JULY 1983 / $2.50

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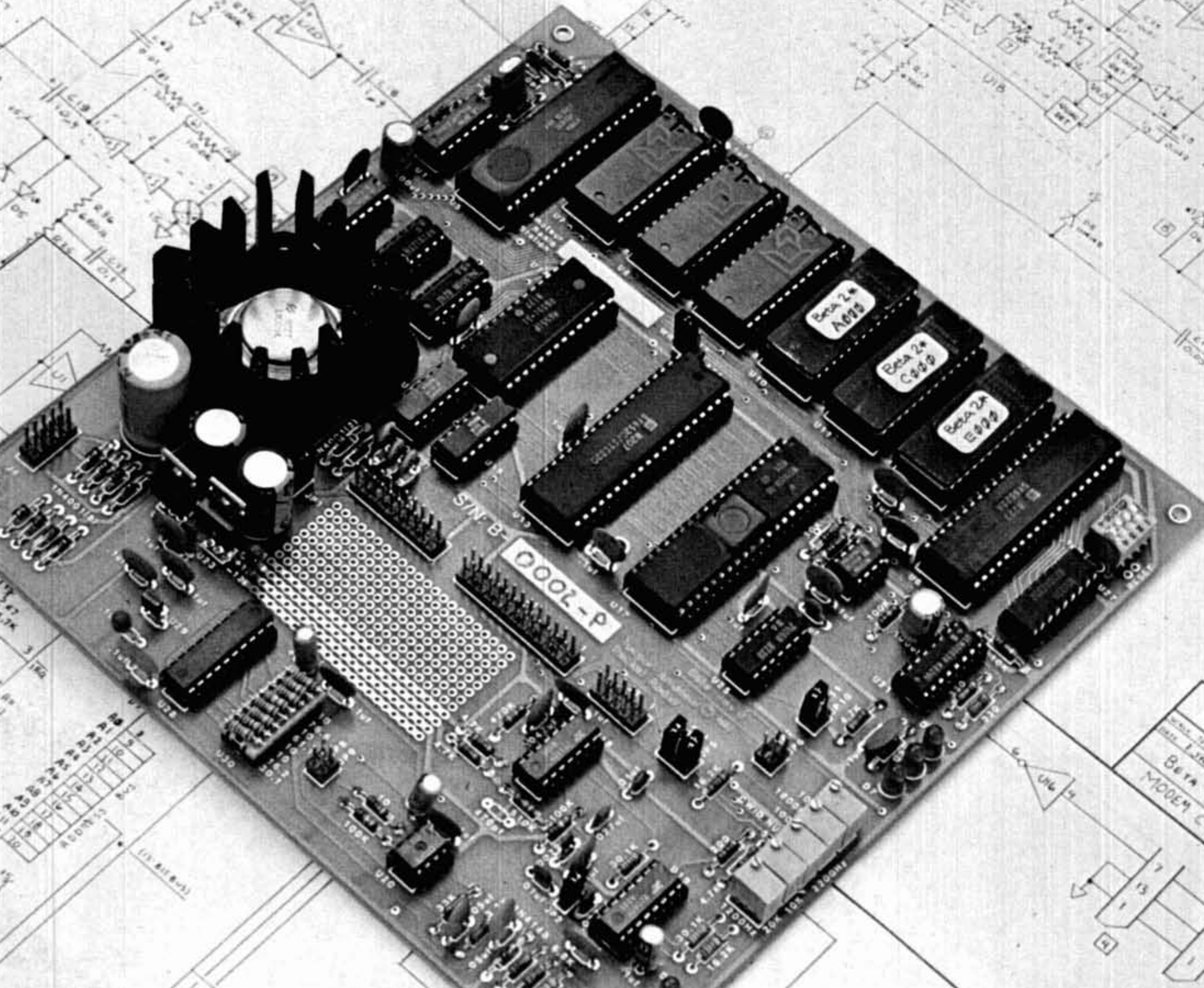
ham radio magazine



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IC-271A

NEW!

25 Watts of FM, SSB, CW for 2 Meters

ICOM presents the most advanced all mode, two meter base station available today . . . the IC-271A.

25 watts of power from 12 VDC or from 117 VAC with the optional internal power supply/32 full function memories/multimodes/subaudible tones/PLL locked to 10Hz/high visibility, multi-color flourescent display/RIT readout/scanning/dual VFO's/new size.

25 watts. Now a 2 meter base station with 25 watts of power and an optional internal power supply. The IC-271A is a complete station.

32 full function memories. Each memory holds frequency, offset, offset direction, mode, and subaudible tone. Frequency, tones and offset are selected by rotating the main tuning knob.

Subaudible tones. Subaudible tones are selected by rotating the main tuning knob and may be stored into memory.

PLL locked to 10Hz. Extremely low noise and a good signal-to-noise ratio PLL allow synthesizer lock to 10Hz.

High visibility display. ICOM's new high visibility, multi-color display gives easy to read at-a-glance display of frequency, mode, offset, VFO in use, memory channel, and RIT offset direction and amount.

Scanning. The IC-271A can scan memories, programmable sections of the band, or modes. Mode-S scan is a mode scan and can be used to scan memories with a particular mode or to lock out frequencies continuously busy so that the receiver will not stop at that memory channel each time.

Dual VFOs. ICOM's dual VFO system is now even more versatile with the ability to transfer from memory to VFO. This allows frequencies from the tunable memories to transfer directly into another memory without moving a VFO to the new frequency first.

New size. Only 11¼"W x 4⅜"H x 10¾"D the IC-271A is styled to look good and engineered for ease of operation.

Other features. To make the IC-271A functional and easy to use, ICOM has incorporated many asked for features: UP/DN buttons, dial lock, switchable preamplifier, duplex check, all mode squelch, receive audio tone control, S meter, center meter, computer interface, and 7 year lithium battery memory backup.

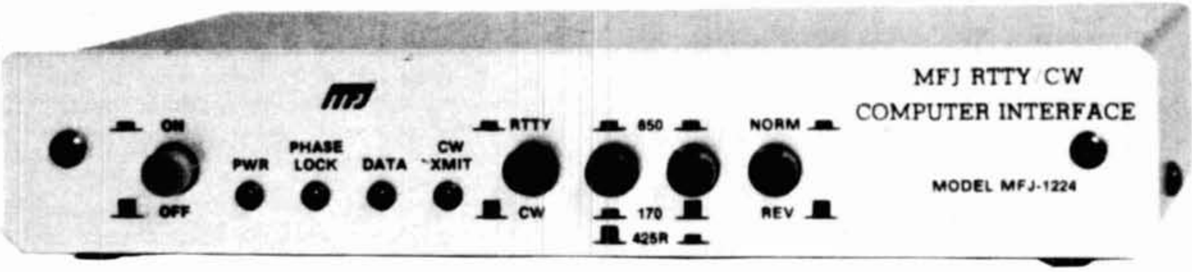
ICOM
The World System

✓ 148

ICOM America, Inc., 2112-116th Ave NE, Bellevue, WA 98004 **(206)454-8155** / 3331 Towerwood Drive, Suite 307, Dallas, TX 75234 **(214)620-2780**

MFJ RTTY / ASCII / CW COMPUTER INTERFACE

Lets you send and receive computerized RTTY/ASCII/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 Kantronics software and most other RTTY/CW software.



- *Copies on both mark and space tones.*
- *Plugs between rig and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 and most other personal computers.*
- *Uses Kantronics software and most other RTTY/CW software.*

$99.95

MFJ-1224

This new MFJ-1224 RTTY/ASCII/CW Computer Interface lets you use your personal computer as a computerized full featured RTTY/ASCII/CW station for sending and receiving.

It plugs between your rig and your VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64, and most other personal computers.

It uses the Kantronics software which features split screen display, 1024 character type ahead buffer, 10 message ports (255 characters each), status display, CW-ID from keyboard, Centronic type printer compatibility, CW send/receive 5-99 WPM, RTTY send/receive 60, 67, 75, 100 WPM, ASCII send/receive 110, 300 baud plus more.

You can also use most other RTTY/CW software with nearly any personal computer.

A 2 LED tuning indicator system makes tuning fast, easy and positive. You can distinguish between RTTY/CW without even hearing it.

Once tuned in, the interface allows you to copy any shift (170, 425, 850 Hz and all shifts between and beyond) and any speed (5 to 100 WPM on RTTY/CW and up to 300 baud on ASCII).

Copies on both mark and space, not mark only or space only. If either the mark or space is lost the MFJ-1224 maintains copy on the remaining tone. This greatly improves copy under adverse conditions.

A sharp 8 pole active filter for 170 Hz shift and CW allows good copy under crowded, fading and weak signal conditions. Uses FET input op-amps.

An automatic noise limiter helps suppress static crashes for better copy.

A Normal/Reverse switch eliminates retuning while stepping thru various RTTY speeds and shifts.

The demodulator will even maintain copy on a slightly drifting signal.

A +250 VDC loop output is available to drive your RTTY machine. Has convenient speaker output jack.

Phase continuous AFSK transmitter tones are generated by a clean, stable Exar 2206 function generator. Standard space tones of 2125 Hz and mark tones of 2295 and 2975 Hz are generated. A set of microphone lines is provided for AFSK out, AFSK ground, PTT out and PTT ground.

FSK keying is provided for transceivers with FSK.

High voltage grid block and direct outputs are provided for CW keying of your transmitter. A CW transmit LED provides visual indication of CW transmission. There is also an external hand key or electronic keyer input jack.

In addition to the Kantronics compatible socket, an exclusive general purpose socket allows interfacing to nearly any personal computer with most appropriate software. The following TTL compatible lines are available: 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.

For example, you can use Galfo software with Apple computers, or RAK software with VIC-20's. Some computers with some software may require some external components.

DC voltages are IC regulated to provide stable AFSK tones and RTTY/ASCII/CW reception.

Aluminum cabinet. Brushed aluminum front panel. 8x1¼x6 inches. Uses 12-15 VDC or 110 VAC with optional adapter, MFJ-1312, $9.95.

RTTY/ASCII/CW Receive Only SWL Computer Interface

$69.95

MFJ-1225

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

The MFJ-1225 automatically copies all shifts (850, 425, 170 Hz shift and all others) and all speeds.

It plugs between your receiver and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 and most other personal computers.

It uses Kantronics software which features CW receive 5-99 WPM, RTTY receive 60,67,75,100 WPM, and ASCII receive 110, 300 baud, plus more.

An automatic noise limiter helps suppress static crashes for better copy, while a simple 2 LED tuning indicator system makes tuning fast, easy and positive.

In addition to the Kantronics compatible socket, a general purpose socket provides RTTY out, RTTY inverted out, CW out, CW inverted out, ground and +5VDC for interfacing to nearly any personal computer with most appropriate software.

Audio in, speaker out jacks. 4½x1¼x4¼ in. 12-15 VDC or 110 VAC with adapter, MFJ-1312, $9.95.

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TS-830S

"Top-notch"...VBT, notch, IF shift, wide dynamic range

The TS-830S has every conceivable operating feature built-in for 160-10 meters (including the three new bands). It combines a high dynamic range with variable bandwidth tuning (VBT), IF shift, and an IF notch filter, as well as very sharp filters in the 455-kHz second IF.

TS-830S FEATURES:

- LSB, USB, and CW on 160-10 meters, including the new 10, 18, and 24-MHz bands. Receives WWV on 10 MHz.
- Wide receiver dynamic range, Junction FETs in the balanced mixer, MOSFET RF amplifier at low level, and dual resonator for each band.
- Variable bandwidth tuning (VBT). Varies IF filter passband width.
- Notch filter high-Q active circuit in 455-kHz second IF.
- IF shift (passband tuning).
- Noise-blanker threshold level control.
- Built-in digital display, (fluorescent tube), with analog dial.
- 6146B final with RF negative feedback. Runs 220 W PEP (SSB)/180 W DC (CW) input on all bands.
- Built-in RF speech processor.
- Narrow/wide filter selection on CW.
- SSB monitor circuit.
- RIT and XIT (transmitter incremental tuning).

Optional accessories:

- SP-230 external speaker.
- VFO-230 external digital VFO with five memories, digital display.
- VFO-240 external analog VFO.
- AT-230 antenna tuner.
- YG-455C (500 Hz) or YG-455CN (250 Hz) CW filter for 455 kHz IF.
- YK-88C (500 Hz) or YK-88CN (270 Hz) CW filter for 8.83 MHz IF.
- KB-1 deluxe heavyweight knob.

TS-530S

"Cents-ational"...IF shift, digital display, narrow-wide filter switch

The TS-530S SSB/CW transceiver covers 160-10 meters using the latest, most advanced circuit technology, yet at an affordable price.

TS-530S FEATURES:

- 160-10 meters, LSB, USB, CW, all amateur frequencies, including new 10, 18, and 24 MHz bands. Receives WWV on 10 MHz.
- IF shift tunes out interfering signals.
- Built-in digital display (six digits, fluorescent tubes), with analog dial.
- Narrow/wide filter selector switch for CW and/or SSB.
- Built-in speech processor, for increased talk power.
- Wide receiver dynamic range, with greater immunity to overload.
- Two 6146B's in final, allows 220W PEP/180 W DC input on all bands.
- Advanced single-conversion PLL, for better stability, improved spurious characteristics.
- Adjustable noise-blanker, with front panel threshold control.
- RIT/XIT front panel control allows independent fine-tuning of receive or transmit frequencies.

Optional accessories:

- SP-230 external speaker with selectable audio filters.
- VFO-240 remote analog VFO.
- VFO-230 remote digital VFO.
- AT-230 antenna tuner/SWR/power meter.
- MC-50 desk microphone
- KB-1 deluxe VFO knob.
- YK-88C (500 Hz) or YK-88CN (270 Hz) CW filter.
- YK-88SN (1.8 kHz) narrow SSB filter.

TS-660

The TS-660 "QUAD BANDER" covers 6, 10, 12, 15 meters.

- FM, SSB (USB), CW, and AM
- Dual digital VFO's
- Digital display
- IF shift built-in
- 5 memories with memory scan
- UP/DOWN microphone
- All-mode squelch
- Noise blanker
- CW semi break-in/sidetone
- 10 W on SSB, CW, FM; 4 W on AM.

Optional accessories:

- PS-20 power supply
- VOX-4 speech processor/VOX
- SP-120 External speaker
- MB-100 Mobile mount
- YK-88C, YK-88CN CW filters
- YK-88A AM filter.

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ham radio magazine

contents

REFLECTIONS

where were you, Idaho?

Dayton Hamvention '83 is now a thing of the past but memories of the hundreds of hams I spoke to at the show are still vivid. In looking through my logbook (and I do thank everyone who stopped by the booth, chatted with me, and signed the log*) I notice that most states were well represented (I counted 43), as were most provinces of Canada and quite a few other countries. I enjoyed seeing all of you in person, finally being able to associate faces with voices I have spoken to many times over the years.

One of the highlights occurred when I met whom I believe many of us consider the finest CW/phone operator around, a very fine gentleman, — Katashi Nose, KH6IJ. For almost three decades (that I can remember), his crisp fist has given us not only Hawaii, but also an operating style to admire and emulate. This is in addition to his many technical and personal contributions to the hobby.

Speaking of operators, it was good to see Gene (KR2N), Gary (W1EB), Dwight (W9UQO), Ted (K1OX), Rolf (KE1Y), and many other 75-meter aficionados at Dayton and commiserate on recent band conditions, discuss the latest solid-state receiver or dream about the ultimate antenna system that opens and closes the band. By the way, David (5Z4DD), thanks for making the sked at Dayton to meet one week after on 3782 — unfortunately an ionospheric storm increased attenuation on those three nights.

Besides being a great place to renew acquaintances, Dayton gave me an opportunity to discuss with you, the readers, your likes and dislikes, the type of articles you enjoy reading, specific subjects or sections that should be talked about more often or dropped. Below is just a sample of opinion expressed by the 300 or so I spoke to during the three days. Where do you fit in with your preferences? Readers told me that today's *ham radio* magazine is, in general...

... as good as the original *ham radio*
... not as good as the original
... still THE technical journal.

In regard to technical content, readers said *ham radio* is...

... not technical enough
... too technical
... just right

What do *ham radio* readers want to see? They want more construction articles, simple circuits, antenna articles; more about computer interfaces; and more coverage of VHF through microwave. They want more on RTTY, SSTV, Packet Radio, and OSCAR .... They love Bill Orr's "Ham Radio Techniques" and wonder, "Whatever happened to the DX Diary?" (Bear in mind that *every* opinion had considerable support — both pro and con.)

Some people even said they enjoy reading the editorials.

This impromptu sampling of opinion will be followed next month with a more precise evaluation of what *ham radio* readers say they want to see.

Finally, did anyone hear me say anything about the fleamarket? Here goes. It's a four letter word that starts with R and ends with N. It rained again. Too bad — Dayton Hamvention's reputation was, to a large extent, built on its flea market. Wait till next year.

Rich Rosen, K2RR
Editor-in-Chief

*Here's a random sample of some of the people I spoke to at the show:

KC4EG	WB1ADY	W8PJ	KR2N	W8TP	VE5ZV	K6IR
WD4C	WB9NDF	W8IMF	W1EB	G3ZAY	W7CFX	HL9KT
KA0APK	W4LQX	XE2UAA	W9UQO	WA0QNZ	W6HPH	W4ETO
WA9JWL	WB3JZO	N8DRI	K1OX	KH6KD	JA2AQO	N8CGG
KA9OTX	W0TN	5Z4DD	VE3APG	VE3MFO	JA2CEJ	W6SUI
K4KJ	WB8MVR	K8SS	KH6IJ	WB8GJP	N9CZK	W7FFP
W5XQ	K8UCN	N3BM	WA2LQQ	W3LPL	K1FI	CP1PO
K2GHV	VE3NGI	KB0PM	K9HI	W8LRL	OA4HJ	KA4QVK
WD8IKV	N9BW	VE5XK	N2NY	DK4EI	KA7NKX	W0ZO
WB2ABD	K1CKS	KE1Y	WB6QMD	W0RAN	N2CF	W5DFU
WA2AOG	AF9B	K2BQ	N4DKE	KB2M	XE1LL	WB9IVR

TECHNOLOGICAL BREAKTHROUGH!

NEW

AMERICA'S SECOND GENERATION MICROWAVE RECEIVER

SATURN-15XHP

JDL Leads Again

The **Saturn-15 XHP,** *an engineering break-through* from JDL laboratories, has new State-of-the-Art technology never before incorporated in amateur band general microwave receivers. This technology increases reception from distances never before achieved. By designing totally **new circuitry**, and using **new ultra-sensitive components**, coupled with a precision tuned 30 inch receiving dish, a system gain of 68 decibles makes the Saturn-15 XHP *the leader in micro*-wave receivers. In field tests, the Saturn-15 XHP received clear, crisp pictures, where other units tested were snowy. During these tests the Saturn-15 XHP's highly sensitive downconverter probe was able to receive a color picture without a dish. No other unit tested could pass this test.

Free Movies for You

That's right! **Free** movies, sports, and special events, 24 hours a day and all commercial free. The Saturn-15 XHP super deep fringe microwave receiver can be used by homeowners outside the service area of local **over-the-air** pay TV stations (ex. HBO, Showtime). Yes, if the local pay TV station *installs microwave receivers* on homeowners TV mast, you too can receive those unscrambled signals free by *installing* the Saturn-15 XHP on your TV mast in minutes. A signal can be received up to 100 miles, depending on the height and power of the local transmitter, and the installed height of the Saturn-15 XHP. If you have waited to own a microwave receiver, or own a low power unit, *call and order your Saturn-15 XHP and own the* most powerful receiver available today. Free TV—yours for a call. Note: **General microwave receivers cannot be used for receiving scrambled signals. Nor can they pick up from cable TV or their relay towers.**

A Total Unit

The Saturn-15 XHP comes complete with a 30 inch precision tuned receiving dish, advance design downconverter, power tuner, 60 feet coaxial cable, necessary adapters, mounting hardware, and installation instructions. A six month parts and service warranty covers the Saturn-15 XHP.

Information for your Area

By calling our **information number** (916) 454-2190 and talking *to one of our trained technicians*, we can help determine if the Saturn-15 XHP will work for you.

A Very Special Introductory Offer!!!!

As JDL Industries has and continues to provide the very best in products and customer service, we want everyone to be able to enjoy our new system, Saturn-15 XHP. The regular price for the *Saturn-15 XHP is $285.00. Order C.O.D., pay only* $260.00 and save $25.00. Trade in your old unit, from any manufacturer or home built, working or not, with your order, pay only $235.00—save $50.00. Or if you own our original Saturn-5 and wish to upgrade to the Saturn-15 XHP, return your unit and pay only $210.00—a savings of $75.00. We also accept Visa and Mastercharge at the regular price, $285.00. Sorry—no personal checks. Shipping *($9.50) and 6% sales tax for* Calif. residents not included. Trade-in units become the property of JDL Industries and **cannot** be returned under any circumstances.

Call our toll free number for placing **orders only. Information is not available at this number.**
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Saturn-15 XHP **must** be returned within 14 days of delivery for refund if not satisfied, and is subject to a 25% restocking charge.

presstop de W9JUV

PCB CONTAMINATED DUMMY LOADS MAY POSE A SERIOUS HEALTH HAZARD in many ham shacks! According to the Center for Disease Control in Atlanta, many RF dummy loads manufactured as recently as the late 70s utilized transformer cooling oil containing PCBs, which have been linked with liver cancer. PCB use is now prohibited by law, and all contact with any oil that could contain PCB should be avoided. Even fumes from a warm load could be dangerous in a poorly ventilated shack! Area EPA offices may have disposal suggestions.

EXPANSION OF THE 10-METER REPEATER SUBBAND DOWN TO 29.0 MHZ was proposed by the FCC at its May 12 meeting. Ten meter repeaters are presently restricted to 29.5 to 29.7 MHz, with 100 kHz offset the accepted standard. Under this new proposal, PR Docket 83-485, Amateur satellite downlinks at 29.3-29.5 MHz would become subject to FM repeater interference.

10-Meter Simplex Interference To Satellite Users Has Become a significant problem in the past few years. Increased use of 10-meter FM has driven FM users to below 29.5 to find clear frequencies, while more and more SSB operators have moved above 29 MHz for the same reason. The resulting interference to 29.3-29.5 MHz satellite downlink signals has become a major problem at times, and even triggered some on-the-air confrontations.

Without Suggesting Any Solutions To This Problem the FCC asked that it be one of the factors considered by Comment submitters. The comment due date was pending at press time.

The 28.3 MHz Lower Phone Limit Proposed In The FCC's further NPRM on the phone band expansion, PR Docket 82-83, is also being questioned by some 10 meter users. A world-wide system of beacons now operate between 28.2 and 28.3 MHz, but setting the lower U.S. limit at the top of the beacon band would push some foreign SSB operators into the midst of the beacons. Perhaps a 28.4 MHz lower limit would be better, leaving 28.3-28.4 MHz open for foreign phone operation. Comments close July 1, with Reply Comments open until August 1.

HAND-HELD RADIOS VS. USER HEALTH HAS BECOME a legal issue in New Jersey. A fire chief there has sued General Electric, alleging his use of one of their hand-helds over a 14-year period damaged his sight and hearing. At issue is GE's alleged negligence in not providing a warning of possible health hazards, despite a recommendation by the federal government in 1973 that such a warning be provided with portable transceivers.

Whether Close Exposure To Moderate RF Fields actually causes physical ailments has been the subject of heated debate for years. Despite many government and industry studies no clear-cut consensus has been reached. Attempts have been made on the local level, most recently in Massachusetts, to closely regulate all transmitter operators, and an on-going effort (strongly supported by ARRL's Biological Effects of RF Energy Committee) is being made for the adoption of a federal preemption law with exemptions for Amateur Radio.

The Effects Of A Decision Favoring The Fire Chief could have an even more serious effect on Amateur Radio than the current antenna ordinance problems, barring federal preemption. Local governments, acting to protect citizens, could enact legislation that would severely restrict if not bar operation of Amateur transmitters within their borders.

VOLUNTEER ADMINISTERED AMATEUR EXAMS WERE "AN ABSOLUTE, UNQUALIFIED SUCCESS" at this year's Dayton Hamvention, according to the FCC's John Johnston. With only one FCC staff member present to act as "overseer," Dayton Amateur Radio Association members were able to administer 683 exams to 484 applicants. The volunteers were obviously well prepared for their task, as the program came off extremely smoothly despite only one evening of "formal training" with the FCC. Oddly enough, the ARRL quietly made a last minute attempt to scuttle the Dayton exam session, on the grounds that it was likely to be improperly done and would thus set the entire volunteer program back!

Proposed Questions For The Volunteer Exam Program are already being sought informally from the Amateur community, even though the exam program itself is still to be acted on by the Commission. It's felt that having a pool of appropriate questions on hand would facilitate preparation when the FCC is ready to move on both the overall exam program, PR Docket 83-27, and the Novice "No-Mail-Back" proposal, PR Docket 82-727. Action on the latter could take place as early as June.

BURBANK (ILLINOIS) TOWER CASE MOVED CLOSER TO COURT after a magistrate recommended to the presiding judge that the city's motion to dismiss the Amateurs' suit be denied. In his recommendation the magistrate agreed that the Amateurs' argument that their constitutional rights of free speech and civil rights were both violated by Burbank's anti-tower ordinance raised a federal issue, so the case did belong in U.S. District Court.

A Status Call Has Been Set By The Judge for June 21, when he's expected to adopt the magistrate's recommendation. A date for the trial should be set soon after that.

ARRL Funding Of Amateur Radio Legal Cases will essentially cease, following a vote to that effect at the April 21-22 League Directors' meeting. The League will, however, continue to offer other forms of support to Amateurs with legal problems and may, under special circumstances, offer financial assistance as well.

PHASE III-B COULD BE IN SPACE BY THE TIME THIS SEES PRINT with a June 16 launch date announced at press time. An AMSAT crew was to leave momentarily for the French Guiana launch site for final checkout and fueling. If Phase III-B is up, check with ARRL or an AMSAT net for status, as it's not to be used until completion of the post-launch test.

OSCAR 8 Is Now On Mode J Only, due to ongoing battery problems with the aging bird.


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AMTOR NOW OFFICIALLY APPROVED IN U.S.A.

AMT-1
The Definitive AMTOR Terminal Unit

$499.95 Introductory Price

AMTOR is the system of error correcting RTTY which has been rapidly overtaking conventional RTTY in Europe, just as its marine equivalent, SITOR, has been taking over in ship to shore communications.

It was originated by Peter Martinez, G3PLX (see June 1981 QST, p. 25). He first interpreted the international marine CCIR 476-1 specification for amateur use. Virtually all of the 400+ stations presently on AMTOR world wide are using software/hardware designs originated by Peter. The AMT-1 is a proven product which represents his latest and most highly refined design. It represents the culmination of over three years of development and on the air testing, and sets the standard against which all future AMTOR implementations will be judged.

Not only does it incorporate the latest AMTOR specification, but it gives superlative performance on normal RTTY, ASCII and CW (transmit only). As well as some fairly incredible real time microprocessor software, the AMT-1 boasts a four pole active receive filter, a discriminator type demodulator, a crystal controlled transmit tone generator, and a 16 LED frequency analyzer type tuning indicator, which is very easy to use.

Driven from a 12 volt supply, the AMT-1 connects to the speaker, microphone and PTT lines of an HF transceiver and to the RS-232 serial interface of a personal computer or ASCII terminal. All mode control is via ESCAPE and CONTROL codes from the keyboard (or computer program).

It used to be that C.W. was the ultimate mode for "getting through" when QRM and fading were at their worst. That's no longer true — AMTOR will get through with perfect error-free copy when all other conventional transmission modes become useless.

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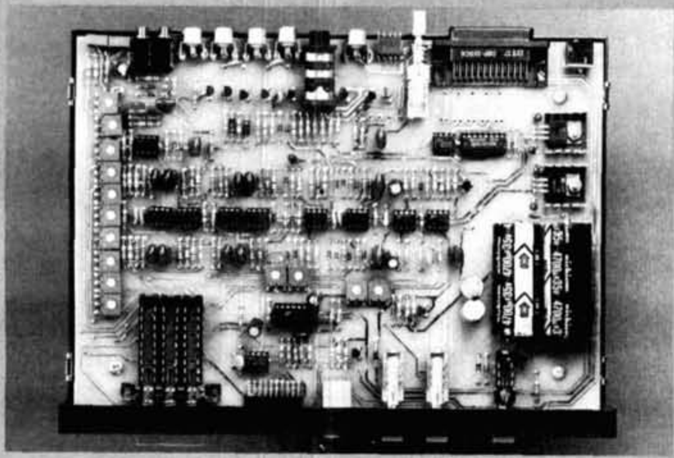

CP-1 Computer Patch™ Interface

The AEA Model CP-1 Computer Patch™ interface will let you discover the fastest growing segment of Amateur Radio: computerized RTTY and CW operation.

When used with the appropriate software package (see your dealer), the CP-1 will patch most of the popular personal computers to your transceiver for a complete full-feature RTTY/CW station. No computer programming skills are necessary. The CP-1 was designed with the RTTY neophyte in mind, but its sophisticated circuitry and features will appeal to the most experienced RTTY operator.

The CP-1 offers variable shift capability in addition to fixed 170 Hz dual channel filtering. Auto threshold plus pre and post limiter filters allow for good copy under fading and weak signal conditions.

Transmitter AFSK tones are generated by a clean, stable function generator. Plus (+) and minus (-) output jacks are also provided for CW keying of your transmitter. An optional low cost RS-232 port is also available. The CP-1 is powered with 16 VAC which is supplied by a 117 VAC wall adaptor included with the CP-1.

54 YEARS OF SERVICE

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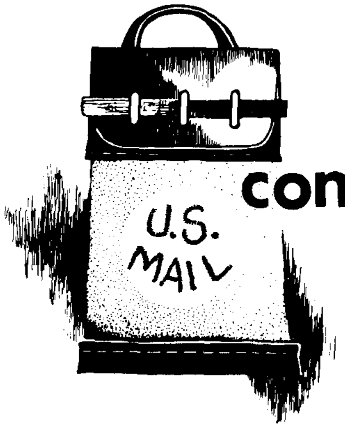

comments

briefcase Bobtail

Dear HR:

Just a few comments in regards to W6BCX's article on the Bobtail curtain featured in the February and March issues of *ham radio*.

I received word just four days before departure for Haiti that I had a license waiting for me. What to do about an antenna for 20 meters? I had just reviewed the few paragraphs on the Bobtail curtain in the *ARRL Antenna Book* when W6BCX's timely article came along. This was enough for me to make preparations to build such an array.

During the last couple of days before I was to leave, I built up a parallel tuned network consisting of a 70 pF variable capacitor and 12 turns of No. 14 wire spaced 1 inch apart. Ten turns tapped one turn up from cold end and about 3/4 maximum capacity gave a perfect match into 2000 ohms. So with a roll of No. 18 copperweld wire, some insulators made from 1/2 × 2 inch pieces of 1/4 inch phenolic, my Swan dual meter SWR bridge, the parallel tuned network built into a 4-1/2 × 5 × 2-1/2 inch aluminum box and a few short lengths of RG-58 stuffed into my briefcase, I was off. Destination, 120 miles west of Port au Prince in the mountains of the panhandle of western Haiti.

It took me, with help from my son, about 20 minutes to build the antenna. Twenty feet of bamboo put the northeast leg 24 inches above the new galvanized metal roof of his carport. The center leg also was 24 inches above the metal of the back porch roof and just six feet above my proposed operating position. The southwest leg was about three feet from the ground on a sloping hillside of about 45 degrees.

Results were outstanding. From deep in a mountain valley, with a ridge all across the north from east to west, 300 to 500 feet higher and a quarter to half a mile away, I worked all areas of the United States. I received 59+ reports from my home country of northwest Wyoming and southern Montana and 59+20 from the Denver area. The rig was HH2DR's TS520, sometimes operating on battery power. I worked a CN8 off the northeast end of the antenna just before the ARRL DX contest and had an OE6 and an HA6 call me during the contest even though I was not contesting. They gave me 55 to 57 reports. I probably had some distortion of the signal because of the large mango trees near both end elements. Compared to the 2-element quad of HH6BG located just 100 yards north, whom I had worked quite a few times from my home QTH, it was 2 to 4 S-units better. It was not the fault of the quad but instead of its location. The mountain hillside is 200-300 feet higher, begins 50 feet directly in front of the quad and at a 45 degree angle.

I brought the antenna home and will be using it on Field Day. By fall I hope to have a 40 meter version up and aimed at Europe and the South Pacific. I'm looking forward to some good 40 meter DX next winter. A match for my 20 meter 5-element log-Yagi at 70 feet it is not, but truly a fine, easy-to-pack antenna with gain broadside and rejection off the ends.

Thanks to W6BCX for his research.

Paul M. Rich, WA7BPO
Cody, Wyoming

power supply

Dear HR:

In the March, 1983, article "Dual Voltage Power Supply," the LM317 could be replaced with a 723-type regulator IC realizing the following benefits: lower cost, current limiting features, and, what I view as the most important improvement over any LM317 series pass transistor design, improved voltage regulation. An additional benefit could be improved ripple rejection.

The only drawback is an increase in circuit complexity required to accommodate the feedback and the internal voltage reference. The 723 has enough output current to drive the existing pass transistor. The 723 is available at Radio Shack with required specs and circuits for about 89 cents.

Peter J. Schuch, WB2UAQ
Little Ferry, New Jersey

noise figure data

Dear HR:

I was rather surprised at some of the noise figure data presented by Dennis Mitchell, K8UR, in the article "GaAs FET Performance Evaluation and Preamplifier Application" in *ham radio*'s March issue, and I would like to present some additional information regarding the performance of the Mitsubishi devices tested by Mr. Mitchell.

At the 1982 meeting of the Central States VHF Society, at Baton Rouge, Louisiana, there was a preamplifier noise figure competition. These tests were conducted with the current Hewlett-Packard programmable automatic noise figure meter with matching noise head. The results, however, departed significantly from the figures quoted in the article, particularly for the MGF-1200s.

Here are some of the results:

device	noise figure (dB)	frequency
MGF-1200	0.27	144
MGF-1200	0.42	144
MGF-1402	0.42	144
MGF-1200	0.48	144
MGF-1200	0.38	220
MGF-1402	0.39	220
MGF-1402	0.45	220
MGF-1200	0.47	220
MGF-1402	0.49	220
MGF-1402	0.40	432
MGF-1402	0.58	432

The Central States VHF Society results were significantly better than those of the author for the MGF-1200 at 144 MHz. Assuming that Mr. Mitchell presented median noise figure values in his article, then the figures presented above are at least 0.1 dB better in the worst case, taking the stated ±0.23 dB root-sum of squares uncertainty into account. In the best case for the MGF-1200 at 144 MHz the deviation from the author's noise figure is 0.3 dB!

The figures for the MGF-1402 are included to show that this device seems to reach a plateau at 432 MHz, and is not really a cost effective device at 144 MHz, with most GaAs FET users preferring the MGF-1200 or other similarly priced device at lower frequencies. Finally, the price structure that is mentioned in the article is about one year out of date, with the MGF-1200 currently selling for around $10, rather than the $15 indicated, and the MGF-1402 available for $15 or less, as opposed to $30.

From my experience, anyone using the MGF-1200 at 144 MHz should expect, and get, substantially better results than those indicated by Mr. Mitchell, in terms of noise figure attainable.

Jack C. Parker, KCØW
Bismarck, North Dakota

Amateur packet radio: part 1

The history and operation of packet radio are examined along with its requirements for software and hardware

***Imagine sitting down** in front of your station for an evening. You get out your 2-meter fm transceiver, attach it to a cable coming from an 8 × 8 × 3-inch "black box" connected to your data terminal. After turning everything on and initiating a short dialog between the terminal and the box, you enter a friend's call letters. After a short pause you see:*

****CONNECTED to (call sign)*

on your terminal. From this point on, everything you type appears on your friend's terminal, and everything he types appears on yours. Your friend could be within simplex range, or within voice repeater distance, or accessible only via a series of linking stations. In fact, you might need a satellite link to talk to your friend!

He asks, "Would you like a copy of my latest program for playing 'Escape The Maze'?"

"Sure," you reply, "only my compiler can't handle your gigantic programs. Why don't you just send me a dump of the machine language (binary) program?"

"No problem. Let me know when you're ready," he sends back.

You go over to your home computer, power it up, load your communications program, connect it to the box instead of the terminal, and type, "OK, let 'er rip."

Then you start your file-loading program and wait. Soon, binary data begins arriving from your friend at slightly less than 120 bytes of data per second. You sit back relaxed, knowing that even though the QSO is being held under noisy conditions, with occasional QRM breaking through, you won't receive a single bit incorrectly.

After the program has been stored away, you resume your conversation. It is almost boringly error-free, and with the speaker disconnected from your radio you don't even hear the QSO, which is being periodically interrupted by the automatic identification of both stations in CW. Later on you try out the new program and, sure enough, find you've received the whole thing perfectly.

Does this sound like magic? It shouldn't — it's happening right now with packet radio.

Packet radio promises to open new worlds of communications undreamed of just a few years ago by making possible the rapid transfer of digital information over great distances — with a virtual guarantee of integrity down to the last bit. This is tremen-

By Margaret Morrison, KV7D, and Dan Morrison, KV7B, 4301 E. Holmes, Tucson, Arizona 85711

dously attractive. Not only can traffic be exchanged between hams equipped with data terminals, but just as easily between a ham and a computer, or between two computers.

Let's look first at what a packet is and then at the history of packet communications and the kind of hardware and software packet radio requires. We will use the two most familiar systems to serve as examples, although others are in use as well. These two are the VADCG (Vancouver Amateur Digital Communications Group) system and the TAPR (Tucson Amateur Packet Radio) system.

what is a packet?

Packet radio is a relatively new form of digital communications. It has some characteristics in common with older forms, such as ASCII and RTTY, now both familiar to the Amateur community. In all of these modes information is coded in binary form, that is, as a series of 1s and 0s. The information is translated into an audio signal consisting of alternations between two tones, and the audio signal then used to modulate an rf signal to produce an FSK or AFSK transmission.

In an ASCII or RTTY system, the transmission typically consists of a sequence of individual characters separated by periods of unmodulated carrier transmission. In order for the receiving station to interpret the characters correctly, extra transitions are added at the beginning and end of each character (start and stop bits). Depending on reception conditions, anywhere from all the information to virtually none of it may be received correctly; what's not received correctly may be garbled or missed completely.

A packet consists of binary data (which might be ASCII, Baudot, or some other code), and the modulation techniques may be essentially the same as for conventional ASCII or RTTY, although the exact interpretation of the tones may be different. The VADCG and TAPR TNCs produce AFSK, but more sophisticated schemes are being developed. (The TNC, or terminal node controller, is the "black box" referred to in the introduction to this article. It is a complete microcomputer-based communications system with a good-sized memory, 30 kilobytes in the case of the TAPR TNC. It does all the work involved in sending and receiving packets).

In a packet, the individual characters, or bytes, are run together with no space at all between. This eliminates the need for both the start and stop bits as well as the dead time between characters. The result is much more efficient information transfer. The analog of start and stop bits are sent only for the beginning and end of the packet, and the transmitter is keyed only while information is actually being sent.

Extra information is inserted into each packet that enables the receiving station to determine automatically whether the packet was received without error. Thus every correctly received transmission is acknowledged. The sending station can keep retransmitting its information until it is assured that it has gotten through. Other features of the packet which facilitate this "handshaking" are described later.

history of packet radio

Packet switching is a technology that was developed to tie computer users into a network which could extend over a wide area. It has been used for many years over common carrier lines, both commercially and by government. The first large-scale packet network in North America was ARPANET, set up in 1969 by Bolt Beranek and Newman, Inc., for the Defense Advanced Research Projects Agency. This network introduced packet switching, in which each message sent is broken up into small packets and each is switched to its destination over the quickest communications path available at that instant. Data interconnections are typically 50-kilobit-per-second wideband lines, and the packets are passed from node to node until they arrive at their destination. Typical end-to-end times are 250 milliseconds, and receipt of data is acknowledged.

Other networks around the world soon began operation, and today there are many government and commercial computer networks, such as TYMNET and TELENET, which allow users all over the country to access thousands of computers remotely.[1]

Packet radio experiments began in the 1970s. One of the largest packet radio systems, based at the University of Hawaii and known as the ALOHANET, linked together a number of computers and users, and also provided access into ARPANET and satellite links.[2] Other systems were developed for the purpose of providing distributed automatic digital communications for remote sensing stations.

Packet switching networks (both wire and radio based) generally use one of two methods for routing packets from the originating station, through intermediaries, to the destination. In one system used by TYMNET and others, a central controller determines the optimum path for a particular pair of stations on the basis of the stations present in the network at any time. In the other system, the network itself is intelligent and determines the routing between stations. This is the system that was pioneered by ARPANET.

North American Amateurs first entered the picture in Canada, where, beginning in 1978, the Department of Communications encouraged the use of packet radio by permitting Amateur packet transmissions and by giving exclusive use of 221 to 223 MHz and 433 to 434 MHz to packet and digital transmissions. Taking advantage of this ruling, VADCG, a group in Vancouver, British Columbia, designed the first well-known Amateur packet radio TNC, and soon TNCs became widely distributed.[3] Their use in the U.S. followed a rule by the FCC making such ASCII transmissions legal in March of 1980. Finally, in October of 1982, the FCC revised Part 97.69, lifting many restrictions on digital communications and advanced data transmission. Today many experimenters using the VADCG TNC, the TAPR TNC, and homebrew systems are hard at work, developing this new mode of communications.

anatomy of a packet

The basic element in packet radio is the frame — a string of bits with a specific format. The bits are presented to the transmitter on a modulator output line. In the case of the TAPR and VADCG TNCs, the modulation system uses 1200-Hz and 2200-Hz tones and coherent (phase-continuous) FSK, with a data rate of up to 1200 bits per second; it is compatible with the Bell 202 standard modem. Other modulation systems being developed for Amateur use include minimum shift keying (MSK), and various forms of phase shift keying (PSK). These schemes, which are more efficient than ordinary FSK, are useful for long-haul traffic, especially via satellite.[4]

The FSK signal is related to the bit stream according to specific digital encoding rules. The most commonly used system is non-return to zero inverted (NRZI) encoding. In this system, a transition from one tone to the other is interpreted as a 0, whereas no transition during the bit period is a 1. Such a method is used because, according to the rules by which the frame is constructed, a transition is guaranteed at least once in every five bit periods. This is needed to keep the receiving station in "sync" with the incoming data.

The actual structure of the frame varies from one packet radio system to another. The structure makes possible, among other things, the delivery of the message to the proper recipient and a system for ensuring data integrity. The most frequently encountered format for frames is known as HDLC, or High Level Data Link Control. Each HDLC frame consists of six fields, as shown in **fig. 1**.

In order of transmission, FLAG1 is first. It is at least eight bits long, consisting of the bit pattern 01111110. This particular combination is unique to FLAG1 and FLAG2, and appears nowhere else in the frame. Part of the transmitting station's job is to alter the message content of the frame to prevent this combination from appearing elsewhere (a process

FLAG1	*ADDR*	*CONTROL*	*DATA*	*FCS*	*FLAG2*

fig. 1. Schematic representation of an HDLC frame.

known as bit-stuffing). This alteration is, of course, undone by the receiving station. FLAG1 (which may be repeated several times before the rest of the frame is sent) says, "Get ready! Here comes a frame!"

The ADDR (address) field varies among the various packet radio systems developed in the Amateur community. HDLC requires only that it be at least one byte long. It typically contains the source address, and may contain the destination address and perhaps routing information. The address field contains the information which permits delivery of the packet.

The CONTROL field also varies among systems. The length of this field specified by HDLC is one or two bytes. The information contained in this field typically includes acknowledgment information for previous packets successfully received; an indication that the sender would like to begin talking (connect) to the destination station; a request to terminate the conversation (disconnect); or other "supervisory" functions, such as requests to stop transmitting or to resume transmitting (referred to as flow control).

The DATA field consists of zero or more bytes of information (zero in the case of simple acknowledgments, for example). They may be in any bit pattern — ASCII characters, part of a binary program, you name it. (The FCC, however, would like you to have available enough information so they can decipher your data!) The HDLC standard requires that when five consecutive 1s appear a 0 be inserted. This is the bit-stuffing mentioned above. It prevents data from being mistaken for flags, and also ensures frequent tone transitions if NRZI encoding is used. Upon reception, these extra 0s are discarded. Typically, the maximum data length is 128 to 256 bytes.

The last item in the frame prior to the ending flag bits is the FCS, or frame check sequence, an extremely important two-byte number computed by the transmitting station based on all the bits in the frame following FLAG1. If the frame is received in garbled condition it is extremely unlikely that it would be garbled in such a way as to produce the same FCS. The FCS is separately computed by the receiving station and, if both numbers agree, there is virtual certainty that the frame was received as sent.

Finally, the frame ends with another byte of flag field, thus indicating to the receiving station that the previous two bytes were indeed the FCS.

protocols

What we have described is not yet truly packet radio. It could be called "frame radio," the exchange of frames of information. The protocol, in addition to specifying the structure of the frame, determines the contents of the ADDRESS, CONTROL, and possibly the DATA fields. It also determines action to be taken in various situations. For example, just exactly what should be done if the first, second, and fourth frames received in a single transmission check out, but the third does not? Or, what should be done if the other station suddenly stops responding? The list of "what-ifs" increases rapidly as other users join the frequency.

The interchange of packets results in communications between the participating stations on more than one level. The ISO, International Standards Organization, has defined a model network structure consisting of seven "layers." The first three, levels 1, 2, and 3, are concerned with communications and are the ones of interest to us. Each consists of a set of related tasks which would ordinarily be handled by correspondingly related processes (electrical or software). The ISO layer structure does not define the specific protocol to be followed to accomplish the tasks of any level, and the operation of each level should be independent of how lower-level tasks are performed.[5]

Furthermore, each layer is "transparent" to the levels above it. This means, for example, that information used to direct actions by a level 3 process is treated as data by the level 2 process. A packet is structured like an onion. Each process peels off the applicable control information before passing the remainder to the next higher level.

The bottom layer is called the physical layer. It is concerned with such things as modulation and transmission techniques, signaling the beginning and end of packets, bit-stuffing, and maintaining synchronization with the incoming data stream. The second level, or data link layer, defines the use made of the address, control, and FCS fields of the packet. Level 2 is responsible for setting up and maintaining a connection or data link with the other station. This includes verifying data integrity, acknowledging receipt of intact frames, retransmitting unacknowledged frames, and performing various link control functions. The third level, the network layer, defines routing functions and inter-network communication. Level 3 is concerned with setting up and maintaining routing tables for communication between stations which are not in direct contact. Amateur packet radio has implemented some level 3 functions but not all.

An additional set of rules, a collision avoidance protocol, is necessary for packet radio but not for communications over wires. Since stations cannot receive at the same time they are transmitting, "collisions" occur when two or more stations transmit simultaneously. A scheme for avoiding repeated collisions must ensure different retransmission times after an initial transmission has failed. If all stations can hear each other, as is the case when all transmissions are made on the same frequency and all stations are close together, all that is needed is to impose a short random wait time for stations retransmitting a packet. If a central controller (or a satellite) transmits on one frequency and listens for all other transmissions on another frequency, a more elaborate scheme is required.

The HDLC frame structure described above is imposed on levels 1 and 2 of all protocols implemented so far for Amateur packet radio, and both the VADCG and TAPR TNCs use LSI chips that perform many of the level 1 and 2 tasks. The two most widely used protocols, VADCG and AX.25, are thus functionally equivalent on level 1 and quite similar on level 2.[6,7] AX.25 is modeled on X.25, a standard developed by the Consultative Committee for International Telegraph and Telephone (CCITT) of the ITU[8]. AX.25 was put forward by a group of Amateurs at the AMSAT packet conference in October of 1982. AX.25 specifies the address as containing Amateur call signs of both the sending and receiving stations, with optional routing information in the form of the call signs of stations requested to relay, or digipeat, the packet. The VADCG address field contains a numeric address of the sending station only; packets setting up the connection contain call sign information in the data field. Relay by an unspecified digipeater can be requested. The control functions implemented in AX.25 are summarized in **table 1**. Most control func-

table 1. Level 2 control functions.

RR	Receive ready: acknowledge receipt of information frames by specifying the sequence number of the last packet received.
RNR	Receive not ready: request to stop sending (receive buffers full).
REJ	Request retransmission of missed frames after receipt of a frame number larger than expected.
DM	Disconnected mode: response to a packet other than a connect request.
SABM	Set asynchronous balanced mode. This is a connect request.
DISC	Disconnect request.
UA	Unsequenced acknowledgment: sent in response to a connect or disconnect request.
FRMR	Reports an abnormal condition; that is, receipt of a packet with an undefined or invalid control byte.

tions can be performed by a packet which also transmits data. Fewer level 2 control functions are specified in the VADCG protocol.

implementation

If you have a home computer, you are probably wondering where you can get a packet radio program for it. You may even be thinking about writing one yourself. The only hitch here is that you need more than a program. At a minimum, you need some hardware to enable the computer to control the radio push-to-talk line, put signals into the microphone input, and interpret signals on the speaker output. Specialized hardware, such as an HDLC controller, is very desirable. This hardware must be able to generate interrupt requests to the computer. The program itself should take care of the input and output requirements of both the radio and the terminal through interrupt processing. You can't afford to miss part of an incoming packet because you got busy parsing a line from the terminal! This means that the program probably has to be written at least partly in assembly language. Interpreted languages, such as BASIC, are commonly used on small computers, but they are neither fast enough nor versatile enough for real-time programming of this kind. These obstacles are not insurmountable, and in fact many hams have been successfully running packet radio programs on various home computers.

There are disadvantages with this approach, however. These programs are not very portable: they work on a specific computer with a specific operating system, and depend on the specific configuration of the hardware "extras." The programming has to be done over for each different type of computer. Modifying a protocol would be a major undertaking involving reprogramming many computers. Furthermore, many hams who don't own computers or who don't want to get involved in a programming project are interested in packet radio. After all, an RTTY terminal unit or a CW keyboard need not be connected to a computer. This is why most Amateurs involved in packet radio are using a terminal node controller. The TAPR and VADCG TNCs have standard terminal interface connections, and provisions for versatile radio interfaces. The ROM memory chips can be programmed with software implementing a standard packet radio protocol, and, once such software is written, it can be easily transferred to any similar TNC. Since the TNC is basically a dedicated microprocessor, the demands of radio communications do not interfere with a resident operating system.

packet radio — communications of the future

Hams all over North America are now involved in sending packet radio messages across town on VHF on UHF bands. Digipeater relays and ordinary voice repeaters make it possible to communicate over distances of 100 miles or more. Packet radio mailboxes and bulletin boards are on the air in several areas. Interest is growing rapidly in this newest mode of communications. With more experimentally inclined packeteers joining the ranks, exciting developments will be forthcoming. The emphasis for the future will be on long-distance communications and inter-network linking protocols. Experimental hf packet communications has been done on 10 meters. Inter-network communications through UHF and microwave linking stations using high data rate modulation techniques is envisioned. The digital special communications channel on the AMSAT Phase III-B satellite will see use by packet radio stations. Groups are working on protocol standards for this application and on L-band amplifiers to allow inexpensive access to this satellite mode. Possibly the most ambitious project in the works is a packet radio satellite with a store-and-forward mailbox as well as direct relay capability.

Part two will continue with a detailed description of the TAPR terminal node controller; it will provide a clearly defined set of interface requirements and point out pitfalls to be avoided in making reliable radio connections.

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Tucson Amateur Packet Radio Corporation Packet System Beta Test (1983). This manual contains information on AX.25, VADCG protocol, modulation, and HDLC.

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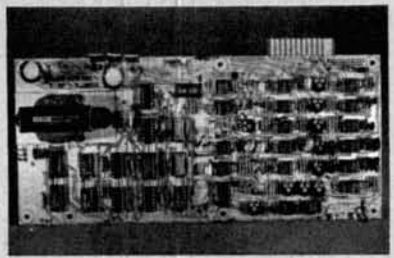

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Surplus houses sell them for around $12, but you can pick them up new at ham flea markets for around $4. These fans run from 120 Vac, but are fast and noisy, masking the speaker signal. To slow the fan down, put a 600 ohm 20/30 watt resistor in series with the 120 volt line. I put mine in front of the breeze to keep it cool. A four-inch resistor will mount on clips attached to the holes in the fan used for mounting (see **fig. 1**).

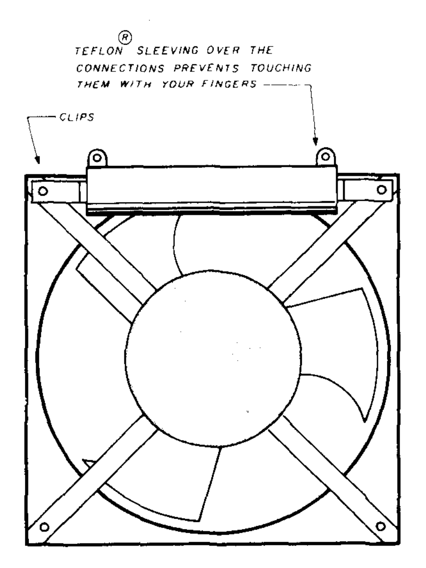

fig. 1. Heat sink cooling fan.

Ed Marriner, W6XM

HF antenna

Some time ago I tried a 160-meter antenna described in *Editors & Engineers Radio Handbook* by Bill Orr, W6SAI, (21st Ed., Section 27-17, fig. 22). The results were quite gratifying, probably because of the high ground conductivity under the antenna. The ground for the antenna was at the base of a 40-foot TV tower.

I now have a small home at the seashore on a small lot, too small to put up a 120-foot dipole for 75 meters. In the past I had tried a single-wire 1/4-wave antenna, but with only limited success. Then this year I put up the one shown in **fig. 2**. I first put up the 75-meter portion, made with 300-ohm TV ribbon to the specs given in the *Handbook.* My results on 75 were much better than with the 1/4-wave dipole, but this antenna, of course, worked on only one band.

Next I tried using two lengths of 300-ohm ribbon, cut for 40 meters and 20 meters, and slung under the 75-meter section. Because of the close coupling to the 75-meter section, these did not work. But it was interesting to note that the performance of the 75-meter antenna was not affected by the addition of these two sections. I replaced the 40-meter and 20-meter sections with wire, to form a 1/4-wave antenna on these bands. Now all three antennas tuned up well. VSWR at 3.825 MHz was 1.4, at 7180 it was 1.2, at 14275 it was 1.4, and at 21.300 it was 1.4. Normally it would not be necessary to use an antenna tuner, but with the TS-120S solid-state transceiver, maximum output occurs at only 50 ohms. Also, by using the tuner I work over the full portion of these phone bands.

construction

The spacers were made from three plastic clothes hangers purchased at the local discount store for 97 cents. Each hanger was cut up to get the straight sections. Six were cut to 9-inch lengths and these were used for the 40-meter and 20-meter sections. Four were cut to 6-inch lengths for the outer supports of the 40-meter section. Holes were drilled for passing the wires through them, and then the wire was tied to the supports with a piece of fishline. See **fig. 3** for details.

Here I might remind you to make sure the grounded portion of the SO-239 cable connector is secured to the tower base with a strap or heavy wire (#14 or larger). The one grounded side of the 300-ohm ribbon is soldered to the SO-239 casing and the other three wires are soldered to the center pin. After soldering, the SO-239 was coated with Dow-Corning DC-9 for weather protection. Connection to the equipment is by means of thirty-five feet of RG8/U.

For use on a small lot, this system seems to work quite well, and it has a high angle of radiation, which I prefer for contacts up to 800 miles on 75. Don't expect this type of antenna to compete with a high half-wave antenna on any of these bands, but it does perform well for reasonable distances — even with its short length.

J.F. Sterner, W2GQK

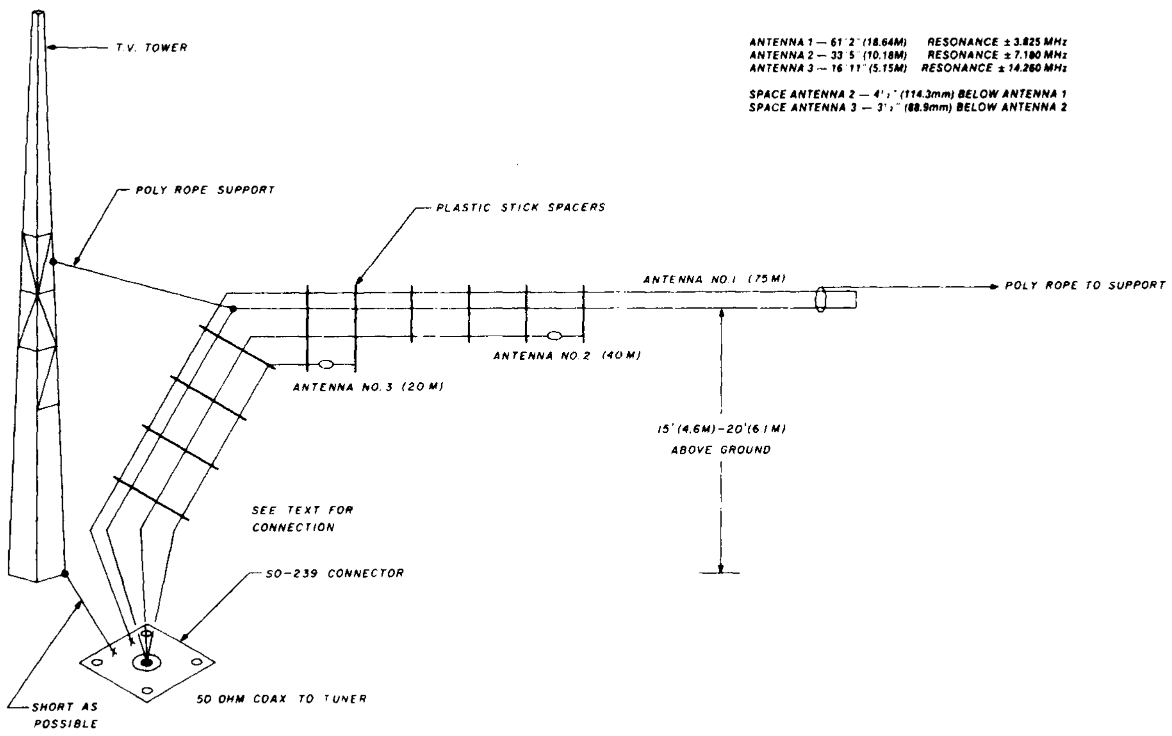

fig. 2. Construction details of the antenna for 75 through 15 meters.

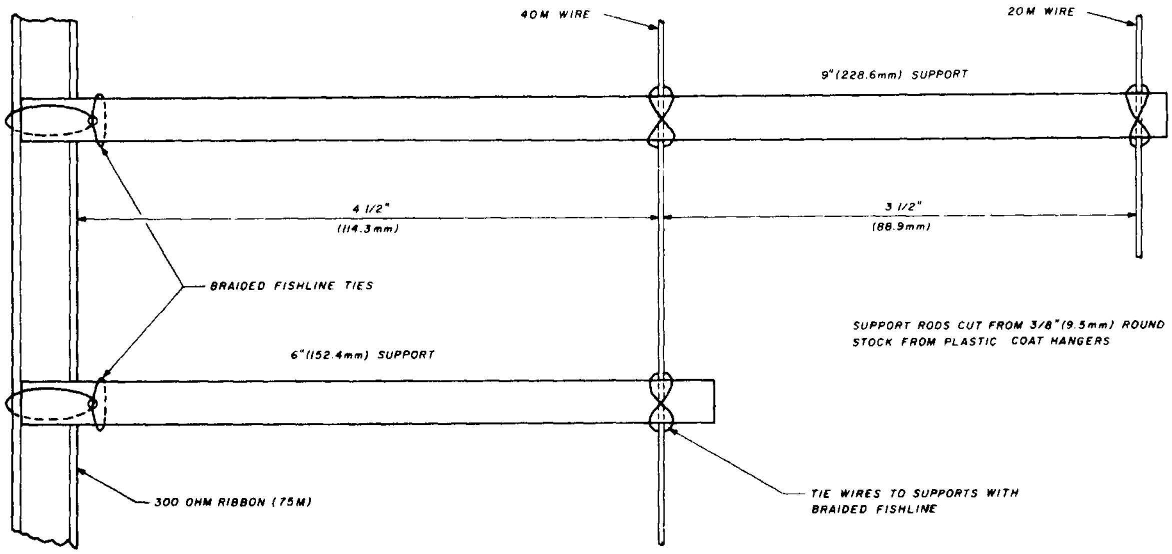

fig. 3. Support sketch.

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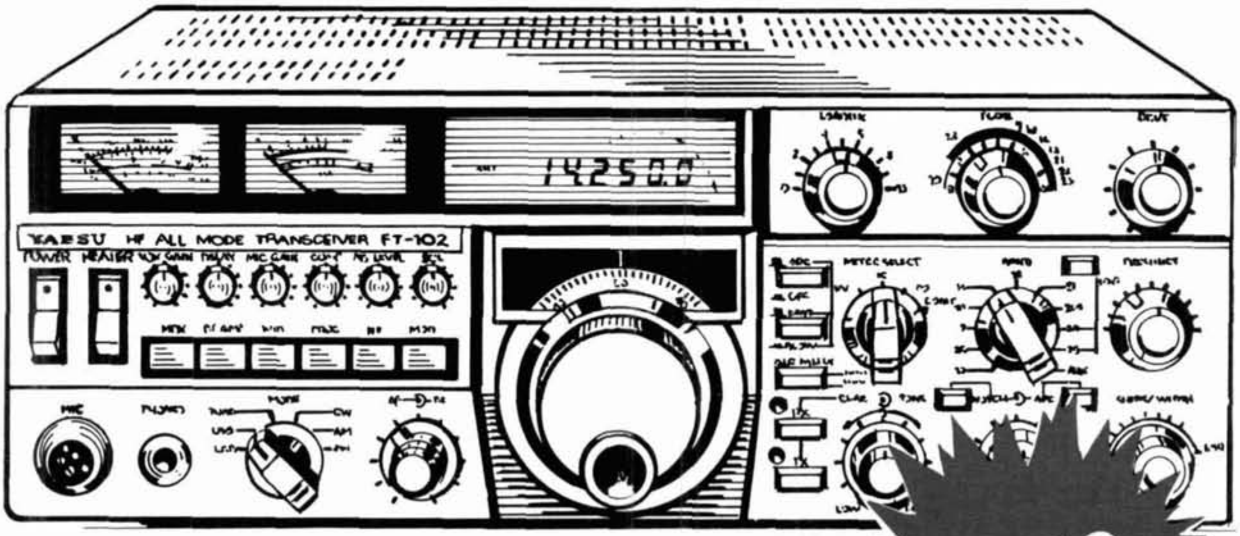

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vertical phased arrays: part 3

Array impedances, measurements, and calculations

This is the third in a series of articles on phased vertical arrays by K2BT.

In Part 1 (May), the author examined essential design parameters, and more importantly, the *assumptions* underlying design. (In the past, incorrect assumptions have misled designers into constructing less than optimally performing arrays.)

Part 2 (June) continued with relative power plots of two- to four-element arrays indicating the correlation between physical and electrical (phase) spacing and performance.

This month, K2BT's discussion includes the determination of self- and mutual-impedances, the importance of an extensive ground system, and a tabulation of mutual and driving point impedance values for some popular vertical phased arrays. — **Editor**.

In Part 2[1] various types of arrays were examined and relative power (in dB) plots were shown. We saw how specific physical arrangements of elements, current amplitude ratios, and phase displacements formed beams. By varying current amplitude ratios and phases, the forward beam width or the rejection characteristics of a given physical array were modified. The question now is how can these drive conditions be created in a real array? To do this we need information about element impedances in order to design the feed network.

Knowledge of self-impedance and mutual impedances, as well as factors that influence them, is essential because everything will be either directly or indirectly affected by these parameters.

self-impedance

The self-impedance of an antenna at any frequency is a function of the element length, its radius, ground plane loss, and coupling with other nearby antennas. Strictly speaking, the last two items are not components of self-impedance. However, when measuring self-impedance, both may be present in the reading of *apparent* self-impedance.

Although resonant elements are not required for an array, their use simplifies calculations and provides the following advantages:

1. An *open-circuited* 1/4-wavelength element presents virtually no coupling. This simplifies measurement procedure and ensures best conditions for accuracy of self- and mutual impedance readings.

2. The resistive component of self-impedance is normally higher than ground loss resistance which results in reasonable efficiency.

3. Ground plane evaluations and comparisons are easier to make because more information is available about the 1/4-wavelength resonant antenna than about other types of vertical antennas.

element length and radius

An article on Yagi design by James Lawson, W2PV[2] provides data on the relationship between an element's resonant length and its radius. (When using this source, be sure to refer to error corrections[3]) It's important to use a full wavelength when calculating length-to-radius ratio, K, for W2PV's equations. For determining parameters of a resonant grounded 1/4-wavelength element, I have revised W2PV's chart as shown in **fig. 1**. In the Yagi antenna

By Forrest Gehrke, K2BT, 75 Crestview Road, Mountain Lakes, New Jersey 07046

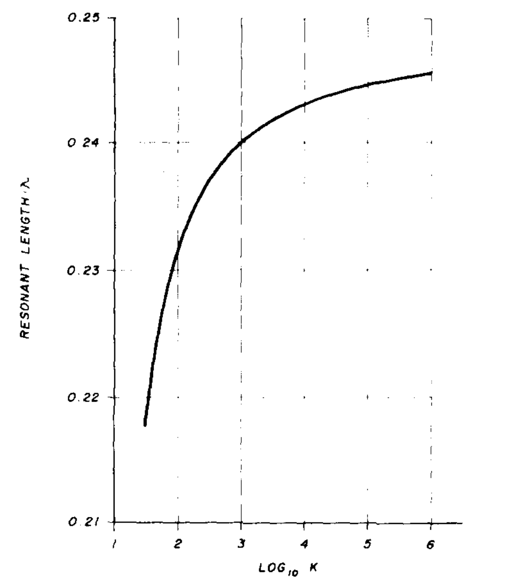

fig. 1. Resonant length of a quarter-wavelength grounded element as a function of k (operating wavelength to element radius ratio).

design, emphasis was placed on the reactance component of self-impedance, ignoring the effect that radius has upon the resistive component. In an all-elements-driven array as compared to a parasitic array, it is more important to know this effect. A review of the Amateur literature yields a range of values for a 1/4-wavelength vertical resistive component of impedance; these values are probably all correct. Any disparity is probably due to the different antenna element diameters that are used. The theoretical self-impedance of a physical 1/4-wavelength high vertical is 36.5 + j21[4] which assumes the use of an infinitely conducting ground plane and an infinitely thin element. Obviously neither of these conditions is physically realizable. However, even if an infinitely thin element could be used, it still would have to be shortened to achieve resonance — and in so doing the resistive component would decrease. A real element, having real thickness, would reduce resistance some more since it requires a further reduction in length in order to achieve resonance. Kraus[5] shows that l/r ratios in the range of 60 to 1000 are equal to a resistance variation from 34 to 36 ohms, with 35 ohms as an average value. He uses an element's actual length when calculating l/r. The comparable data for *reactance* change compiled by W2PV would show a variation for K from 240 to 4000. When resistance is plotted against the logarithm of K, we see a virtually straight line, showing a slow reduction in resistance as the element diameter is varied from 1.5 to 24 inches.

ground planes

Considerable controversy surrounds the subject of required ground plane size and its influence on antenna performance. The ground plane essentially establishes an image antenna to represent the other half of a dipole. The better that image, the lower the ground loss and the lower the radiation angle. How large the ground plane should be is answered by examining the near field (within the first 1/2 wavelength), and far field (to at least 6 wavelengths) components. The near field requirements for proper pattern formation is satisfied by a ground system composed of wire radials; a sufficient quantity allows us to get quite close to the theoretical resistance. At the lower frequencies the far field usually must be left to nature, since it would be prohibitively expensive to provide so large a radial wire or mesh ground system. Even the large a-m broadcast antennas are located in salt marshes whenever available to take advantage of the high conductivity of earth for many wavelengths beyond the reach of the radials.

My experience correlates closely with the work reported by Jerry Sevick, W2FMI.[6,7] His graph of resistance versus number of radials used on 40 meters is applicable for 80 meters as well. I used radials averaging 0.3 wavelength in length, composd of PVC No. 24 hookup wire, and laid them on the ground. The only difference noted is that resistance did not decrease as rapidly as his graph shows. For instance, I never found resistance below 40 ohms with 40 radials, but at 60 radials and greater the data correlated more closely. This discrepancy is probably attributable to the differences in soil conductivity; the land under my array is part of a moraine, and consequently represents very low conductivity earth. All indications are that with 120 1/4-wavelength radials, resistance of a resonant 1/4-wavelength vertical is within a half ohm of the theoretical value regardless of the underlying soil conductivity. Another effect I noticed which W2FMI did not comment upon was that as radials were added, the element length had to be slightly but continually adjusted upward to maintain resonance.

coupling with other antennas

The attempt to approach the theoretical self-impedance value can be frustrated by inadvertent coupling of the antenna under test to another antenna. As will be seen when discussing mutual impedance, the effects are subtle and can be easily mistaken for ground plane differences. These effects can go in both directions — you may think you are achieving theoretical self-impedance with a 30-radial ground plane, or conversely that a 120-radial ground plane has several ohms loss. If you encounter either of

these indications, suspect coupling with another antenna (or something acting like one even if you don't "see" it). Another indication of this problem is a significant departure (at 80 meters — several inches) in element length for resonance. I had a tower guy wire (adequately broken up with insulators, I thought) whose lowest section ran to an anchor at the base of a tree. This section was approximately 1/4 wavelength and it found sufficient ground conductivity in the tree roots to present lossy coupling to one of my array elements. Though I knew that element wasn't right, I could not see anything that would act as a resonant antenna around it. That guy wire didn't look as if it had a ground plane! The solution was to insulate it at the anchor, thus decoupling the section of guy wire.

I am sure many Amateurs will identify with this frustrating experience: the first element of a multi-element array is erected and adjusted for resonance. The length is carefully recorded and the second erected. Then, letting the first element remain connected to its feed cable, the second element is checked for resonance, found too long, and is readjusted downward. Reconnecting the second element to its feeder, the first element is now found too long. And so it continues; the result is that the elements end up considerably shortened below their uncoupled resonant length. This is mutual coupling at work and the error was in failing to open-circuit other elements when making self-impedance measurements. Other elements, at or near resonance and within about 0.35 wavelength of the antenna being measured, will manifest inductive coupling. Unless you're aware of what is happening, you may diagnose this inductive reactance to be due to the element's being too long. Shortening it will bring it to "resonance" and this may be accompanied by a satisfactory reduction in resistance (perhaps even below theoretical), but all this changes when the second element is open-circuited. It is well to remember that this situation can also occur inadvertently with a conductor not recognized as acting as an antenna. However, as we shall soon see, this same effect — mutual coupling — is the very same process used to advantage to create field enhancement and cancellation in arrays.

mutual impedance

Coupling between elements is a function of element lengths, distance between elements, relative attitudes of elements (e.g., parallel, co-linear, echelon), and ground plane losses. Ground losses are not actually a component of theoretical mutual impedance but in a practical situation they become a part of the *apparent* mutual impedance. (Mutual impedance is a term that relates to the interaction of two or more antennas which are close enough to each other to cause their driving impedances to be different from their self-impedances.) The unit of measurement — ohms — may be, like any impedance, resistive or reactive, or both. Such antennas are coupled by an impedance which appears to be in common with all elements. (Driving point impedance calculations only require the mutual impedance between pairs — that is, two elements at a time be measured.) Mutual impedance between antennas is similar to mutual inductance between coupled coils; the impedance relationship can be both depicted and its value measured in the same way. In **fig. 2** the driving point impedance Z_1 or Z_2 of each vertical as measured at either set of terminals reacts to the presence of the other vertical as though its self-impedance Z_{11} or Z_{22} had a common impedance Z_{12} in series with it. Z_{12} is, by definition:

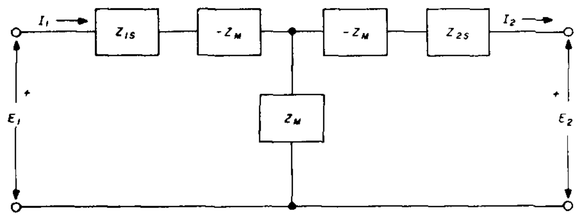

fig.2. Four-terminal equivalent network for two verticals.

$$Z_{12} = -E_2/I_1$$

Although useful mathematically, it doesn't provide a practical basis for measurement. The voltage and current relationships existing in a system of antenna elements, each mutually coupled to one another, have the same form as the voltage and current in a general network. Writing their mesh equations produces:

$$E_1 = I_1Z_{11} + I_1Z_{12} + \dots + I_nZ_{1n}$$

$$E_2 = I_1Z_{21} + I_2Z_{22} + \dots + I_nZ_{2n}$$

$$\vdots$$

$$E_n = I_1Z_{n1} + I_2Z_{n2} + \dots + I_nZ_{nn}$$

where $E_1, E_2 \dots, E_n$ are voltages applied to elements 1,2,...N

$I_1, I_2 \dots, I_n$ are element drive currents

$Z_{11}, Z_{22} \dots, Z_{nn}$ are element self-impedances

Z_{12}, Z_{21} ...,Z_{1n}, Z_{2n} are mutual impedances and are denoted by dual subscripts which are always different. As in general networks, mutual impedances with the same subscripts but with reversed positions, (e.g., Z_{12} and Z_{21}), describe the identical impedance (from the Reciprocity Theorem).

If the equation for each drive voltage is divided by that element's drive current, the following driving point impedance terms are obtained:

$$Z_1 = E_1/I_1 = Z_{11} + I_2Z_{12}/I_1 + \ldots + I_nZ_{1n}/I_1 \qquad (1)$$

$$Z_n = E_n/I_n = I_1Z_{n1}/I_n + I_2Z_{n2}/I_n + \ldots + Z_{nn}$$

Notice that each element's driving point impedance consists of its self-impedance and includes terms for the mutual impedances between it and each of the other elements. The *influence* of the mutual impedances upon the driving point impedance is a function of the drive currents (amplitude and phase) to other elements. Although at first glance these equations appear quite formidable and look like there are too many unknowns for solution, this is not the case. Having selected an array configuration and the driving current ratios and displacements for the field plot, we already know what the currents need to be.[1] If we could find a way to reduce the complexity and consequently the number of unknowns, a means for deriving mutual impedances might be devised. Fortunately there is one. Since each mutual impedance we need to know exists between only two elements, we can write a simpler set of equations:

$$E_1 = I_1Z_{11} + I_2Z_{12}$$

$$E_2 = I_1Z_{12} + I_2Z_{22}$$

If the terminal of element 2 is connected to its ground plane, the drive voltage E_2 becomes zero and:

$$\begin{aligned} E_1 &= I_1Z_{11} + I_2Z_{12} \\ O &= I_1Z_{12} + I_2Z_{22} \end{aligned} \qquad (2)$$

Solving for the driving point impedance yields:

$$Z_1 = E_1/I_1 = Z_{11} - (Z_{12})^2/Z_{22}$$

and solving for the mutual impedance Z_{12} gives

$$Z_{12} = \pm \sqrt{Z_{22}(Z_{11} - Z_1)} \qquad (3)$$

Note that all references to voltages and currents have been eliminated. We are now in a position to find all the remaining unknowns.

mutual impedance measurement

Provided the elements are 1/4 wavelength or less, the procedure is: open-circuit all elements; measure the self-impedance of element 1; connect element 2 terminal to its ground plane; measure the driving point impedance of element 1; and open-circuit element 2.

If there are additional elements, connect element 3 terminal to its ground plane; measure the driving point impedance of element 1; and open-circuit element 3.

Following the same sequence, all remaining elements are measured from element 1. When completed, a similar set of measurements are taken from element 2, starting with self-impedance and then measuring the various pairs of driving point impedances, and so on with each remaining element. This procedure allows each element to be individually treated as the reference element of each pair of elements for mutual impedance measurements. When completed, the same mutual impedance will have been read from each side of every pair. This provides a check on previously determined calculations. I am continually amazed (even though I know it is supposed to happen) by the close coincidence of the resulting value for mutual impedance as determined from either element of a pair! This occurs, as it should, even when the two self-impedances are quite *different*.

using 1/2-wavelength elements

What if the elements are significantly longer than 1/4 wavelength, specifically a 1/2 wavelength? Open-circuiting these elements from the ground plane will not decouple them (in all likelihood, coupling will be found to increase if the length is exactly a 1/2-wavelength). Means for temporarily sectioning other elements into two electrically separate halves must be provided so that self-impedances are measured with the temporary sectioning reconnected and *that element* connected to its ground plane. I have no experience with this situation but I believe the array can be driven properly, provided the high impedance at the bases of the elements can be handled.

In antenna texts, mutuals are always referred to current loops (maximum current points). Mutuals derived from measurements as above are referred to the base of the elements. These are quite different values, just as self-impedances differ according to whether they are measured at a voltage or current loop.

mutual impedance calculations

Data is taken from a 40-meter 4-square array with elements spaced 0.272 wavelength at 7.0 MHz. The elements are not alike, not resonant, and the ground plane is quite lossy. Data are shown for two elements and mutual coupling was measured from each.

table 1. List of mutual resistance and reactance between two physical 1/4-wavelength verticals separated by 0 through 1.5 wavelength spacings.

spacing	R	X	spacing	R	X
0	+36.57	+21.27	.80	−9.25	+6.13
.05	+35.83	+12.14	.85	−6.66	+8.15
.10	+33.67	+3.77	.90	−3.75	+9.28
.15	+30.22	−3.55	.95	−.78	+9.50
.20	+25.70	−9.59	1.00	+2.00	+8.87
.25	+20.40	−14.18	1.05	+4.38	+7.52
.30	+14.63	−17.22	1.10	+6.16	+5.61
.35	+8.75	−18.71	1.15	+7.26	+3.36
.40	+3.11	−18.72	1.20	+7.63	+0.97
.45	−1.99	−17.39	1.25	+7.28	−1.33
.50	−6.27	−14.97	1.30	+6.30	−3.35
.55	−9.53	−11.71	1.35	+4.81	−4.92
.60	−11.66	−7.94	1.40	+2.99	−5.94
.65	−12.61	−3.97	1.45	+1.00	−6.35
.70	−12.43	−0.13	1.50	−.94	−6.15
.75	−11.25	+3.32			

Equation 3 is used to calculate the mutual impedance.

Measurements from Element A (referenced as Element #1)

Element A	Z_{11}	= 45.73 + j 8.19	Self-impedance of A
Element B	Z_{22}	= 42.53 + j 5.72	Self-impedance of B
Element A	Z_1	= 46.98 + j15.66	Driving point impedance of A with B grounded
	Z_{12}	= 12.53 −j12.95	Calculated mutual impedance

Measurements from Element B (referenced as Element #1)

Element B	Z_{11}	= 42.53 + j 5.72	Self-impedance of B
Element A	Z_{22}	= 45.73 + j 8.19	Self-impedance of A
Element B	Z_1	= 44.20 + j12.79	Driving point impedance of B with A grounded
	Z_{12}	= 12.63 − j13.34	Calculated mutual impedance

Note the following:

1. There is a nomenclature interchange for the self-impedances of the elements, denoting the change in reference element for the measurement of mutual coupling.

2. There is only a small increase in resistive component when measuring the effect of coupling, requiring a highly accurate impedance bridge.[8]

3. At this spacing, the effect of coupling is decidedly inductive on the measured element.

4. There is reasonably good correspondence in the mutual impedance calculation from either side of the pair of elements, despite the differences in the individual elements.

5. The measured mutual impedance is quite different from theoretical values. (See **table 2.**)

As a further verification of measurements and calculations, this test is useful and instructive: With element 2 connected to its ground plane, drive element 1 from a 50 to 100 watt source while measuring current at the terminals of each element. The ratio of the current flowing in element 2 to element 1 is equal to the ratio of the mutual impedance to element 2 self-impedance:

$$I_2/I_1 = -Z_{12}/Z_{22}$$

(This identity is a rearrangement of **eq. 2.**)

Since ratios are involved, the only restraint on the current measuring device is that it be linear. Although phase angles are difficult to measure when the reference points are located at some distance, current amplitudes can be measured and this identity is useful as a verification of impedance measurements and calculations, even if only the magnitude of the mutual impedance vector can be obtained. When performing this test, if there are more elements, open circuit them. If driving with more than 50 watts be careful of those open-circuited elements; don't provide a ground return through your body. You may be surprised to find how much energy is being coupled.

The calculations for mutual impedances require a square root extraction. Which sign to use? As general guidance, the polar vector angle of the root is *always* lagging except at spacings less than about 0.15 wavelengths. For a specific calculation the pattern of sign changes seen in published sources is an aid. Mutual resistance and reactance vary with element separation in the nature of a damped sine wave, starting with both signs positive at zero separation and proceeding through cyclic sign variations thereafter. For example, suppose at 1/4-wavelength separation with 1/4-wavelength elements your calculator or computer produces the square root extraction $-13.7 + j15.1$ (polar notation $20.4 \quad +132.2°$). The polar angle shows lead and it should be lagging. Looking at published sources we see confirmation for this. Subtracting 180° from the polar vector angle will produce the correct signs for resistance and reactance. To aid in determining signs I have converted the table of mutual resistances and reactances shown by W2PV, to grounded physical 1/4 wavelength values in **table 1**.

The question arises: "Why bother measuring mutual impedances? Why not use published values from antenna texts?" The best answer is another question: "Why not also use textbook values for self-impedance?" Most Amateurs measure self-impedance because they want to be sure the element length is resonant at the frequency of interest or because they know from experience that the actual self-impedance can differ considerably from the theoretical value. Theoretical mutual impedance derivations are quite complex and solutions often use different simplifying assumptions. The result is that few textbook sources — except those which obtained data from a common origin — agree exactly. Regardless of source, the following assumptions apply: infinitely conducting ground plane; infinitely thin element; and element lengths measured in physical wavelengths. Element radius has a relatively small effect on mutuals. The element length assumption can be determined from the values for zero separation between elements (see first line in **table 1**). This is the self-impedance of a single element and may be recognized as identical with theoretical self-impedance. (Applies to equal length element data only.) For example, the value $36.5 + j21$ means that physical 1/4-wavelength elements had been assumed. The length difference (over resonant length) will not seriously affect driving point impedance calculations, but the assumption of lossless self-impedances will. **Table 2** lists mutual impedance between 1/4 wavelength high elements from several sources compared to an average of 16 measurements I have made.

table 2. Values of mutual impedance between two quarter-wavelength high verticals. Data from five different sources. (Gehrke's entry represents *measured* data for a real vertical over a real ground.)

source	mutual impedance (0.272 spacing)	mutual impedance (0.385 spacing)
Brown	17.49 −j17.01	2.96 −j18.47
Jasik	17.47 −j16.01	6.00 −j17.50
Jordan	17.55 −j16.37	1.66 −j18.99
Mushiake	17.51 −j15.70	4.80 −j18.75
Gehrke	13.20 −j16.24	0.20 −j16.61

The resistive component differs most. Despite these differences, if no means of measurement is available, there is something to be said for using theoretical values; at least there is recognition they exist rather than ignoring them entirely. However, as I have previously emphasized, the significance of deviation from optimum drive conditions increases with the complexity of the array. When I first became aware of the need to take mutual impedances into account for the feed network, I used theoretical values. There was improvement in F/B, but it was still far from what is achievable.

You may have wondered if an element driving-point impedance could have a negative resistive component, and if so, what that means. This is entirely possible with arrays of more than two elements, particularly with close spaced arrays or arrays employing non-unity current ratios. Elements exhibiting this condition are being driven by energy coupled from other elements; instead of *receiving* any drive from its feeder, this element is *sending* drive back into the feed network. This is still a coupled passive system, in equilibrium, merely observing the law of conservation of energy.

calculations of driving-point impedances

Using **equation 1**, I have calculated and listed in **table 3** the driving-point impedances of several arrays discussed in **Part 2** using measured mutuals. (For smaller spacings, values were estimated based on extrapolations of my data). For a comparison, the 4-square array driven impedances are also calculated using mutual impedances from **table 1**.

Data common to all calculations:

Element effective radius = 0.7 inch
Element height = 62.7 feet
Self-impedance = $36.4 + j0$ ohms
Frequency = 3.8 MHz

notes and comments

1. The 3 element in-line and the 1/8-wavelength 4-square have elements which exhibit substantial negative resistance components in their driving point impedances.

2. Nearly all driving point impedances show substantial reactance, requiring some care in establishing correct phasing.

3. All arrays except one exhibit unlike driving impedances, *ruling out equal power* distribution networks where *equal current* amplitude is intended.

4. Note the difference in driving point impedances in table 3. **Mutual and driving point impedance values for some popular vertical phased arrays.**

array	current ratio	mutual impedances	driving point impedances
2-element, $\lambda/4$ spacing*	1/1; 0°, −90°	$Z_{12} = 15 - j15$	$Z_1 = 21.4 - j15$ $Z_2 = 51.4 + j15$
3-element in-line, $\lambda/4$ spacing	1/2/1; 0°, −90°, −180°	$Z_{12} = Z_{23} = 15 - j15$ $Z_{13} = -9 - j13$	$Z_1 = -6.6 - j21$ $Z_2 = 51.4 + j0$ $Z_3 = 79.4 - j39$
2-element, $\lambda/2$ spacing	1/1; 0°, −180°	$Z_{12} = -9 - j13$	$Z_1 = 45.4 + j13$ $Z_2 = 45.4 + j13$
triangular array, 0.289λ spacing	1/0.5/0.5; 0°, −90°, −90°	$Z_{12} = Z_{23} = Z_{13}$ $= 10 - j16$	$Z_1 = 28.4 - j10$ $Z_2 = 78.4 + j4$ $Z_3 = 78.4 + j4$
4-square array, $\lambda/4$ spacing	1/1/1/1; 0°, −90°, −90°, −180°	$Z_{12} = Z_{13} = Z_{24} = Z_{34}$ $= 15 - j15;$ $Z_{14} = Z_{23} = 3 - j17.5$	$Z_1 = 3.4 - j12.5$ $Z_2 = 39.4 - j17.5$ $Z_3 = 39.4 - j17.5$ $Z_4 = 63.4 + j47.5$
4-square array, $\lambda/4$ spacing (using table 1 mutual impedance data)	1/1/1/1; 0°, −90°, −90°, −180°	$Z_{12} = Z_{13} = Z_{24} = Z_{34}$ $= 20.4 - j14.18;$ $Z_{14} = Z_{23} = 8.41 - j18.72$	$Z_1 = -0.37 - j22.08$ $Z_2 = 44.81 - j18.72$ $Z_3 = 44.81 - j18.72$ $Z_4 = 56.35 + j59.52$
2 × 2 array of arrays, $\lambda/4$ spacing	1/1/1/1; 0°, 0°, −90°, −90°	$Z_{12} = Z_{13} = Z_{24} = Z_{34}$ $= 15 - j15,$ $Z_{14} = Z_{23} = 3 - j17.5$	$Z_1 = 18.9 - j33$ $Z_2 = 18.9 - j33$ $Z_3 = 83.9 + j3$ $Z_4 = 83.9 + j3$
4-square array, $\lambda/8$ spacing	1/1/1/1; 0°, −135°, −135°, −270°	$Z_{12} = Z_{13} = Z_{24} = Z_{34} =$ $= 30 - j3,$ $Z_{14} = Z_{23} = 25 - j9$	$Z_1 = -1.27 - j13.18$ $Z_2 = 18.97 - j4.76$ $Z_3 = 18.97 - j4.76$ $Z_4 = -10.78 + j21.67$

*This 2-element, 1/4-wavelength spaced array is probably the most common phased array configuration used by Amateurs today. Please note that the driving point impedances are different.
Editor.

the 1/4 wavelength spaced 4-square using actual mutual impedances as compared to the use of theoretical values. Current and phases in the latter case will not occur as intended in a real array.

5. Note the 2 element 1/2 wavelength spaced array (not shown in Part 2). Because of the equal driving impedances, here is one of the few instances of an array which operates as intended regardless of feeder length, as long as they are equal and a 1/2 wavelength delay line is inserted in series with one of them. Except for VSWR, Z_0 of coax is not important. The antenna pattern in this case is *not* a function of the coaxial cables Z_0 (characteristic impedance) though the VSWR still is.

We tend to become accustomed to thinking of an antenna, just as any discrete component, as having a fixed impedance at any frequency. The concept that elements within an array present impedances that are determined by other element drive currents (amplitude and phase) is, at first, difficult to appreciate. That these impedances may have negative components of resistance also can be a bit unsettling. Yet when an array is looked at mathematically as a general network which includes the impedance branches represented by mutual impedances, these seemingly unusual effects can be seen to be physical realities. Consequently, the rest of this coupled system, the feed network, must be designed for these driving impedances as the terminations.

If we expect to switch directions with this array, then we need to be sure that each physical element presents the same driving point impedance appropriate to the electrical position in the array it is assuming. I have found that equalizing self-impedances is the best means for doing this. Each element is adjusted for length to present the identical reactance (if resonance is the objective, then this is zero reactance). Assuming all elements have the same radius, radials are added to those elements showing higher resistive components. At the 100 radial level, it is not unusual for a spread of +20 radials to occur among the ground planes of the elements in this effort at equalization.

summary

We have worked our way through the design of vertical phased array antennas. A number of typical arrays were examined, as well as the current requirements of each element and the driving point impedances that must exist to cause the array to operate as designed. What remains is to design the feed network which will create conditions as they must appear, not at the element terminals, but at the end of the feed lines coming from those terminals. By now you are aware, if you weren't already, that feed lines are an integral part of the feed network.

There is no unique network which achieves the necessary current amplitude ratios and phase displacements. We can get to that objective in a number of different ways. In the next article the design task will be of use A,B,C,D parameters in single matrices as a tool. If this technique is new to you, I believe you will find this approach most interesting. You will see that this is a powerful and versatile means of network design, useful not just for antenna arrays, but for other network applications as well.

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7. Jerry Sevick, W2FMI, "Short Ground-Radial Systems for Short Verticals," *QST*, April, 1978, page 30.
8. Forrest Gehrke, K2BT, "A Precision Noise Bridge," *ham radio*, March, 1983, page 50.

In commenting on vertical phased arrays, several writers have cautioned against placing arrays near trees. The apparent assumption is that trees represent resonant loss elements or somehow disturb the field so that the radiated pattern will be changed. I remain unconvinced. At wavelengths 40 meters and longer, I have measured self- and mutual impedances of elements, among trees, at all seasons of the year without seeing any significant changes that are not also seen on a pair of 40-meter elements completely away from trees. Small variations (0.3 to 0.5 ohms) are seen in self-impedances, depending upon soil moisture conditions, which are reflected in mutual impedance measurements. Since all elements are affected in the same way, these small changes cannot significantly affect radiation patterns. Examination of published mutual impedance data indicates that the presence of conductive elements, *resonant or not*, within about 0.1 wavelength of an element will significantly affect mutual impedance in unanticipated ways. Prudence would therefore dictate that nothing conductive, or even partially so, which could act as an antenna be allowed within that distance. If despite this precaution array patterns are indeed disturbed, my advice is to look for something that may be acting as a real conductive antenna in the immediate area of the array, or to re-evaluate the feed network. — K2BT

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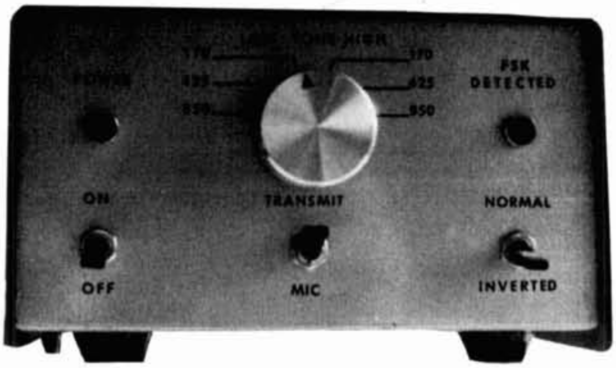
Proven Success

More Details? CHECK—OFF Page 92



RTTY and the Atari™ computer

Turn your Atari home computer into an RTTY terminal for either Baudot or ASCII

If there's one area in Amateur Radio that is becoming dominated by microprocessors, it's certainly RTTY. It's now common to find an RTTY operator using either a home computer or a piece of commercial gear fully dedicated to RTTY. RTTY is basically a digital form of communications, and as such it lends itself well to the use of computers. Applying a computer to RTTY requires that some basic problems first be solved. This article describes those problems and shows how they are solved in the process of making an Atari computer into an RTTY terminal (**fig. 1**).

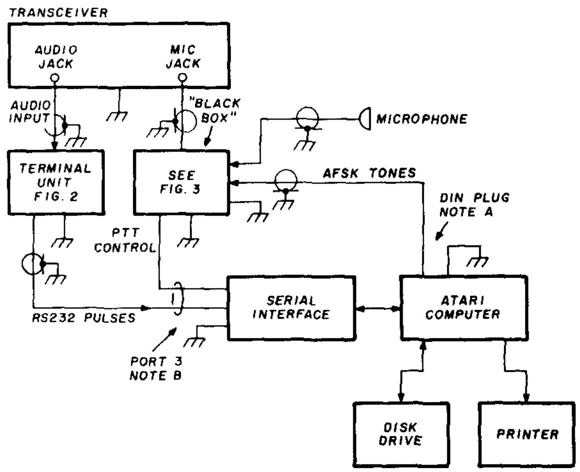
basic problems: receiving and transmitting

When you tune your receiver to a ham RTTY station, you hear an alternation of two tones, called a low tone pair, which consist of a 1275-Hz "mark" and a 1445-Hz "space." The duration of these tones determines the character speed, measured in words per minute. A device called a terminal unit receives the two tones and generates a voltage-on state when mark is present and a voltage-off state when space is present (see **fig. 2**).

It's here that the serial interface to the computer comes into play. The serial interface detects the start of the pulse string, all on/off voltage transitions, and the end of the pulse string coming from the terminal unit. A pulse string represents a single character, and is stored as a binary number in a holding register in the interface. The computer reads this binary number and processes it before the next character appears in the serial interface. Processing usually means printing the character on a CRT, TV screen, or LED display.

The terminal unit designed for this application is shown in **fig. 3**. It is a receive-only device whose operation is controlled by the XR2211 chip. The resis-

By David W. King, K5VUV, 743 Rodney Drive, Baton Rouge, Louisiana 70808



NOTES:
A. AFSK TONES COME FROM PIN 1; GROUND IS PIN 3; USE DIN PLUG ON SIDE OF ATARI COMPUTER.
B. "RS232" INPUT TO PIN 4; PTT CONTROL TO PIN 1; GROUND TO PIN 5; USE PORT 3 ON ATARI 850 SERIAL INTERFACE.
C. USE 2 CONDUCTOR, SHIELDED CABLE FOR ALL CONNECTIONS. GROUND ALL SHIELDS AT TERMINAL UNIT ONLY - LEAVE SHIELDS DISCONNECTED AT SERIAL INTERFACE AND COMPUTER.

fig. 1. Cabling arrangement between the Atari computer, transceiver, and terminal unit.

tors and capacitors connected to this chip are used to change its frequency response characteristics. This circuit provides digital pulse strings when either low tone pairs or high tone pairs with a frequency difference of 170, 425, or 850 Hz are received.

All parts except the XR2211 chip come from Radio Shack; the XR2211 is available from Jameco.* Application note AN-01 from Exar Integrated Systems† explains chip operation. The serial interface used in this application is the Atari™ 850. With this interface, it is possible, under program control, to receive Baudot or ASCII at rates from 60 to 960 WPM. Although this interface is billed as an RS232-level device, it works fine with the 0 to 12 volt signal generated by the terminal unit described.

To transmit RTTY, there must be some way of choosing the character or number you wish to send. This is normally done via a keyboard. Pressing a keyboard button closes a switch which is detected by the computer program and decoded into a unique binary number. This number is normally converted into a pulse string, which is subsequently converted to either mark or space tones, depending on the voltage level of the pulses. These audio frequency tones must be held for the appropriate time (approximately 22 milliseconds for 60 WPM) and fed to the microphone input circuit of the transmitter.

detailed solutions

The audio tones sent to the microphone jack need to be fairly precise in frequency and duration. In this application, advantage may be taken of a feature in the Atari computer itself. The Atari has a set of internally programmable sound generators (they are used to simulate explosions, battle tanks, and so forth in game programs). These sound chips happen to generate the audio frequencies for mark and space at all frequencies and shifts needed. Although these tones are neither precisely those specified for RTTY (plus/minus 10 Hz) nor perfectly sinusoidal, they work flawlessly.

This feature makes it unnecessary to build an external tone generator — thus the receive-only terminal unit. To control the time duration of the tones a small assembly-language program was used. The BASIC language that composes most of the program is not fast enough to turn the tones on and off at the required speed.

The same assembly language program is used for all of the different tone duration times. The main BASIC program modifies the timing constants in this assembly-language program whenever you change from one WPM rate to another.

FCC regulations require that Amateur Radio operators provide CW identification at the end of their RTTY transmissions. This is accomplished using the same method as the tone pair generation. The program transmits the CW ID at approximately 20 WPM at a single pure tone that is between the mark and

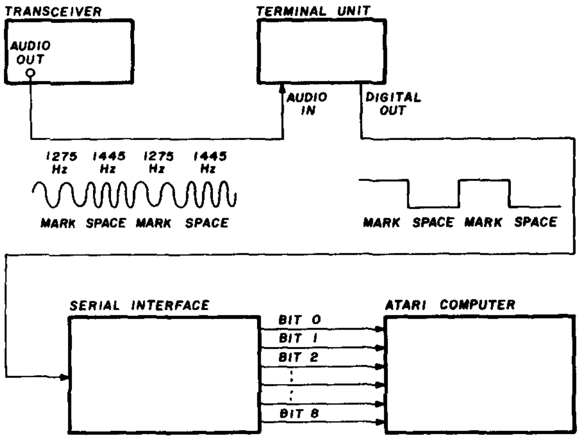


fig. 2. The terminal unit converts tones to a digital pulse train.

*Jameco Electronics, 1355 Shoreway Road, Belmont, California 94002.
†Exar Integrated Systems, Inc., 750 Palomar Avenue, P.O. Box 62229, Sunnyvale, California 94088.

space frequencies. This enables the receiving station to hear your CW ID without retuning the receiver.

Baudot computer program options

The program allows you to select any of several options, which include receiving RTTY; transmitting at 60 WPM using the low tone frequency pair, 170-Hz shift; transmitting at 60 WPM using the high tones frequency pair, 170-Hz shift (for VHF); transmitting at 100 WPM-low tones, 170-Hz shift; transmitting at 100 WPM-high tones, 170-Hz shift; printing using a hardcopy device; and "go to ASCII program."

Other options included in the program are:

A. Automatic transmitter turn-on/turn-off using the PTT feature, accomplished by using a spare pin on the Atari 850 serial interface. One of the signals available at the output of this interface is called Data Terminal Ready. This pin supplies either + 12 or − 12 volts and is switchable under program control. It is therefore ideal for driving a transistor switch to activate PTT when transmitting and deactivate the PTT when receiving (see **fig. 4**).

B. Brag tapes (pre-recorded messages) are nice to have, so there is a feature in the program that allows you to call up and transmit any one or all of seven Brag tapes stored on the disk. When you are transmitting, a Control A will read Brag tape 1 from the disk and send it. Control B sets Brag tape 2, and so on up to Control G. Control H is reserved for the CW ID To Follow announcement and automatically sends your CW ID. A separate program is used to build the Brag tapes.

C. Hard copy on a printer is possible. The program stores all received characters in memory and after the QSO allows you to list it to the printer. This application is programmed to store 4000 characters. It can be increased or decreased depending on memory availability.

D. Some systems permit transmission of date and time. Control T will do this if you enter the correct time and date into the program when it first runs. (This piece of coding is not smart enough to change the month if you transmit past midnight on the last day of the month — a good thing for you to modify!)

E. Sometimes a reception error occurs and you go into the Numbers printing mode erroneously. Pressing Start forces you back to Letters mode immediately.

F. Pressing Select clears the screen and printer storage buffer, and reprograms the serial interface to change the expected reception baud rate (WPM). You can cycle the WPM reception rate from 60 to 66 to 75 to 100 back to 60 with four pressings of the Select key. This is handy for copying commercial RTTY broadcasts.

G. The Option key aborts the receive portion of the program and allows you to begin transmission, begin printing, select a different WPM transmit rate, or go back to receiving.

H. Control I aborts the transmit section of the program and goes to the Option section without sending a CW ID.

I. Control H sends CW ID To Follow-DE (Your Call), in RTTY, then sends your call in CW and immediately

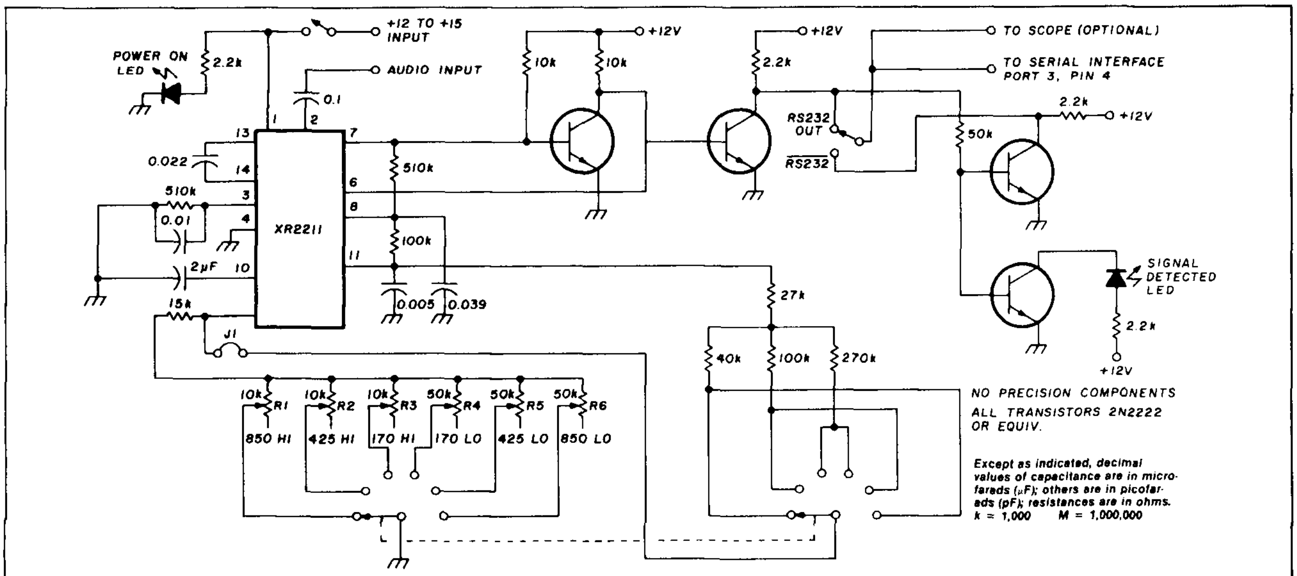
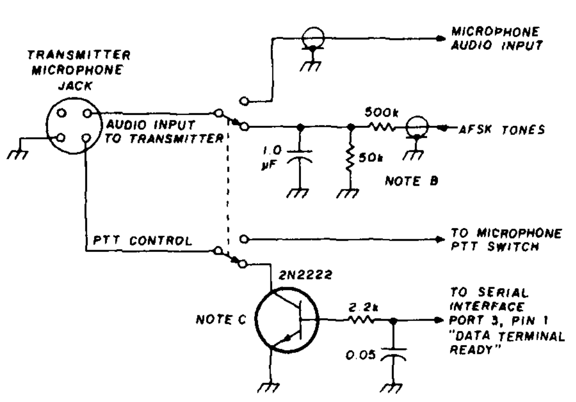


fig. 3. Schematic diagram of the terminal unit.



NOTES

A. ALL OF THE ABOVE CIRCUITRY WAS PHYSICALLY BUILT IN THE SAME BOX THAT HOUSED THE TERMINAL UNIT.

B. VOLTAGE DIVIDER MAY BE NECESSARY FOR YOUR TRANSMITTER INPUT.

C. IF TRANSISTOR SWITCH WON'T HOLD IN YOUR PTT CIRCUIT, USE IT TO DRIVE A RELAY.

fig. 4. A method of activating PTT by means of the Atari computer serial interface.

switches to receive at the same baud rate you were using in transmission.

differences in the ASCII program

The ASCII program is similar to the Baudot program just described. Its option section permits: receiving ASCII; transmitting at 110 Baud, 170-Hz shift, low tones; transmitting at 300 Baud, 425-Hz shift, high tones (for VHF); transmitting at 600 Baud, 425-Hz shift, high tones; transmitting at 1200 Baud, 850-Hz shift, high tones; printing to a hardcopy device; "Go to Baudot" program. (Receiving and transmitting at Baud rates above 300 have not been tested extensively to date.)

All of the options described above except Control T and the Letters-mode-forcing exist in the ASCII program. All of the equipment remains the same as for the Baudot program.

future possibilities

Some additional attractions you may want to add to the program could be: split-screen viewing of both typing and reception simultaneously; buffering your input so it's not sent immediately upon entry, but in fast strings to impress your contact with how smoothly and fast you type; automatic logging to the disk of time, date, call, and other QSO information; and CW reception — hint: This could be done through the joystick input port using the terminal unit described and an assembly language program.

getting started

Copies of the three BASIC program listings and the assembly language program listing described above are available from *ham radio*.*

For those of you who don't want to type all of these program listings into your computers, I'll be happy to send them to you on a 5¼ inch floppy diskette. I'll customize your diskette with your name and call. (Sorry, I can't send cassettes — just disks.)†

terminal unit construction adjustments

The circuit was built on perfboard and wire wrapped. No printed circuit board is available. Layout is not critical. I would advise using a metal box enclosure and shielded cable. Open Jumper J1 as shown in **fig. 2**.

Use an ohmmeter to measure the resistance from pin 12 of the XR2211 chip to ground. As you change the six-position switch's location, adjust R1 to R6 to give the following ohm readings:

ohm reading	adjust	switch position
17825	R1	850-Hz-shift high tones
19445	R2	425-Hz-shift high tones
20568	R3	170-Hz-shift high tones
26738	R4	170-Hz-shift low tones
30558	R5	425-Hz-shift low tones
33422	R6	850-Hz-shift low tones

Replace J1. The application notes from Exar give a more elaborate tune-up method, but mine worked fine with the above procedure. My settings were ±2 percent of the above values. These resistances are theoretically calculated from Exar's design information.

conclusion

The programs and equipment described in this article have been in use since November of 1982. They have resulted in numerous RTTY QSOs on both the hf and VHF bands. If you have an Atari computer, try it on RTTY! Please feel free to write if you have questions or run into problems with the programs. Include an SASE; I'll do what I can to help.

acknowledgments

My thanks to N5IB, Jim Giammanco, who put me onto the XR2211 chip and to my daughters, Wendy and Melanie, who let me onto their computer long enough to develop these programs.

*For copies of the program listings, send a stamped (37¢), self-addressed #10 envelope to PROGRAM LISTINGS, *ham radio* magazine, Greenville, N. H. 03048.

†To order a program diskette, send $10.88 directly to the author, David W. King, K5VUV, 743 Rodney Drive, Baton Rouge, LA 70808. The price includes diskette, postage, and service fee.

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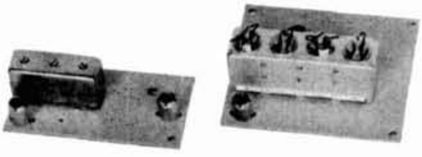

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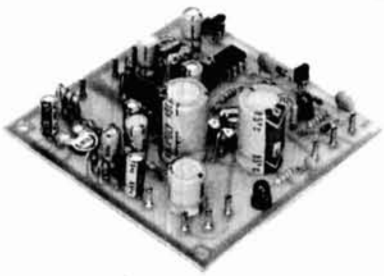

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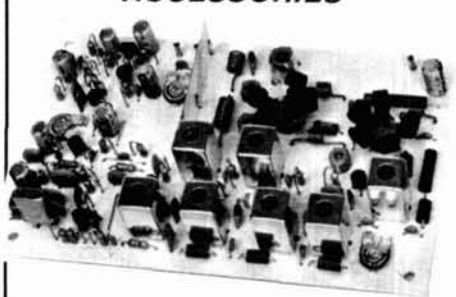

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ham radio TECHNIQUES

Bill Orr W6SAI

Now that we have temporary operating privileges for the 10 MHz band, we can look forward to the opening of the 18 and 24 MHz Amateur bands, another outcome of the 1979 World Administrative Radio Conference; the bands encompass 18.068 to 18.169 MHz and 24.890 to 24.990 MHz. As this column is being written (late February), it looks as if these bands are far away indeed for U.S. Amateurs, unless somebody pulls a rabbit out of the hat.

Operation on the new bands is authorized in many European and South American countries, although to date activity has been sparse except on weekends. Most stations congregate around 18.07 MHz and 24.9 MHz. In California, European signals came through very well on both bands in the morning hours during the winter.

The Federal Communications Commission has adopted Docket 80-739 NPRM of December 30, 1982, and the planned action (for "action" you may read "inaction") includes use of these frequencies by the fixed services until July 1, 1989. There is no indication of any plan for implementation of the WARC Resolution 640, and no indication that any interim action is contemplated.

So here we sit, as the sunspot count slowly sinks toward the next minimum, due to arrive in a few years. If the FCC follows its present policy of inaction, by the time the bands are opened for Amateur Radio *they will be useless* for long-distance communications. The next sunspot minimum is predicted to cover the period 1985 through 1990, so if we do achieve operating privileges in these bands in 1989, they will be of little use to us until about 1992. That's nine years from now! If the FCC really wishes to aid Amateur Radio, they should amend Part 97 of the Rules to permit operation on these bands on a noninterfering basis now.

As far as Amateur interference to existing fixed stations is concerned, both bands are a wilderness. Despite the FCC count of stations authorized to operate on these frequencies, few do. Six months of listening has logged very few fixed-service stations, far fewer in fact than the number noted on the 10-MHz band before it was authorized for Amateur operation.

I hope this frustrating hang-up can be solved, if possible before the end of this year.

the Kenwood R-600 communications receiver

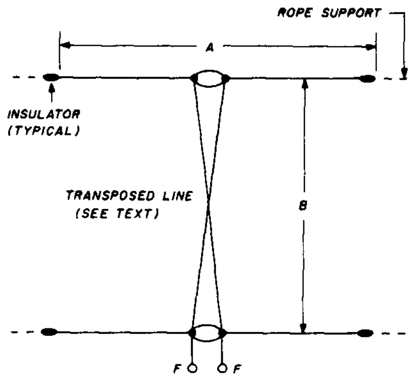
This is not a product review but rather two ideas for improving this interesting receiver.

My general-coverage Collins 51J-4 receiver seems to grow more massive as the years roll by. It is an invaluable adjunct to my station, as it provides a-m/CW and SSB reception over the range of about 480 kHz to 30 MHz. With multiple mechanical filters, it serves in a pinch as a good Amateur receiver, backing up my regular ham-band-only receiver. I'd had my eye on the Kenwood R-600 receiver (which weighs less than 10 pounds!) for some time, and I finally bought one as a tentative substitute for the 51J-4, which, in its steel cabinet, is a real boat anchor.

I was really pleased with the Kenwood: excellent sensitivity, readout to 1 kHz, and excellent audio quality for listening to shortwave broadcast, regular broadcast, or long-wave reception of local aircraft weather reports. The little receiver exhibited two characteristics, however, that I found improvements for.

First, when I used a random-length wire antenna, cross-talk and birdie problems were evident in the broadcast and the long-wave bands. I found that a 70-pF variable compression mica capacitor placed at the antenna terminal, in series with the wire antenna, proved to be the cure. The capacitor is simply adjusted for minimum cross-talk; it does not hinder shortwave reception at all.

Second, I noticed a peculiar buzz-



FREQUENCY (MHz)	A	B
28.6	16'4" (4.98m)	17'2" (5.23m)
50.1	9'4" (2.84m)	9'9" (2.97m)

fig. 1. View of dipole stack beam for 10 or 6 meters. Directional pattern is into and out of page. Array is fed at F-F with 50 or 75 ohm coaxial line, as discussed in text. Coax connection at F-F should be waterproofed.

ing on the high-frequency bands, particularly around 20 MHz. The high-pitched buzzing noise grew loudest when I brought my hand near either the receiver's tuning dial or the digital frequency readout immediately above it.

It only took a moment to ascertain that the receiver was listening to the counting pulses that drove the digital frequency display. Moving the antenna about in the room alleviated the problem somewhat; and the use of an elevated dipole fed with coax a distance from the receiver completely eliminated the noise. But the dipole is useless for general coverage reception. What to do?

Using a short test lead as a probe connected to the antenna input terminal of the R-600, I found that the counter noise was coming from the glass dial of the frequency readout. Removing the top and bottom covers of the receiver enabled me to see that the readout was well shielded from the rear; but the shield was open to the front to make the readout visible.

My cure was quick, inexpensive, and simple. I removed the knobs and front panel (the panel is held in place by top and bottom bolts, plus two bolts under the tuning dial). At the hardware store I bought an envelope of "screen door patches," which are little squares of aluminum screening. I cut one of these squares down so that it was about 2 inches long and 1 inch high, just big enough to place behind the glass window. When the glass was replaced, it pressed the screen against the metal chassis, making a good ground connection. Before reassembly I sprayed both sides of the screen with flat black enamel to remove any reflection, leaving the edges of the screen clear of paint to make a good ground.

That did the trick! It bottled up the counter noise so well that it cannot be heard on any band.

Most modern ham equipment has some kind of frequency display. Does yours generate noise that can get into the front-end of the receiver? Perhaps some of those funny noises you've noticed from time to time are caused by this problem. You can make a quick check by disconnecting your regular station antenna and using a short pickup wire as a substitute antenna. Place the free end near the digital display and check it on all ham bands. If you hear any high pitched birdies, reconnect your station antenna and see if you can still hear them. If not, you probably have nothing to worry about. But if you do notice any counter noise, try a small piece of screening to bottle it up — provided the manufacturer shielded the readout assembly on the *inside* of your receiver.

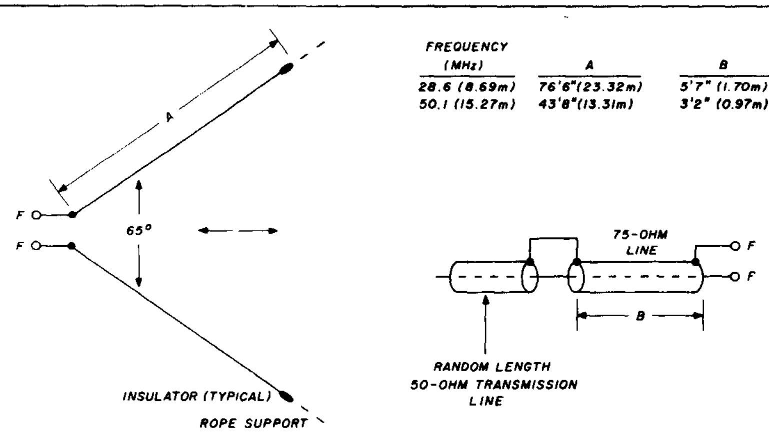
wire antennas for 10 and 6

It's fun to build antennas! And you don't need an advanced degree in computer engineering to do it. There are plenty of simple wire antennas that you can build in a few hours, antennas that will outperform the popular ground plane or dipole. This is especially true on 6 and 10 meters, where high-gain antennas become a manageable size.

Shown in this section are two wire beam antennas for these bands. The first is a stack of dipoles and the second is a simple V-beam. Both designs were popular years ago but have been obscured by the rotary Yagi and quad.

Even if you don't have room or money for a rotary, you can build one of these simple beams for just a few dollars. They have a bi-directional (figure 8) pattern, like the dipole, and they provide worthwhile gain on both transmit and receive.

The dipole stack beam is shown in **fig. 1**. The array consists of two dipoles, one above the other, the lower dipole fed from a coaxial transmission line. The dipoles are cross-connected by an open wire line, as shown in the illustration. Power gain is about 4 dB or more over a dipole when the bottom of the antenna is at least one-half wavelength above ground. Dimensions for the two bands are given in the illustration. The two-wire interconnecting line is made of No. 16



FREQUENCY (MHz)	A	B
28.6 (8.69m)	76'6"(23.32m)	5'7" (1.70m)
50.1 (15.27m)	43'8"(13.31m)	3'2" (0.97m)

fig. 2. Plan view of the V-beam. Array is fed with 50-ohm line and 75-ohm transformer. Joint between lines and coax connection at F-F should be waterproofed.

enamel wires, spaced 3 inches apart. The spacers are made of Lucite® or plastic rods about 4 inches long. They are drilled to pass the wires, which are tied to the insulators with short sections of scrap wire. A half-twist is given to the line to reverse the connections at the opposite ends.

The stack beam is fed at points F-F with either a 50 or 75 ohm coaxial line. Feedpoint impedance at resonance is about 60 ohms so the SWR at antenna resonance should be well below 1.5-to-1 using either cable. The antenna is hung in the vertical plane, broadside to the direction or radiation. The coaxial line is wrapped into a four-turn coil directly below the feedpoint, to decouple the outside of the line from antenna currents. Keep the decoupling coil at right angles to the antenna wires.

The bottom of the antenna should be at least as high above ground as dimension B — the higher the better.

The V-beam is shown in **fig. 2**. The wires are parallel to the ground and their length (2-1/4 wavelengths) plus the selection of the included angle between the wires provides a bidirectional array which shows a power gain over a dipole of about 4.5 dB. Feedpoint resistance of the antenna is matched by the use of a 50-ohm transmission line and a 75-ohm quarter-wave impedance-transforming section, as shown in the illustration.

The beam is constructed of No. 16 enamel wire. Either hard-drawn wire or prestretched softdrawn wire is recommended. The coaxial transformer section of the line is wrapped into a four-turn coil directly at the feedpoint to decouple the outside of the line from antenna currents. At the design frequency, the measured SWR on the line should be below 1.5-to-1. For best results the V-beam should be mounted at least one-half wavelength above ground.

One nice fact about both of these beam antennas is that they are virtually invisible once they are up in the air. That's a plus if you live in a neighborhood that has an anti-ham bias!

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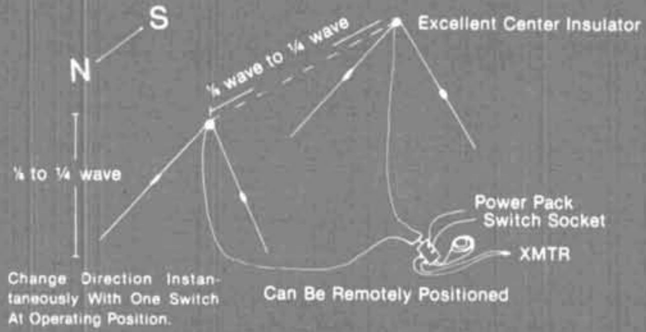

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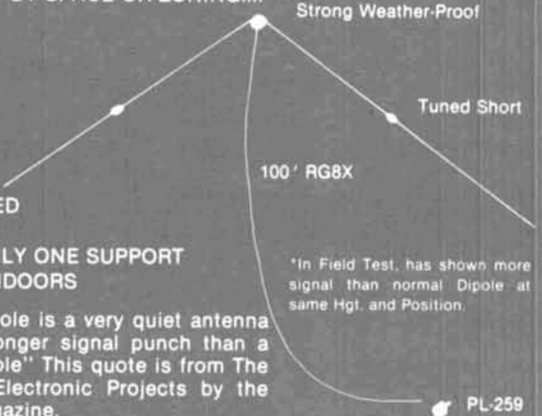

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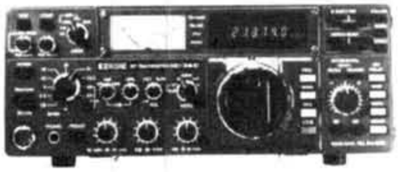

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Three different versions of the receiver, two of which have been expanded into transceivers. The one on the left is the original which was built in modules. It uses a cabinet available from Radio Shack, and a homemade front panel. On the top right is the basic receiver described in this article. It uses an inverted chassis with cover plate. Wooden rails have been added to both sides and an aluminum trim strip adds a finishing touch to the front panel. A bar graph display has been used here instead of an S-meter. It is mounted just above the digital readout. On the bottom right is a unit built by Bob Kirby, WA3DYF. His version includes an antenna tuner, so that a random length wire can be used as an antenna.

modular two-band receiver

State-of-the-art circuitry with digital frequency readout

I have often been impressed by the many excellent articles which have been published about my favorite subject — communications receivers. A problem I have found with most of the articles, however, is that duplicating some of the circuits is often difficult. Some receivers use surplus or discontinued parts, or parts not readily available. In some cases extremely expensive, custom-made components are used.

There is no reason why a top-quality, high-performance receiver should cost a small fortune to build — or require a bench full of sophisticated test equipment to adjust. You *can* build a receiver for less money than you would have to spend to purchase one of similar performance.

This article describes my answer to these problems. Here is a reliable, high-performance Amateur communications receiver that will perform as well as some of the best receivers available to Amateurs today. The basic two-band design can be expanded to cover the other bands, and, with the addition of two boards, can operate as a transceiver on CW and SSB.

the evolution of the design

The typical receiver should be able to handle strong signals (both on and off frequency), such as

By Jim Forkin, WA3TFS, 3210 Shadyway Drive, Pittsburgh, Pennsylvania 15227

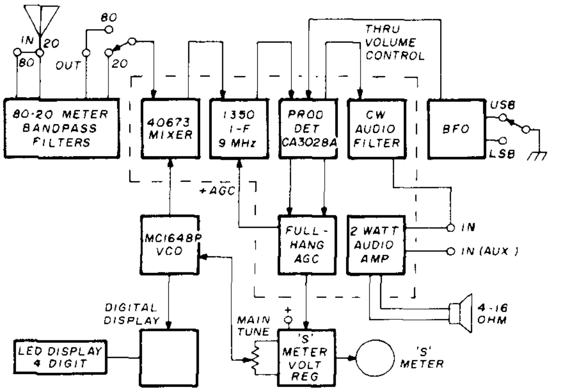


fig. 1. Block diagram of the SSB/CW receiver.

those typically found under Field Day type operation. Many otherwise excellent receivers sold to Amateurs are terrible at this. Manufacturers, in an attempt to improve poor dynamic range, add an attenuator to the front end of their receiver. This does not really cure the problem, but substitutes one problem for another. Yes, the receiver no longer overloads on strong signals, but now the operator can hear only the strongest signals. It should not be necessary to use an attenuator or to run an rf-gain control at less than maximum sensitivity under any type of operation encountered on the Amateur bands today.

Most interference heard on the lower Amateur bands is generated in the receiver. Poor dynamic range, as well as excessive gain in the front end, are usually to blame. Selectivity in the front end and i-f are also factors which are not given proper consideration in many designs.

A typical receiver should have excellent calibration. Digital readout is by far the best way to achieve this. Also, a digital-readout system eliminates the need for a mechanical dial drive, which can be extremely difficult to construct in the typical home workshop.

The receiver must have selectivity suitable for both SSB and CW reception. In this design, a KVG XF9B eight-pole crystal filter has been used. This filter is readily available, reasonably priced, and has excellent skirt selectivity, (see **table 1**). An audio filter with a bandwidth of less than 200 Hz can be switched in before the audio amplifier to help slice through the thickest QRM.

Any modern rig should, ideally, be able to operate on 12 volts dc. This not only simplifies portable operation, but during an emergency, this feature may save the day. Even during the worst disaster, a truck, auto, or motorcycle battery can provide enough power to get the communications started. The receiver draws only about 100 mA at normal volume level.

With emergency and portable operation in mind, small size and minimum weight are nice features to consider. One weight- and time-saving method involves eliminating the mechanical dial drive, readout, and tuning capacitor. I used a Jackson Brothers 6:1 reduction drive, which turns a ten-turn potentiometer, giving sixty turns to cover a 500-kHz band. The regulated voltage from this control is used to tune the VFO. Since the varactor diodes in the VFO require only a dc voltage, the packaging of the various boards needs not be influenced by any mechanical considerations. This packaging flexibility opens up a few new possibilities.

If mobile operation is contemplated, a remote-mount type of packaging could be used. The main receiver board, along with the VFO and BFO, could be in one box. The digital readout, tuning control, volume control, and S-meter, in a small box mounted under the dash, would complete the receiver. This idea is especially attractive for use in the small cars which are becoming so popular.

Finally, and of major importance, any circuit used in a receiver should be entirely reliable. By this I mean that only readily available, well-proven, solid-state devices should be used in circuits which are easy to duplicate without problems of instability. No changes or critical adjustments should be required to get the receiver working the first time.

In this design, I have relied heavily on the use of integrated circuits. This cuts size, complexity, and cost. The design has shown itself to be reliable and trouble-free. I know of no better way to put two pounds of circuitry into a one pound box.

the design

The two-band receiver consists of six printed circuit boards (see block diagram in **fig. 1**). The main receiver board contains the mixer, i-f filter and amplifier, product detector, AGC circuitry, active audio filter, and audio power amplifier. Other boards include the VFO, BFO, the voltage regulator and S-meter board, and the digital-readout board. Both of the bandpass filters are on one board.

table 1. Specifications for the KVG XF-9B filter.

application		SSB/RX
number of filter crystals		8
bandwidth (6 dB down)		2.4 kHz
passband ripple		<2 dB
insertion loss		<3.5 dB
input-output	R_t	500 ohms
termination	C_t	30 pF
shape factor		(6:60 dB) 1.8 (6:80 dB) 2.2
stop band attenuation		>100 dB

bandpass filters

Each band has its own double-tuned bandpass filter (**fig. 2**). This filter design has good rejection of unwanted signals both above and below the band of interest.[2] The two coils for each band are wound on ferrite cores and tuned with ceramic or mica trimmer capacitors.[3] (See **table 2**.) Once initially adjusted at the center of each band, the filters require no other tuning or adjustments.

One drawback of this type of front-end filter is the fact that the antenna must present a 50-ohm load.

Two more versions of the receiver, both of which have been expanded in function. The one on top has been designed for mobile use. It is built in a compact package measuring only 4 × 7 × 11 inches. The cabinet is formed by using two chassis fastened together with a top and bottom cover. A separate front panel hides the seam where the two chassis join together. The bottom unit is the dual-diversity unit mentioned in the article. Note the two dot displays to the left of the digital readout. These give a direct comparison of signal strength on each channel.

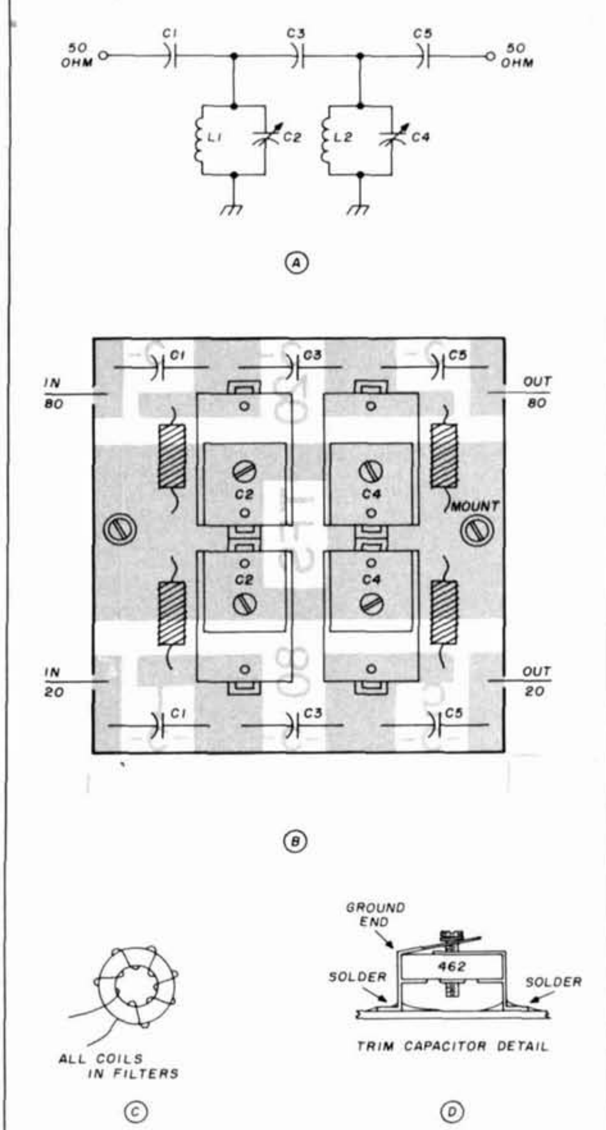


fig. 2. *Schematic diagram* (A) *of the bandpass filters,* and parts location (B). All coils are wound on a toroidal core as shown by (C); see table 2 for values. The tabs *on trimmer capacitors are bent outward and soldered* to the circuit board as in (D). All parts are on foil side of board.

Severe mismatch at the antenna will detune the filter and cause a loss in sensitivity. It is not possible to just hang a wire on the antenna input and obtain good results. With a matched antenna, the filters are excellent.

table 2. Component values for the bandpass filters. C1, C3, and C5 are silver-mica capacitors. Coils are wound with No. 28 enamel wire.

	C1-C5	C3	C2-C4	L1-L2
80 meters	100 pF	12 pF	ARCO 464	35 turns on T37-2 core (red)
20 meters	15 pF	2 pF	ARCO 462	27 turns on T37-6 core (yellow)

the mixer

Initial experiments with the mixer stage involved double-balanced diode mixers, but these were rejected in favor of a dual-gate mosfet stage, as shown in the receiver-board schematic (**fig. 3**).

In theory, the diode double-balanced mixer is, perhaps, the ultimate design. However, in practice, the maximum capabilities of this device are rarely achieved in a home-built receiver.

The diode mixer, in order to work properly, must be terminated at all frequencies present — not just the i-f. This requires a circuit called a diplexer. This circuit can be very difficult to get working properly with simple test equipment. This type of mixer exhibits a loss and also requires a high-level local-oscillator signal. This not only consumes extra power, but makes interstage coupling of the local oscillator signal a problem.

A dual-gate mosfet mixer, on the other hand, is not in the least bit temperamental, and good performance can be obtained without any adjustments. The drain is terminated in the eight-pole crystal filter. Impedance matching is handled by a 510-ohm resistor in the drain circuit of the mixer, which approximates the 500-ohm input impedance of the KVG filter.

the intermediate frequency amplifier

The local-oscillator signal and the desired incoming signal are mixed (heterodyned) to produce an output signal at the i-f center frequency of 9.0 MHz. This signal is then passed through the eight-pole crystal filter with a −6 dB bandwidth of 2.4 kHz. The outstanding skirt selectivity of this filter (1.8 shape factor) rejects off-frequency signals very well. It is this selectivity which allows you to separate the closely spaced signals which are common on the Amateur bands.

The signals at the output of the crystal filter must be amplified, of course, and this is handled by an integrated circuit which provides about 50 dB of gain and a bit more than 60 dB AGC control.

Although this eight-pin chip appears quite simple, the MC 1350 is really quite sophisticated.[1] It is also inexpensive. The gain of this stage is controlled by applying a voltage of 5 volts or greater to pin 5. An increase in voltage on this pin causes a decrease in gain in the chip.

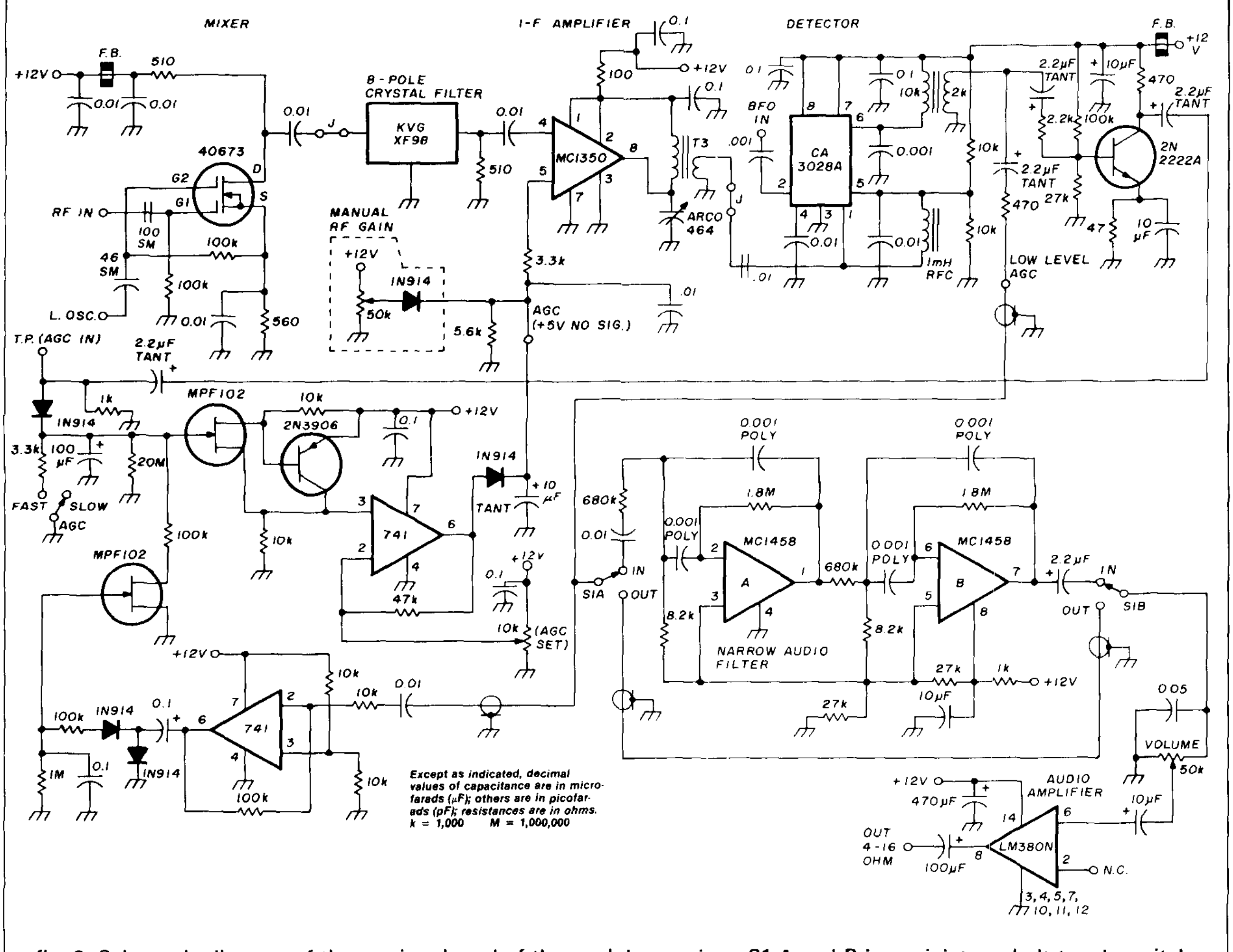


fig. 3. Schematic diagram of the receiver board of the modular receiver. S1 A and B is a miniature dpdt toggle switch. Capacitors in audio filter must be polystyrene or mica. Capacitors marked + can be either tantalum or other electrolytic. T3 primary is twenty-five turns No. 28 enameled wire on T37-6 core; secondary is five turns No. 28 wound over primary.

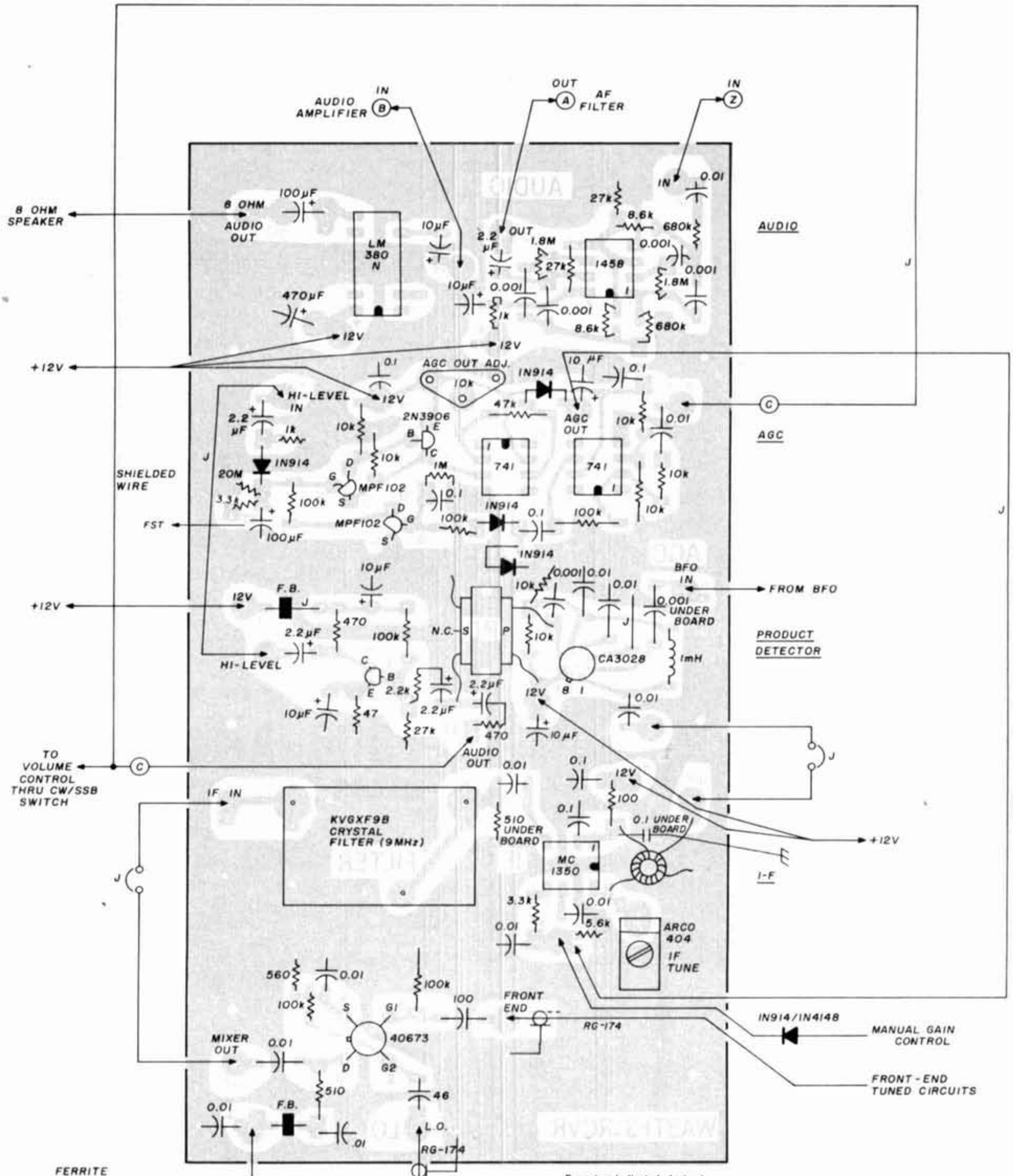


fig. 4. Component placement guide for the receiver board, viewed from the component side of the board with the printed circuit board in the background.

More Details? CHECK—OFF Page 92

The printed circuit board (**fig. 4**) is designed so that the entire i-f amplifier stage, along with the crystal filter, can be diode or relay switched whenever this receiver is modified for use as a transceiver.

Although it was not included in the original design, a two-pole crystal filter was added at the output of the i-f amplifier. This was not necessary to realize excellent performance in the receiver, but it does produce a quieter receiver by eliminating most of the noise generated in the i-f amplifier. The use of the filter is especially noticed and appreciated when copying extremely weak signals near the noise floor of the receiver.

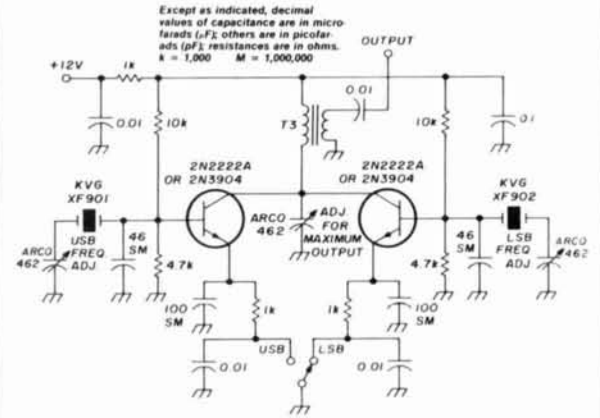


fig. 5. Schematic diagram of the BFO for the receiver. T3 primary is forty-five turns No. 28 enameled wire on T50-2 core; secondary is three turns No. 28 over primary.

The low cost involved by adding the two-pole filter is justified by the increased performance. The filter can be added without modification to the printed circuit board.

the product detector

I have experimented extensively over the past several years with direct conversion receivers (synchrodyne) and have found that the RCA CA3028-A integrated circuit works very well as a product detector. I have, therefore, used this device in this receiver. It exhibits good gain, low noise, excellent stability, low distortion, and a reasonable level of recovered audio. BFO level requirements are reasonable and non-critical. This chip also handles strong signals very well and this ability simplifies the design of the AGC system.

the audio stages

Detected signals from the product detector are coupled through an audio interstage transformer to the following stages. If more selectivity is desired for the reception of CW signals, the audio is routed through an audio filter.

Operational amplifiers have made filtering for selectivity at audio frequencies a practical method to use in the design of a new receiver or to improve an older receiver. This receiver uses a design based on an MC1458 dual-operational-amplifier integrated circuit. No critical parts are required, as experiments have shown that excellent performance can be obtained using typical 5 percent resistors and polystyrene capacitors. When it comes right down to it, it is

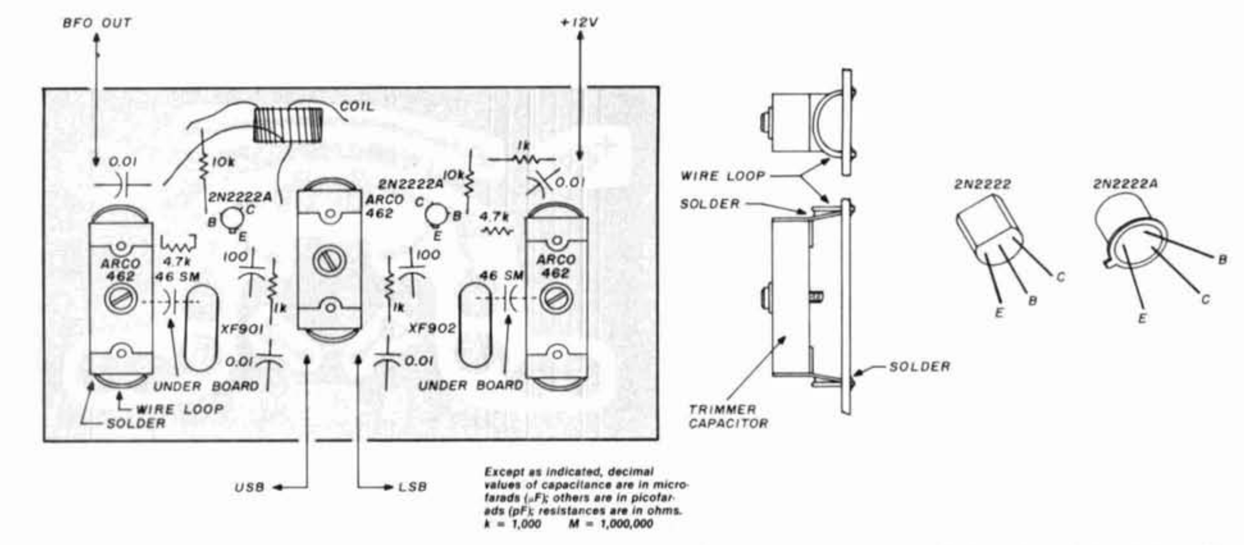
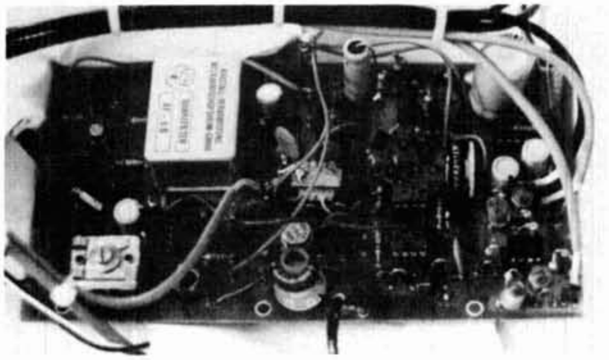
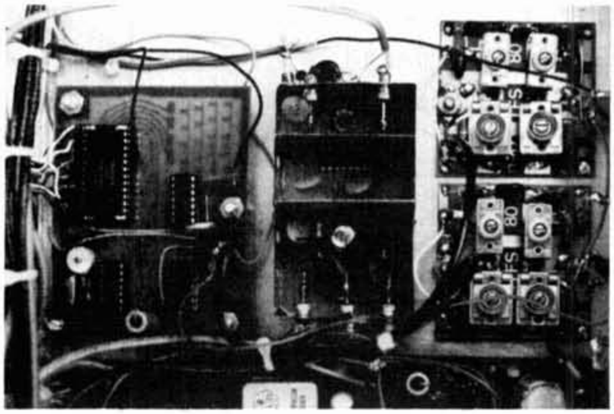


fig. 6. Component placement guide for the BFO board, shown from the component side with the printed circuit board in the background.



The main receiver board. Note the shielded wiring used on all audio and rf connections. From left to right are the mixer, crystal filter, i-f amplifier, product detector, AGC circuit, audio filter, and audio amplifier.



Three of the assembled boards. From left to right they are the digital readout board, the VFO, and the bandpass-filter board for 80 and 20 meters. A shielded control line goes to the VFO.

not important whether the center frequency is at 1.0 kHz or 1.1 kHz, or that the bandwidth at −6 dB is 200 Hz or 210 Hz. The design specifications call for a bandwidth of about 200 Hz at −6 dB, and a center frequency of 1.0 kHz. This is wide enough to eliminate any ringing tendency, yet narrow enough to cut through some of the worst interference.

One of my most basic concepts of receiver design is that simple is usually best. This idea is carried to the extreme when you consider the audio output stage. Only three parts are needed. The LM380-N integrated circuit will provide about 2 watts output in this configuration. It has low distortion, good gain, and is even thermally protected so you don't have to be concerned if the speaker becomes disconnected. I have used this receiver mobile and have found the audio output to be more than adequate when connected to an external speaker of good quality. The output stage will drive any load between 3 and 16 ohms. Don't ruin the excellent audio quality of this receiver by using an inferior speaker. Any of the many CB-type mobile speakers should be a good choice.

Incidentally, the audio chip has two input pins. One is used here, the other left floating. If the receiver is used as part of a transceiver, the other pin can be connected to the sidetone oscillator.

the AGC system

After weeks of experimenting with both audio- and rf-derived AGC systems, it became apparent that an audio-derived, full-hang AGC system worked best under signal conditions ranging from casual ragchews to weak-signal CW work, DX pileups, and Field Day QRM.

Perhaps you have used a receiver and noticed that the S-meter (actually an indicator of AGC action in the receiver) would deflect up scale on signals not even detected in the audio output. This is typical of receivers using rf derived or i-f derived AGC systems that do not have sufficient selectivity ahead of the detectors for the AGC.

Because of this problem, the desired signal completely disappears or appears to become very weak because of the AGC action. Obviously, this is not an ideal situation. The receiver sensitivity should be totally controlled by the signal you wish to detect, not by QRM.

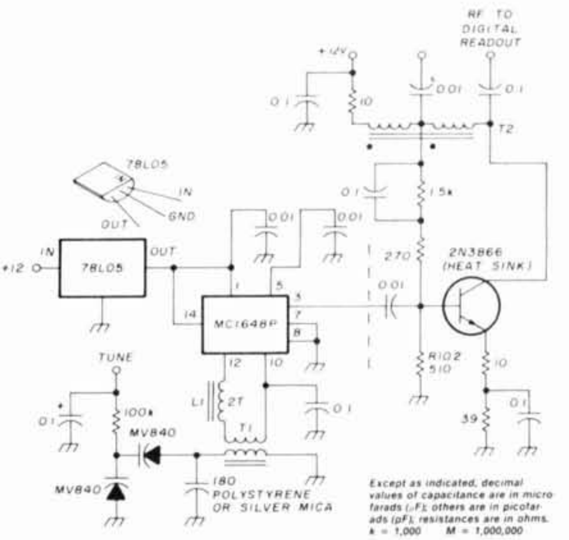


fig. 7. Schematic diagram of the VFO (local oscillator). T1 primary is thirty-five turns No. 28 enameled wire on T37-6 core; secondary is eight turns No. 28 over primary. T2 is ten turns No. 28 enameled wire wound bifilar on FT37-43 core. L1 is two turns No. 28 enameled wire on ferrite bead.

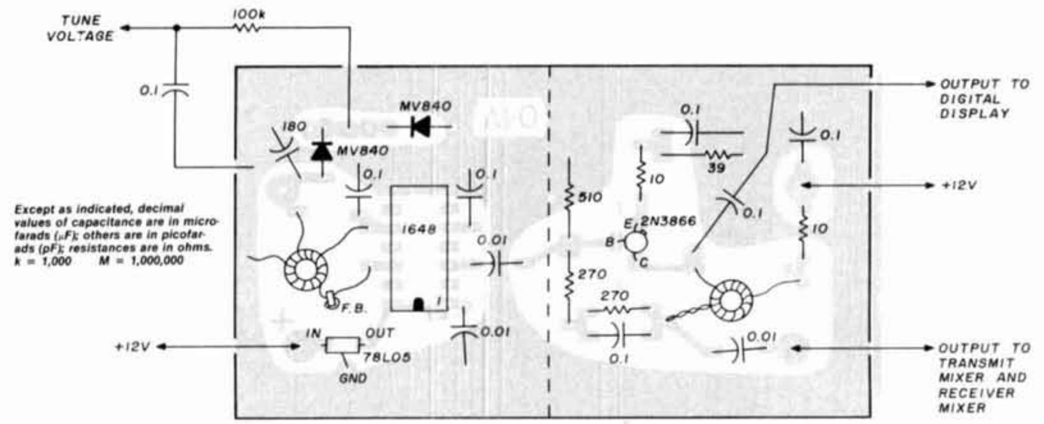


fig. 8. Parts placement guide for the VFO board with the printed circuit board in the background.

In practice, this is nearly impossible to do. But, through the use of selective filters and an audio-derived AGC system (as used in this receiver), this ideal comes closer to reality than you find in many commercial receivers.

A signal, first of all, must be detected and be present in the product-detector output to produce any AGC action. The strength of this signal determines how much AGC voltage will be applied to the i-f amplifier stage. When the need for a control voltage no longer exists, an FET switch is turned on, thereby shunting this voltage to ground, which brings the receiver back to maximum gain within a period of time determined by the time constants. The type or strength of the signals received does not affect this hold-in time. This type of circuit is discussed in greater detail in an ARRL publication.[1]

Two AGC time constants are available. The slower one is excellent for general SSB and CW use and the faster one allows good copy under adverse conditions.

the BFO

The beat-frequency oscillator is crystal controlled for stability. The circuit consists of two oscillators which share a common output tuned circuit (see **figs. 5** and **6**). The upper and lower sideband crystals are selected by grounding the appropriate control line. This board, like all the others, can be placed anywhere in the cabinet. Since only dc is being switched, it is not necessary to keep the control wires very short.

Each crystal has a trimmer capacitor so it can be set exactly on frequency. Another trimmer capacitor peaks the output tuned circuit at 9.0 MHz.

the VFO

Readers who are familiar with synthesized 2-meter equipment will probably recognize the MC1648 integrated circuit used in the VFO (**figs. 7** and **8**). It has become fairly common in VHF equipment but has not been used before, as far as I know, in a high-frequency receiver. It operates very well in this configuration.

One problem which may occur when using this integrated circuit is that it can oscillate above 250 MHz. The high-frequency oscillation is prevented by link coupling the tuned circuit to the IC through an rf choke. This low value inductance, as well as short lead length, proper pc board layout, and proper bypassing, prevents instability.

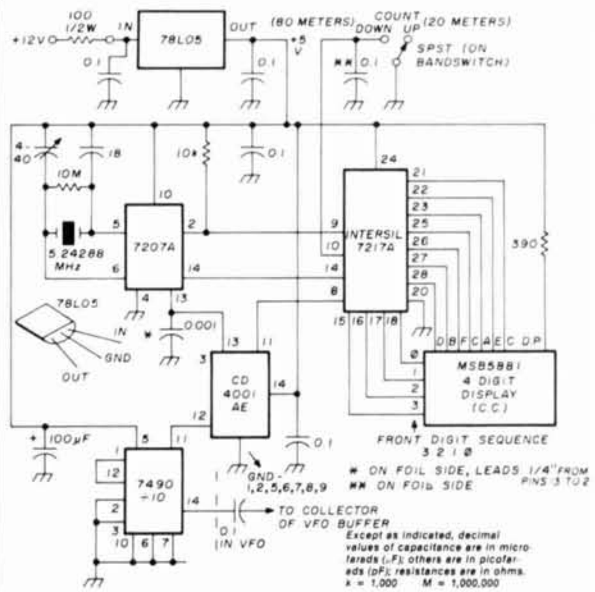


fig. 9. Schematic diagram of the digital frequency readout for the receiver.

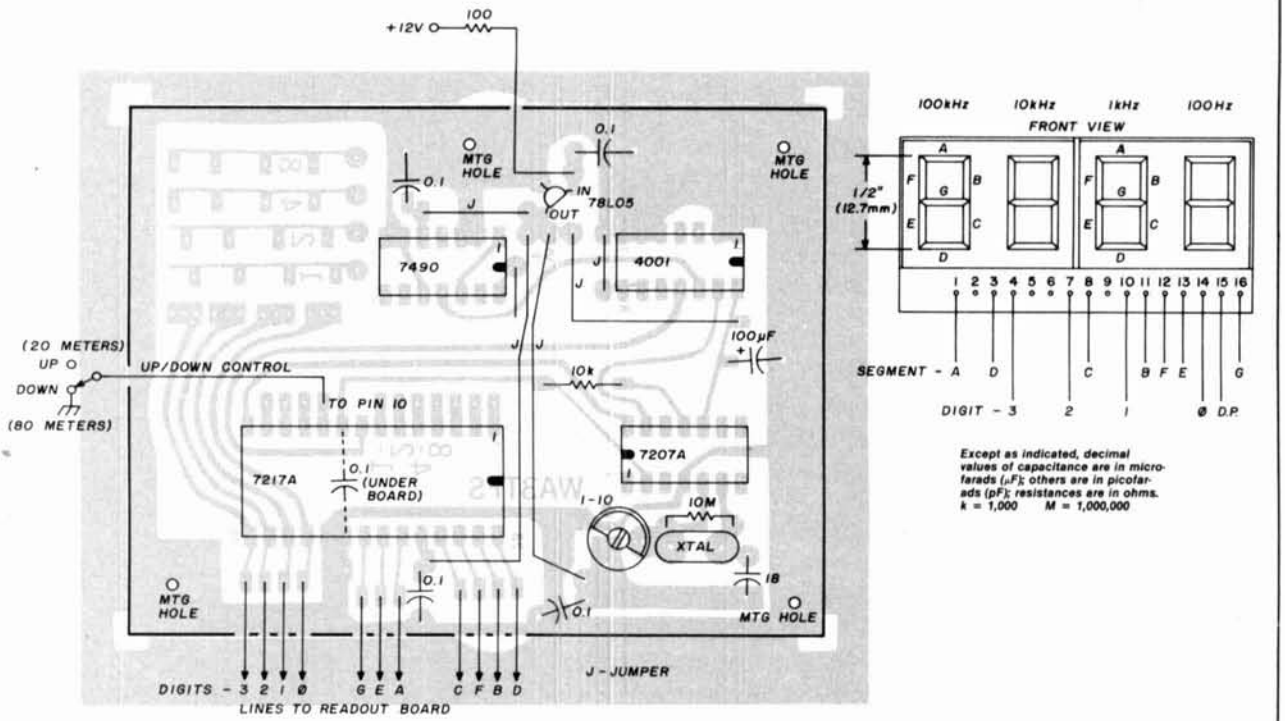


fig. 10. Parts placement of the frequency readout board with a printed circuit board in the background. The display is NSB5881 by National Semiconductor. To calibrate the readout, check against a freqency counter or calibrated receiver and adjust the 1-10 pF trim capacitor until readout is correct. Note that the first figure (MHz) of the VFO frequency (or the received frequency) is not displayed. Example: 5243.6 kHz (VFO) will be displayed as 243.6. Similarly, 14243.6 kHz will be displayed as 243.6 on the readout.

Two varactor diodes are biased by a regulated dc voltage which is controlled by a panel-mounted ten-turn potentiometer. A Jackson Brothers 6:1 vernier drive gives good bandspread.

VFO output is amplified and buffered by a Class-A 2N3866 stage. Output from the buffer is applied to the mixer stage in the receiver. Output to the digital readout is taken via a capacitor from the collector of this stage. This eliminates the need to add pulse shaping in the digital counter.

The regulated voltage, which is used to tune the VFO, is derived from a 6-volt, three-terminal integrated-circuit regulator which is mounted on the S-meter/voltage-regulator board.

Temperature compensation was found to be unnecessary for base-station applications. After a short warm-up period the drift is low enough to allow me to copy the ARRL RTTY bulletins without retuning. If you wish to use your receiver under adverse conditions, such as might be encountered during mobile operation, it may be necessary to add some sort of temperature compensation. Several schemes have been published and just about any of them will work. One simple method I suggest is to wire a 120-pF N750 ceramic capacitor in series with a low-value piston trimmer (approximately 2-5 pF) across the two varactor diodes. The trimmer should be adjusted to mid-range with a cold receiver. Hook a frequency counter to the VFO output and turn on the receiver. Plot the drift over about an hour's time. If drift is excessive, adjust the trimmer slightly, allow the receiver to cool and try the test again. This takes quite a bit of time, but once the magic combination is found, no further adjustment is needed.

digital readout

From the initial planning stages of this receiver, I decided to use a digital frequency display, but did not want the high current consumption, heat, or complexity of the usual designs. An Intersil LSI counter chip, along with three other integrated circuits, provides a four-digit readout with an accuracy of ±100 Hz (**fig. 9**) with a components layout and printed circuit board shown in **fig. 10**.

The counter counts the VFO output and displays the last four digits. This corresponds to the frequency of the received signal. For example, a received frequency of 14,230.6 kHz is displayed as 230.6. On 80 meters, the counter counts down so that a received frequency of 3,976.8 kHz is displayed as 976.8.

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Current consumption with this design is very low, and no noise from the counter can be heard in the audio output. The time base for the counter is a 5.24288 MHz crystal.

S-meter/voltage regulator

A meter amplifier designed to drive a low-current meter is included on this board (see **figs. 11** and **12**). The meters are readily available as CB surplus. Their current ranges are between 50 and 250 μA, and their cost is very low. A trim pot is used to set the meter to zero under no-signal conditions. Sensitivity of the amplifier is adjusted by changing the input resistor.

The board also holds a 6-volt, three-terminal integrated circuit and trim pots to set the upper and lower tuning range of the VFO. The trim pots should be set to allow a tuning range of about 4990 kHz to 5510 kHz. This range could be extended slightly to allow tuning in MARS or CAP frequencies.

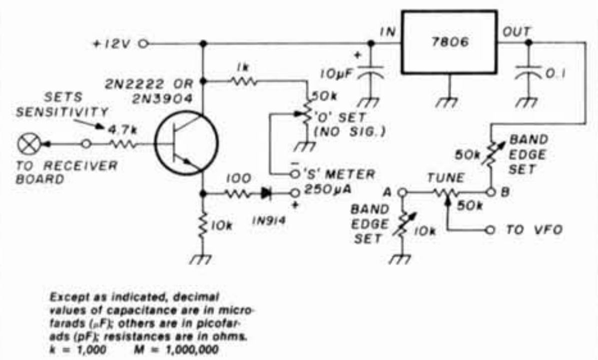

fig. 11. Schematic diagram of the voltage-regulator/S-meter board.

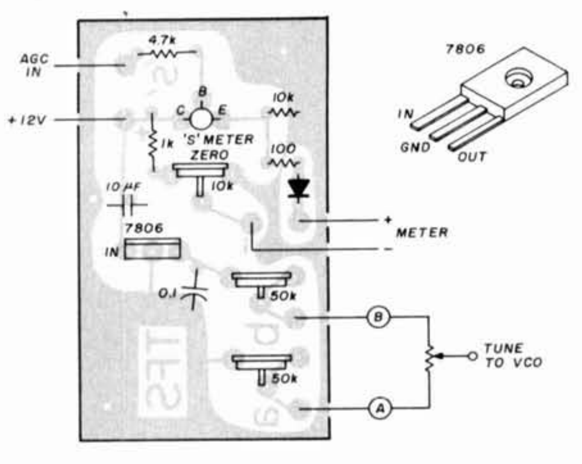

fig. 12. Parts placement guide for the voltage-regulator/S-meter board, component-side view with a printed circuit board in the background.

tuneup

Tuneup is a breeze!

1. Set BFO to frequency on either upper or lower sideband.

2. Peak i-f amplifier for maximum signal strength.

3. Peak bandpass filters for maximum at the center of each band.

4. Set AGC level at +5 volts with no signal on the input.

5. Set the timebase for the display on the digital display board so that the displayed frequency is accurate.

6. Set trimpots on the VR/S-meter board for the proper tuning range.

7. Set the zero adjust for the meter with no signal input.

8. Repeat as needed.

This receiver has been compared with some of the best available to Amateurs; in all cases it's held its own. The receiver sounds much quieter than any of the other receivers. Signals seem to pop out of the background. There is no roar of noise in the speaker when no signal is being received.

Single-tone dynamic range tests at 14.2 MHz work out to about 124 dB (**table 3**). This is with a signal

table 3. Specifications for the two-band receiver.

tuning range	3.5 to 4.0 MHz 14.0 to 14.5 MHz
VFO frequency	5.0 to 5.5 MHz (remotely tuned via dc)
i-f	9.0 MHz center frequency
BFO	USB: 8998.5 MHz LSB: 9001.5 MHz
digital readout time base	5.24288 MHz crystal
tuning resolution	± 100 Hz
voltage requirements	+ 12 Vdc; on-board regulation supplied as needed
current requirements	approximately 100 mA at medium volume setting
selectivity	SSB: 2.4 kHz (6 dB down) 1.8 shape factor (6.60 dB) 2.2 shape factor (6.80 dB) CW: peak type audio filtering; approximately 1-kHz center frequency with 6-dB bandwidth of 200 Hz
blocking	Better than 120 dB. (20-kHz spacing, 1-μV received signal strength at 14.2 MHz)

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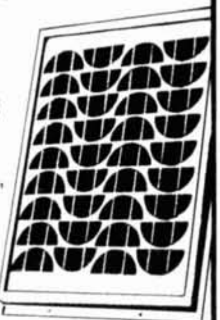

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✓ 111

for restoration and eventual museum exhibit. Need Hallicrafters, National, Hammarlund, Patterson, RCA, RME, Grebe, etc. Condition not important. Also need QST mags Vols. I & II and old tubes. All letters answered. Write Dave Medley, WA5YXA, 6621 Duffield Drive, Dallas, Texas 75248.

WANTED: Schematics-Rider, Sams or other early publications. Scaramella, P.O. Box 1, Woonsocket, RI 02895-0001.

BACK ISSUES of Ham Radio, QST, CQ and 73 magazines in good condition. 1960 thru 1980. Sold by the year only, $12.00 per year postpaid. Bill DuHart, W4VMS, 3846 Winona, Pensacola, FL 32504.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

WANTED: 2C39 tubes for local repeater. Must be good. Ken Booher, 1421 Williamsburg Rd., Flint, MI 48507. (313) 238-8272.

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.

I AM INTERESTED in setting up a regular sked with other hams who are interested in working the Historical Processes of Photography such as Carbro, Bromoil, Oil Transfer, etc. Please contact W2OQK, Tracy Diers, 58-14-84th St., Elmhurst, NY 11373.

RADIO WEST! High quality coverage communications receivers with Collins filters and other DX modifications! Catalog 50¢ (refundable). Radio West, 3417 Purer Rd., Dept HR, Escondido, CA 92025 (619) 741-2891.

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SIGNAL/ONE transceiver, model CX-11A. Solid state 1.5 to 30 MHz, full QSK cw, 150 watt model. Very clean, little use. Contact Mike Russell, at 8668 Celestine Ave., San Diego, CA 92123, or call (619) 278-9333 for details.

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SIGNAL/ONE transceiver, model CX-7B. One tube in transmitter. Carefully modified power supply, all production updates, receiver RIT, and more. Unit includes spare PA tubes and power supply components. Contact Mike Russell, WB5CSO, at 8668 Celestine Avenue, San Diego, CA 92123, or call (619) 278-9333 for details.

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IBM-PC RTTY & ASCII. SASE for full details. E. Alline, NE5S, 773 Rosa, Metairie, LA 70005.

VARIABLE VOLTAGE SUPPLY, 0-25V, 3A. Kit $50, Assembled $65. (+$3.00 shipping.) Hollan Electronics, P.O. Box 18632, Austin, TX 78760.

LOW VOLTAGE MEMORY ADAPTER for your present Voltmeter. $25.00 + $1.00 shipping to: Hollan Electronics, P.O. Box 18632, Austin, TX 78760.

CUSTOM P/C BOARDS. Send schematic for quotes. 1-4 transistors and/or IC's, $15 single board. Orders of 1-10 please enclose payment. Hollan Electronics, P.O. Box 18632, Austin, TX 78760.

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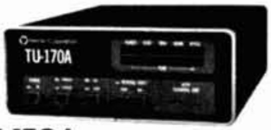

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spacing of 20 kHz. A CW signal of 0.2 μV is very easily copied.

At the time of this writing, the receiver which I have described has been duplicated several times with consistent results. The receiver design has since been expanded to include two other boards which give it transceive capability on SSB and CW. This combination has been used to work forty-six states and several countries. Output power is four watts.

I have also designed a heterodyne-oscillator board that allows the receiver to be used on 160 through 10 meters.

packaging

The photographs show a few ideas for packaging your receiver. One uses a cabinet available from Radio Shack and other similar stores. Other versions are built into aluminum chassis which are used as cabinets. Surplus cabinets salvaged from old test equipment can be found for a minimal price. One of the receivers shown makes use of two standard Bud chassis (AC402 — 7 × 5 × 2 inches) assembled top-to-top with a front panel.

A very economic approach is to strip out an old low-cost receiver or transmitter. This will provide you with not only the chassis and cabinet, but also all the hardware you may need. Because of the design of the receiver, you need not worry about the mechanical arrangement of the various controls, as everything is switched with voltages. An old CB transceiver is another possibility. A new paint job and some rub-on letters will give a modern appearance. The only limit to the project is your imagination.

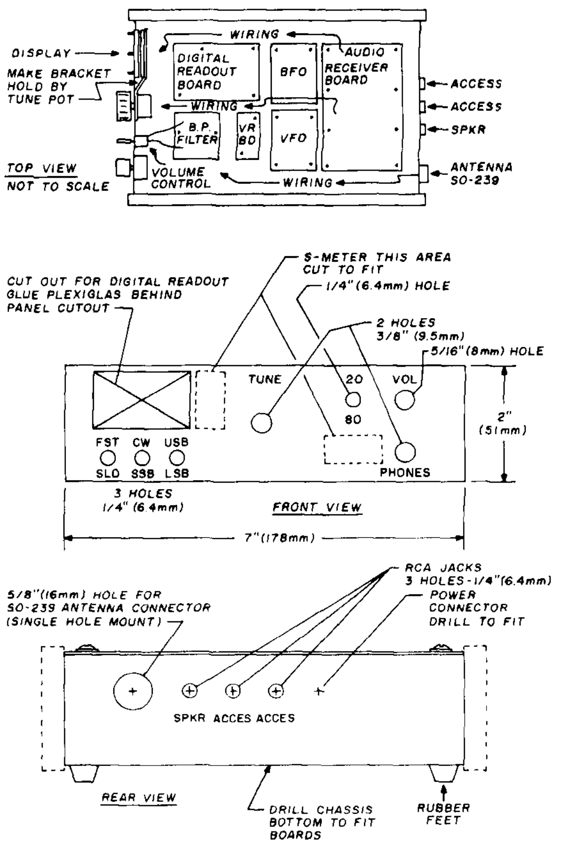

fig. 13. Suggested packaging for the two-band receiver. The enclosure is a standard 2 × 7 × 11 inch aluminum chassis (Bud AC402) with cover plate. Wood rails are added to the side and stained. The cabinet and panel can be painted to choice. Miniature toggle switches are used, and the volume control is a miniature type with on/off switch.

conclusion

Experiments have been performed using this design in a dual-diversity configuration, with excellent results. Basically, the design consists of one VFO board, one BFO, a digital frequency readout, two receiver boards, one audio stage, and a logic board to complete the hook-up.

This entire project has been approached from the viewpoint of an Amateur Radio operator, rather than as an engineer. It is relatively inexpensive and provides maximum performance at minimum cost, compared to receivers of similar performance. The design is easy to build, adjust, and package. None of the circuits are unstable, nor do they require any tinkering to achieve best performance. Best of all, the very nature of the design project promotes experimenting in the fascinating field of communication receivers.

As I have done with several of my projects, I have assembled several kits of parts for this two-band receiver. The kit includes all six pc boards and all parts needed to assemble them. A four-digit, ½-inch display and a Jackson Brothers vernier drive are also included. Documentation includes schematics, parts lists and layouts, block diagrams, and instructions. Drilling templates are provided for the version using a 2 × 7 × 11 inch (5 × 17.8 × 27.9 cm) chassis as a cabinet, **fig. 13**. The builder must supply the hardware, wiring, and cabinet. The cost of the kit is $320 here in the United States. Please send an SASE to the author with any inquiry.

references

1. Wes Hayward and Doug DeMaw, *Solid State Design for Radio Amateurs*, ARRL Inc., Newington, Connecticut 06111, pages 89, 92-94, 111-114, 117-119.

2. Doug DeMaw, *ARRL Electronics Data Book*, ARRL Inc., Newington, Connecticut 06111, page 55.

3. *Toroid Core Data Sheets*, Amidon Associates, 12033 Otsego Street, No. Hollywood, California 91607.

ham radio

Coming Events

ACTIVITIES

"Places to go..."

COLORADO: The Ski Country Amateur Radio Club's second annual Swapfest, July 23, Colorado Mountain College, 1402 Blake Avenue, Glenwood Springs. Free admission. Tables $5.00 each. Talk in on 07/67. For further information: Frank, WAØBBI, Box 280, El Jebel, Colorado 81628.

ILLINOIS: The Hamfesters Radio Club is having its 49th annual Hamfest and Picnic, Sunday, August 14, Santa Fe Park, 91st and Wolf Road, Willow Springs, southwest of Chicago. Exhibits for OMs and YLs. Famous Swappers Row. Tickets $3.00 at gate; $2.00 advance. For tickets send check or MO with SASE to Hamfesters, P.O. Box 42792, Chicago, IL 60642.

ILLINOIS: The annual Belvidere Hamfest, Sunday, July 31, Boone County Fairgrounds, Highway 76, Belvidere. Tickets $2.00 advance; $2.50 at gate. Tables $2.00 each. Saturday night camping. Talk in on 52 simplex. For information: Bob Anderson, K9DCG, 910 Locust Street, Belvidere, Illinois 61008.

ILLINOIS: The DuPage Amateur Radio Club's Hamfest/Computerfest, Sunday, July 10, 9 AM to 4 PM, Downers Grove American Legion Post grounds. Tickets $2.00 at gate only. Large outdoor flea market. Plenty of parking. Refreshments available. Talk in on 144.89/145.49. For information SASE to: W9DUP, P.O. Box 71, Clarendon Hills, IL 60514. (312) 971-1156.

ILLINOIS: The Quad-Co. Amateur Radio Club's 26th annual Hamfest of the "Breakfast Club", July 16 and 17, Terry Park, just east of Palmyra. Saturday night dancing and movies. Bring your basket lunch. Games, contests, golf and fishing. Bring your swap gear. Talk in on 3973 kHz from noon Saturday to 11 AM Sunday. Camping facilities from Friday afternoon to Monday AM. Pre-registration by July 7, $1.50. $2.00 at gate. Write Hamfest, c/o Quad-Co. ARC, 602-D East Walnut, Chatham, IL 62629.

ILLINOIS: The Fox River Radio League Hamfest, the oldest in Illinois, Sunday, August 21, Kane County Fairgrounds, St. Charles. Exhibits, contests, demos and part of the flea market indoors. Additional outdoor flea market area. Tickets $2.00 advance, $3.00 at gate. Overnight parking Saturday, August 20, for campers and motorhomes advance only $3.00. Talk in on 146.94 simplex or 147.21/82 (Aurora). Campers, exhibitors, flea market space: George R. Isely, WD9GIG, 736 Fellows Street, St. Charles, IL 60174. Advance tickets: Business SASE to Gerald Frieders, W9ZGP, 1501 Molitor Road, Aurora, IL 60505.

INDIANA: The combined LaPorte-Michigan City Amateur Radio Clubs will sponsor their Summer Hamfest, Sunday, July 17, LaPorte County Fairgrounds, State Road 2, 8 AM to 2 PM. Donation $3.00 at gate. Refreshments. Indoor tables 40¢/ft. by reservation to P.O. Box 30, LaPorte, IN 46350.

KENTUCKY: The Bluegrass Amateur Radio Society will sponsor the Central Kentucky ARRL Hamfest, Sunday, 8 AM to 5 PM, August 14, Scott County High School, Longlick Road and US 25, Georgetown. Tech forums, awards, exhibits. Free outdoor flea market space. Tickets $3.50 advance, $4.00 at gate. For information/tickets: Edward B. Bono, WA4ONE, P.O. Box 4411, Lexington, KY 40504.

LOUISIANA: The Central Louisiana Amateur Radio Club will sponsor a Hamfest, Saturday and Sunday, July 30 and 31, Bolton Avenue Community Center, Alexandria. Swap tables available. For information: KA5HCJ, Central Louisiana ARC, P.O. Box 68, Alexandria, LA 71309.

MARYLAND: BRATS, the Baltimore Radio Amateur Television Society's famous Maryland Hamfest, Sunday, July 31, Howard County Fairgrounds, West Friendship, 15 miles west of Baltimore. Fairgrounds available for setup Saturday, July 30 at 2 PM. Overnight RV facilities. Talk in on 147.03 (+600), 146.76 (−600), 146.52 and 29.54/64. For table reservations and information: Mayer Zimmerman, W3GXK (301) 655-7812.

MICHIGAN: The Hiawatha Amateur Radio Association is celebrating its Golden Anniversary by sponsoring the 35th annual Upper Peninsula Hamfest, July 30, 9 AM to 5 PM, Michigan National Guard Armory, Ishpeming. Registration $1.00. Tables available at $3.00 each. Talk in on 146.16.76. Come and help us celebrate! For information: George Lehitnen, W8IOC, 100 N. R2, Ishpeming, MI 49849. (906) 485-5038.

MICHIGAN: The Amateur Radio Public Service Association of Saint Joseph County will hold its 5th annual Swap and Shop, Sunday, July 31, Saint Joseph County Fairgrounds, Centreville. Doors open 8 AM. Tickets $2.00 advance, $3.00 at gate. Indoor tables $3.00. Trunk sales free. Saturday night camping available at $6.00. Talk in on 52. For information: Warren Harder, N8EOX, 14820 Broadway Rd., Three Rivers, MI 49093.

MISSOURI: The 5th annual North Missouri Hamfest, sponsored by the NEMO ARC, Kirksville and the Tri-County ARC, Moberly, Sunday, August 7 at the air-conditioned Moberly Municipal Auditorium, Moberly. Inside flea market with limited number of free tables. Doors open for flea market and distributors 8 AM. Hamfest 9 AM to 3 PM. Tickets $2.00 at door, $1.50 advance. Refreshments served all day. Coffee and donuts for early birds. For information/tickets: Sam Fischer, KAØILO, P.O. Box 341, Moberly, MO 65270. Talk in on 147.69/09.

NEW HAMPSHIRE: Fly-in to NH's 3rd largest electronic flea market, Saturday, July 16, Manchester Municipal Airport. Starts 9 AM. General admission $1.00. Sellers $5.00 with own tables. Refreshments available. Pre-registration to New Hampshire FM Association, 30 Meadowglen Drive, Manchester, NH 03103. Talk in on 146.52 FM. For information: Dick DesRosiers, W1KGZ, (603) 668-8880 or Doug Aiken, K1WPM, 30 Meadowglen Drive, Manchester, NH 03103. (603) 622-0831.

NEW JERSEY: SCARC '83, the Sussex County Amateur Radio Club's fifth annual Hamfest, Saturday, July 16, Sussex County Farm and Horse Show grounds, Plains Road, off US 206, Augusta. General registration $2.00. Outdoor flea market space $4.00 advance, $5.00 at gate. Indoor sellers $5.00 advance, $6.00 at gate. Talk in on 147.90/30 and 146.52. Free parking. For information or registration: Lloyd Buchholtz, WA2LHX, 10 Black Oak Drive, RD 1, Vernon, NJ 07462.

NEW YORK: The Mt. Beacon Amateur Radio Club's Hamfest, Saturday, July 23, Arlington Senior High School, Poughkeepsie/LaGrange. Doors open 8 AM. Tickets $2.00. XYL's and kids free. Tailgating space $3.00. Tables $4.00 (1 free table and admission). Talk in on 146.37/97 and 146.52. For information: Art Holmes, WA2TIF, 2 Straub Drive, Pleasant Valley, NY 12569. (914) 635-2614.

NORTH CAROLINA: The Cary Amateur Radio Club's 11th annual Mid-Summer Swapfest, Saturday, July 16, Lion's Club Shelter next to Cary Senior HS, Cary. 9 AM to 3 PM. Free admission. Buy, sell, trade. Open auction. Talk in on 146.28/.88; 147.75/.15; and 146.52. For information: Cary ARC, P.O. Box 53, Cary, NC 27511.

NORTH CAROLINA: The Western Carolina Amateur Radio Society's all new Hamfest and Computer Fair, July 30 and 31, Buncombe County Firemen's Training Center, Asheville. Open 9 AM. ARRL booth, seminar by Bob Grove, WA4PYQ, CW competition, RV parking and free camping (no hookups). See the latest in computer hardware and software. Talk in on 31/91, 16/76, 52 simplex. For ticket information: Garland Lance, NC4N, 854 Sandhill Road, Asheville, NC 28806.

OHIO: The 19th annual Wood County Ham-A-Rama, Sunday, July 17, Wood County Fairgrounds, Bowling Green. Gates open 8 AM. Free admission and parking. Trunk sales. Refreshments available. Dealer tables $5.00 advance registration. Saturday setup until 8 PM. K8TIH talk in on .52. For information, dealer rentals, SASE to: Wood County ARC, c/o Craig Henderson, Box 366, Luckey, OH 43443.

OHIO: The Northern Ohio Amateur Radio Society's NOARSFEST, Saturday, July 23, Lorain County Fairgrounds, Wellington. 8 AM to 5 PM. Donations $2.50 advance, $3.50 at gate. Children under 12 free. Blacktopped flea market area, $1.00 per car space. Free general parking. Refreshments available. Free overnight camping Friday night, no hookups. Mobile check-in, K8KRG, 146.52/52. Directions and info 144.55/145.15. For information/tickets: NOARSFEST, P.O. Box 354, Lorain, OH 44052.

OREGON: The 8th annual Lane County Ham Fair, July 16 and 17, Oregon National Guard Armory, 2515 Centennial, Eugene. Doors open 8 AM each day. Tech seminars, swap tables, 2 meter Bunny Hunt, kids' activities, computer demos. All day snack bar. Free parking for RV, no hookups. Saturday pot luck supper. Talk in on 52-52, 146.28/88, 147.86/26. For tickets and tables: Tom Temby, WB7WPU, 3227 Crocker Rd., Eugene, OR 97404. (503) 689-1761. Checks payable to Lane County Ham Fair.

PENNSYLVANIA: Nittany Amateur Radio Club's Hamfest & Computer Faire, July 9, New Location, Pleasant Gap Firemen's Park, Route 144, Pleasant Gap. Gates open 8 AM. All day technical operating sessions. Large tailgating area. Tickets $3.00. Tailgaters $5.00. Talk in on 146.16/.76 and 146.25/.85. For information: Dave Buckwalter, KC3CL, 1635 Circleville Rd., State College, PA 16801. (814) 234-0759.

TEXAS: The Austin ARC and the Austin Repeater Organization will sponsor Summerfest '83, August 12, 13 and 14, Austin Marriott Hotel, I-35 at Highway 290. Exhibits, meetings, indoor swapfest. Outdoor family activities. Admission $5.00 advance; $6.00 at door. Swapfest tables available at door. Reserved swapfest tables $1.00 advance. Talk in on 146.34/.94. For information: Austin Summerfest '83, P.O. Box 13473, Austin, TX 78711.

WEST VIRGINIA: The Triple States Radio Amateur Club will present its 5th annual Wheeling, WV Hamfest at Wheeling Park on Sunday, July 24, from 9 AM to 4 PM. Dealers, flea market and auction, free parking, refreshments, ARRL, SWOT booths, etc. Admission $2.00, children under 12 free. Indoor display, tables available, price of admission only but reserve space. CONTACT: TSRAC, Box 240, RD 2, Adena, OH 43901. Phone (614) 546-3930.

WASHINGTON: The Western Washington DX Club, W7FR, hosts the 31st annual Northwest DX Convention, Friday, Saturday and Sunday, July 29, 30 and 31, Double Tree Plaza Hotel, near South Center Shopping Mall and Seattle Tacoma Airport. Saturday night banquet, Sunday morning breakfast. Speakers, slides, symposia and more. For registration: Ruth Bennett, WA7RVA, 6729 Beach Drive S.W., Seattle, WA 98116. (206) 932-1335.

WYOMING: The 1983 ARRL Rocky Mountain Division Convention in conjunction with the 51st W.I.M.U. Hamfest, August 5, 6, and 7, Virginian Motel, Jackson. Talk in on 146.22/82 and 3923 kHz. For more information: R.L. "Pete" Stull, WB7AMP, (307) 382-9023 or Dave Gregory, N7COA, (307) 875-5324.

WYOMING: Fourth annual High Plains Ham Roundup, September 9 and 10, Medicine Bow National Forest, 10 miles east of Laramie, I-80. Enjoy a real Western Ham Roundup. Bring your own food and drink. Roast beef furnished for Saturday pot luck supper. Blue Grass band, barbershop quartet and sing-a-long. Talk in on 146.25/85, 146.22/82 or 146.52 simplex. For information: Mick Marchitelli, P.O. Box 731, Laramie, WY 82070.

MONTANA-ALBERTA: The 49th Glacier-Waterton International Hamfest, July 15-17, H.Q. at Waterton Homestead Campground, north of Waterton National Park entrance, Alberta, Canada. Bunny hunt, tech sessions, entertainment, swap tables. For information/pre-registration: P.O. Box 148, Milk River, Alberta, T0K 1M0.

BRITISH COLUMBIA: The Okanagan International Hamfest, July 30 and 31, Oliver Centennial Park, Oliver. Activities from Saturday, 1 PM, to Sunday, 2 PM. Entertainment, bunny hunts, pot luck luncheon Sunday. Talk in on 34/94 OKN Repeater - 76/76. For information: John Juul-Andersen, VE7DTX, 8802 Lakeview Dr., Vernon, BC V1B 1W3 or Lota Harvey, VE7DKL, 584 Heather Rd., Penticton, BC V2A 1W8.

RADIO EXPO: Sponsored by the Chicago FM Club, Saturday and Sunday, September 24 and 25, Lake County Fairgrounds, Routes 120 and 45, Grayslake, Illinois. Flea market opens 6 AM. Exhibits open 9 AM. Indoor flea market tables available at $5.00 per day. Tickets $3.00 advance, $4.00 at gate, good for both days. Seminars, tech talks, ladies' programs. Talk in on 146.16/76, 146.52 and 222.5/224.10. For information: SASE to Radio Expo 83, Box 1532, Evanston, IL 60204 or (312) 582-6923.

OPERATING EVENTS
"Things to do..."

JULY 3 AND 4: The Hannibal ARC will issue a third annual special certificate from the National Tom Sawyer Days celebration in Mark Twain's boyhood home town, Hannibal, Missouri. Hours: 1500-2100 UTC both days. Frequencies: Phone 7.245, 14.290, 21.400, 28.770. CW 7.125 and 21.125 MHz. To receive the certificate send large SASE and personal QSL card confirming contact to Hannibal ARC, WØKEM, 2108 Orchard Avenue, Hannibal, MO 63401. For further information: Tony McUmber, 2108 Orchard Avenue, Hannibal, MO 63401. (314) 221-6199.

JULY 4 AND 5: High Plains ARC will operate K7YPT at the historic Fort Laramie from 0000Z July 4 to 0000Z July 5. Frequencies: Phone 3.900-3850, 7.250, 14.250-14.300, 21.300-21.360. Certificate for large SASE to: K7YPT, Rt. 2, Box 303, Torrington, WY 82240.

JULY 9: The Waterville, NY, Central School ARC, WD2ALL, will operate from 1300-2000 UTC to commemorate the birth of George Eastman of Photography fame. Frequencies: lower portion of General phone and Novice CW bands. FM operation also planned for 146.52. Certificate and Club QSL available for SASE to WD2ALL via Callbook.

JULY 9 AND 10: The Cascades ARS (CARS) in conjunction with the Michigan Space Center in Jackson, is offering a Space Day certificate to all stations who work WB8CSQ on 3.900, 7.235, 14.285, 21.360 and 28.510 starting 0000 GMT July 9 through 1700 GMT July 10. Mail log information and $1.00 contribution for postage and materials to: CARS, Space Day 83, P.O. Box 512, Jackson, MI 49204.

JULY 16 AND 17: Wapakoneta, Ohio. Reservoir ARA will operate K8QYL from 1400Z July 16 to 0400Z and from 1400-1900Z July 17 from the home town of astronaut Neil Armstrong. Frequencies: Phone 7.260 and 14.285 MHz ± QRM. Certificate for QSL and large SASE to: K8QYL, P.O. Box 268, Celina, Ohio 45822.

JULY 16 AND 17: The Eastern Michigan Amateur Radio Club, K8EPV, will commemorate the annual Port Huron to Mackinac Island Yacht Race. Operation begins 10 AM EST (1500Z) through 10 PM EST (0300Z) on Saturday and Sunday. Frequencies: 3910, 7235 and 14285 phone; 3710, 7110 and 21110 CW. For an attractive certificate send legal size SASE to: K8EPV, 654 Georgia, Marysville, MI 48040; or C.B.A.

JULY 23: The Miami County ARC of Peru, Indiana, will operate K9ZEV in celebration of the 24th annual Peru Circus City Festival. Operation primarily in the General class SSB portion of 40 meters from 1400 to 2300 UTC. Check on 20, 15 and 10 meters as conditions permit. For a special commemorative QSL card send SASE to: Les Cattin, KA9FMZ, 163 W. Third Street, Peru, IN 46970.

JULY 30: The Tuscarora Amateur Radio Association will operate KI3D from 1200Z to 2400Z, from the National Historic Site of Tuscarora Academy, established 1839. Frequencies: 10 kHz up from lower edge of the General phone bands. Certificate for business SASE to: William Bratton, Box 31E, Star Route, Mifflintown, PA 17059.

JULY 30: The Tank-Automotive Command ARC will operate W8JPW from 1300-2000Z to commemorate the 42nd year of the Detroit Arsenal, home of the nation's first defense plant and the US Army Tank-Automotive Command. Frequencies: Phone 7.250-7.274, 21.400 and 146.49 MHz. CW 7.055 from 1500-1700Z. Send 9 × 12 SASE for unfolded certificate to: W8JPW, US Army Communications Command, Att: CCNC-TAC-M, 28251 Van Dyke, Warren, MI 48090.

JULY 30 AND 31: The Pike County ARC will operate W9CZH from the Lincoln Boyhood Memorial, Lincoln City, Indiana, from 1700Z July 30 to 1700Z July 31. Frequencies: 3.925, 7.265, 14.305, 21.395 phone; 14.090 RTTY; 146.52 FM; 7.133 CW. A special QSL will be issued for your QSL and SASE to KC9VH, Box 311, RR 1, Winslow, IN 47598.

JULY 30: Reservoir ARA will operate KR8M from 1330-1900Z from the Courthouse steps during the Celina, Ohio, Lake Festival. Frequency: 7.260 ± QRM. Certificate for QSL and large SASE to: KR8M, P.O. Box 268, Celina, Ohio 45822.

AUGUST 6 AND 7: The 21st annual Illinois QSO Party sponsored by the Radio Amateur Megacycle Society (RAMS) from 1800Z August 6 to 2300Z August 7, rest period 0500Z to 1200Z August 7. Frequencies: CW — 40 kHz from low end. Phone — 3890, 7230, 14280, 21375 and 28675. Novice — 25 kHz from low end. Exchange RST and County by Illinois stations. RST and state, province or country by others. For filing and further information: RAMS, K9CJU, 3620 N. Oleander Avenue, Chicago, IL 60634.

AUGUST 13, 14 AND 15: The 24th annual New Jersey QSO Party sponsored by the Englewood ARA. From 2000 UTC Saturday August 13 to 0700 UTC Sunday August 14 and 1300 UTC Sunday August 14 to 0200 UTC Monday August 15. Phone and CW same contest. A station may be contacted once on each band — phone and CW are considered separate bands. No CW contacts in phone band segments. General call "CQ New Jersey" or "CQ NJ". Suggested frequencies: 1810, 3535, 3900, 7035, 7135, 7235, 14035, 14280, 21100, 21355, 28100, 28610, 50-50.5 and 144-146. For filing or information: Englewood Amateur Radio Association, P.O. Box 528, Englewood, NJ 07631.

AUGUST TO DECEMBER 1983: Jamaica Amateur Radio Association Award commemorating Jamaica's 21st year of independence, August 6, 1983. This award is available to all licensed Amateurs for CW, phone or mixed modes. Rules: Contact with 5 different 6Y5 stations, any band, August to December 1983. Submit QSL cards or written proof with time, date, band, mode and 6Y5 stations worked and fee of $3.00 U.S. or 10 IRC's and 8 × 10 SASE to: Awards Chairman, Gerald Burton, 6Y5AG, Box 214, Kingston 20, Jamaica W.I.

More Details? CHECK—OFF Page 92

audio filter building blocks

Active filters in theory and practice

In single-sideband and CW communications, the received audio signals are simple frequency-translated versions of the rf signal received at the antenna. This translation is accomplished by one or more mixer stages. The receiver block diagram usually includes an intermediate-frequency (i-f) stage that does most of the filtering to obtain selectivity. That is, this stage passes the desired signal on through but rejects any unwanted signals.

Fig. 1 is a block diagram of a simple receiver, which consists of a mixer and variable oscillator, i-f amplifier/filter, product detector, oscillator, and audio amplifier. The mixer and its variable oscillator translate the incoming signal from its original frequency to the i-f frequency. The i-f amplifier is also labeled as a filter since it has a bandpass frequency response and performs most of a receiver's filtering for selectivity. The output of the i-f stage is translated by the product detector to audio frequencies which are then fed to the audio amplifier and speaker. Since the signal present at the audio amplifier is a frequency-translated version of the signal at the i-f stage, filtering at the audio stage is equivalent to filtering at the i-f stage. Thus, receiver selectivity can be improved by adding an audio filter between the output of the receiver and the speaker or headphones.

In practice, audio filtering has a few disadvantages when compared with i-f filtering. Any automatic gain control (AGC) action that takes place in the i-f because of a strong interfering signal may wipe out the desired signal, regardless of how good the audio filtering may be. Also, any distortion introduced in the i-f system due to interfering signals cannot be completely eliminated by audio filtering. However, audio filtering does improve reception and, since it can be added externally, no receiver modifications are necessary.

building blocks

Here are some basic building blocks which can be used either individually or in cascade to produce a filter which meets your needs. These filters will all have unity gain (0 dB) in the passband to simplify their interconnection. All of the op-amps have been designed to use a single 12-volt supply. The circuits draw little current (typically 10-20 mA), so any simple power supply or battery can be used.

cw filter

A very simple active audio filter for CW can be made using a state-variable filter (see **fig. 2**).[1] This filter has a bandpass characteristic which can be of

By Bob Witte, KB0CY, 2227 114th Drive, N.E., Lake Stevens, Washington 98258

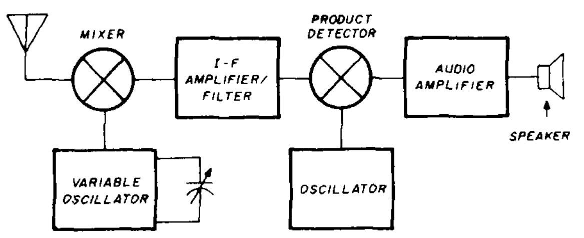

fig. 1. Block diagram of a simple receiver. Signals at the antenna are frequency-translated down to audio.

table 1. Equations for bandpass filter.

$$\frac{V_{out}}{V_{in}} = -\frac{1}{R_oC_2}\left(\frac{S}{S^2 + S\left(\frac{1}{R_QC_2}\right) + \frac{R_4}{R_1R_2R_3C_1C_2}}\right)$$

$$bandwidth\ (Hz) = \frac{1}{2\pi R_QC_2}$$

$$center\ frequency\ (Hz) = \frac{1}{2\pi}\sqrt{\frac{R_4}{R_1R_2R_3C_1C_2}}$$

$$passband\ gain = \frac{R_Q}{R_o}$$

fairly high Q (very selective), and the center frequency of the filter can be varied using one variable resistor. The bandpass can also be varied, but two resistance values must be changed to keep the bandpass gain constant. The values shown give a 3-dB bandwidth of 100 Hz and 400 Hz, although other bandwidths can be produced by changing R_o and R_Q, which must remain equal to preserve unity gain. The design equations for the filter are given in **table 1**. Also, be aware that decreasing the bandwidth much beyond 100 Hz is likely to result in an oscillator instead of a filter because of the less-than-ideal nature of op-amps. The LF356 op-amp (which is a fairly wideband device) was used to minimize these effects. With a lesser op-amp, the filter will have a more peaked response at higher center frequencies and the bandwidth will not be constant as the center frequency is varied. As with all high-gain, wide-bandwidth devices, be sure to keep the power supply well bypassed (a 0.1-μF ceramic capacitor near each IC).

This particular configuration can be adapted to a notch filter by adding just one op-amp. This op-amp is configured as a summing amplifier which adds together the output of the bandpass filter and the input to the system. Since the bandpass-filter output is inverted (180-degrees phase shift) relative to the input, the net result is that the bandpass output is subtracted from the input. This results in a notch filter, since the signals in the passband of the bandpass filter cancel when the inverted and non-inverted signals combine.

The depth of this notch is limited by the matching of the gain-setting resistors in the summing amplifier and also in the bandpass filter. Therefore, the 10-kilohm variable resistor was included to allow some compensation for gain errors. The notch depth can be adjusted by tuning in a carrier or crystal calibrator on a receiver, adjusting the tune control to notch out the carrier, and then adjusting the 10-kilohm variable resistor for minimum audio signal. The minimum notch will probably not occur at the same setting for both bandwidths, but tuning with one bandwidth should result in an adequate notch on the other.

SSB filter

An audio filter for use with single sideband can be built using only two op-amps. One op-amp is configured as a highpass filter with cutoff frequency around 300 Hz, and the other is configured as a lowpass filter with a cutoff frequency of about 3 kHz. This results in a bandpass characteristic encompassing the standard audio frequency range for voice transmission.

The design equations are given so that other highpass and lowpass cutoff frequencies can be used. A Q of 1 was chosen so that the peaking in the passband is limited to about 10 percent. For simplicity, all capacitors are of equal value in the lowpass filter. The design equations for these filters are given in **table 2**. The op-amps in this case can be one like the LM307, since the gain-bandwidth demands of the circuit are not excessive.

These two filters can, of course, be used separately. The highpass would be useful for filtering out 60-Hz hum from an older tube-type rig, and the lowpass alone will help most any sideband rig in reducing the high-frequency adjacent-channel interference.

table 2. Equations for SSB filter.

Equations for highpass section.

$$\frac{V_{out}}{V_{in}} = \left(\frac{S^2}{S^2 + S\left(\frac{3}{R_2C}\right) + \frac{1}{R_1R_2C^2}}\right)$$

when $R2 = 10R_1$

and

$Q = 1$

$$f_{3dB} = \frac{0.77}{6\pi R_1C}$$

Equations for lowpass section.

$$\frac{V_{out}}{V_{in}} = -\frac{1}{R^2C_1C_2}\left(\frac{1}{S^2 + S\left(\frac{3}{RC_1}\right) + \frac{1}{R^2C_1C_2}}\right)$$

when $C_1 = 10C_2$

and

$Q = 1$

$$f_{3dB} = \frac{1.3}{6\pi RC_2}$$

driving headphones

All of these circuits can be used to drive headphones without an additional amplifier stage. **Fig. 4** shows a circuit to be used for connecting virtually any headphone to the output of an op-amp. The capacitor blocks the dc voltage that is present at the output of the op-amp, and the two resistors act as a voltage divider to reduce the level into the headphones. Most headphones are so sensitive that they need very little drive, so the signal is attenuated by these resistors.

driving speakers

Fig. 5 shows a simple audio amplifier which uses one-half an LM1877 stereo-amplifier IC. The output of any of the filter sections can be used to drive the input of this amplifier. This is one of many audio-amplifier ICs that are ideal for this sort of application. This circuit was taken directly from the manufacturer's data book[2] and care should be taken in adjusting any of the values since the device is not necessarily stable at unity gain. Care should also be taken in by-

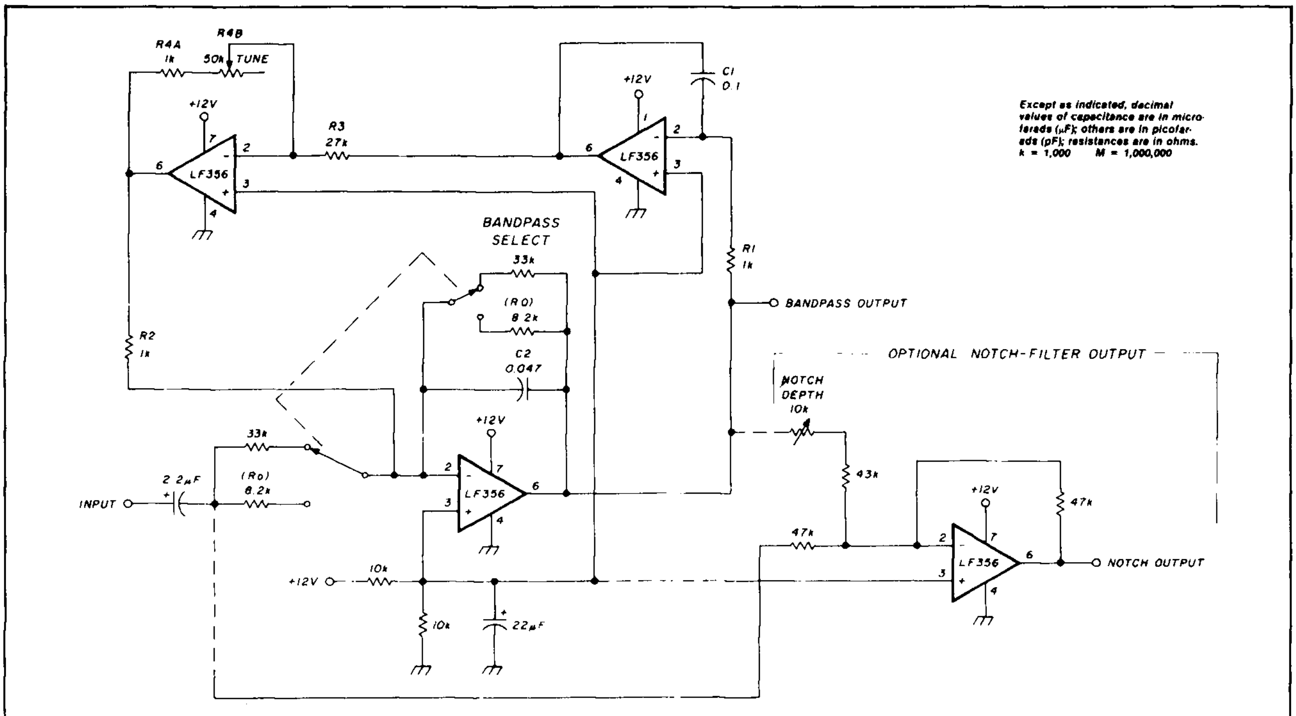

fig. 2. A variable-center-frequency and selectable-bandwidth filter is useful for CW reception.

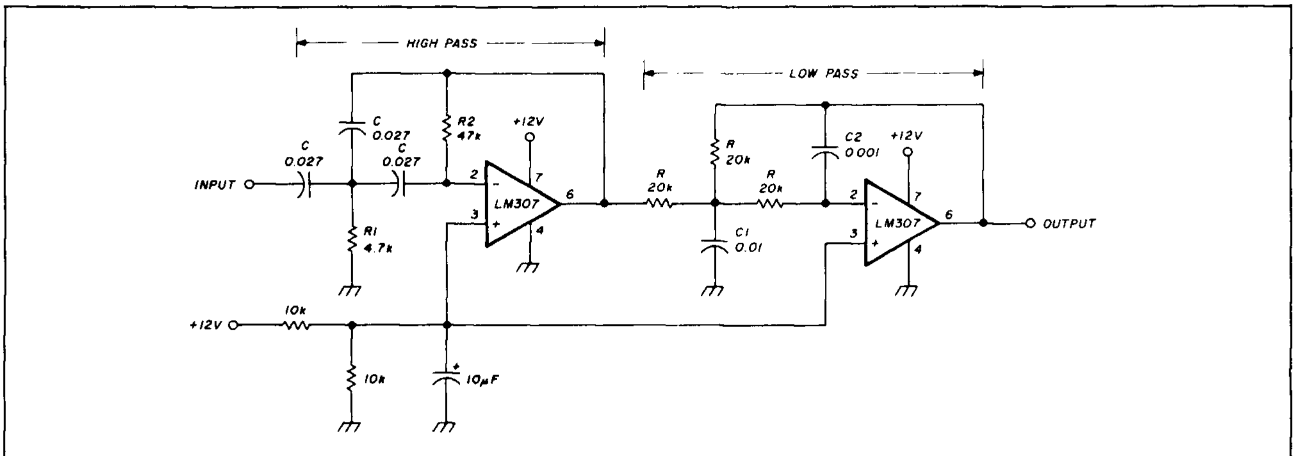

fig. 3. A combination 300-Hz highpass and 3-kHz lowpass filter for SSB use.

More Details? CHECK—OFF Page 92

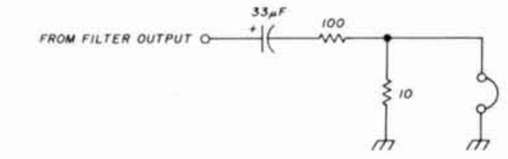

fig. 4. A circuit for coupling headphones to filter output.

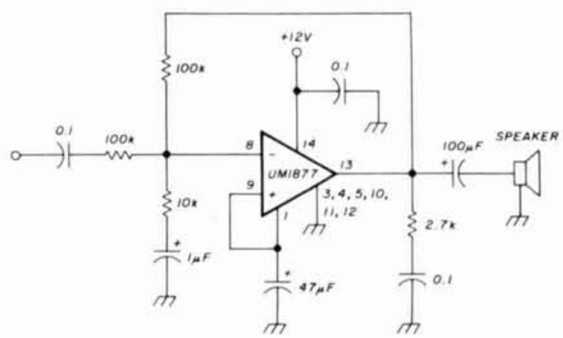

fig. 5. Unity-gain audio amplifier useful for driving a speaker from the filters.

passing the power supply near the chip, and all ground pins on the chip should be used.

summary

Now that you have the basic blocks, you can string them together to form a variety of filter combinations. A simple one-evening project can be made out of the bandpass filter, either with or without the notch output. I built the filter with simple perforated-board techniques and housed it in a small case. Add the SSB filter if you work phone and, of course, provide some means of switching the filters in and out. The audio amplifier is necessary only if headphones alone don't quite suit you. With unity-gain stages, the output should be the same level as the input, so if the audio is taken from a speaker or headphone jack the level can be easily adjusted with the receiver volume control to a usable level.

Please send me an SASE with any inquiries concerning this article. For more information on op-amps in general, see reference 3.

references

1. Aram Budak, "Passive and Active Network Analysis and Synthesis," Publisher Houghton-Mifflin, Boston, Massachusetts, 1974.
2. *Linear Databook*, National Semiconductor Corporation, Santa Clara, California, 1978.
3. Walter Jung, *IC Op-Amp Cookbook*, Howard W. Sams & Co., Indianapolis, Indiana, 1976.

ham radio

short circuits

power supply

In the article "Dual Voltage Power Supply" (*ham radio*, March, 1983) there is an error on the schematic on page 35. The two outputs of power supply A are tied together at the voltmeter connections. This should not be. Also, at the top of the same schematic, resistor R24 had been labeled R2H.

sideband transceiver

The following corrections should be made to the schematics and text of "15-meter Sideband Transceiver" (*ham radio,* March, 1983):

fig. 1: Change value of R26 from 100 to 10k ohms and value of R28 from 10k to 330 ohms.

fig. 6: Change component designations C66 to C60 and Q18 to Q24.

fig. 7: Add component values to R105 (100 ohms) and R106 (4700 ohms). R110 is a 2-watt resistor. Insert a resistor (R101, 330 ohms) in the collector lead of Q33.

fig. 8: Reroute emitter lead of Q25 to R88 and Q26 base junction. (It no longer goes directly to +10 volt bus.)

In the right-hand column on page 19, change component designations Q29 to Q20 and R66 to R67.

Be sure to check the artwork against the parts layout before beginning construction.

repeater antenna beam tilting

In K7NM's article, "Repeater Antenna Beam Tilting" (May, 1983), **eq. 2** should read as follows:

$$E_a = \frac{Sin\; n \left[(180^\circ s) \cos\theta + \dfrac{d}{2} \right]}{n\; Sin \left[(180^\circ s) \cos\theta + \dfrac{d}{2} \right]}$$

Eq. 4 should read this way:

$$A_h = \frac{0.0153P}{\sqrt{P}}$$

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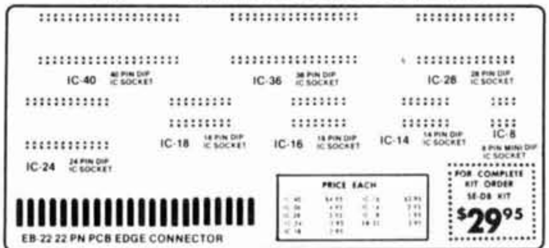

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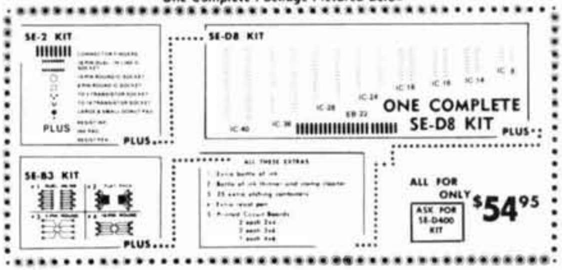

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DX FORECASTER

Garth Stonehocker, K0RYW

last-minute forecast

The conditions this July will probably be considerably different from last year's. The summer months — normally a season of low maximum usable frequencies (MUFs) will bring even lower MUFs because of an advanced cycle smoothed sunspot number (SSN) as low as 60. Mid-latitude, zero-distance MUFs (f_oF_2-local noon) show a nearly linear variation with SSN, with 5.5 MHz, 8 MHz, and 11 MHz corresponding to SSNs of 10, 60, and 120 respectively.

July's forecast on the higher hf bands (10-30 meters) is for good long-skip conditions occurring the first and last weeks of the month and decreasing at other times. High and low latitude short-skip openings are expected to increase through sporadic E propagation during disturbed periods around the 5th, 10th, 21st, and 31st of the month. The lower bands (30-160 meters) should have the best nighttime DX during the in-between non-disturbed periods.

A full moon occurs on the 25th and perigee on the 11th of the month. The Aquarid meteor shower starts the 18th, peaks the 28th, and lasts until August 7th (all dates approximate). The radio-echo rate at maximum is about 34 per hour.

fading — QSA and QSB

Carefully observing daily DX signal levels will provide information on the state of the ionosphere and enable near future forecasting. Signal strength variations, fading, either decrease (attenuation) or increase (focusing), and possibly signal distortion will be heard. Fading is characterized by the duration of the interval between fades and the depth or decrease in amplitude of the signal during those periods. Most of the attenuation occurs as the signal travels through the D region (60-80 kilometer height) of the ionosphere. However, significant variations also occur at the area of reflection in the ionosphere, with signal levels modulated by geomagnetic field variations.

The following table lists four common types of fading conditions with the first two related to D region travel and the latter two occurring during layer reflection:

type of "fade"	cause	when/where	duration
SID	flare-ultraviolet and X-rays	daylight	1-2 hours
PCA	flare-proton particles	polar daylight	1-3 days
shortwave	solar wind-electrons (explained next month)	auroral zone (night)	2-5 nights
MUF failure	decreasing ionosphere (explained next month)	PM	½ hour

Solar radiation (ultraviolet and X-ray) produces D region absorption or attenuation, an attenuation that varies with the part of the sunspot cycle we're in, the time of year, and time of day. Signal level changes are slow and stable, except during solar flare induced sudden ionospheric disturbances (SID). These signal fades occur within 8 minutes on the sunlit propagation paths. The attenuation is a function of the cosine of the zenith angle to the sun. The typical time scale is a 10 to 20 minute decrease to maximum attenuation (lowest signal) and logarithmic return to the normal value within about one-half hour to two hours. The overall time (SID duration) is roughly related to flare size (importance or type) and radio flux (0.3 centimeter) burst shape and length.

Polar cap absorption (PCA) is also a D region slowly-varying attenuation effect produced inside of the auroral zone (polar cap) by protons arriving within an hour's time from certain solar flares. The attenuation is greater during daylight than at night. Therefore, the signal recovers somewhat each night then decreases during the day again, but shows improvement each day. The overall PCA attenuation duration is one to three days before normal propagation conditions are achieved again.

Both of these D region events occur mainly during the sunspot cycle peak and consequently should not bother us for a while. The shortwave fade and MUF failure are problems that can occur any time during the solar cycle and particularly during the solar cycle minimum. More about them next month.

band-by-band forecast

Ten and fifteen meters will have long-skip conditions in the afternoon during the peak times of the *27-day* solar maximum. Otherwise, look to sporadic E short-skip and multihop openings around *local* noon for DX on these bands. Transequatorial evening openings do not usually occur in the summertime.

JULY

WESTERN USA

JULY	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	GMT
	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	PDT
ASIA FAR EAST	20	20	20	20	20	20	20	20	20	—	—	—	—	—	—	—	20	20	20	20	20	20	20	20	N
EUROPE	20	20	20	20	20	20	20	20	20	20	—	—	—	—	20	20	20	20	20	20	20	20	20	20	NE
S. AFRICA	20	20	20	20	20	20	20	20	20	20	20	—	—	30	20	20	20	20	30	40*	30	30	30	30	E
S. AMERICA	15	15*	15*	15	15	15	15	15	15	15	20	—	—	30	20	20	20	20	20	15	15	15	15	15	SE
ANTARCTICA	15	15	20*	20	20	20	30	—	—	—	—	—	30	30	30	20	20	20	20	20	20	20	20	20	S
NEW ZEALAND	10	15*	15*	15	15	20	20	20	20	20	20	20	20	15	15	15	15*	10	10	10	10	10	10	10	SW
OCEANIA AUSTRALIA	15*	15*	15	15	20	20	20	20	—	—	20	20	20	20	15	15	15	15	10	10	10	10	10	10	W
JAPAN	20	20	20	20	20	20	—	—	—	—	—	20	20	20	20	20	20	15	20	20	20*	15	15	15	NW

MID USA

	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	GMT
	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	MDT
ASIA FAR EAST	—	—	—	—	20	20	20	20	20	20	—	—	—	—	—	—	—	20	20	20	20	15	20*	20	N
EUROPE	20	20	20	20	20	20	20	20	20	20	—	—	—	20	20	20	20	20	20	20	20	20	20	20	NE
S. AFRICA	20	20	20	20	20	20	20	20	20	20	—	—	20	20	20	20	20	20	30	40*	30	30	30	30	E
S. AMERICA	15	15	10	10	10	15	15	15	15	15	—	20	20	20	20	20	20	20	20	15	15	15	15	15	SE
ANTARCTICA	20	20	20	20	20	20	20	—	—	—	—	—	—	30	30	30	30	30	30	30	30	30	20	20	S
NEW ZEALAND	15	15	15	15	15	20	20	20	20	20	—	—	20	20	20	20	15	15	15	15	15	15*	15*	15*	SW
OCEANIA AUSTRALIA	15	15	15	15	20	20	20	20	20	—	—	—	20	20	20	20	20	15	15	15	15	15*	15*	15	W
JAPAN	20	20	20	20	20	—	—	—	—	—	—	—	—	20	20	20	20	20	20	20	20	20	20*	15	NW
	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	CDT

EASTERN USA

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

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

Twenty and thirty meters will be open all day and much of the night. If twenty does not stay open through the night, thirty probably will. Sporadic E short-skip is also often effective on these bands throughout the day. Propagation paths to most areas of the world are viable in a sequence that follows the sun's journey across the sky: east in the morning, south during mid-day, and west during the evening.

Thirty and forty meters will be the main nighttime DX bands this time of year, though long-skip distances will be shorter. Sporadic E openings are possible during more of the day into pre-sunrise and after sunset. With thunderstorm-induced static levels high in the evening, look to pre-dawn periods for best results.

Eighty and one-sixty meters are difficult DX bands this time of year. Short nights and high noise levels hamper DX operation with eighty having slightly lower noise levels. Most useful openings may occur during the pre-dawn hours. Sporadic E propagation signal strengths may exceed the static level near sunrise and sunset.

technical forum

Welcome to the ham radio *Technical Forum. The purpose of this feature is to help you, the reader, find answers to your questions, and to give you a chance to answer the questions of your fellow Radio Amateurs. Do you have a question? Send it in!*

Each month our editors will select the best answer received to a question previously posed in Technical Forum. We'll send the writer a book from our Bookstore as a way of saying thanks.

measuring inductances

In February, 1983, Technical Forum published a request from K9EBA for information on the measurement of low values of inductance.

Several years ago the San Bernardino Microwave Society addressed this problem and came up with a simple circuit for measuring small values of inductance. It was published as a NASA Tech Brief. This circuit used the parts on hand at the time. The circuit works well and has been duplicated by several experimenters. It measures inductances between 30 nH and 30 μH. This is not the only way the circuit can be implemented, nor even the best way, but it is one method that works.

The only trick in building the circuit is to minimize the stray shunt capacity across the unknown inductance. I used a 1-inch hole, with a 4-40 (M3) screw in the center and a thin sheet of plastic to support it. Fiber shoulder washers for the unknown terminal have too much stray capacity, but other than this, the circuit is straightforward and should pose no problems. — **Richard B. Kolbly, K6HIJ.**

Ed. note: An SASE to *ham radio* will bring the interested reader a copy of the NASA Tech Brief and associated technical support package describing the direct-reading inductance meter.

impedance matching

I wound an rf impedance matching transformer on an iron powder toroid core (T225-2 mix) for a 50-ohm to 300-ohm transformation. I used a turns ratio of just under 2.5 to 1; that is, I wound seventy-three turns of No. 20 Formvar enamel wire next to the toroid core (300-ohm winding) and thirty turns of No. 16 Teflon-covered wire on top of it (50-ohm winding). There is more than one inch of empty core space between the ends of the high-impedance winding. The thirty turns of the low-impedance winding are centered over the middle of the seventy-three-turn winding. It is wound in the same direction and covers about half of the circumference of the toroid.

I tried to feed a few watts of rf power into a 300-ohm carbon resistor attached to the 300-ohm winding as a test on 29 MHz. It failed completely. It would not load up and had an SWR of over 10:1. I then checked the impedance of the low-impedance winding with an rf noise bridge (with the 300-ohm resistor still connected to the seventy-three-turn winding). I found that the impedance was indeed between 50 and 60 ohms resistive, but it had a very high capacitive reactive component of 60 to 70 pF.

Does anyone have any explanation of this result? — **Joseph Neiman, WB2NTQ.**

static mystery

Over the past thirty-seven years of shortwave listening I have observed a steady increase of that hammering and hissing noise called "rain static." I do not remember a single incident of this phenomenon while operating in Switzerland from 1946 to 1948.

The first time I encountered it was in late 1948 in the vicinity of Cleveland, Ohio. At the time I guessed that the Cleveland weather conditions might be somehow different from Swiss weather conditions.

Through 1949 and 1950 I got used to rain static in New Jersey. When I returned to Switzerland I found things quiet again no matter how heavy the rain. But by about 1955 I began to notice subtle signs of Swiss rain static which appeared, through the years, more frequently and more intensively.

At present about forty percent of all medium-strength rainfalls here cause rain static, and the amount seems to be increasing.

It is known that split water droplets can become charged, probably by a kind of tribo-electric effect. If such droplets hit antenna elements, charge compensation by the antenna could account for the observed receiver noise. So the question remains, why was the effect not observed in Switzerland before 1955, but already encountered in Ohio by 1948 and in New Jersey shortly thereafter?

Could there be some connection with air pollution caused by industry and automobile traffic, thus enhancing charge separation of water droplets?

Not knowing enough about electrostatics and electrochemistry, let me present this problem to you and your readers in the hope that someone might provide a physical model or references to published work.

Are there any effective countermeasures which could eliminate this kind of interference? — **Bruno Binggeli, HB9FU.**

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NEW products

power triode

The EIMAC Division of Varian has announced the availability of a new ceramic/metal power triode intended for use as a cathode-driven amplifier for hf and vhf service. This compact tube (3CX800A7) is intended for high power linear amplifier service. A single tube will produce a full 2 kW PEP or 1 kW CW input power.

The rugged 3CX800A7 is rated for 800 watts plate dissipation and will deliver full power output with less than 40 watts peak drive power. Power gain is better than 15 dB. The air-cooled anode requires less than 20 cfm with a backpressure rating of 0.35 cfm for full dissipation at sea level.

Height of the 3CX800A7 above the socket plane is only 2-1/4 inches (5.7 cm), making the tube well suited for compact linear amplifier design and compatible with modern, low-profile styling.

For further details, contact Varian, EIMAC Division, 301 Industrial Way, San Carlos, California 94070. RS#301

Editor's Note: Both Henry Radio and Ehrhorn Technological Operations (ETO) have designed new amplifiers around this new tube. Contact them for details.

polarization control

TEM Microwave Corporation is pleased to announce its model SC-10 polarization control interface. The SC-10 is designed to interface with satellite TVRO receivers that have odd/even channel logic output signals, such as the R.L. Drake ESR-24, or SPDT contacts, such as the Automation Techniques GLR-500 series. The SC-10 produces the correct power and drive signals to control the popular servo motor type feed systems, such as the Chaparall Polarotor 1™ or the Boman EFH-75. Other features of the SC-10 include independent front panel horizontal and vertical fine adjustment control and LED indicators that show which control is enabled, a mode switch for choice of either Satcom or Westar-type polarization, and a built-in regulated power supply.

The size is 4 × 5 × 2 inches (10.16 × 12.7 × 5.08 cm). Power is UL listed plug-in wall transformer. For more information, contact TEM Microwave Corporation, 22518 - 97th Avenue North, Corcoran, Minnesota 55374. RS#302

1/4-wave replacement antennas

Centurion International, Inc., has introduced a new line of 1/4-wave, flexible, miniaturized replacement antennas for VHF frequencies. The new "style-S" antennas measure approximately 3 inches in length by 3/8-inch in diameter. These antennas are smaller in diameter than other 1/4-wave miniaturized antennas and are more flexible. Their reduced size makes them a good choice for use with smaller portable two-way radios and speaker microphones.

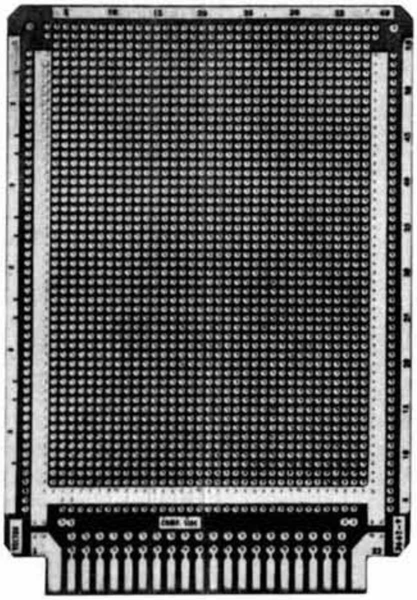
Designated the "Skinny Mini," the antennas are encapsulated in high-gloss PVC and remain flexible from −55C to 100C. Style-S antennas, like style-M, are available with any of more than twenty different base connector configurations, to fit virtually any radio made.

For more information, contact Centurion International, Box 82846, Lincoln, Nebraska 68501. RS#303

plug-in circuit boards

Three new plug-in circuit boards from Vector Electronic Company incorporate individual solder pads and drilled, plated-through holes. The design allows complete freedom in component location and spacing while providing quick and easy solder mounting of components with solderable or wrap-post leads. The boards have 2064 holes in the component area, allowing placement of up to fifty fourteen-pin DIPS or forty sixteen-pin DIPS. One card, the Model 4610-3, is form and fit compatible with STD system cards with 28/56 card-edge contacts. The Model 3662-9 and Model 3619-6 have 22/44 and 36/72 card-edge contacts to mate with the most frequently used connectors.

All boards are 4.5 inches wide by 6.5 inches long by 0.062-inch thick (11.43 × 16.51 × 0.16 cm) and have 0.042-inch (0.107-cm) diameter plated-through holes on 0.1-inch (0.25-cm) centers.



Fabricated of FR-4 (G10) epoxy glass laminate, the pads are 2-ounce copper cladding with bright tin plating for easy soldering. Card-edge connectors are nickel plated and gold flashed to ensure long life and low resistance. Zoned-wiring locations, etched into the cladding, permit easy component identification.

In single quantities, the 22/44-contact Model 3662-9 is priced at $26.80 each; the 28/56 contact Model 4610-3 is $26.50 each; and, the 36/72 contact Model 3619-6 is $26.80 each. For more information, contact Vector Electronic Co., Inc., 12460 Gladstone Avenue, Sylmar, California 91342. RS#304

Say You Saw It In HAM RADIO

NEW products

ten-meter fm transverter

A unique 2-meter to 10-meter linear translator recently introduced by Heil, Ltd., allows a 2-meter radio to receive and transmit on the ten-meter band from 28.00 to 29.70.

The Model 210 is primarily designed for use in the 29.30 to 29.70 fm band using a one-watt "handie talkie" or mobile transceiver for excitation, but is also usable on SSB, CW, a-m, and RTTY by exciting with an all-mode two-meter rig. The Model 210 has three SO-239 connectors on the rear panel, a two-meter one-watt input, a two-meter antenna, and a ten-meter antenna. With the front panel function switch in the "out" position, the two-meter antenna is connected to the two-meter transceiver or "handie talkie." Switching to the "in" position will cause the transverter to operate and produce a signal in the ten-meter band. The receiver sensitivity is 0.3 μV for 10 dB quieting. The output power is approximately 4 watts out at 29.60.

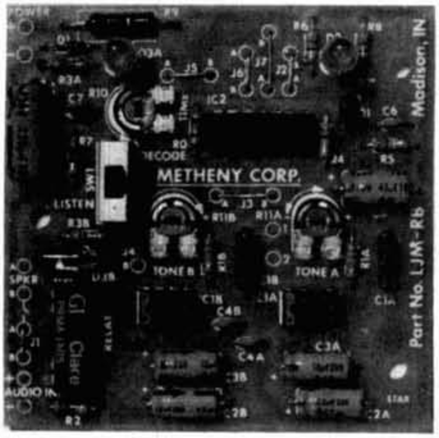
The price (subject to change) is \$100.00. For further details, write Heil Sound System, Heil Industrial Blvd., Marissa, Illinois 62257. RS#305

emergency tone decoder

The Storm Alert LJM2RK time-dual tone emergency decoder kit from Metheny converts receivers into special-purpose receivers or controls. When a user-selected time-tone combination is received, the output provides a relay control for activating speakers or other devices.

Special features include single or dual tones adjustable over the touch tone range; adjustable time delay; relay output; manual or auto reset; single tone ON latching with different single tone reset OFF; and interfacing of multiple boards for multi-digit sequential activation and reset.

Kit LJM2RK includes a printed circuit board with components, relay, and a silk screened component identification and solder mask for ease of assembly. An optional enclosure kit, LJM2RC, includes a custom-molded case, speaker, audio input cable, and hardware for



the decoder kit. Kit LJM2RK costs \$15.00; the enclosure kit, LJM2RC, is priced at \$5.00.

For complete details and information about specific applications, contact The Metheny Corporation, 204 Sunrise Drive, Madison, Indiana 47250. RS#306

multimode transceiver

The FT-726R — the world's first Amateur HF/VHF/UHF transceiver capable of full duplex operation for satellite work — is now available from Yaesu Electronics Corporation.

The basic unit comes equipped for 2-meter operation on SSB, CW, and fm. Optional units may be plugged in, enabling operation on 10 or 6 meters, 430 to 440 or 440 to 450 MHz on 70 cm. The optional SU-726 satellite unit allows crossband full duplex operation, for simultaneous uplink transmit and downlink receive operation on Amateur satellites.

Controlled by an eight-bit microprocessor, the FT-726R features a dual VFO and memory frequency management system, with independent frequency/mode storage on each VFO or memory; mode-inverting satellite transponders are therefore covered with ease. The transmit and receive frequencies may be varied during satellite work to allow easy zero-beat capability while following Doppler shift.

Equipped with many features found only on

hf transceivers, the FT-726R includes an SSB speech processor, i-f shift, variable i-f bandwidth tuning, i-f noise blanker, RIT, multimode squelch, and a receiver audio tone control. A CW filter, DTMF encoding microphone (YM-48), desk microphone (MD-1B8), external speaker (SP-102), and CTCSS units are all available as options.

For further information, contact Yaesu Electronics, P.O. Box 49, Paramount, California 90723. RS#307

handheld airband transceiver

The TR-720 is a solid-state, fully synthesized, portable airband transceiver covering the 720 COM channels between 118 and 136 MHz and 200 NAV channels from 108 to 118 MHz. It measures only 6.6 × 2.6 × 1.5 inches and weighs just 19 ounces. It employs microprocessor technology, has a twist-off battery pack, comes with a complete set of accessories, is FCC type accepted, and carries a full one year warranty. It is available for \$795.00 from local Avionics dealers, or directly from the manufacturer.

For information, contact Communications Specialists, Inc., 426 W. Taft Ave., Orange, California 91665. RS#308

power bars

A new line of Hammond power bars features an attractive, contemporary, brushed-aluminum case with matte black receptacle housing. Reduced in size, (11, 14 and 17 inches in length), standard models are available in four, six, or eight-receptacle sizes with either 6 or 15 foot cords, and with or without lighted, rocker type on/off switches. Also available are 4 and 6 foot long power bars, each with eight receptacles. Appropriate for work station mounting, all power bars are CSA approved and fitted with 120 Vac, 15A circuit breaker.

For more information, contact Hammond Manufacturing Company, Inc., 1690 Walden Avenue, Buffalo, New York 14225. RS#309

uhf linear amplifier

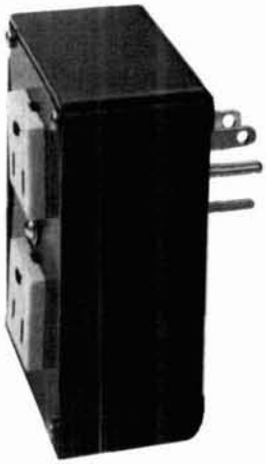
The newest uhf linear amplifier from Tokyo-Hy Power Labs is designed for use with 10-watt output 430-450 MHz crystal-controlled or synthesized rigs. Input for the HL-45U is 2 to 15 watts with output of 10 to 45 watts. It operates from a 13.8 volt dc source and draws 7 amps at 45 watts output. It is all-mode (SSB, CW, and fm), has a built-in 12 dB low noise receiver preamplifier, and employs carrier operated switching (COX).

The HL-45U measures 4.9 × 2.7 × 6.7 inches (124 × 68 × 170 mm) and weighs 2.76 pounds (1.25 kg). The suggested retail price of the HL-45U is $199.95.

For further information contact THL Sales Department, Encomm, Inc., 2000 Ave. G, Suite 800, Plano, Texas 75074. RS#310

wall socket RFI control

Electronic Specialists' new Direct Plug Super Filter and Suppressor features a dual-pi filter to control electrical interference. A 6500-ampere spike/surge suppressor protects equipment from damage caused by lightning or heavy machinery spikes.



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- All tones in Group A and Group B are included.
- Output level flat to within 1.5db over entire range selected.
- Separate level adjust pots and output connections for each tone Group.
- Immune to RF
- Powered by 6-30vdc, unregulated at 8 ma.
- Low impedance, low distortion, adjustable sinewave output, 5v peak-to-peak
- Instant start-up.
- Off position for no tone output.
- Reverse polarity protection built-in.

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77.0 XB	100.0 1Z	131.8 3B	173.8 6A
79.7 SP	103.5 1A	136.5 4Z	179.9 6B
82.5 YZ	107.2 1B	141.3 4A	186.2 7Z
85.4 YA	110.9 2Z	146.2 4B	192.8 7A
88.5 YB	114.8 2A	151.4 5Z	203.5 M1

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FM "Dual-Bander."

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2 m & 70 cm in single compact package, LCD, 25 W, optional voice synthesizer.

TW-4000A

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 a single compact package.

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- **2 m and 70 cm FM in a Compact Package** Covers the 2 m band (142.000-148.995 MHz), including certain MARS and CAP frequencies, plus the 70 cm FM band (440.000-449.995 MHz), all in a single compact package. Only 6-3/8 (161)W x 2-3/8 (60)H x 8-9/16 (217)D inches (mm), and 4.4 lbs. (2.0 kg.).
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- **25 Watts RF Power on 2 m/70 cm.** Hi/Lo power switch.
- **Optional "Voice Synthesizer Unit"** Installs inside the TW-4000A. Voice announces frequency, band, VFO A or B, repeater offset, and memory channel number.
- **Front Panel Illumination**
- **10 Memories with Offset Recall and Lithium Battery Backup** Stores frequency, band, and repeater offset. Memory 0 stores receive and transmit frequencies independently for odd repeater offsets, or cross-band operation.
- **Programmable Memory Scan** Programmable to scan all memories, or only 2 m or 70 cm memories. Also may be programmed to skip channels.
- **Band Scan in Selected 1-MHz Segments** Scans within the chosen 1-MHz segment (ie., 144.000-144.995 or 440.000-440.995, etc.). The scanning direction may be reversed by pressing either the "UP" or "DOWN" buttons on the microphone.
- **Priority Watch Function** Unit switches to memory 1 for 1 second each 10 seconds, to monitor the activity on the priority channel.
- **Common Channel Scan** Memory 8 and 9 are alternately scanned every 5 seconds. Either channel may be recalled instantly.
- **Dual Digital VFO's** Selectable 5-kHz or 10-kHz for 2 m, and 5-kHz or 25-kHz for 70 cm. Depress "UP" or "DOWN" key on the front panel for band change in 1-MHz steps.
- **16-Key Autopatch UP/DOWN Microphone (Supplied)**
- **Repeater Reverse Switch**
- **High Performance Receiver/Transmitter** GaAs FET RF amplifiers on both 2 m and 70 cm, high performance MCF's in the 1st IF section, provide high receive sensitivity and excellent dynamic range. The high reliability RF power modules assure clean and dependable transmissions on either band.
- **Rugged Die-cast Chassis**
- **Optional Two-Frequency CTCSS Encoder** Easily mounted inside the radio, allows DIP switch programming of two different tone frequencies, for 2 m and 70 cm.
- **"BEEPER" sounds through speaker.**
- **Easy-to-Install mobile mount**

TW-4000A accessories:

- **VS-1 Voice Synthesizer**
- **TU-4C Two-Frequency Programmable CTCSS Encoder**
- **KPS-7A Fixed station power supply**
- **SP-40 Compact mobile speaker**

More information on the TW-4000A and TS-780 is available from all authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.

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TS-780

2 m & 70 cm all mode, dual digital VFO's, 10 memories, scan, IF shift...

TS-780 FEATURES:

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- 10 memories include band and frequency data, backed up by internal batteries (not supplied). Battery life exceeds one year. Memories 9 and 10 for priority instant recall.
- Band scan, with selectable 0.5, 1, 3, 5, and 10-MHz scan bandwidth.
- Memory scan selectable for all memories, or 2 m or 70 cm only.
- IF shift circuit rejects adjacent interference.
- High sensitivity and wide dynamic range • 7-digit fluorescent tube digital display • 10 watt RF output • 2 m ±600-kHz TX offset switch with reverse switch • Tone switch for optional TU-4C two frequency tone encoder unit • VOX and semi break-in CW built-in • FM center-tune meter • Noise blanker for SSB, CW.

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