gate No. 1. L4 is direct coupled — *not link coupled* — to Q3. Also, schematic omitted RFC1 on Q4.

EXCITER MODULE: Schematic omitted 0.1 bypass on U5 pin 3. Delete 1k resistor shown between mic gain and U6 pin 1.

RECEIVER MODULE: Schematic omitted 0.1 bypass capacitors on U1 pin 7, +R, and U3 pin 7. On PCB, move 0.1 bypass from ALC input to U2 pin 5.

Finally, use silver mica capacitors in the transmitter BPF. Parasitic oscillation of the driver was traced to inferior quality ceramic capacitors in the two units.

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let's hear it for the good guys

I have noticed a slight tendency, on the part of some high-tech people, to look down on hams and ham activity — as if such a hobby somehow lessened the professionalism of those whose livelihood is RF engineering. I challenge that notion. Quite to the contrary, experience as a practical operator cannot but deepen one's understanding of electromagnetic wave generation and propagation. In fact, if there are any computer kids among our readers who are not hams, we urge you to give it a try. It will give you much of the education, in this strange "new" field, that you're looking for.

These interesting and encouraging words appeared in an editorial by Keith Aldrich, publisher of *rf design* (August, 1985).*

Other Radio Amateurs in the technical fields have noticed the professional "snub" on occasions, but this is far outweighed by the great number of professionals that *are* hams. All one has to do is attend the Radio Amateur dinner and reception at the National Association of Broadcasters Convention, or the Amateur luncheon held at the annual gathering of the Armed Forces Communications and Electronics Association. You'll find an eye-popping number of top-notch professionals — who are also enthusiastic Radio Amateurs — at these meetings! So, let's hear it for the good guys and for Keith Aldrich, who I hope will become a ham himself one of these days!

the phasing SSB system — born again!

Old-timers will recall the phasing

system of SSB. Remember the Central Electronics 10A exciter? This thought should bring tears to the eyes of any sidebander who was active in the early 1950s. The phasing system died a quick death with the advent of the latest edition of the *ARRL Handbook*. (A friend of mine chided me for including a short section on the phasing SSB system in the latest edition of *Radio Handbook*. My reply to him was that it is still a valid system of generating a sideband signal and possesses some virtues that the filter system does not have. His only reply to me was a look of pity.)

But now it looks as if the phasing system has finally come into its own, especially in the field of VHF/UHF operation.

A major disadvantage of SSB is that it requires relatively inefficient linear amplifiers to reach high power levels. Unfortunately, reasonable efficiencies at VHF and higher are obtainable only with class C amplification, which precludes the use of a low level SSB driving signal. If the modulation takes place in the high level RF amplifier, however, linearity is not a problem. High audio power is required for high level modulation, but today's digital techniques make possible pulse-width modulated audio systems having a 90 per cent, or better efficiency level.

Finally, in some UHF frequency control systems a subaudible tone must be transmitted to phase-lock the product detector of the receiver. A typical SSB crystal or mechanical filter does not pass frequencies closer to the carrier than 250 to 300 Hz without sacrificing sideband rejection. But with a phasing transmitter, there's no such problem, because there's no low frequency limitation to the audio signal transmitted. The system can handle modulation down to the DC level.

The modern UHF SSB transmitter

makes use of high-power FETs because of their high class C efficiency. A block diagram of part of the audio phase shift and modulation system is shown in **fig. 1**. The audio signal is amplified and compressed and run through a bandpass filter. In the following buffer stage, the pilot or control tones are added to the audio signal. It then passes through a conventional audio phase shift network which provides two ports, separated by 90 degrees in phase. A differential amplifier follows the network. The amplifier is temperature compensated by mounting the two units on a common thermal link so that stable and equal gain are achieved in the two chains.

The audio signals are fed to a voltage-controlled astable multivibrator which has a resting frequency of 100 kHz with a 50 percent duty cycle. This stage drives a monostable multivibrator with a 10 microsecond reset time. With no modulation, these devices produce a square wave of 100 kHz with a 50 percent duty cycle. Any change in the frequency of the voltage controlled multivibrator will result in the change in the duty cycle of the following stage.

The multivibrators drive switching transistors (Q1, Q2) that reproduce the driving signal at the appropriate power level. The output passes through an integrator (L,C) which provides an exact reproduction of the input audio signal applied to the system. A protective diode (CR1) suppresses switching spikes that might damage the switching transistors.

The push-pull audio signals are fed to high level balanced modulators whose carriers are shifted 90 degrees in phase. The result represents cancellation of one sideband and reinforcement of the other. Upper or lower sideband can be chosen by reversing the audio phasing.

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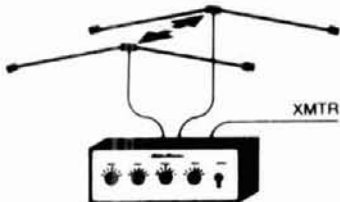
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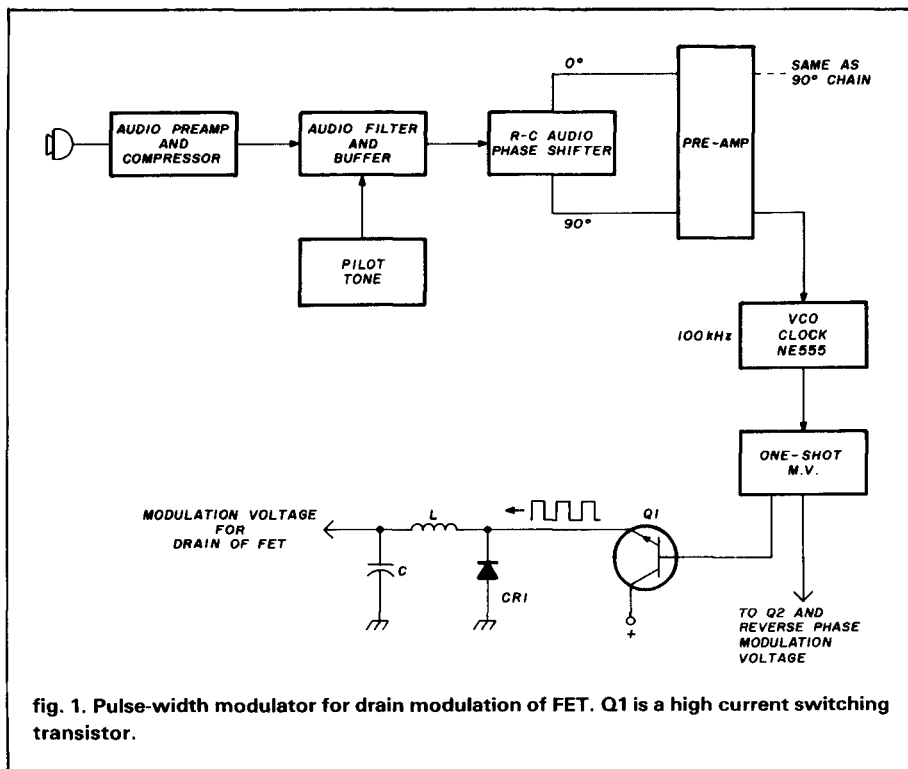


fig. 1. Pulse-width modulator for drain modulation of FET. Q1 is a high current switching transistor.

For high frequency operation, the RF phase splitter employs conventional coil and capacitor circuits. However, in the UHF region, these are replaced by a stripline hybrid circuit for stability and simplicity.

So the phasing system rises from the ashes to take part in today's exploration and utilization of the UHF frontier. Amateurs will soon rediscover this old technique and put it to new uses. †

the compact dipole: the general case

In previous articles I've discussed coil-loaded, compact dipoles of interest to the Amateur who wants to operate on the HF bands but has limited antenna space. The designs shown, which placed the loading coil in the middle of the dipole leg, represent specific instances of the general case, where the loading coil (L) may be placed at any point in the dipole leg (fig. 2).

There are good reasons why the loading coil is centrally located in a dipole element. If the coil is placed near the feedpoint, less inductance is required, but current in the coil is higher and losses are higher. If the coil

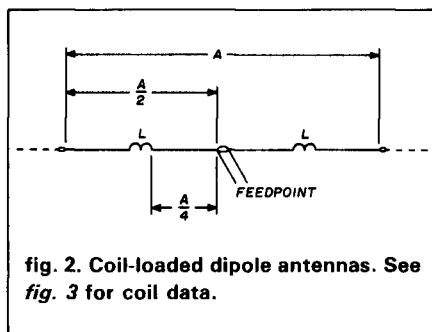


fig. 2. Coil-loaded dipole antennas. See fig. 3 for coil data.

is located near the dipole end, less current flows in the coil, but more turns are required, increasing coil loss. Theoretically, if the coil were to be placed at the end of the dipole, the number of turns required would be infinite. (Efficiency aside, valid reasons may exist for placing the loading coil at some point in the dipole other than the center of the leg. It has been proven that feedpoint loading works well, even though loading coil efficiency

† This material prepared and abstracted from "Technology Rejuvenates the Phasing SSB System," by Eric P. Nichols, in the August, 1985, issue of *Microwaves & RF* magazine, a Hayden Publishing Company monthly publication. (Hayden Publishing Company, Inc., 10 Mulholland Drive, Hasbrouck Heights, New Jersey 07604).

may not be the highest — but that's another story.)

A good summary of dipole loading is contained in *The ARRL Antenna Book*,¹ in which a chart provides general design information for dipoles of various length and loading.

For the case of the center-loaded leg, the ARRL chart may be simplified as shown in fig. 3 to indicate the reactance (X_L) required in a loading coil for antenna sizes ranging from 10 to 80 percent of normal. The graph is quite linear in the center portion but departs from linearity at both extremities.

As an example, assume a dipole only 100 feet long is needed for 3.8 MHz operation. A normal-sized dipole (made of wire) at this frequency would be 123.16 feet (37.53 meters) long. The required dipole, then, would be $100/123.16 = 0.81$, or 81 percent the length of the regular dipole. This point falls just outside the right-hand edge of the graph, but the required loading coil reactance can be estimated as about 305 ohms.

The inductance required is found by the formula:

$$L = \frac{X_L}{6.28 \cdot f}$$

where f is the frequency in MHz and L is the inductance in microhenries.

A second example: assume a dipole is needed for 1.8 MHz operation, but can be only 40 percent the length of a full-size dipole, which would be 260 feet. The compact dipole length would be $260 \times 0.4 = 104$ feet (31.69 meters) long. Finding 40 percent on the x-axis and tracing the point up to the curve and over to the y-axis indicates that the loading coil for this antenna should have a reactance of 1,300 ohms. The formula given above will convert this value into microhenries.

Enterprising Amateurs have taken this whole concept and computerized it into a simple program so that once the antenna size is established in relation to a full-size dipole, the inductance of the coil, the number of turns, and coil diameter can be quickly determined for a center loaded element. How about that, computer fans?

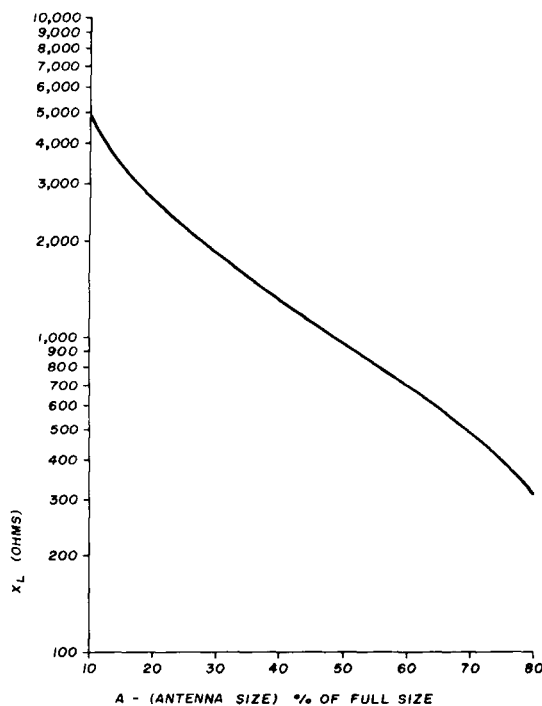


fig. 3. Loading reactance as a function of antenna length (A).

and now the bad news

Every HF operator is thoroughly familiar with the "Russian Woodpecker," the high power OTHB (over-the-horizon, backscatter) radars run by the Soviet Union. Repeated complaints about this obnoxious QRM generator have gone unheeded over the years. And now, I understand, the United States will soon have one running. But tests conducted with an experimental American OTHB radar revealed that the final version will not be a QRM-blast as the Russian one has proven to be.

The American OTHB was discussed in some detail by O.G. Villard, Jr., W6QYT, writing in *QST*.² And the April, 1985, issue of *Amateur Radio*, the publication of the Wireless Institute of Australia, revealed that the prototype of an Australian OTHB radar was built and tested in 1978. The radar is located in the general area of Alice Springs, with the actual transmitter some 60 miles to the northeast. It is reported that the installation has successfully tracked commercial aircraft

flying along the air route from Singapore to Australia. The radar receiving antenna array, which includes 468 pairs of broadband monopole antennas with each pair phased and sitting atop a very large ground mat, stretches over a distance of 1.7 miles (2.8 km). (*That should be very effective in a DX contest.*)

The power output of the transmitter is not disclosed, but it is reported to be over 400 kW. An array of vertically polarized log periodic antennas are used, with the beam steerable in azimuth.

Received echo signals, which are very weak, are analyzed in a computer. Frequency shifts on the returned signals caused by moving targets are analyzed to give an indication of the target speed. Thus the return signal from an aircraft is easily distinguished from a return signal from a small ship or other surface vehicle.

A frequency surveillance system prevents transmitted signal from operating on any occupied channel. The author of the article, Ian Hunt, of the

Australian Department of Defense, writes that he "can state with certainty that the HF Amateur Radio bands are thoroughly protected in this manner. This fact...should make it obvious that statements (claiming) that OTHR signals emanating from the Jindalee system are observed in the Amateur bands would be ill advised, alarmist, and irresponsible in nature."

The OTHR system can track commercial aircraft for safety, keep track of military flights, detect unauthorized flights (such as used in drug smuggling), and watch wave systems on the ocean to advise shipping of possible hazards. It can also be used for increasing the knowledge of the ionosphere and the study of long-haul propagation.

how does the OTHR affect ham radio?

The Australian OTHR appears to be a well-run project that promises to produce little interference to the various high frequency services, including Amateur Radio. It's comforting to know that this radar is programmed to avoid the Amateur bands. Good thinking!

Pandora's box?

The photographs of the Australian installations reveal the immense size of the project. Yet dollar-wise, it seems to be quite modest. It seems to me that Australia, unintentionally, may be pointing the way toward the day when any country with a few bucks and lots of open space can set up its own "do-it-yourself" backscatter radar system. The newcomers to the game may not be so charitably inclined as our Australian friends, and in a few years we could all be plagued by many worldwide backscatter radars, situated all over the globe and making HF communications a thing of the past.

references

1. *The ARRL Antenna Book*, 14th edition, American Radio Relay League, Newington, Connecticut 06111, page 10-5, (figs. 9 and 10).
2. O.G. Villard, Jr., W6QYT, "Over-the-Horizon or Ionospheric Radar," *QST*, April, 1980, page 39.

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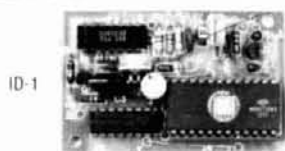
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Despite conventional wisdom, which holds that a transmission line transformer can be built only with integral turns ratios, it's entirely possible to build a practical 2:1 impedance change transformer — that is, a 1.5:1 turns ratio transformer. Many other fractions are also possible. But first let's review the evolution of RF transformers, keeping an eye out for some of the possible pitfalls along the way.

basic transformer

Consider a basic autotransformer, which has one winding, with a tap. If there are five turns from start to tap, and two more from tap to finish, then the input impedance from start to finish, assuming 25 ohms between start and tap, is $(25 \times 7 \times 7)/(5 \times 5)$, or 49 ohms. This is within 2 percent of 50 ohms, so it could serve as a 2:1 transformer.

leakage inductance

Leakage inductance occurs when the flux from any part of a turn doesn't cut all of another turn. Leakage inductance is always present — it's just a question of *how much*. One might think that any flux that cuts the cores couldn't possibly contribute to leakage inductance, because it would then couple to the other turns. Thus many early transformer designs stressed placing the windings close to the cores. Note that by definition, both the primary and secondary have separate, and therefore probably unequal, leakage inductances. These leakage inductances limit the high frequency response because they are very real inductors in series with the transformer's leads.

twisted and braided windings

One might think that lowest leakage inductance is achieved when all the wires are wound tightly together. Imagine a rope consisting of five parallel strands of insulated wire twisted together. This rope is wound through a core for five turns only. Then a group of three of the strands are unwound one turn and then cut off, leaving two strands with five turns and three strands with four turns. The three four-turn strands are then connected in parallel to one another.

These are in turn connected in series, aiding with both of the remaining five-turn windings. To summarize: from the bottom up, there are five turns in series with five turns to the tap, and then four turns to the top-end, producing a 14:10 ratio.

Another idea is to use seven strands twisted together as a rope with only one turn of this rope around the core. Connect five of these turns in series out to a tap, then add the remaining two in series. In theory this method might offer the lowest leakage inductance of any construction, but I can't handle the rat-nest of splices and still keep the leads short! And both of these techniques ignore capacitive effects that limit high frequency response.

transmission line

As the primary and secondary wires are brought closer to each other, rather than closer to the core, their mutual inductance and capacitance increases. It then becomes easier to envision the pair of wires as a transmission line. At first one might think the extra capacitance would limit the high frequency response, but it doesn't. The capacitance and leakage inductance combine to make a transmission line. The closer the wires are, the lower the transmission line's impedance. Considering the windings as transmission lines is a useful conceptual aid. It is now the standard method for making RF transformers, because it leads to wider-bandwidth performance. The high frequency end is helped without affecting the low frequencies.

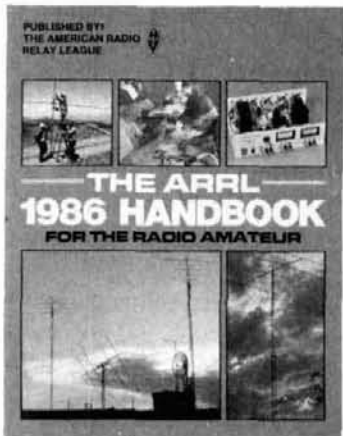
bandwidth limitations

A transformer's low frequency response is a function of the type of core, its cross-sectional area, and the number of turns. The high frequency response depends on the inductance and the turn-to-turn capacitance as well as the length of the winding. The limiting length occurs when the induced voltage of a single turn adds to the next turns' (voltage) at a significantly *later* angle. This equates to a transmission line whose delay angle is determined by its length and velocity of propagation. The phase delay of the transformer limits its high frequency usefulness.

balanced transmission lines

Consider a pair of parallel conductors arranged so closely that when the current in one conductor flows in one direction, the current in the other flows in the

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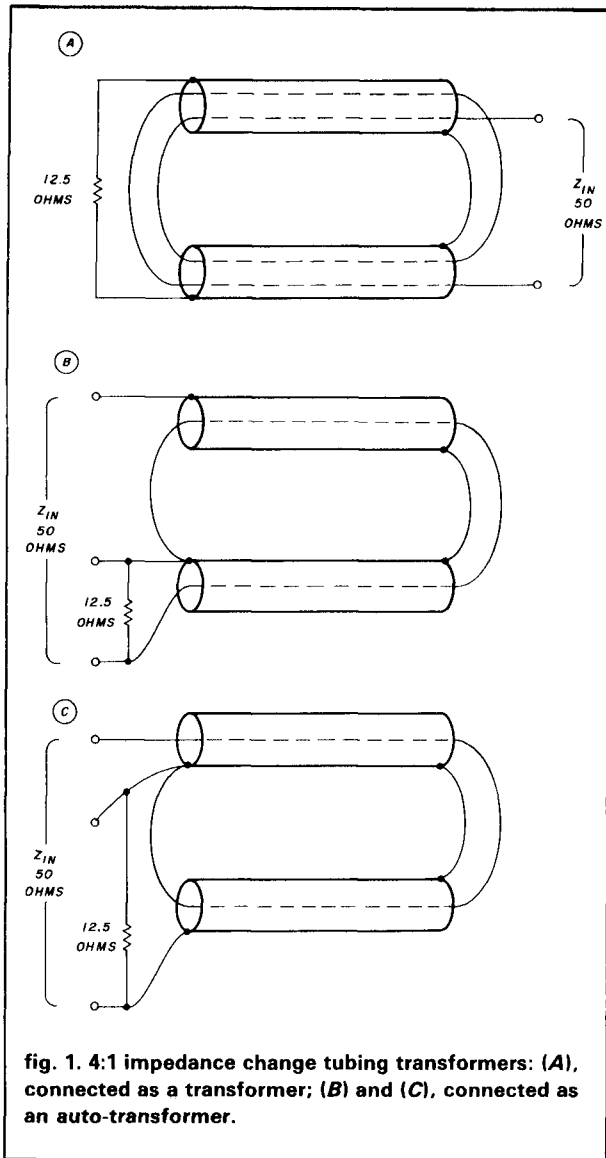


fig. 1. 4:1 impedance change tubing transformers: (A), connected as a transformer; (B) and (C), connected as an auto-transformer.

opposite direction. (Both are equal in magnitude.) This allows their magnetic fields to cancel out as soon as one is outside the space between the wires. As long as the currents are equal, the magnetic field does not need to intercept the cores. The inter-wire space also has an electric field due to the potential difference between the wires. The electric field diminishes as soon as one is away from the wires several times their spacing, especially if a material with a high dielectric constant is between the wires. Consequently, electromagnetic field propagates between the wires and transmission line theory applies. The uncoupled magnetic lines result in a leakage inductance, analogous to a transmission line unbalance which results in line radiation.

transmission line impedance

The impedance of a transmission line is sometimes

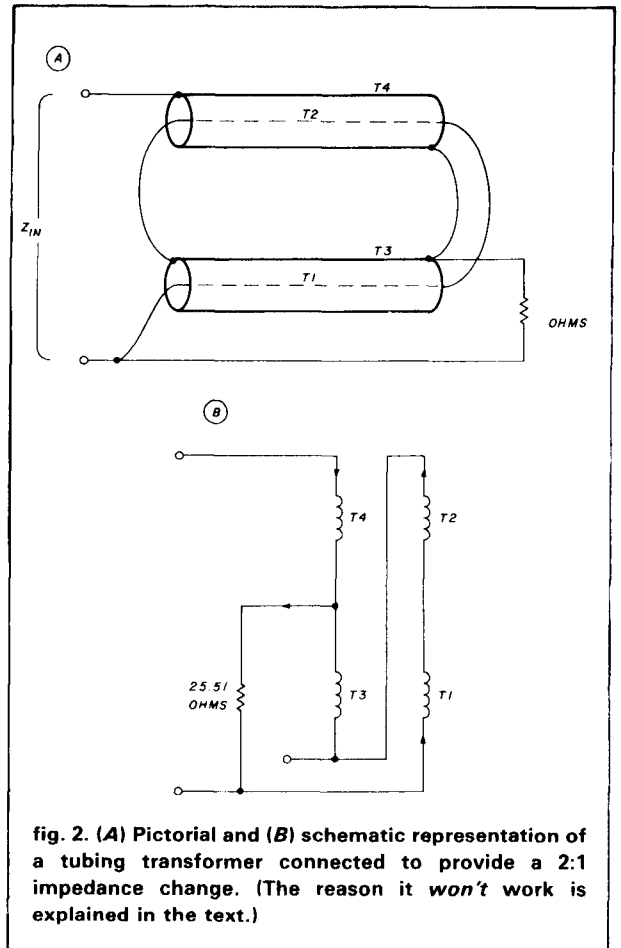
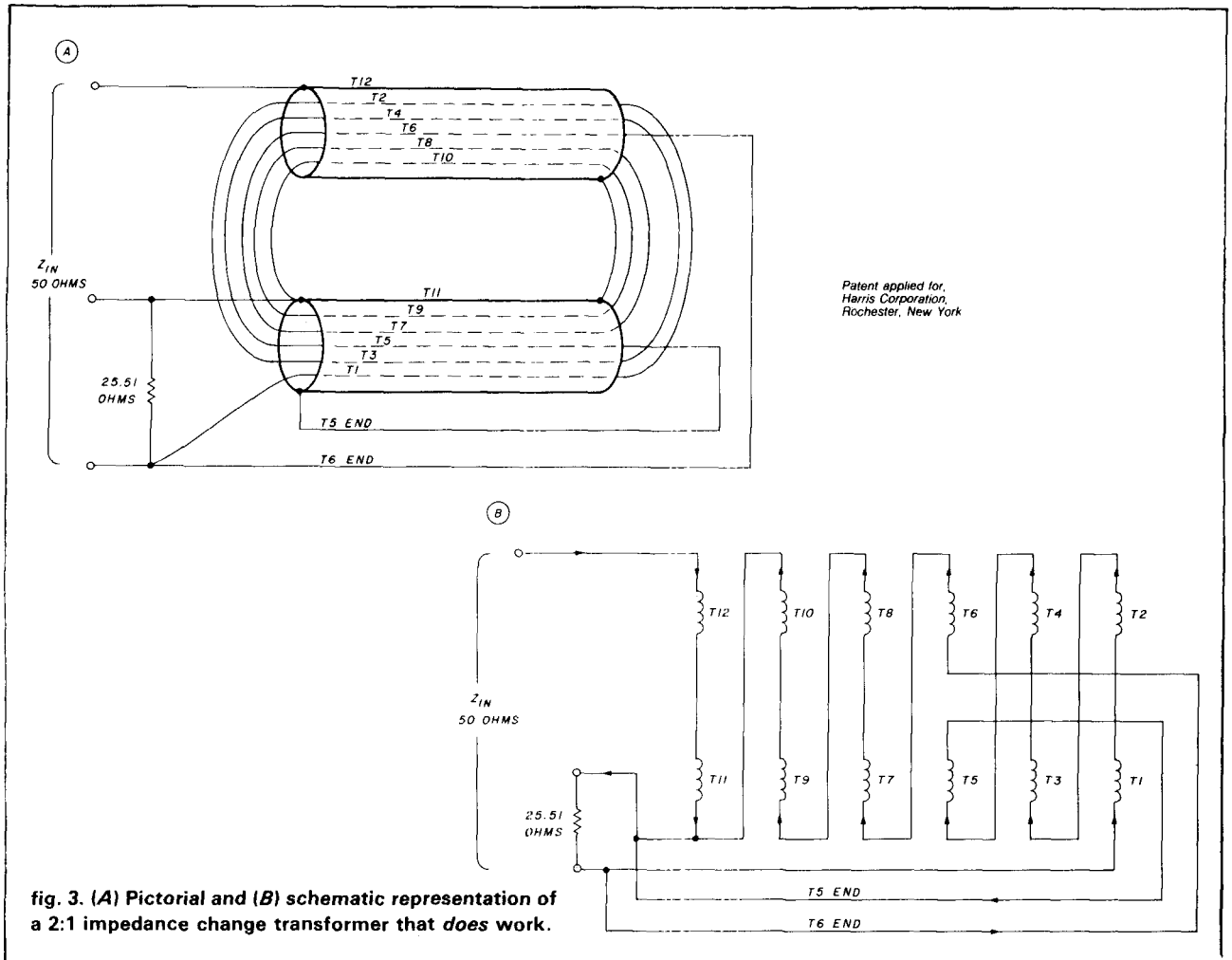


fig. 2. (A) Pictorial and (B) schematic representation of a tubing transformer connected to provide a 2:1 impedance change. (The reason it *won't* work is explained in the text.)

defined as the square root of the ratio of inductance per unit length divided by the capacitance per unit length. If one has inductance and capacitance meters, this can be measured easily by shorting the output end of the transmission line and measuring the inductance at the other end. Capacitance is measured directly after the short is removed. Measurements are taken at a frequency in which the line length is less than 1/10 of a wavelength. Divide the Henries by the Farads and take the square-root of this ratio to get the impedance of the transmission line in ohms. A vector impedance meter can be used to measure the line impedance by varying the frequency at about the 1/8 wavelength point until the magnitude of impedance stays the same as the other end of the line is alternately shorted and left open. The phase swings from inductive to capacitive; its amount is ignored. The surge impedance can be read directly.

We must be able to identify every conductor with a mate carrying current in the opposite direction, resulting in the absence of an external magnetic field and consequently small leakage inductance. However, even this procedure is difficult, since the capacity of each wire is not only to every adjacent wire(s), but also to ground; and the currents in parallel conductors still



must be kept equal and opposite for each sub-grouping of closely spaced conductors.

This means that every wire can have several individual characteristic impedances, each of which should be constructed to provide the same impedance as obtained by dividing voltage by current, or Z_f . Z_f is determined by wire size, spacing, insulation, and number of conductors. The ultimate limit in high frequency response is the physical length of all the turns, considered as a percentage of its electrical wave length. There's another paradox here: if one looks at it as a conventional transformer, the induced voltage of each turn must be the same because the flux is changing at the same time in each turn. However, with transmission line analysis, there isn't any external field, so it's much easier to see that it's the total length that counts.

tubing transformers

Tubing transformers, now very popular in transistor transmitters, use two parallel sections of metal tubing electrically connected at one end. The free ends of the tubing have terminals. The tubing itself can then

be used as part or all of one of the windings, or the tubing may simply be grounded to serve as an electrostatic shield for the cores. Cores of ferrite or powdered iron are threaded onto the exterior of the tubes to increase the low frequency inductance. Wire is then run through the interior of the tubing to make the other winding(s). The wires can come out at either the terminal ends of the tubing or at the common connected end; it makes no difference. The wires must make a complete turn, so the turns ratio is again always an integer. **Figure 1A** shows a 12.5 to 50-ohm transformer. **Figures 1B** and **1C** show a similar construction, connected as an autotransformer to transform 12.5 to 50 ohms.

If a transformer similar to the one shown in **fig. 1C** were used to transform a 25-ohm resistor to 50 ohms by tapping up on the winding or tubing to get a fractional turn, the results would be poor (see **fig. 2A**.) In **fig. 2B** arrows indicate the direction of the currents. Note that T2's and T4's currents are in opposite directions canceling the magnetic fields. But T1's and T3's currents are in the same direction! This means that the fields can't cancel, so instead of a transmission

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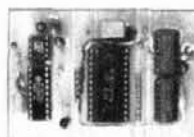
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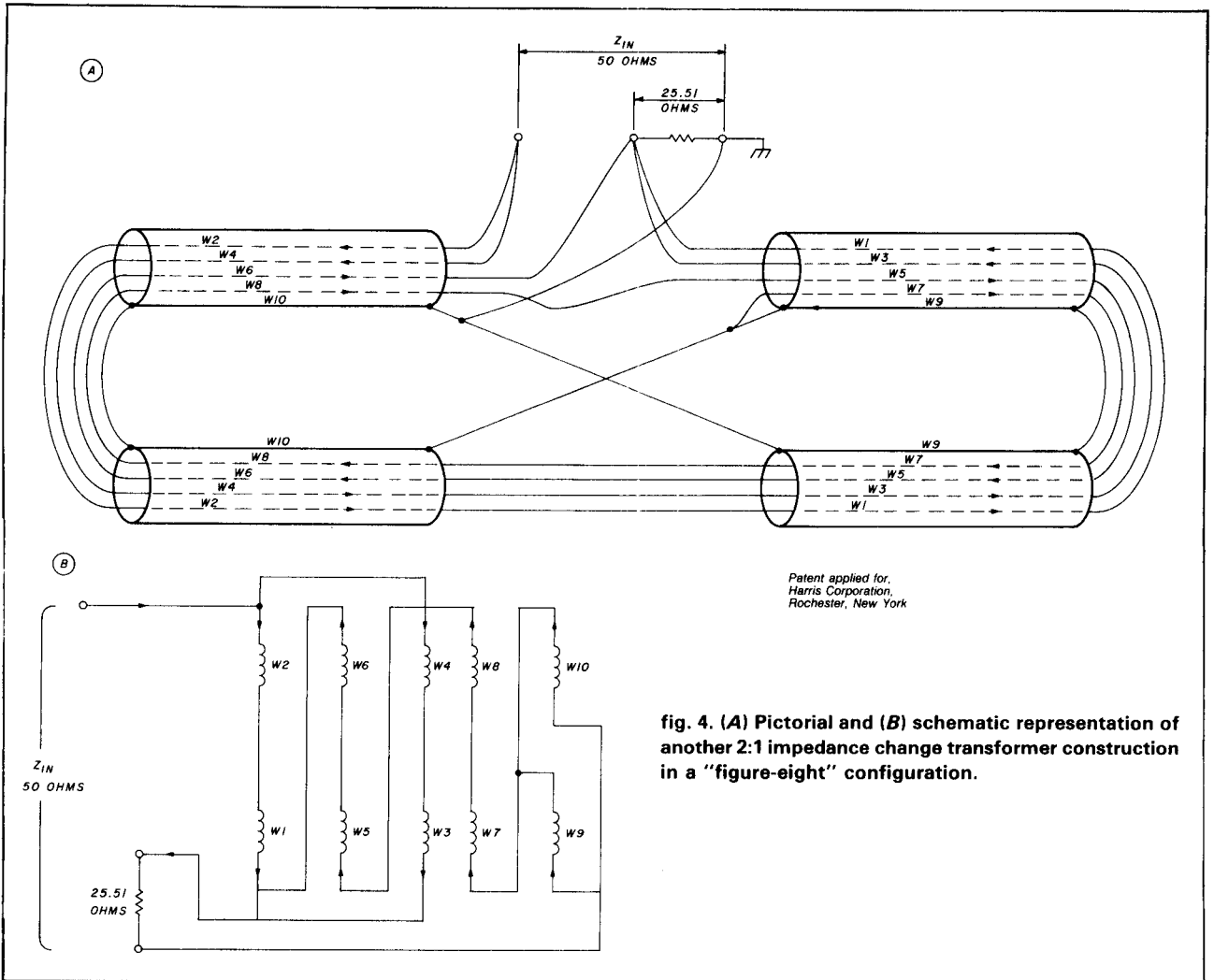


fig. 4. (A) Pictorial and (B) schematic representation of another 2:1 impedance change transformer construction in a "figure-eight" configuration.

line, we have a very good inductor — just what we *don't* need because it limits the high frequency response.

split the winding

Yes — you can use fractional turns and still have a transmission-line type device. The key is to add an extra winding that's mostly in parallel with the first so that two separate windings exist. The first winding has an extra half turn; the second winding skips that half turn and picks up the remaining half turn. Then the pair will function just like a single winding with a half-turn, but without a flux or current unbalance! Each of the two windings carries half as much current as the single winding did before it was split into two windings, so they can be made of smaller wire. (See figs. 3A and 3B.)

The fractional turn transformer in fig. 3 has a turns ratio of 7:5, which gives an impedance ratio of 49:25. The secondary has two windings in parallel: T1 through T5, in five sections; and T6 through T10, also in five sections. The primary has seven sections

because it adds T11 and T12 to the secondary's five sections. Thus if one counts the complete turns, it's a three-and-a-half-turn to two-and-a-half-turn transformer! Note that the T5 end and T6 end are longer leads, but that their currents flow in opposite directions, and the voltage between them is the secondary voltage; thus they can be envisioned as a transmission line. The fields are balanced in one direction because the currents are equal/and opposite, so the net ampere-turns is zero. It works well.

ampere-turn and Z_0 analysis

To see this balancing action more clearly, consider that for the amp-turns to be zero, the current total of T2, T4, T6, T8, and T10 must equal T12's. Let's assume 25 volts across the secondary load resistor, so the output current is then 1 ampere. The power out is $(25 \times 25) / 25.51 = 24.5$ watts. From symmetry, the voltage across each of the "T" sections must be equal to each other, and since there are five in series across the secondary, each section has 5 volts. The total voltage input across the seven sections is

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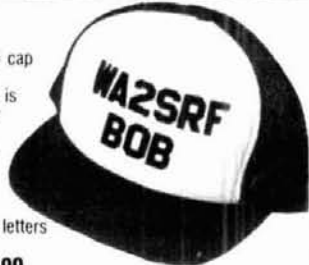
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then 35 volts. If we assume a lossless transformer, there must be 24.5 watts input. The input impedance is, then, equal to $(35)(35)/24.51 = 50$ ohms. The input current in T12 and T11 must therefore, from Ohms law, equal $(35 \text{ volts})/(50 \text{ ohms}) = 0.7$ amperes. Likewise, the current out of the transformer is $(25 \text{ volts})/(25.51 \text{ ohms}) = 0.98$ amperes. Since T5 and T6 are in parallel and symmetrical, the current flowing through each of them is equal and is: $I = (I_{\text{out}} - I_{\text{in}})/2$ or $(0.98 - 0.7) = 0.14$ amperes.

Because we know all the currents, we can now calculate the amp-turn balance. Again, refer to the direction of the arrows in **fig. 3B**, noting that T2 plus T4, plus T6, plus T8 plus T10's currents must equal T12's. Five times the 0.14 ampere = 0.7 ampere, which was T12's current, verifying that the net external flux is zero.

The impedance of the T5-T6 lead transmission line should be 25 volts divided by 0.14 ampere or 178.6 ohms. Spacing the leads in the air can achieve this.

heat problems

Note that the tubing, which is the largest conductor, is used for the section of the transformer that carries the most current. This is good news. The bad news is that if high power operation is required, one finds that the hot spot is the ferrite cores, not the windings, which heat because of dielectric loss in the cores. The electric field is high on the cores because the tubing is at the highest RF voltage and the transformer is mounted near a chassis ground. Thus another novel technique, resulting in longer life at high power, evolved.

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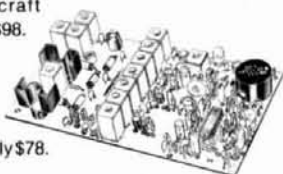


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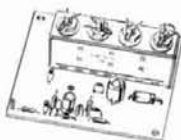
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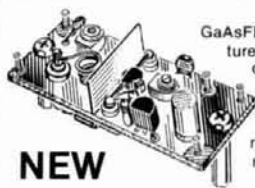
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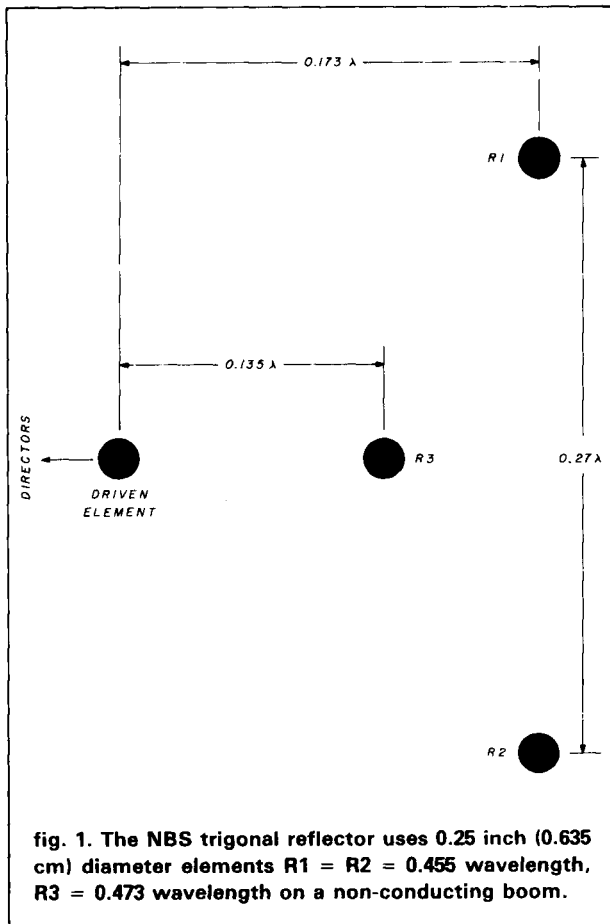
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optimizing a Yagi trigon reflector



One of the most valuable sources of Yagi antenna designs is *NBS Technical Note 688*.¹ In addition to the seven measured and patterned Yagis fully discussed, it also includes suggestions for further enhancing Yagi designs.

One of the suggestions presented is the use of a three-element (trigon) reflector to increase the gain of the 4.2 wavelength Yagi. The trigon provided a stated 0.75 dB gain increase for this Yagi, representing the maximum increase obtainable by using more than one reflector. The 4.2 wavelength Yagi was the only Yagi with which this type of experiment was performed.²

Because the possibility of obtaining more gain from the six shorter Yagis was intriguing, it was pursued with the same Yagi computer model I described in several previous *ham radio* articles.³ But analyzing the use of parasitic elements not in the same plane with other Yagi elements would have required extensive modification to the model's code; to avoid that chore, I chose to use other software capable of modeling elements in multiple planes.

At the 1983 and 1984 Dayton Hamventions, Dr. James Breakall, WA3FET/6, described his use of the Numerical Electromagnetics Code (NEC) as the basis for his presentations on Yagis, dipoles, and vertical antennas. A complex FORTRAN software system, NEC requires a mainframe for execution. A shorter version, MININEC, is written in BASIC and is designed specifically for execution on microcomputers.* For those familiar with MININEC, the entire NBS series of Yagis was modeled using both eight and 18 segments per element. However, to speed the modeling process, trigon Yagis were stated in terms of eight segments per element.

*An Apple-readable version of the MININEC code can be obtained by sending a blank floppy disk to: Dr. Edmund K. Miller, L-153, Lawrence Livermore National Laboratories, P.O. Box 5504, Livermore, California 94550.

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

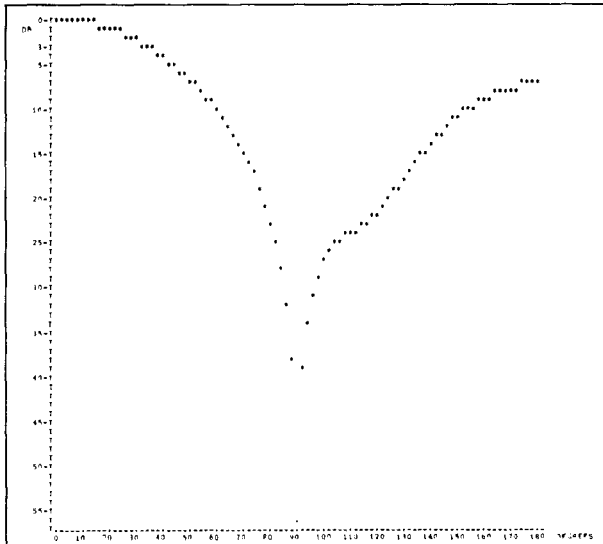


fig. 2. E-plane plot of NBS 0.2 wavelength, 2-element Yagi measured at 400 MHz. Notice in this and in figs. 3 through 75 the pattern amplitudes are normalized. Maximum response occurs at boresight (0 degrees) and is labeled 0 dB.

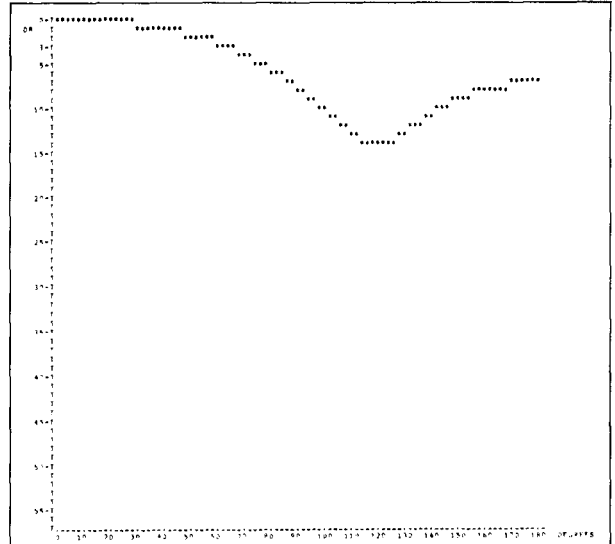


fig. 3. H-plane plot of NBS 0.2 wavelength, 2-element Yagi measured at 400 MHz. This Yagi shows a calculated gain of 6.62 dBi and a F/B of 7.28 dB.

Table 1 contains a summarized comparison of the published NBS findings, the WB3BGU model, MININEC, and pattern integration based on the radiation patterns in reference 1.⁴ The differences in gain figures are due to the different pattern integration code executed in each of the two models. Even slight variations in the overall pattern can affect how a single lobe (the main lobe) is defined in terms of the overall pattern. An examination of the seven E-plane and seven H-plane patterns resulting from each method of analysis (not shown) indicates a high degree of qualitative agreement. In many instances the MININEC patterns were more indicative of nuances in the NBS plots than the WB3BGU model. Reference 1 states that the original gain figures are accurate to within 0.5 dB, meaning that the NBS baseline is not exact. This is in part due to the fact that the NBS Yagis were measured for gain on one range but patterned on another.⁵ The lack of pattern symmetry indicates that the range

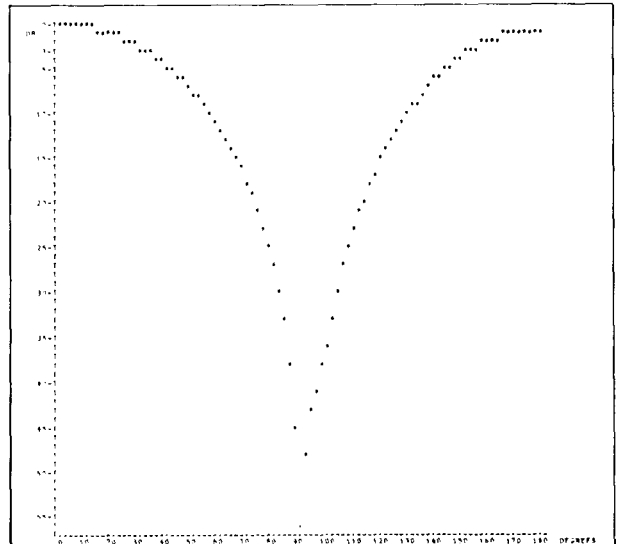


fig. 4. E-plane plot of baseline (stock) trigon reflector and driven element Yagi measured at 400 MHz.

table 1. Comparative gain and F/B figures for the NBS Yagi family. Note: NBS Technical Note 688 did not specify exact F/B measurements. The NBS F/B figures are taken from the cartesian plots provided for each Yagi.

NBS Yagi antenna		NBS		WB3BGU		MININEC-8		MININEC-18		pattern integration
boom in wavelengths	number of elements	gain (dBi)	F/B (dB)	gain (dBi)	F/B (dB)	gain (dBi)	F/B (dB)	gain (dBi)	F/B (dB)	gain (dBi)
0.2	2	6.71	6	6.70	6.71	6.62	7.28	6.58	7.90	6.71
0.4	3	9.15	8	9.15	12.07	9.27	11.82	9.47	11.97	9.62
0.8	5	11.35	15	10.71	22.71	10.69	24.53	10.93	20.76	11.41
1.2	6	12.35	19	11.75	19.05	11.67	19.11	11.97	27.88	12.64
2.2	12	14.40	23	14.00	30.47	13.75	22.68	13.99	36.43	14.28
3.2	17	15.55	24	15.22	24.06	14.99	22.55	15.20	27.82	15.47
4.2	15	16.35	22	15.70	19.26	15.38	21.21	15.72	21.93	16.22

used for patterning may not have been totally free of reflecting surfaces. Nevertheless, MININEC's calculated gain, F/B, and patterns can be considered to be very good replications of the NBS findings.

the NBS trigon reflector

Reference 1 provides a list of the multiple reflector arrangements NBS examined during the trigon evaluation. Maximum gain, the sole criterion in selecting the trigon configuration, is used as the main criterion in

evaluating the modeled trigons. As is the case for all other NBS parameters, an element diameter of 0.25 inches, a design frequency of 400.0 MHz, and a non-conducting boom apply. The stock NBS trigon is shown in **fig. 1**.

The 4.2 wavelength Yagi was modeled with the stock trigon. A significant reduction in both gain and F/B resulted. The first experiment involved varying the trigon element lengths (spacing was held constant) in order to achieve maximum gain. All three trigon elements were iterated over a range of plus and minus 0.015 wavelengths, in increments of 0.001 wavelengths. Increased gain correlated with increased trigon element length, reaching a calculated maximum with simultaneous extensions of 0.009 wavelengths. These iterations were repeated for each of the remaining six Yagis. **Table 2** contains the results of replacing the 0.2 wavelength Yagi's single 0.482 wavelength reflector with the stock (0.000 increment) trigon and successively incremented trigons. For this Yagi only, the 0.007 increment produces the maximum calculated gain. **Figures 2 and 3** contain the E- and H-plane plots for the original single reflector 0.2 wavelength Yagi. **Figures 4 and 5** contain these same plots using the stock trigon, and **figs. 6 and 7** present these same plots for the gain maximizing 0.007 increment trigon. For comparison, **figs. 8 and 9** do likewise for the 0.008 increment trigon, resulting in a minimal reduction in calculated gain but an increase of 0.77 dB in F/B ratio.

Either of the two incremented 0.2 wavelength Yagi versions would be useful as a single HF (7 MHz in particular) array or as a building block in a VHF/UHF col-

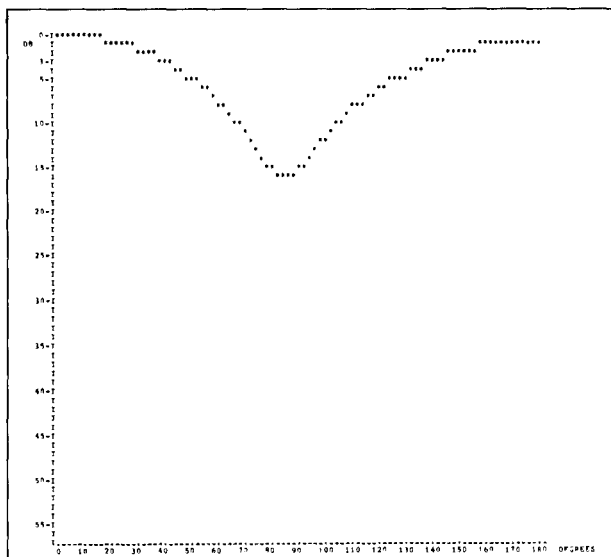


fig. 5. H-plane plot of baseline trigon reflector and driven element Yagi measured at 400 MHz. Gain is calculated at 6.42 dBi. F/B equals 0.76 dB.

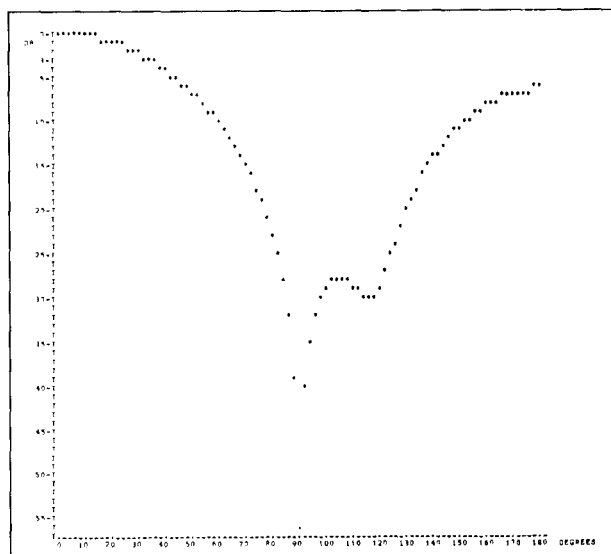


fig. 6. E-plane plot of 0.007 wavelength extended length trigon reflector and driven element Yagi measured at 400 MHz.

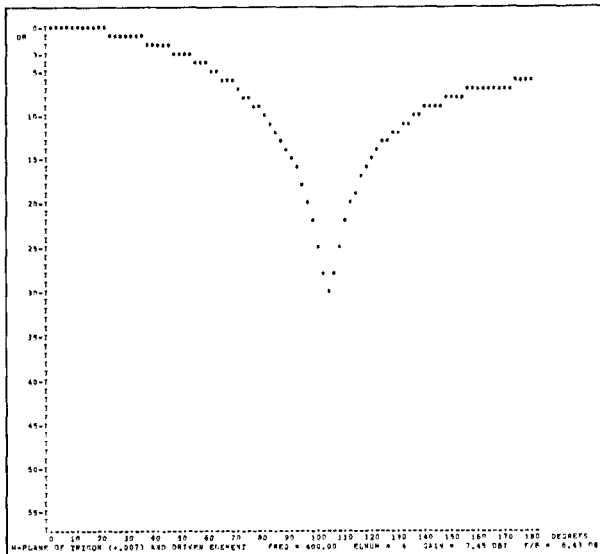


fig. 7. H-plane plot of 0.007 wavelength extended length trigon reflector and driven element Yagi measured at 400 MHz. Calculated gain equals 7.45 dBi and F/B equals 6.43 dB.

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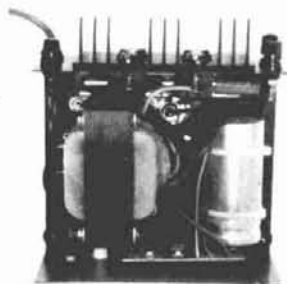
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RS-10A	7.5	10	4 x 7 1/2 x 10 3/4	11
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RS-50M	37	50	6 x 13 3/4 x 11	46

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RS-10L(For LTR)	7.5	10	4 x 9 x 13	13
RS-12S	9	12	4 1/2 x 8 x 9	13
RS-20S	16	20	5 x 9 x 10 1/2	18

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table 2. Gain and F/B calculations resulting from iterating the trigon reflector on the 0.2 wavelength NBS Yagi.

increment in wavelengths	gain (dBi)	F/B (dB)
0.000	6.42	0.76
0.001	6.54	0.99
0.002	6.69	1.33
0.003	6.87	1.85
0.004	7.07	2.64
0.005	7.26	3.75
0.006	7.40	5.10
0.007	7.45	6.43
0.008	7.44	7.34
0.009	7.40	7.66
0.010	7.34	7.58
0.011	7.29	7.32
0.012	7.25	7.03
0.013	7.22	6.79
0.014	7.20	6.59
0.015	7.18	6.45

linear array. At 7 MHz a relatively short 25-foot boom would yield a high gain Yagi with good sidelobe structure. At VHF/UHF this same array serves as a relatively high performance building block for collinear arrays. In **table 3** the seven NBS Yagis are compared in terms of their respective single reflector versions and three trigon variations: stock, gain maximized, and F/B maximized. With the exception of the 0.2 wavelength Yagi, maximum gain occurs when each trigon element is extended 0.009 wavelengths from its stock length. With the exception of the 0.4 wavelength Yagi, calculated F/B maximas occur at even longer extensions. The 0.4 wavelength Yagi achieved both calculated maximas with the 0.009 extensions, and had the only single frequency F/B maxima.

table 3. Comparative performance calculations for the NBS Yagis with three specified sets of trigon reflectors. Note: Column 2 includes two additional elements in the trigon reflector. Column 1 shows the original Yagi length.

NBS Yagi antenna		Basic Yagi		stock trigon		gain maximum trigon		F/B maximum trigon		F/B maximum trigon increment
boom in wavelengths	number of elements	gain (dBi)	F/B (dB)	gain (dBi)	F/B (dB)	gain (dBi)	F/B (dB)	gain (dBi)	F/B (dB)	(dBi)
0.2	4	6.62	7.28	6.42	0.76	7.45	6.43	7.39	7.66	0.009
0.4	5	9.27	12.07	6.57	4.17	9.28	30.91	9.28	30.91	0.009
0.8	7	10.69	24.53	8.79	7.15	10.82	17.01	10.62	25.53	0.014
1.2	8	11.67	19.11	10.18	6.03	11.92	12.39	11.73	14.73	0.015
2.2	14	13.75	22.68	12.05	8.55	13.90	16.34	13.81	18.91	0.013
3.2	19	14.99	22.55	13.44	9.69	15.16	18.23	15.10	19.70	0.013
4.2	17	15.38	21.21	13.86	9.27	15.67	18.53	15.63	19.44	0.011

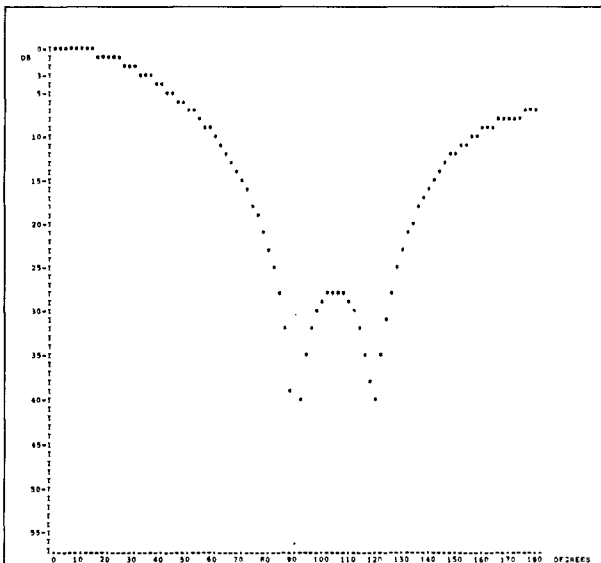


fig. 8. E-plane plot of 0.008 wavelength extended length trigon reflector and driven element Yagi measured at 400 MHz.

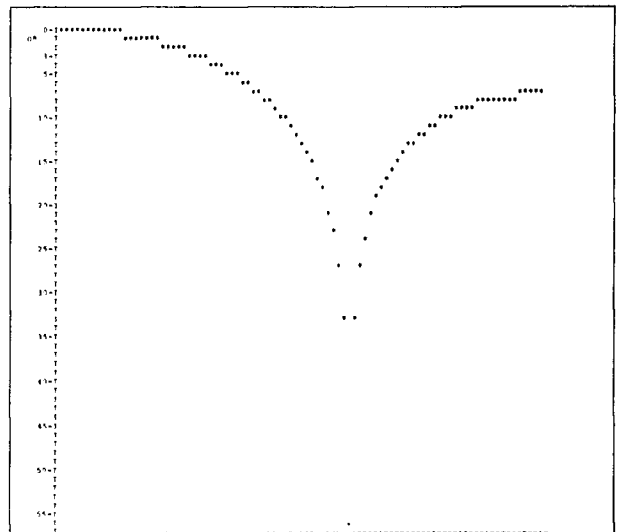


fig. 9. H-plane plot of 0.008 wavelength extended length trigon reflector and driven element Yagi measured at 400 MHz. Calculated gain equals 7.44 dBi and F/B equals 7.34 dB.

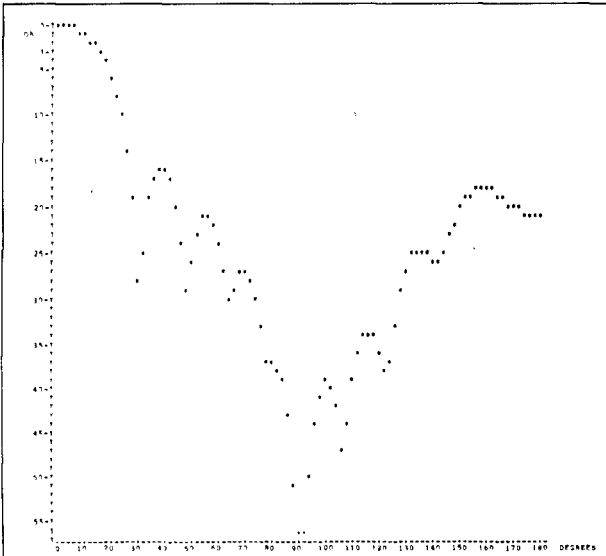


fig. 10. E-plane plot of 4.2 wavelength, 15-element Yagi that uses a single reflector.

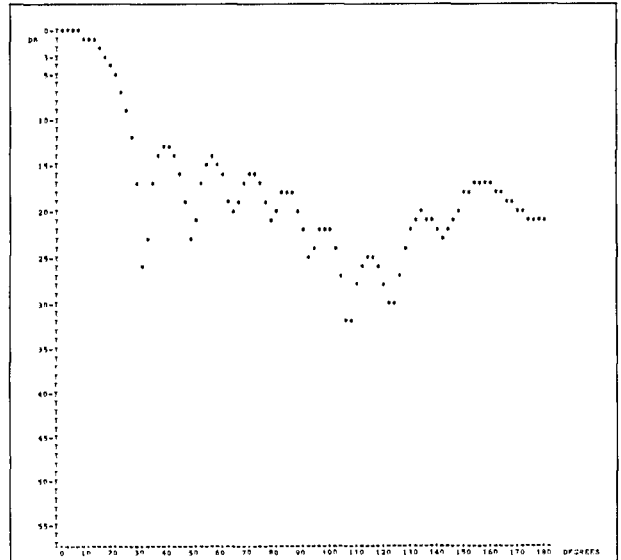


fig. 11. H-plane plot of 4.2 wavelength, 15-element Yagi that uses a single reflector. Calculated gain equals 15.38 dBi and F/B equals 21.21 dB.

Figures 10 and 11 illustrate E- and H-plane plots for the single reflector 4.2 wavelength Yagi. In figs. 12 and 13 a stock trigon reflector is used. In figs. 14 and 15 the 0.009-wavelength extended reflector length gain optimized version is plotted. For the first 80 degrees in the E-plane plot, the stock trigon actually improves the suppression of the minor lobes. This is also true for the first 55 degrees of the H-plane plot, but at the expense of gain, F/B, and other minor lobe levels in both planes. The gain maximizing 0.009 wavelength extensions provide the clean pattern normally associated with this Yagi, and additional 0.34 dB in gain, and further (1-2 dB) reduction of the first few minor lobes in both the E- and H-plane plots. While calculated F/B is reduced, the resulting first minor lobe permits an increased stacking distance and hence more incremental gain from a stack. As reference 1 did not report any patterns from the trigon experiment, it is not known whether NBS noted these other improvements along with increased forward gain.

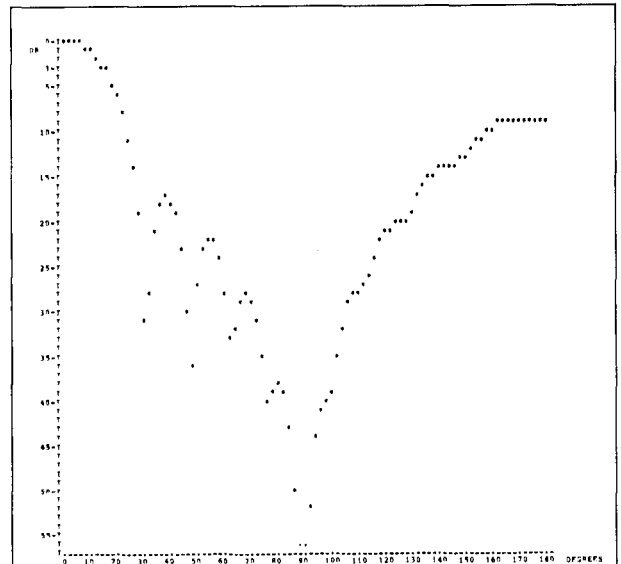


fig. 12. E-plane plot of 4.2 wavelength, 15-element Yagi that uses a stock trigon reflector.

validating the calculated trigon findings

Several questions about the validity of these calculated findings versus the published NBS findings arise. There is a measurable difference between the 4.2 wavelength trigon Yagi's calculated performance and what is given in reference 1. As NBS did not provide plots for this Yagi, even qualitative comparisons cannot be directly made. There is still the issue of the trigon's dimensions. Use of the stock element lengths

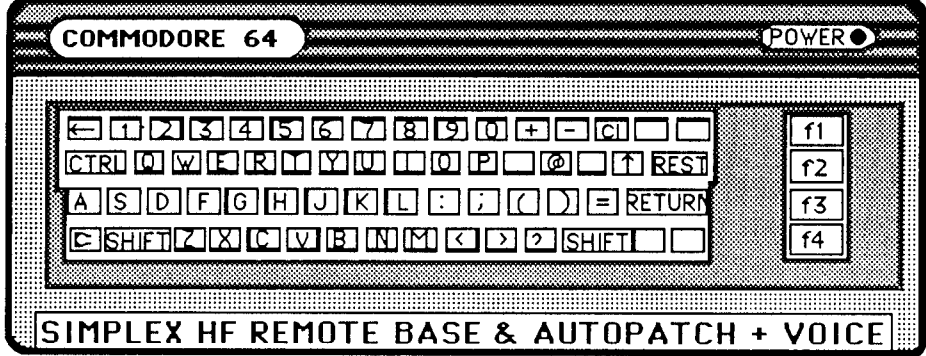
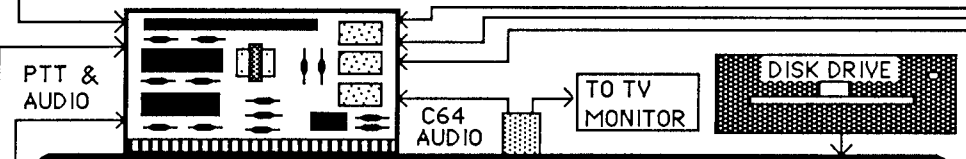
results in degrading the 4.2 wavelength Yagi's performance as well as that of the six others.

Before these iterations were begun, Joe Reisert, W1JR, had performed extensive analyses based on the use of a trigon reflector of the 2.2 and 3.2 wavelength NBS Yagis on an antenna range.⁶ He found that for these two Yagis the stock trigon reflector reduced the measured gain by just over 1.6 dB, and that a nominal gain increase of nearly 0.2 dB over the single reflector Yagi could be obtained by lengthening all three

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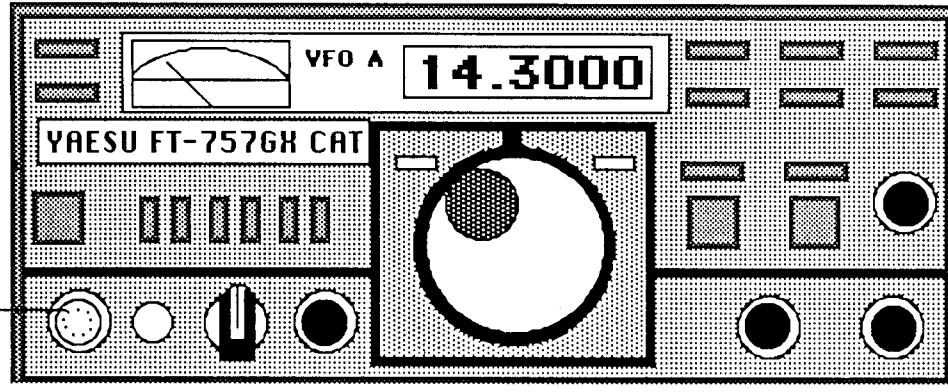
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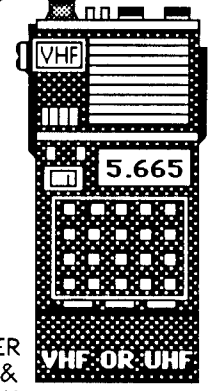


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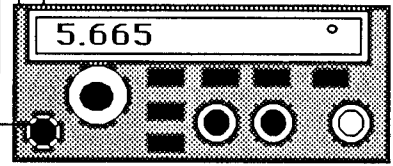
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- *RING DETECT & AUTOMATIC VOICE ALERT OF INCOMING TELEPHONE CALL
- *INACTIVITY TIMER TURNS OFF SYSTEM (USER PROGRAMABLE)
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- *FAST SCAN & SLOW SCAN + DIAL UP ANY FREQUENCY WITH DTMF TONES ALL FROM YOUR HANDHELD VHF/UHF PORTABLE OR MOBILE
- *USE THE AUTOPATCH OR THE REMOTE BASE BOTH FOR THE PRICE OF ONE!
- *USER DEFINED TIMING WINDOW, ACCESS CODES, CALL SIGN
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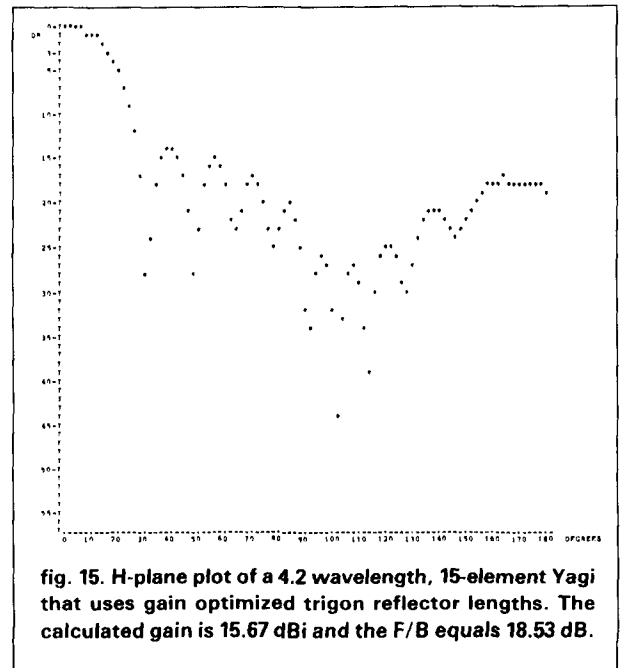
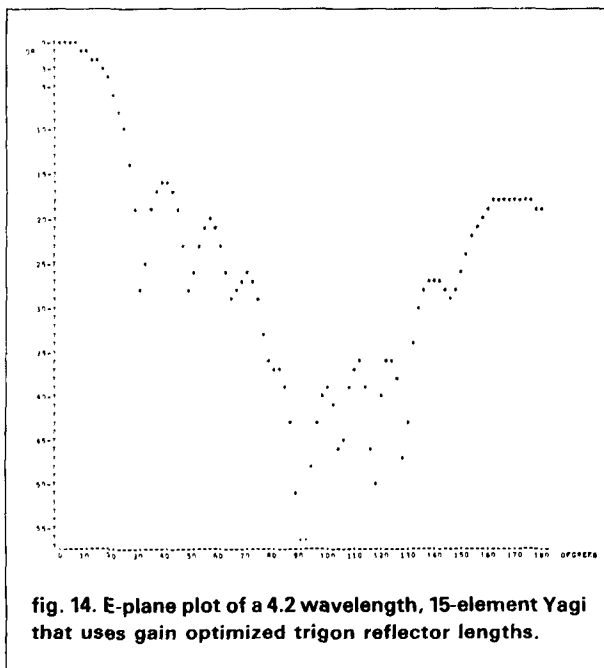
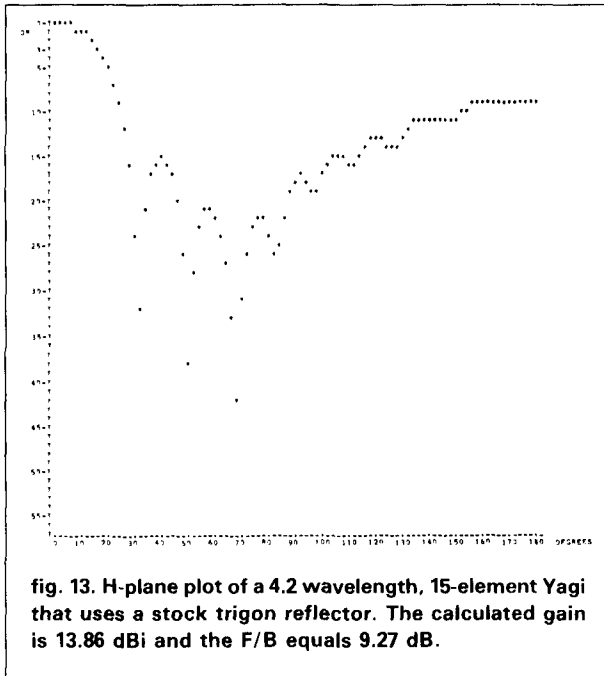
reflector elements by approximately 0.008 wavelengths. Trigon element spacing remained constant. These empirical findings are in very good agreement with the MININEC calculations in **table 1**. Günter Hoch, DL6WU, has reported similar gain findings for a broad range of multiple element reflector arrangements.⁷ While there is no reason to doubt that Peter Viezbicke, W0NXB, the author and principal investigator for the experiments reported in reference 1, actually measured what was reported, it is unfortunate

that neither subsequent empirical experiments nor mathematical modeling can exactly reproduce these well known findings.

conclusions

The trigon reflector can provide increases in (calculated) gain for all seven NBS Yagis. For the 0.2 wavelength Yagi this increase is at its maximum value. For the 0.4 through 3.2 wavelength Yagis, this increase is mostly nominal. For the 4.2 wavelength Yagi used to develop the trigonal reflector, the increase is more pronounced, but less than initially reported. For all NBS Yagis it is necessary to use reflector element lengths (with spacing held constant) longer than the stock lengths reported in reference 1. The stock lengths severely reduce the performance level of any NBS Yagi on which they are used.

Reference 1 presents a series of design curves in its table 21 for converting director and reflector elements to other diameter-to-wavelength ratios. Mathematical analysis indicated that reflector curves for trigon elements that were drawn parallel to the curves for single reflectors would result in accurate conversions. As is the case with the other curves, these trigon curves had to be drawn through the point of intersection between 0.0085 wavelengths in diameter (X axis) and the trigon element's optimal length on the Y axis. This was confirmed by reference 6. A more recent and easier to read version of these curves had been found, and with the trigon curves is presented as **fig. 16**.⁸ These curves can now be used exactly in the same fashion as the other design curves.



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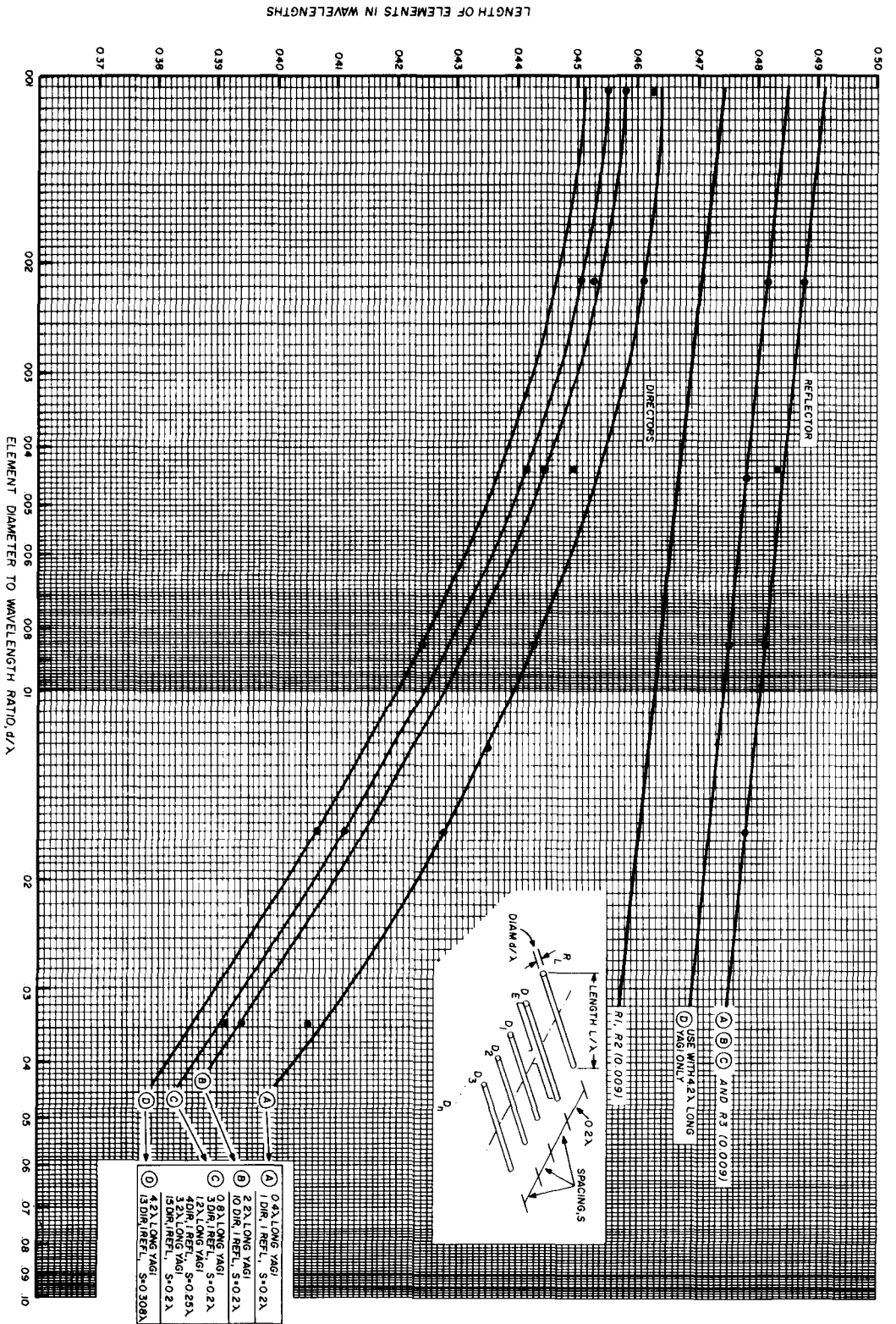


fig. 16. Yagi antenna design nomograph shows the relationship between element diameter and wavelength ratio (d/λ), and element length for different antennas.

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The procedure for compensating for the diameter of a conducting boom is the same as for other NBS Yagi elements.

A great deal of experimentation can still be performed on the NBS Yagi antenna. Whether performed on an antenna range or by computer iteration, the results should be presented so that all Radio Amateurs can benefit from these experiments.

references

1. Peter Viezbicke, "Yagi Antenna Design," *NBS Technical Note 688*, Department of Commerce, Washington, D.C., 1976.
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5. Dr. Karl G. Kessler, Director of the NBS Center for Basic Standards, personal communication.
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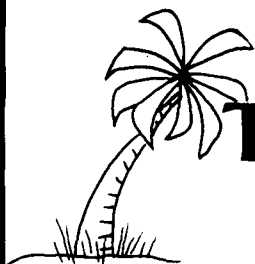
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a simple solution

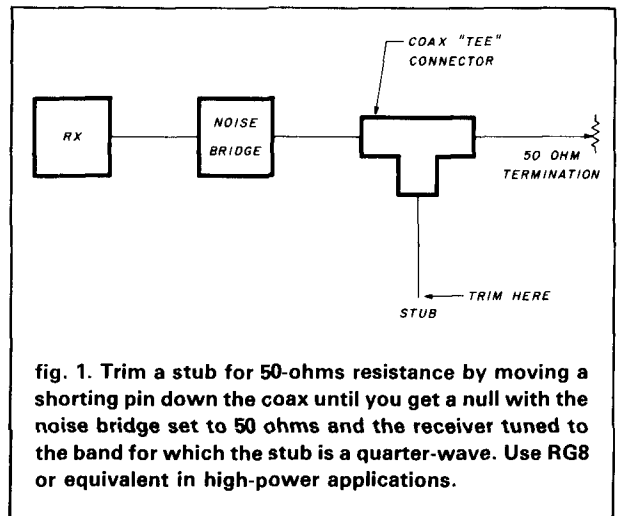
What makes coax-stub filters an easy solution to the problem is their simplicity; all you need is some coax and a few connectors. And stub filters don't have any coils to wind or capacitors to tweak. They don't require a sweep generator or network analyzer to tune. Just trim the stubs to length with the aid of a noise bridge.

Table 1 lists the HF Amateur bands and the filter combinations you can use to eliminate harmonics and, in the case of 20 meters and 15 meters, intra-band interference and front-end overload in your receiver. Each filter consists of one or two stubs.

how they work

A half-wave, single-stub filter acts as a subharmonic filter by introducing a short circuit into the transmission line at the frequency it's an open-circuited quarter-wave for. At the frequency for which the stub is a half wave, it looks like an open circuit and passes the desired signal.

A quarter-wave, single-stub filter acts as an even-harmonic filter by introducing a short circuit into the



transmission line at the frequency it's a half-wave-length for. At the frequency for which the stub is a quarter wave, it looks like an open circuit and passes the desired signal. Because a shorted quarter-wave stub traps even harmonics, the 160-meter and 80-meter bands need just one filter each to trap all harmonics that fall in the Amateur bands below 30 MHz.

Some of the stubs introduce reactance on the line. In these cases, a second compensating stub tunes out the reactance by introducing an equal and opposite reactance. (The net effect is analogous to a parallel-resonant LC circuit; at resonance, the inductive and

By Robert M. Clarke, N1RC, 150 Stimson Street, West Roxbury, Massachusetts 02132

table 1. HF Amateur bands and filter combinations used to eliminate harmonics.

stub filter ¹ needed to prevent interference to						
band	160	80	40	20	15	10
160	x	$\frac{\lambda}{4}$ S	$\frac{\lambda}{4}$ S	$\frac{\lambda}{4}$ S	$\frac{\lambda}{4}$ S	$\frac{\lambda}{4}$ S
80	x	x	$\frac{\lambda}{4}$ S	$\frac{\lambda}{4}$ S	$\frac{\lambda}{4}$ S	$\frac{\lambda}{4}$ S
40	x	x	x	$\frac{\lambda}{4}$ S	$\frac{\lambda}{12}$ O ²	$\frac{\lambda}{4}$ S
					$\frac{\lambda}{6}$ O ⁴	
20	x	x	x	x	$\frac{\lambda}{6}$ O ²	$\frac{\lambda}{4}$ S
					$\frac{\lambda}{12}$ S ⁴	
15	x	x	x	$\frac{\lambda}{8}$ O ³	x	x
				$\frac{3\lambda}{8}$ O ³		
10	x	x	x	x	x	x

S = short-circuited stub O = open-circuited stub

Notes:

1. Electrical wavelength (feet) = $984 \frac{V}{f}$ = $\frac{300 V}{f}$ = (meters)
where V = velocity factor
f = frequency in MHz
2. This stub is a quarter-wavelength on 15 meters.
3. This stub is a quarter-wavelength on 20 meters.
4. Compensating stub.
5. TVI prevention.

capacitive reactances cancel.) In general, what you do to tune a filter is adjust the half- or quarter-wave stub by itself and then add and trim the compensating stub.

trimming to length

Figure 1 shows the test setup used to trim the stub filters. To make a filter, cut the stubs to the lengths listed in table 1 and add 10 percent to allow for variation in the velocity factor of the coax. Put a connector on one end and open or short-circuit the free end as required by table 1.

In adjusting the stubs, you have two cases to deal with: open-circuited half-wave stubs and short-circuited quarter-wave stubs. Trim the open-circuited stub, at the center frequency of the band for which it is a half-wavelength, until the noise bridge reads 50-ohms resistance with zero reactance.

For case of the shorted stub, trim it in the same way on the center frequency of the band on which it is a quarter wave. This trimming may simply involve moving a shorting pin down the cable until you reach the 50-ohm point. Remember that what you're really doing in this exercise is establishing an integral number of quarter-wavelengths of coax — by short- or open-circuiting a stub, you can treat it as a half- or quarter-wave on a convenient frequency — to arrive at the right length.

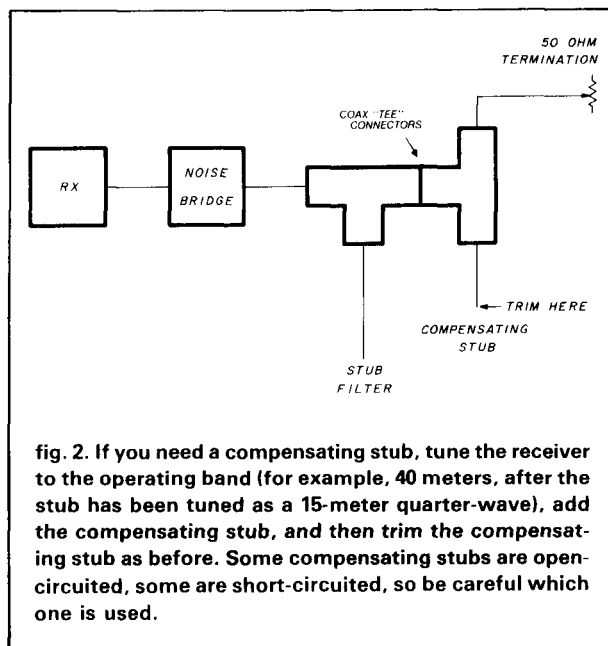


fig. 2. If you need a compensating stub, tune the receiver to the operating band (for example, 40 meters, after the stub has been tuned as a 15-meter quarter-wave), add the compensating stub, and then trim the compensating stub as before. Some compensating stubs are open-circuited, some are short-circuited, so be careful which one is used.

When you add a compensating stub (see fig. 2), trim its length to bring the noise bridge reading to 50-ohms resistance. This trimming adjusts the compensating stub's reactance to cancel out the filter stub's reactance.

velocity factor varies

Electromagnetic energy travels more slowly in a dielectric than it does in free space. The velocity factor is a constant that scales wavelength to reflect the media in which the energy is traveling. Because air is essentially free space, open-wire line with its air-dielectric has a velocity factor of 0.97.

Foam-dielectric coax is mostly air, so its velocity factor is about 0.8. In contrast, solid-dielectric coax, containing practically no air, has a velocity factor of 0.66. One word of caution: although foam-dielectric coax has less loss than solid-dielectric coax, its velocity factor varies with the amount of air in the foam. Consequently, the velocity factor can vary from roll to roll or from section to section of coax within the same roll. Don't assume the velocity factor for any two pieces of foam coax is the same. Always allow extra length in a stub before trimming it to size.

bibliography

- Jordan, Edward C. and Balmain, Keith G., *Electromagnetic Waves and Radiating Systems*, 2nd Edition, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1968, Chapter 7.
The Radio Amateur's Handbook, 49th Edition, American Radio Relay League, Newington, Connecticut, 1972, Table 20-1, page 569.

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L-band ground wave propagation program

Update your VHF/UHF propagation program to include three additional ham bands

The increasing popularity of VHF/UHF communications has prompted us to expand our computer programs, described previously in *ham radio*, to include three additional ham bands.¹ If you have a working copy of the VHF propagation prediction program listed in our earlier article, you can easily update it to include the 1215-1300, 2300-2450, and 3300-3500 MHz ham bands by using the modifications described below.

L-band propagation data

The data for propagation predictions we used is taken from the ESSA Technical Report.² The curves from which we derived the L-band data are for 1.6 GHz (1600 MHz), but the program scales any input frequency from 1.0 to 3.5 GHz by a $20 \log (f/f_{REF})$ factor to accommodate all three ham bands within this frequency range. Although the original program included ground-to-air and air-to-air data, we have included only ground-to-ground data here, since most of you will not be working these bands aeronautical mobile.

entering the program

It's not necessary to type the entire new program into your computer.

If you have a Commodore 64 or 128PC, you can easily add the new data to your old program. First load your old program, then type the new lines listed in fig. 1, hitting <RETURN> at the end of each new line

typed. The BASIC editor will automatically replace the old line numbers in the program with the new ones, and the new data lines (4000-4610) will be automatically added to the end of the program. Now save the new program to either tape or disk (using a new program name such as "Propagation V2.0"), and you have a propagation program covering 100 MHz through 3.5 GHz.

Changes to the TI-99/4A program are similar, but because of the limited RAM in this computer, you'll need a separate program for each band (see previous article). Load your VHF program and then do the following:

- Delete the VHF data (lines 2005-2610)
- In lines 14, 38, and 430, change "VHF" to "L-BAND"
- In lines 38 and 426, change "100" to "1000"
- In lines 40 and 428, change "175" to "3500"
- In line 70, change "GOSUB 2005" to "GOSUB 4005"
- In line 258, change "100-175" to "1000-3500"
- In line 424, change "125" to "1600"

Now add the L-band data statements (lines 4005-4610) from the Commodore program listing in fig. 1 and save your new program.

If you've entered our previous program into another brand of computer, make the appropriate changes for your computer.

using the programs

Use of the new version is no different than use of the previous VHF/UHF programs, except that only ground-to-ground data has been included.¹ (When the program is running and you're asked to select your antenna height from the menu, select only heights of 25, 50, 100, or 500 feet.)

By Lynn A. Gerig, WA9GFR, R.R. #1, Monroeville, Indiana 46773, and Joseph R. Hennel, 4316 Winston Drive, Ft. Wayne, Indiana 46806

```

10 PRINTCL#:PRINT" VHF/UHF/L-BAND PROPAGATION PROGRAM
14 PRINT:PRINT" V2.0 C 1985 BY
50 PRINTCL#:PRINT"THIS PROGRAM CALCULATES EXPECTED RANGES
52 PRINT"FOR VHF (100-175 MHZ) UHF (225-400 MHZ)
54 PRINT"AND L-BAND (1-3.5 GHZ). APPROXIMATE
100 PRINTCL#"PRESS <V> FOR VHF, <U> FOR UHF, OR <L> FOR L-BAND":PRINT
108 IFF#="L"THENPRINT"ENTERING L-BAND DATA":GOSUB4000:GOTO200
110 GOTO102
300 PRINTCL#;:IFF#<>"L"THEN PRINTF#"HF PROPAGATION: FREQ ="F"MHZ
301 IFF#="L"THEN PRINT"L-BAND PROPAGATION: FREQ ="F"MHZ
4000 F1=1600:FL=1000:FU=3500:REM L-BAND DATA
4005 H*( 1, 1)="140010175024190050200088224208
4010 H*( 1, 2)="140012175028190057200092225212
4015 H*( 1, 3)="140014175032190060200098225218
4020 H*( 1, 4)="140030175045190070200106225225
4080 H*( 2, 2)="130009175030190060200095230240
4085 H*( 2, 3)="130010175035190065200100230245
4090 H*( 2, 4)="135027175052190078200110230258
4150 H*( 3, 3)="130015175040190065200105230250
4155 H*( 3, 4)="135035175055190078200120230260
4215 H*( 4, 4)="135040136050175067195100235300
4610 RETURN

```

fig. 1. BASIC LIST of Commodore 64 program changes.

If you don't want to make these changes yourself, or if you want a verified copy of the entire program (including the ground-to-air and air-to-air data), send a blank tape or formatted disk (tape only for the TI version) with a stamped, self-addressed return mailer and a check or money order for \$5.00. If you want a full program listing, send an SASE (with 2 first-class units of postage) and \$1.00. Send all Commodore requests to Lynn A. Gerig, and all TI requests to Joseph R. Hennel, at the addresses listed at the beginning of this article.

references

1. Lynn A. Gerig, WA9GFR, and Joseph R. Hennel, "Trade off Power for Antenna Gain at VHF?," *ham radio*, July, 1985, page 32.
2. *ESSA Technical Report ERL 111-ITS 79, Transmission Loss Atlas for Select Service Bands from 0.125 to 15.5 GHz*, Institute for Telecommunication Sciences, Boulder, Colorado, May, 1969. (Available for \$1.25 from Superintendent of Documents, United States Government Printing Office, Washington, D.C. 20402.)

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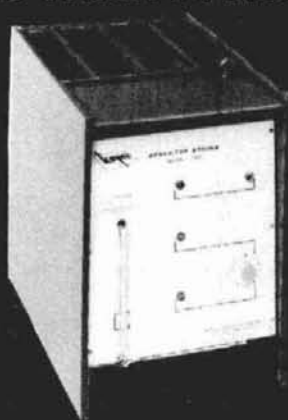
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designing Yagis with the Commodore 64

Add screen enhancements to original WA3EKL program

Last summer, *ham radio* published WA3EKL's article, "Designing Yagis with the Commodore 64" (June, 1985, page 59). While running this technically excellent program, it occurred to me that certain features could be added to the program to enhance the quality of the visual display.

As is, the program may be confusing — for example, when the primary input of the frequency is suggested, input appears at the lower boundary of the screen and breaks into the next line, while the upper part of the screen continues to display the unnecessary data.

table 1. Summary of Commodore graphics commands. When you see bracketed commands [] in the instructions, press the keys as indicated. Do not type in brackets!

[CLR]	Press SHIFT & CLR HOME
[5 SPC]	Press SPACE BAR five times, or as many times as indicated by the number
[RVS ON]	Press CTRL & 9
[RVS OFF]	Press CTRL & 0
[4 DOWN]	Press CRSR DOWN four times, or as many times as indicated by the number shown.

Figure 1 lists WA3EKL's program, with the general sections rewritten to provide highlighted information and clear data input screens. Table 1 provides a summary of Commodore graphics commands, to simplify recall of specific symbols.

Just follow the instructions step by step and you'll enjoy an "easy on the eyes" computer program that will allow you to ignore the program and concentrate instead on the dimensions of your next antenna project.

instructions

Load your previously typed WA3EKL program from disk or cassette, but *do not run* the program. Then type in the enhancement program.

Note that the numbered lines of the enhancement program will automatically replace the existing lines of the WA3EKL program memory. Some new lines have also been added.

Spacing is important. Type each line *exactly* as shown. You'll notice that some words are run together; this is intentional — doing so places them in the proper location on the screen.

You'll have to use the symbol ? instead of typing **PRINT** for some lines to get the computer to accept the long line. (See your copy of *The Commodore User's Guide*.)

Line 80 changes the screen/border/letter colors. If you like the standard blue, omit all the **POKE** statements, and type in only **PRINT "[CLR]"**.

When you've finished typing, save the enhanced program under a new name of your choice.

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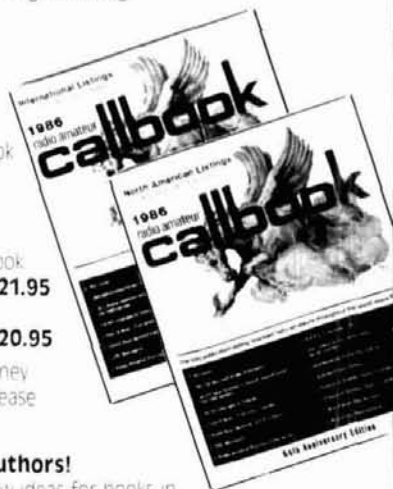
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80 POKES3280,13:POKES3281,11:POKE646,7:PRINT"[CLR]"
100 PRINT"***** MONOBAND ANTENNA DESIGN *****":PRINT
106 IFCS="N"THEN311
108 PRINT:PRINT"[CLR]"
110 PRINT"THIS PROGRAM WAS WRITTEN USING THE
111 PRINT"FORMULAS PUBLISHED IN 1980 HAM RADIO
112 PRINT"MAGAZINE AND WRITTEN BY W2PU WHO PROVED MATHEMATICALLY AND EXPERIMENTA
LLY
114 PRINT"THAT ANTENNA ELEMENT RESONATE FREQUENCY LENGTH IS NO SIMPLE CALCULATIO
N"
116 PRINT"ESPECIALLY WHEN TAPERED ELEMENTS ARE[4 SPC]INVOLVED."
130 PRINT"***** MECHANICAL RECOMMENDATIONS *****":PRINT
140 PRINT"20 METER BOOM SHOULD BE 3 OR 4 INCH"
141 PRINT"DIAMETER ALUMINUM IRRIGATION PIPE"
150 PRINT"DEPENDING ON LENGTH."
160 PRINT"ELEMENTS SHOULD BE TAPERED SEGMENTS FROM 1 1/4 INCH TO 1/2 INCH"
184 PRINT"[DOWN]"
185 PRINT:PRINT"TO CONTINUE INSTRUCTION PRESS [RVS ON]RETURN[RVS OFF]";:INPUTIS
186 PRINT"[CLR]"
190 PRINT:PRINT"10-15 METER BOOMS SHOULD BE MADE OF[5 SPC]2 INCH ALUMINUM IRRIGA
TION PIPE.
200 PRINT"ELEMENTS SHOULD BE TAPERED FROM 7/8 INCH TO 5/8 INCH DIAMETERS OF"
215 PRINT"FOR MAXIMUM FRONT TO BACK RATIO USE 1/4 WAVELENGTH BOOM ON A 3 ELEMENT
"
220 PRINT"BEAM AND 3/4 WAVELENGTH BOOM ON A 4,[5]3 SPC]OR 6 ELEMENT BEAM."
225 PRINT"EQUALLY SPACE ALL ELEMENTS ALONG THE[4 SPC]BOOM REGARDLESS OF LENGTH."
230 PRINT"FOR A GOOD 2 ELEMENT BEAM USE A BOOM[4 SPC]LENGTH OF .150 WAVELENGTH."
240 PRINT"FOR A GOOD 3 ELEMENT BEAM USE A BOOM[4 SPC]LENGTH OF .300 WAVELENGTH."
244 PRINT"[4 DOWN]"
245 PRINT:PRINT"TO CONTINUE INSTRUCTION PRESS [RVS ON]RETURN[RVS OFF]";:INPUTIS:
PRINT"[CLR]"
250 PRINT:PRINT"IMPORTANT ALL TOTAL LENGTH DIMENSIONS[3 SPC]WILL BE ELEMENT HALF
LENGTH,"
255 PRINT"MEANING THE LENGTH OF THE ELEMENT[7 SPC]MEASURED FROM THE BOOM OUT TO
THE"
260 PRINT"TIP OF THE ELEMENT. ENTER ELEMENT SEGMENT LENGTHS AND DIAMETERS JUST"
270 PRINT"(WHICH CROSSES OVER THE BOOM) TO THE[5 SPC]SMALLEST DIAMETER SEGMENT AT
THE"
275 PRINT"ELEMENT TIP. THE OBJECT IS TO ADJUST THE ORIGINAL SEGMENT LENGTHS SO"
280 PRINT"THAT THE TOTAL EQUIVALENT LENGTH IS[5 SPC]EQUAL TO OR VERY CLOSE TO TH
E"
285 PRINT"NORMALIZED LENGTH FOR THE PARTICULAR[4 SPC]ELEMENT YOU ARE WORKING ON.
"
289 PRINT"[3 DOWN]"
290 PRINT:PRINT"TO CONTINUE INSTRUCTION PRESS [RVS ON]RETURN[RVS OFF]";:INPUTIS
291 PRINT"[CLR]"
295 PRINT"WHEN THE COMPUTER ASKS FOR INFORMATION[2 SPC][DOWN][RVS ON]-ENTER IN T
HE INFORMATION-[RVS OFF]"
296 PRINT
300 PRINT"THEN PRESS [RVS ON]RETURN[RVS OFF] - NOTHING WILL HAPPEN [DOWN]UNTIL[2
SPC]YOU PRESS [RVS ON]RETURN[RVS OFF]"
301 PRINT
305 PRINT"IF NOTHING HAPPENS IMMEDIATELY, WAIT --- [DOWN][RVS ON] THE COMPUTER MA
Y BE THINKING![RVS OFF]"
309 PRINT"[9 DOWN]"
310 PRINT:PRINT"TO START CALCULATIONS PRESS [RVS ON]RETURN[RVS OFF]";:INPUTIS
311 PRINT"[CLR]"
450 PRINT:PRINT"ENTER CENTRAL DESIGN FREQUENCY IN MHZ";:PRINT"[DOWN]":INPUTCDF
470 PRINT"ENTER NUMBER OF ANTENNA ELEMENTS 2,3,4,5 OR 6";:PRINT"[DOWN]":INPUTP
490 PRINT"ENTER BOOM DIAMETER";:PRINT"[DOWN]":INPUTBD
500 PRINT"ENTER NUMBER OF ANTENNA SEGMENTS";:PRINT"[DOWN]":INPUTN
550 PRINT:PRINT"ENTER (IN INCHES) LENGTH OF SEGMENT";:PRINT"[DOWN]":INPUTA
570 PRINT"ENTER (IN INCHES) DIAMETER OF SEGMENT";:PRINT"[DOWN]":INPUTB
970 PRINT:PRINT"INCHES-TOTAL EQUIV. LENGTH
972 PRINT:PRINT"HARDCOPY (Y/N)";:PRINT"[DOWN]"
980 PRINT"WANT TO CHANGE A SEGMENT LENGTH(Y/N)";:PRINT"[DOWN]":INPUTBS
1001 PRINT"[DOWN]"
1130 PRINT"ENTER NEW SEGMENT LENGTH (IN INCHES)";:PRINT"[DOWN]":INPUTU
3030 PRINTR;"INCHES-NORMALIZED REFLECTOR[20 SPC]1/2 LENGTH"
3040 PRINTDE;"INCHES-NORMALIZED DRIVEN EL.[19 SPC]1/2 LENGTH"
3050 PRINTDR;"INCHES-NORMALIZED DIRECTORS[20 SPC]1/2 LENGTH"
4000 PRINT:PRINT"[RVS ON]PLEASE WAIT ..... I'M THINKING[RVS OFF]"

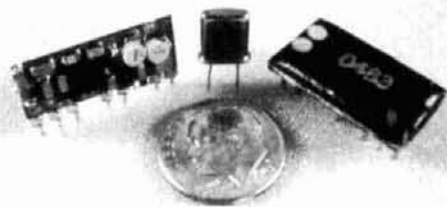
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READY.

fig. 1. Yagi design screen enhancement program listing.

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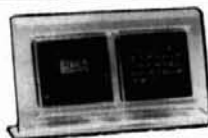
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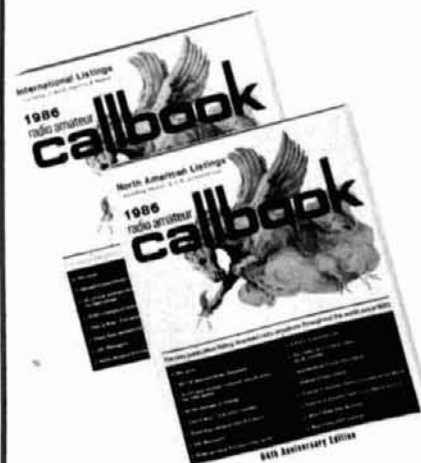
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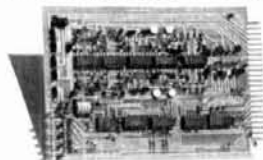
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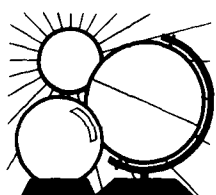
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DX FORECASTER

Garth Stonehocker, KØRYW

MUF patterns and trends

For years computer programs have been used to provide the engineering (design) and operating maximum usable frequencies (MUF) necessary for a radio link between communications stations. These calculations define the equipment design and operation based on the minimum and maximum of sunspot cycle (years), season (months), and night and day (hours) for the transmission distance involved. The calculated hourly MUF is statistically based on the middle value (median) available during the month. There are variations from this median value throughout the month. The 10 and 90 decile values of the distribution are 15 percent under and over the median value for 27 days (90 percent) of a 30-day month. The 90 percent reliability figure is achieved by using a frequency 15 percent below the median value. Radio Amateurs can use the 15 percent *above* MUF median value, which should be reliable 10 percent of the time or three days a month.

A study has been done on the ratios (10 and 90 percentiles) to the median MUF. The largest variations in these distributions are diurnal and seasonal. **Table 1** summarizes some of the results in terms of percent below (- %) and above (+ %) for day and night deviations for three seasons (Winter, Equinox, and Summer) at propagation control point latitudes.

Interestingly, the daily MUF or foF2 making up the distribution in a monthly median is precisely the daily or next-day value forecasters are trying to determine. Some patterns and trends are worth noting. Nighttime variations from the median MUF are greater than daytime variations. The midlatitudes

table 1: Variations in the 10 percent, 90 percent ratio from median MUF values.

latitude	season	ratio interval			
		- %	day + %	- %	night + %
70	Winter	27	29	26	34
	Equinox	25	27	30	35
	Summer	19	18	22	20
50	Winter	16	13	19	23
	Equinox	24	21	24	21
	Summer	22	19	19	17
30	Winter	13	15	22	27
	Equinox	17	14	21	22
	Summer	20	23	21	20
20	Winter	16	19	25	33
	Equinox	14	14	24	31
	Summer	19	19	24	26
10	Winter	12	15	23	27
	Equinox	13	15	24	25
	Summer	16	21	24	27

show lower variations and these variations rise as one approaches the equator because of the geomagnetic equator. The variations increase toward high latitudes (because of the geomagnetic pole-auroral oval) during the night. The equatorial effect is more noticeable in winter and equinox than summer. This helps explain and confirm observed transequatorial DX openings to the southern hemisphere. However, in the daytime when ion production is more stable the MUF dispersion decreases from high latitudes (70 degrees) all the way to the low latitudes (10 degrees).

At the high latitudes the increased MUF dispersion reflects the influence of solar wind particles coming into the ionosphere at the auroral oval around the geomagnetic poles. This is the region where short time variations occur (QSB), and low signal strengths associated with geomagnetic storms are received. Propagation on east-west paths to Europe and Japan are those mostly affected. However, this ionospheric movement also causes unusual propagation openings to occur. This high-latitude MUF increased distribution dispersion should be sunspot number-sensitive and next month's column will look at that.

last-minute forecast

The higher frequency bands (10-30 meters) are expected to be very good during the first and last weeks of the

month. Don't look for too much in this winter season because the 27-day solar cycle isn't a big increase even though the ionosphere has increased sensitivity, as discussed last month. Little enhancement from geomagnetic field disturbances of transequatorial propagation (openings) is expected, since January is one of the most geomagnetically stable months of the year. The lower frequency bands will be best during the middle of the month. Low noise and signal absorption work together to make excellent signals, even out of the weak DX. However, abnormally weak signals (the winter anomaly) might be received for a few days this month on high midlatitude east-west and north directed paths.

Lunar perigee occurs on the 8th, with a full moon on the 26th this month. An intense but short-duration meteor shower, the Quadrantids, will occur between January 2nd and 4th and last a few hours.

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 highest solar flux and a disturbed geomagnetic field.

WESTERN USA

QMT	PST	Directional Indicators							
		N	NE	E	SE	S	SW	W	NW
0000	4:00	40	40	20	10	10	10	10	20
0100	5:00	30	40	20	12	10	10	10	20
0200	6:00	30	40	20	20	12	10	10	20
0300	7:00	30	40	20	20	15	12	12	20
0400	8:00	30	40	20	20	15	20	20	30
0500	9:00	40	40	20	20	20	20	20	30
0600	10:00	40	40	30	20	20	20	20	30
0700	11:00	40	40	30	20	20	20	20	30
0800	12:00	40	40	30	20	20	20	20	40
0900	1:00	40	40	30	30	20	20	30	40
1000	2:00	40	40	30	30	30	30	30	40
1100	3:00	40	40	30	30	30	30	30	40
1200	4:00	40	40	30	30	30	30	30	40
1300	5:00	40	40	20	20	30	30	30	40
1400	6:00	40	30	20	12	15	30	30	40
1500	7:00	40	20	12	12	15	20	30	40
1600	8:00	40	20	10	10	15	20	40	40
1700	9:00	40	20	10	10	12	20	80*	40
1800	10:00	40	30	10	10	12	15	20	80
1900	11:00	40	30	10	10	12	20	80	80
2000	12:00	40	40	15	10	12	15	30	80
2100	1:00	80	40	15	10	12	15	20	80
2200	2:00	80	40	20	10	12	12	20	80
2300	3:00	80	40	20	10	10	12*	20	80

MID USA

MST	Directional Indicators							
	N	NE	E	SE	S	SW	W	NW
5:00	40	40	20	12	10	10	15	20
6:00	40	40	20	15	15	10	12	30
7:00	40	40	20	20	15	12	20	30
8:00	30	40	20	20	20	20	20	30
9:00	30	40	20	20	20	20	20	40
10:00	30	40	20	20	20	20	20	40
11:00	40	40	30	20	20	20	20	40
12:00	40	40	30	20	20	20	20	40
1:00	40	40	30	30	30	30	30	40
2:00	40	40	30	30	30	30	30	40
3:00	40	40	30	30	30	30	30	40
4:00	40	40	30	30	30	30	30	40
5:00	40	30	20	30	30	30	30	40
6:00	40	20	15	20	30	30	30	40
7:00	40	20	12	12	20	30	30	40
8:00	40	20	10	12	20	20	40	40
9:00	40	20	10	10	20	20	40	40
10:00	40	20	10	10	20	20	80	40
11:00	40	30	10	10	12	15	20	80
12:00	40	30	10	10	12	12	20	80
1:00	80	40	15	10	12	12	15	30
2:00	80	40	15	10	12	10	12	20
3:00	80	40	20	10	12	10	12	20
4:00	80	40	20	10	12	10	12	20

EASTERN USA

EST	Directional Indicators							
	N	NE	E	SE	S	SW	W	NW
7:00	40	40	20	15	15	20	12	30
8:00	40	40	20	20	20	20	20	30
9:00	40	40	20	20	20	20	20	40*
10:00	40	40	20	20	20	20	20	40
11:00	40	40	20	20	20	20	20	40
12:00	40	40	20	20	20	20	20	40
1:00	40	40	30	20	20	20	30	40
2:00	40	40	30	20	20	30	30	40
3:00	40	40	30	20	20	30	30	40
4:00	40	40	30	30	30	30	30	40
5:00	40	30	15	30	30	30	30	40
6:00	40	20	12	20	30	30	30	40
7:00	30	20	10	15	20	30	30	40
8:00	40*	20	10	12	20	20	20	40
9:00	40	20	10	12	15	20	20	40
10:00	40	20	10	10	15	20	20	40
11:00	40	20	10	10	12	20	20	40
12:00	40	20	10	10	12	15	20	40
1:00	40	20	10	10	12	15	20	80
2:00	80	30	10	10	12	12	15	80
3:00	80	40	15	10	12	10	12	80
4:00	80	40	15	10	12	10	12	80
5:00	80	40	20	10	12	10	12	80
6:00	80	40	20	12	12	10	12	80

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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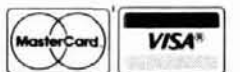
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Circle #312 on Reader Service Card.

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An extra-life battery pack and an AC operated quick-charger for the Kenwood TH-Series pocket transceivers are now available.

The PB-21H is an extra-life 500 mAh NiCad battery pack measuring just half an inch more than the standard PB-21 battery pack, and weighs only 6.5 ounces. (The standard PB-21 NiCad pack is rated at 180 mAh.)

The new BC-6 is an AC-operated, two-pack quick-charger that doubles as a DC power source for the TH-Series radios. The BC-6 can fully charge either the standard PB-21 or the new extra-life PB-21H in just one hour. The two-pack quick-charger comes complete with an adapter cable so you can operate your HT while the battery packs are charging.

For further information, contact Trio Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.

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The new MFJ-818 automatic digital SWR/Wattmeter from MFJ Enterprises, Inc., is unique in several ways. First, it's digital, with easy-to-read, 1/2 inch bright-orange digits on the SWR display. But more importantly, MFJ-818 is automatic. It eliminates three steps in reading SWR: switching to set, setting the meter needle for full-scale deflection, and switching back to SWR 1:1 to 9.9:1 directly and instantaneously. There's no need to adjust the SWR set knob!

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tantly and correctly to read instantaneous peak power. The unit features a tri-color indicator that lights up to show the antenna matching condition: green for good, yellow for "not very good," and red for a mismatched condition.

Despite all the features packed into this model, it measures only 5-1/2 x 4-1/4 x 1 inches and retails for only \$89.95 each. Like all MFJ products, the MFJ-818 carries a one-year unconditional warranty. In addition, if you order directly from MFJ, you get a 30-day money back guarantee: if you're not completely delighted, just send the SWR/wattmeter back within 30 days for a full refund (less shipping). For information, contact MFJ Enterprises, Inc. P.O. Box 494, Mississippi State, Mississippi 39762

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A new 160-page catalog of hard-to-find tools, service kits, and test equipment is offered free by Jensen Tools Inc. Illustrated in full color, this catalog contains more than 1000 items, including an expanded line of circuit board equipment.

To obtain a free copy, contact Jensen Tools Inc., 7815 South 46th Street, Phoenix, Arizona 85044.

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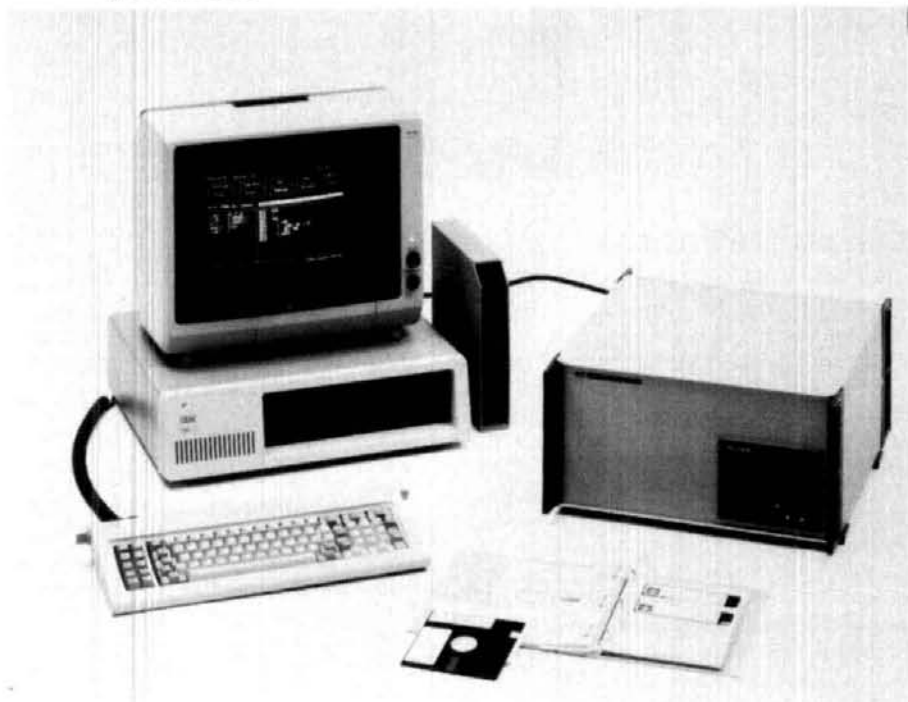
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new software from Fluke

John Fluke Mfg. Co., Inc. has announced a new software package that links an IBM PC, XT or AT with the Fluke 2400B Intelligent Computer Front End. ProLink PC™ Program Development Package simplifies creation of data acquisition and control applications that, once developed, are executed on the 2400B, freeing the host PC for other tasks.

The package's main benefit is the ability to turn an IBM PC to that one task. ProLink allows the PC to download its application program to the 2400B. The Fluke 2400B in turn handles all A/D conversions, linearizations, limit checking and data buffering.

The friendly programming environment provides a set of menu choices that allows the operator to create and edit 2400B measurement and control programs using menu selection. Menu choices allow programs to be downloaded to and retrieved from the 2400B. Additional menu choices allow the user to check programs for errors and execute these programs while monitoring 2400B variables and data on the PC's screen. Up to 100 channel systems can be supported by this system. The user can also select the desired IBM serial port, set the port characteristics, or exit to PC-DOS.

ProLink PC contains everything needed to get an IBM-PC and 2400B working together. Included is a floppy diskette, manual, and RS-232-C cable. ProLink PC can be ordered immediately,

with a normal delivery time of six weeks. The price of the ProLink PC package is \$450.

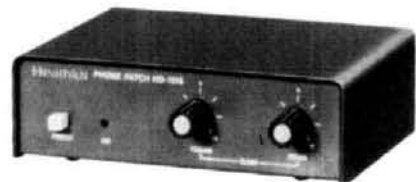
For additional information, contact John Fluke Mfg. Co., Inc., at P.O. Box C9090, Everett, Washington 98206.

Circle 308 on Reader Service Card.

new phone patch

A unique phone patch has been introduced by the Heath Company, one of the world's largest manufacturers of high technology kit products. The HD-1515 Phone Patch kit employs a unique design and special speech transmission circuits to transfer audio signals between a telephone line and two-way radio equipment.

New active circuitry uses automatic gain control to help compensate for the varying attenuation introduced by different line lengths or loop distance on the external phone circuit. The integrated active speech and transmission circuit also allows the Phone Patch to be directly connected to the phone line, thereby eliminating



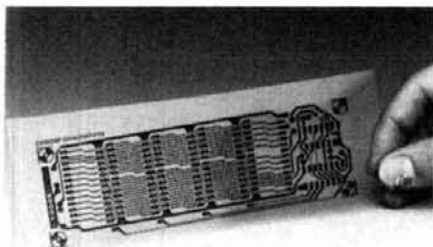
conventional hybrid transformers that convert 4-wires to 2-wires.

A high degree of electrical isolation from the radio equipment makes the Heathkit Phone Patch ideal for voice-operated installations. In addition, the transmission can be monitored on the phone line. An 8-pole filter in the input circuit makes the Patch compatible with all subscriber loop-frequency voice standards as prescribed by the FCC.

For information contact Heath Company, Dept. 150-575, Benton Harbor, Michigan 49022. Circle #301 on Reader Service Card.

film simplifies making PCBs at home

Anyone who's ever made a PCB at home knows that applying the etch resist takes patience, skill, and experience.



But TEC-200™ Image Film, a special plastic film available from Meadowlake, simplifies the process to three easy steps: first, the desired circuit pattern is photocopied directly from any magazine or book, using a sheet of TEC-200 film in the paper tray of any standard "plain paper" copier that uses toner. The high heat resistance of TEC-200 and the quality of modern photocopiers result in excellent reproduction with minimal pattern distortion.

Next, the photocopied circuit pattern is transferred to a piece of copper-clad board using a hot iron. The toner deposited on the photocopy melts and forms a varnish-like, acid-proof, etch-resist coating. Just remove the film from the board, and the board is ready for etching.

For information about TEC-200 Image Film, contact The Meadowlake Corporation, 25 Blanchard Drive, Northport, New York 11768.

Circle #302 on Reader Service Card.

curlycode™

Minds Eye Publications has announced a new publication: Curlycode™, a new way to learn Morse code.

Not "just another code course" but instead a new learning experience, it lets you become familiar with all the characters in one quick reading of the manual. It shows you how to let the rhythm of the code build shapes that you see in your mind's eye. Each sound adds to the

shape you already "see," so you never have to change your mind about the shape. Each shape is the character, so you can write it down instantly.

The beginner will remember most of the shapes without any study because only eight basic shapes are needed to know half of everything and nearly all the letters! Remember two additional endings for each shape and you'll know all 61 characters.

If you're already an expert, you'll find Curlycode an exciting new way to increase receiving speed. With a little practice, you may soon find the Curlycode shapes forming automatically in your mind's eye at practically any speed.

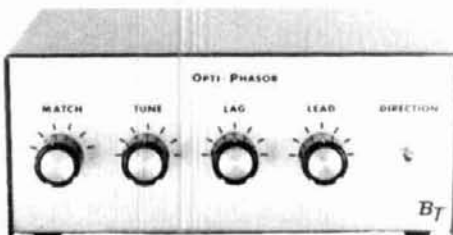
The price of the full set (including manual, wall chart, pocket card, and beginner's chart) is \$11.50. The manual alone (without the separate charts) is available for \$6.50. You or your club can save money by buying ten or more complete sets and deducting 20 per cent. All prices include postage and handling.

For further information, contact Minds Eye Publications, Dept. PH1, Box 1310, McLean, VA 22101.

Circle #303 on Reader Service Card.

antenna phasing unit

BaileyTech has introduced a new type of antenna product — the Opti-Phasor, an in-the-shack 40-meter phasing unit designed to drive a pair of dipoles or inverted vees to obtain a directional pattern and 4 dB gain. Either of two directions may be selected by merely throwing a switch. Variable reactance phasing allows the currents to be precisely balanced in the two dipoles so that deep nulls off the back and optimum gain can be achieved.



A front-to-back ratio of 20 dB or more is typical and the null is steerable. The five controls are "lead," "lag," "match," "tune," and the "direction" switch. Standard female UHF connectors are provided on the back of the phasor for the transmitter and two feedlines. A separate 52-ohm coax feedline is needed to drive each dipole. The Opti-Phasor will match a 52-ohm transmitter at full legal power. An SWR indicator or reflected power meter is needed to adjust the match. The user-supplied dipoles are hung parallel about 25 feet apart. Size is 7 1/2 x 3 3/8 x 6 1/8 inches; color is beige with black. The list price is \$120.

For details, contact BaileyTech, 304 West S. College Street, Yellow Springs, Ohio 45387.

Circle #304 on Reader Service Card.

RF TRANSISTORS

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P/N	2-30 MHz 12V (* = 28V)		Match Pr
	Rating	Each	
MRF406	20W	\$14.50	\$32.00
MRF412/A	80W	18.00	45.00
MRF421	100W	25.00	56.00
MRF421C	110W	—	60.00
MRF422*	150W	38.00	82.00
MRF426/A*	25W	18.00	42.00
MRF428**	150W	55.00	125.00
MRF433	12.5W	12.00	30.00
MRF435*	150W	42.00	90.00
MRF449/A	30W	12.50	30.00
MRF450/A	50W	14.00	31.00
MRF453/A	60W	15.00	35.00
MRF454/A	80W	16.00	36.00
MRF455/A	60W	12.00	28.00
MRF458	80W	20.00	46.00
MRF460	60W	18.00	42.00
MRF464*	80W	25.00	60.00
MRF466*	40W	18.75	48.00
MRF475	12W	3.00	9.00
MRF476	3W	2.75	8.00
MRF477	40W	11.00	25.00
MRF479	15W	10.00	23.00
MRF485*	15W	6.00	15.00
MRF492	90W	18.00	40.00
SRF2072	75W	15.00	33.00
SRF3662	110W	28.00	60.00
SRF3775	75W	15.50	34.00
SRF3795	85W	16.50	37.00
CD2545	50W	23.00	52.00
SD1076	70W	17.00	40.00
SD1451	50W	15.00	36.00

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VHF/UHF TRANSISTORS

Rating	MHz	Net Ea.	Match Pr
MRF212	10W	136-174	\$16.00
MRF221	15W	136-174	10.00
MRF222	25W	136-174	14.00
MRF224	40W	136-174	13.50
MRF231	3.5W	66-88	10.00
MRF234	25W	66-88	15.00
MRF237	4W	136-174	3.00
MRF238	30W	136-174	12.00
MRF239	30W	136-174	15.00
MRF240	40W	136-174	18.00
MRF245	80W	136-174	28.00
MRF247	75W	136-174	27.00
MRF250	50W	27-174	20.00
MRF260	5W	136-174	7.00
MRF261	10W	136-174	9.00
MRF262	15W	136-174	9.00
MRF264	30W	136-174	13.00
MRF607	1.75W	136-174	3.00
MRF641	15W	407-512	22.00
MRF644	25W	407-512	24.00
MRF646	40W	407-512	26.50
MRF648	60W	407-512	33.00
2N3866*	1W	30-200	1.25
2N4427	1W	136-174	1.25
2N5591	25W	136-174	13.50
2N5642*	20W	30-200	13.75
2N5945	4W	407-512	10.00
2N5946	10W	407-512	12.00
2N6080	4W	136-174	6.25
2N6081	15W	136-174	7.50
2N6082	25W	136-174	8.90
2N6083	30W	136-174	9.30
2N6084	40W	136-174	11.75

TMOS FET

MRF134*	5W	2-200	\$10.50
MRF137*	30W	2-200	22.50
MRF138**	30W	1.5-150	35.00
MRF150**	150W	1.5-150	80.00
MRF172*	80	2-200	65.00

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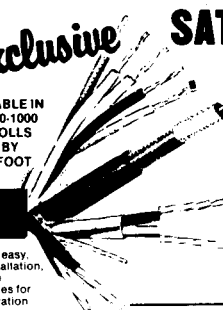
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3 - 20 Gauge	3 - 18 Gauge	3 - 18 Gauge	3 - 20 Gauge	3 - 18 Gauge
4 - 20 Gauge Shielded plus Tinned Copper Drain Wire	3 - 20 Gauge Shielded plus Tinned Copper Drain Wire	3 - 20 Gauge Shielded plus Tinned Copper Drain Wire	3 - 20 Gauge Shielded plus Tinned Copper Drain Wire	3 - 20 Gauge Shielded plus Tinned Copper Drain Wire
5 - 20 Gauge Shielded plus Tinned Copper Drain Wire	3 - 20 Gauge Shielded plus Tinned Copper Drain Wire	3 - 20 Gauge Shielded plus Tinned Copper Drain Wire	3 - 22 Gauge Shielded plus Tinned Copper Drain Wire	3 - 22 Gauge Shielded plus Tinned Copper Drain Wire

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beam antenna handbook by Bill Orr, W6SAI and Stu Cowan, W2LX

Completely revised and updated, the *Beam Antenna Handbook* includes the latest state-of-the-art antenna design. Computer generated beam dimensions for the 40, 30, 20, 17, 15, 12, 10, and VHF bands are included, eliminating the need for time-consuming math calculations. Also covered are: beam height and optimum angle of radiation, how element types and hardware effect performance, effect of nearby objects on radiation patterns, feedlines, baluns, and matching systems and much more. *ham radio* VHF columnist Joe Reiser, W1JR, and noted European VHF'er DL6WU's VHF antenna designs are covered extensively as well as NBS VHF long Yagis. 286 clearly written pages — 204 easy-to-understand illustrations make this the book to buy for beam construction. The price is \$9.95 softbound.

For more information, contact Ham Radio's Bookstore, Greenville, New Hampshire 03048.

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 - RG58U 80% shield.....07¢/ft.
 - RG58U 95% shield.....10¢/ft.
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For information, contact QSKY Publishing, P.O. Box 3042, Springfield, Illinois 62708.

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KW-12 antenna coils allow trapped dipole coverage of the new 12-meter band (24.89-24.99 MHz). Resonant frequency is designed to provide a perfect half-wave dipole. The power handling capability is 1500 watts PEP maximum. The pair is installed 9 feet, 5 inches from the balun.



Hi-Q characteristics are obtained by optimum form factor on polystyrene. Coil dimensions are 5 1/2 inches by 1/8 inch diameter; the unit weighs 6 ounces, with tensile strength rated at 800 pounds. An acrylic lacquer waterproof coating and all-aluminum hardware help provide resistance to corrosion. A specification sheet and installation instructions are supplied.

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

Circle #306 on Reader Service Card.

SSTV transceiver

Davtrend has introduced two new products: the DRAE SSTV Transceiver and — for those who already have the receiver — a Transmit Module that upgrades the DRAE receiver to transceiver status.



The system specification is the standard 8.5 second SSTV format of 16 grey shades with a 128 x 128 pixel picture. Further specification details are available.

For further information, contact Davtrend Limited, Sanderson Centre, Lees Lane, Gosport, Hampshire PO12 3UL England.

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THE GOOD SAM HAMS invite RV operators to check in the Good Sam Ham net 14.240 ± Sundays 1900Z also 3.880 ± Tuesdays at 2359Z. Net control N5BDN, Clarksville, IN

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COMING EVENTS

Activities — "Places to go . . ."

CALIFORNIA: FCC exams, Novice-Extra. Sunnysvale VEC ARC. (408) 256-9000 24 hour. 73, Gordon, W6NLG, VEC.

MICHIGAN: The Southfield High School Amateur Radio Club is sponsoring their 20th annual Swap & Shop, January 26, Southfield High School, 24675 Lahser, Southfield. Doors open 6 AM for exhibitors. Public 8 AM to 3 PM. Admission \$2.50. Reserved tables \$20.00 (paid in advance) for two 8 ft. tables. Additional reserved tables \$10.00 each. Tables also available at door. For information and reservations: Robert Younker, Southfield High School, 24675 Lahser, Southfield, MI 48034.

NEW YORK: Yonkers Amateur Radio Club's Electronics Auction, Sunday, January 26, Lemko Hall, 556 Yonkers Avenue, Yonkers. Inspection 9 AM to 10 AM. Auction starts promptly at 10 AM. Admission \$3.00. Children under 8 free. Plenty of seats and parking. Unlimited free coffee all day. Club commission on successful sales only. 10% on first \$100, 5% on remainder.

SOUTH BEND, INDIANA: Hamfest Swap & Shop, January 5 (first Sunday after New Year's Day) Century Center downtown on US 33 one way North between St. Joseph Bank Building and river. Industrial history museum in same building. Carpeted half acre room. Open tables \$1 per ft. Four lane highways to door from all directions. Talk in freq: 52-52, 99-39, 93-33, 69-09, 145-29.

MASSACHUSETTS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday January 22, 1986, 7 PM, MIT Room 1-134, 77 Mass Ave, Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann (617) 253-5820/646-1641 or Craige Rodgers at 225-6616. Exam fee \$4.00. Bring copy of current license, 2 forms of picture ID and completed form 610 (available from FCC in Boston: 223-6609).

WISCONSIN: The Wild Rivers Amateur Radio Club will hold their mid-winter swapfest, Sunday, February 16, 10 AM to 3 PM. Spooner Experimental Farm east of Spooner on highway 70. VE exams by advance registration only. Tables available. Talk in on 147.81/21. For information: Tom Young, KD9FC, Route 5, Box 5239, Hayward, WI 54843.

OHIO: The Mansfield Mid-Winter Hamfest/Auction, Sunday, February 16, Richland County Fairgrounds, Mansfield. Doors open to public 7 AM. Tickets \$3.00 advance and \$4.00 at door. Tables \$5.00 advance and \$6.00 at door. Talk in on 146.34/94, W8WE. For information/tickets/tables SASE to Dean Wrasse, K8BMG, 1094 Beal Road, Mansfield, Ohio 44905 or phone (419) 589-2415 after 3 PM EST.

MASSACHUSETTS: The Algonquin ARC will hold its annual Hamfest/Swapfest Electronic Flea Market, Sunday, February 16, Marlboro Junior High School, Marlboro. Doors open 8:30

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

AM for sellers, 10 AM for buyers. Admission \$1.00. Tables \$7.50 advance (by February 9) or \$10.00 at the door. Food available. For information/table reservations: AARC, PO Box 258, Marlboro, MA 01752 or call (617) 393-9920.

PENNSYLVANIA: Amateur Radio Social. The Chaverm of Delaware Valley will hold their 6th annual mid-winter social in downtown Philadelphia on Sunday, January 12, at 10 AM. Traditional buffet brunch, installation of new officers, entertainment and lots of eye-balling. Everyone invited. Reservations a must. Contact Bill Sobie, W3QXT (215) 676-6769 or write to 9357 Hoff Street, Philadelphia, PA 19115 for full details.

OHIO: Dayton Hamvention, April 25, 26, 27, Hara Arena and Exhibition Center. For more information write or phone Box 44, Dayton, OH 45401 (513) 433-7720. See display at this issue.

FLORIDA: Citrus County Ham Flea Market. February 8, 9 AM to 4 PM, County Fairgrounds, US 41 south, Inverness. License exams. For information: SHARC Hamfest, PO Box 572, Lecanto, FL 32661 or call Bob Gordon, W1KUL (904) 628-5045.

OPERATING EVENTS

"Things to do . . ."

1986 CLASSIC RADIO EXCHANGE 2100 UTC January 26 to 0400 UTC January 27. Object - restore, operate and enjoy old radio equipment with like-minded hams. A classic radio is any equipment built since 1945 and at least 10 years old. Exchange name, RST, state/province/country, receiver and transmitter type and other interesting information. CW call "CQ CX", phone call "CQ Exchange". Send logs, comments, etc to Stu Stephens, K8SJ, 1407 Hollywood Road, Sandusky, OH 44870. Include SASE for Classic Radio Newsletter printed January and September. 1986 Fall Classic Exchange is September 28-29.

1986 NEW HAMPSHIRE QSO PARTY sponsored by the NH Amateur Radio Association. 1900Z February 1 to 0700Z February 2 and 1400Z February 2 to 0200Z February 3. Exchange signal report and NH county or ARRL section/DXCC country. Stations may make contact on more than one band or mode. Logs must be submitted by March 25, 1986. Include large SASE for results. Send logs and comments to Mount Moriah Repeater Association c/o Bud Valcourt, N1BYQ, 19 Teague Drive, Salem, NH 03079.

MICHIGAN YL QSO PARTY sponsored by the TASYL's from 1800Z January 25 to 1800Z January 26, phone and CW. No crossband, net or repeater QSO's. Work stations once. Exchange call, signal report, QTH and TASYL # if working a member. Send logs to TASYL President, Verline Ferris, K1BV, 308 E. Harry, Hazel Park, Michigan 48030. Entries must be received by February 28, 1986.

CELEBRATE KANSAS' 125th Birthday Special Event Station KD0ZK will operate all General and Novice bands during January 1986. An 8-1/2 x 11 certificate is available for contact. Send QSL and large SASE to KD0ZK, Barry Horowitz, 715 West 5th Street, Junction City, Kansas 66441.

YORK RADIO CLUB will celebrate its 50th anniversary with several special programs in 1986. Starting January 1 through December 31, 1986, members of the YRC will work all HF bands at all class levels. Members will use their own call signs and add York Radio Club to all CO's and contacts. Submit proof of contact, SASE and one dollar for a certificate. Send to York Radio Club, 861 Fairfield, Elmhurst, IL 60126. Include time, date, condx and member's call letters.

YL-OM CONTEST All licensed men and women operators throughout the world are invited to participate. OMs call "CQ YL" and YLs call "CQ OM". All bands may be used. No cross-band operation, nets or repeater operation will count. Exchange station worked, QSO number, RS(T), ARRL section or country. Log entries must show time, band, date and transmitter power. Send logs to Mary Lou Brown, NM7N, Vice President, 504 Channel View Drive, Anacortes, WA 98221. Logs must be postmarked by March 10 and received no later than March 31, 1986.

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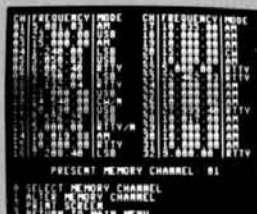
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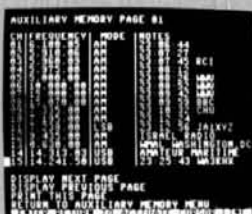
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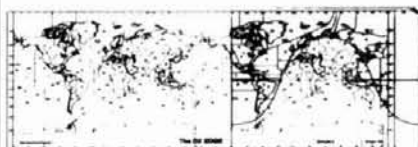
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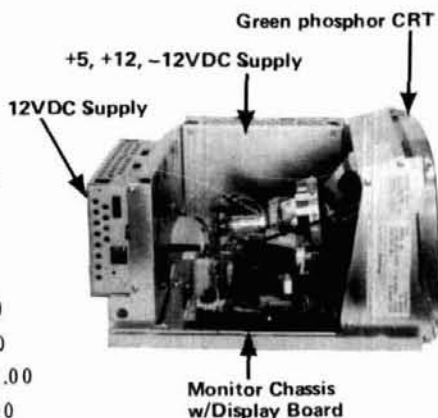
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THE GUERRI REPORT

by Ernie Guerri, W6MGI

computer graphics become more powerful

Next to word processing and accounting functions, graphics applications are rapidly becoming one of the most widely used functions of microcomputers. Unfortunately, small computers of the Apple/IBM PC class have relatively modest memory and data rate capabilities, and sophisticated graphics applications require enormous processing ability. For example, the IBM PC, using one of its most advanced graphics adapter boards, is capable of producing a picture consisting of 600 horizontal x 400 vertical picture elements (pixels) with 16 shades of gray (or 16 colors). This requires about 200,000 eight-bit bytes of memory, and can produce one full screen of picture each $\frac{1}{3}$ second. To produce just one second of television-grade picture would require *ten* times the computer power of the PC, and to add the full 64 shades of gray that the average eye can discern would double that requirement again!

But this is only the beginning. Advanced graphics applications such as computer aided engineering (CAE) require displays with 1200 x 1000 pixels and as many as 256 different colors. This requires memories capable of storing several hundred million bytes, computers operating at 5-10 million operations/second, and CRT data rates of up to 125 MHz. Typical of the computers in this class are the DEC VAX and the Gould 32/67 — half a million dollars without the chrome and tailfins.

To produce full-color moving pictures of entertainment quality requires displays capable of 4000 x 4000 pixels with 1000 colors. The memory requirements may be in the trillions of bytes, and the computers must be capable of

nearly a billion operations/second. The CRAY supercomputer is one of the few in this class — and is priced at about \$10 million! LucasFilm has reportedly invested in several CRAY's for the purpose of making movies that are 100 percent computer generated. Take heart, ATVers — these goodies should be available surplus in about 50 years!

super broadband amplifiers on the horizon

We've become accustomed to the notion that "broadband" generally means that a circuit or amplifier can cover all of a given band of interest with the same characteristics that we would expect of a circuit optimized for a specific frequency. Recent advances in hybrid microwave IC's, however, are redefining the concept of "broadband." Design groups at Philips Research in England have developed hybrid ICs using MESFETs that have measured bandwidths of nearly 12 GHz with about 7 dB of gain, and a noise figure of less than 8 dB. Moreover, the unit is capable of over $\frac{1}{4}$ watt of output over the entire band! Meanwhile, researchers at Hughes aircraft report an amplifier which is flat over the range from 2-40 GHz, giving 8 dB of gain. Scientists at several other organizations are reporting similar results which would indicate great progress in the development of devices and circuit concepts. HEMT GaAs FETs promise very low noise and high gain at these frequencies, and new computer aided modeling techniques will be required to optimize the circuit layouts and structures required to yield these bandwidths. Silicon bipolar transistors still seem to have plenty of life left for these applications. The AT200 series from Avantek, used in oscillators at 20 GHz, demonstrates better stabil-

ity and lower noise than GaAs designs, when followed by GaAs distributed amplifiers. Not surprisingly, the geometry and dimensions of the silicon devices is similar to the GaAs counterpart. Applications will initially be in highly sophisticated areas like electronic warfare and in the terminal ends of optical signal processors, but within a few years we should see this capability forming the basis for a whole new generation of lab and test equipment. Within a decade we could see low power transceivers that cover all the Amateur bands in a single unit.

vacuum tube ICs make debut

For the past several years investigators have contemplated the notion of using techniques that implement the microgeometries of transistors in order to make vacuum tubes with correspondingly small dimensions. The advantages would include the characteristics that make tubes attractive — high-temperature operation, radiation resistance, and substantial forgiveness of voltage surges.

Designers at Los Alamos National Laboratory have fabricated a vacuum tube "IC" that contains about 200 triodes and measures 40 mils on a side. It's expected that in about two years, devices that contain four to five times as many "tubes" and require only one-fourth as much space will be possible.

Because of the inherent high-temperature capability of these devices, the thermal consequences of increasing active device density may not be as serious as with semiconductors. It isn't yet clear that the small geometries associated with the "microtubes" translate to correspondingly improved high-frequency performance.

ham radio

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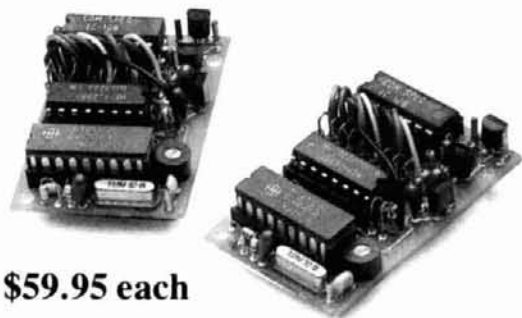
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THINGS TO LOOK FOR (AND LOOK OUT FOR) IN A PHONE PATCH

- One year warranty.
- A patch should work with any radio. AM, FM, ACSB, relay switched or synthesized.
- Patch performance should not be dependent on the T/R speed of your radio.
- Your patch should sound just like your home phone.
- There should not be any sampling noises to distract you and rob important syllables. The best phone patches do not use the cheap sampling method. (Did you know that the competition uses VOX rather than sampling in their \$1000 commercial model?)
- A patch should disconnect automatically if the number dialed is busy.
- A patch should be flexible. You should be able to use it simplex, repeater aided simplex, or semi-duplex.
- A patch should allow you to manually connect any mobile or HT on your local repeater to the phone system for a fully automatic conversation. Someone may need to report an emergency!
- A patch should not become erratic when the mobile is noisy.
- You should be able to use a power amplifier on your base to extend range.
- You should be able to connect a patch to the MIC and EXT. speaker jack of your radio for a quick and effortless interface.
- You should be able to connect a patch to three points inside your radio (VOL high side, PTT, MIC) so that the patch does not interfere with the use of the radio and the VOL. and SQ. settings do not affect the patch.
- A patch should have MOV lightning protectors.
- Your patch should be made in the USA where consultation and factory service are immediately available. (Beware of an inferior offshore copy of our former PRIVATE PATCH II.)

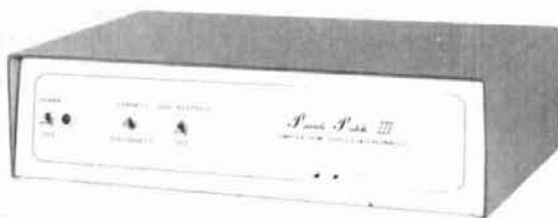
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With a flick of the new connect switch you can patch your friends on the repeater into the phone system. One of them may need to report an emergency!

No hassles with busy signals! If you call a number that is busy, just put your MIC down and relax. PRIVATE PATCH III will disconnect automatically.

The new CW ID keeps you completely informed as to patch status. ID occurs when you access and again when you disconnect. ID is also sent after toll call attempts, all automatic disconnects, manual disconnect and when timeout is imminent. And of course your CW ID chip is free.

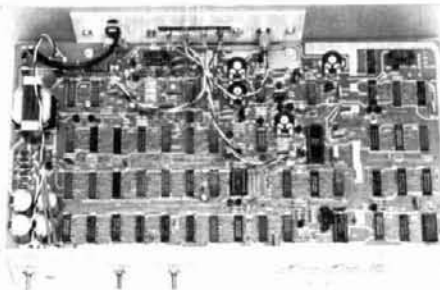
PRIVATE PATCH III does not interfere with the normal use of your base radio. A new audio pre-amp permits audio take off before the VOL. control. As a result, the VOL. and squelch settings do not affect patch operation. Of course you can also connect PRIVATE PATCH III to the MIC and EXT speaker jacks as before.

A new digit counting system makes the toll restrict positive even in areas where you do not have to dial "1" first. A secret five digit code disables the toll restrict for one toll call. Re-arm is automatic.

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