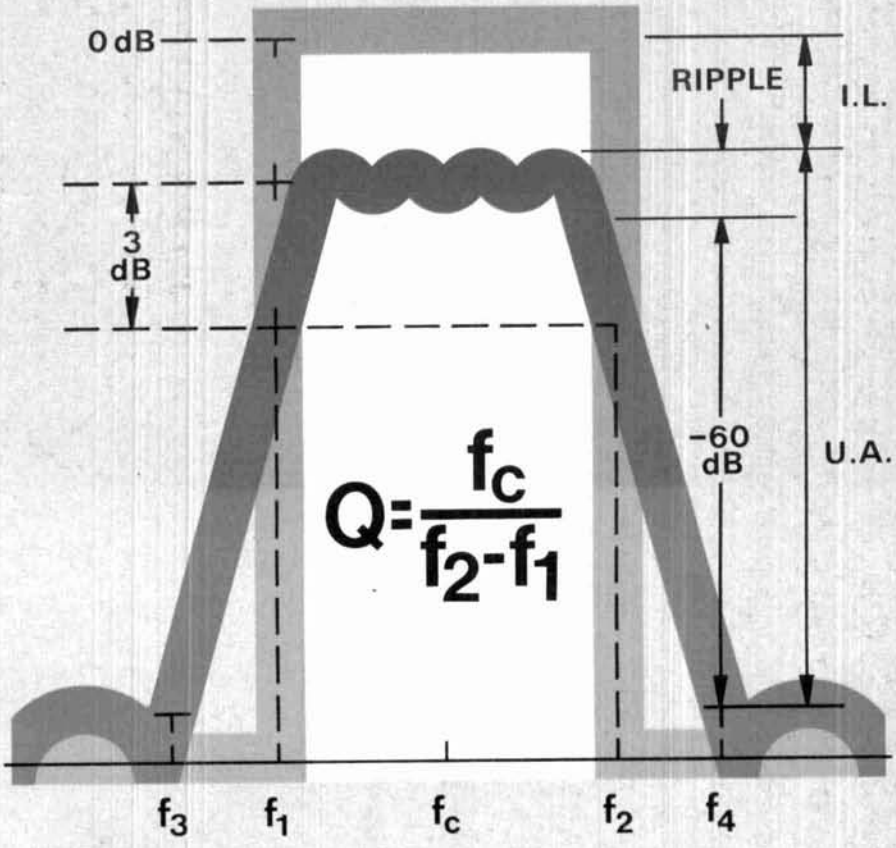
APRIL 1984 / $2.50

NEW: SHORT CIRCUIT HOTLINE — see page 6

ham radio magazine

- a portable SW receiver
- homebrew spectroscope
- graphic filter design
- master the Morse keyboard
- PL tone generator
- high-voltage power supply
- understanding the interface loop
- branch-line hybrid



RESONANT CIRCUITS EXPLAINED

focus on communications technology

ICOM IC-R71A

The Best Just Got Better

IC-GC4
World Clock

ICOM introduces the IC-R71A 100KHz to 30MHz superior-grade general coverage receiver with innovative features including keyboard frequency entry and wireless remote control (optional).

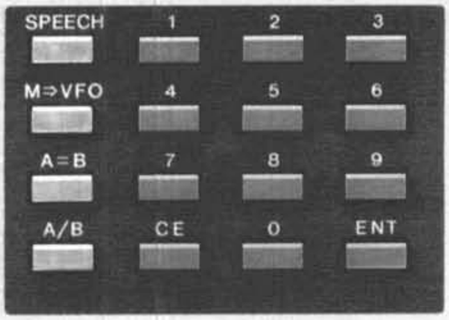
This easy-to-use and versatile receiver is ideal for anyone wanting to listen in to worldwide communciations. Demanding no previous shortwave receiver experience, the IC-R71A will accommodate an SWL (shortwave listener), Ham (amateur radio operator), maritime operator or commercial operator.

With 32 programmable memory channels, SSB/AM/RTTY/CW/FM (optional), dual VFO's, scanning, selectable AGC and noise blanker, the IC-R71A's versatility is unmatched by any other commercial grade unit in its price range.

Superior Receiver Performance. Utilizing ICOM's DFM (Direct Feed Mixer), the IC-R71A is virtually immune to interference from strong adjacent signals, and has a 100dB dynamic range.

IC-RC11
Infrared
Remote
Controller

Passband tuning, a deep IF notch filter, adjustable AGC (Automatic Gain Control) and noise blanker provide easy-to-adjust clear reception, even in the presence of strong interference or high noise levels. A preamplifier allows improved reception of weak signals.



Keyboard Entry. ICOM introduces a unique feature to shortwave receivers... direct keyboard entry for simplified operation. Precise frequencies can be selected by pushing the digit keys in sequence of frequency. The frequency will be automatical entered without changing the main tuning control. Memory channels may be called u by pressing the VFO/M (memory) switch, the keying in the memory channel number from to 32.

VFO's/Memories. A quartz-locked rock solid synthesized tuning system provides superb stability. Three tuning rates are provided: 10Hz / 50Hz / 1KHz.

32 Tunable Memories. Thirty-two tunable memories, more than any other general coverage receiver on the market, offer instant recall of your favorite frequenc Each memory stores frequency, VFO and operating mode, and is backed by an interna lithium memory backup battery to maintai the memories for up to five years.

Options. FM, synthesized voice frequency readout (activated by SPEECH button), RC11 wireless remote controller, IC CK70 DC adapter for 12 volt operation, MB12 mobile mounting bracket, two CW filters FL32 — 500Hz, and FL63 — 250Hz, an high-grade 455KHz crystal filter FL44A.

ICOM

The World System

ICOM America, Inc., 2112-116th Ave NE, Bellevue, WA 98004 **(206)454-8155** / 3331 Towerwood Drive, Suite 307, Dallas, TX 75234 **(214)620-278**

More Details? CHECK—OFF Page 128

KENWOOD

...pacesetter in amateur radio

Optional FC-10 Frequency Controller
Connects to the TM-201A or TM-401A. Convenient control keys for frequency UP/DOWN MHz shift, VFO A/B, and MR (memory recall or change memory channel). A green LCD display indicates transmit/ receive frequencies, memory channel number, ALERT, and SCAN (with blinking MHz decimal).

TM-201A/TM-401A

TM-201A/TM-401A "comp-ACT"... tough act to follow.

The word "compact" best describes the TM-201A VHF (a big 25 watts!) or the TM-401A 70-cm (12 watts) mobiles. Measures 5.6Wx1.6Hx7.2D inches (the TM-201A and TM-401A are the most compact rigs available). Ideal in size, their performances are superlative. Each features a HI/LO power switch, dual digital VFO's built-in, 5 memories plus a "COM" channel with lithium battery back-up, memory scan, programmable band scan, priority alert scan, and GaAs FET RF (front end) amplifiers. They have a highly visible yellow LED digital display, a repeater offset switch, a reverse switch, and a "beeper" to confirm operation of various switches. For superior sound quality, the separate, external speaker, can be easily mounted to project the sound in the desired direction. A 16-key autopatch UP/DOWN mic. allows easy remote operation of majpr front panel functions. Thanks to KENWOOD, compact radios are now available for the popular VHF and UHF bands providing high performance and superior sound quality.

Other TM-201A/TM-401A Optional Accessories:
TU-3 Programmable two-frequency CTCSS encoder, KPS-7A fixed station power supply, MA-4000 dual-bander mobile antenna with duplexer, SW-100A/B SWR/power meter, MC-55 mobile microphone with time-out timer.

TW-4000A

TW-4000A FM "Dual-Bander"

KENWOOD'S TW-4000A FM "Dual-Bander" provides new versatility in VHF and UHF operations, uniquely combining 2-m and 70-cm FM functions in one compact package. It covers the 2-m band (142.000-148.995 MHz), including certain MARS and CAP frequencies, and the 70-cm band (440.000-449.995 MHz), all in a package only 6-3/8 W x 2-3/8 H x 8-9/16 D inches. RF output power measures 25 watts on either band. The TW-4000A features a large, easy-to-read LCD display, front panel illumination for night operations, 10 memories with OFFSET recall and lithium battery backup, programmable memory scan, band scan in selected 1-MHz segments, priority watch function, common channel scan, dual digital VFO's, repeater reverse switch, GaAs FET front ends, rugged die-cast chassis, "beeper" through speaker, a mobile mount, and a 16-key autopatch UP/DOWN mic.

The new optional VS-1 voice synthesizer has everyone talking! A voice announces the frequency, band, VFO A or B, repeater offset, and memory channel number when these functions are selected.

Other TW-4000A optional accessories:
VS-1 voice synthesizer, TU-4C programmable two-frequency CTCSS encoder, KPS-7A fixed station power supply, SP-40 compact mobile speaker, SP-50 compact mobile speaker, MA-4000 dual-band mobile antenna with duplexor, MC-55 mobile microphone with time-out timer, and a SW-100B SWR/power meter.

More information on the TM-201A/TM-401A and TW-4000A is available from authorized dealers of Trio-Kenwood Communications 1111 West Walnut Street Compton, California 90220.

Specifications and prices are subject to change without notice or obligation.

ham radio magazine

APRIL 1984

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contents

cover design: Wayne Pierce, K3SUK

Welcome to the Hotline

Have you ever read a construction article in a magazine, then become all excited about putting the equipment together — spending weeks searching through junk boxes, flea markets, and your local radio outlet for all the parts — only to find that when you sat down and put it all together it didn't work? Then, when you dug into the circuit and made sure it was wired correctly — per the article — you found an error in the schematic? Needless to say, your feelings at times like this are nothing short of unprintable.

All publishers, *ham radio* included, have a difficult problem in this area. We work extremely hard to catch any errors as our material is prepared for publication. Unfortunately, no matter how much effort is put into error control, problems sometimes occur. To further compound the problem, it takes at least two or three months to publish a correction; by the time the correction finally appears in print, a number of people have been inconvenienced.

After giving some serious thought to this whole matter we realized we could improve this situation, at least for the readers of *ham radio*. So as of April 1st we'll be operating a special "Ham Radio Short-Circuit Hotline" that you can call from 9 AM to Noon and 1 to 3 PM, Eastern Time, Monday through Friday. Here you can find out whether there are any last-minute changes or problems you should be aware of in your particular project *before* you start work on it. The Hotline number is **603-878-1441**. (No collect calls, please.)

As an additional service, we'll keep your name in a file of readers we know are working on a particular project. If any problems should arise after your call, we'll drop you a line telling you what changes are involved.

In using this service, please remember that the Hotline isn't a technical advisory service. You'll be talking with a clerk, not a technically trained Amateur. *Please don't call the Hotline for help with construction; if you have a problem, write to the author of the article in question.*

And if you find an error in an article, tell us in a brief letter. We'll check it out, and if we find that there is indeed an error, we'll add it to our Hotline file and prepare a "Short Circuit" for publication in the next available issue.

It's important to remember that this service will cover only problems that would render the project either unusable or unsafe. We regret that we cannot act as a clearing house for design ideas or offer advice on how to squeeze the last dB of performance out of the equipment concerned. If you have comments of that nature, we'd welcome them; just jot them down and address them to Rich Rosen, Editor-in-Chief, in a letter.

Hopefully, this will be a good step toward helping to solve this familiar problem and will make *ham radio* even more valuable to all of you builders.

Skip Tenney, W1NLB
Publisher

MFJ RTTY / ASCII / AMTOR / CW
COMPUTER INTERFACES

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

NEW

MFJ-1228
$ 69 95

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

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

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

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

Has mark and space outputs for scope tuning.

Normal/Reverse switch eliminates retuning.

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

Easy, positive tuning with twin LED indicators.

Narrow 800 Hz active CW filter. Automatic PTT.

Exar 2206 sine generator for AFSK output.

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

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

Glass epoxy PCB. Aluminum enclosure. 4½x4½x1".

MFJ INTERFACE plus MFJ SOFTWARE CARTRIDGE

for VIC-20 or Commodore 64. MFJ-1228 PLUS MFJ-1250 or MFJ-1251 for one low price

$ 99 95
Save $20.00

SOFTWARE CARTRIDGE FOR VIC-20/C-64

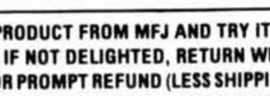
MFJ-1250/MFJ-1251
$ 49 95

Powerful MFJ software cartridge for VIC-20 (MFJ-1250, $49.95) and Commodore 64 (MFJ-1251, $49.95). Plugs into expansion port. Developed by MFJ.

Features RTTY/ASCII/CW send and receive, split screen display, type ahead buffer, message ports, status display, automatic CW speed tracking, parallel printer compatibility plus much more.

SUPER RTTY FILTER

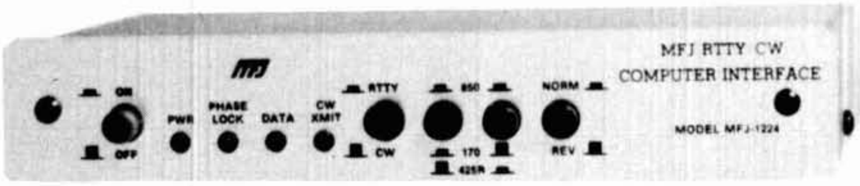
MFJ-725
$ 39 95 NEW



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

GENERAL PURPOSE RTTY/ASCII/AMTOR/CW COMPUTER INTERFACE

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



MFJ Software plus MFJ Interface for VIC-20/C-64

Software cartridge alone, $49.95. Order MFJ-1250/MFJ-1224 for VIC-20, MFJ-1251/MFJ-1224 for Commodore 64. Includes cable to interface MFJ-1224 to VIC-20 or C-64.

$ 129 95

MFJ-1224
$ 99 95

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

Use MFJ (see MFJ-1250/1251 below) software for VIC-20, Commodore 64 and Kantronics for Apple, TRS-80C, Atari, TI-99 and most other software for RTTY/ASCII/AMTOR/CW.

Easy, positive tuning with twin LED indicators.

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

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

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

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

Automatic tracking copies drifting signal.

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

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

Kantronics compatible socket.

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

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

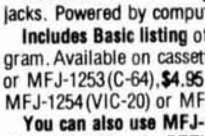
Metal cabinet. Brushed alum. front. 8x1¼x6 in. 12-15 VDC or 110 VAC with adapter, MFJ-1312, $9.95.

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

CW INTERFACE CARTRIDGE FOR VIC-20/C-64

NEW

$ 39 95



MFJ-1226

High performance CW Interface cartridge. Gives excellent performance under weak, crowded, noisy conditions. Works for both VIC-20 and Commodore 64. Plugs into user's port.

4 pole 100 Hz bandwidth active filter. 800 Hz center frequency. 3 pole active lowpass post detection filter. Exclusive automatic tracking comparator.

Plus and minus CW keying. Audio in, speaker out jacks. Powered by computer.

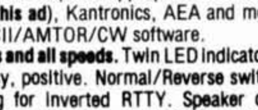
Includes Basic listing of CW transmit/receive program. Available on cassette tape, MFJ-1252 (VIC-20) or MFJ-1253 (C-64), $4.95 and on software cartridge, MFJ-1254 (VIC-20) or MFJ-1255 (C-64), $19.95.

You can also use MFJ-1250 (VIC-20) or MFJ-1251 (C-64), $49.95 each, RTTY/ASCII/CW software cartridge. Or use Kantronics, AEA and others.

Also copy RTTY with single tone detection.

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

MFJ-1225
$ 69 95



MFJ-1225 plus MFJ-1250 or MFJ-1251 $99.95.

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

Plugs between receiver and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 and most other personal computers. Requires appropriate software.

Use MFJ (see this ad), Kantronics, AEA and most other RTTY/ASCII/AMTOR/CW software.

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

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APPOINTMENTS FOR AMATEUR EXAMS ARE FILLED UNTIL AUGUST in many FCC Field Offices, as a result of the drastic cutback in FCC-administered exams effective January 1. Word about the new four-exam-per-year schedule got around very quickly following the first session in February, and both potential new Amateurs and present licensees wishing to upgrade have already filled all available slots in many offices' May session. The effect is also being seen in the number of new licenses being issued, which dropped drastically in late January after applications from December testing were processed by Gettysburg.

FIVE VOLUNTEER EXAMINER COORDINATORS HAVE NOW BEEN AUTHORIZED by the FCC, with VEC agreements with groups in Alaska, Puerto Rico, and the second, eighth, and ninth call areas all signed February 23. Formal acceptance of all five had been delayed by internal FCC procedural problems, not unexpected when such a far-reaching new program goes into effect for the first time. However, even though the new VECs have been formally accepted it will still take some time for them to get their programs on line. Serious efforts toward setting up VECs in the fifth and sixth call areas are also reported under way, but the remaining districts seem to be a long way from an adequate testing schedule.

ARRL Progress In The VEC Program Seems To Be At A Standstill, with the directors still agreeing that they won't proceed any further until the FCC agrees to permit the collection of a fee. In addition, it appears likely that the ARRL doesn't want to be involved in the exam program at all unless it is on a national basis—despite the FCC's report and order that VECs be regional though permitting one VEC to serve in more than one district.

FCC's NPRM To Permit Amateur Exam Fee Collection Is Due momentarily, and may well be out before you read this. Key questions the FCC would like addressed in responses to its Notice of Proposed Rule Making include what portion (if any) of the fee should go to the examiner, and who should collect the fee. The NPRM may have a very short Comment time, so those wishing to file comments should be prepared to respond rather quickly.

RE-EXAMINATION FOR CODE PROFICIENCY EVERY TWO YEARS is being sought in a Petition for Rule Making submitted by Wayne Green, W2NSD. In addition, he also proposes requiring five wpm upgrades at each two-year interval, to a final level of 35 wpm. Failure to improve CW speed would lead to loss of license. At presstime no RM number had been assigned.

Novice Phone Privileges On 220 MHz Have Been Proposed in another Petition for Rule Making filed by WA2MCT/5. He'd permit simplex voice and RTTY operation by entry-level licensees from 223.4 to 223.95 MHz. Such a move would, he feels, help protect the 220-MHz band from developing pressures by commercial services. It has no RM number yet, either.

COMMUNICATIONS FOR THE U.S. 1984 OLYMPIC TORCH RUN will be provided by Amateur Radio. The run, which begins May 8 on the East Coast and will cover 13,000 miles and all the 48 contiguous states before ending July 28 in Los Angeles, will be coordinated by Amateurs operating from stations in the fleet of support vans. AT&T is supporting the event, and the Amateur operators will be AT&T or subsidiary employees donating their vacation time.

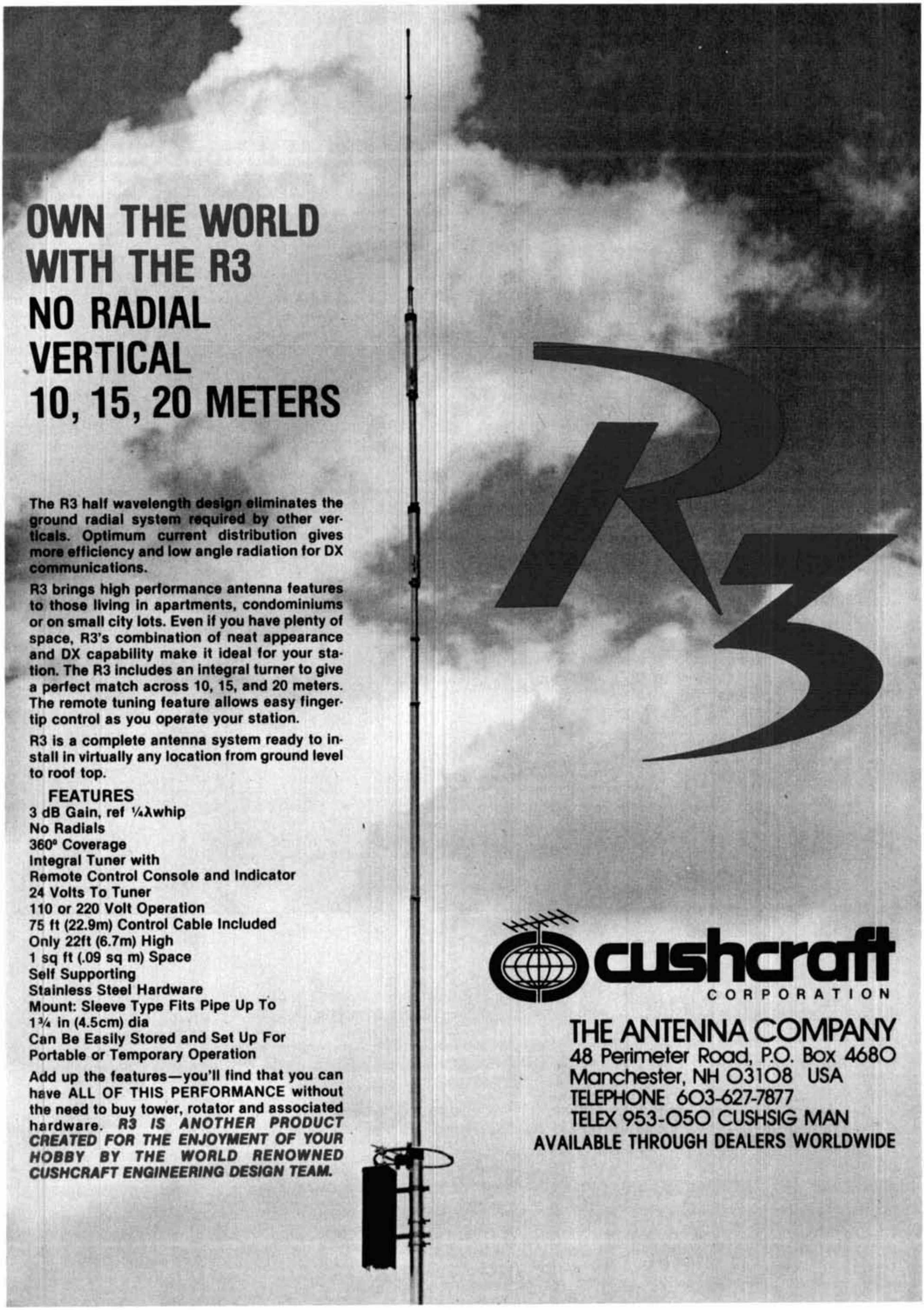
The FCC Is NOT Directly Involved With Olympic Communications, Amateur or otherwise, at this summer's Olympics. Amateurs with questions regarding Olympic communications and Amateur Radio should contact W6EJJ or K6ZT. It presently appears that, because of security considerations, there may be no Amateur Radio operation from the Olympic village as there has been in previous Olympics. The FCC does plan a strong, well coordinated effort against jammers or other radio abusers on Amateur bands and other frequencies during the Olympics.

THE FORMAL AGREEMENT BETWEEN ARRL AND REACT to facilitate cooperation between the two groups during emergency situations may now be a dead issue. The effort, which had begun last May by the ARRL board, was tabled at the October board meeting in Houston, reportedly out of concern for the results of CB delicensing. Despite a letter from REACT Executive Director Gerald Reese noting that the agreement would be with the REACT organization and not individual CB operators, and that it would simply recognize officially a mutually beneficial arrangement that already exists in many parts of the country, it now appears the board does not plan to proceed with an agreement in the foreseeable future.

QRM TO AMATEURS ON 70 CM HAS RESULTED IN THE SHUTDOWN of coastline navigation devices in California and may bring similar action along the Gulf Coast. Navigation Services, Inc., turned off eight 433 and 437 MHz transmitters in Southern California after the FCC confirmed their operation was causing harmful interference to area fast-scan ATV users.

The Gulf Coast Situation Is Similar, though in that case an attempt to arrange for "peaceful coexistence" is being made with the navigation system operator, Sercel. Amateurs do share the 70-cm band with other users, but on a strict non-interference basis.

"THE AMSAT-STONER CHALLENGE CUP," an OSCAR 10 operating competition, celebrates the 25th anniversary of W6TNS's April, 1959 proposal in CQ magazine that there could be an Amateur communications satellite. Competitors are to work (or for SWLs, hear) as many grid squares as possible from April 15 to July 14, 1984. First place winner will receive a silver cup—other top winners, plaques. Complete rules appear in Amateur Satellite Report and Orbit magazine. A contest "package" that includes copies of the historic articles that led to the contest is available from AMSAT for $2.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NO RADIAL
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10, 15, 20 METERS
The R3 half wavelength design eliminates the ground radial system required by other verticals. Optimum current distribution gives more efficiency and low angle radiation for DX communications.
R3 brings high performance antenna features to those living in apartments, condominiums or on small city lots. Even if you have plenty of space, R3's combination of neat appearance and DX capability make it ideal for your station. The R3 includes an integral turner to give a perfect match across 10, 15, and 20 meters. The remote tuning feature allows easy fingertip control as you operate your station.
R3 is a complete antenna system ready to install in virtually any location from ground level to roof top.
FEATURES
3 dB Gain, ref ¼λwhip
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Integral Tuner with
Remote Control Console and Indicator
24 Volts To Tuner
110 or 220 Volt Operation
75 ft (22.9m) Control Cable Included
Only 22ft (6.7m) High
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Mount: Sleeve Type Fits Pipe Up To
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Can Be Easily Stored and Set Up For
Portable or Temporary Operation
Add up the features—you'll find that you can have ALL OF THIS PERFORMANCE without the need to buy tower, rotator and associated hardware. R3 IS ANOTHER PRODUCT CREATED FOR THE ENJOYMENT OF YOUR HOBBY BY THE WORLD RENOWNED CUSHCRAFT ENGINEERING DESIGN TEAM.
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TELEX 953-050 CUSHSIG MAN
AVAILABLE THROUGH DEALERS WORLDWIDE

← 191

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MINI KITS - YOU HAVE SEEN THESE BEFORE NOW HERE ARE OLD FAVORITE AND NEW ONES TOO. GREAT FOR THAT AFTERNOON HOBBY.

FM MINI MIKE

A super high performance FM wireless mike kit! Transmits a stable signal up to 300 yards with exceptional audio quality by means of its built in electret mike. Kit includes case, mike, on-off switch, antenna, battery and super instructions. This is the finest unit available.

FM-3 Kit **$14.95**
FM-3 Wired and Tested **$22.95**

Color Organ

See music come alive! 3 different lights flicker with music. One light each for high, mid-range and lows. Each individually adjustable and drives up to 300 W. runs on 110 VAC.

Complete kit, ML-1 **$8.95**

Video Modulator Kit

Converts any TV to video monitor. Super stable, tunable over ch 4-6. Runs on 5-15V, accepts std video signal. Best unit on the market! Complete kit, VD-1 **$8.95**

Led Blinky Kit

A great attention getter which alternately flashes 2 jumbo LEDs. Use for name badges, buttons, warning panel lights, anything! Runs on 3 to 15 volts.

Complete kit, BL-1 **$2.95**

Super Sleuth

A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2 W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker.

Complete kit, BN-9 **$5.95**

CPO-1

Runs on 3-12 Vd... SOLD OUT ...good for CPO. Alarm. Audio O... ...mplete kit **$2.95**

FM Wireless Mike Kit

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

FM-1 kit **$3.95** FM-2 kit **$4.95**

Whisper Light Kit

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

Complete kit, WL-1 **$6.95**

Tone Decoder

A complete tone decoder on a single PC board. Features: 400-5000 Hz adjustable range via 20 turn pot, voltage regulation, 567 IC. Useful for touch-tone burst detection, FSK, etc. Can also be used as a stable tone encoder. Runs on 5 to 12 volts.

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

Universal Timer Kit

Provides the basic parts and PC board required to provide a source of precision timing and pulse generation. Uses 555 timer IC and includes a range of parts for most timing needs.

UT-5 Kit **$5.95**

Mad Blaster Kit

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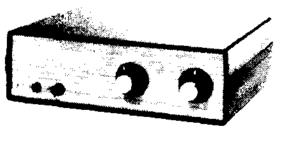

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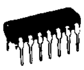

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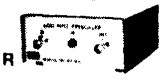

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resonant circuits

Understanding the relationship between component and circuit Q and source and load impedances

How well do you understand the basic resonant circuit? In this excerpt from his recent book, *RF Circuit Design*, Chris Bowick explains the fundamentals of RF circuitry.

The resonant circuit is certainly nothing new in Amateur Radio. Used in practically every transmitter, receiver, or piece of test equipment in existence, it selectively passes a frequency or group of frequencies from a source to a load while attenuating all other frequencies outside of this passband.

The ideal resonant circuit passband, as pictured in **fig. 1**, would be rectangularly shaped, with infinite attenuation above and below the frequency band of interest. No attenuation would be introduced at the signal frequency. But the realization of this filter is, of course, impossible because of the physical characteristics of the components which make up the filter; because there is no such thing as a perfect component, there can be no perfect filter. However, understanding the mechanics of resonant circuits enables us to tailor an imperfect circuit to suit our needs.

Fig. 2, a more realistic representation, shows what a practical filter response might resemble. Applicable definitions are presented below:

The **bandwidth** of any resonant circuit is commonly defined as the difference between the upper and lower frequency $(f_2 - f_1)$ of the circuit at which its amplitude response is 3 dB below the passband response. It is often called the half-power bandwidth.

The ratio of the center frequency of the resonant circuit to its bandwidth is defined as the *circuit-Q*.

$$Q = \frac{f_c}{f_2 - f_1} \quad (1)$$

This Q should not be confused with *component Q* which is defined as the ratio of a component's reactance (X) to its series resistance (R_s). While component Q does have an effect on circuit Q, the reverse is not true; circuit Q is a measure of the selectivity of a resonant circuit. The higher its Q, the narrower its bandwidth, and thus, the higher its selectivity.

The **shape factor** of a resonant circuit is typically defined as the ratio of the 60 dB bandwidth to the 6 dB bandwidth. For example, with a 60 dB bandwidth of 3 MHz and a 6 dB bandwidth of 1.5 MHz the shape factor is:

$$SF = \frac{3\ MHz}{1.5\ MHz} = 2$$

Shape factor is a measure of the steepness of the skirts; the smaller the number, the steeper the response. Notice that our perfect filter of **fig. 1** has a shape factor of 1, which is the ultimate. The passband for a filter with a shape factor *smaller* than 1 would have to look similar to the one shown in **fig. 3**. Obviously, this is a physical impossibility.

Ultimate Attenuation, as the name implies, is the final *minimum* attenuation that the resonant circuit presents outside of the specified passband. A perfect resonant circuit would provide infinite attenuation outside of its passband. However, with real components, infinite attenuation is impossible to obtain. (Keep in mind that if the circuit presents response peaks outside the passband, as shown in **fig. 2**, then this, of

*Adapted with permission from *RF Circuit Design* by Chris Bowick, Howard W. Sams & Co., Indianapolis, Indiana 46206. (Available from Ham Radio's Bookstore, Greenville, NH 03048, $24.95 postpaid.)

By **Chris Bowick, WD4C**, 200 Abri Place, Lilburn, Georgia 30247

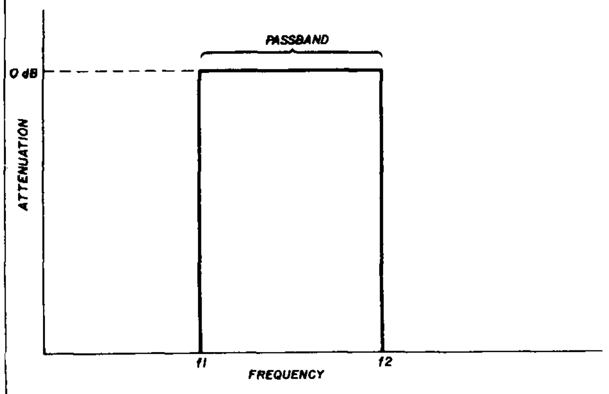

fig. 1. Ideal filter response.

course, will detract from the ultimate attenuation specification of that resonant circuit.)

Insertion Loss occurs whenever a component or group of components is inserted between a generator and its load, and some of the signal from the generator is absorbed in those components as a resistive loss. The resulting attenuation, called insertion loss, a very important characteristic of resonant circuits, is usually expressed in decibels (dB).

Ripple, a measure of the flatness of the passband of a resonant circuit, is also expressed in dB. It is the difference between the maximum and minimum attenuation *in the passband.*

resonance (lossless components)

What is resonance? What causes it to occur,and how can it be used to best advantage? Using voltage division, whenever a shunt element of impedance Z_p is placed across the output of a generator with internal resistance R_s, **fig. 4**, the maximum output voltage available from this circuit is:

$$V_{out} = \frac{Z_p}{R_s + Z_p}\,(V_{in}) \tag{2}$$

V_{out} is always less than V_{in}. If Z_p varies with frequency, such as would occur with capacitive or inductive reactance, then V_{out} is also frequency dependent and the ratio of V_{out} to V_{in}, which is the gain (or in this case, loss) of the circuit, is also frequency dependent. Let's take, for example, a 25 pF capacitor as the shunt element (**fig. 5A**) and plot the function V_{out}/V_{in} in dB versus frequency, where we have:

$$\frac{V_{out}}{V_{in}} = 20\log_{10}\frac{X_c}{R_s + X_c} \tag{3}$$

where $\frac{V_{out}}{V_{in}}$ = loss in dB

R_s = source resistance

X_c = capacitive reactance = $\frac{1}{j\omega C}$

The plot of this equation is shown in **fig. 5B**. Note that loss increases as the frequency increases; thus we have formed a simple *lowpass filter*. Notice also that the attenuation *slope* eventually settles down to the rate of 6 dB for every octave (doubling) increase in frequency (also called 6 dB "roll-off"). This is due to the single reactive element in the circuit. This attenuation slope increases an additional 6 dB for each *significant* reactive element that we insert into the circuit.

If we now delete the capacitor from the circuit and insert a 0.05 μH inductor in its place, we obtain the circuit of **fig. 6A** and the plot of **fig. 6B**, where

$$\frac{V_{out}}{V_{in}} = 20\log_{10}\frac{X_L}{R_s + X_L} \tag{4}$$

where $\frac{V_{out}}{V_{in}}$ = loss in dB

R_s = source resistance

X_L = coil reactance = $j\omega L$

Here we have formed a simple *highpass filter* with an attenuation slope of 6 dB per octave.

Simple calculations using the basic voltage division formula (**eq. 2**) enabled us to plot the frequency response of two separate and opposite reactive components. But what happens if we place both the inductor and capacitor across the generator simultan-

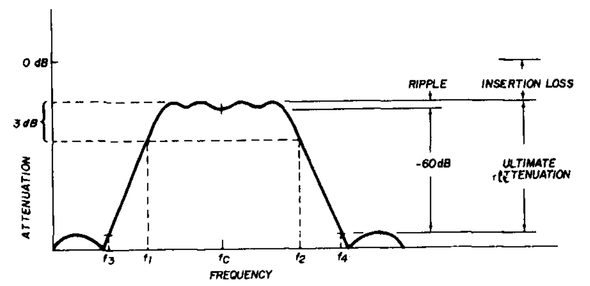

fig. 2. A practical filter response.

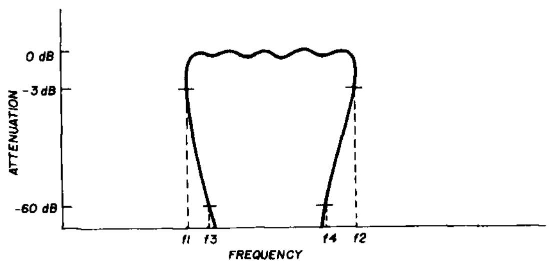

fig. 3. An impossible filter shape factor.

eously? This case is no more difficult to analyze than the previous two circuits. In fact, at any frequency, we can simply apply the basic voltage division rule as before. The only difference here is that we now have two reactive parallel components to deal with instead of one. The circuit is shown in **fig. 7A** and its response is plotted in **fig. 7B**. Notice that as we approach the resonant frequency of the tuned circuit, the slope of the resonance curve increases. This occurs because two *significant* reactances are present and each one is changing at the rate of 6 dB per octave, with slopes in opposite directions. As we move away from resonance in either direction, however, the curve again approaches a 6 dB/octave slope because again only one reactance becomes significant. The other reactance presents a very high impedance to the circuit at these frequencies and the circuit behaves as if that reactance were no longer there.

loaded-Q

The Q of a resonant circuit was defined earlier to be equal to the ratio of the circuit's center frequency to its 3 dB bandwidth (**eq. 1**). This "circuit Q," as it was called, is often given the label "loaded-Q" because it describes the passband characteristics of the resonant circuit under actual in-circuit or *loaded* conditions. The loaded-Q of a resonant circuit is dependent upon three main factors (see **fig. 8**): (1) the source resistance (R_S), (2) the load resistance (R_L), and (3) the component Q.

effect of R_S and R_L on loaded Q

The role that source and load impedances play in determining the loaded Q of a resonant circuit is probably best illustrated through an example. In **fig. 7** we plotted a resonance curve for a circuit consisting of a 50-ohm source, a 0.05 μH lossless inductor, and a 25 pF lossless capacitor. The loaded Q of this circuit, as defined by **eq. 1** and determined from the graph, is approximately 1.1. Obviously, this is not a very narrow band or high-Q design. However, after replacing the 50 ohm source with a 1000 ohm source and again plotting the results, the response in **fig. 9** is applicable. (The resonance curve for the circuit with the 50 ohm source is shown in dashed lines for comparison. Notice that the Q, or selectivity of the resonant circuit, has increased dramatically to approximately 22. Thus, by raising the source impedance, we have increased the Q of our resonant circuit.

However, neither of these plots addresses the effect of the load impedance on the resonance curve. If an external load were attached to the resonant circuit, as shown in **fig. 10A**, the effect would be to broaden or "de-Q" the response curve, depending

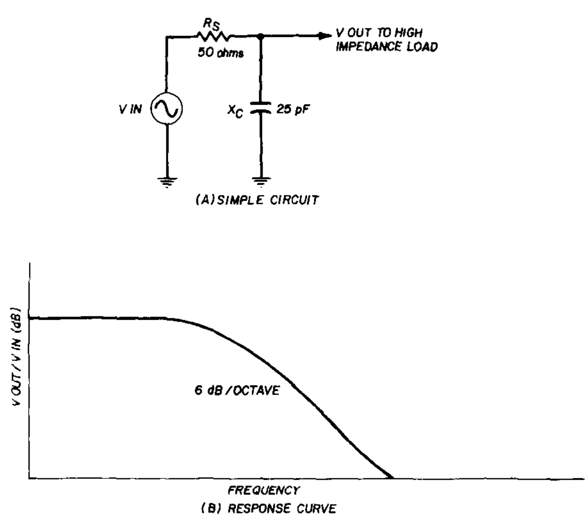

fig. 5. Frequency response of a simple RC lowpass filter: *(A)* shows simple circuit; *(B)*, response curve.

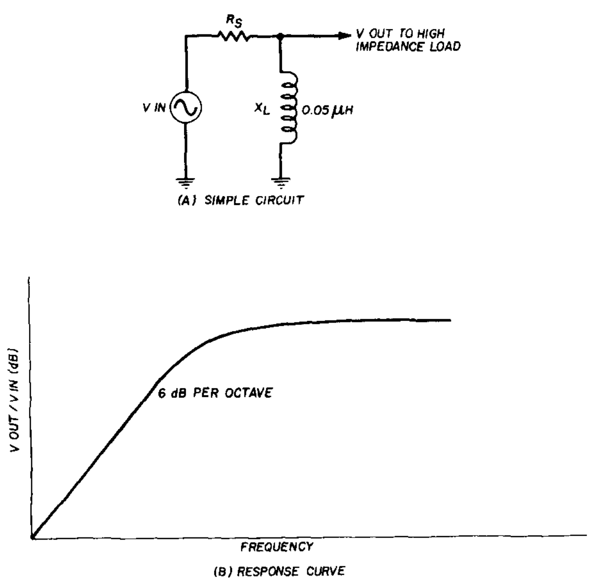

fig. 6. Simple highpass filter: *(A)* shows simple circuit; *(B)*, response curve.

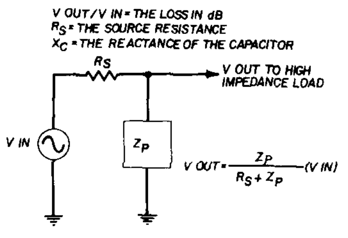

fig. 4. Voltage division rule.

upon the value of the load resistance. The equivalent circuit is shown in **fig. 10B**. The resonant circuit sees an equivalent resistance of R_s in parallel with R_L as its true load. Because this total external resistance is, by definition, smaller in value than either R_s or R_L, the loaded Q must decrease. That is, assuming lossless components,

$$Q = \frac{R_p}{X_p} \tag{5}$$

where R_p = equivalent parallel resistance of R_s and R_L

X_p = either the inductive or capacitive reactance (they are equal at resonance)

Eq. 5 illustrates that a decrease in R_p also decreases the Q of the resonant circuit and an increase in R_p increases the circuit Q. It also illustrates another very important point: the same effect can be obtained by keeping R_p constant and varying X_p. Consequently, for a given source and load impedance, the optimum Q of a resonant circuit is obtained when the inductor is a small value and the capacitor is a large value; in either case, X_p is decreased. This effect is shown in **figs. 11** and **12**.

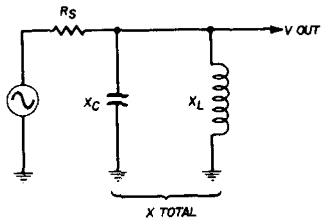

fig. 7A. Resonant circuit with two reactive components.

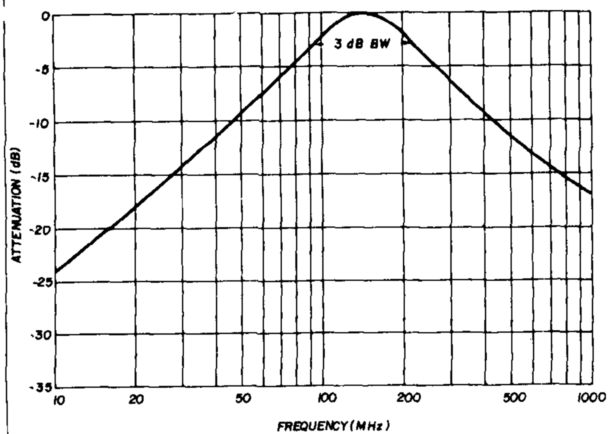

fig. 7B. Frequency response of an LC resonant circuit.

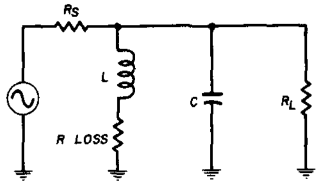

fig. 8. Circuit for loaded-Q calculations.

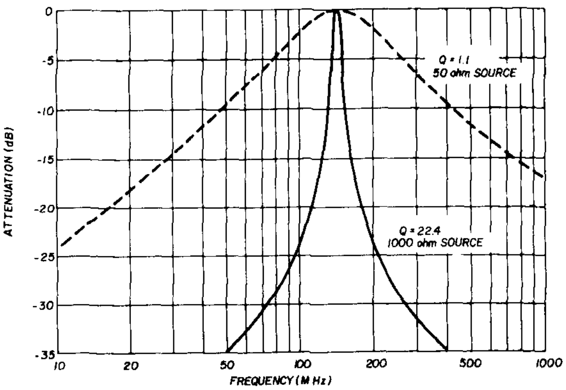

fig. 9. The effect of R_s and R_L on loaded Q.

Two possible approaches to designing a resonant circuit with a particular Q are available: selecting an optimum value of source and load impedance or selecting L and C component values which optimize Q. Often there is no real choice because in many instances the source and load are defined and cannot be varied. When this occurs, X_p is automatically defined for a given Q and we usually end up with component values that are impractical at best. Methods of eliminating this problem will be shown.

example 1

Design a resonant circuit to operate between a source resistance of 150 ohms and a load resistance of 1000 ohms. The loaded Q must be equal to 20 at the resonant frequency of 50 MHz. Assume lossless components and no impedance matching.

Solution: The effective parallel resistance across the resonant circuit is 150 ohms in parallel with 1000 ohms, or

$$R_p = 130 \text{ ohms}$$

Using **eq. 5**

$$X_p = \frac{R_p}{Q} = \frac{130}{20} = 6.5 \text{ ohms}$$

and $X_p = \omega L = \frac{1}{\omega C}$

therefore $L = 20.7\ nH$

$$C = 489.7\ pF$$

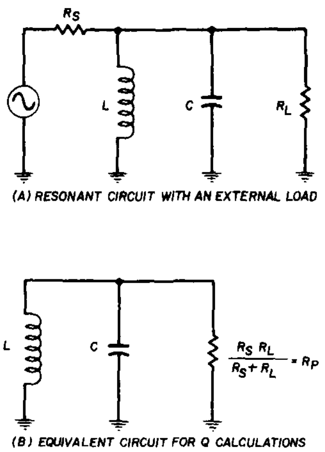

fig. 10. The equivalent parallel impedance across a resonant circuit: *(A)* shows resonant circuit with an external load; *(B)*, equivalent circuit for Q calculations.

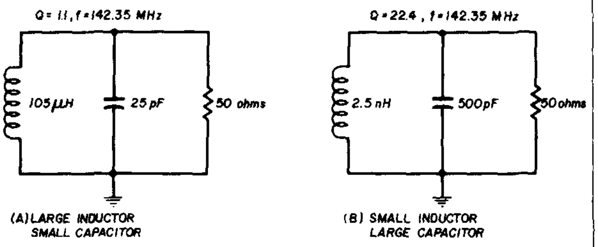

fig. 11. Effect of Q versus X at 142.35 MHz: *(A)* shows large inductor, small capacitor; *(B)*, small inductor, large capacitor.

the effect of component Q on loaded Q

Up to this point we have assumed that the components used in the resonant circuits are lossless and do not degrade the loaded Q. In reality, however, such is not the case; individual component Q's must be taken into account. In a lossless parallel resonant circuit, the impedance seen across its terminals at resonance is infinite. In a practical circuit, however, due to component losses, some finite equivalent parallel resistance exists, as shown in **fig. 13**. This resistance (R_p) and its associated shunt reactance (X_p) can be found from the following transformation equations:

$$R_p = (Q^2 + 1)\, R_s \qquad (6)$$

where R_p = equivalent parallel resistance

$Q = Q_s = Q_p =$ *component Q*

R_s = component series resistance

and

$$X_p = \frac{R_p}{Q_p} \qquad (7)$$

If the Q of the component is greater than 10, then

$$R_p \approx Q^2 R_s \qquad (8)$$

and

$$X_p \approx X_s \qquad (9)$$

These transformations are valid at only one frequency because they involve the component reactance which is frequency dependent. The following example illustrates this point.

example 2

Given the 50 nanohenry coil shown in **fig. 14A**, compute its Q at 100 MHz. Then transform the series circuit of **fig. 14A** into the equivalent parallel inductance and resistance circuit of **fig. 14B**.

Solution: The Q of this coil at 100 MHz is:

$$Q = \frac{X_s}{R_s}$$

$$= \frac{2\pi\,(100 \times 10^6)\,(50 \times 10^{-9})}{10} = 3.14$$

Since the Q is less than 10, **eq. 6** is used to find R_p.

$$R_p = (Q^2 + 1)\, R_s$$

$$= [(3.14)^2 + 1]\, 10 = 108.7 \text{ ohms}$$

Next, we find X_p using **eq. 7**.

$$X_p = \frac{R_p}{Q} = \frac{108.7}{3.14} = 34.62$$

and, the parallel inductance becomes

$$L_p = \frac{X_p}{\omega}$$

$$= \frac{34.62}{2\pi(100 \times 10^6)} = 55.1 \text{ nH}$$

These values are shown in **fig. 14B**.

Example 2 clearly illustrates the undesirable effects of using low Q components in highly selective resonant circuit designs; doing this is equivalent to placing a low value shunt resistor directly across the circuit. As we saw in an earlier section, any low-value resistance shunting a resonant circuit drastically reduces its loaded Q and increases its bandwidth.

In most cases, we only need to know the Q of the *inductor* in loaded Q calculations. The Q of most capacitors is quite high over their useful frequency range, and the equivalent shunt resistance they pre-

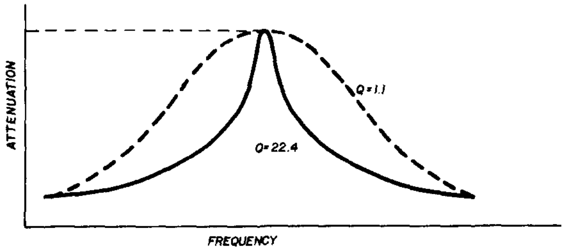

fig. 12. Plot of loaded-Q curves for circuits in *fig. 11*.

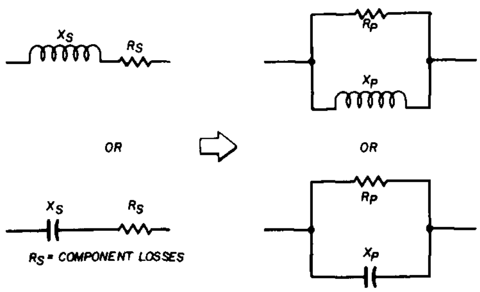

fig. 13. A series-to-parallel transformation.

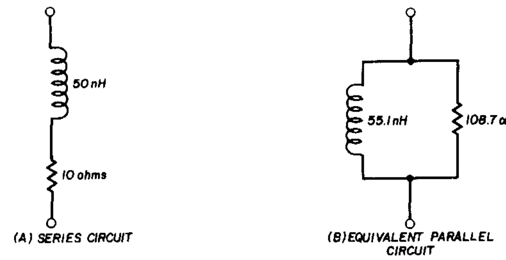

fig. 14. Example of a series-to-parallel transformation: *(A)* shows series circuit; *(B)*, shows equivalent parallel circuit.

sent to the circuit is also quite high, and can usually be neglected. Care must be taken, however, to ensure that this is indeed the case.

insertion loss and component Q

If inductors and capacitors were perfect, rather than lossy, then insertion loss for L-C resonant circuits and filters would not exist. This is, of course, not the case and as it turns out, insertion loss is a very critical parameter in the specification of any resonant circuit.

Fig. 15 illustrates the effect of inserting a resonant circuit between a source and its load of equal value. In **fig. 15A**, the source is connected directly to the load. Using voltage division, we find that

$$V_l = 0.5\ V_{in}$$

Fig. 15B shows a resonant circuit placed between the source and the load. **Fig. 15C** is the equivalent circuit at resonance. Notice that the use of an inductor with a Q of 10 at the resonant frequency is equivalent to a shunt resistance of 4500 ohms. This resistance, combined with R_L, produces a 0.9 dB voltage loss at V_l in comparison with the equivalent point in **fig. 15A**.

An insertion loss of 0.9 dB doesn't sound like much, but it can add up very quickly if several resonant circuits are cascaded. **Example 3** may help to clarify things.

example 3

Design a simple parallel resonant circuit to provide a 3 dB bandwidth of 10 MHz at a center frequency of 100 MHz. The source and load impedances are each 1000 ohms. Assume the capacitor to be lossless. The Q of the available inductor is 85. What is the insertion loss off the network?

Solution: From **eq. 1** the required loaded Q of the resonant circuit is:

$$Q = \frac{f_c}{f_2 - f_l} = \frac{100\ MHz}{10\ MHz} = 10$$

To find the inductor and capacitor values to complete the design requires that we know the equivalent shunt resistance and reactance of the components at resonance.
From **eq. 7**

$$X_p = \frac{R_p}{Q_p}$$

where X_p = reactance of the inductor and capacitor at resonance
R_p = equivalent shunt resistance of the inductor
Q_p = Q of the inductor = 85

Thus $R_p = 85X_p$ **(10)**

The loaded Q of the resonant circuit is equal to

$$Q = 10 = \frac{R_{TOTAL}}{X_p}$$

where R_{TOTAL} = shunt resistance
$= R_p || R_s || R_L$
(three parallel values: R_p, R_s and R_L)

or $$Q = 10 = \frac{\frac{R_p(500)}{R_p + 500}}{X_p} \quad \textbf{(11)}$$

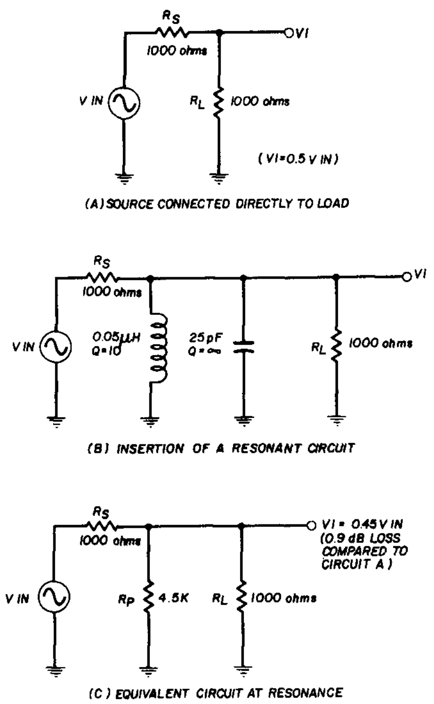

fig. 15. The effect of component Q on insertion loss: *(A)* shows source connected directly to the load; *(B)*, insertion of a resonant circuit; *(C)*, equivalent circuit at resonance.

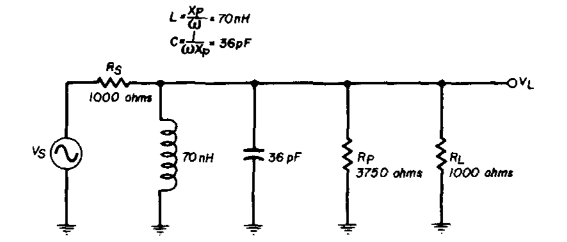

fig. 16. Resonant circuit design illustrates example 3.

We now have two equations and two unknowns (X_p, R_p). If **eq. 10** is substituted into **eq. 11**

$$X_p = 44.1 \text{ ohms}$$

Plugging this value back into **eq. 10** gives

$$R_p = 3.75 \text{ K}$$

Thus, our component values are

$$L = \frac{X_p}{\omega} = 70 \text{ nH}$$

$$C = \frac{1}{\omega X_p} = 36 \text{ pF}$$

and the final circuit is shown in **fig. 16**.

The insertion loss calculation, at center frequency, is found by applying the voltage division rule as follows: R_p in parallel with R_L is equal to 789.5 ohms. The voltage at V_L is, therefore

$$V_L = \frac{789.5}{789.5 + 1000}(V_s)$$

The voltage at V_L without the resonant circuit in place is equal to $0.5\ V_s$ due to the 1000 ohm load giving

$$\text{insertion loss} = 20 \log_{10} \frac{0.44\ V_s}{0.5\ V_s}$$

$$= 1.1 \text{ dB}$$

impedance transformation

As we have seen, low values of source and load impedance tend to load a given resonant circuit down and thus decrease its Q and increase its bandwidth. This makes it very difficult to design a simple L-C high-Q resonant circuit for use between two very low values of source and load resistance. In fact, even if we were able to come up with a design on paper, it would most likely be impossible to build such a circuit because of the extremely small (or negative) inductor values that would be required.

One method of circumventing this problem is to make use of one of the impedance transforming circuits shown in **fig. 17**. These circuits increase the value of the source or load resistance presented to the resonant circuit. For example, an impedance transformer could present an impedance (R_s') of 500 ohms to the resonant circuit, when in reality we have an R_s of 50 ohms. By using transformers, the Q of the resonant tank and its selectivity can be increased. In many cases these methods can make a previously unworkable problem workable again, complete with realistic values for the coils and capacitors involved.

The design equations for each of the transformers are presented below and are useful for designs needing loaded Qs of greater than 10. For the tapped-C transformer (**fig. 17A**)

$$R_s' = R_s \left(1 + \frac{C1}{C2}\right)^2 \quad \textbf{(12)}$$

And the equivalent capacitance (C_T) that will resonate with the inductor is equal to $C1$ in series with $C2$ or

$$C_T = \frac{C1C2}{C1 + C2} \quad \textbf{(13)}$$

For the tapped-L network of **fig. 17B**

$$R_s' = R_s \left(\frac{n}{n_1}\right)^2 \quad \textbf{(14)}$$

Example 4 illustrates the use of these equations in a simple design.

example 4

Design a resonant circuit with a loaded Q of 20 at a center frequency of 100 MHz which will operate between a source resistance of 50 ohms and a load resistance of 2000 ohms. Use the tapped C approach and assume that the inductor Q is 100 at 100 MHz.

Solution: The tapped-C transformer is used to step the source resistance up to 2000 ohms to match the load resistance for optimum power transfer,

$$R_s' = 2000 \text{ ohms}$$

and from **eq. 12**, we have

$$\frac{C_1}{C_2} = \sqrt{\frac{R_s'}{R_s}} - 1$$

or $$C1 = 5.3\ C2 \quad \textbf{(15)}$$

Proceeding as we did in **example 3**, we know that for the inductor

$$Q_p = \frac{R_p}{X_p} = 100$$

therefore

$$R_p = 100\ X_p \quad \textbf{(16)}$$

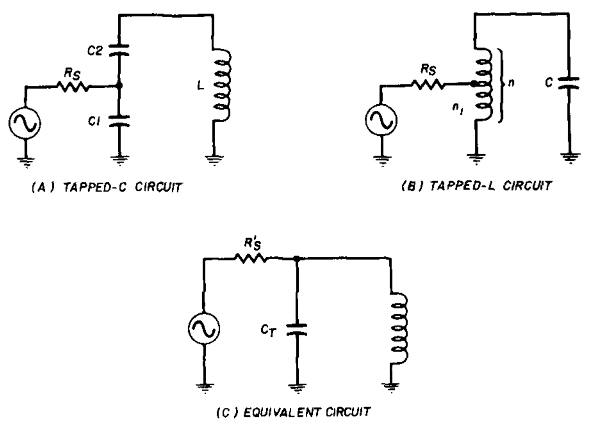

fig. 17. Two methods used to perform an impedance transformation: *(A)* shows tapped-C circuit; *(B)*, tapped-L circuit. *(C)* shows equivalent circuit.

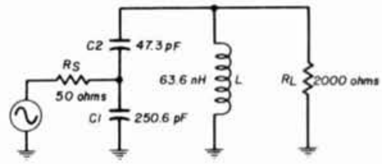

fig. 18. Final impedance transformation circuit.

We also know that the loaded Q of the resonant circuit is equal to

$$Q = \frac{R_{TOTAL}}{X_p}$$

where R_{TOTAL} = *total equivalent shunt resistance* $= R_s' || R_p || R_L = 1000 || R_p$

and where we have taken R_s' and R_L to each be 2000 ohms in parallel.

Hence the loaded Q is

$$Q = \frac{1000 R_p}{(1000 + R_p)\, X_p} \tag{17}$$

Substituting **eq. 16** into **eq. 17** and solving for X_p yields

$$X_p = 40 \text{ ohms}$$

And substituting this result back into **eq. 16** gives

$$R_p = 4000 \text{ ohms}$$

and

$$L = \frac{X_p}{\omega} = 63.6 \text{ nH}$$

$$C_T = \frac{1}{X_p \omega} = 39.78 \text{ pF}$$

We now know what the total capacitance must be to resonate with inductor. We also know from **eq. 15** that $C1$ is 5.3 times larger than $C2$. Thus, if we substitute **eq. 15** into **eq. 13** and simultaneously solve the equations we get

$$C2 = 47.3 \text{ pF}$$
$$C1 = 250.6 \text{ pF}$$

The final circuit is shown in **fig. 18**.

As an exercise, you might want to rework **example 4** without the aid of an impedance transformer. You will find that the inductor value which results is much more difficult to obtain and control physically because it is so small.

conclusion

The parallel resonant circuit, as simple as it may seem, certainly offers quite a lot to think about. We've discovered why good quality, high-Q, components are desirable in any low-loss, narrowband, tuned circuit, and why lossy components (low-Q components) increase insertion loss and broaden the bandwidth of the circuit. We've also discovered the effects of source and load impedances on the loaded Q of the resonant circuit. More importantly, however, by understanding these effects we have mastered a method of controlling them through the use of impedance transformers.

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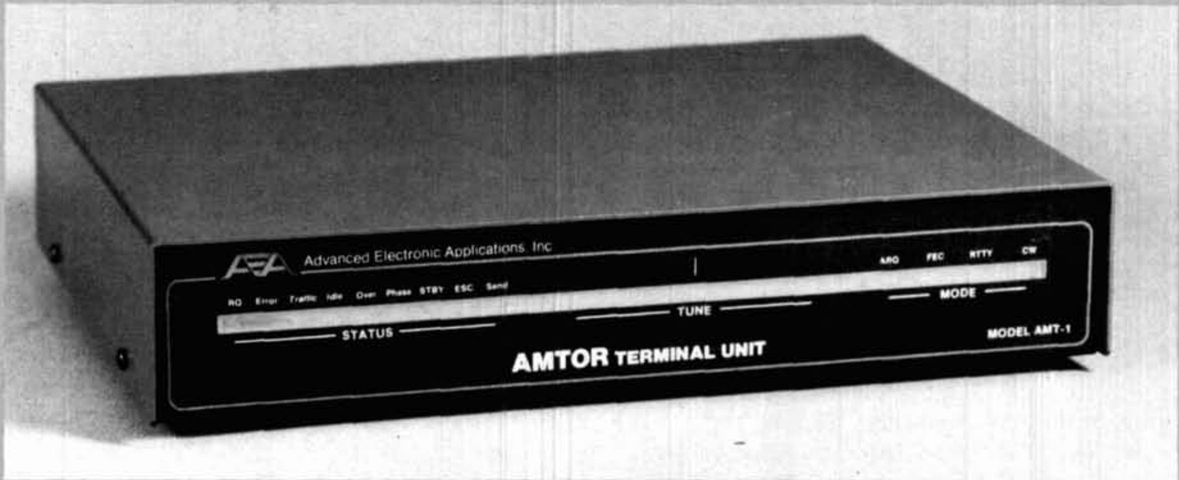

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Experiment with light build an inexpensive homebrew spectroscope

The history of Amateur and commercial radio, has been marked by the use of ever-increasing frequencies. Each era has seen applications found for the previously useless short wavelengths. With the introduction of lasers, communication in the optical frequency band is becoming attractive. Long distance fiber optic links use semiconductor laser diodes to achieve bandwidths up to several Gigahertz. Amateurs have communicated using gas and semiconductor lasers over moderate paths, and as the price of lasers continues to decline, more and more applications will be found — particularly by Amateurs in their role as experimenters and innovators in communications technology. But lasers are not the only usable source of light. Incandescent lamps, fluorescent lamps and especially light emitting diodes can and will continue to be used to transmit data.

basic spectrum analyzer

Most people do not consider light to be in the same class of phenomena as radio signals; after all, one cannot *see* radio, television, or radar waves. However, light is, in fact, actually extremely high frequency *radio* waves. Red light has a wavelength of about 600 nanometers (1 nanometer equals 10^{-9} meter), about 130 million times shorter than an 80-meter signal. Blue light has a wavelength of about 400 nanometers. The Amateur Radio high frequency bands span from 10 meters to 80 meters, a ratio of 1:8. The visible spectrum extends from about 400 nm to 650 nm, a ratio of 1:1.6.

Most people know that white light is made up of many colors or wavelengths. If we could see radio signals, the myriads of different wavelengths would appear white. But just as radio signals can be separated according to wavelength using narrow filters — i.e., radio receivers — white light can be separated by optical filters. To determine the strength of each wavelength present in a radio band, a spectrum analyzer — generally in the form of a rapidly tunable receiver that scans the wavelength or frequency band and displays its output on an oscilloscope — is used. To determine the wavelength or frequency of a segment of the visible spectrum, an optical spectrum analyzer is used.

Complex, high-resolution optical spectrum analyzers, or spectroscopes, spectrographs, or monochrometers, can be built using film or high gain electronic detectors. But low-resolution optical spectrum analyzers can be built more cheaply and more simply than either radio frequency spectrum analyzers or sophisticated electronic optical analyzers because the human eye can serve as the detector.

The simplest spectroscope is the prism. Newton is known for his work with these: he was the first to apply the word "spectrum" to the band of colors produced by the prism.

Some of Newton's experiments can be duplicated at home. For example, you can demonstrate the separation of white light into colors by building the simple low-resolution system shown in **fig. 1.** First make a small hole (1/16 to 1/8 inch) in a sheet of dark, opaque paper or thin sheet metal. Prop the sheet up against a sunny window, blocking out all light except that which escapes through the hole. Hold a prism about three feet (one meter) from the hole, and a spectrum will appear on the white card as shown. While the colors produced by this system appear to be continuous — red, orange, yellow, green, blue, indigo, violet — dark, narrow gaps can be detected with higher resolution.

By J.M. Franke, WA4WDL, 1310 Bolling Avenue, Norfolk, Virginia 23508

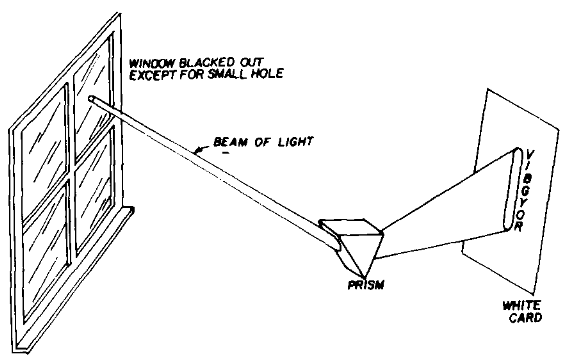

fig. 1. Repeating Newton's experiment with the first optical spectrum analyzer.

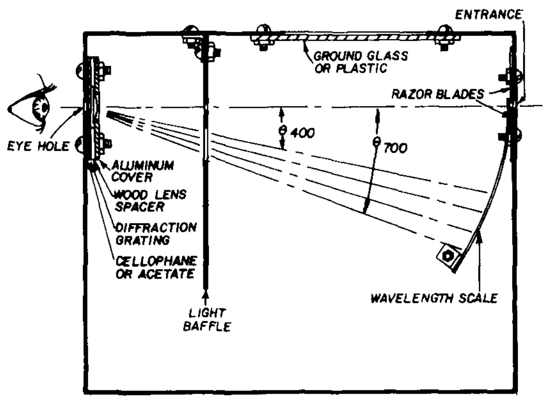

fig. 2. Mechanical illustration of an optical spectrum analyzer.

A higher resolution spectroscope, with a calibrated scale, can be built for less than ten dollars. The design that follows is neither unique nor critical; it works extremely well — considering the cost — and should provide hours of interesting observation. The layout of the spectroscope is shown in **fig. 2**.

design approach

The first thing you may notice is the absence of a prism. A diffraction grating is used instead, because the grating is cheaper than a prism and more easily calibrated. The transmission type grating is made with many finely spaced grooves — 13,400 lines per inch, or 528 per millimeter. (A good microscope would be needed in order to see the grooves.) The grating is available from Edmund Scientific,* in two forms, sheets or slides. The sheets (No. E40267) measure 8-1/2 inches × 11 inches (22 × 28 cm) and sell for $4.95. The slides are small pieces cut from sheets and mounted in 35 mm slide mounts (No. E30282) at $8.50 for 40 slides. The slides are convenient to handle, but I prefer the sheets because of their increased versatility. (A word of caution, however: don't touch, brush, or attempt to clean the delicate grating surface; you'll destroy it.)

construction

Next to the grating is the lens, which should have a focal length equal to or slightly longer than the box you use. The lens serves to collimate, or yield parallel, the light incident on the grating from the entrance slit, which is one focal length or slightly less from the lens. In this position, the slit is imaged to be at or near infinity.

I used a BUD-AU1209 box measuring 6 × 5 × 4 inches (15 × 12.5 × 10 cm); my lens had a focal length of 6 inches (15 cm). The lens should be at least 1/4 inch (1 cm) in diameter. Mine measured 1/2 inch (2 cm). A simple plano-convex, flat-bulged lens works well. (An achromat would be wasted in this application.) Suitable lenses are available from Edmund Scientific. The lens is clamped against the eye hole wall. Then a thin piece of cellophane or acetate is placed against that wall, followed by the grating and two paper spacers. The lens is positioned next, with its curved side facing the slit, a wooden spacer set around the lens, and finally the aluminum plate clamp. (The assembly is held in place with two No. 6 sheet metal screws.)

The eyepiece hole measures 1/8 inch (4 mm) in diameter. A larger hole would produce a brighter image, but parallax with the scale would increase. A horizontal slot 1/8 inch × 1/4 inch (4 × 8 mm) would be best. The spectrum is sighted through the eye hole. Looking straight through, the zero order or direct light is seen. Looking downward through the hole, the spectrum will be seen superimposed on the wavelength scale.

The entrance slit is formed with two razor blades. I used single edge industrial blades with the reinforcing splines removed. Each of the blades is held in place with a No. 4 screw, nut, and washer. The slit *must* be horizontal for this design. The slit height (called "slit width," even when the slit is actually horizontal) is a compromise between image brightness and resolution: the wider the slit, the brighter the image. The effective length of the slit is determined by the 1/4 inch entrance hole. Mount the upper blade first. Then, looking through the eye hole, point the spectroscope at the sky or a shaded lamp. Mount and adjust the lower blade to produce a thin, horizontal, even line of light.

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table 1. Values of the angle θ and its sine value throughout the visible light spectrum.

wavelength (nanometers)	θ	sinθ
400	12.18	0.211
450	13.73	0.237
500	15.30	0.264
550	16.87	0.290
600	18.46	0.317
650	20.06	0.343
700	21.67	0.369

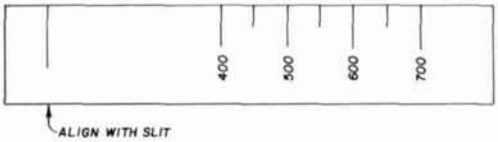


fig. 3. Wavelength scale pattern (not to scale). Actual size will depend on focal length of lens (see text).

Then tighten the lower screw. You can experiment with the slit width after you become accustomed to using the instrument.

calibration

The wavelength scale is easily made and calibrated. Unlike a prism, the dispersion of a grating is given by a simple formula:

$$n\lambda = d \sin \theta \quad (1)$$

where n is the spectral order, in our case 1, and λ is the incident wavelength. The grating line spacing is d and the angle at which you must look down through the eye hole to see that wavelength is θ.

Rewriting, $\sin \theta = \frac{\lambda}{d} = 0.0005276\,\lambda$ (in nanometers). **Table 1** is a listing of values of θ and $\sin \theta$ for the visible spectrum from 400 nm to 700 nm. The wavelength scale is based on this table. The scale is made on a piece of white paper pasted on an aluminum strip bent into an arc. The center of the arc is the eye hole. The arc radius is the distance from the lens to the scale, about 5.8 inches (14.5 cm) in my model. Laying out the scale is not difficult. First the linear distance along the scale that represents one degree must be determined. I call this number "L."

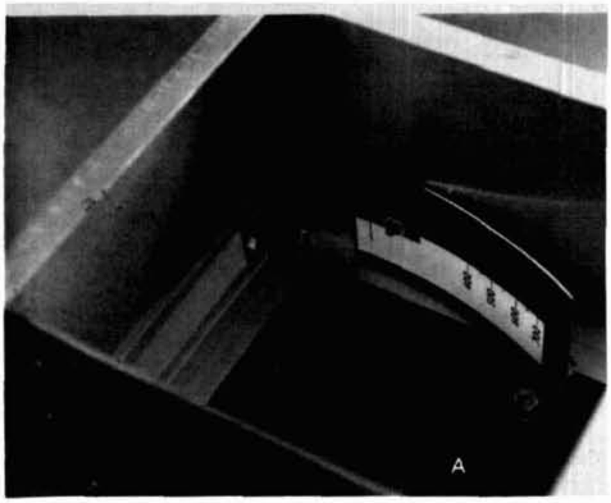
$$L = \frac{2\pi r}{360} \quad (2)$$

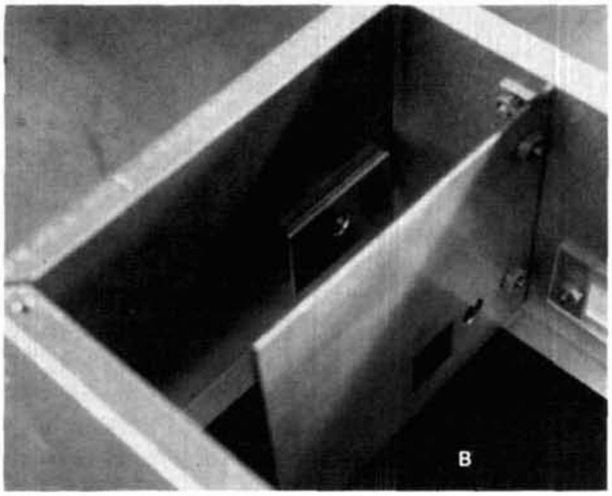
where r is the arc radius.

The scale mark for 400 nm should be 12.18 degrees from the slit position. Mark the slit position, measure out L × 12.18 inches, and then mark and label the 400 nm line. Similarly multilply each value of θ by L, measure out from the slit position, then mark and label the point. The scale is held in place with an angle bracket. The zero or slit position is aligned with the slit. A rectangular hole on the top of the instrument admits light to illuminate the scale. A ground glass or ground plastic sheet diffuses the illumination to smooth it out and reduce glare. A light baffle prevents the illuminating light from reaching the eye hole directly. The baffle and entire interior is painted flat black. (Obviously, the slit blades, scales, lens, and grating should not be painted.)

Few dimensions are shown in **fig. 2** because your final dimensions will depend on the focal length of your lens and the size of the box. I recommend breadboarding the instrument before final construction.

Once assembled, the spectroscope is ready for final alignment and use. Only two parts should need adjust-





Interior view *(A)* shows razor blade slit and wavelength scale. Note ground plastic scale light diffuser at left. View *(B)* shows light baffle and lens mounting arrangement.

ment: the slit, which should be horizontal and narrow, as previously mentioned, and the grating, which must be rotated so that the grooves are parallel to the slit. This is done by pointing the instrument at a nearby unshaded lamp and rotating the grating until the spectrum is perpendicular to the slit and falls on the wavelength scale.

applications

The spectrum produced by an incandescent lamp is called a continuum because it is continuous from the infrared to the ultraviolet wavelengths; watch what happens when you place cellophane or colored glass filters in front of the slit. Discharge lamps such as neon bulbs and ornamental signs produce line spectra — that is, they emit most of their energy on discrete narrow wavelengths which appear as thin lines in a spectroscope. Try looking at a distant mercury or sodium street lamp with this instrument.

While **the sun should never be observed directly** (irreversible eye damage may result), the slit width can be reduced greatly and sunlight *reflected* from a distant object — a car, for example — may be observed to produce a continuous spectrum crossed with thin, dark horizontal lines caused by absorption by gases in the solar and earth atmospheres. If the same gases were ionized, bright emission lines would be seen instead.

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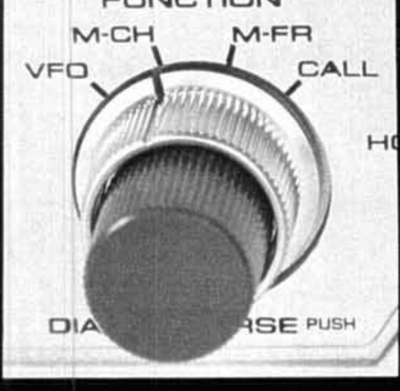

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graphic filter design

Response to pulse or steady state signals determines design approach

What would you say if I were to claim that the main burst of sound resulting from hitting a bell with its striker is not "ringing?"

I don't want to hear it.

But that statement would indeed be true if the definition of "ringing" as used by most texts on electronic filter design were applied to a church bell, because what happens when a bell is struck is analogous to what happens when a noise pulse rips into an electronic filter.

It would appear that those who wrote about video pulse amplifiers years ago defined ringing in a peculiar way which then became extended, by word of mouth, to apply to bandpass filters. As a consequence, "flat-top," or Butterworth filters acquired a bad reputation[1]; at the very least, exaggerated benefits for "round top," or Gaussian filters, were implied. Soon the general notion was that flat-top filters ring and round-top filters do not.

In fact, this happens to be true — *but only in the case of low-pass filters driven by a video pulse.*

All band-pass filters "ring," but there are important differences. Assuming equal bandwidths, number of poles, and a unit impulse excitation (much like a sharp noise pulse in our communications systems), a round-top filter will ring with a higher peak amplitude but for a shorter time than a flat-top filter. And a flat-top filter not only rings, but also undulates, which corresponds to what is called "ringing" in lowpass filters. The basic ringing frequency is at or near the filter's center frequency; the undulation frequency is proportional to one-half of the filter bandwidth. In exchange for this ringing difference, the flat-top design provides steeper skirts with slightly more difficult design requirements. **Fig. 1** provides a general picture showing several filter forms with their response to impulse noise and steady-state frequency responses for comparison.

It seems to me that the criteria for whether or not a filter's ringing (or ringing plus undulation) characteristic is a problem should be based upon the real signal environment and how the signals are detected. Clearly a laboratory instrument may well utilize an 8-pole Butterworth with a 10 Hz bandwidth in the metric evaluation of noise-free steady state signals. But that same filter would be useless to those of us who wish to copy CW with our

By Don E. Hildreth, W6NRW, P.O. Box 60003, Sunnyvale, California 94068

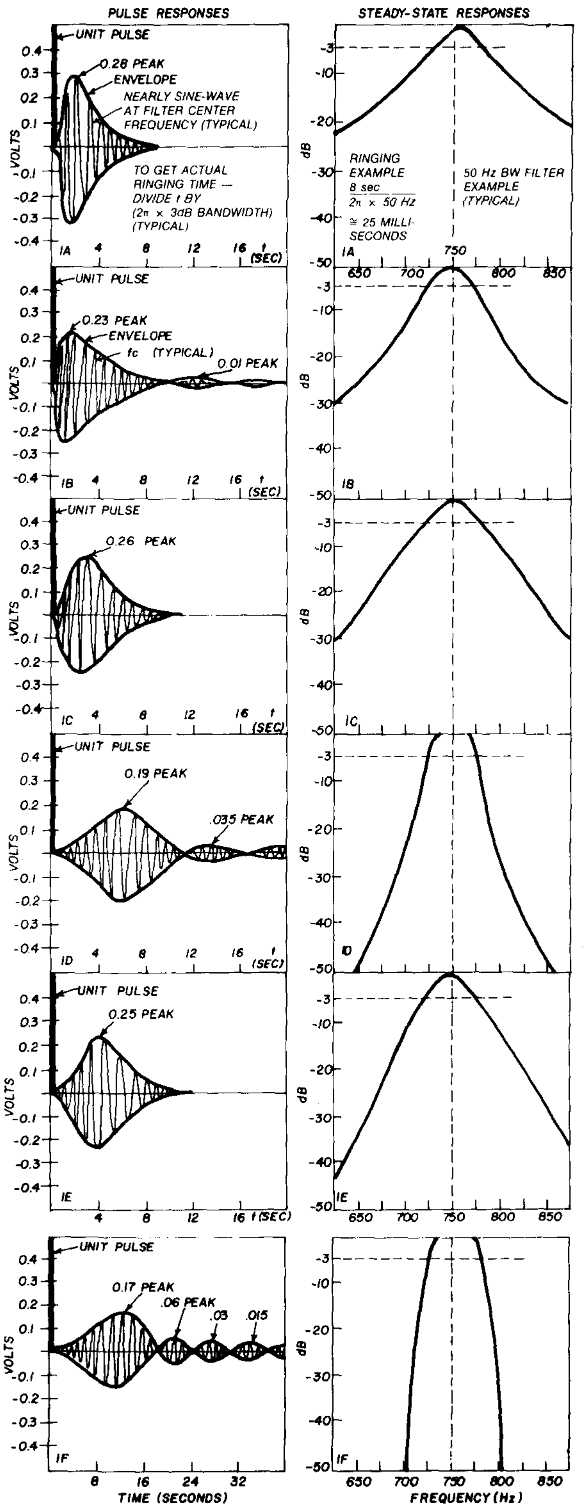

fig. 1. Pulse and steady-state filter response is compared for Gaussian and Butterworth types: ***(A)*** **2-pole Gaussian;** ***(B)*** **2-pole Butterworth;** ***(C)*** **4-pole Gaussian;** ***(D)*** **4-pole Butterworth;** ***(E)*** **8-pole Gaussian; and** ***(F)*** **8-pole Butterworth.**

table 1. Multiplication factor showing stage bandwidth increase necessary when cascading a number of stages to arrive at a required system bandwidth.

number of poles	stage BW multi-plication factor
2	1.56
3	1.96
4	2.30
5	2.58
6	2.86
7	3.10
8	3.32

logarithmic hearing response and a signal environment that almost always contains a train of randomly spaced noise pulses both from natural and manmade sources. Because of this, we are forced to apply nearly equal weight to a filter's impulse and steady-state characteristics in our receiver designs.

Fig. 1D illustrates an example using the data on ringing. For a 100 Hz bandwidth design, the main ringing response to a noise pulse would rise and fall in about 13 milliseconds. If you include the time for the second undulation, which is around 16 dB below the main energy bundle, the duration would be 26 milliseconds.

To determine how this may affect CW signal copy, consider that the length of a CW "dit" at 20 WPM is approximately 50 milliseconds. Because in my experience it seems that the human brain is able to ignore energy bursts lasting for fifty pecent or less of the time duration of the basic dit element, this filter appears generally acceptable.

In addition to ringing time, a filter creates a time delay and an increase in rise time (the rate at which the ringing builds up). This provides a secondary benefit in that the clicks and pops of impulse noise and/or key clicks are softened. Consequently, a total rise and fall time of ten milliseconds or more is satisfactory[1] and a lot easier on your ears.

For wide filters such as an 8-pole Butterworth with a nominal 3 kHz bandwidth, the ringing time — even including the third undulation — is only 1.5 milliseconds. While a frequently used IF filter of this type will not confuse CW copy with its ringing, it will not soften those signals that have key clicks.

using multi-pole filters

In general, there are two ways to design multi-pole filters: the ladder, or lattice network method, and the direct synthesis method, in which each pole is isolated. RF and IF filters usually use the first type; audio filters using op-amp active filter elements use the second. In the method using active filters, each op-amp circuit

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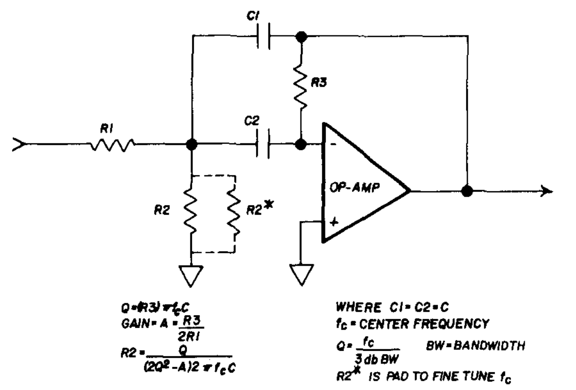

fig. 2. Typical bandpass active filter circuit and design equations.

represents one pole (actually a complex conjugate pole-pair, but since our filter designs are derived by transforming lowpass prototypes, the pair is referred to as one pole) and the very low output impedance of the op-amp provides isolation between it and the following stage. Using the basic active filter design of **fig. 2**, just cascade these circuits together with each one tuned to a required frequency and Q to get just about any function you want within the gain-bandwidth limitations of the selected op-amp. Using this basic building block, design examples are given for Gaussian and Butterworth filter types.

Gaussian filters

Round-top filters, usually implemented by the synchronous tuning of a number of stages, are a member of the Gaussian class. Although relatively easy to design, they have one peculiarity that reduces their popularity: as you add poles you must also increase the bandwidth of each stage to obtain a given bandwidth. As a result, ringing time increases *very little* as stages are added, and the filter system skirts do not fall as fast with added stages as they do with the Butterworth class. To design a multi-pole filter of this type you first decide the system bandwidth you want then determine what the bandwidth of each stage must be from **table 1**, or

$$BW stage = BW system/(2^{1/n} - 1)^{1/2} \qquad \textbf{(1)}$$

where n = number of stages.

For example, if a 4-pole round-top filter with 3 dB points of 700 and 800 Hz is needed, then the design center frequency is $(700 \times 800)^{1/2} = 748.33\ Hz$ and the bandwidth of each stage is $100 \times 2.30 = 230\,Hz$ for a design Q of 3.25. Since each stage is tuned to the same frequency, the gain through the filter is the product of the stage gains. Knowing these requirements, the general equations in **fig. 2** can be used to find component requirements for each of four identical stages.

Butterworth filters

To obtain the flat-top Butterworth response, the center frequency and Q of each stage used is different. However, the geometric pattern used to determine requirements is simple, symmetrical and easy to remember and apply. An example of the initial step in designing a 2-pole filter with a 50 Hz 3 dB bandwidth (725 Hz to 775 Hz) is shown in **fig. 3A**. In this case the semicircle end points represent the 725 Hz and 775 Hz 3 dB points of the final response with the poles located symmetrically and separated by 180 degrees/number of poles. Subordinate semicircles complete the design as illustrated in **fig. 3B**, which enables you to determine the center frequency and bandwidths for both stages as shown. Transient and steady-state responses for this filter are shown in **fig. 1B. Fig. 4** shows the pattern for three, four, and eight poles. From this basic pattern, the design for any number of poles follows. Also as the number of poles increases, some of the resulting Qs become quite large, with steeper skirts *and* increased undulation. These patterns are normally plotted on a linear, or undefined, scale in a number of texts. This linear construction scale assumes arithmetical symmetry, which is a reasonable approximation only when the bandwidth is less than 10 percent or so of the center frequency. To show how to handle these designs for larger percentage bandwidths,

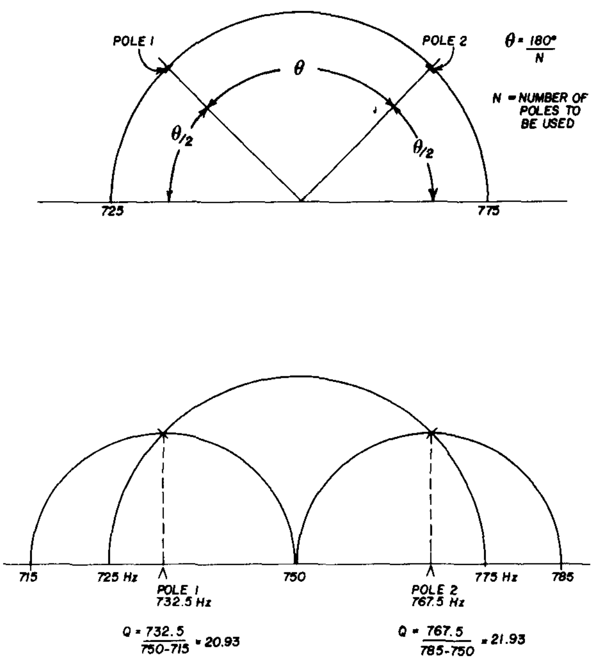

fig. 3. Design sequence to obtain required center frequency and Q for each pole of a maximally flat 2-pole Butterworth filter centered at 750 Hz with 3 dB points at 725 and 775 Hz.

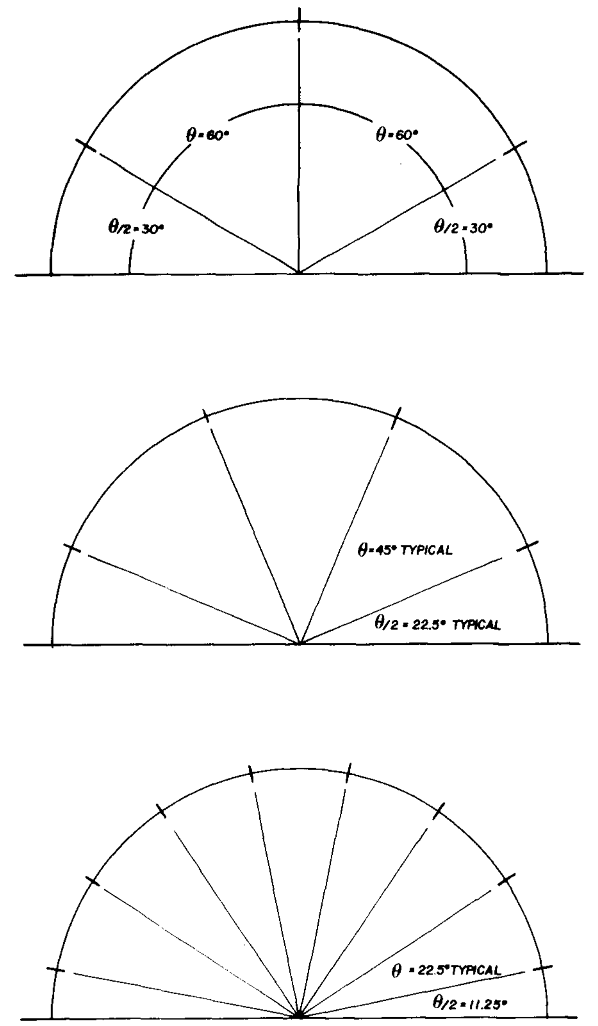

fig. 4. Pole patterns for 3, 4, and 8-pole Butterworth filters.

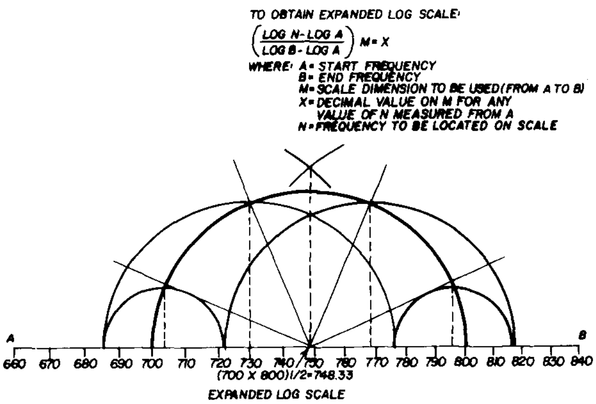

fig. 5. Exact flat 4-pole Butterworth with 3 dB bandwidth from 700 to 800 Hz.

refer to the four-pole example in **fig. 5**. In this figure the only thing that has been changed is the baseline. The physical construction is the same, but by using a log scale the true geometric symmetry of electronic filter circuits becomes apparent resulting in a more accurate design. Clearly, if you design each stage for a gain of 1 there will be some attenuation through this filter type because of the "stagger" tuning. And although it may seem odd, the particular gain of each stage and the order in which they are arranged has no effect on the system frequency response. However, as a practical matter, to avoid a possible reduction in dynamic range, put the low Q stages first with a gain of 1 or so and then design some gain into the latter stages to offset the system loss, if desired. **Fig. 6** shows a complete 4-stage design for both a round-top and a flat-top filter.

active filter component considerations

Using the circuit of **fig. 2** as a reference, the value for R1 *is not critical*, provided it is at least four or five times the resistance of R2. This is usually the case unless you try to obtain a lot of gain with your filters. However, R2, R3, C1 and C2 directly influence the filter stage's center frequency, which is of prime importance. Q, which is the second important parameter, is determined by R3, C1 and C2 — assuming that R2 is adjusted to obtain the design frequency. It is preferable to select the magnitude of C to force R3 to be less than 1 megohm for the required Q to avoid potential problems caused by input currrent of an op-amp. If you intend to build the filter without testing and tuning it, the capacitors should be accurate to ±1 percent or better, within the temperature range in which most ham equipment is used.

NPO ceramic, mica, or polystyrene capacitors are excellent, but expensive and hard to find. I have had good results for typical ham shack environments using mylar-film capacitors, which are reasonably priced and available in ±1 percent units.

While carbon composition resistors can be employed, they are difficult to use because they tend to experience semi-permanent value shifts when temperature-cycled by a soldering iron and also over time. Data on carbon-film resistors indicates that they are about ten times better in this respect; ±1 percent metal-film resistors are better yet. I use carbon-film, ±5 percent, 1/4 watt resistors and mylar-film capacitors for filters with greater than 50 percent bandwidths and switch to metal-film resistors for narrow multi-pole CW filters.

Integrated circuits such as the 741 op-amp are abundant and inexpensive. There are a multitude of others, all with a nominal open-loop gain-bandwidth product of 1 MHz. With these units, if your active filter stages are designed to have a gain-bandwidth product of less than 1 kHz and an upper frequency limit of 5 kHz or so, you can just forget the op-amp's characteristics when designing the filter. This is assumed in the equations of **fig. 2**. With more exotic op-amps, of course, you can increase the numbers. In addition, if a resistance with the same magnitude as R3 is included at the op-amp's plus input for bias balance, place a large capacitance from the + terminal to ground to avoid high levels of bias current generated noise voltage across this resistor.

tuning active filters

If you stay within the given op-amp constraints, you can be quite confident of a 10 percent or larger bandwidth design when 1 percent components are used — even without testing. However, if components of this accuracy are not available, you will probably need a signal generator, frequency counter, output indicator and a few components.

Since most active audio filters for CW or SSB will use *Q*s of 5 or less, setting them on center frequency by simply using a signal generator at the input to the filter with a level indicator at the output just isn't practical. The filter will be too broad to enable an accurate adjustment of a frequency tweaking pad on R2. One easy way around this, however, is to take advantage of the fact that the phase slope through the filter is quite sharp and at 180 degrees. Knowing this you can add an op-amp summer as shown in **fig. 7**. With the signal generator set on frequency, and the filter close to its final settings, you adjust the null detector for a minimum indication with the amplitude balance pot, R, then adjust the phase control (frequency) pad across R2 on the filter for a better null. Going back and forth a few times with this technique can set your filter on frequency to an accuracy of ±0.1 percent or so.

To assure this accuracy, it is better to fabricate the filter on one day and tune on the next to let the components settle after exposure to soldering temperatures. After you find the required padding resistance, you can then solder in the nearest 5 percent value. Assuming the pad is much larger than the resistor it parallels, it is possible to arrive at 1 percent or better in final frequency adjustment.

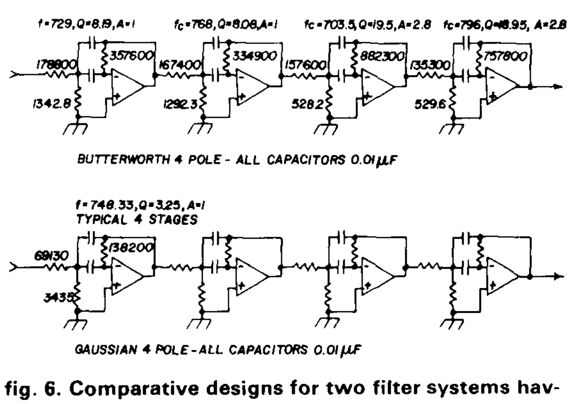

fig. 6. Comparative designs for two filter systems having 3 dB bandwidths from 700 to 800 Hz with unity system gains.

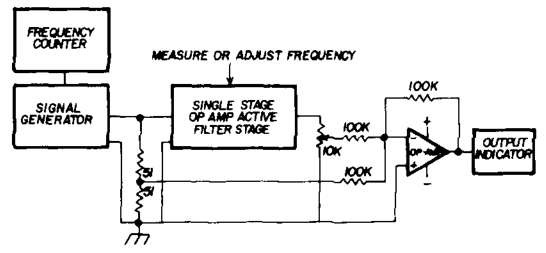

fig. 7. Null-balanced method for accurate determination of filter center frequency.

Because of the excellent isolation afforded by an op-amp active filter, you just tune each stage independently, then string them together. If you have been accurate with your graph work and calculations, chances are excellent that you will have exactly what you want.

summary

After considering the relative advantages and disadvantages of these two basic filter classes, you probably wish there were some way to get the best of both. I haven't been able to find it, but there is a reasonable compromise that performs well: cascaded Butterworth staggered pairs. Study of the undulation magnitude for the 2-pole Butterworth class shows it to be quite small, which makes the cascading of staggered 2-pole sections attractive. I have used this technique for several years[2] and have found it to be very satisfactory.

Be careful, however, about the apparent simplicity of the synchronously tuned filter type. Lower *Q*s in this case do not mean that you can settle for less accuracy. If you are not careful with this filter, you may wind up with an unplanned stagger — complete with undulation ringing.

references

1. Doug DeMaw, W1FB and Wes Hayward, W7ZOI, "Modern Receivers and Transceivers: What Ails Them?" *QST*, January, 1983, page 11.
2. Don E. Hildreth, W6NRW, "Communications Audio Processor for Reception," *ham radio*, January, 1980, page 71.

Notes:

1. *Statements about Butterworth also apply to Chebyshev — only more so.*
2. PC board and filter parts kit are available from Hildreth Engineering, P.O. Box 60003, Sunnyvale, California 94088. For computer programs listed in Basic for quick and accurate design of filter blocks shown in **fig. 2**, and to calculate expanded log scales as used in **fig. 5**, send $2.00 to cover reproduction, postage, and handling to Hildreth Engineering at the address above.
3. Mouser Electronics at 11433 Woodside Ave., Santee, California 92071, 619-449-2222, is one source of components. (Write or call for catalog.)

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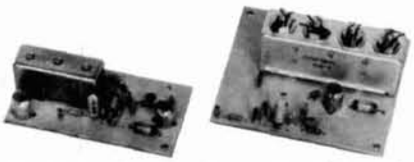

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Wired $69	144-146	28-30
	145-147	28-30
	144-144.4	27-27.4
	146-148	28-30
	144-148	50-54
	220-222	28-30
	220-224	144-148
	222-226	144-148
	220-224	50-54
	222-224	28-30
UHF MODELS	432-434	28-30
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Model XV2	28-29	145-146
Kit $79	28-30	50-52
Wired $149	27-27.4	144-144.4
(Specify band)	28-30	220-222*
	50-54	220-224
	144-146	50-52
	50-54	144-148
	144-146	28-30
For UHF,	28-30	432-434
Model XV4	28-30	435-437
Kit $99	50-54	432-436
Wired $169	61.25	439.25
	144-148	432-436*

*Add $20 for 2M input

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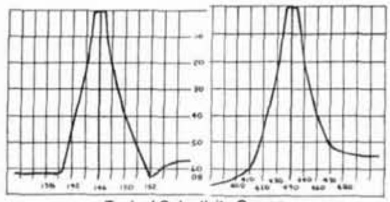

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Save hours of tedious winding with pre-wound high-voltage coil

The power transformer for my old 5-inch oscilloscope failed recently, leaving me with the problem of how to generate the 800 to 1000 VDC needed for the CRT.

The old transformer used a high-voltage winding with output rectified by a 1V2 tube. My junk box yielded a power transformer that was capable of supplying the heater and low-voltage needs, but had no high-voltage winding. I considered taking it apart and winding on many more turns of No. 36 wire for high voltage, but finally decided there had to be an easier way.

Since switching power supplies are in vogue these days, I designed the circuit in **fig. 1**, using the popular 88 mH toroid coil that is readily available and inexpensive. The beauty of this approach is that all the tedious work — winding the high-voltage coil — is already done. The complete 88 mH coil is used "as-is" for the high-voltage secondary. Two added windings, the primary and feedback sections, consist of several dozen turns and take only a few minutes to complete.

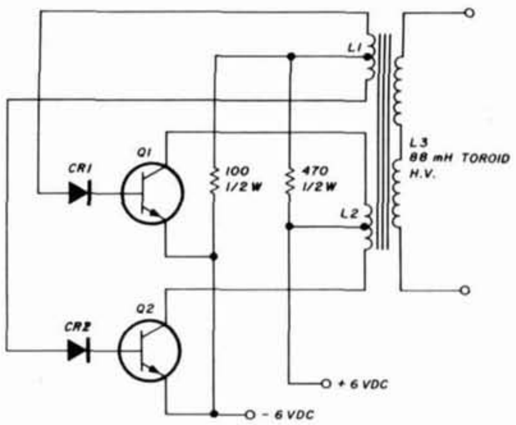
The input current and AC output values shown were measured under no-load conditions. The input current will increase by 100 mA or more under a high-voltage load drawing 0.5 to 1 mA — the usual drain for a CRT. High voltage will also drop several hundred volts under load. I used the voltage-doubler/rectifier circuit shown in **fig. 2**; this yields between 800 and 1000 VDC under load to the 5-inch tube.

the circuit

No particular care need be observed when adding the two windings, other than to keep them in the center of the toroid, away from the ends of the original winding, which will be at a high-voltage potential.

The circuit will work with a wide variety of silicon transistors and I have listed input and output voltages for several varieties. If you have PNPs in your junk box, these can be used by reversing the polarity of the diodes in the base leads as well as reversing the polarity of the DC input. (If you want to use germanium transistors you must change the value of the bias resistors. As a starting point, change the 470-ohm unit to 2000 ohms and eliminate both the 100-ohm resistor and the center-tap connection to the emitters.)

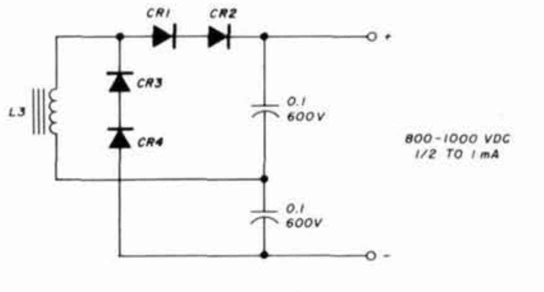
By Jack Najork, W5FG, 3728 East 85th Place, Tulsa, Oklahoma 74136



CR1,CR2 silicon diode, 100 PIV
L1 12 turns No. 28 center-tapped (feedback)
L2 24 turns No. 24 center-tapped (primary)
L3 original 88-mH toroid winding
Q1,Q2 2N3053 or similar
Note: L1 and L2 wound over center of 88-mH toroid

transistor	DC input	no load AC output
2N3394	6 V 160 mA	600
2N3415	6 V 280 mA	750
2N2726	6 V 180 mA	600
2N2222	6 V 280 mA	800
2N3053	6 V 280 mA	800

fig. 1. Switching power supply uses surplus 88-mH toroid with added primary and feedback windings.



CR1, CR2, CR3, CR4: SILICON DIODE, 1000 PIV

fig. 2. Voltage-doubler/rectifier with output suitable for small cathode ray tube.

I used 2N3053s with small, finned heatsinks as switches. These run barely warm under load. 2N2222s will run hot but may be suitable with adequate heatsinks. The 2N2726 and other plastic types would probably be overloaded in this circuit, but, again, may be suitable with good heatsinking. I have not operated the circuit for long periods with these types so I cannot vouch for transistor longevity.

If the circuit does not oscillate, or oscillates with very little AC output when first connected, reverse the feedback winding connections to the diodes in the transistor bases.

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PL tone generator

Produce any frequency from 67 to 250.3 Hz with better than 0.25% accuracy

Now that repeaters have become more common — and their coverage has begun to overlap, especially in metropolitan areas — the use of PL tones has become increasingly necessary to prevent bringing up more than one repeater. Because I use a number of repeaters, I wanted a means of generating any PL frequency so that I could bring up any guarded repeater at the flick of a switch.

I knew that the best PL tone generators relied on crystal-controlled oscillators, the oscillator frequency being divided down by some sort of digital counter and then converted into some semblance of a sine wave. This method ensured accuracy and freedom from drift problems. The question was, could a scheme be devised that would produce *all* the PL frequencies with enough precision in a unit of reasonable size and cost?

I did a little arithmetic based on dividing the frequency of a 4.096 MHz crystal I had handy. I found that integer divisors would produce a frequency within 0.5 Hz of the desired frequency in *every* case — and even closer in most cases. Later I changed over to a 3.579 MHz crystal, since this was more readily available. The results were equally satisfactory.

Next came the problem of how to implement the divider scheme. Since I wanted a circuit with a low power drain, I settled on CMOS devices. The *CMOS Cookbook*[1] gave me the two keys I needed: first, a frequency synthesizer IC, the Hughes HCTR0320; second, the digital sine wave generator circuits, which gave me a means of turning any square-wave clock signal into a low-distortion sine wave of lower frequency, with no need for adjustments or tuned circuits.

Basicaly, then, the design is quite simple: a crystal oscillator drives a divide-by-N counter. The output of the counter feeds a digital sine wave generator, which lowers the frequency still further and produces the desired output waveshape.

crystal oscillator

A pair of CMOS gates can form a crystal oscillator with a few passive components.[1] I chose to use NAND gates because this allows a positive-logic enable signal. If pin 1 of U1 (see **fig. 1**) is grounded, the oscillator is disabled. R3 and C3 provide the necessary feedback, and are chosen to give 180 degrees of phase shift at the crystal frequency. The second gate acts as a buffer. The remaining two gates, with U2, are wired as a divide-by-4 circuit. The reason for this will become clear later.

divide-by-N counter

The HCTR0320 consists of the counter, a phase comparator, and a Schmitt Trigger. Because the input waveform has a fast risetime, the Schmitt Trigger is not needed; but its input (pin 16 in **fig. 2**) must be tied to V_{DD} through a pull-up resistor. The phase detector is not used either, so its polarity (pin 21) and reference frequency (pin 18) inputs should be grounded. The oscillator input goes to pin 15; the counter output, taken from pin 14, clocks the sine wave generator.

By Chris Winter, WBØVSZ, 1206 Vincente Drive #F, Sunnyvale, California 94086

The seven binary-mode control lines are typically used in frequency synthesizers to offset transmit and receive frequencies, as for repeater access. They are not used in this design, and should be grounded. The remaining twelve control inputs are set up as three BCD digits. They allow selection of any division ratio between 3 and 999. The required ratios fall between 179 and 668. (See **table 1** for complete information.) Note that, in this counter, the output duty cycle is the reciprocal of the division ratio; the pulses will be very narrow.

digital sine wave generators

The secret of a digital sine wave generator is the Johnson, or walking-ring, counter, in which a fixed pattern circulates constantly. In this case, the pattern is simply a square wave at any output. The various outputs, each at either V_{DD} or ground, are summed through resistors of different values. With proper choice of values, the result is a waveform that closely resembles a sine wave. For a counter of M stages, the clock frequency must be 2M times the desired output frequency, and the lowest harmonic present in the output is of order M-1. This means that a simple lowpass filter can produce a very clean sine wave.

Digital sine wave generators can be made from chains of D-type flipflops like the MC14013. For example, a pair of 14013s makes a 4-stage counter. It requires three resistors and produces a sine wave at one-eighth the clock frequency. This wave will be riding on a DC level of $V_{DD}/2$. The more stages in the counter, the closer the

table 1. PL tone frequencies accurate to within 0.25 percent of EIA standard.

EIA standard PL frequency Hz	value of N	output frequency	error, Hz	error, %
67.0	668	66.98	−0.02	−0.03
69.3	646	69.26	−0.04	−0.06
71.9	622	71.94	+0.04	+0.06
74.4	601	74.45	+0.05	+0.07
77.0	581	77.01	+0.01	+0.01
79.7	561	79.76	+0.06	+0.08
83.5	536	83.48	−0.02	−0.02
85.4	524	85.39	−0.01	−0.01
88.5	506	88.43	−0.07	−0.08
91.5	489	91.50	0.00	0.00
94.8	472	94.80	0.00	0.00
100.0	447	100.10	+0.10	+0.10
103.5	432	103.57	+0.07	+0.07
107.2	417	107.30	+0.10	+0.09
110.9	403	111.03	+0.13	+0.12
114.8	390	114.73	−0.07	−0.06
118.8	377	118.69	−0.11	−0.09
123.0	364	122.92	−0.08	−0.07
127.3	351	127.48	+0.18	+0.14
131.8	339	131.99	+0.19	+0.14
136.5	328	136.42	−0.08	−0.06
141.3	317	141.15	−0.15	−0.11
146.2	306	146.22	+0.02	+0.01
151.4	296	151.16	−0.24	−0.16
156.7	286	156.45	−0.25	−0.16
162.2	276	162.12	−0.08	−0.05
167.9	266	168.21	+0.31	+0.18
173.8	257	174.10	+0.30	+0.17
179.9	249	179.70	−0.20	−0.11
186.2	240	186.43	+0.23	+0.12
192.8	232	192.86	+0.06	+0.03
202.7	221	202.46	−0.24	−0.12
203.5	220	203.38	−0.12	−0.06
210.7	212	211.06	+0.36	+0.17
218.1	205	218.26	+0.16	+0.07
225.7	198	225.98	+0.28	+0.12
233.6	192	233.04	−0.56	−0.24
241.8	185	241.86	+0.06	+0.02
250.3	179	249.97	−0.33	−0.13

output is to a true sine wave. The MC14018 is very convenient here because it has five suitable stages in one package. A pair of 14018s is doubly convenient because a 10-stage counter divides the clock frequency by 20. Only an additional factor of 4 is needed to bring the total divisor within range of the HCTR0320. This factor, of course, is supplied by U2.

The resistor values shown in the sine wave generator

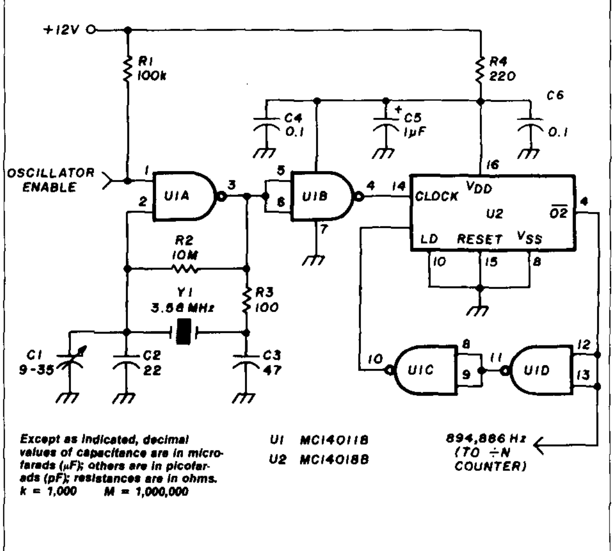

fig. 1. Clock frequency for the PL tone generator is produced by a crystal oscillator and divide-by-four circuit.

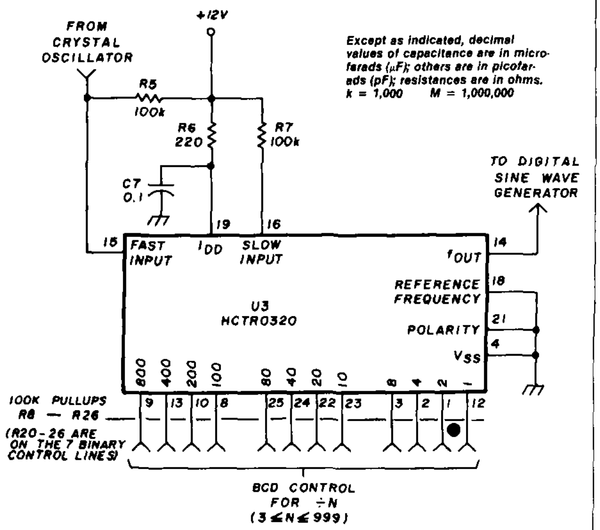

fig. 2. A Hughes frequency-synthesizer IC divides the clock frequency by the desired integer.

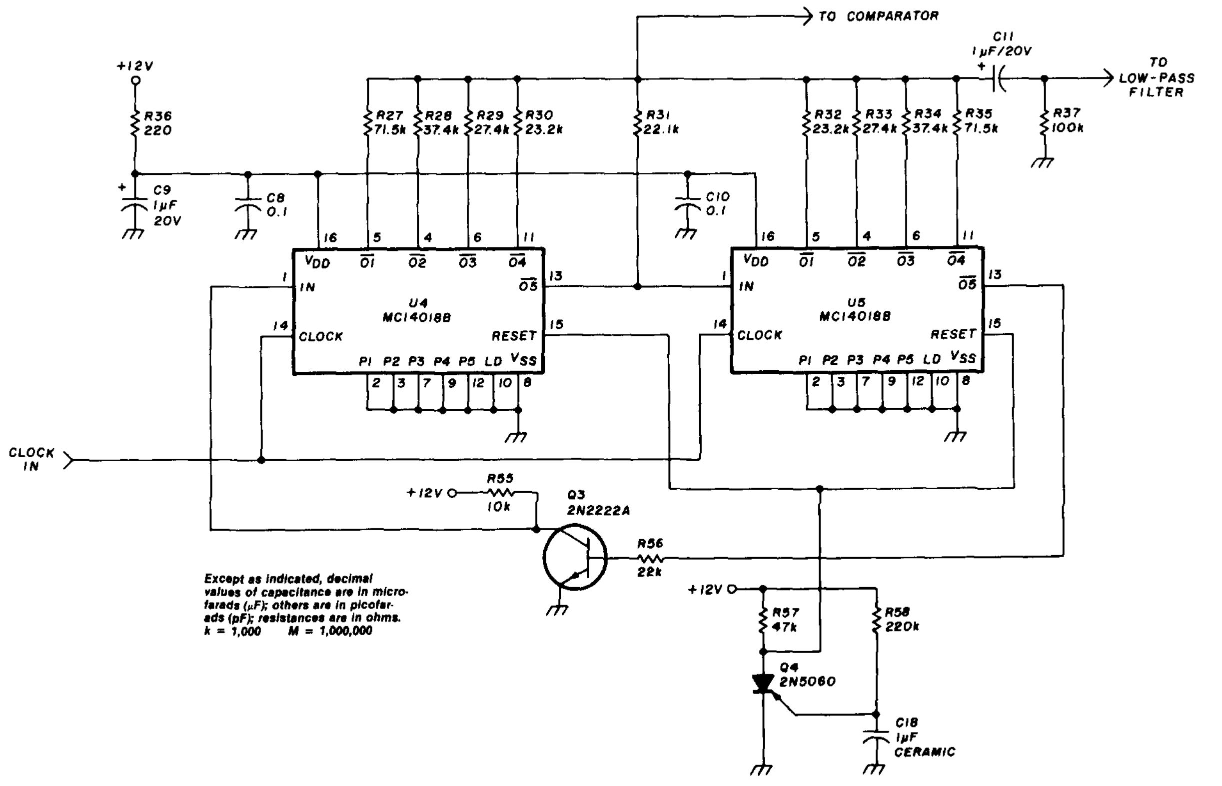

fig. 3. A 10-stage digital sinewave generator produces an output with very low harmonic distortion.

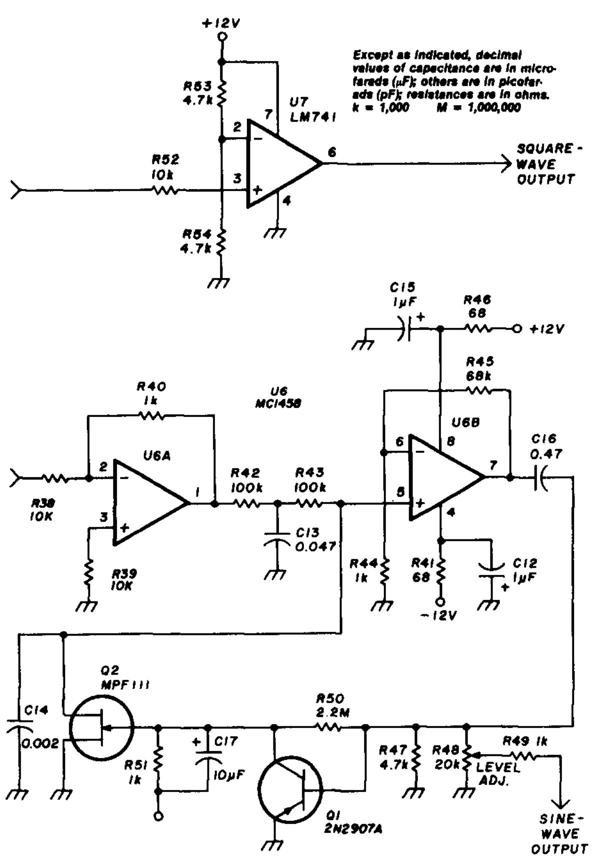

fig. 4. A lowpass filter and AGC amplifier condition the sinewave output. U7 provides a test signal for frequency checks.

parts list

item	*description*
C1	9-35 pF trimmer
C2	22 pF 100V 5 percent mica
C3	47 pF 100V 5 percent mica
C4,C6,C7, C8,C10,C19	0.1 µF 50 ceramic
C5,C9,C11, C12,C15	1 µF 20V tantalum
C13	0.047 µF 50V ceramic
C14	0.002 µF 50V ceramic
C16	0.47 µF 50V ceramic
C17	10 µF 20V tantalum
C18	1 µF 50V ceramic
Q1	2N2907A
Q2	MPF111
Q3	2N3704
Q4	2N5060
R1,R5,R8-R26, R37,R42,R43	100k 1/4 watt 10 percent
R2	10 meg 1/4 watt 10 percent
R3	100 ohm 1/4 watt 10 percent
R4,R6,R36	220 ohm 1/4 watt 10 percent
R27,R35	71.5k 1/8 watt 1 percent
R28,R34	37.4k 1/8 watt 1 percent
R29,R33	27.4k 1/8 watt 1 percent
R30,R32	23.2k 1/8 watt 1 percent
R31	22.1k 1/8 watt 1 percent
R38,R39,R52,R55	10k 1/4 watt 10 percent
R40,R44,R49,R51,(1 MHz)	1k 1/4 watt 10 percent
R41,R46	68 ohm 1/4 watt 10 percent
R45	68k 1/4 watt 10 percent
R47,R53,R54	4.7k 1/4 watt 10 percent
R48	20k potentiometer
R50	2.2 meg 1/4 watt 10 percent
R56	22k 1/4 watt 10 percent
R57	47k 1/4 watt 10 percent
R58	220k 1/4 watt 10 percent
U1	MC14011B
U2,U4,U5	MC14018B
U3	HCTR0320
U6	MC1458
U7	LM741
Y1	3.579545 MHz crystal

PCB1 is a 3 × 5 inch (7.62 × 12.7 cm) double-sided PC board with plated-through holes. It mates to double-readout 15-position edge connector. A bare board with complete documentation is available for $15 from: Zombico, P.O. Box 61831, Sunnyvale, California 94088.

circuit (**fig. 3**) work only for a 10-stage counter. (The *CMOS Cookbook* includes information on values for counters of various lengths.) Precision resistors are nice, but quite acceptable results can be obtained with ordinary carbon 10 percent tolerance resistors.

Two pitfalls should be mentioned. The first is the fact that at power-on, the 14018s may contain an undesired pattern of bits; in a sine wave generator, this will produce really incredible waveshapes. The solution is to include a power-on reset circuit. The other pitfall is the need for an additional inverter between the two 14018s. While the *Cookbook* does not emphasize this point, an inverter is necessary to obtain the proper waveshape and division ratio. In my design, there was no room for another IC so the SCR does power-on reset, and Q3 provides logic inversion.

other features

I included some signal conditioning in the design. There is a lowpass filter, of course, and a blocking capacitor to remove the sine wave from the half-V_{DD} DC level. Also included are an output level adjustment, and a circuit to hold the level constant.[2] For ease in checking the operation of the unit with a frequency counter, a comparator provides a square wave at the output (PL) frequency. These features are shown in **fig. 4**.

application information

The unit is simple to use. Voltages required are +12 and −12 volts at a current drain of about 20 mA. Maximum output is better than 1 V_{p-p}. The divider control lines can be wired to three BCD thumbwheel switches; a 12-bit latch controlled by a computer could be used instead. The PCB layouts are shown in **fig. 5** on page 56.

references

1. Don Lancaster, *CMOS Cookbook*, Howard W. Sams Co., Indianapolis, Indiana, 1977. (Available from Ham Radio's Bookstore, Greenville, NH 03048, $14.95 post paid.)

2. Chris Winter, WB0VSZ, "Tone Encoder for 2-Meter Autopatches," *ham radio*, June, 1980, page 51.

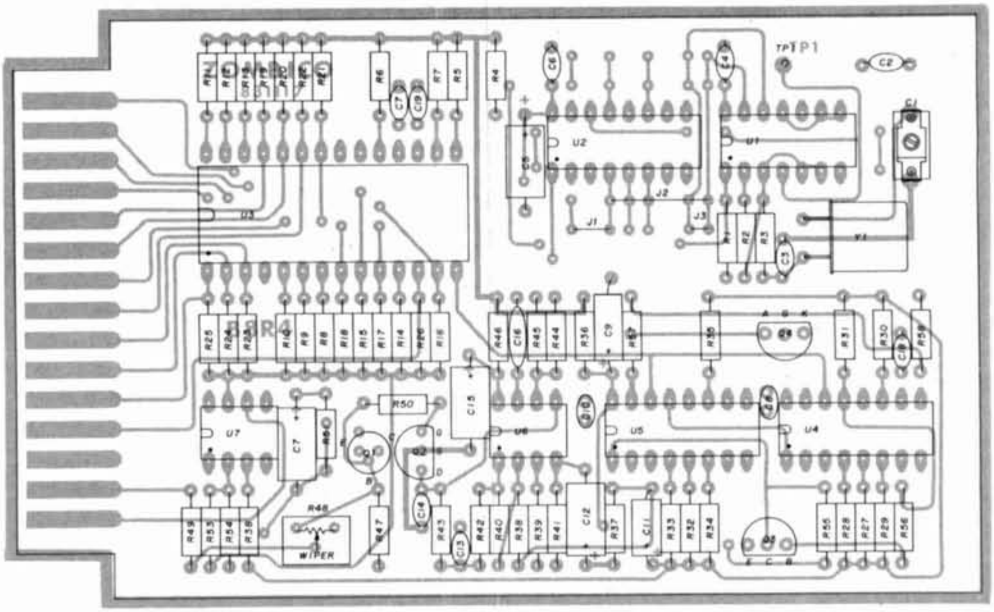

fig. 5A. PL tone generator, PCB component side.

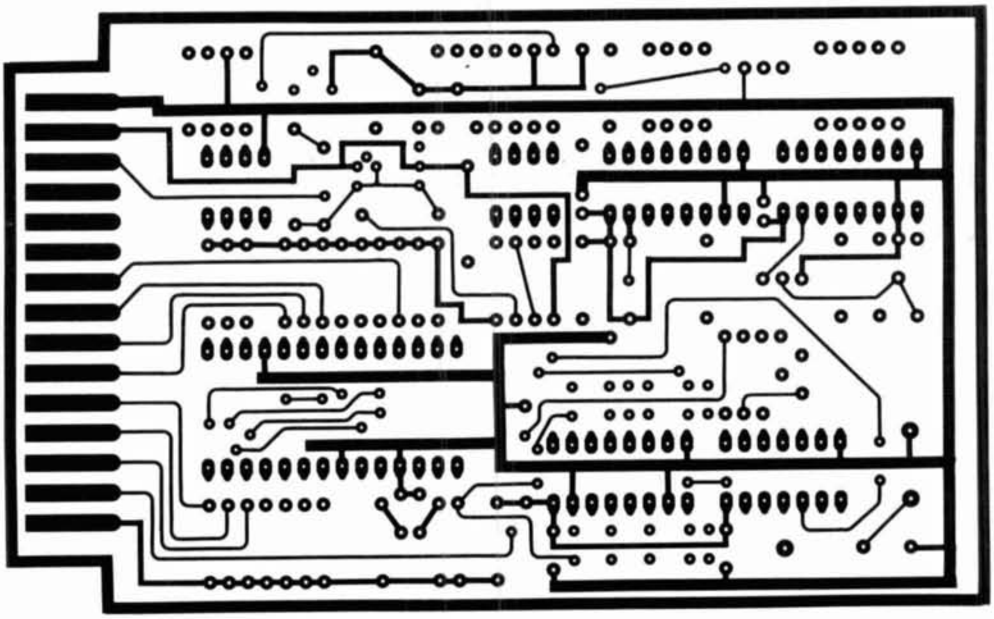

fig. 5B. PL tone generator, PCB ground plane side.

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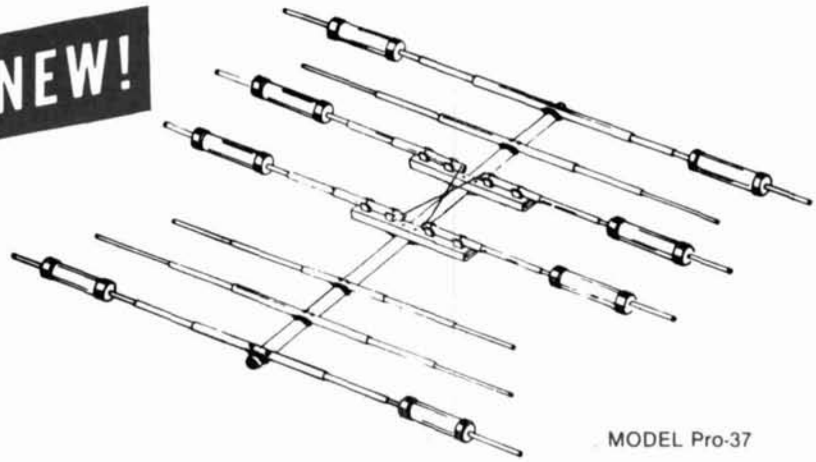

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SSB	5.0 KWPEP
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VSWR (1.5/1 or better)	1.5/1
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MAXIMUM ELEMENT LENGTH	29.9
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RECOMMENDED MAST SIZE	2"
TURNING RADIUS	19'8"
WIND SURFACE AREA (in sq. ft.)	13.1 sq. ft.
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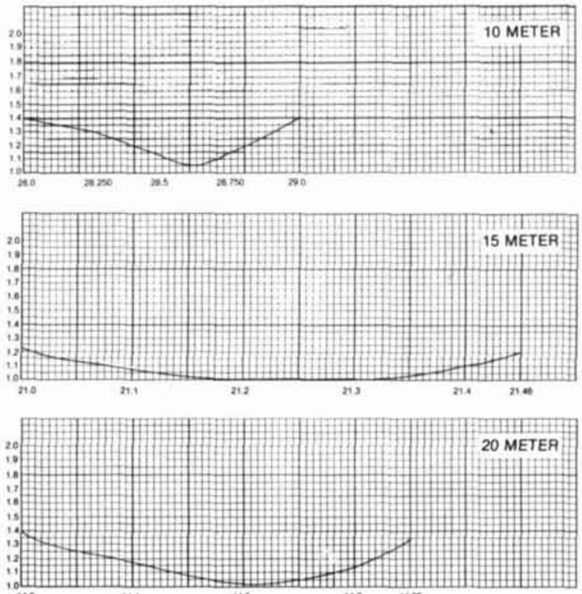
ASSEMBLED WEIGHT (approx.)	81 lbs.
SHIPPING WEIGHT (approx.)	86 lbs.



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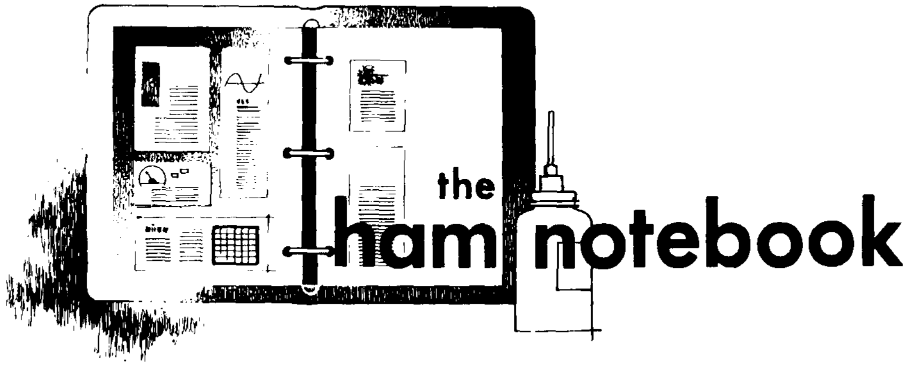

Ten-Tec Corsair modification

Separation of the AGC and RF/IF gain functions in modern transceivers provides improved receiver operation. In a receiver in which the AGC remains on when the RF/IF manual gain control is backed off from the maximum position, SSB reception can be improved by adjusting the gain until the received noise signal is just above the receiver minimum-signal threshold. The Ten-Tec Corsair incorporates separate receiver AGC and manual IF-gain controls.

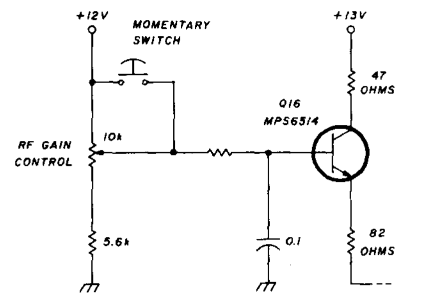

fig. 1. The addition of a momentary switch provides normal operation and instantaneous S-meter check capability to the Ten-Tec Corsair.

When operating the Corsair with the IF-gain turned down, the S-meter readings for a given signal strength are reduced. In order to obtain meaningful S-meter readings, it is necessary to momentarily turn the IF gain to maximum. This modification provides that function through the addition of a "momentary" switch as shown in **fig. 1**.

The switch is a subminiature, normally-open, spring-return push button. To take an S-meter reading the button is depressed shorting the wiper to the top of the control. Due to the excellent AGC characteristics of the receiver, there's no blast from the speaker.

There's a convenient space on the Corsair's front panel for mounting the push button — to the right and above the center of the manual IF-gain control (RF GAIN). Radio Shack subminiature push-button switch No. 275-1571 is a good, if not exact, match for the SPOT push button on the Corsair panel.

This technique can probably be adapted to other transceivers with an AGC function that remains operative over the full range of the RF/IF manual gain control.

Jack Geist, N3BEK

visual telephone ring indicator

At the company where I work, there are four offices — each with its own telephone — along a corridor, with a conference area across the hall. Whenever the staff was gathered in the conference area and one of the office phones would ring, it was impossible to tell whose phone it was; obviously, a light above each office door to indicate a ringing telephone would minimize interruptions and save steps.

The telephone company offered to install such a device for $52 per phone, and charge a monthly rental fee as well. **Fig. 1** shows how I solved the problem inexpensively and without the phone company; perhaps it will be of special interest to deaf persons and to all who use RTTY to communicate with them.

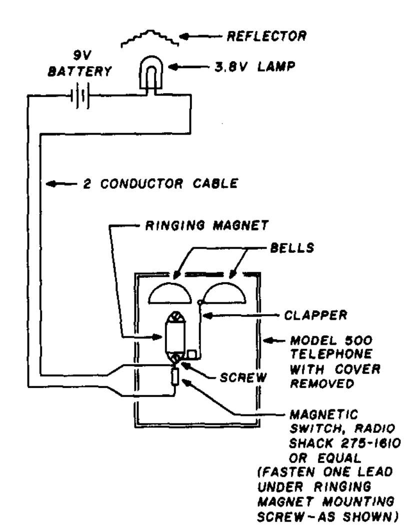

fig. 1. Circuit for simple telephone-ring indicator.

J. W. Dates, W2QLI

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John Labaj, W2YW

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1412 1412G	144	160	30	199 239
2210 2210G	220	130	10	225 265
2212 2212G	220	130	30	199 239
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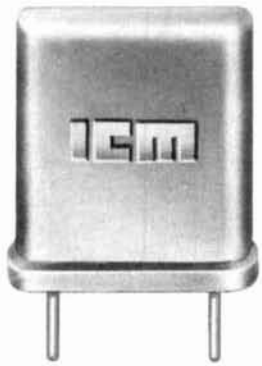

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Kantronics Interface II

The Interface For
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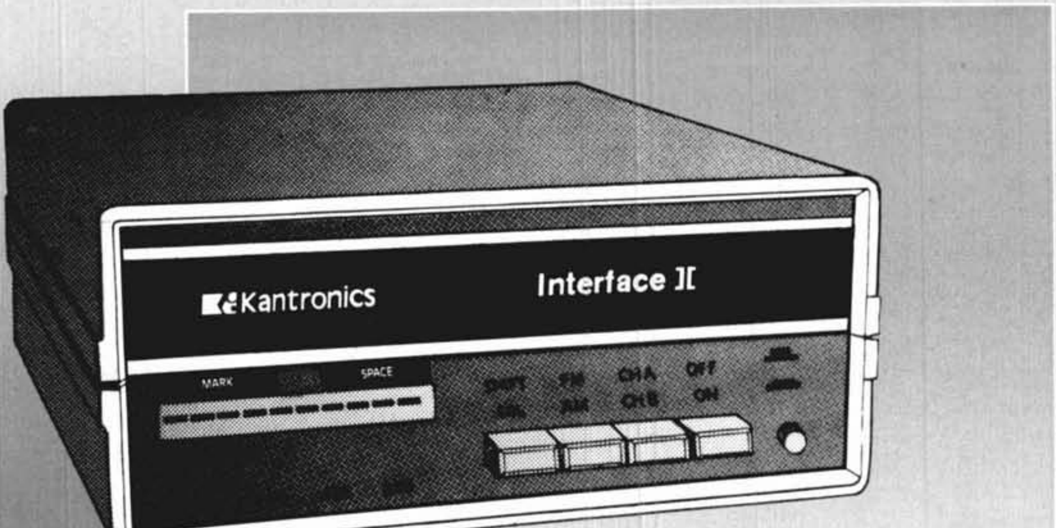

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Amtorsoft

For the serious AMTOR operator using a VIC-20, Commodore 64, or Apple computer. This program is similar to Hamtext in capabilities, but can only be used for AMTOR. The Apple version includes both Hamtext and Amtorsoft on one diskette ($139.95), while the Vic-20 and Commodore 64 cartridge is just Amtorsoft ($89.95).

✓ 162

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portable shortwave receiver

Compact unit covers 46 through 100-meter bands

The design of this compact, high performance shortwave receiver has evolved over several years.[1,2,3] Its underlying concept, namely low power consumption, makes it ideal for DXpeditions. The unit provides spurious-free, stable operation and sensitivity comparable to commercially-manufactured receivers.

While the earlier projects sported a digital frequency readout using a mechanical counter with a 455 kHz IF strip and mechanical filter,[4] the current design includes electronic frequency readout and higher frequency IF (in the 9-10 MHz range). With the primary objective of low power drain, a multiplexed counter was used, incorporating the Intersil 7207-7208 IC combination. In this configuration a frequency response exceeding 25 MHz was achieved.

To avoid adding additional ICs to this project, the VFO output was read directly without any signal conditioning. For receive it was desired that the displayed frequency be equal to the tuned frequency; there are several methods of accomplishing this.

Use of a 10 MHz IF strip and a VFO tuned above the IF frequency is one method. By deleting the first digit of the display, one reads the true receiver frequency.[4] Use of a 9 MHz IF strip and a VFO tuned above the HF frequency is another method. Again, deleting the first digit from the display will produce a readout indicating exactly 1.0 MHz above the received frequency. By rewiring the MHz digit, this can be made to display 1.0 MHz lower (i.e., than the true tuned frequency).

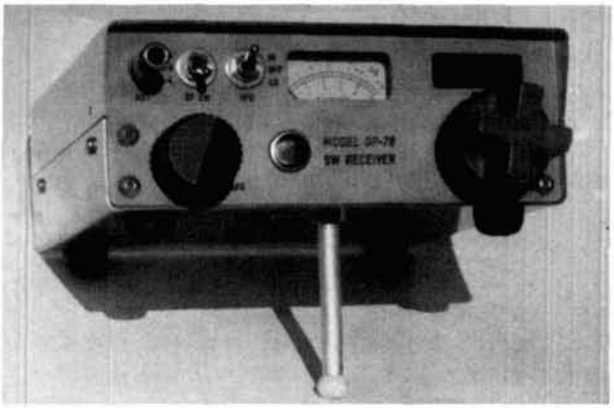

fig. 1. Front view of receiver shows unit mounted on 4-inch removable slip-on tilting pin, which eliminates parallax effects on S-meter readings and frequency display. Panel controls (left to right) include: antenna, RF bandswitching, VFO bandswitching, and gain knob (below). S-meter is in center, tuning knob is at right, just below 4-digit display.

The first method is particularly convenient from a mechanical standpoint. Judging from the response to earlier articles, most builders have had difficulty in locating a convenient source of 10 MHz crystal filters. Considering the costs involved, it may pay to build your own crystal filter.[5,6]

Other methods (still using a 9 MHz filter and a VFO tuned above IF) involve reading only the last three digits (1, 10, and 100 kHz) and reading the MHz number off the skirt of the bandswitch knob. While this may sound a bit crude, it offers the advantage (over bandswitching the MHz digit with diodes) of reduced current drain. It is also possible to control the MHz digit by a push-button switch, and to switch it on only when the MHz reading is actually needed.

One improvement over the earlier designs is the replacement of the antenna trap, set at the IF frequency, by a notch that attenuates IF signal feed-through considerably; this is particularly helpful because in some areas the 10 MHz signal from standard frequency stations may reach a local field strength level high enough to cause performance degradation. Extensive shielding and care in front-end design should be used in such cases.

design

This approach employs the later method and covers 3.0-6.5 MHz in two bands. Its coverage can be expanded to include the 7 MHz ham band or other frequencies of interest by making provisions for proper readout options, and adding more digits, if needed. However, if one prefers to leave this project in its simpler form, satisfactory results can be achieved by adding an external converter.[7]

All bandswitching is performed electronically, using transistors and miniature toggle switches. Because transistors are back-to-back diodes, using input-output signal isolation appears to be better than using diodes. This is particularly true for the VFO circuit.

The power supply circuit takes either 12 VAC or DC at its input jacks and acts as a polarity inversion protector. To keep power consumption down, the counter can be turned off when not in use — for example, when you remain on the same frequency for an extended period of time.

Another improvement is the adoption of a passive balanced mixer, using Germanium diodes; the receiver front-end response thus becomes considerably "cleaner," as cross modulation and spurious response is reduced.

By Jack Perolo, PY2PE1C, P.O. Box 2390, Sao Paulo, Brazil

Driving a passive mixer requires a high injected VFO signal level. Consequently a suitable amplifier was designed for this purpose. Under load conditions, the VFO output is 3.0-3.2 volts. The value of the buffer emitter capacitor was selected for flattest output voltage within the VFO frequency range desired.

construction

The photos (**figs. 1, 2,** and **3**) illustrate construction details, while the schematics in **figs. 4, 5**, and **6** provide the electrical circuits.

This set measures 5.5 × 2 × 6 inches (140 × 50 × 150 mm) and weighs 4.6 pounds (2.1 kg), excluding the wall adapter. In Brazil, the cost of parts comes to about $280; the unit requires about 300 hours to build.

Cabinet material is 18 gauge stainless steel, with a 16-gauge front panel to permit better engraving. The back panel and main chassis are made from 1/8 inch thick aluminum; the shields are also aluminum, but only 1/16 inch thick. All PC boards are fastened with 4-40 stainless steel screws, and use 1/4 inch aluminum round pillars.

The weight could be reduced by using lighter components and thinner plates. However, for greater stability, and as a matter of habit, I prefer to use the thicknesses specified.

Some substitution of components may be necessary if specified parts are difficult to obtain. For example, the Polar 104 pF main variable capacitor is a high quality British import, fully silvered, on ceramic insulation, with bearings at both ends. (J.W. Miller used to distribute these in the U.S.) The 10:1 vernier, manufactured by Jackson in the U.K., is also heavy-duty. The 9 MHz crystal filter is Japanese, with a 1.8 kHz bandwidth at −6 dB and 3.5 kHz at −60 dB. (It's available through Yaesu dealers.) Should substitution be required, the German import by KVG is also suitable, and available. The S-meter, of Japanese manufacture, uses a 1 mA movement and is directly calibrated in S-units. The IF coil forms are made in Brazil; their base measures about 0.6 × 0.6 inch (15 × 15 mm), 0.8 inch (20 mm) high, with a coil diameter of 1/4 inch. (J.W. Miller distributes a similar unit in the United States.)

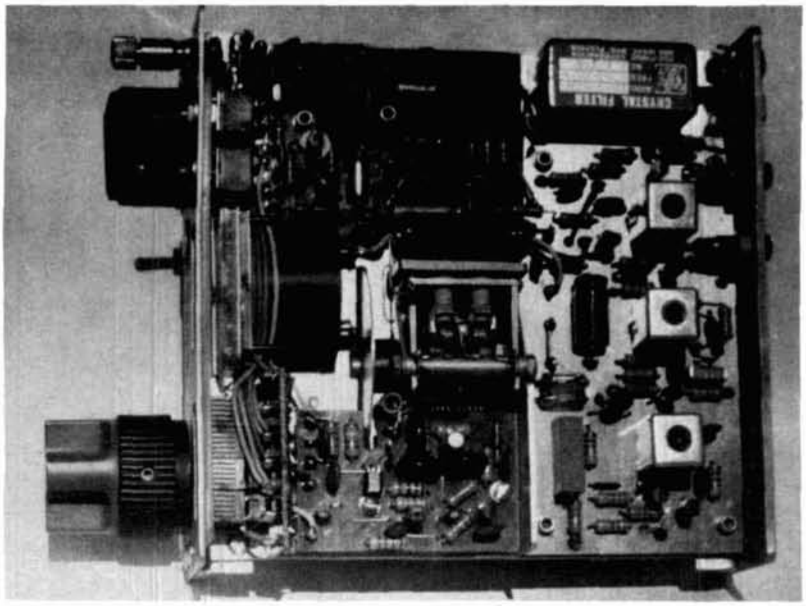

fig. 2. Top view of receiver. ***Top left PC*** **board includes regulated power supply and audio stages.** ***Right side PC*** **includes IF stages, detectors, AVC amplifier and S-meter zero setting trimpot on this double-sided board.** ***Bottom left PC*** **includes VFO transistor, amplifier, and buffer together with electronic bandswitching components. (Note the use of silver mica capacitors on VFO input circuit.)**

Note: **The 9 MHz antenna trap is at the top left, near the antenna input. The 9 MHz crystal filter is at the top right, near input of IF PC board. Even though it is not visible in this picture, the crystal filter input pin is shielded below the receiver chassis to avoid stray coupling with the RF/mixer PC, located on the opposite side of the chassis. At bottom left, maintained in a vertical position by aluminum brackets, is a small PC board holding the four-digit display. The back panel contains 12V input jacks, and two phone jacks, the second used for tape recording.**

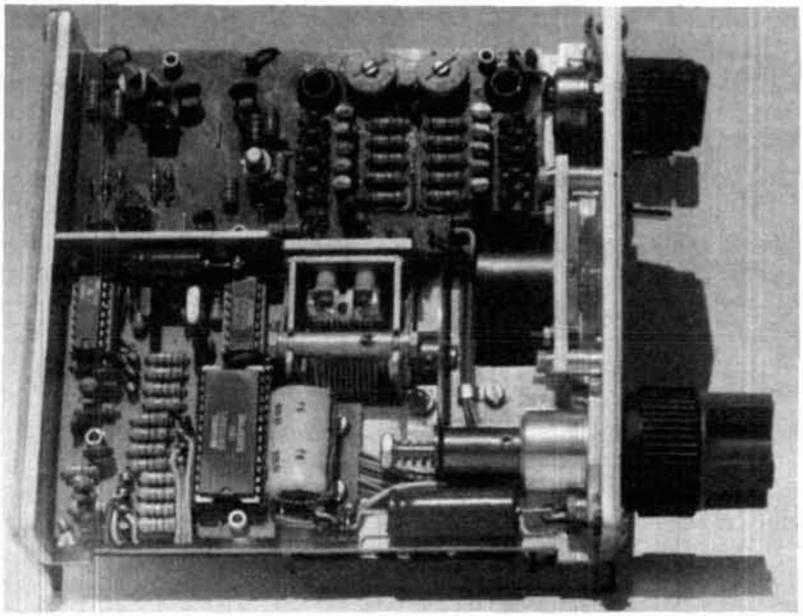

fig. 3. Bottom view of receiver. Top PC: mixer stage is shown on the left. RF circuits, with the toroidal coils and trimmers, are clearly visible. The ten aligned resistors and nearby transistors provide electronic bandswitching for the front end. Note that the 40841 transistor is plugged into a socket, for replacement in case of burnout during field-day operation. Bottom (left) PC houses the entire frequency counter, complete with input signal processing. The tuning (VFO) variable capacitor is in the center, linked by an aluminum disc to the pinch-rim drive coupled to the tuning vernier. Two electrolytic power supply capacitors are visible below the variable capacitor. Note the shielding between the RF/mixer stages and counter, and the bracket on back of the S-meter, holding it in place.

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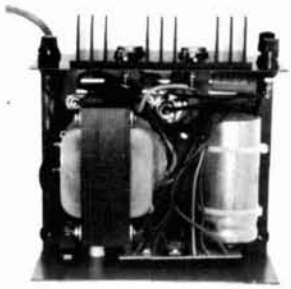

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MODEL RS-50A

MODEL RS-50M

MODEL VS-50M

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RM-50A	37	50	5¼ × 19 × 12½	50

RS-A SERIES

MODEL RS-7A

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

RS-M SERIES

MODEL RS-35M

- Switchable volt and Amp meter

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

VS-M SERIES

MODEL VS-20M

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

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

RS-S SERIES

MODEL RS-12S

- Built in speaker

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

✓ 112

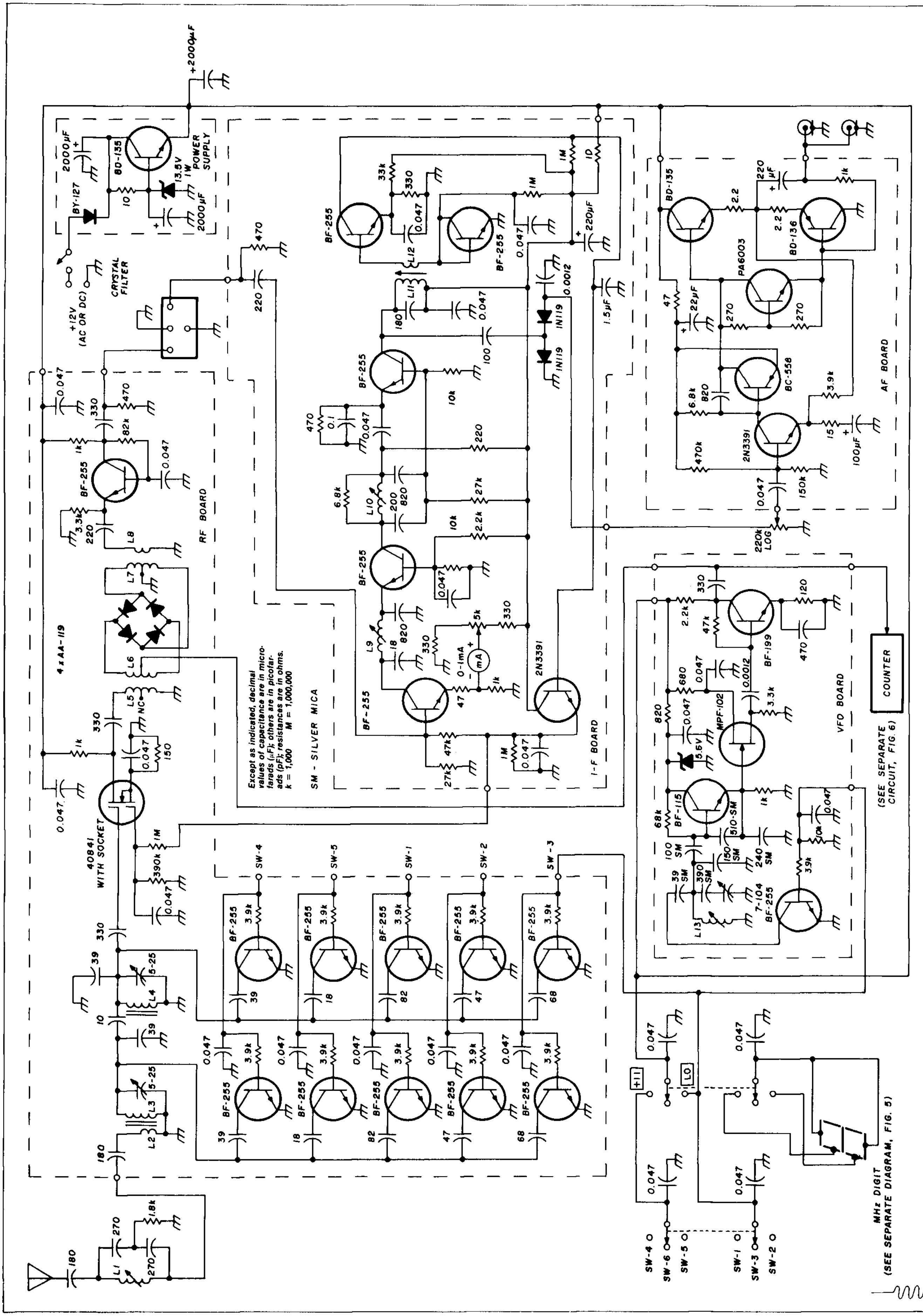

fig. 4. Schematic of portable shortwave receiver.

table 1. Coils required for construction of portable shortwave receiver. (Unless otherwise noted, all wire is No. 28 enamel.)

coil	description	frequency range, MHz
L1	18 turns in 3 layers on a 3/16" slug-tuned ceramic form (No. 31 wire)	9.0
L2, L3	RF coil 6 turns and 50 turns (No. 31 wire), respectively on Amidon T-37-2 toroid	3.0-6.5
L4	RF coil 50 turns No. 31 wire on Amidon T-37-2 toroid	3.0-6.5
L5, L6	mixer input — Quadrifilar wound on a 3/8 × 3/8 × 1/4-inch ferrite bead, 6 turns + 6 turns, with the center tap of the primary coil not connected	
L7, L8	mixer output — Trifilar wound on a 3/8 × 3/8 × 1/4-inch ferrite bead, 6 turns + 6 turns	
L9	first IF coil — 40 turns in 2 layers on a 1/4 inch slug-tuned nylon form with aluminum shield	9.0
L10	second IF coil — 18 turns on a 1/4 inch slug-tuned nylon form with aluminum shield	9.0
L11, L12	third IF coil — 18 turns and 6 turns on a 1/4 inch slug-tuned nylon form with aluminum shield	9.0
L13	VFO coil — 10 turns in 2 layers on a 3/16 inch slug-tuned ceramic form	12.0-15.5

The pinch-rim drive mechanism has an 8:1 reduction ratio and is homebuilt, using a 1/32 inch thick duraluminum disc and a 1/2 inch brass shaft. This gives the tuning unit a "velvety" feel and, considering that the variable capacitor swing required a rotation of about 160 degrees, an overall reduction ratio of about 1:35.

Depending on the size of the tuning knob, comfortable tuning can be achieved up to a tuning rate of 40-50 kHz/turn; therefore, each bandspread should not exceed (35)(50) = 1,750 kHz.

choosing coils

Table 1 lists the coils necessary for the coverage given; all wire is No. 28 enamel, except where noted.

If other band coverage is desired, coils L2, L3, L4 and L13 should be modified accordingly to tune the new bands of interest; all other coils remain unchanged. For the sake of miniaturization, the trimmer capacitor used to adjust the counter readout has been replaced by a fixed capacitor, marked with an asterisk on the schematics. This capacitor should be adjusted for the crystal and the filter center frequency used, generally falling in the range of 15-47 pF. Because this circuit is extremely stable, I haven't noticed any need to recalibrate this unit even after years of operation.

circuit boards

The full project uses six 1/16-inch thick epoxy printed circuit boards as follows:

1. RF front-end and mixer, complete with band-switching, 2.3 × 4.7 inches (58 × 118 mm).

2. 9 MHz IF strip and AVC amplifier, on double-sided board, 2.3 × 4.4 inches (56 × 110 mm).

3. Audio strip and power supply, 1.9 × 2.0 inches (48 × 50 mm).

4. Frequency counter, 2.2 × 2.7 inches (55 × 67 mm).

5. Four-digit display, 0.9 × 1.8 inches (23 × 44 mm).

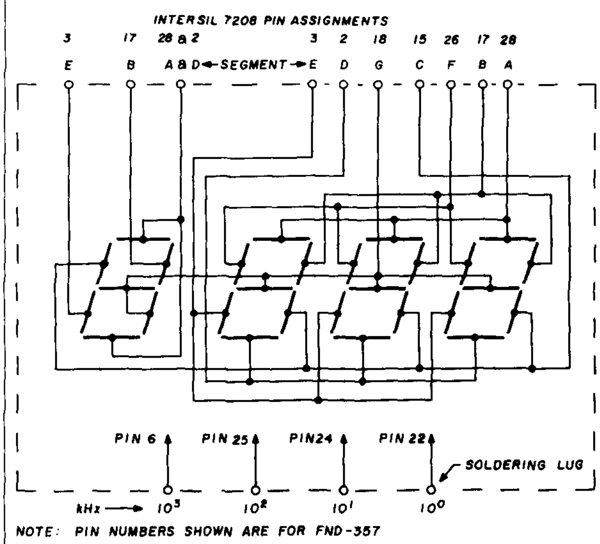

fig. 5. Four-digit display schematic.

6. VFO, amplifier, and buffer, complete with band-switching, 1.4 × 2.2 inches (36 × 55 mm).

These circuits, shown inside the dotted lines on the main schematic (**fig. 4**), were prepared using a resist ink, and then etched in a ferric chloride solution. The double-sided IF PC board is protected with Contac™ during etching. After etching, the PC boards are cleaned with steel wool and painted with acrylic lacquer.

semiconductor devices

Philips makes the BF-115, BF-255, A-119, and BY-126. Siemens supplies the BC-548, BD-135, and BD-136.

The MPF-102 and zeners are from Motorola; the 40841 is made by RCA while the 2N3391 is from Texas Instruments. Substitutions can be made, provided care is taken to confirm equivalency.

ICs 7207 and 7208 are manufactured by Intersil; the 74LS90, a low-drain variety of the 7490, is available from many sources.

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LS30	.28	LS242	.90
LS32	.36	LS243	.90
LS42	.49	LS244	1.25
LS51	.24	LS245	1.50
LS74	.40	LS251	.50
LS85	.60	LS257	.55
LS86	.39	LS258	.55
LS90	.50	LS266	.50
LS93	.55	LS273	1.25
LS109	.39	LS279	.45
LS112	.39	LS283	.60
LS123	.75	LS290	.85
LS124	2.75	LS293	.85
LS125	.45	LS298	.89
LS132	.50	LS299	1.60
LS133	.49	LS366	.45
LS138	.60	LS367	.50
LS139	.60	LS368	.40
LS151	.50	LS373	1.25
LS153	.50	LS374	1.35
LS154	1.75	LS375	1.19
LS155	.50	LS377	1.49
LS156	.55	LS378	.85
LS157	.60	LS390	1.19
LS161	.60	LS393	1.19
LS162	.65	LS399	1.25
LS163	.50		

TTL

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7402	.19	74151	.50
7404	.19	74154	1.19
7408	.24	74157	.50
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7440	.19	74174	.85
7474	.35	74175	.79
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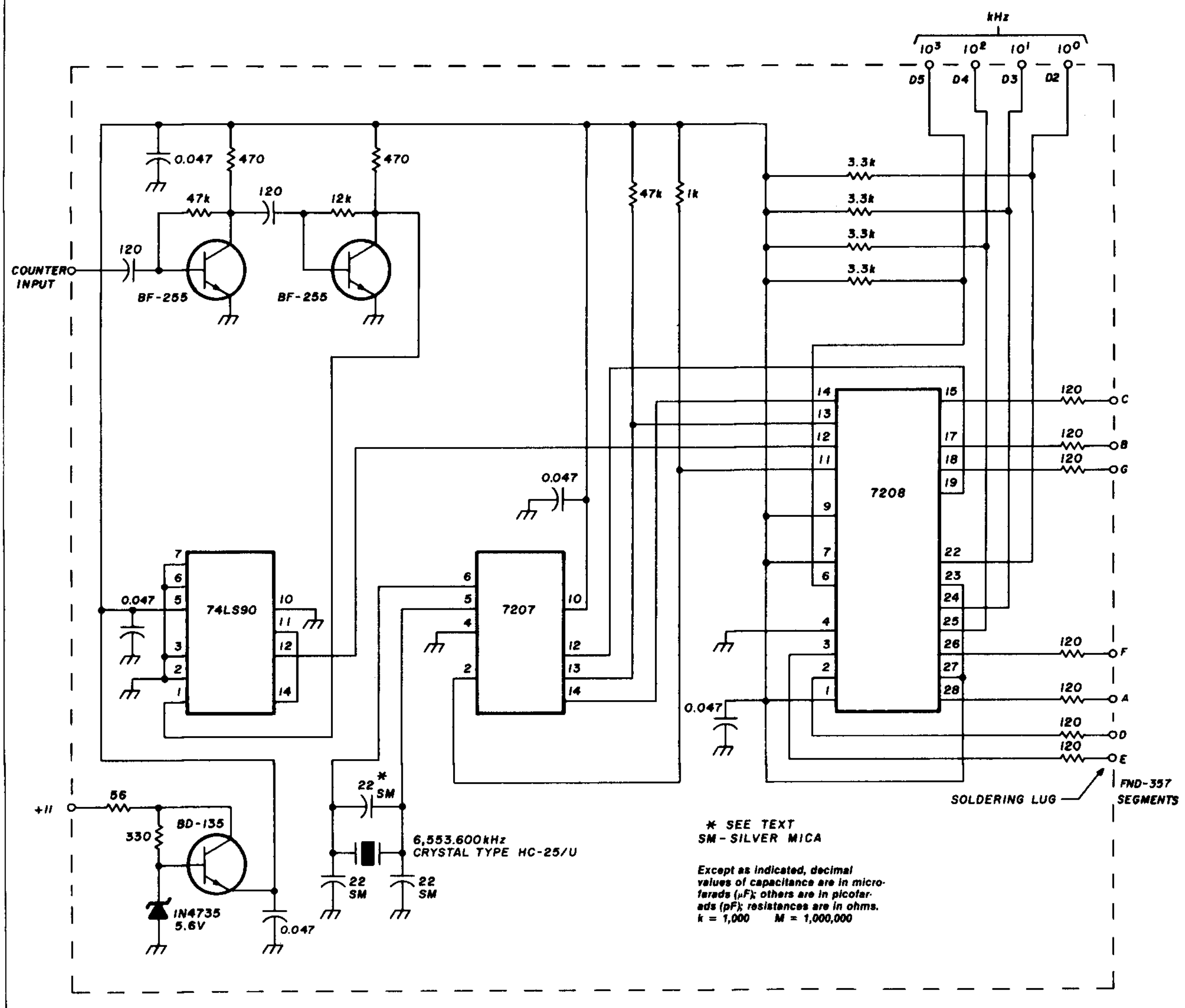

fig. 6. Frequency counter schematic.

The FND-357 display is manufactured by Fairchild.

performance

Current drain on a 12 VDC supply with the display on and the volume set at a comfortable listening level is 90-95 mA; using power supplied by a car battery. Field-day type operation can be extended for several days in a row without any need to recharge. The counter is responsible for 50-55 mA of the current drain. Overall sensitivity, at 5.0 MHz, is about −125 dBm, using the specified crystal filter; loss of sensitivity becomes noticeable when the feed voltage drops below 10 volts.

After a five-minute warm-up period, stability is ±20 Hz/hour at 4.0 MHz (i.e., with the VFO running at 14.0 MHz); this stability is achieved by operating the VFO transistor at low voltage (5.6 volts), by selecting the best capacitive feedback ratio, by using high parallel capacitance and, finally, by installing silver mica capacitors. The counter is sensitive and stable at an input level of 12 mV into 50 ohms.

acknowledgement

I thank Fernando, PY2DQU, for his considerable help on the theory and measurement equipment.

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2. J. Perolo, PY2PE1C, "A General Coverage Solid-state Communications Receiver with Direct Digital Frequency Read-Out," *CQ*, August, 1973, page 28.
3. J. Perolo, PY2PE1C, "Double Conversion HF Receiver with Mechanical Digital Frequency Read-Out," *ham radio*, October, 1976, page 26.
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5. J. Perolo, PY2PE1C, "Practical Considerations in Crystal Filter Design," *ham radio*, November, 1976, page 34.
6. Doug DeMaw, WF1B, "Simple Ladder IF Filter," *QST*, August, 1978, page 18.
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ham radio

ham radio TECHNIQUES

a *very* wideband no-tune antenna

It's always refreshing to find an example of original thinking, especially when it pertains to antennas! (The dipole and the ground plane have been reinvented too many times.) This novel antenna was recently described in *Amateur Radio*, the publication of the Wireless Institute of Australia,* a magazine I highly recommend to the readers of this column.

Some months ago I discussed the so-called Australian dipole, a cage-like antenna that covers most of the high-frequency spectrum.[1] This large, heavy array has been widely used in Australia and Africa, but is still virtually unknown in the United States.

Recently, experiments conducted by VK6IM and VK6YX of Western Australia have resulted in a grounded version of the wideband dipole that can be used as a vertical or a sloper antenna. This new design covers the frequency range of 1.8 to 14.34 MHz, with a measured SWR on the feedline across the span of about 1.2:1. Thus it seems the "VK6-broadband" antenna is an excellent choice for multiband coverage with the new solid-state transceivers that demand a low value of SWR on the antenna system.

The schematic of the antenna is shown in **fig. 1**. Basically it is a "fat" monopole with an impedance matching network placed about a third of the way down from the free end. The antenna is worked against a counterpoise ground system and is fed through a simple broadband transformer.

antenna assembly

The "VK-6 broadband antenna" is about 75 feet long and is formed of a five-wire cage about 6 feet in diameter. It is composed of two parts joined by a parallel-connected resistor and inductor. The

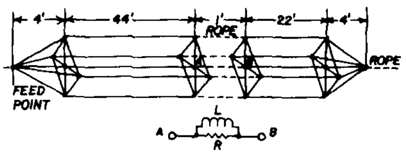


fig. 1. Oblique view of the VK-6 broadband cage antenna. Spreaders are 72 inches long. All five wires are bonded together at each spreader as shown. Connecting ropes join the antenna sections. The matching network is placed between points A and B of the cages. The antenna is fed at the left and a balun is used.

lower cage section is connected to the feedline by means of a transformer. The upper section is about half the length of the lower section. The five-wire cages are made of No. 18 semi-hard drawn copper wire and the spreaders are 1/4-inch diameter fiberglass rods, each 73 inches long. The rods are drilled in the center and at 1-1/2 inches from each end with a 1/16-inch diameter drill, the end holes being at right angles to the center hole.

To fasten a cage wire to the end of a spreader, a short length of steel wire is passed through the end hole and the ends are wrapped around the antenna wire. Another short section of steel wire joins the four arms at the center hole.

This antenna should be asssembled in a clear, flat area such as a driveway. A firm support at each end of the assembly area is required. Four fiberglass spreader assemblies are required; the two center spreader assemblies are connected with insulating ropes to take the strain off the resistor-inductor assembly. It's a good idea to start at one end of the antenna and work towards the other, with the first wire (preferably the center one) strung tightly between the supports. The remaining wires can be built up around the taut center wire.

When the assemblies are completed, short lengths of copper bonding wire connect the outer cage wires to the central wire at each spreader assembly. If the wires are all pre-cut, the spreaders can be adjusted after final assembly to make up for minor inaccuracies in construction.

the fixed network

The network coil is composed of 50 turns of No. 18 wire closewound in the center of a 14-inch section of one-inch (outer diameter) PVC plastic tubing. The ends of the coil are secured by passing them through holes drilled in the form. Six 2.2K, 1-watt resistors connected in parallel (366 ohms, 6 watts) are placed across the coil. The coil assembly is mounted in the center of the two spreader assemblies and secured in position with nylon cord. The wires of the cage sections are connected to the coil ends. The whole assembly should be protected from the weather.

---

*P.O. Box 300, Caulfield, South Victoria, Australia 3162.

the matching transformer

The broadband matching transformer is shown in **fig. 2.** It has a bifilar winding (2 wires). Note that one of the windings is tapped. Take two 4-1/2 foot lengths of two different color No. 18 flexible hookup wires and twist them together by holding the wire ends in a vise and placing the other two ends in a chuck of a hand drill. Keeping the wires taut, wind the drill to twist the wires until there are about two turns per inch. Wind 24 turns of the twisted pair on an Amidon T-200-2 powdered-iron core.** Keep the turns pressed against the surface of the core. Connect the start of one winding to the end of the other as shown in the drawing.

Mark one end of the dual winding with a spot of paint and consider this end the ground end. Count around the core 18 turns from the ground end, then carefully cut one wire of the winding and scrape the exposed ends. Tin the ends and solder them together with a *short* length of wire, making a loop in wire for a tap point. The transformer is now finished and can be mounted, with coaxial fittings, in a weatherproof box at the base of the antenna. The ground end of the transformer is attached to the ground rod and appropriate ground radials or water pipes.

installing the antenna

Because this is an experimental antenna, it would be nice to have the input end at or near ground level for a convenient adjustment and the free end up in the air. To achieve this, the sloper configuration is suggested. The original antenna was run from near gound level at a 45-degree angle to a point 30 feet high. Tests with the antenna in this position showed that it had a nearly-omnidirectional pattern across the operating range and that the antenna was capable of operating at, or slightly above, the 100-watt power output level of the test transmitter, a Drake TR-7. Measurements indicated the antenna feedpoint was capacitive below 5 MHz, rising to an inductive peak at 8 MHz, near zero-reactance between 9 and 13 MHz, and that it presented a gradual rise in inductive reactance above 13 MHz. The mean input impedance over the operating range was about 154 ohms.

**Red coded, powdered-iron core, permeability = 10. Two inches O.D., 1.25 inch I.D. A_L value = 120. Available from Amidon Association, 12033 Otsego Street, North Hollywood, California 91607.

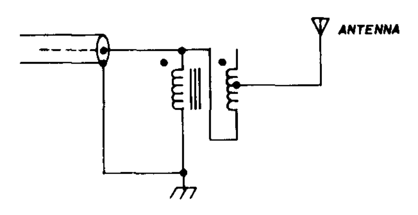


fig. 2. The matching transformer is wound on an Amidon T-200-T powdered-iron core. Twenty-four bifilar turns are used. One winding is tapped for the antenna connection 18 turns from ground. *Note that the tap is on the winding not connected to the coaxial line.* (See text for details.)

On-the-air tests were run on all bands (including 30 meters) with good results. Only daylight tests were run on 160 meters, with excellent signals reported out to 50 miles or so. Best of all, no *antenna tuning unit was required*, making band changing for those with solid-state equipment a breeze.

a vertical version of the VK6 broadband antenna?

This is an interesting antenna for the ham-experimenter who has the time for and interest in new concepts. How might the original design, a wire cage, be modified to form a self-supporting vertical broadband antenna? Such a device would be a popular addition to any ham station, particularly where it would be difficult to erect any other form of efficient broadband antenna. I'll be anxious to hear from anyone who works with this one. (Thanks to VK6IM and VK6YX for refining the concept of the Australian dipole!)

the 4Z4RS two-band quad loop

More and more Amateurs are discovering that the single quad loop makes an excellent and inexpensive single-band antenna. It has the radiation pattern of a dipole and provides a small amount of gain over a dipole mounted at the mid-point height of the loop.

Dave, 4Z4RS, has modified his quad loop to work on two bands without the need for an antenna tuner or balanced feed (**fig. 3**). His design is for 20 and 15 meters. The loop perimeter is one wavelength, 70 feet 9 inches, (21 meters) on 20 meters. The top of the loop is open and a shorted one-half wave, 20 meter open-wire stub is attached at this point. The length of the stub is 34 feet 8 inches (10 meters).

The loop is fed at the bottom by two gamma matches which are parallel-connected to a coaxial transmission line. The whole assembly, including the gammas, is made of wire and the loop is maintained in position by nylon ropes attached to the side points.

General dimensions for the gammas are given in the drawing. The length of the gamma wires and the value of the capacitors determine the degree of match. For adjustment, the 20-meter gamma capacitor is set at minimum capacitance and adjustments are made to the 15-meter gamma to reduce the SWR on the transmission line below 1.5-to-1. The connection between the gamma and the loop is made by a copper clip which can be moved about to

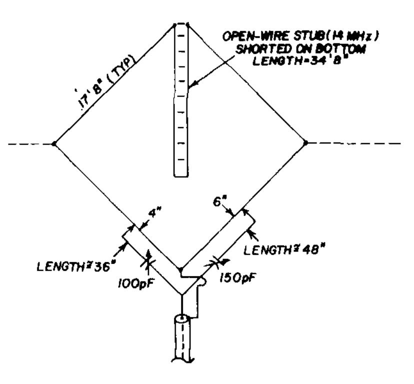
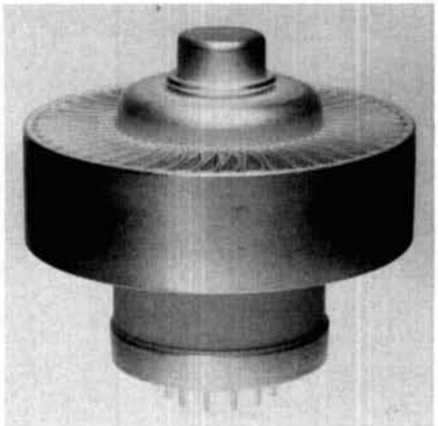


fig. 3. The 4Z4RS two-band quad loop antenna for 20 and 15 meters. Loop is cut for 20 meters and has shorted stub which acts as electrical switch for 15 meters. *Parallel-connected gamma* matches provide good match to coaxial line. Approximate gamma dimensions are shown.

find the proper tap point. Once the 15-meter gamma is approximately set, the 20-meter gamma is adjusted for lowest SWR on the transmission line on that band. The adjustments tend to interact. A second adjustment of each gamma will bring the SWR to near-unity at the center frequency of each band. When properly adjusted, the loop provides a very low SWR across each band with typical readings of SWR at the band edges being 1.5:1, or less.

The higher the loop is suspended in the air, the lower will be the main lobe of radiation; DX operation will be improved if the apex of the loop is over 35 feet high. This puts the bottom of the loop about 10 feet above ground level.



new triode

EIMAC has recently announced the 3CX800A7, a new tube which should be of interest to both Radio Amateurs and the HF/VHF world at large. It's an 800-watt dissipation, "grounded grid," high-mu triode rated for full-power operation to 350 MHz and is useful to 450 MHz. A compact powerhouse, it measures only 2-3/8 inches high from the plate cap to the tip of its base pins. Two tubes will provide 1500 watts PEP or CW output for Amateur service in accord with the latest FCC ruling.

A data sheet including complete specifications can be obtained by writing to me at EIMAC, 301 Industrial Way, San Carlos, California 94070.

reference

1. William I. Orr, W6SAI, "ham radio techniques," *ham radio*, January, 1983, page 67.

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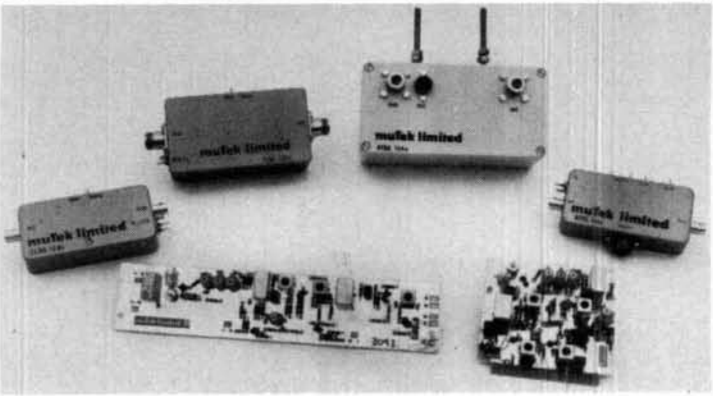

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an easier approach to mastering the Morse keyboard

Learn to type and CW is yours

When the semi-automatic paddle key (better known as "the bug") came along it allowed for code speeds far higher than had ever been possible with a hand key. Its arrival heralded a new era in which CW communications could be exchanged in a shorter period of time and CW was widely accepted among hams. Then came the electronic keyer which, because of its ease of operation and better code generation, rendered the bug almost obsolete. It, too, allowed for faster communications and remains in wide use today.

Over a dozen years ago the integrated-circuit Morse keyboard appeared in the ham journals. The next step in the progression of improved keying devices, it could not only outrun the electronic keyer in speed, but generated flawless CW with a fraction of the effort. I built one from an old typewriter and was so impressed with its operation that it seemed certain KB operating would sweep like wildfire through the ranks of CW operators, but it didn't. Few of the signals heard on today's bands emanate from KBs, despite the fact they can be homebrewed for substantially less than the cost of a paddle keyer, or even purchased ready-made. You would have to have a virtually empty junk box to spend more than $10.00 to create the required logic circuitry, and if you don't have an antique typewriter to mutilate, boards are available in the $20.00 range.

So what went wrong? Why do so few of us use these wonderful devices while the majority continue to struggle along, pushing, pulling, squeezing, or just generally batting around their paddle? The biggest drawback to the use of KBs seems to be that many hams never learned to operate a typewriter and fear that years of practicing monotonous drills would be required to achieve the same speed they have already attained on their paddles. The intent of this article is to dispel this fear.

Another reason for the lack of KB acceptance might be that unless one has the opportunity to operate one on the air, there is no way to appreciate how a KB can add to your enjoyment of CW. Most operators have a desire to increase their code speed, but when listening to the speed merchants who QRQ at 80 or better WPM, believe that such a feat is beyond them and must require an inborn gift or talent. This just isn't so . . . you can do it in less time, and with less effort than you may think.

keyboard operation

Few articles have appeared on the use of a basic KB, so a short refresher might be in order. When a key is depressed it closes a circuit, one way or another, instantly causing the logic circuitry to begin generating the particular character associated with that key *plus* a space. Once started, the logic continues to generate the character even though the key switch is opened before the character is completed. If the key is held down continuously, the character will repeat continually, with perfect character generation and flawless spacing between characters. The logic can produce only one character, plus its space, at a time. The key switches are locked out, or not enabled (if you prefer IC jargon), until that specific character is completed.

By Chet Francis, W1KZ, 83 Main Street, Pittsfield, New Hampshire 03263

Therefore, for smooth CW operation it is only necessary to depress the next succeeding character before the character being transmitted is completed. The longer spacing required between words is merely a pause in typing when no key is depressed.

The preceeding paragraph relates to basic KB logic without so-called memory capability. In recent years some of the logic circuits have been expanded to allow you to type continuously into memories or buffers at a somewhat erratic rate, and have the output appear a few seconds later, automatically smoothed of any timing inconsistencies that occurred in the input.

There is little benefit in being able to type Morse at a high rate of speed if your receiving ability is not equal to it. If there was ever a secret weapon for increasing your receiving speed, it's the basic KB. It may sound like something out of the Twilight Zone, but consider this: young children without the slightest knowledge that Morse characters are formed from dits and dahs have become proficient at Morse by listening to their own typing on a KB and recognizing the various characters by sound only. Most of us learned code the hard way. First dots, dashes, and timing had to be understood and then the characters were memorized. Finally the dots and dashes made letters into words. In transmitting Morse by means of a key or paddle, the brain is called upon to recall all that it learned about the formation of characters. The KB, which makes a sound for the character the instant it is keyed, eliminates that whole process.

In essence, the KB is a tireless teacher that communicates directly with your subconscious with no effort on your part. It follows that, as your typing speed increases, so does your ability to receive, because the brain is no longer required to busy itself with character formation but instead can concentrate on hearing what has been transmitted. You have only to think the letter A, strike that key, and immediately hear dit-dah. The faster you type, the faster you go.

In the early days of keyboarding it was discovered that contrary to popular notion, the speed at which CW could be received was not so much limited by the ability of the ear and brain to comprehend, as much as it was the limitation of the sending device to shape legible code. Few operators have the dexterity or endurance to operate a paddle at sustained high speeds and maintain consistency.

For the most part, ham CW is recreational communication. We're not operating aboard the Titanic, grinding out vital messages with a letter-perfect copy for the captain. In fact, we don't have to make any copy at all; just a few notes will keep a QSO going. With the KB as a teacher, not only does the brain recognize the sound of individual letters at increasingly higher speeds, but a point is reached where you suddenly realize that instead of hearing the individual letters that make up a word, you hear the complete word itself. Morse at that time becomes similar to another language, as if you were hearing French, Spanish, or some other language in which you are fluent. You might be hard-pressed to make a running verbatim translation, but the complete thoughts come through loud and clear.

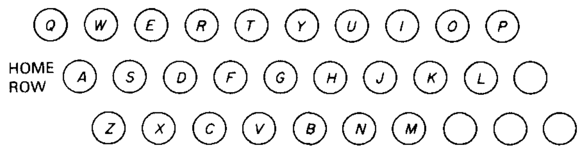


fig. 1. Letters as they appear on the standard keyboard (Qwerty).

Thus, the KB in and of itself can create a whole new world of improved CW communications for anyone who is interested. With a basic KB and the ability to use it, increased Morse proficiency is assured.

keyboard arrangements

Fig. 1. shows the letter characters as they appear on a standard KB. Numerals, punctuation marks, etc., have been omitted. This alphabetical monstrosity is a hodge-podge of letters that could have been set up by any moderately intelligent chimpanzee. Its only redeeming feature is that the first six letters on the top row can at least be pronounced and hence give rise to its name: the Qwerty keyboard. One might like to think that there was some profound scientific basis for the arrangement of the letters, but none has ever been uncovered. Instead, it apparently evolved in 1872 when some inventors were working the bugs out of a typesetting machine. It seems that the type slugs were stored in a basket and suspended on wires to permit movement. These wires often became entangled, particularly when the most frequently used keys were struck. To solve the problem, KB designers simply separated the most frequently used letters from each other, placing less frequently used keys between and among the more useful ones.

Take a look at **fig. 2**; at first glance it may look like the work of another chimp. This KB arrangement, based on the use of letters in the English language, was developed in 1932 by August Dvorak, a professor of education at the University of Washington at Seattle, with funds provided by the Carnegie Corporation (who knew there just had to be a better way to punch a KB). It is generally known as the Dvorak Simplified Keyboard, or DSK. Dvorak spent the grant money well by studying the most-used English words, and how best to type them with the strongest fingers, while minimizing finger travel. His KB layout was proven to be superior to Qwerty in every respect, and his students ran circles around Qwerty experts in learning time, speed, and accuracy. Unfortunately, the DSK failed to catch on because of the inertia that arises when one must make a change from the norm. (Will present-day textbooks ever admit that electrical current doesn't flow from positive to negative?) Much progress is stifled because of the human tendency to resist change.

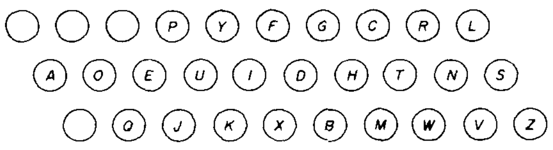


fig. 2. Letters as they appear on the Dvorak simplified keyboard (DSK).

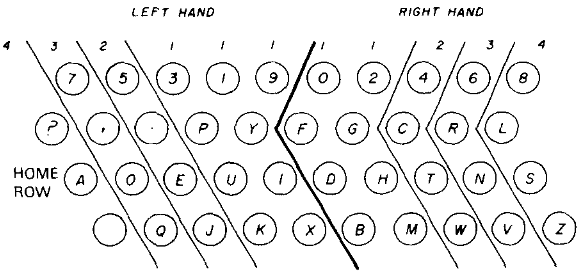


fig. 3. Recommended fingering of the DSK.

To touch-type on any KB, the operator positions his or her hands with the fingers over the center, or "home", row. Any departure from the home row requires effort and concentration. Dvorak placed all the vowels and the most used letters on the home row. Other letters are within reach of the strongest fingers in accordance with the frequency of their use. Think up some common words and mentally type them on the DSK. Try the same words again on the Qwerty board, and make your own decision as to which is easier. You can type about 3000 common words without ever leaving the DSK home row. The DSK system allows 70 percent of the typing to be done on the home row, 22 percent on the upper row, and 8 percent below.

Fig. 3 shows the recommended fingers to use with each key, as well as where Dvorak located the numerals and some punctuation marks. The stronger fingers do double-duty at the center of the board, where the most-used letters are located. The weaker pinky-fingers loaf along and don't often leave the home row. For hamming purposes, location of the numerals is somewhat arbitrary. Most boards have many more keys than shown, so additional punctuation marks and CW procedural signs can be placed on unused keys wherever they seem most convenient.

The DSK is not completely dead, and many typewriter manufacturers will supply them at additional cost. Self-study books are available, but not necessary. The board can be learned quite readily by placing the fingers over the home row, with pinky fingers over the A and S. Stroke the keys and return the fingers to their home position each time they are required to leave it. As each character is learned, cover its key-top with a piece of tape to avoid cheating by peeking.

A few cautions: don't practice by typing from printed material. You can make good progress this way but somehow the printed words flow directly from the eyes to the fingers without stopping in the brain. The brain must be involved, or when QSOing your typing mind is quite likely to go blank. Second, when practicing always type a little faster than you think you can. If you slow down, the choice factor rears its ugly head and errors are much more likely to occur. Be sure to use a keying transistor in the output of your logic circuit, as mechanical relays or magnetic reeds will not move fast enough when you get into high gear. And by all means use a break-in system that allows you to hear incoming signals between your dits.

There is a rhythmic difference between typing alphabetic letters and typing Morse characters, which probably prompted development of the memory learning systems previously mentioned. In alphabetic typing the keys are all stroked at the same speed, in an even cadence. With CW, however, you can linger a while on the longer characters, such as Y, before going on to the next character. The shorter characters, such as E, must be vacated as soon as they are struck and the succeeding character immediately activated. This demands irregular finger movements but, by monitoring the output, perfect timing is readily achieved on the DSK. Storage systems are an unnecessary adjunct to the basic KB, and defeat its usefulness in gaining higher receiving speeds.

Most people are able to learn the locations of all the letters in about two weeks. That's the hard part, but once accomplished you're into a typing system that will have you typing more than 100 WPM in less than a year. And believe it or not, there are ears out there that will be able to copy you.

ham radio

VHF/UHF WORLD

Joe Reisert W1JR

VHF/UHF exciters

It wasn't too many years ago that VHF/UHF'ers used AM, FM, and CW with tube or varactor multiplier transmitters almost exclusively. While signals weren't always that stable, neither were the receivers; VHF was considered a quiet refuge away from the QRM on HF and was considered good only for local ragchews or experimentation.

With worldwide DX becoming commonplace on the frequencies above 50 MHz,[1] those days are now a distant memory. Most modern receivers have low noise figures and are very frequency stable.[2] Hence most weak-signal VHF/UHF'ers now prefer to use either CW or SSB at the flip of a switch. DX is suddenly possible where it was never expected to appear, and as a result, the old tube or varactor multipliers with their chirps and key clicks are now being replaced.

With this in mind I thought it would be a good time to review some of the techniques presently being used as exciters on the VHF/UHF bands and to show some simple circuits you can build in your shack. Hopefully this will convince you that trying out some of the higher frequency bands doesn't have to be expensive or complicated. Who knows? Maybe you'll find that there's still some room for exploration and experimentation, and that you, too, can contribute to the state-of-the-art. New propagation modes are rarely discovered without activity!

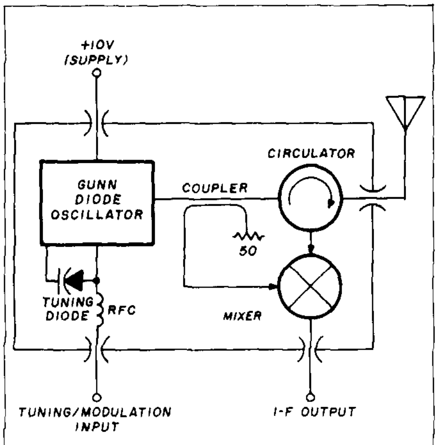


fig. 1. Typical Gunnplexer™ configuration.

exciter techniques

There are basically three ways to build a VHF/UHF exciter: first, a free-running oscillator; second, a multiplier; and third, a transverter. Although the free-running oscillator may seem ludicrous, don't forget that this technique, shown in **fig. 1**, is still very popular on the 3 cm (10 GHz) band. Gunn-Plexers™[3], transceivers that use a single common Gunn diode oscillator as both a varactor-modulated FM transmitter and as the local oscillator for the receiver downconverter, are in widespread use. However, this scheme is not stable enough for narrowband work unless it is frequency-locked to a reference.

Tube multipliers (**fig. 2**) used to be very popular. Since the oscillator was usually at some low frequency (for ex-

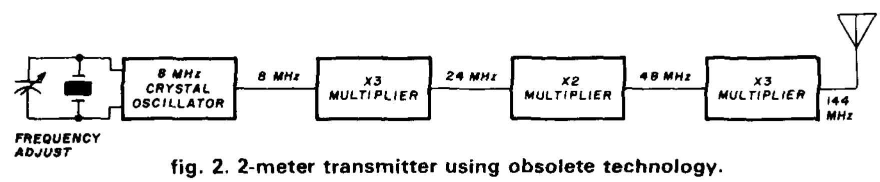


fig. 2. 2-meter transmitter using obsolete technology.

ample, 8 MHz), the only way to adequately control frequency was by using a crystal oscillator. Some VHF/UHF'ers added a variable capacitor across the crystal to slightly "rubber" the frequency. However, especially when using vacuum tube local oscillators, the frequency stability was poor. Hence, in the "good old days," some EME'ers even buried their oscillators in the ground in order to make their stability more acceptable!

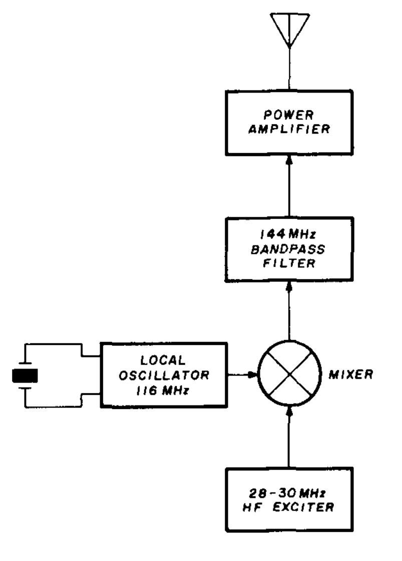


fig. 3. Typical 2-meter transverter.

Most of these problems disappeared when transverters (**fig. 3**) became popular, especially when transistor oscillators were used. A transverter is basically an upconverter or mixer working inverse to the normal receiver downconverter. The primary advantage is that the local oscillator can run continuously and thereby attain a high order of stability. A low frequency transmitter (driver) is mixed with this LO and is usually the main frequency-determining element. Since HF rigs are now quite stable up through 30 MHz, they make a natural driver for such an application.

transverter basics

There are basically two types of transverters: low level and high level. In the low level type, the signal from the driver is typically less than one watt; 1 to 10 milliwatts is most common. This approach requires considerable gain, but is easy to obtain using inexpensive solid-state devices. The high level type has most often been used with vacuum tube mixers such as the 5894, 6360, 6939, or 2C39/7289.

Although I started out on VHF/UHF using 6360s and 6939s, I soon tired of all the drifting and warm-up problems associated with vacuum tubes. Furthermore, I didn't appreciate all the different high voltages and the heat associated with tubes. So I spent many hours developing solid-state approaches, especially those that were low in cost and easy to duplicate. What eventually evolved was a compatible system for all the VHF/UHF bands through 13 cm (2304 MHz), using only 1 milliwatt of drive from my HF exciter and providing 200 to 500 milliwatts of output power on each of the bands mentioned. Because space is necessarily limited, I'll discuss only the 2 meter through 70 cm (432 MHz) circuits in this column. A block diagram of their scheme is shown in **fig. 4**. (Is there any interest in circuits for any of the other bands mentioned? *Let me know.*)

circuit details

The heart of any transverter scheme is the mixer. Single diodes, bipolar transistor and dual gate FET mixers were all discarded for various reasons in the early stages of development and

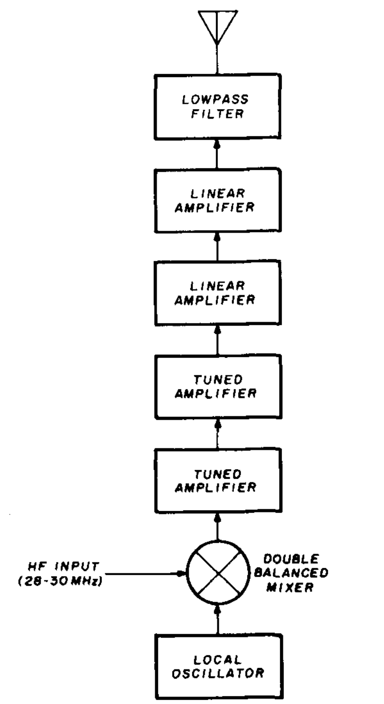


fig. 4. Block diagram of the 144/220/432 MHz transverter discussed in text.

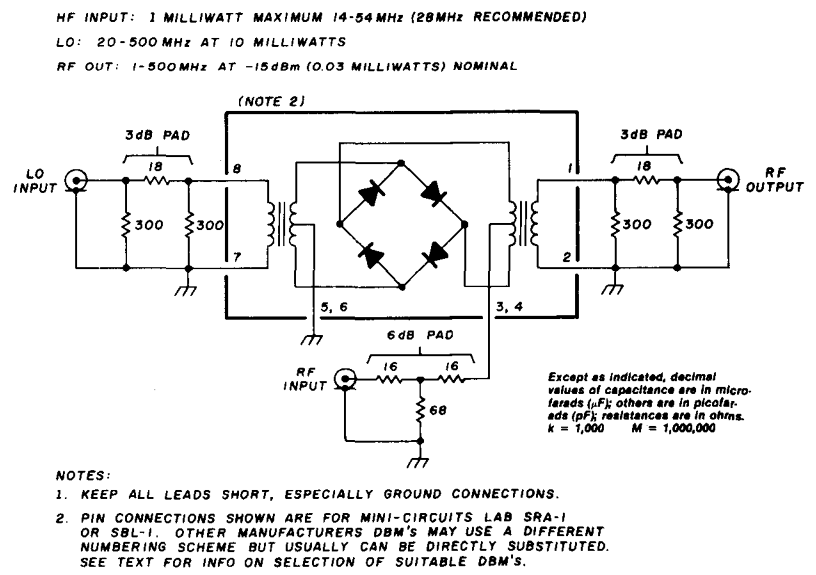


fig. 5. DBM up-converter for VHF/UHF transmitters.

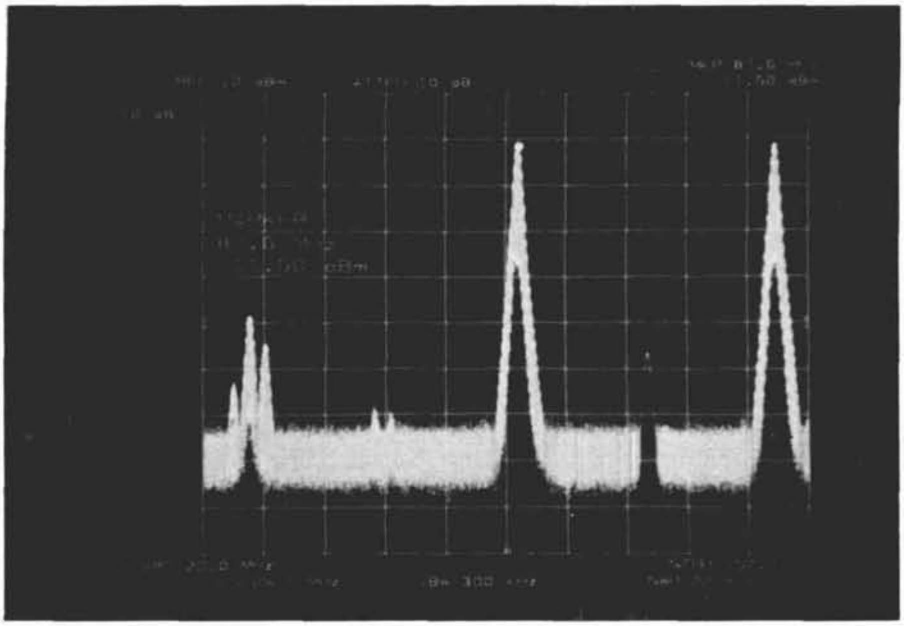


fig. 6A. 2-meter transmitter converter output spectrum from DBM.

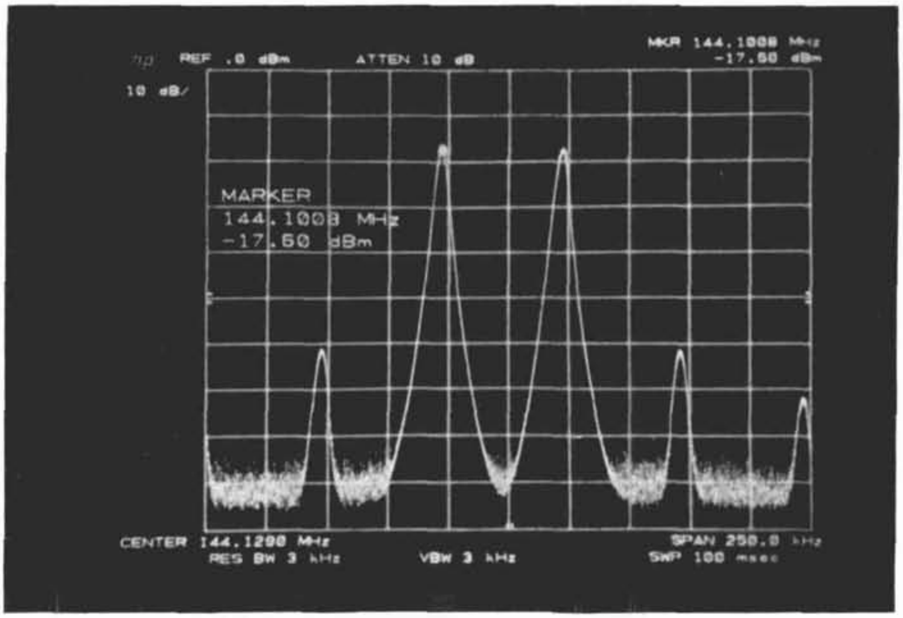


fig. 6B. 2-meter transmitter converter output spectrum at desired frequency range.

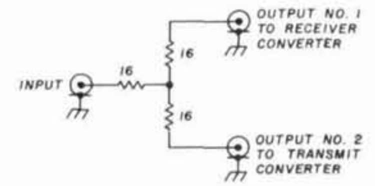


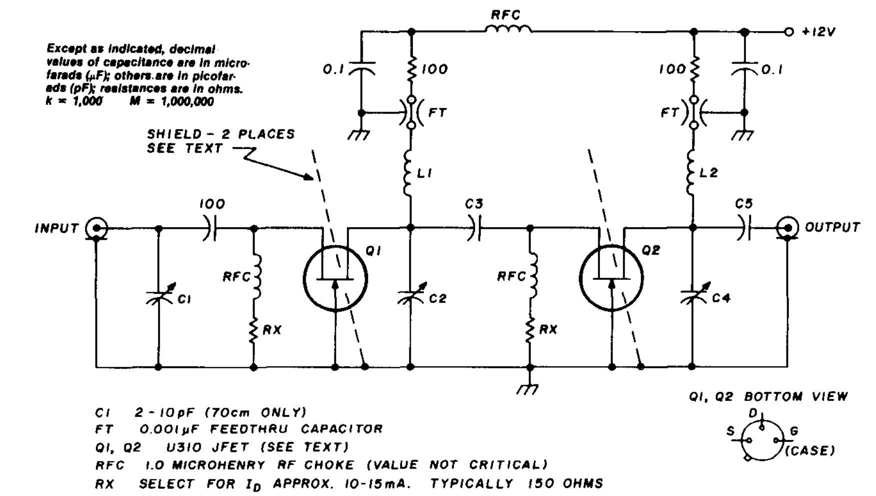
fig. 7. Simple two-way 50 ohm power splitter.

eventually replaced with the ubiquitous DBM (double balanced mixer), which is 50 ohms at all ports. The common low level (5 milliwatt LO) DBM was chosen because higher level DBMs cost more than twice as much as low level DBMs and require 10 dB more local oscillator power. The circuitry is quite similar in concept to the receiver downconverter described in last month's column.[2] The main differences are that the receive input is now the transmitter output, and the IF output is now the input (see **fig. 5**).

Early in the design phase I decided that the IMD (intermodulation distortion) in the mixer had to be quite good — (much greater than 30 dB down) — because each successive amplifier stage would degrade the final performance by a small amount. The use of 1.0 milliwatt drive from the exciter and a 6 dB attenuator pad on the IF port provided the optimum balance between the IMD desired and the conversion loss in the mixer. A typical broadband two-tone output spectrum from the mixer of 2-meter transverter using this scheme (see **fig. 5**) is shown in **fig. 6A**. A close-in output spectrum is shown in **fig. 6B**. Note that the output level is approximately 0.02 milliwatts and that the IMD is down over 40 dB, a good start for a low-level transverter. Again, the Mini-circuits Labs SRA-1 was much better than their SBL-1. Additional details on the DBM selection are described in reference 2.

The LO (local oscillator) is provided by a solid-state overtone oscillator and multipliers where required, with typically 10 milliwatts output similar to the one described in last month's column.[2] If transverter operation is desired, a simple minimum-loss "T" pad (**fig. 7**) can be substituted in place of the output attenuator in the LO and thus provides the required dual outputs. The LO will not be described here since it was well documented in last month's column.

The output of the DBM is the desired signal plus its image and feedthrough from the LO and driver (**fig. 6A**). Therefore some filtering is required. Until recently I used a bandpass filter following the DBM, but I now find that if you use narrow-band tuned amplifiers with good input VSWR, extra filtering is usually not required. My favorite tuned amplifier uses two simple grounded gate U310 JFETs (**fig. 8**). The U310 is usually thought of as a low-noise receiving preamplifier, but it makes an excellent stable linear amplifier with a typical



	144 MHz	220 MHz	432 MHz
C2, C4	2-18pF	2-10pF	2-10pF
C3, C5	3.0pF	2.0pF	1.0pF
L1, L2	4T, NO.20 AWG 1/4" (6.4mm) ID x 1/2" (12.7mm) LONG	3T, NO. 20 AWG 1/4" (6.4mm) ID x 1/2" (12.7mm) LONG	1.0" (25.4mm) NO. 20 1/4" (6.4mm) ABOVE PC BOARD

fig. 8. Low-level JFET linear amplifier schematic.

gain of 10-12 dB per stage and over 10 milliwatts linear output. Input VSWR is typically 1.5:1 without matching networks, and half-power bandwidth is typically 2 to 3 percent of the operating frequency. *Do not substitute any other JFET for the U310 since others may not have the gain and/or stability necessary for this circuit to perform to specification. The J310, for instance, is the same chip in a plastic package, but it is potentially unstable above 100 MHz.*

The output of the two-stage U310 circuit is typically 1 to 5 milliwatts if used with the DBM as shown in **fig. 5** — hardly enough to make many DX contacts! Hence more gain is required. A broadband feedback type linear amplifier using constant current source biasing (**fig. 9**) was designed. This amplifier design has moderate gain (typically 10 to 15 dB per stage) and good linearity with typically 100 to 250 milliwatts on SSB and 0.5 watts output on CW. It uses low-cost ($5.00 - $10.00) CATV type stud-mounted transistors. Most of my linear amplifier circuits use the Microwave Semiconductors Inc. 82091 but other similar devices such as the Acrian CD1899, NEC NE74020/2SC1251, Solid-State Microwave SD1005, and TWR LT2001 will also deliver similar performance. This kind of device is typically a 1-watt output transistor with a 1.5-2.5 GHz F_T that has been optimized with internal emitter ballasting resistors for good linear operation in CATV type amplifiers. Class "C" type transistors are not recommended because they are usually highly non-linear.

The constant current source[4] allows the emitter to be at a low impedance or directly grounded while providing excellent controlled collector current in the power amplifiers. The 39 and 13 ohm resistors (R3 and R4) "set" the stage current at nominally 50 and 150 mA respectively regardless of the device. A simple lowpass filter on the output stage eliminates any harmonic output if this is the final stage of your transmitter.

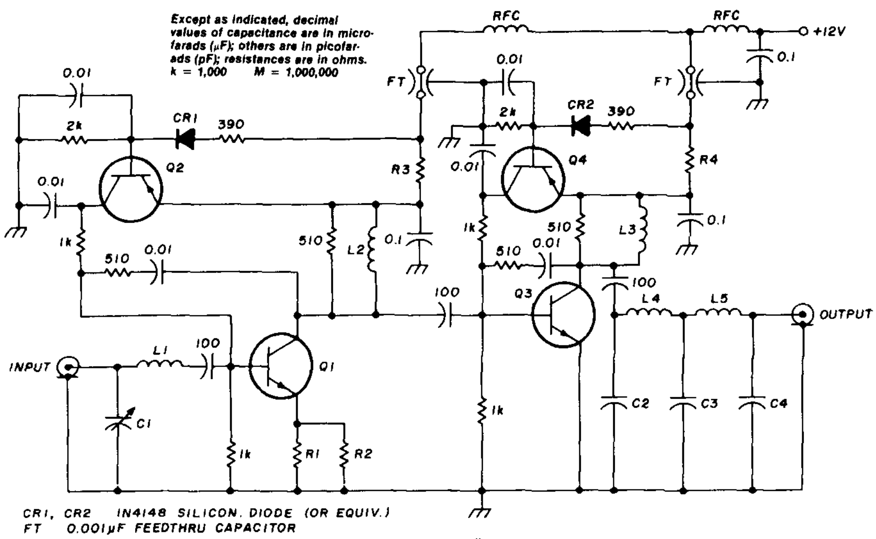
The above amplifier was specifically designed to work on 12 to 13 volts DC. Greater output power is available if the supply voltage is increased and the biasing resistor values are changed, but this is beyond the scope of this article. Also, if you are fortunate enough to have access to typical general purpose broadband hybrid amplifiers or CATV amplifier chips, these may also work; but they must be evaluated on a one-on-one basis because they come in a variety of gains and power output, and may therefore require different power supply voltages.

construction notes

The leads on the DBM — particularly the grounds — should be kept as short as possible. If you substitute another DBM, check the pin connections carefully since some manufacturers number the pins differently. I prefer to mount the DBM in its own shielded box with 3 "BNC" type connectors. If you do this, you can use the same mixer for any band within the specified frequency range of the DBM by just changing the LO!

The low level U310 amplifier is quite easy to build. Again I suggest that this circuit be built in its own shielded box; I suggest the Bud CU-124 or any equivalent cast aluminum box. First cut a piece of double-clad PC board to fit inside the cover of the box. Then drill the holes for the input/output connectors ("BNC" preferred), the transistors and feed-through connectors with the PC board in place. Next attach the feed-through capacitors and input/output connectors which hold the PC board in place. The U310s are inserted upside-down in a round hole (use a No. 11 drill) approximately 0.191 inch (4.85 mm) in diameter. The can is then quickly soldered to the PC board ground. Next the rest of the RF circuitry is soldered in place; all grounds can be easily attached with short leads to the PC board. Next, shields approximately 0.75 inch (19 mm) high and the width of the PC board are made from the same type material. They are first notched to pass the U310 leads and then sweat-soldered directly to the PC board across the JFET, providing input-to-output isolation. The 100-ohm resistors and associated circuitry in the drain lead can be mounted on top of the box on standoff insulators.

The output amplifier is constructed



CR1, CR2 IN4148 SILICON DIODE (OR EQUIV.)
FT 0.001µF FEEDTHRU CAPACITOR
L2, L3 5T NO. 20 AWG ON 1/4" (6.4mm) DIAMETER x 0.5" (12.7mm) LONG
Q1, Q3 SEE TEXT
Q2, Q4 2N2905 OR EQUIV. HIGH GAIN PNP TRANSISTOR
RFC 1.0 MICROHENRY RF CHOKE. VALUE NOT CRITICAL
R1, R2 10 OHMS, 1/4 WATT
R3 39 OHM, 1/4 WATT
R4 13 OHM (THREE 39 OHM, 1/4 WATT, RESISTORS IN PARALLEL)

	144 MHz	220 MHz	432 MHz
C1	NOTE 1	NOTE 1	1-10pF
C2, C4	24pF	18pF	NOTE 1
C3	47pF	36pF	NOTE 1
L1	NOTE 1	NOTE 1	1/2" (12.7mm) LEAD ON THE 100pF CAPACITOR
L4, L5	6T, NO. 24 AWG ON 0.1" (2.5mm) DIAMETER 0.25" (6mm) LONG	3T, NO. 24 AWG ON 0.1" (2.5mm) DIAMETER 0.125" (3mm) LONG	NOTE 1

fig. 9. Medium-power linear amplifier.

in the same type box and in the same manner as the U310 stages. In this case the linear transistors are stud-mounted. First drill the hole to clear the transistor stud. Then enlarge this hole only on the PC board to approximately 0.32 inch (8 mm) in diameter to allow the body of the transistor to pass through. Next bolt the connectors and transistors to the cover. Again, all wiring is point-to-point and grounds are kept to a minimum by soldering directly to the PC board. The box cover acts as a heatsink for the power transistors.

testing

The DBM doesn't really require any testing. First connect the LO with 10 milliwatts to the proper input. Then set your driver output for 1 milliwatt. With the modern solid-state rigs an auxiliary output with typically 10 to 500 milliwatts is usually available. To insure that the driver is operating properly, it is best to operate at normal levels so that the ALC is activated. Therefore I recommend that you place an external "T" or "Pi" pad of the required value on the driver output to guarantee that only 1 milliwatt is present at the mixer input connector rather than just turning the gain control down. If you do not have a low-power output connection, use a suitable dummy load and capacitively couple out the proper power level.

Now connect the RF output from the mixer through a short coax cable to the two-stage JFET amplifier. Apply the proper power and input frequency from the exciter and peak each stage for maximum output. There may be some interaction between the stages, so repeat the peaking until you can't obtain any more output power. If you have a power meter, measure the output level. It should be between 3 and 10 milliwatts, less at the higher frequencies.

Next connect the low power stage through a cable to the medium power stage and put a power meter on the output. Lower the exciter drive so that the output is about 100 milliwatts and peak the input trimmers (if used) for maximum power. Also repeak the last U310 output stage. Apply the proper drive and measure the output power. If it is greater than 500 milliwatts, you may want to reduce the exciter input slightly, or better yet, place a low value pad between the JFET and bipolar stage to preserve linearity. This output level should be sufficient to work locals. If more power is desired, there are many suitable circuits or commercial amplifiers available to get you to the desired power level.

summary

In this month's column we have discussed several approaches to building VHF/UHF exciters, but have recommended the transverter for its stability, linearity, and versatility. Several circuits and construction techniques have been presented to allow you to "roll your own." You no longer have a good excuse for not trying these frequencies. Furthermore, if you use this method, you can build on more gain and power later without having to start all over again!

references

1. Joe Reisert, W1JR, "VHF/UHF World: the VHF/UHF Challenge," *ham radio*, January, 1984, pages 42-43.
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3. James Fisk, W1HR, "Solid-State Microwave RF Generators," *ham radio*, April, 1977, pages 10-22.
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VHF/UHF coming events

April 7-8: Best EME Weekend
April 16: ARRL 2-meter Sprint Contest
April 21: Predicted Peak, Lyrids Meteor Shower (0800 UTC)
April 24: ARRL 220 MHz Sprint Contest
April 27-29: UHF/VHF Conference, Dayton Hamvention (Contact WA8ONQ for information.)

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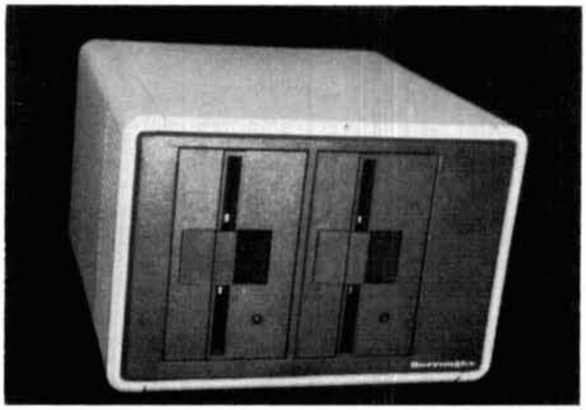

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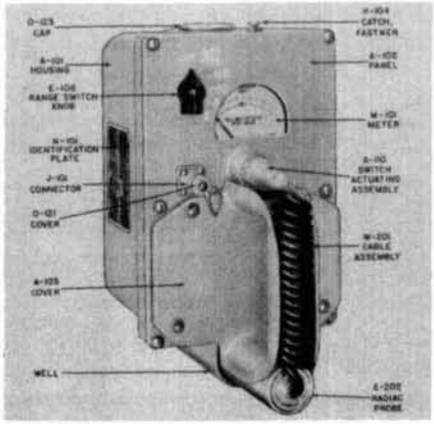

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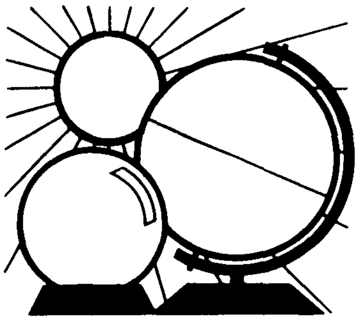

DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

April is an equinoctal (i.e., the length of day and night is approximately equal) month. Consequently, it's reasonable to expect geomagnetic-ionospheric disturbances, with enhanced transequatorial propagation on the 10 to 30-meter bands. Disturbances are most likely to occur between April 1-5, 8-13, 16-19, and 25-28.

DX openings for the higher frequency bands, 10-30 meters, should be best about the 8th or 21st; because solar flux and activity are becoming more difficult to predict for this part of the forecast, be sure to monitor WWV at 18 minutes after the hour for the most current solar flux information.

The lower frequency bands are expected to be very good this month. But this will be one of the last months before the general northern hemisphere thunderstorm noise buildup becomes noticeable.

The perigee of the moon's orbit (for moonbounce DX) is on the 13th; the moon will be at full phase on the 15th. There will be a short meteor shower, the Lyrid, on April 20-22 with a rate of five per hour — hardly much help for meteor-scatter DX. But a bigger shower, the Aquarid, starts before the end of April, peaks on May 5, and ends in mid-May. Its rate is 10 to 30 per hour.

solar cycle effects

In September's column I reviewed the solar cycle and presented a formula relating critical frequency, foF2, in the mid-latitudes to solar indices. Its significance is that the foF2 is the most variable factor of radio signal propagation. The maximum usable frequency (MUF) for the path is approximately 2.5 times the critical frequency.

How has the solar cycle/MUF cycle decline progressed so far? From early 1982 until December, 1983, the sunspot number (SSN) declined quite rapidly — about 40 units per year. Since then a more leisurely decrease (about 20 units per year) has been reported. This rate is expected to continue until the SSN "bottoms out" in 1986.

The SSN for May, 1983, was down to 77.1. The energy output of the sun (solar flux) decreased along with SSN, and with that the foF2 and MUF have been dropping, too.

You probably noticed the drop, particularly by November and December of last year; low radio flux and solar activity for nearly two weeks in a row made MUF decreases very noticeable. Ten meters was not open very long — if at all from some locations — by the end of the period. The 15-meter band wasn't too much better. Even the 20-meter band closed earlier in the afternoon. Several of the beacons I monitor dropped out early in the day, and my WWV monitoring and data-gathering activity had to drop down a standard frequency band for that two-week period.

Another solar cycle effect noticeable over the last few winter months was longer distances and better signal strengths on the lower frequency bands during the daytime; this was particularly noticeable on 40 meters. The lower level of D region ionization, near sunspot minimum, combined with the sun's being in the southern hemisphere, caused lower signal attenuation. Lower ion densities mean less signal absorbed in the D region. The effect should be somewhat effective even this summer, and next winter, even more so, as the SSN will have decreased a bit more. However, even the lowering of the attenuation or lowest usable frequency (LUF) does not make up for the decrease in maximum usable frequency. Because the extent of the frequency range, LUF to MUF, decreases during these SSN minimum years, we should try to use the 160-meter band more effectively to compensate for loss of propagation on the higher frequency bands.

band-by-band summary

Ten meters will be open to the south and southeast for a short period before local noon, to the south at noon and to the southwest in the afternoon. The openings will be longer when the solar flux is at its 27-day cycle maximum. Even better transequatorial one-long-hop conditions will occur during disturbed periods. Tune in WWV at 18 minutes after the hour and note particularly the geomagnetic field status announcement.

Fifteen and twenty meters, almost always open to some part of the world, will be the main daytime DX bands. Twenty should stay open on long southern paths into the night, while 15 will drop out in the late afternoon. Operate 15 first and move down to 20 meters. DX is 5000 to 7000 miles (8000 to 11,200 km) on these bands and one-long-hop transequatorial propagation is also possible as on 10 meters.

APRIL

WESTERN USA

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

MID USA

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

EASTERN USA

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

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

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

Thirty and forty meters are both day and night bands. Intermediate distances (1000-1500 miles, 1500-2200 km) in any direction is daytime DX. Nighttime DX on these bands may be expected to offer a greater distance than on 80 meters and, like 80, follow the darkness path across the sky. Reduced midday signal strengths and distances may occur on days of high solar-flux values, with 30-meter openings disappearing in the pre-dawn hours on the morning after the high radio-flux value.

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

Coastal stations and those with good low-angle radiating systems will usually have the edge for working rare DX. QRN will be as low as on some nights as experienced during the wintertime DX season.

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the HP-IL serial loop

new method transfers digital data

As noted in last month's article,[1] Hewlett Packard was the driving force behind the definition and subsequent universal acceptance of the HP-IB or Hewlett Packard-Interface Bus. After having established this standardized method of exchanging parallel digital data, the company has once again set out to establish (if they haven't already) another digital data transfer method called the HP-IL, short for *H*ewlett *P*ackard *I*nterface *L*oop.

To encourage universal acceptance of this serial, considerably less expensive, and simpler convention, the company has developed the innovative HP-IL Interface kit. This kit, the simple serial data transfer convention (soon to be a standard), and various pieces of HP-IL-compatible equipment already developed are the subject of this article.

The loop concept. Table 1 compares the important features of HP's two digital data transfer methods, noting also their important differences. Unlike the HP-IB, the HP-IL is a *uni*directional transmitter of serial digital data that transmits data to the next HP-IL device. Along with the data, sufficient energy is transmitted to energize the next HP-IL device in the loop. The waiting device rests idly until energized, making battery-powered portable operation a reality. Once the data has been transmitted through all the HP-IL devices, it returns to the transmitter/controller and is checked for errors. This checking process simply compares the data initially transmitted with the data returned after completion of the loop.

Master/slave configuration. Digital data transfer schemes use a concept of a "talker" (transmitter) and a "listener" (receiver), as discussed in the previous article. With the HP-IL, one talker is designated as the controller, or master; by necessity, all other devices within the loop are slaves — regardless of whether they are inherently listeners or talkers by design. It is possible, however, to operate without a controller. For example, a voltmeter (talker) could log readings onto a printer (listener). The use of multiple controllers with prioritized levels of interrupts is also possible.

The two HP controllers most useful with the HP-IL are the HP41 handheld calculator and the HP85A computer (**fig. 1**). Since the HP41 enjoys widespread popularity, we'll discuss only calculator controller applications in this article.

Novel logic conventions. Conventional digital data, logic highs and lows, have certain inherent and distinct voltage levels: for example, a TTL high is approximately 3.2 V and a low is near ground. However, in the NRZ (non-return to zero) convention, a change in magnetic flux is interpreted as a logic high and a lack of change, as a logic low. (This is very useful with magnetic tape recording). Therefore, with NRZ, only transitions (whether they be rising or falling edges) — not levels — constitute logic states. All non-transitions are logic zeros.

The HP-IL uses an unusual but clever convention called three-level codes. This convention results in greater noise immunity, higher reliability, and less power consumption than normal two-level codes, with their narrow pulse widths that require precise one-shots or digital timers (which are difficult to accomplish with micropower IC technology).

With three-level codes, a logic high pulse is a + 1.5 V followed by a − 1.5 V and the opposite is a logic low (see **fig. 2**). This is good because if a high or low pulse occurs during an electrical interference, it must be followed by a pulse of the opposite magnitude or it will be ignored as invalid. Transmissions are each 11 bits long and occur in frames with a special encoded 1 and 0 for synchronization at the beginning of a frame. (These are designated as 1S and 0S respectively in **fig. 2**. The "S" stands for *synchronization*.) Five of the 11 bits are for device identification; that is, $2^5 = 32$, but since a state of all zeros is invalid, a possibility of 32 minus this one state yields 31, and this is precisely how many HP-IL devices can reside within the loop.

Pulse transformers. Instead of semiconductor line drivers and receivers, transformer-isolated line drivers and receivers are used. Transformers make it easier to generate the three voltage levels required with the HP-IL code. As passive elements, they require no standby power, as previously mentioned. Transformers also have no DC component and help avoid ground loops; a 100 ohm transmission line driven with a 1.5 V level requires 10 times less power than one driven with a 5 V level. With a transformer, impedance transformation is also easy,

By Vaughn D. Martin, 114 Lost Meadows, Cibolo, Texas 78108

table 1. Comparison of HP-IL (loop) to HP-IB (bus).

		function	
model	**speed**	**data format**	**semiconductor technology**
HP-IL	20 Kbits/sec. theoretical 5 Kbits/sec. actual	serial	CMOS
HP-IB	1 M bytes/sec.	parallel in bytes	TTL/bipolar
	transmission length limit	**power consumption**	**addressing/ease of programming**
HP-IL	100 meters with twisted shielded pair, 10 meters with zip cord wiring	low, state-of-the-art in conductor and micro-power design techniques	automatic
HP-IB	20 meters (62 feet)	moderate, typical bipolar rate	conventional
	ease of physical interfacing	**connector type**	**characteristics of intended instrument group**
HP-IL	very easy, male-to-female/ data flows out of male into female	simple 2-pin male/ female plug	low cost, relatively simple
HP-IB	relatively easy	25-pin subminiature "D"	moderate cost, more sophisticated

fig. 1. HP41 and HP85A controllers.

as we will later discover when examining the HP-IL Interface kit.

Compatibility. Shortly after the announcement of anything new in electronics, a flurry of kindred devices inevitably appears — generally with no apparent standardization in mind — resulting in a total lack of compatibility among equipment. Remember the first op-amps with all sorts of packages and pin configurations? Once standardization occurred, an 8-pin minidip had to have its pins in an accepted pattern because when manufacture of a product was begun, the production line couldn't be stopped for alteration of the PC board to accommodate a different pinout. A more recent example occurred in the struggle between the two EPROM giants, Intel and Texas Instruments, when each produced electrically identical 24-pin ICs with different pin configurations.

In response to these circumstances, HP developed the HP82166A HP-IL converter (**fig. 3**), which transforms noncompatible general-purpose I/O devices into HP-IL devices. I believe this will be the key to the HP-IL's success, since this device interfaces the HP-IL with the outside world. One would hope that other manufacturers will build this capability into measurement instruments in the future rather than require the use of more costly computers to interface with the instrument.

Those readers who own home computers may be familiar with the VIA (versatile interface adaptor) or PIA (peripheral interface adaptor), which are programmable I/O ICs with ports programmable as inputs and outputs. While based on the same underlying concept as PIAs and VIAs, the HP-IL converter is much "smarter" than these devices and can recognize HP-IL instructions and data, and change both from the HP-IL serial format to an 8-bit parallel format. This is done by control logic manipulating a transfer buffer. A buffer is no more than a group of registers (in this case 32) that holds data. It also, through its control logic, stores operating information, implements selected operating modes, and controls the flow of and the way in which data is interpreted within the converter.

Calculator as controller. Of the multiple plug-in ports on the back of the HP-41 — a feature that has intrigued many owners — four are available for plug-in RAMs,

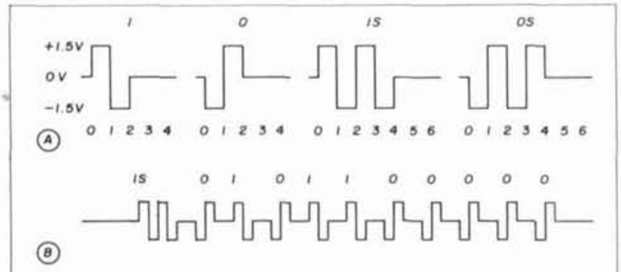


fig. 2. Three-level code (A) makes information a function of level transmissions only. An example of an encoded message — the Send Data ready frame — is shown in (B).

fig. 3. HP82166A HP-IL converter.

fig. 4. The HP-41 can be safely linked to the HP-IL by using the HP82160A module.

fig. 5. HP3468A HP-IL DMM and the HP3478A HP-IB DMM.

fig. 6. HP8216A HP-IL digital cassette drive.

ROMs, a card reader, a thermal printer, and a bar-code reader. Not surprisingly, HP-41 owners have yearned for a way to use these ports for communication with the outside world, but Hewlett-Packard has been reluctant to accommodate this desire, and with good reason: the unit's delicate CMOS circuitry can be easily damaged by improper connections made by overeager experimenters.

The HP-41, however, can be linked to the HP-IL via the HP82160A module (**fig. 4**), which plugs into any of the four ports mentioned above. The module receives its power from the HP-41; two 28-inch (71 cm), two-wire cables extend from the module. Their ends are composed of two male and two female connectors. Cables can be up to 32.8 feet (10 meters) with simple stranded wire or up to 328 feet (100 meters) with twisted, shielded pair wire. Each HP-IL peripheral is in turn supplied with two connectors.

Applications. The unique ability of the HP-IL to poll its accessories allows the operator to simply enter a PRINT command; the network is then searched for the first available printer upon which any message in plain English may be printed. (This function would be ideal in a manufacturing facility in which relays had to be controlled, indicators read, and decisions made with this data that would allow plant operators to obtain essential information without delay.)

A DMM made just for the loop. The HP3468A DMM measures all five electrical parameters (AC and DC current and voltage, and resistance), is self-calibrating, and works in the loop. This 5 1/2-digit instrument costs $695 compared to its near-twin, the HP3478A, which costs $1300 (see **fig. 5**). While the 3478A does have added RAM calibration constants and is characteristically much faster because it is an HP-IB, rather than an HP-IL, instrument, the HP-IL DMM, HP3468A, can be used with the HP-41 handheld calculator and other HP-IL instruments such as the HP8216A digital cassette drive and the HP82162A thermal printer (see **figs. 6** and **7**) to make a data logging system suitable for data from semiconduc-

fig. 7. HP82162A HP-IL thermal printer.

fig. 8. HP82905B impact printer.

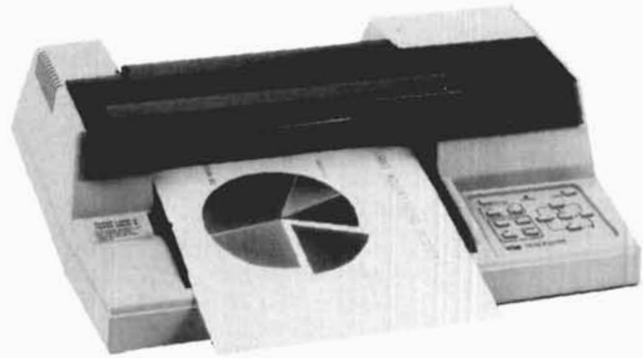


fig. 9. HP7470A graphics plotter.

fig. 10. HP82163A video interface.

fig. 11. HP82938A HP41-to-80 series computer interface.

tors or thermocouples. The HP41 also allows computation of complex math functions such as converting a voltage into dBs and then printing it out.

Other HP-IL devices include the HP82905B impact printer; the HP7470A graphics plotter; the HP82163A video interface, which permits 16 video lines of 32-characters to interface with a VHF TV; and the HP82938A interface, which allows the HP41 to link with the larger 80 series HP computers. **Figs. 8** through **11** illustrate these devices.

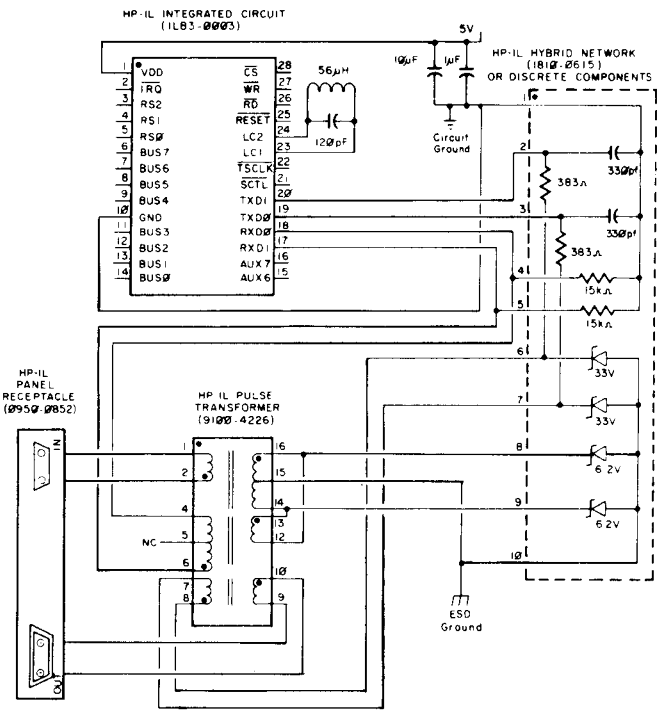


fig. 12. HP-IL interface connection diagram.

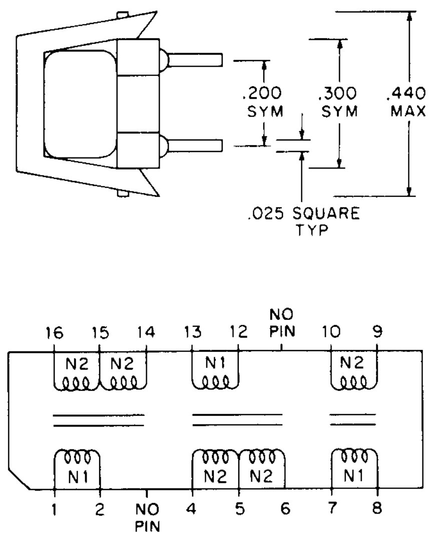


fig. 13. HP-IL transformer set (16-pin DIPheader).

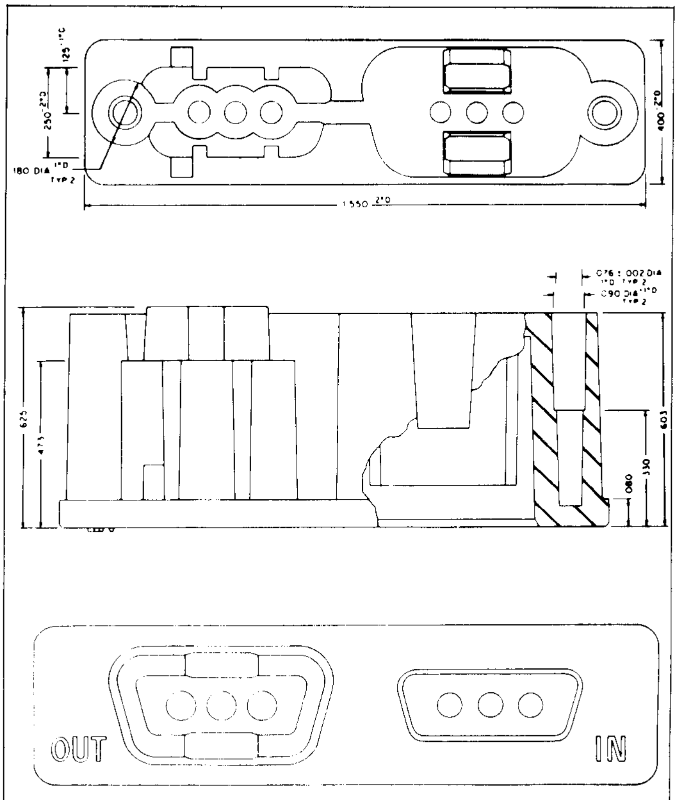


fig. 14. HP-IL panel receptacle.

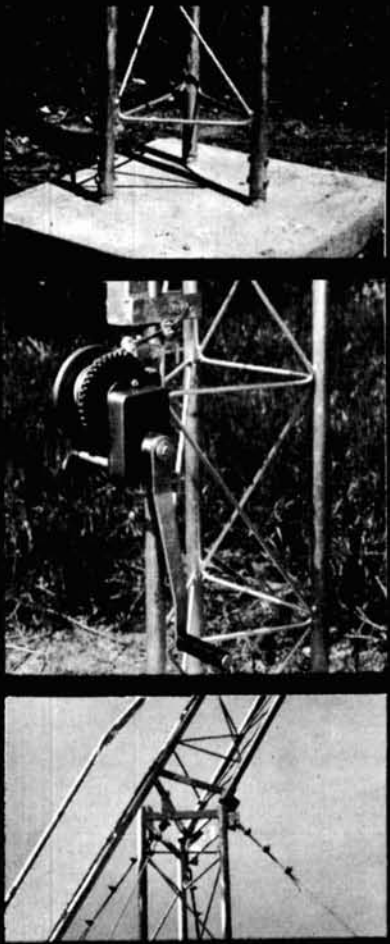
The HP-IL interface/prototyping kit. This kit, the HP82166C, costs $395 and consists of two converters, a test board, cabling, and excellent documentation which allows prototyping of loop-compatible products. Its key components consist of the HP-IL interface connection, the HP-IL transformer set, and the HP-IL panel receptacle (see **figs. 12** through **14**).

The HP-IL IC appears to most standard microprocessors as eight memory or I/O locations. Reading and writing into its registers results in such actions as transferring data or a whole message and setting service request bits. This IC also handles all aspects of the loop's time-critical protocol. The ESD beside the ground symbol in **fig. 12** stands for *e*lectro *s*tatic *d*ischarge and is there for protection of the IC's delicate micropower CMOS circuitry. The transformer set provides for electrical isolation, impedance matching, and voltage level conversion, as previously mentioned, and the panel receptable set provides for foolproof mechanical connections and naturally proper direction to the flow of data.

reference

1. Vaughn D. Martin, "The HP-IB Greatly Simplified," *ham radio*, March, 1984, page 65.

ham radio



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the branch-line hybrid: part 1

Applications include power splitting/combining, impedance transformation and attenuation

Connect four quarter-wave transmission lines end-to-end, add four RF connectors, and what do you have? A hybrid branch-line coupler, a simple device that cannot only divide power from a signal source, but also maintain isolation between the two output ports. And because the hybrid coupler is reciprocal, it can combine power from two equal phase and amplitude sources while maintaining isolation between the two inputs. If two amplifiers are paralleled together with a branch-line coupler, any input or output mismatch from one amplifier will not be reflected into the other.

The hybrid branch-line coupler consists of four transmission lines, two connected in series with the transmission path and two connected in shunt or "branching" the transmission line. Generally, one can expect a 0.5-dB maximum coupling imbalance, 14-dB return loss (SWR $\leq$ 1.5:1), and 15-dB isolation over a 20 percent bandwidth from a simple transmission line branch-line coupler. (These values can be improved as more sections are added, but the intermediate branching impedances become very difficult to realize.)

The single-section branch line coupler may be readily constructed using printed microstrip transmission lines and easily reproduced from a single etching mask at minimal cost. Experimental results are presented here to convince the Amateur that one needs only to compute the physical dimensions of the lines, etch the printed circuit board,[1] and cut the coaxial cable, in order to fully expect the coupler to function reasonably well over the Amateur band of interest. The lumped-constant version of the branch-line coupler is easily adjusted using a grid-dip meter.

The principal advantage of choosing the branch-line hybrid for power division and combining is the good input match and the amplifier output intermod improvement. Applications of the hybrid that illustrate these advantages are included at the end of this article.

derivation of coupler

When the power entering a network splits evenly between the output ports, the device is called a hybrid; if it divides in *any* other ratio, it is called a directional coupler. In a 20-dB directional coupler, for example, 99 percent of the power flows through one path while 1 percent of the input power appears at the other output port. The branch-line hybrid (**fig. 1**),

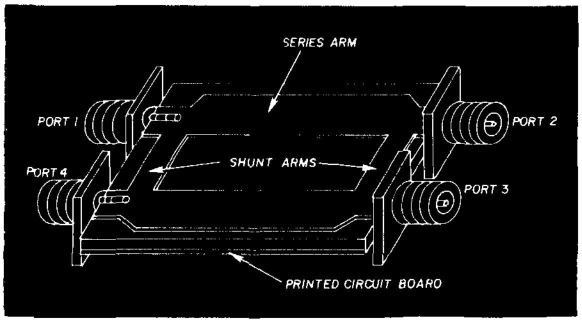

fig. 1. The branch-line hybrid can be formed using two series and two shunt microstrip transmission lines on a printed circuit board.

is composed of four quarter-wave transmission lines: two series arms and two shunt arms. Power input to port 1 is equally split between ports 2 and 3. Any mismatch power at either of these output ports appears

By Ernie Franke, WA2EWT, 63 Hunting Lane, Goode, Virginia 24556

at port 4. The output can be explained through use of either matrix manipulation or by sleight-of-hand. We shall use the latter.

The hybrid branch-line coupler, (**fig. 2**), is constructed using a series transmission arm, 1-2, and a shunt transmission arm, 2-3. Power input at port 1 travels along series transmission line 1-2. At point 2 the power is equally split between a 50-ohm load, placed at port 2 and shunt transmission line 2-3.

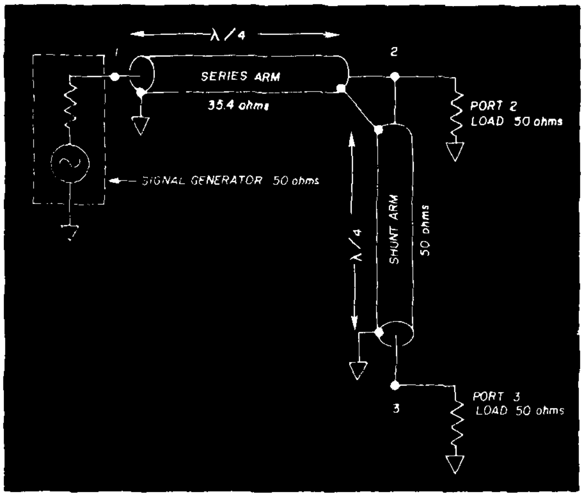

fig. 2. A simple equal-split power divider is formed using a series and a shunt transmission line.

Transmission line 2-3 is also 50 ohms, resulting in the parallel combination of the load and the input impedance to the shunt transmission line 2-3 of 25 ohms. This impedance must be transformed to present 50 ohms at input port 1. This is accomplished using series quarter-wave transmission line 1-2. The characteristic impedance of this quarter-wave matching section is equal to the square root of the product of the source and load impedances:

$$Z\,series\,arm = \sqrt{50\,ohms \cdot 25\,ohms} = 35.4\,ohms \quad (1)$$

The second output terminal, port 3, is also terminated with 50 ohms. This effectively terminates transmission line 2-3 in its characteristic impedance.

Thus we have formed a power divider using a series and shunt transmission line; but we have not, however, formed a true hybrid. Output ports 2 and 3 are isolated from each other by only 6 dB. Transmission lines 3-4 and 4-1 must be added, (**fig. 3**), to provide isolation between the output ports. The reflected wave due to any mismatch at port 2 is indicated as a dashed line traveling in two paths toward port 3. The counterclockwise path, however, is one half-wave longer than the clockwise path. Therefore, the

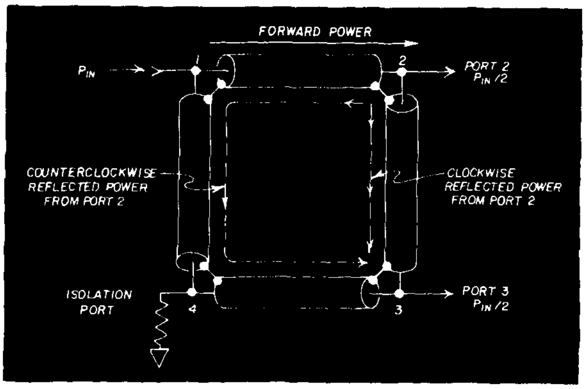

fig. 3. Reflected waves (dashed lines) from a mismatch at output port 2 cancel at output port 3 to provide isolation.

two reflected signals cancel at port 3 and port 3 is isolated from any mismatch at port 2. If the impedance mismatch occurs at port 3, the energy in the two paths likewise cancel at port 2.

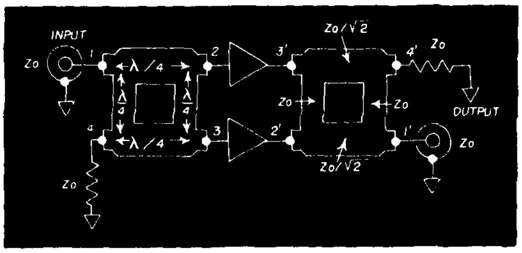

fig. 4. A 3-dB branch-line hybrid is used to parallel two amplifiers while maintaining isolation between them.

Isolation is especially necessary when combining two amplifiers in parallel, as shown in **fig. 4**. The output ports for the branch-line hybrid are 90 degrees apart, hence it falls into the category of quadrature hybrids. The output power at port 2 is delayed 90 degrees from the input power at port 1. The output power at port 3 undergoes an additional 90 degrees of phase delay. When recombining the power from the amplifiers, this must be considered by proper phasing.

The theoretical response of the single-section branch-line hybrid (**fig. 5**) is computed both for a 35.4-ohm and a 37.5-ohm series transmission arm. (The value of 37.5 ohms for the series transmission line was chosen because it can be simulated using two 75-ohm cables in parallel.) The 75-ohm coaxial cable is readily available from CATV sources. The graph of input return loss is an expression of the

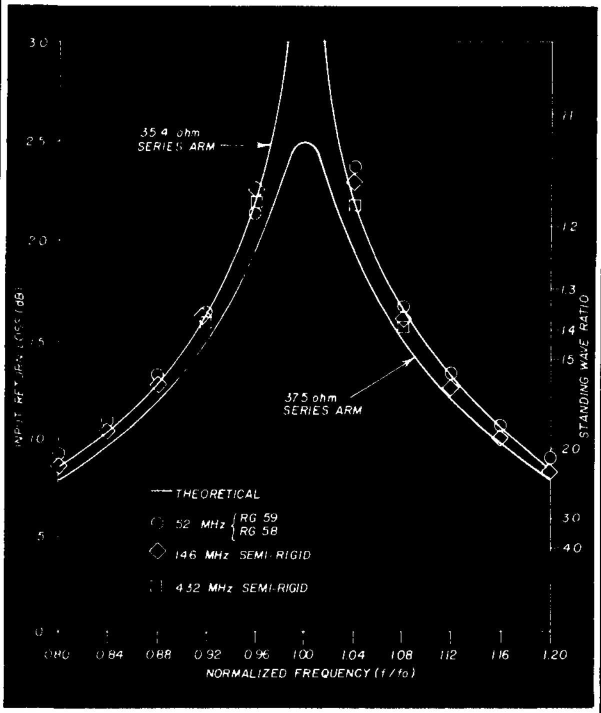

fig. 5. Experimental results for branch-line hybrids formed with coaxial cable closely follow the theoretical (solid line).

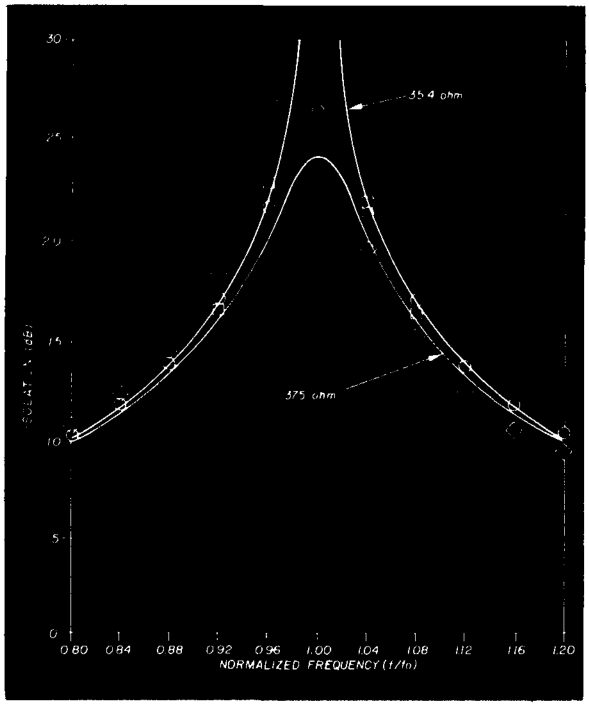

fig. 5B.

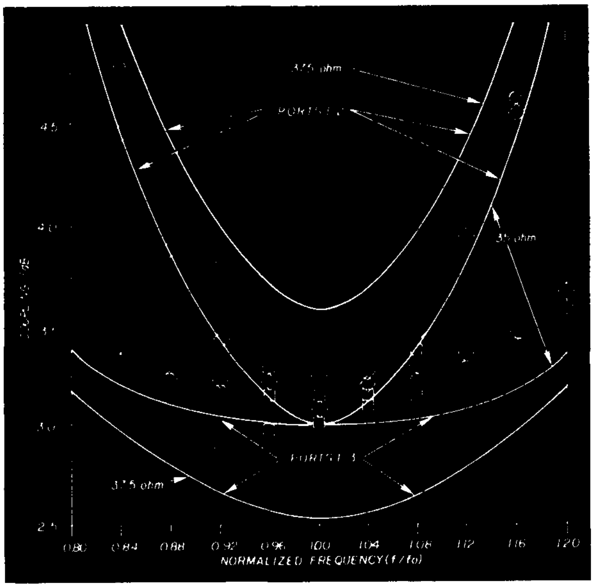

fig. 5C.

power ratio of the input power to reflected power in decibels. To convert return loss to the familiar SWR, the following equation is used:

$$SWR = \frac{10^{RL/20} + 1}{10^{RL/20} - 1} \quad (2)$$

where RL is the return loss.

To convert from SWR back to input return loss:

$$return\ loss = 20 \log_{10} \left[\frac{SWR + 1}{SWR - 1}\right] \quad (3)$$

Expressing the value of the input match in terms of return loss is becoming more popular. This is the ratio indicated on a directional wattmeter expressed in dBs. A value of 6 dB input return loss ($SWR = 3{:}1$) means that one-fourth of the input power is reflected. The value of theoretical coupling loss for a hybrid assumes no insertion loss. Hybrids typically display an insertion loss of 0.1 to 0.2 dB due to transmission line loss or low-Q lumped-constant elements (loss). A figure of 3.01 dB expresses an equal power division between ports 2 and 3 and does not mean that the hybrid dissipates half the power. The value of isolation is measured between ports 2 and 3. A signal applied to port 2 will be reduced by the value of the isolation before arriving at port 3. This is equally true for an input signal reflected at output port 2 appearing at port 3. Because the hybrid is symmetrical, this is also the isolation between ports 1 and 4.

The models constructed using flexible coaxial cable employed two 75-ohm quarter-wave sections in parallel to simulate each series arm (**fig. 6**). The parallel impedance is 37.5 ohms, which is close to the desired 35.4 ohms; the difference in response is shown in **fig. 5**. Each shunt arm was formed with

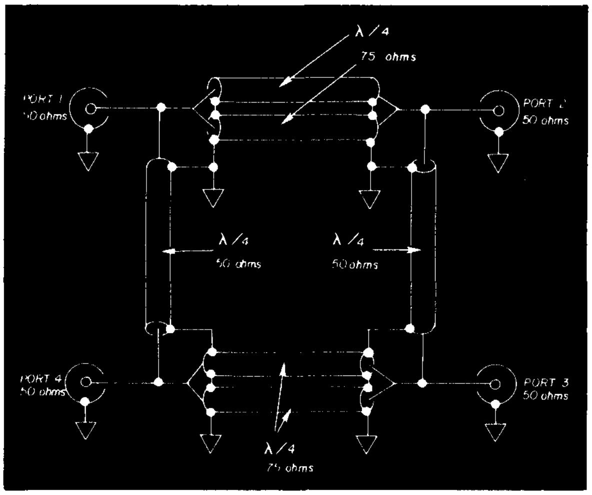

fig. 6. A 50-ohm branch-line hybrid may be formed with readily available 50-ohm and 75-ohm coaxial cable.

common 50-ohm coaxial cable. Models constructed with semi-rigid coaxial cable relied on two 70-ohm lines in parallel, which yielded results very close to the theoretical value of 35.4 ohms.

The physical length, L, of each quarter-wavelength transmission line may be calculated using:

$$L = \frac{c \cdot V_p}{4f} \qquad (4)$$

where c = speed of light (3×10^8m/sec) or 9.84×10^8ft/sec

f = frequency (Hz)

V_p = relative velocity of propagation = $1/\sqrt{e}$, where e is the relative dielectric constant

dielectric	V_p
solid polyethylene	0.66
foam polyethylene	0.78
solid teflon	0.69

The value of L, (**table 1**), is calculated in the same units as the speed of light constant chosen.

The coaxial cable may be trimmed exactly by measuring its resonance with a grid-dip meter after cutting the cable slightly longer than the length computed above and preparing the ends. The center conductor is shorted to the braid at one end only, and the grid-dip meter is positioned close to the loop formed at the shorted end. The shorted quarter-wavelength transmission line acts as a parallel-resonant circuit.

If the branch-line hybrid is redrawn in a circular manner (**fig. 7**), rather than in the square representation, it resembles the familiar hybrid ring or "rat race."[2] The hybrid ring, however, uses three sections of quarter-wavelength line joined together by a three-quarter-wavelength section.

next month:

In part 2, branch-line hybrids that use lumped constant components for operation below 100 MHz are described. Additional applications discussed include impedance transformers and pin-diode attenuators.

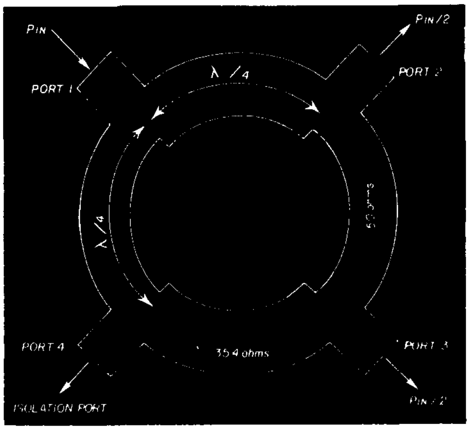

fig. 7. Circular form of the branch-line hybrid resembles the hybrid ring.

table 1. Cable length for various dielectrics.

frequency (MHz)	solid polyethylene (0.66)	foam polyethylene (0.78)	solid teflon (0.69)
3.75	43 ft 3 in	51 ft 1 in	45 ft 2 in
7.15	22 ft 8 in	26 ft 9 in	23 ft 8 in
14.20	11 ft 5 in	13 ft 6 in	11 ft 11 in
21.25	7 ft 8 in	9 ft 0 in	7 ft 11 in
28.50	5 ft 8 in	6 ft 9 in	5 ft 11 in
52.00	37.4 in	44.2 in	39.1 in
146.00	13.3 in	15.7 in	13.9 in
222.00	8.7 in	10.3 in	9.2 in
435.00	4.47 in	5.29 in	4.67 in
1250.00	1.56 in	1.84 in	1.63 in

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REVIEWS

action monitor

JC Labs of Wales, Wisconsin, has introduced the Action Monitor, a voice-operated switch (VOX) that will connect between any ordinary cassette or other type tape recorder and a receiver.

Hookup is simple. You feed the audio from the receiver to the Action Monitor. The audio then goes two ways: one to a speaker, the other to the mike input on the tape recorder. You also connect the Action Monitor to the tape recorder's on-off switch. As soon as the Action Monitor "hears" a transmission, it activates the tape recorder via the on-off switch; when the transmission is completed, the unit will continue taping for several seconds to record any replies and then the Action Monitor shuts off the tape recorder until another message is received.

The best thing about the Action Monitor is what it does: eliminate the need for a high priced, special-purpose type recorder. All you need is an ordinary cassette recorder, or any other type recorder, a receiver and the Action Monitor, and you're ready to record any service you wish. Whether you want a permanent record or just want to know what went on while you were asleep or away from home, the Action Monitor will provide a taped record of what transpired. Some suggested uses include recording from the business bands, police and fire calls, Amateur Radio repeaters, aircraft band, even CB. (You must remember that all transmissions are protected by the Secrecy in Communications Act.)

The next best thing about the Action Monitor is its price: only $39.95 plus $2 for shipping in the U.S., $3 for shipping to Canada.

The lightweight unit comes in a sturdy black plastic case measuring 2-3/4 × 4 × 1-1/2 inches. It operates from a 9-volt battery or optional AC power supply ($8.95).

For complete information, contact JC Labs, Inc., P.O. Box 183, Wales, Wisconsin 53183.

— **N1ACH**

Circle #301 on Reader Service Card.

non-iambic paddle

Bencher has just released a new single lever, non-iambic paddle for hams like me who never were able to master the intracacies of iambic keying.

Bencher paddles use stainless steel bearings, stainless fasteners and a stainless steel, lifetime spring. Dot-dash contacts are gold-plated silver to ensure positive contact. The heavy leaded steel base is designed to eliminate paddle "creep" while being used. All in all, the paddles are built for a lifetime of use and the quality of their construction reflects that fact.

The non-iambic paddle is manufactured to the same standards as Bencher's iambic paddle. When the review unit was received, I eagerly opened it up and wired it to my keyer. I felt immediately at home with the new paddle.

You can adjust two basic parameters on the Bencher key. The first is spring tension, which is adjusted by either tightening or loosening a ferruled nut at the back of the key. I favor light spring tension, so I set the spring on the review unit quite loosely. The dot and dash contacts are adjusted by loosening a lock-screw and then moving them either closer or farther away with an Allen wrench. In adjusting my iambic key I misplaced my Allen wrench and wound up searching for it any time adjustments were necessary. Fortunately Bencher has added a Fahrnstock clip underneath the non-iambic paddle to eliminate losing the Allen wrench altogether.

I haven't used the new key in a contest yet, so I can't report on how well it works or stays put when I get excited. I would expect that it will work rather well.

The Bencher non-iambic key comes in three models: with black base at $46.95, chrome base at $59.95, and a gold plated presentation model at $150.

For more information, contact Bencher at 333 West Lake Street, Chicago, Illinois 60606.

Circle #302 on Reader Service Card.

N1ACH

Novice Class Amateur Radio Operator Test Guide

The name Bash evokes mixed feelings in the Amateur community. Some love him, others dislike him intensely. His latest book, however, should be favorably received by instructors and prospective Novices alike.

Since the Novice exam is written and administered by the examiner, the controversial question-and-answer-format used in Bash books for General, Advanced and Extra Class licenses will not work. Instead, Bash has written an easy-to-read, complete, informative, but extremely informal Novice licensing guide.

Bash starts off with the basics of getting a license, Amateur Radio rules and regulations, and electronics. As you progress through the book, Bash explains many of the mysteries of radio and electronics theory without getting needlessly complex. One problem with other study guides is that they sometimes tell you much more than you need to know. Bash cuts away at all extraneous information and gives you exactly what you need to be capable of passing a test based upon the FCC exam syllabus. For those who are looking to go beyond the scope of a basic study guide, Bash makes extensive reference to *Amateur Radio Theory and Practice* by Robert Shrader, W6BNB. This handy cross-reference virtually ensures that a prospective Novice can get the exact answer that is needed.

Bash also has a 34-question Q&A section that will help the reader test his or her learning prior to taking the exam. And so that the prospective Novice can be fully prepared for the exam, Bash has included a complete copy of the official FCC Novice exam study guide.

Finally, Bash has gone to the trouble of filling the book with handy tips and hints that will help answer many of the often-asked questions about radio operation.

For prospective Novices planning to study independently or in organized classes, Bash's new Novice study guide, priced at $9.95, will be helpful. (Copies are available from Ham Radio's Bookstore; add $1.00 for postage and handling.)

For more information, contact Bash Educational Services, P.O. Box 2115, San Leandro, California 94577.

Circle #303 on Reader Service Card.

N1ACH

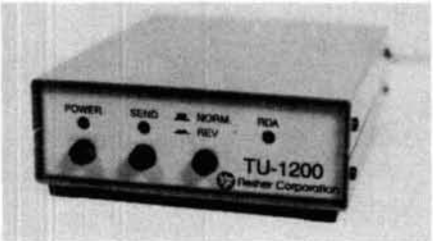
NEW products

UHF/VHF RTTY terminal

The new TU-1200 UHF/VHF RTTY terminal unit from Flesher receives all Baudot and ASCII rates to 1200 baud and uses Bell 202 standard tones (1200 Hz and 2200 Hz) useful in many applications, including RTTY repeater systems. It provides TTL and RS-232C compatible I/O and includes transmitter PTT output for complete remote control. The TU-1200 also provides AFS output and RDA (received data available).

Only three push-button switches are required for operation: POWER, SEND, and NORMAL/REVERSE SHIFT. Three LED indicators show POWER, SEND, and RDA status. The TU-1200 is constructed with a quality all-metal case to assure proper RF protection. Its small size (5 1/8″W × 1 3/4″H x 6″L) and rear panel DB-25 I/O connector make installation and use simple.

The TU-1200 is available either wired ($129.95) or in kit form ($99.95) and comes complete with a mating DB-25 I/O plug, power sup-



ply and an easy-to-understand step-by-step OPERATOR/ASSEMBLY manual.

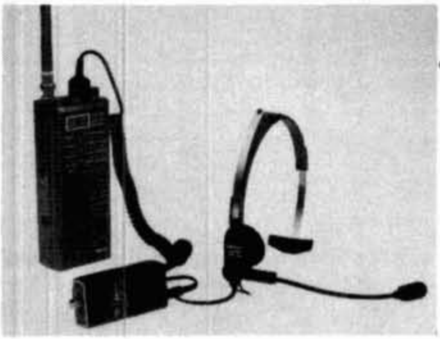
For more information, contact Flesher Corporation, P.O. Box 976, Topeka, Kansas 66601.

Circle #304 on Reader Service Card.

ICOM accessories

The new ICOM IC-HS10 Headset and IC-HS10SB PTT Switchbox can be used with all ICOM handheld transceivers: the IC-2A and 2AT; IC-3A and 3AT; IC-4A and 4AT; IC-02A and 02AT; and IC-04A and 04AT. The lightweight headset includes the following features: crystal-clear reception, pivoting microphone, and adjustable boom; it folds up for storage and adjusts for comfortable fit.

The switchbox measures 3 × 1.5 × 0.75 inches and features a belt clip, transmit-receive switching control, mic gain control, and a molded plastic connector for speaker/mic connection to handheld.



The IC-HS10 Headset and IC-HS10SB PTT Switchbox are available immediately and may be purchased separately for $19.50 each or $39.00 for the set.

For more details, contact ICOM, 2112 116th Ave. N.E., Bellevue, Washington 98004.

Circle #305 on Reader Service Card.

miniature soldering system

With Wahl's new assortment of 15 miniature soldering irons and 23 tips, a user can choose from over 270 different soldering combinations to match precise soldering needs. The 15 Oryx® miniature irons, all weighing 1/2 ounce, or less, are available in temperatures ranging from 575 to 850 degrees F; from 5 to 25 watts; and from 4.5 to 24 volts. Their compact size and precise temperature control make them a good choice for soldering heat-sensitive components.

The irons can be combined with any of 23 tips ranging in size from 1/25 to 3/32 inch in several choices of configuration. Tip construction is nickel-plated or iron-plated copper for most applications, with solid nickel, gold end, and bare copper alloy (NASA) tips available for special requirements. Tip changes are easy, with no tools required. Cooled tips simply slide off and on.

For further information, contact Wahl Clipper Corporation, Sterling, Illinois 61081.

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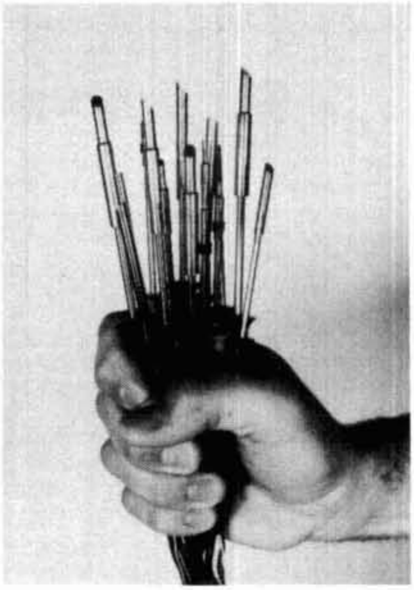


NEW products

new antenna rotator for blind hams

Telex/Hy-Gain has introduced the HAM-SP rotator specially designed for visually impaired Amateur Radio operators.

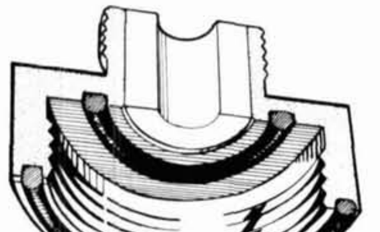
The control unit functions are marked in both Braille and conventional lettering. The unit also emits a high frequency tone to indicate rotator action. Since the brake release as well as delayed brake engagement is automatic, operation of the rotator is a simple one-hand, one-touch operation.

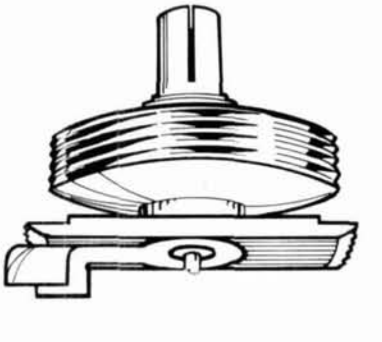
When mounted inside a tower, the new HAM-SP rotator is designed to operate large antenna arrays of up to 15 square feet (1.4 m²) wind load area. The HAM-SP (catalog No. 307) carries a suggested list price of $337 and is available at Amateur Radio dealers.

For further information, contact Telex Communications, 9600 Aldrich Ave. So., Minneapolis, Minnesota 55420.

mounting kits

The Larsen PO-K mounting kit features SO-239 style mounting hardware that can be installed entirely from outside any vehicle. The PO-series mount looks like the SO-239 connector





(sometimes called a female UHF connector), but unlike the SO-239 can be installed from outside. Its two "O" rings and one gasket offer superior moisture sealing. The PO-K includes complete mounting kit and coax; the PO-B contains mounting hardware only.

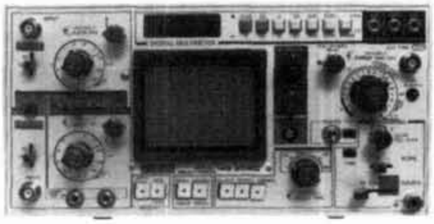
For further information, contact Larsen Electronics, P.O. Box 1799, Vancouver, Washington 98668.

Circle #307 on Reader Service Card.

digital storage oscilloscope

The Model MS-3020 Multi-Scope from North American SOAR employs features never before available in a single compact package, including a 15-MHz triple trace real time oscilloscope with 3 1/2 inch flat face internal graticule CRT; variable trigger delay plus single sweep; a built-in "quick tracer" type component tester for cold circuit, individual component or full board circuit evaluation; a five-function 3 1/2 digit LED display DMM that can be operated independently or simultaneously in the same circuit as the oscilloscope; a digital storage section with 1024 words of memory; and rear panel BNC connectors for pen recorder output of X-Y sync of the stored Channel 1 waveform.

The MS-3020 is housed in a small, easily transportable case with U bracket handle measuring 10 inches wide × 5 inches high × 12 1/4 inches deep. It weighs approximately 13 1/2 pounds and is priced at $1995.



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

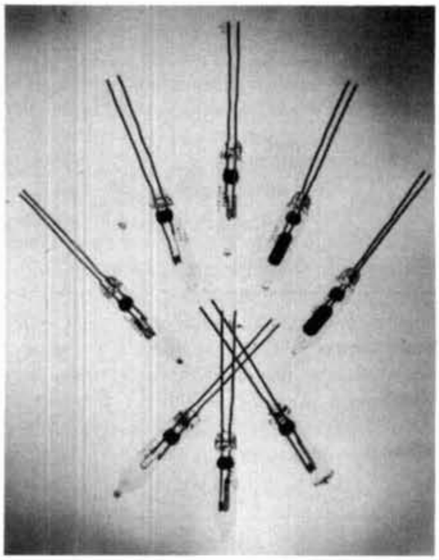
Circle #308 on Reader Service Card.

thermo protectors

A series of thermo-protectors designed to provide efficient, low-cost protection for electrical equipment, are included in the EGG semiconductor replacement line available from the Distributor & Special Markets Division of Philips ECG, Inc.

Designated ECG 202, 204, 205, the units are intended for replacement use in small fractional horsepower motors and products such as audio speakers, transformers, HID lamps, automotive antenna motors, CATV amplifiers, and television circuits.

Each thermo-protector contains a prestressed bimetal blade; fault conditons producing excessive current or heat will cause the bimetal to snap the contacts open. Encased in a strong, shock-



resistant hermetically sealed glass cartridge, the unit can withstand external pressures exceeding 5,000 PSI.

The entire ECG semiconductor replacement line, including more than 3200 solid-state devices, is available from authorized distributors of Philips ECG components.

For more information, contact Philips ECG, Inc., 100 First Avenue, Waltham, Massachusetts 02254.

Circle #309 on Reader Service Card.

Worldwide Sunrise/ Sunset Tables

Noted 80-meter DXer and author John Devoldere, ON4UN, has just released the latest edition of the *World Wide Sunrise/Sunset Tables.*

As sunspot activity declines, more and more DX'ers are turning to 160, 80, and 40 meters and finding that "gray line" propagation is an integral part of successful DX'ing on those bands.

ON4UN's book provides sunrise and sunset times for 502 geographical locations in all DXCC countries and includes 100 listings in the U.S.A. Also included are fairly detailed instructions so the reader can accurately utilize the information in the book. For example: Is there a long path between San Francisco and Budapest on January 1?

In looking at both San Francisco and Budapest, we find:

San Francisco	Sunrise West 1524	Sunset West 0058
Budapest	Sunrise East 0632	Sunset East 1503

NEW products

For long path conditions to exist, you must be at or near a peak propagation path at sunrise with the station at the western end of the path or at sunset with the station at the eastern end of the path. With our example Sunrise West is later than Sunset East and there will be a 1/2 hour-long path opening between approximately 1500 and 1530 hours Z.

Devoldere also talks about crooked paths between two locations in the same hemisphere in the middle of local winter, such as exists between the U.S. and Japan during December and January. These paths do not follow the "great circle" paths and are skewed by passage through the Polar regions area.

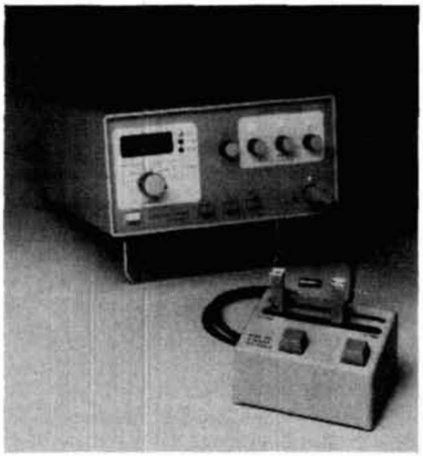
This book is available directly from the author and comes with a personalized beam heading printout and an enlarged personalized Sunrise/Sunset Chart. Price is $10 postpaid (air mail).

For more information, contact the author directly at:

John Devoldere, ON4UN
215 Poelstraat
B9220 Merelbeke
Belgium

lower price for L/C meter

The Model 522 digital L/C meter and test fixture combination is being offered by Cambridge Technology at a new low price — $875.00.



This instrument combination allows measurement and sorting of inductances and capacitances at a basic accuracy of 0.25 percent, with dual measurement frequencies, and 0 to 10 VDC internal capacitor bias, for less than $1000.00. (The closest competitor to the Model 522 costs over 40 percent more.)

A built-in comparator allows simultaneous sorting for high and low tolerances, as well as dissipation limits. Measurement frequencies of 120 Hz or 1 kHz are automatically selected. The instrument is autoranging and a range-hold feature permits fast repetitive measurements.

The electrical contacts of the test fixture provide four-terminal measurement capability. A push button allows both electrical contacts to be held open simultaneously so that components with very fine leads can be inserted conveniently. A second push button allows each set of contacts to be individually opened for components with flying leads such as coils or transformers.

Other features include a rugged all-metal enclosure, tilt stand, and lead capacitance null. The instrument is protected against damage from charged capacitors and comes with a one-year warranty on materials and workmanship. A full refund within 30 days is available if the instrument is found unsatisfactory for any reason.

For more information contact Cambridge Technology, Inc., 2464 Massachusetts Avenue, Cambridge, Massachusetts 02140.

Circle #310 on Reader Service Card.

selective call controller

The SCC-1 Selective Call Controller, from Acquis Communications, Inc., was designed for use with mobile or base FM radio systems. Its features include a touchtone encoder; 10-number auto dialer with battery backup; a touchtone decoder with two programmable selective call codes for group or individual calls; an internal monitor speaker; LED displays for call status; and an accessory relay for control of external devices. The small size of the SCC-1 (3 × 4 × 2 inches) and flexible mounting hardware make it easy to adapt for either mobile or base station applications. A mobile mounting bracket and protective desk pads are included.

The SCC-1, priced at $325, is particularly useful for emergency groups such as RACES or radio clubs. The selective call feature with programmable call codes allows for group or private monitoring of radio communications.

For further information, contact Acquis Communications, Inc., 17192 Gillette Avenue, Irvine, California 92714.

Circle #311 on Reader Service Card.

code practice aid

The Noise Maker was originally conceived to assist those with problems hearing code as it is usually generated. We usually listen to code in the form of a keyed tone — usually pure — somewhere in the range from 500 to 1000 Hz. But because this kind of sound is troublesome for some listeners, W6NRW put together a white-noise generator with a keying circuit designed to enable fast, click-free keying.

His idea was to spread the energy over a wide audio spectrum, in the expectation that enough sound energy would be emitted within a person's hearing range to enable reception. Since the sound energy generated within any particular narrow frequency range is low, the listener will not be irritated by high levels of tones that may be troublesome. And because white noise is a more "natural" form of sound energy than a pure tone, practicing with the noise maker may cause less fatigue.

For more information on the Noise Maker ($12.95 plus $2.50 shipping and handling) and an optional electronic switch that allows white noise code practice using conventional oscillator tapes or a receiver ($7.00), contact Hildreth Engineering, P.O. Box 60003, Sunnyvale, California 94088.

Circle #312 on Reader Service Card.

model 234 encoder

SYT had introduced a new low-cost mobile DTMF encoder for autopatch and selective call radio systems. This compact device features a new high-speed, crystal controlled DTMF encoder circuit with a tactile feedback keypad, ATK, and interdigit hold timer. The 234 is housed in an attractive metal housing with a variable tilt mounting bracket. Ideal for small car installations, the 234 is the first budget-priced, quality mobile encoder available.

For details, contact SYT Corporation, 1220 Barranca Street, El Paso, Texas 79935.

Circle #313 on Reader Service Card.

equipment protection

A new 40-page catalog (No. 831) from Electronic Specialists presents their line of protective and interference control equipment. Protective devices available include equipment isolators, AC power line filter/suppressors, AC line voltage regulators and modem surge suppressors.

Descriptive sections outline specific communication problems and suggested solutions. Typical applications and uses are highlighted.

For further information, contact Electronic Specialists, Inc., 171 South Main Street, Natick, Massachusetts 01760.

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

DEADLINE 15th of second preceding month.

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

QSLs & RUBBER STAMPS — Top Quality! Card Samples and Stamp info — 50¢ — Ebbert Graphics 5R, Box 70, Westerville, Ohio 43081.

TRAVEL-PAK QSL KIT — Converts post cards, photos to QSLs. Stamp brings circular. Samco, Box 203-c, Wynantskill, New York 12198.

WANTED: Manual for Dumont oscillograph type 304AR. WU4C, Leon, Rt. #6, Box 751A, Macon, GA 31201.

COUNSELORS: Connecticut brother-sister camp. Completely equipped with ham radio station. Program includes electronics, kit building, code and communications. June 25 - August 22. Send resume: Lloyd Albin (N2DMO) Ken-Mont and Ken-Wood Camps, 2 Spencer Place, Scarsdale, NY 10583.

ATTENTION DXers! Get Russian cards faster. All local Soviet QSL Bureau addresses $4.00. Ed Kritsky, KA1MXO, PO Box 715, Brooklyn, NY 11230.

NEED TO CONTACT James Navarchi concerning Yaesu gear. C.T. Huth, 146 Schonhardt St., Tiffin, OH 44883.

ATTENTION C-64 USERS. Don't buy a logging program until you've read our fact sheet. For free information write to Crumtronics, PO Box 6187, Ft. Wayne, IN 46896.

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WANTED: MFJ-1224 computer interface, RS232 cable, software for H89A. Zenith trans-oceanic model 7000 radio. W4BUZ, Don Harris, 1703 Verdun Dr., Rt. 11, Greensboro, NC 27410.

ROHN TOWERS — Wholesale direct to users. All products available. Write or call for price list. Also we are wholesale distributors for Antenna Specialists, Regency, and Hy-Gain. Hill Radio, PO Box 1405, 2503 G.E. Road, Bloomington, IL 61701-0887. (309) 663-2141.

ELECTRON TUBES: Receiving, transmitting, microwave . . . all types available. Large stock. Next day delivery most cases. Daily Electronics, 14126 Willow Lane, Westminster, CA 92683. (714) 894-1368.

WANTED: Technical, computer and broadcast books by Harold E. Ennes. C.J. Klaue, 9871 Martinique Drive, Miami, FL 33189.

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

"THE SWAP LIST" has bargains galore. Subscribe now! 6 months for $4.00; 1 year only $6.50. The Swap List, Box 988-H, Evergreen, CO 80439.

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SAN ANTONIO, TEXAS QTH for sale. 4-2-2 with 70 foot tower, etc. W8CM, (512) 684-6129.

CABLE CONVERTERS, decoders. Catalog $1 refundable. APS, POB 263 HR, Newport, RI 02840.

VHF + TRADING POST. Buy, sell, trade your VHF, UHF and microwave equipment and accessories. SASE for sample. 1420 East Sweet Avenue, Bismarck, ND 58501.

WANTED: Cash paid for used speed radar equipment. Write or call: Brian R. Esterman, PO Box 8141, Northfield, Illinois 60093. (312) 251-8901.

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RECONDITIONED TEST EQUIPMENT $1.00 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

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Coming Events

ACTIVITIES

"Places to go..."

ARIZONA: The Cochise Amateur Radio Association is sponsoring a Hamfest, May 4, 5 and 6 in St. David. Tours are planned to Tombstone, the Bisbee Lavendar Pit and other places of interest. There will be a flea market and tailgaters are welcome. Talk in on 16/76 and 52 simplex. For details contact C.A.R.A., PO Box 1855, Sierra Vista, AZ 85636, attention KB7HB.

ARKANSAS: The Northwest Arkansas ARC will hold its 4th annual Hamfest/Swapmeet, Saturday, May 12, Rogers Youth Center, 315 West Olive Street, Rogers. 8 AM to 4 PM. Doors open 6 AM for setup only. Commercial exhibitors and flea market tables/space $2.00. Free admission. Programs and activities scheduled. Parking on premises. Talk in on 16/76 and 52 simplex. For more information: Roy Milliren, AF5W, 2014 South 16th Street, Rogers, AR 72756.

CALIFORNIA: The West Coast VHF/UHF Conference will be held May 4, 5 and 6 at the Paso Robles Inn, Paso Robles. For further info contact: K6HXW, Mike Goshay, PO Box 493, Arroyo Grande, CA 93420.

CONNECTICUT: The seventh annual Pioneer Valley Radio Association (P.V.R.A.) Flea Market, Sunday, April 29, 10 AM to 4 PM at Penney High School, Forbes Street, East Hartford. Talk in on 19/79. For information and reservations contact: Jon Patz, KA1FYL, 34 Whiting Lane, West Hartford, CT 06119 or call (203) 232-8772, evenings.

GEORGIA: The Atlanta Hamfestival 1984, sponsored by the Atlanta Radio Club, June 16 and 17, at the Atlanta Civic Center. 70,000 square feet of air-conditioned exhibitor space and over 800 outdoor flea market spaces will be available. Flea Market $12.50 per space in advance; $15.00 at the gate for both days. Hamfest registration $5.00 in advance, $6.00 at the door. To be pre-registered for the Flea Market or Hamfest, we must receive your application and check by June 8. Pre-registration applications received after June 8 will be returned. Hours 8 AM to 5 PM on Saturday. 8 AM to 2:30 PM on Sunday. Talk in on 3.97 MHz, 146.22/82 and 146.94 simplex. For pre-registration or other information write Atlanta Radio Club, PO Box 77171, Atlanta, GA 30357.

ILLINOIS: M.A.R.K. Hamfest, sponsored by the Moultrie Amateur Radio Klub, May 6, 4-H Fairgrounds, Cadwell Road, Sullivan. Covered facilities, free swappers row, lunch served. Talk in on 14-.655-.055 and 146.520. For more information: WA9WOB (217) 268-3139 evenings.

ILLINOIS: The Chicago Amateur Radio Club's evening Mini-Hamfest, Wednesday, May 2, 6 to 10 PM, Edgebrook Golf Course Field House, 6100 N. Central between Elston and Devon. Admission $1.00. Card table spaces $3.00. Talk in on 146.52 MHz. Refreshments. For info/tickets/space reservations SASE to C.A.R.C., 5631 W. Irving Park Rd., Chicago, IL 60634 or phone (312) 545-3622.

ILLINOIS: A Computer and Electronics Swapmeet, sponsored by Micro International, computer equipment distributors, will be held Sunday, April 15, 10 AM to 5 PM at the American Legion Hall, Butterfield and Spring Roads in Elmhurst. Admission $2.00 advance, $3.00 at the door. For more information contact Micro International, Dept. M, PO Box 774, Highland Park, IL 60035. (312) 530-1552.

ILLINOIS: The Centralia Wireless Association's annual Hamfest, Sunday, May 6, Kaskaskia College Gym, 3 miles northwest of Centralia. No charge for flea market and exhibit space; doors open 7 AM for set up. Free admission and free parking. Refreshments available. Talk in on 147.27/.87 and 146.52. For further information: Bud King, WB9QEG (618) 532-6606, Lou Hodges, W9IL (618) 533-4724 or write CWA, Inc., PO Box 1166, Centralia, IL 62801.

ILLINOIS: The annual Kankakee Hamfest, May 6, Kankakee County Fairgrounds. Gates open 8 AM. Large indoor/outdoor flea market. Refreshments available. FCC booth. Shuttle service available from nearby Greater Kankakee Airport. Advance tickets $2.50; $3.00 at the gate. Talk in on 146.34/.94. For further information call Don Kerouac before 5 PM at (815) 937-2750 or write KARS Hamfest, 1377 Circle Dr. N.W., Kankakee, IL 60901.

INDIANA: The Annual Evansville TARS Hamfest, May 20, all indoors at the Vanderburgh County 4-H Fairgrounds. Open 6 AM CDT. Admission $3.00. Indoor tables $7.50. Outdoor flea market $3.00. Talk in on 147.75/.15 and 146.19/.79. For table reservations and information contact Mike Anderson, KA9LQM, PO Box 3284, Evansville, IN 47732.

MINNESOTA: The 7th annual Rochester Area Hamfest, Saturday, April 7, John Adams Junior High School, 2535 N.W. 31 Street, Rochester. Sponsored by the Rochester ARC and the Rochester Repeater Society. Doors open at 8:30 AM. Large indoor flea market, refreshments and plenty of free parking. Talk in on 146.22/82 MHz. For further information: RARC c/o WBØYEE, 2253 Nordic Ct. N.W., Rochester, MN 55901.

MISSISSIPPI: ARRL Mississippi State Convention/Capital City Hamfest, April 14 and 15, Communications Workers of America Building, Jackson. Dealer exhibits, indoor flea market, concessions, free parking, forums. Free admission. Flea market tables $5.00. Talk in 146.16/76 MHz. Contact Carol Kemp, NA5Y, 3581 Beaumont Drive, Pearl, MS 39208. (601) 939-7612.

MISSOURI STATE ARRL Convention, Kansas City. April 7-8, 1984. For information write or call PHD Amateur Radio Association, PO Box 11, Liberty, MO 64068-0011. (816) 781-7313.

NEW ENGLAND: The Hosstraders Spring Tailgate Swapfest, Saturday, May 12, sunrise to sunset at Deerfield, NH, Fairgrounds. Admission $2 includes tailgaters and commercial. Friday night camping for self-contained rigs at nominal fee. None admitted before 4 PM Friday. No reserved spaces. Profits benefit Boston Burns Unit of Shriners' Hospital. Last year's donation over $4700.00. For map to northeast's biggest Ham Flea Market SASE to Norm, WA1IVB, RFD Box 57, West Baldwin, ME 04091 or Joe, K1RQG, Star Route Box 56, Bucksport, ME 04416 or Bob, W1GWU, Walton Road, Seabrook, NH 03874.

NEW HAMPSHIRE: Springfest '84, the 4th annual Hamfest-Flea Market sponsored by the Great Bay Radio Association, Saturday, April 7, 9 AM to 3 PM, Rochester V.F.W. Post 1772 Hall, Pickering Rd., Rochester (Gonic). Food and refreshments available. Free parking. Admission $1.00. Talk in on 147.57. For table reservations and information write: Great Bay Radio Assn., PO Box 911, Dover, NH 03820.

NEW JERSEY: TCRA Hamfest Tri County Radio Association, rain or shine, Sunday, May 13, Passaic Valley Community Center off Valley Road, Stirling, NJ. 9 AM to 4 PM. Indoors, refreshments, rest rooms, free parking. Tables $6, registration $2.50. Table reservations call or write Dick Franklin, W2EUF (201) 232-5955 or 270-3193, PO Box 182, Westfield, NJ 07090.

NEW YORK: Suffolk County Radio Club Indoor/Outdoor Flea Market, Sunday, May 6, 8 AM to 3 PM, Republic Lodge No. 1987, 585 Broadhollow Road (Rt. 110), Melville. Refreshments, free parking. General admission $2.00. Wives and children under 12 free. Indoor sellers' tables $7.00. Outdoor space $5.00 (includes one admission). Talk in on 144.61/145.21 and 146.52. For additional information contact: Richard Tygar, AC2P. (516) 643-5956 evenings.

NEW YORK: The 25th annual Southern Tier Amateur Radio Club's Hamfest, Saturday, May 5, Treadway Inn, Owego. Flea market opens 8 AM. Displays, tech and non-tech talks, refreshments. There will be a dinner at 6:30 PM by advance tickets only. Talk in on 22/82, 16/76 or 146.52 simplex. For further information SASE to KF2X, C. England, RD #1, Box 144, Vestal, NY 13850.

OHIO: The Dayton-Cincinnati Chapter of the Quarter Century Wireless Association will hold its annual banquet during the Dayton Hamvention, Friday, April 27, Neil's Heritage House Restaurant, 2189 S. Dixie Drive, Dayton. C.O.D. bar opens at 6:30 PM, dinner 7:30 PM. Dr. Jerrold Petrofsky, developer of computerized equipment which enables paraplegics to walk, will give an illustrated presentation. Tickets $12.50. Contact Doug Horner, W8PH for details or call (513) 859-3210.

OHIO: The 15th annual B*A*S*H will be held Friday evening of the Dayton Hamvention, April 27, Convention Center, Main and Fifth Streets. Parking in adjacent City Garage. Free admission. Sandwiches, snacks and C.O.D. bar available. Live entertainment. Two exciting top awards and many others. For further information: Miami Valley F.M. Association, PO Box 263, Dayton, OH 45401.

SOUTH CAROLINA: The Blue Ridge Amateur Radio Society's Greenville Hamfest, Saturday, May 5 and Sunday, May 6, American Legion Fairgrounds, White Horse Road 1/2 mile north of I-85 in Greenville. Admission $4.00. Advance tickets $3.00. Talk in on 146.01/61. For information: Phil Mullins, WD4KTG, Chairman, PO Box 99, Simpsonville, SC 29681. For advance sales: Sue Chism, N4ENX, Rt. 6, 203 Lanewood Drive, Greenville, SC 29607.

TEXAS: The San Antonio Area Radio Club's FIRST annual Swapfest and Bar-B-Q, April 7 at Comanche Park, 7 AM to 5 PM. Talk in on 147.36 MHz. For details: Melvin Anderson, 8932 Saddle Trail, San Antonio, Texas 78255.

WISCONSIN: The Ozaukee Radio Club's 6th annual Swapfest, Saturday, May 5, 8 AM to 1 PM, Circle B Recreation Center, Highway 60, Cedarburg. Admission $2.00 advance, $3.00 at the door. 6' tables $2.00; 8' tables $3.00. Food and refreshments. Sellers admitted at 7 AM for set up. For tickets, tables, maps or more information send business SASE to 1984 Ozaukee Radio Club Swapfest, PO Box 13, Port Washington, WI 53074.

OPERATING EVENTS

"Things to do..."

MAY 4: The Gloucester County Amateur Radio Club will operate W2MMD on May 4, 1700Z to May 5, 1700Z to commemorate the Club's 25th anniversary. Phone operation in lower portion of General Class bands 80-10 and CW in Novice bands. Commemorative certificate by QSL to G.C.A.R.C., PO Box 370, Pitman, NJ 08071.

MAY 12: The Greater Fairfield (CT) ARA will operate WB1CQO from 1300 UTC to 2200 UTC during the annual Dogwood Festival. Certificate for SASE. Frequencies 3.975, 7.235, 14.330, 21420.

APRIL 5-8: Dordtse Electronica Club members will be active from Luxembourg (LX) on all bands including WARC and 160 from 1800 GMT til 2400 GMT. QST is Bech. They will all sign /LX. QSL via PO Box 523, Dordrecht, the Netherlands or via bureau.

APRIL 21-22: QRP Amateur Radio Club International QSO Party, Saturday, April 21, 1200 UTC to 2400 UTC, Sunday, April 22. Exchange: Members give RS(T), state/province/country and WRP ARCI membership number. Non-members give RS(T), state/province/country and power output. QSO points (total all bands) times total number of states/provinces/countries (may be worked on more than one band) times power multiplier times bonus multiplier (if any) equals claimed score. Send large SASE or IRCs to contest chairman for scoring summary sheet in advance of contest. Send full log data plus separate worksheet showing details and time off air. No logs returned. For results and scores send large SASE or ICSs. Logs must be received by May 21, 1984. QRP ARCI Contest Chairman, Eugene C. Smith, Jr., KA5NLY, #16 Fairmont Drive, Little Rock, AR 72204.

MAY 5-6: Cape Canaveral — the Florida Solar Energy Center of the State University system of Florida and the Indian River ARC will celebrate SUN DAY, 1500Z to 2200Z. 5,880 photovoltaic 4" diameter solar cells will provide heating, cooling, cooking and Amateur Radio operations during this event. W4NLX/4 will operate on SSB 7.240, 14.240, 21.370 and 28.518. CW 7.040, 14.040, 21.040 and 28.003. FM 146.28/88. A beacon will be on 1296.05 MHz. For all SWL and Amateur Radio operators the quarterly high tech newsletter "The Solar Collector" is available free on request. Also a multicolor certificate. Send business SASE to FSEC, 300 State Road 401, Cape Canaveral, FL 32920.

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

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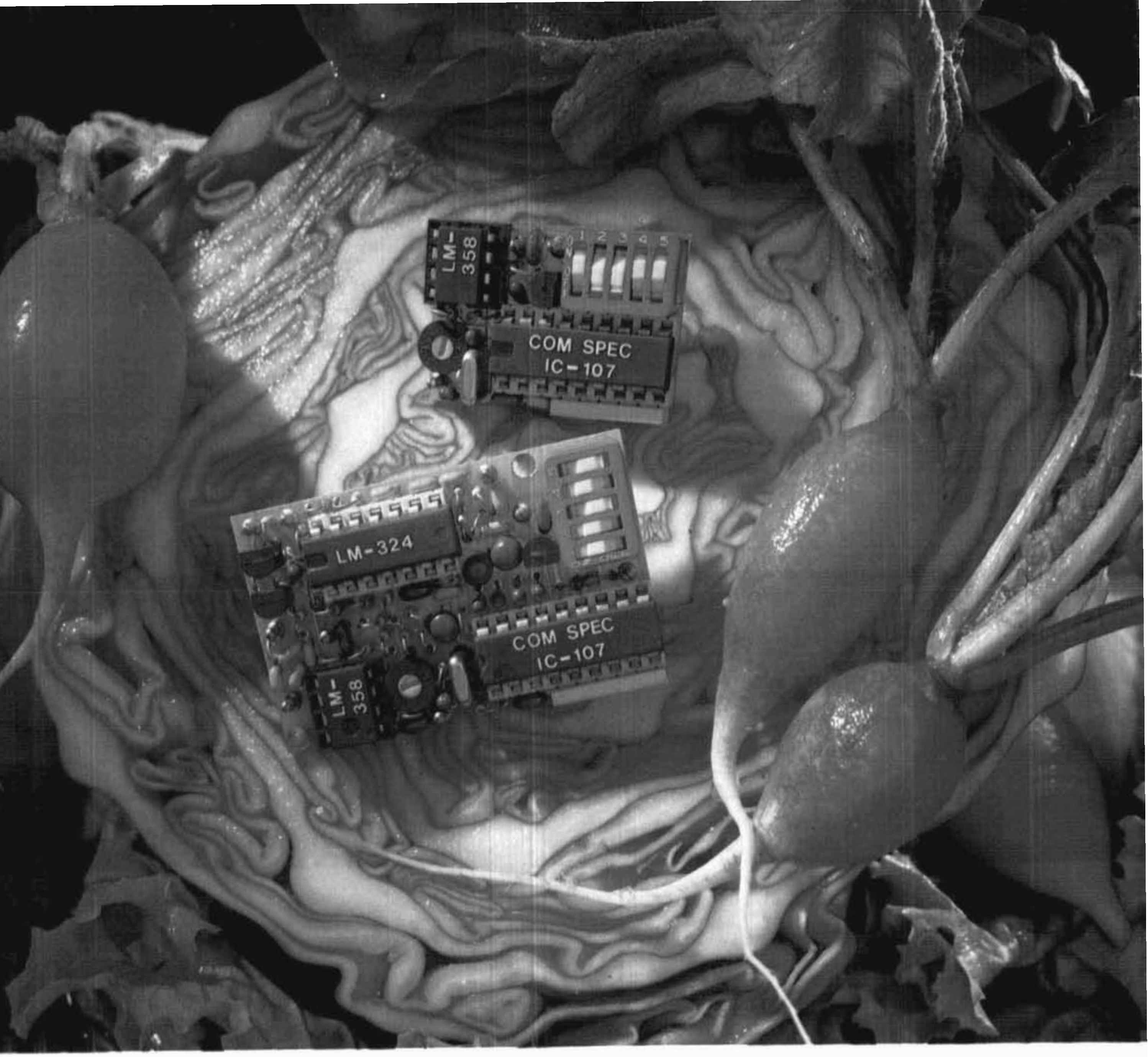

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April 1984

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YAESU FT-726R TRIBANDER

NEW GALAXIES OF PERFORMANCE ON VHF AND UHF

FULL DUPLEX!!

ATELLITES!! SCATTER!!

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The New Yaesu FT-726R Tribander is the world's first multiband, multimode Amateur transceiver capable of full duplex operation. Whether you're interested in OSCAR, moonbounce, or terrestrial repeaters, you owe yourself a look at this one-of-a-kind technological wonder!

Multiband Capability

Factory equipped for 2 meter operation, the FT-726R is a three-band unit capable of operation on 10 meters, 6 meters, and/or two segments of the 70 cm band (430-440 or 440-450 MHz), using optional modules. The appropriate repeater shift is automatically programmed for each module. Other bands pending.

Advanced Microprocessor Control

Powered by an 8-bit Central Processing Unit, the ten-channel memory of the FT-726R stores both frequency and mode, with pushbutton transfer capability to either of two VFO registers. The synthesized VFO tunes in 20 Hz steps on SSB/CW, with selectable steps on FM. Scanning of the band or memories is provided.

Full Duplex Option

The optional SU-726 module provides a second, parallel IF strip, thereby allowing full duplex crossband satellite work. Either the transmit or receive frequency may be varied during transmission, for quick zero-beat on another station or for tracking Doppler shift.

High Performance Features

Borrowing heavily from Yaesu's HF transceiver experience, the FT-726R comes equipped with a speech processor, variable receiver bandwidth, IF shift, all-mode squelch, receiver audio tone control, and an IF noise blanker. When the optional XF-455MC CW filter is installed, CW Wide/Narrow selection is provided. Convenient rear panel connections allow quick interface to your station audio, linear amplifier, and control lines.

Leading the way into the space age of Ham communications, Yaesu's FT-726R is the first VHF/UHF base station built around modern-day requirements. If you're tired of piecing together converters, transmitter strips, and relays, ask your Authorized Yaesu Dealer for a demonstration of the exciting new FT-726R, the rig that will expand your DX horizons!

Price And Specifications Subject To Change Without Notice Or Obligation

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