the HF/VHF decade frequency marker

that does it all
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 IC-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-SM6 desk mic, IC-SM8 two-cable desk mic, IC-EX70 desk mic, RC-10 external controller, and a variety of filters.

FILTER SPECIFICATIONS

<table>
<thead>
<tr>
<th>Filter</th>
<th>Model</th>
<th>Center Freq.</th>
<th>Att [KHz]</th>
<th>Width</th>
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<tr>
<td>STANDARD FILTERS</td>
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<tr>
<td>AM Ceramic</td>
<td>CFM 455 IT</td>
<td>455</td>
<td>0.1</td>
<td>4.0</td>
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<tr>
<td>SSB [PBT] XTAL</td>
<td>FL-30</td>
<td>9015</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>FM Filter</td>
<td>WMA5A</td>
<td>9015</td>
<td>15 (1 dB)</td>
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<tr>
<td>SSB Narrow</td>
<td>FL-44A</td>
<td>455</td>
<td>2.4</td>
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<tr>
<td>SSB Narrow</td>
<td>FL-50A</td>
<td>455</td>
<td>0.250</td>
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<tr>
<td>SSB Wide</td>
<td>FL-44A</td>
<td>455</td>
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<tr>
<td>CW Narrow</td>
<td>FL-50A</td>
<td>455</td>
<td>0.500</td>
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<td>CW Narrow</td>
<td>FL-63</td>
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<tr>
<td>AM</td>
<td>FL-33</td>
<td>9010</td>
<td>4.0</td>
<td></td>
</tr>
</tbody>
</table>

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

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!
What To Look For In A Telephone Watch

The best way to decide what a telephone watch should do is to first decide what a patch should do. A patch could:

- 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 (flip switches), tone or rotary dialing, programmable patch and activity times, and front panel indicators of channel and patch status.

**ONLY SMART PATCH HAS ALL OF THE ABOVE.**

**low 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 autotapatch, The SMART PATCH.

**SMART PATCH is Easy To Install**

1. Install SMART PATCH, connect the multicolored computer style ribbon cable to mic audio, receiver discriminator, PTT, and mic. A modular phone cord is provided for connection to your phone system. Sound simple? IT IS!

How To Use SMART PATCH

Placing a call is simple. Send 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 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 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
Accessories

TL-922A 150 15 m 2 kW PEP/1 kW DC input Linear Amplifier. Part of EIMAC 3-MO/2 tubes and excellent IMD characteristics. Perfect safety protection with built-in turn-off delay circuit.

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


MC-85 (8-pin) Multi-function desk-top microphone (8-pin) 700 0.undirectional 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).

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.


SP-40 Compact mobile speaker

SP-50 Mobile speaker

Not Shown:

MC-50 Desk-top microphone. Hi/Lo 2. 4-pin connector.

MC-80 Desk-top microphone. 700 0.undirectional 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. 18 pins.

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 0.4-pin.

MC-30S As above, but 500 0.

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-5 Deluxe headphones.

HS-6 Lightweight headphones.

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.

LF-30A Low-pass filter. 1 kW. 50 0. Insertion loss: less than 0.5 dB at 30 MHz.

MA-4000 2 m/70 cm dual band mobile gain antenna Duplexer supplied. Ideal for use with the 1W-4000A "Dual Bander" and TM-211A/TA-411A. (Mount not supplied.)

AL-2 Lightning and static arrester 1 kW. 50 0.

KS-7A 13.8 V DC. 7.5 A intermittent DC power supply.

RA-3 2 m. 3/4 A telescoping antenna with BNC connector.

RA-5 2 m. 3/4 A/7.7 cm 3/4 A telescoping antenna with BNC connector.

RA-8B 2 m StubbyDuk with BNC connector.

RA-9B As above, for 220 MHz.

RD-20 Dummy load, 50 0. DC: 500 MHz to 20 W continuous. 50 W intermittent.

PG-3A With line filter for mobile use.

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

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January 1986
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, Telelocator, 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.
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 430-450 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.
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-related 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-related telephone conversation by anyone except those actually participating as a federal crime -- with possibly no exception for Amateur autotapatches 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 and 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 Examiners), 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 FR Docket 85-51. The question of whether the 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 any part of the license term, who has surrendered his license for cancellation if so ordered. The 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.
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.

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.

---

TR-2600A shown. TR-3600A is available for 70 cm operation.
Complete service manuals are available for all Trio-Kenwood transceivers and most accessories.
Specifications and prices are subject to change without notice or obligation.
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.

SUPER KEYBOARD

MFJ-406 $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 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 operation. You get text buffer, programmable and automatic message memories, error deletion, buffer preload, buffer hold.

TRIPLE OUTPUT LAB POWER SUPPLY

MFJ-4002 $149.95

Lab quality power supply gives you plenty of voltage and current for all your analog and digital circuits. 3 completely isolated outputs: 2 variable 1.5-20 VDC at 6 amp and a fixed 5 VDC at 1 amp. Connect in series or parallel for higher voltage and current. It's short circuit protected, has excellent line regulation, is over 99% linear and current limited, has less than 0.2% (0.01%) voltage ripple and current ripple. MFJ-4002 has 5 positions: 1/2 x 1/2 x 1/2 x 1/2 x 1/2.

ORDER ANY PRODUCT FROM MFJ AND TRY IT-NO OBLIGATION. IF NOT SATISFIED RETURN WITHIN 30 DAYS FOR PROMPT REFUND (less shipping).

2 KW COAX SWITCHES

MFJ-1702 $19.95

MFJ-1701 $29.95

Instantly select any antenna or rig by turning a knob. Organizes coax cables and eliminates plugging and unplugging. Unused terminals are grounded to protect your equipment for stray RF, static and lightning. 2 KW PEP, 1 KW CW. For 50 to 75 dbm Negligible loss, SWR, and crosstalk gives high performance. SO-239s. Convenient desk or wall mounting.

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 card, 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.

2 new coax wire SWR/Power meter lines.

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.

2 KW COAX SWITCHES

MFJ-1702 $19.95

MFJ-1701 $29.95

INSTANTLY SELECT ANY ANTENNA OR RIG IN ONE SECOND!

This new breakthrough MFJ Antenna Current Probe lets you monitor RF antenna currents — no connections needed! Detects transmission line radiation due to high SWR, poor shielding or antenna unbalance. Detects re-radiation from rain gutters and wires that can distort antenna field patterns. Detects RF radiation from ground leads, power cords or building wiring that can cause RFI. Determine if ground system is effective. Pinpoint RF leakage in shielded enclosures. Locate the best place for your mobile antenna. Use as tuned field strengt meter. Complete instructions. Fits anywhere, 2/10 x 2 x 2 inches.

ANALOG SWR,WATTMETER

MFJ-418 $89.95

Fully automatic Digital SWR/Wattmeter reads SWR 1:1 to 1:99 directly and instantly — no SWR knob to set. 1.8 db accuracy with automatic gain control. 10.5 to 100 MHz. 25 W for VHF. Directly readable scale. Error is less than 0.2% x 0.2% at 1:1 SWR. MFJ-418 is a true digital display that makes it ideal for mobile use. For 50 ohm systems. 1.8-30 MHz. 12 VDC or 110 VAC with MFJ-1312. $9.95.

MOBILE ANTENNA MACHETE

MFJ-910 $19.95

Lower your SWR and get more power into your mobile whip. Has upper and lower frequency bands for solid signals and more QSOs. Your solid state rig puts out more power and generates less heat. For 10-80 meter whips. Easy plug-in installation.

TO ORDER OR FOR YOUR NEAREST DEALER, CALL TOLL-FREE

800-647-1800

Call 601-323-5689 in Mississippi or Write to:

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

8 January 1986
Novice Privileges

Dear HR:

With reference to T. Dillingham’s (KABD0E) comments concerning Novice privileges, (“Comments,” September, 1985, page 151, it seems KABD0E 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

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

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, KDBE0V
Omaha, Nebraska

Comments

Novice Privileges

Dear HR:

With reference to T. Dillingham’s (KABD0E) comments concerning Novice privileges, (“Comments,” September, 1985, page 151, it seems KABD0E 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

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?

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Michael S. Lennen, KDBE0V
Omaha, Nebraska
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.

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

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

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 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-μs (1-MHz) pulses represents, in fact, a pulse of relatively longer duration. If such an event occurs regularly every 10 μs, 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-μs 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 μs) 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
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 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
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 μV, 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 μV.

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 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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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 $1 \text{ MHz} + 100 \text{ kHz} + 10 \text{ kHz}$. 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.
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 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.
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 1 MHz. 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

---

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.
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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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?

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 well.

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

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

January 1986
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.

<table>
<thead>
<tr>
<th>dBm</th>
<th>Power (watts)</th>
<th>Volts (50 ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+70</td>
<td>10 kW</td>
<td>707.0 V</td>
</tr>
<tr>
<td>+60</td>
<td>1 kW</td>
<td>223.0 V</td>
</tr>
<tr>
<td>+50</td>
<td>100 W</td>
<td>70.7 V</td>
</tr>
<tr>
<td>+40</td>
<td>10 W</td>
<td>22.3 V</td>
</tr>
<tr>
<td>+30</td>
<td>1 W</td>
<td>7.07 V</td>
</tr>
<tr>
<td>+20</td>
<td>100 mW</td>
<td>2.23 V</td>
</tr>
<tr>
<td>+10</td>
<td>10 mW</td>
<td>707.0 mV</td>
</tr>
<tr>
<td>0</td>
<td>1 mW</td>
<td>223.0 mV</td>
</tr>
<tr>
<td>-10</td>
<td>100 µW</td>
<td>70.7 mV</td>
</tr>
<tr>
<td>-20</td>
<td>10 µW</td>
<td>22.3 mV</td>
</tr>
<tr>
<td>-30</td>
<td>1 µW</td>
<td>7.07 mV</td>
</tr>
<tr>
<td>-40</td>
<td>100 nW</td>
<td>2.23 mV</td>
</tr>
<tr>
<td>-50</td>
<td>10 nW</td>
<td>707.0 µV</td>
</tr>
<tr>
<td>-60</td>
<td>1 nW</td>
<td>223.0 µV</td>
</tr>
<tr>
<td>-70</td>
<td>100 pW</td>
<td>70.7 pV</td>
</tr>
<tr>
<td>-80</td>
<td>10 pW</td>
<td>22.3 pV</td>
</tr>
<tr>
<td>-90</td>
<td>1 pW</td>
<td>7.07 pV</td>
</tr>
<tr>
<td>-100</td>
<td>100 fW</td>
<td>2.23 pV</td>
</tr>
<tr>
<td>-110</td>
<td>10 fW</td>
<td>707.0 nV</td>
</tr>
<tr>
<td>-120</td>
<td>1 fW</td>
<td>223.0 nV</td>
</tr>
</tbody>
</table>

![fig. 1. Pin-out of NE604.](image)

![fig. 2. Functional diagram of NE604.](image)
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

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

<table>
<thead>
<tr>
<th>S-unit</th>
<th>dBm</th>
<th>Volts (50 ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S9</td>
<td>-73</td>
<td>50.0 μV</td>
</tr>
<tr>
<td>S8</td>
<td>-79</td>
<td>25.0 μV</td>
</tr>
<tr>
<td>S7</td>
<td>-85</td>
<td>12.6 μV</td>
</tr>
<tr>
<td>S6</td>
<td>-91</td>
<td>6.3 μV</td>
</tr>
<tr>
<td>S5</td>
<td>-97</td>
<td>3.2 μV</td>
</tr>
<tr>
<td>S4</td>
<td>-103</td>
<td>1.6 μV</td>
</tr>
<tr>
<td>S3</td>
<td>-109</td>
<td>0.792 nV</td>
</tr>
<tr>
<td>S2</td>
<td>-115</td>
<td>0.397 nV</td>
</tr>
<tr>
<td>S1</td>
<td>-121</td>
<td>0.199 nV</td>
</tr>
</tbody>
</table>

---

**Figure 3. Complete S-meter circuit.**

**Figure 4. Output voltage versus RF level input.**

**Figure 5. Input calibration control.**
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For a given IF signal level range, including a potentiometer because of their inferior peak reading response. Readout displays are not recommended for S-meters, a bar graph would also make a suitable display. Digital readouts 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 and adjusting the pot for 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 generated voltage would also be ideal for the following if certain precautions are taken. Most S-meters use the AGC function to be disabled. Alternatively, this circuit will provide an accurate S-meter reading 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

---

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passive audio filter design
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Improving the response of filters constructed with low-\(Q\) inductors

In parts 1 and 2\textsuperscript{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, $K$. 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 $\alpha_\infty \text{ dB}$ at infinite frequency. The value of $\alpha_\infty$ 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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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 \( \alpha_{\infty} \) of 1, 2,
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.

![Graph showing 0-10 kHz response of 500-ohm, 3-kHz highpass attenuation equalizer showing simulation results for various values of \( K \).](image)

**table 1. Low-pass attenuation equalizer component values.**

<table>
<thead>
<tr>
<th>Component</th>
<th>1 ohm, 1 rad/sec value</th>
<th>500 ohm, 3 kHz theoretical value</th>
<th>500 ohm, 3 kHz rounded value</th>
<th>1 ohm, 1 rad/sec value</th>
<th>500 ohm, 3 kHz theoretical value</th>
<th>500 ohm, 3 kHz rounded value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ideal inductor</td>
<td>Real inductor</td>
<td></td>
<td>Ideal inductor</td>
<td>Real inductor</td>
</tr>
<tr>
<td>C1</td>
<td>0.1152 F</td>
<td>0.0733</td>
<td>0.068</td>
<td>0.2308 F</td>
<td>0.1469</td>
<td>0.15</td>
</tr>
<tr>
<td>L1</td>
<td>0.1152 H</td>
<td>18.33 mH</td>
<td>18 mH</td>
<td>0.2308 H</td>
<td>36.73 mH</td>
<td>39 mH</td>
</tr>
<tr>
<td>R1, R2</td>
<td>0.0575</td>
<td>28.75</td>
<td>27</td>
<td>0.1147</td>
<td>57.35</td>
<td>56</td>
</tr>
<tr>
<td>R3</td>
<td>8.668</td>
<td>4334</td>
<td>4700</td>
<td>4.304</td>
<td>2152</td>
<td>2200</td>
</tr>
<tr>
<td>R4</td>
<td></td>
<td>0</td>
<td>17</td>
<td></td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>K = 1.122</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>0.3482 F</td>
<td>0.2217</td>
<td>0.22</td>
<td>0.4647 F</td>
<td>0.2968</td>
<td>0.27</td>
</tr>
<tr>
<td>L1</td>
<td>0.3482 H</td>
<td>55.42 mH</td>
<td>56 mH</td>
<td>0.4647 H</td>
<td>73.96 mH</td>
<td>68 mH</td>
</tr>
<tr>
<td>R1, R2</td>
<td>0.1715</td>
<td>86.75</td>
<td>82</td>
<td>0.2269</td>
<td>113.15</td>
<td>120</td>
</tr>
<tr>
<td>R3</td>
<td>2.830</td>
<td>1415</td>
<td>1500</td>
<td>2.0962</td>
<td>1048</td>
<td>1000</td>
</tr>
<tr>
<td>R4</td>
<td></td>
<td>0</td>
<td>58</td>
<td></td>
<td>0</td>
<td>66</td>
</tr>
<tr>
<td>K = 1.414</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>0.5835 F</td>
<td>0.3715</td>
<td>0.39</td>
<td>0.7071 F</td>
<td>0.4602</td>
<td>0.47</td>
</tr>
<tr>
<td>L1</td>
<td>0.5835 H</td>
<td>92.87 mH</td>
<td>100 mH</td>
<td>0.7071 H</td>
<td>112.54 mH</td>
<td>120 mH</td>
</tr>
<tr>
<td>R1, R2</td>
<td>0.2801</td>
<td>140.1</td>
<td>150</td>
<td>0.3333</td>
<td>166.67</td>
<td>180</td>
</tr>
<tr>
<td>R3</td>
<td>1.6453</td>
<td>822.7</td>
<td>620</td>
<td>1.3333</td>
<td>666.67</td>
<td>680</td>
</tr>
<tr>
<td>R4</td>
<td></td>
<td>0</td>
<td>82</td>
<td></td>
<td>0</td>
<td>97</td>
</tr>
<tr>
<td>K = 1.778</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>0.825 F</td>
<td>0.5715</td>
<td>0.59</td>
<td>0.9141 F</td>
<td>0.6012</td>
<td>0.61</td>
</tr>
<tr>
<td>L1</td>
<td>0.825 H</td>
<td>115.87 mH</td>
<td>115 mH</td>
<td>0.9141 H</td>
<td>122.74 mH</td>
<td>124 mH</td>
</tr>
<tr>
<td>R1, R2</td>
<td>0.4125</td>
<td>203.6</td>
<td>200</td>
<td>0.5596</td>
<td>227.4</td>
<td>230</td>
</tr>
<tr>
<td>R3</td>
<td>3.290</td>
<td>2122.7</td>
<td>2100</td>
<td>3.1322</td>
<td>2626.6</td>
<td>2650</td>
</tr>
<tr>
<td>R4</td>
<td></td>
<td>0</td>
<td>82</td>
<td></td>
<td>0</td>
<td>97</td>
</tr>
<tr>
<td>K = 2.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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).

![Diagram of highpass attenuation equalizer](image)

**fig. 9.** 0.3 kHz response of 1-dB/5-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>
<thead>
<tr>
<th>component</th>
<th>(1 \text{ ohm}, 1 \text{ rad/sec value})</th>
<th>(500 \text{ ohm, } 3 \text{ kHz theoretical value})</th>
<th>(500 \text{ ohm, } 3 \text{ kHz rounded value})</th>
<th>(1 \text{ ohm, } 1 \text{ rad/sec value})</th>
<th>(500 \text{ ohm, } 3 \text{ kHz theoretical value})</th>
<th>(500 \text{ ohm, } 3 \text{ kHz rounded value})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(C_1)</td>
<td>8.681 F</td>
<td>0.921</td>
<td>1 (\mu)F</td>
<td>4.333 F</td>
<td>0.460</td>
<td>0.47</td>
</tr>
<tr>
<td>(L_1)</td>
<td>8.681 H</td>
<td>220.3 mH</td>
<td>220 mH</td>
<td>4.333 H</td>
<td>114.95 mH</td>
<td>120 mH</td>
</tr>
<tr>
<td>(R_1, R_2)</td>
<td>0.0575</td>
<td>28.75</td>
<td>27</td>
<td>0.1147</td>
<td>57.35</td>
<td>56</td>
</tr>
<tr>
<td>(R_3)</td>
<td>8.668</td>
<td>4334</td>
<td>4700</td>
<td>4.304</td>
<td>2152</td>
<td>2200</td>
</tr>
<tr>
<td>(R_4)</td>
<td></td>
<td>0</td>
<td>95</td>
<td></td>
<td>0</td>
<td>97</td>
</tr>
</tbody>
</table>

\(K = 1.122\)

| \(C_1\)   | 2.672 F                         | 0.3047         | 0.33           | 2.152 F                         | 0.2283         | 0.22           |
| \(L_1\)   | 2.672 H                         | 76.19          | 82 mH          | 2.152 H                         | 57.09 mH       | 56             |
| \(R_1, R_2\) | 0.1715                          | 85.75          | 82             | 0.2263                          | 113.15         | 120            |
| \(R_3\)   | 2.830                           | 1415           | 1500           | 2.0962                          | 1048           | 1000           |
| \(R_4\)   |                                 | 0              | 71             |                                 | 0              | 56             |
\(K = 1.414\)

| \(C_1\)   | 1.714 F                         | 0.1819         | 0.18           | 1.4142 F                        | 0.1500         | 0.15           |
| \(L_1\)   | 1.714 H                         | 45.47 mH       | 47 mH          | 1.4142 H                        | 37.52 mH       | 39 mH          |
| \(R_1, R_2\) | 0.2801                          | 140.1          | 150            | 0.3333                          | 166.67         | 180            |
| \(R_3\)   | 1.6453                          | 822.7          | 820            | 1.3333                          | 666.67         | 680            |
| \(R_4\)   |                                 | 0              | 52             |                                 | 0              | 45             |
\(K = 1.778\)

| \(C_1\)   | 1.174 F                         | 0.1819         | 0.18           | 1.4142 F                        | 0.1500         | 0.15           |
| \(L_1\)   | 1.174 H                         | 45.47 mH       | 47 mH          | 1.4142 H                        | 37.52 mH       | 39 mH          |
| \(R_1, R_2\) | 0.2801                          | 140.1          | 150            | 0.3333                          | 166.67         | 180            |
| \(R_3\)   | 1.6453                          | 822.7          | 820            | 1.3333                          | 666.67         | 680            |
| \(R_4\)   |                                 | 0              | 52             |                                 | 0              | 45             |
\(K = 2.000\)

| \(C_1\)   | 1.174 F                         | 0.1819         | 0.18           | 1.4142 F                        | 0.1500         | 0.15           |
| \(L_1\)   | 1.174 H                         | 45.47 mH       | 47 mH          | 1.4142 H                        | 37.52 mH       | 39 mH          |
| \(R_1, R_2\) | 0.2801                          | 140.1          | 150            | 0.3333                          | 166.67         | 180            |
| \(R_3\)   | 1.6453                          | 822.7          | 820            | 1.3333                          | 666.67         | 680            |
| \(R_4\)   |                                 | 0              | 52             |                                 | 0              | 45             |
\(K = 2.500\)
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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 $\omega_0$ 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/60.1-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 \( R_1 \) and \( R_2 \). \( R_1 \) and \( R_2 \) 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, \( C_i \), 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

![Diagram of 0.18-dB/50.1-dB elliptic low-pass filter in series with highpass equalizer for K = 1.259.](image-url)
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...

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*See Niewiadomski, part 1, September, 1985, page 17.
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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 tones\(^5\) 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.

**references**


**bibliography**


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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. 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. 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 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. 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 letter 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.

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Record Holder 1</th>
<th>Date of QSO</th>
<th>Prop Mode</th>
<th>DX Miles (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1296 MHz</td>
<td>KH6HME-N6CA</td>
<td>6/24/84</td>
<td>Tropoducting</td>
<td>2472 (3977)</td>
</tr>
<tr>
<td>2.3 GHz</td>
<td>VK5QR-VK6WG</td>
<td>2/17/78</td>
<td>Tropoducting</td>
<td>1170 (1883)</td>
</tr>
<tr>
<td>3.3 GHz</td>
<td>G3LQR-SM6HYG</td>
<td>7/11/83</td>
<td>Ducting</td>
<td>576 (927)</td>
</tr>
<tr>
<td>5.7 GHz</td>
<td>G3EZX-SM6HYG</td>
<td>7/12/83</td>
<td>Ducting</td>
<td>610 (981)</td>
</tr>
<tr>
<td>10 GHz</td>
<td>I0SNY/E9-I0YL/IE9</td>
<td>7/08/83</td>
<td>Ducting</td>
<td>1032 (1660)</td>
</tr>
<tr>
<td>24 GHz</td>
<td>I3SOY/3-IW9EHQ/3-I4BER/6, I4CHY/6</td>
<td>4/25/84</td>
<td>LOS</td>
<td>180 (289)</td>
</tr>
<tr>
<td>47 GHz</td>
<td>HB9AMH/P-HB9MIN/P</td>
<td>6/11/84</td>
<td>LOS</td>
<td>33 (53)</td>
</tr>
</tbody>
</table>

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”.

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Record Holder 1</th>
<th>Date of QSO</th>
<th>Prop Mode</th>
<th>DX Miles (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1296 MHz</td>
<td>KH6HME-N6CA</td>
<td>6/24/84</td>
<td>Ducting</td>
<td>2472 (3977)</td>
</tr>
<tr>
<td>2.3 GHz</td>
<td>K2UYH-VK5MC</td>
<td>12/06/81</td>
<td>EME</td>
<td>10,562 (16995)</td>
</tr>
<tr>
<td></td>
<td>W4WSP-WA5TKU</td>
<td>6/03/85</td>
<td>Tropo</td>
<td>1112 (1790)</td>
</tr>
<tr>
<td>2.3 GHz</td>
<td>PA0SBS-W6YFK</td>
<td>4/5/81</td>
<td>EME</td>
<td>5491 (8836)</td>
</tr>
<tr>
<td></td>
<td>W4HHK-W8YIO</td>
<td>7/28/83</td>
<td>Tropo</td>
<td>583 (938)</td>
</tr>
<tr>
<td>3.3 GHz</td>
<td>K6HIJ/6-W6IFE/6</td>
<td>6/18/70</td>
<td>LOS</td>
<td>214 (344)</td>
</tr>
<tr>
<td>5.6 GHz</td>
<td>K5FUD-K5PJR</td>
<td>9/20/77</td>
<td>Tropo</td>
<td>267 (430)</td>
</tr>
<tr>
<td>10 GHz</td>
<td>WA4GKH/4-WD4NGG</td>
<td>8/07/94</td>
<td>Ducting</td>
<td>297 (478)</td>
</tr>
<tr>
<td></td>
<td>W7JIP/7-W7LHL/7</td>
<td>7/31/60</td>
<td>LOS</td>
<td>265 (426)</td>
</tr>
<tr>
<td>24 GHz</td>
<td>KXG0/0-W0MXY/0-NKDP/0, WA0VSL/0</td>
<td>8/24/65</td>
<td>LOS</td>
<td>74 (119)</td>
</tr>
<tr>
<td>48 GHz</td>
<td>W2SZ/1-WA2AAU/1</td>
<td>9/08/84</td>
<td>LOS</td>
<td>0.3 (.5)</td>
</tr>
<tr>
<td>71-250 GHz</td>
<td>None reported</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above 300 GHz</td>
<td>K6MEP-WA6EJO</td>
<td>6/09/79</td>
<td>LOS</td>
<td>15 (24)</td>
</tr>
</tbody>
</table>

Table 4. Worldwide claimed EME Microwave DX records.

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Record Holder 1</th>
<th>Date of QSO</th>
<th>Prop Mode</th>
<th>DX Miles (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1296 MHz</td>
<td>PA0SBS-ZL3AAD</td>
<td>6/13/83</td>
<td>EME</td>
<td>11595 (18657)</td>
</tr>
<tr>
<td>2304 MHz</td>
<td>PA0SBS-W6YFK</td>
<td>4/05/85</td>
<td>EME</td>
<td>5491 (8336)</td>
</tr>
<tr>
<td>3300 MHz and above</td>
<td>None reported</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.” 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 gunnplexer 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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have the band, but only for A3J emissions. What a great challenge this band offers! Gear for this band is easier to design and more readily available than gear for the upper microwave bands.

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 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, crossband 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. 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 transceiver 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. 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. The lower noise figure high mobility electron transistors (HMETS) are coming. 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-parallely 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.\(^{18}\) 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.\(^{26}\) 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 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.

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- 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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- LR-1 Repeaters boast superb RF circuitry at an economical price.
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amplifiers have been used through 2304 MHz. 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. 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. 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.

feedlines

The microwave bands are a transitional region for feedlines. Coaxial
The 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 Heliax™, 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 flexibility 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.³⁵ 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.

---

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.
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references

important VHF/UHF events:
January 3: Peak of Quadransirds
January 8: EME perigee
January 11-12: ARRL VHF Sweepstakes Contest
February 4: EME perigee

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 ± 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.
Radio May 1983

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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.
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 signal, 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 RF 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. 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 stages.”

“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.

“We 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 stages.”
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 succession. Then switch to the AF mode on the sig-tracer. If the bad stage is not found, use to eliminate certain stages. You 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?"

"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?

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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 µF on gate of Q1. If so, substitute 1 or 1.5 µF.

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

A good summary of dipole loading is contained in The ARRL Antenna Book,† 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<sub>L</sub>) 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 x 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 centered loaded element. How about that, computer fans?
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-blaster 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. 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**

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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 \((25 \times 7 \times 7)/(5 \times 51), \) 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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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 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

---

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

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

This means that every wire can have several indi-
vidual characteristic impedances, each of which
should be constructed to provide the same impedance
as obtained by dividing voltage by current, or $\frac{V}{I}$. $Z_i$ is
determined by wire size, spacing, insulation, and num-
ber of conductors. The ultimate limit in high frequency
response is the physical length of all the turns, consid-
ered 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 trans-
mision 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 transis-
tor transmitters, use two parallel sections of metal tub-
ing 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 elec-
 trostatic shield for the cores. Cores of ferrite or pow-
dered 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 must make a complete turn, so the turns ratio is again always an
integer. Figure 1A shows a 12.5 to 50-ohm trans-
former. Figures 1B and 1C show a similar construc-
tion, 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 frac-
tional 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 direc-
tions 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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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 Z₀ 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 (25x25)/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

---

fig. 4. (A) Pictorial and (B) schematic representation of another 2:1 impedance change transformer construction in a “figure-eight” configuration.
### K.V.G. CRYSTAL PRODUCTS

#### 9 MHz CRYSTAL FILTERS

<table>
<thead>
<tr>
<th>MODEL</th>
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<th>Poles</th>
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<td>4</td>
<td>553.15</td>
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<td>SSB</td>
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<td>4</td>
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<td>XJ-BB</td>
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<td>XJ-AD</td>
<td>AM</td>
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<td>XJ-AM</td>
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<tr>
<td>XJ-9M</td>
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<td>500 kHz</td>
<td>4</td>
<td>54.10</td>
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<tr>
<td>XJ-10</td>
<td>IF rotary</td>
<td>15 kHz</td>
<td>2</td>
<td>17.15</td>
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<tr>
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<th>Price</th>
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<tbody>
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<td>$259.95</td>
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<td>MM-1296-144G</td>
<td>$329.95</td>
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<tr>
<td>MM-1432-ATV</td>
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<td>MM-1432-2R(S)</td>
<td>$149.95</td>
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<td>MM-1432-2R(F)</td>
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<td>MM-144-300S</td>
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<td>MM-144-500S</td>
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<td>$79.95</td>
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<td>MM-144-200S</td>
<td>$99.95</td>
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**ANTENNAS**

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<td>10Y-1Y</td>
<td>$49.95</td>
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<tr>
<td>10Y-1Y</td>
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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 $(35)(35)/24.5 = 50$ ohms. The input current in T12 and T11 must therefore, from Ohms law, equal $(35$ volts$)/(50$ ohms$) = 0.7$ amperes. Likewise, the current out of the transformer is $(25$ volts$)/(25.51$ ohms$) = 0.98$ amperes. Since T5 and T6 are in parallel and symmetrical, the current flowing through each of them is equal and is $I = (I_{out} - I_{in})/2$ 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 amperes = 0.7 amperes, 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 amperes 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.

A tubular transformer, shaped as a figure-eight, was developed. This transformer allowed placing the leads closer together, eliminating the external line section, and permitting the tubing to work both as a better electrostatic shield and as the half-turn winding, thereby allowing the tubing to be placed near the chassis ground potential. The highest potential between the tubing and the cores is only a half-turn’s worth, because it is now also used as the split turn. Note that in fig. 4, two labels are provided on each wire. These two quarter-turns are hereafter referred to as one half-turn. The turns of the secondary are W9 in parallel with W10, which serve as the half-turn, plus W7 and W8, W5 and W6. This makes a two-and-a-half-turn secondary. The primary totals three-and-a-half turns because it adds to the secondary W3 plus W4 in parallel. The W3-W4 and W5-W6 are in parallel and symmetrical, the current flowing through each of them is equal and is: $I = (I_{out} - I_{in})/2$ or $(0.98 - 0.7) = 0.14$ amperes.

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One of the most valuable sources of Yagi antenna designs is NBS Technical Note 688. 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.4 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.

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

fig. 1. The NBS trigonal reflector uses 0.25 inch (0.635 cm) diameter elements R1 = R2 = 0.455 wavelength, R3 = 0.473 wavelength on a non-conducting boom.

*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.
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

<table>
<thead>
<tr>
<th>NBS Yagi antenna boom in wavelengths</th>
<th>NBS number of elements</th>
<th>NBS gain (dBi)</th>
<th>WB3BGU gain (dBi)</th>
<th>MININEC-8 gain (dBi)</th>
<th>MININEC-18 gain (dBi)</th>
<th>pattern integration gain (dBi)</th>
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</table>
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. 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-
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MODEL RS-12S
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MODEL RS-50M

MODEL RS-50M

MODEL VS-50M

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<thead>
<tr>
<th>Model</th>
<th>Continuous Duty (AMPS)</th>
<th>ICS* (AMPS)</th>
<th>Size (IN)</th>
<th>Shipping Wt. (lbs)</th>
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<tr>
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</tr>
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<td>35</td>
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<td>38</td>
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<tr>
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<td>50</td>
<td>5 1/4 x 9 1/2</td>
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<td>12</td>
<td>4 7/8 x 8 9</td>
<td>13</td>
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<td>20</td>
<td>5 9 x 10 1/2</td>
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</tr>
<tr>
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<th>Shipping Wt. (lbs)</th>
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<td>12</td>
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<th>ICS* (AMPS)</th>
<th>Size (IN)</th>
<th>Shipping Wt. (lbs)</th>
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<td>4</td>
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<tr>
<td>VS-35M</td>
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<td>7</td>
<td>5 x 11 x 11</td>
<td>29</td>
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<tr>
<td>VS-50M</td>
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<td>10</td>
<td>6 x 13 3/4 x 11</td>
<td>46</td>
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<th>Shipping Wt. (lbs)</th>
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<td>4 x 7 1/2 x 10 1/2</td>
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<tr>
<td>RS-10S</td>
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<td>10</td>
<td>4 x 7 1/2 x 10 1/2</td>
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<tr>
<td>RS-10L (For LTR)</td>
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<td>10</td>
<td>6 x 13 3/4 x 11</td>
<td>46</td>
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<tr>
<td>RS-12S</td>
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<td>12</td>
<td>4 1/4 x 8 9</td>
<td>13</td>
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<tr>
<td>RS-20S</td>
<td>16</td>
<td>20</td>
<td>5 x 9 x 10 1/2</td>
<td>18</td>
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</tbody>
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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 FIB 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 FIB 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 2. Gain and F/B calculations resulting from iterating the trigon reflector on the 0.2 wavelength NBS Yagi.

<table>
<thead>
<tr>
<th>Increment in wavelengths</th>
<th>Gain (dBi)</th>
<th>F/B</th>
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<tbody>
<tr>
<td>0.000</td>
<td>6.42</td>
<td>0.76</td>
</tr>
<tr>
<td>0.001</td>
<td>6.54</td>
<td>0.99</td>
</tr>
<tr>
<td>0.002</td>
<td>6.69</td>
<td>1.33</td>
</tr>
<tr>
<td>0.003</td>
<td>6.87</td>
<td>1.85</td>
</tr>
<tr>
<td>0.004</td>
<td>7.07</td>
<td>2.64</td>
</tr>
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<td>0.005</td>
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<td>3.75</td>
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<td>0.014</td>
<td>7.20</td>
<td>6.59</td>
</tr>
<tr>
<td>0.015</td>
<td>7.18</td>
<td>6.45</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>NBS Yagi antenna</th>
<th>Basic Yagi gain (dB)</th>
<th>Yagi gain (dB)</th>
<th>Stock trigon gain (dB)</th>
<th>F/B maximum trigon gain (dB)</th>
<th>F/B maximum trigon F/B (dB)</th>
<th>F/B maximum trigon increment (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boom in wavelengths</td>
<td>Number of elements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>4</td>
<td>6.62</td>
<td>7.28</td>
<td>6.42</td>
<td>0.76</td>
<td>7.45</td>
</tr>
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<td>5</td>
<td>9.27</td>
<td>12.07</td>
<td>6.57</td>
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<td>13.86</td>
<td>9.27</td>
<td>15.67</td>
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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.
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.

**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. 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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January 1986
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. 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. These curves can now be used exactly in the same fashion as the other design curves.
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| 102 | 114 | 126 | 138 | 150 | 162 | 174 | 186 | 198 | 210 | 222 | 234 | 246 | 258 | 270 | 282 | 294 | 306 | 318 | 330 | 342 |
| 103 | 115 | 127 | 139 | 151 | 163 | 175 | 187 | 199 | 211 | 223 | 235 | 247 | 259 | 271 | 283 | 295 | 307 | 319 | 331 | 343 |
| 104 | 116 | 128 | 140 | 152 | 164 | 176 | 188 | 200 | 212 | 224 | 236 | 248 | 260 | 272 | 284 | 296 | 308 | 320 | 332 | 344 |
| 105 | 117 | 129 | 141 | 153 | 165 | 177 | 189 | 201 | 213 | 225 | 237 | 249 | 261 | 273 | 285 | 297 | 309 | 321 | 333 | 345 |
| 106 | 118 | 130 | 142 | 154 | 166 | 178 | 190 | 202 | 214 | 226 | 238 | 250 | 262 | 274 | 286 | 298 | 310 | 322 | 334 | 346 |
| 107 | 119 | 131 | 143 | 155 | 167 | 179 | 191 | 203 | 215 | 227 | 239 | 251 | 263 | 275 | 287 | 299 | 311 | 323 | 335 | 347 |
| 108 | 120 | 132 | 144 | 156 | 168 | 180 | 192 | 204 | 216 | 228 | 240 | 252 | 264 | 276 | 288 | 300 | 312 | 324 | 336 | 348 |
| 109 | 121 | 133 | 145 | 157 | 169 | 181 | 193 | 205 | 217 | 229 | 241 | 253 | 265 | 277 | 289 | 301 | 313 | 325 | 337 | 349 |
| 110 | 122 | 134 | 146 | 158 | 170 | 182 | 194 | 206 | 218 | 230 | 242 | 254 | 266 | 278 | 290 | 302 | 314 | 326 | 338 | 350 |
| 111 | 123 | 135 | 147 | 159 | 171 | 183 | 195 | 207 | 219 | 231 | 243 | 255 | 267 | 279 | 291 | 303 | 315 | 327 | 339 | 341 |
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Fig 7c, Yeag antenna design nomograph shows the relationship between element diameter and wavelength ratio (d/λ), and element length for different antennas.
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
2. Peter Viezbicke, WQNXB, personal communication.
5. Dr. Karl G. Kessler, Director of the NBS Center for Basic Standards, personal communication.

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<th>Model</th>
<th>Frequency</th>
<th>Power Level</th>
<th>Price</th>
</tr>
</thead>
<tbody>
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<td>IC-751 9 band xcvr. 1-30 MHz</td>
<td>1990.00 1089</td>
<td></td>
<td></td>
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<tr>
<td>PS-35</td>
<td>100.00 144</td>
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<tr>
<td>FL-32 500 Hz CW filter (1st)</td>
<td>44.90 35</td>
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<tr>
<td>FL-53 250 Hz CW filter (2nd)</td>
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<tr>
<td>FL-33 AM filter</td>
<td>65.80 35</td>
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<tr>
<td>FL-70 2.8 kHz wide  SSB filter</td>
<td>46.50 35</td>
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<tr>
<td>FL-12 Extra hand</td>
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<tr>
<td>RC-10 External frequency controller</td>
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<td>MB-18 Mobile unit</td>
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<td>MB-5 Mobile unit</td>
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Easy-to-build coax-stub filters help reduce both harmonics and intra-station interference

trapping stubborn harmonics

When you’re trying to eliminate interference caused by harmonics, you have to stop the offending signals at the transmitter before they’re radiated. In such multi-transmitter situations as Field Day and contests, harmonic interference can mean the difference between an interference-free operation and endless arguments over who’s doing what to whom. By placing a coax stub filter at your transmitter’s output, you can reduce harmonics at the source. What’s more, coax-stub filters can also help reduce harmonic-induced TVI.

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 a half-wave-length 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
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 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.

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 even 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.

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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/fREF) 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
fig. 1. BASIC LIST of Commodore 64 program changes.

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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!*

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[CLR]</td>
<td>Press SHIFT &amp; CLR HOME</td>
</tr>
<tr>
<td>[5 SPC]</td>
<td>Press SPACE BAR five times, or as many times as indicated by the number</td>
</tr>
<tr>
<td>[RVS ON]</td>
<td>Press CTRL &amp; 9</td>
</tr>
<tr>
<td>[RVS OFF]</td>
<td>Press CTRL &amp; 0</td>
</tr>
<tr>
<td>[4 DOWN]</td>
<td>Press CRSR DOWN four times, or as many times as indicated by the number shown.</td>
</tr>
</tbody>
</table>

**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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174 More Details? CHECK — OFF Page 126
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 show lower variations and these variations rise as one approaches the equator because of the geomagnetic field. 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 transsequatorial 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.

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

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**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.*
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*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.*

January 1986 113
RF CAD ELECTRONICS DESIGN PROGRAM — Version 3.51
by Joe Reisert, W1JR and Gary Field, WAI9GRC
For IBM PC and compatible computers
This software package has been written by electronic engineers and contains nearly 40 tested and proven programs that will help the Radio Engineer or antenna designer many common types of radio circuitry. Emphasis has been placed upon ease of use. Whenever possible, menus of choices with examples are displayed. Should the user be computer illiterate, the programs are not copy protected so they can be modified to meet your specific requirements. (full documentation is also provided.) Programs include: Filters, LC active, LP, HP, BP, Inductor design, toroid, solenoid, straight wire, Matching networks, Crystal oscillators, Microstrip, Transmission lines, Antennas, Yagi-Uda, helix, dish, form, element scaling; PI and T attenuators. Also included: Radio Path Calculations; FM modulation analysis, Miscellaneous conversions; Geostationary satellite pointing; Moon tracking aids; Receiver noise figure calculations and Spurious receive response prediction. Requires IBM-PC with at least one floppy drive and 128K of RAM.

RF CAD $39.95

Please enclose $3.50 to cover shipping, handling.

ENGINEERING PROGRAMS
FOR THE IBM-PC

RF NOTES — IBM-PC
by John Simmons, WEMDI

Here's an easy way to get answers for often asked electronics questions. Both volumes contain programs written by RF consulting engineers that answer a number of very important questions often asked by hams. Monochrome and color versions. Written in Basic A and fully menu driven. Graphics card and 128K memory required.

Volume 1
Contains 88 conversions, to convert voltage, current or power levels to dB, dBm conversions, converts voltages or power levels to dBm and dBm to voltage or power, VSWR calculations, calculates VSWR and return loss when both reflected and incident powers are known; Filter design, 14 different filter configurations including schematics (6 low pass, 4 high pass, 2 band pass and 2 band elimination circuits; Basic Microstrip and strip line design, Resonant Circuits, design parallel and series resonant circuits, pi, capacitive and inductive impedance divider circuits.

IE-RF1 (Monochrome) IBM-PC $59.95
IE-RF1C (Color) $59.95

Volume II
This program covers: Attenuator pads, calculates constants for eleven different pad configurations (all with circuit diagrams) inductors, inductance in a single length of wire, single layer coils, both close and wide space wound and Toroidal coil design that gives automatic selection of wire size and toroidal form. Capacitors, calculates self resonant frequencies, determines optimum bypass values and de-coupling applications. Impedance Matching Networks, including, L, pi, T and series L configurations.

IE-RF2 (Monochrome) IBM-PC $59.95
IE-RF2C (Color) $59.95

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

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

ham radio
newest accessories for Kenwood HT

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.

Circle #12 on Reader Service Card.

Complete Novice

"The Complete Novice" is a new package from Gordon West that contains everything the beginner needs to pass the Novice test.

Packaged in a large transparent vinyl hangbag, "The Complete Novice" contains the following study materials: four stereo code learning tapes, two stereo Novice class theory cassettes, a copy of ARRL's Novice theory book, the ARRL FCC Rule Book, a brass telegraph key, a solid-state code practice oscillator, including banana and hook-up wires, instructions for proper tapes, two stereo Novice class theory cassettes, from Gordon West that contains everything the Novice needs to pass the Novice test.

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The 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 instantaeneously. There's no need to adjust the SWR set knob!

The MFJ-818 reads up to 200 watts RF output on its LED bar graph display. The 12 bar LED display indicates the "On Air" power level instantly 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 38752.

Circle #110 on Reader Service Card.

ICOM IC-1271A 1.2 GHz transceiver

ICOM has announced the IC-1271A full featured base station transceiver. With coverage from 1240 to 1300 MHz, the IC-1271A features 10 watts of RF output power, 32 memories, scanning and multi-mode operation including ATV (Amateur TV).

Additional features include front-end GaAs FETs for exceptional receiver sensitivity; CW/FM/upper and lower SSB; scanning (memory, program or mode scan); and 12 VDC or 117/240 VAC operation (optional). The suggested retail price is $99.00.

Options include the TV-1200 ATV interface unit, IC-EX310 voice synthesizer, UT-15S CTCSS encoder/decoder and IC-P525 13.8 VDC internal power supply.

For further information, contact ICOM America, Inc., 2380 116th Avenue, N.E., Bellevue, Washington 98005-9029.

Circle #111 on Reader Service Card.

new Jensen catalog

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.

Circle #10 on Reader Service Card.
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 208 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 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.


film simplifies making PCBs at home

Anyone who's ever made a PCB at home knows that 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 502 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 bigger'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 503 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 50-ohm coax feedline is needed to drive each dipole. The Opti-Phasor will match a 50-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 College Street, Yellow Springs, Ohio 45387. Circle 504 on Reader Service Card.
**12-meter antenna coil**

KW-12 antenna coils allow trapped dipole coverage of the new 12-meter band (24.88-24.99 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 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.

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**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.

Circle 307 on Reader Service Card.

RUBBER STAMPS: 3 lines $4.50 PPD. Send check or MO to G. L. Pierce, 5521 Kirkwood Place, South Bend, IN 46617. SASE brings information.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. Dale Electronics, Box 9269, Compton, CA. 90224.(312) 774-1595.


P. C. BOARD s for all Amateur Radio magazines, various parts, and all other radio magazines. Orders over $10.00 shipped postpaid. D.E. Bowerman, 1532 North 14th St., Lincoln, NE 68508.


Hamfest Sponsorship available. List all for claims made. Liability for correctness of material left corrected in next deadline issue.

DEADLINE 15th of second preceding month.

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

DIRECT DIGITAL DISPLAYS. All transceivers. Six $49.95, six 45.95, six 39.95, six 34.95, six 29.95, six 19.95. Quality Electronics. Box 74148, Chicago, Illinois 60667. (312) 342-9177.


HOME and excellent ARS OGT for sale, 3 bedroom, 1-1/2 baths, 1200 sq. ft., plus 700 sq. ft. shop and shack in separate, insulated, heated and AC block, on 2 acres of land in rural Georgia on paved road 25 minutes from Macon. $144,900 (firm). Write to W4TG, PO Box F, Gray, GA. 30012.

WANTED: Any PC's, expansion cards. FREE by mail, 26 Audio, PO Box 149, Des Moines, IA 50306.


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WANTED: Any PC's, expansion cards. FREE by mail, 26 Audio, PO Box 149, Des Moines, IA 50306.
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: AACRC, PO Box 256, Marlboro, MA 01752 or call (617) 363-9302.

Pennsylvania: Amateur Radio Social. The Chewoum of Delaware Valley will hold their 6th annual mid-winter social in downtown Philadelphia on Sunday, January 17, at 10 AM. Traditional buffet lunch, installation of new officers, entertainment and lots of eye-balling. Everyone invited. Reservations a must. Contact Bill Soble, W3DXT 2710 676-6749 or write to 30407 Huff 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 ad 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, Leucadiot, FL 32661 or call Bill Gordon, W1XUK (904) 688-5645.

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, RS1 and state (province/county), receiver and transmitter type and other interesting information. GW call "CC DK", CW call "CC Exchange". Send logs, comments, etc. to Str Stump, K0EJZ, 1460 Holwood Road, Sandusky, OH 44870. Include large SASE for results. Send logs and comments to Mountain Repeater Association c/o Bud Velutin, NW8YD, 19 Trage Drive, Salem, OH 44460.

1986 New Hampshire QSO Party sponsored by the NH Amateur Radio Association. January 21 to 2 PM, February 2 and 2 PM. Exchange signal report and NH country or DXCC country. Stations may make contact on more than one band or mode. Logs must be submitted by March 26. Include large SASE for results. Send logs and comments to Mount Mansfield Repeater Association c/o Bud Velutin, NW8YD, 19 Trage Drive, Salem, OH 44460.

Michigan YL QSO Party: sponsored by the TASYL from 1800 UTC January 25 to 1800 UTC January 26, and CW. No contact with end of signal reports on QSO's. Stations on exchange call, signal report, OTH and TASYL if working a member. Send logs to TASYL President, Verlene Fenn, KB6I, 308 E. Harry, Hazel Park, Michigan 48042. Entries must be received by February 26, 1986.

Celebrate Kansas' 125th Birthday Special Event Station K6K2XZ will operate at General and Stationなおの density by January 1986. An 8 1/2 x 11 card is available for contact. Send QSL and large SASE to K6K2XZ, Barry Hornowitz, 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 QSO's and contacts. Submit proof of contact, with call and one dollar fee to YRC, 2129 Laramie, Chicago, IL 60610. Include time, date and member's call letters.

YLOm Contest All licensed men and women operators throughout the world are invited to participate. Om's call "CC YL" and It's call "CC OM". All bands may be used. No cross-band operation, nets or repeater operation will count. Exchange station worked, QSO number, RS1, ARRL, country. Logs entries must show time, band, date and transmitter power. Send logs to Mary Lou Brown, NM7N, Vice President, 500 Channel View Drive, Armona, CA 92203. Logs must be postmarked by March 10 and received no later than March 31, 1986.
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<tr>
<td>California</td>
<td>C &amp; A Roberts, Inc.</td>
<td>18511 Hawthorn Blvd, Torrance, CA 90504</td>
<td>213-370-7451</td>
<td>Not the biggest, but the best — since 1962.</td>
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<td>FONTANA ELECTRONICS</td>
<td>8628 Sierra Avenue, Fontana, CA 92335</td>
<td>714-822-7110</td>
<td>The Largest Electronics Dealer in San Bernardino County.</td>
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<td>JUN'S ELECTRONICS</td>
<td>3919 Sepulveda Blvd, Culver City, CA 90230</td>
<td>213-390-8003</td>
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<td>Connecticut</td>
<td>HATRY ELECTRONICS</td>
<td>500 Ledyard St (South), Hartford, CT 06114</td>
<td>203-527-1881</td>
<td>Call today. Friendly one-stop shopping at prices you can afford.</td>
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January 1986
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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 ½ 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 Phillips 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 ¼ 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 stability 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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(AND LOOK OUT FOR)
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- 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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PRIVATE PATCH III
GIVES YOU ALL
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With an amazingly low price, the all new PRIVATE PATCH III is the most powerful personal phone patch system available. You can use it simplex, repeater aided simplex (from your base) or semi-duplex (at the repeater). That's right, you will never have to buy another patch. PRIVATE PATCH III does it all! There are many new and important features which were formerly only available in our top commercial models.

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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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- Programmable scanning.
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Optional accessories:
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- SP-940 external speaker with audio filtering
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- YK-88A-1 (6 kHz) AM filter
- VS-1 voice synthesizer
- SO-1 temperature compensated crystal oscillator
- MC-42S UP/DOWN hand mic.
- MC-60A, MC-80, MC-85 deluxe base station mics.
- PC-1A phone patch
- TL-922A linear amplifier
- SM-220 station monitor
- BS-8 pan display
- SW-200A and SW-2000 SWR and power meters.

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

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