ICOM IC-900
Six Bands in One Mobile!

ICOM IC-900 FIBER OPTIC FM MOBILE

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

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

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

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

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<td>10W/1W</td>
<td>28-30MHz</td>
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<td>UX-29A</td>
<td>25W/5W</td>
<td>138-174MHz Rx; 140-150MHz Tx</td>
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<td>UX-29H</td>
<td>45W/5W</td>
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Interface Unit A is installed in a location near the driver's seat.

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

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KAM gives you CW, RTTY, ASCII, AMTOR, HF and VHF PACKET all together in one unit.

We combined the features of our UTU-XT and KPC-2 to give you the true all mode unit you’ve been asking for, the Kantronics All Mode (KAM™).

KAM features bargraph tuning and user programmable MARK and SPACE tones for RTTY and HF packet, as well as limiter/limiterless operation on HF for weak signal operation.

KAM’s CW demodulator is also programmable for both center frequency and bandwidth.

KAM’s RS-232/TTL terminal interfacing provides universal compatibility to all computers, including Commodores and PC compatibles.

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Suggested Retail $319.00

KAM’s FEATURES

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- HF and VHF radio ports.
- Command driven by your computer with over 100 software commands.
- User programmable baud rates for RTTY/ASCII—selectable in one-baud increments.
- User programmable MARK and SPACE tones on HF, you choose the tones.
- Selective RTTY Autostart operation.
- Separate CW demodulator filter with programmable center frequency and bandwidth.
- Separate CW keying relay for positive or negative keying.
- 12-pole programmable switched capacitance input filtering.
- Quartz synthesized AFSK or direct FSK operation.
- RS-232 or TTL level operation by jumper selection.
- 32K RAM, 256K EPROM, EEPROM for parameter storage.
- Compatible with any computer having an asynchronous serial I/O port.
- FCC Part 15 compliant.

EXTRA SPECIAL FEATURES

★ Simultaneous HF and VHF Packet connects & digipeating.
★ HF/VHF Gateway operation.
HF to Microwaves!

TS-670
40, 15, 10, and 6-meter all mode
“Quad Bander”
- Keyboard selection of frequency, as well as “traditional” VFO
- 80 memory channels store frequency, band, mode data
- All-mode squelch, noise blanker, RF attenuator
- Optional general coverage unit, voice synthesizer, FM unit, IF filters
- QRP 10 W operation

TR-50
1.2 GHz FM transceiver
The perfect portable for microwave mountain-topping!
- 1 watt output
- LCD frequency readout with S & RF power meter
- 5 memory channels
- Odd split on memory channel 5
- Includes: Battery set, charger, external power cable, 16-key DTMF hand microphone, sleeve antenna with adjustable mount, shoulder strap.

TM-221A/321A/421A
The compact FM mobile transceivers
- TM-221A: 2 m, 45 W, with expanded receiver coverage (138-174 MHz).
- TM-321A: 220 MHz, 25 W.
- TM-421A: 70 cm, 35 W. The first compact 35 watt 70 cm transceiver!
- Built-in front panel-selectable CTCSS encoder. Decode optional.
- Famous high performance Kenwood GaAs FET front end.
- 14 full function memory channels, 2 channels for odd split operation.
- 16-key DTMF mic., mic. hook, mounting bracket, and DC cable included.
- Remote control telephone-style handset option (model RC-10).

A complete line of accessories is available for these transceivers.
Specifications and prices subject to change without notice or obligation.
Complete service manuals are available for all Kenwood transceivers and most accessories.
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REFLECTIONS

13 cm: onwards and upwards

Some view the spectrum above 1 GHz as a vast, sterile desert devoid of life, difficult to get to, and of questionable worth once attained. But, just as in the desert (which, of course, teems with life), what you see isn't necessarily what you get.

To the uninitiated, fear of the unexplored prompts questions such as “What the heck’s it good for?”, “Who can I talk to?”, and “How do I get there in the first place?” These aren’t bad questions, but they’ve all been asked before — about 5 meters, 2 meters, 70 cm, and most recently, 23 cm. Yet saturation of 2 meters is a fait accompli in many areas; 70 cm isn’t far behind, and 23 cm is being staked out by many repeater operators looking for turf.

One senses repetition of a familiar pattern. Any “new” band is first occupied by the desert rats who build their own transmit and receive converters, antennas, and preamps. A few of them begin selling their special boxes to friends; soon, the more entrepreneurial types among them begin marketing the product on a limited scale. Later, when the commercial possibilities are obvious, the large, established manufacturers jump in. With their sizeable R&D and engineering resources, they quickly develop commercially attractive boxes, with legible control labels replacing the chicken scratches on bare aluminum typical of the earlier models.

To potential users of the new band, operation now becomes much more feasible. No new skills need be acquired. Often, simply knowing how to use a credit card is sufficient: just unpack the box, hook up the unit, and you’re there.

By my reckoning, critical momentum for 2 meters was achieved in 1971 or 1972; for 70 cm, in 1978 or 1979; and for 23 cm, in 1984 or 1985. By the same measure, I figure “critical mass” for 13 cm (2.4 GHz) will occur sometime about 1989 or 1990. All indicators suggest that a big push into this band is imminent. Entrepreneurs now offer 13-cm transverters, loop yagis, and preamps. Moreover, military and commercial applications of S-band systems, equipment, modules, and components have fueled development of low-cost microwave devices (including integrated circuits) to the point where getting on 13 cm is much less expensive than it was just a few years ago. Obviously, since cost is a predominant design driver in the Amateur market, this development is of paramount interest to would-be manufacturers of 13-cm Amateur equipment.

The demands for spectrum and services in the lower Amateur bands (70 cm and below) exert continuous pressure to move to less congested territory. Digital communications, particularly packet radio networking and digitized voice and video, are notable forces propelling users up to 23 cm and soon, on to 13 cm.

In the context of 13 cm, the answer to the familiar question, “Who can I talk to up there?”, may differ from the answers that were appropriate when the question was raised in regard to 70 cm and 2 meters. This is because important breakthroughs are now occurring in the development of Amateur satellites (OSCARs) — in the frequencies to be used, the modes to be employed, and the platforms (i.e., satellites) used to carry equipment into space. More significantly, however, these breakthroughs may finally allow more Amateurs than ever before to participate in satellite communications.

The first steps will be modest. In 1988, AMSAT will launch Phase 3C, with four transponders aboard; one of these will be a small 70-cm uplink, 13-cm downlink fm repeater. This easily acquired downlink may carry fm voice bulletins suitable for linking through gateway repeaters.

Just a few years from now, in 1991, AMSAT’s Phase 4 geosynchronous satellite will provide several classes of service at 13 cm, including voice and data as well as gateway linking, so that hams in one city will be able to interconnect through a local gateway with gateways and HTs in another. So the question, “Who can I talk to on 13 cm?” will soon be answered by “Who would you like to talk to?”

Progress in these areas will bring new problems, however. As advances in technology drive down the cost of Amateur UHF and SHF equipment, commercial interests will find those portions of the spectrum increasingly appealing. Even now, they’re eyeing the seemingly infertile UHF territory for suitable enclaves. The Amateur allocation at 13 cm is looking more attractive than ever, and has quickly become interesting real estate to those who would sell services based on occupancy of S-band spectrum.

This means that Amateurs can’t afford to delay making productive use of the 13-cm band. In short, we need to get busy and make that 13-cm desert bloom — with useful public service and emergency communications services, packet radio networks, and educationally significant communications as well as our traditional goodwill-building communications. Let’s keep our hold on that band by planning for meaningful occupancy and by supporting those concrete efforts towards widespread utilization of 13 cm — such as Phase 3C and Phase 4 — already underway.

Vern “Rip” Ripportella, WA2LQQ
President, AMSAT
Compact high performance HF transceiver
with general coverage receiver

Kenwood's advanced digital know-how brings Amateurs world-wide "big-rig" performance in a compact package. We call it "Digital DX-citement!" - that special feeling you get every time you turn the power on!

- Covers all Amateur bands
- General coverage receiver tunes from 100 kHz - 30 MHz.
- Direct keyboard entry of frequency
- All modes built-in USB, LSB, CW, AM, FM, and AFSK. Mode selection is verified in Morse Code.
- Built-in automatic antenna tuner (optional) Covers 80 - 10 meters.
- VS-1 voice synthesizer (optional)

Superior receiver dynamic range
Kenwood DynaMix™ high sensitivity direct mixing system ensures true 102 dB receiver dynamic range. (500-Hz bandwidth on 20 m)

- 100% duty cycle transmitter
- Super efficient cooling permits continuous key-down for periods exceeding one hour.
- RF input power is rated at 200 W PEP on SSB, 200 W DC on CW, AFSK, FM, and 110 W DC AM. (The PS-50 power supply is needed for continuous duty.)

- Adjustable dial torque
- 100 memory channels
- Frequency and mode may be stored in 10 groups of 10 channels each. Split frequencies may be stored in 10 channels for repeater operation.
- TU-8 CTCSS unit (optional)
- Subtone is memorized when TU-8 is installed.
- Superb interference reduction: IF shift, tuneable notch filter, noise blanker, all-mode squelch, RF attenuator, RIT/XIT, and optional filters light GRM.
- MC-43S UP/DOWN mic. included
- Computer interface port
- 5 IF filter functions
- Dual SSB IF filtering: A built-in SSB filter is standard. When an optional SSB filter (YK-88S or YK-88SN) is installed, dual filtering is provided.
- VOX, full or semi break-in CW
- AMTOR compatible

Optional accessories:
- AT-440 internal auto. antenna tuner (80 m - 10 m)
- AT-250 external auto. tuner (160 m - 10 m)
- AT-130 compact mobile antenna tuner (160 m - 10 m)
- IF-232CIF-10 level translator and modem
- IC kit + PS-50 heavy duty power supply + PS-430/PS-30 DC power supply + SP-430 external speaker + MB-430 mobile mounting bracket

Kenwood takes you from HF to OSCAR!
DARC awards

Dear HR:

Many DXers in the United States and Canada either do not know that there is such a thing as a “Worked All Europe” (WAE) or other DARC awards, or are afraid to send their cards to Europe because of the cost and the possibility of loss.

I am now the United States/Canadian checkpoint for all DARC awards. All information, including a list of cards to Europe because of the cost and the possibility of loss.

Nature's pecking order puts the eagle at the top of the birds' list of daytime predators. Being nocturnal, owls prey mostly on rodents; perhaps that's why few smaller birds have learned to fear them?

I hope this idea helps.

John D. Seney, KB1HE
Manchester, New Hampshire 03013

for the birds

Dear HR:

I was intrigued with Bernard Kirschner's request for ideas on how to discourage live owls from attacking a plastic owl installed as a bird-deterring antenna ornament (Comments, May, 1987, page 6).

As a salesman, I call regularly on a company that had a similar problem. A small park in the company's front yard was beautiful until the birds came, complete with droppings. Walking through the park turned into an inspiration to take up jogging — make that sprinting.

Fortunately, this is a high technology company full of bright scientists and engineers ready to tackle any problem. First they tried a plastic owl, deployed in a variety of locations in the park with little noticeable effect. Then they tried directing ultrasonic pulses at the park — no effect. Finally, they hung a life-sized plastic eagle from the middle of a drooping wire (you might try nylon rope in order to avoid interfering with antenna patterns) suspended about 20 feet above the park. As the eagle moves up and down in the wind, it spreads its wings, discouraging smaller birds.

short circuit

compact 20-meter travelradio

In K1BQT's article, "Compact 20-meter CW Travelradio" (June, 1987, page 8), part numbers were omitted for the following:

- CW filter 1C 1458 dual op amp
- Q8 2N3906
- Q9 MPS2222
- Q10 BS-170
- Q11 MRF479

With the exception of MRF479, all of the above parts are available from Radio Shack; the MRF479 is available from RF Parts, 1320 Grand Avenue, San Marcos, California 92069.

Figure 7B (main board layout, page 19) should have indicated the positioning of the ICs; the key on U4 goes toward the 10 μF electrolytic, and the key on U2 goes toward T2 (IF can). In fig. 10B (CW audio filter), the key on the 1458 op amp goes away from the 10 μF electrolytic.

The 914 diode shown located next to the 20-k trim pot (S-meter zero control) in fig. 7B should be designated as a 9.0-volt, 400-milliwatt zener diode (Z1 in parts list).

Mary Duffield, WA6KFA
Santa Cruz, California 95062
New compact size! Only 5.9" W x 1.97" H x 7.87" D and weighs less than 4 pounds!
- Proven high performance Kenwood GaAs FET front end receiver.
- Easy to operate! Only 3 knobs and 8 keys on the front panel.
- Separate antenna ports for VHF and UHF. Minimizes loss and increases reliability and performance!
- 10 memory channels. Lithium battery backs up memory. Store frequency, offset, subtone. Two channels store the transmit and receive frequencies independently for odd split or cross band operation.
- Front panel-selectable CTCSS tone (when optional TU-7 is installed.)

• Non-volatile operating system. Even after memory back up cell dies, all operating features remain intact! No re-programming or "board-swapping" necessary!
• Programmable band scan and memory scan with memory channel lock-out.
• Large, illuminated LCD display and main knob. For excellent visibility in direct sunlight or darkness.
• Selectable frequency step for quick and easy QSY.
• Voice synthesizer VS-2 option.

Optional accessories:
- PS-50/PS-430 DC power supplies
- MU-1 DCL modem unit + TU-7 CTCSS encoder + VS-2 Voice synthesizer + SW-100B SWR/PWR/Volt meter 140-450 MHz for mobile use + SW-200B SWR/PWR meter for base station use 140-450 MHz. 0-200 W in 2 ranges + SWT-1/SWT-2 2 m and 70 cm antenna tuner + SP-50B Compact speaker
- MB-11 Extra mobile mount

*Please check FCC regulations on repeater operation.
**Mag mount is not Kenwood supplied.
Minor modification necessary for repeater operation.
Specifications and prices subject to change without notice or obligation.
Complete service manuals are available for all Kenwood transceivers and most accessories.
This article describes two long Yagis for 432 MHz. Both offer excellent gain, given their boomlengths, and exceptionally clean pattern. Details of the development and construction of these Yagis, which were designed to be easily built from a commercial antenna, are given. In addition, dimensions are presented for two higher gain Yagis which offer even better theoretical performance, but have not yet been checked by the construction of test antennas.

Few 432 MHz designs

Three years ago I was searching for a good Yagi design to use in a new 432-MHz array. The selection of commercially available antennas for 432 MHz has always been very limited because the number of stations active on 432 MHz is small enough to make the design and production of commercial antennas for this frequency a proposition of limited, if any, profitability. Consequently, manufacturers have been slow to incorporate the latest developments in Yagi design. Fortunately, Günter Hoch, DL6WU, had developed a director spacing and length combination which offered very good gain, a relatively clean pattern, and the ability to easily lengthen or shorten the Yagi without causing the gain peak to shift appreciably. In all, the DL6WU design was a significant improvement over most previous Amateur designs. Several United States Amateurs had discovered this information and successfully built 432-MHz Yagis from it.

The use of Günter's design data required a start-from-scratch approach. However, most Amateurs find building antennas from scratch is unacceptable because of the lack of convenient sources of materials and the necessity of construction equipment and machining skills. Modifying a commercial Yagi to perform as well or better than the DL6WU design allows more Amateurs to experience the benefits of a high performance 432-MHz antenna system.

Improving a good design

The starting point for the development of these Yagis was the Cushcraft 424B, which offered sound mechanical construction at a reasonable price. By
working from a proven design, it was possible to reuse most of the components and hardware to make a good product even better.

better pattern, higher gain

My goal was to increase the gain, clean up the radiation pattern of the antenna, and get an acceptable wet-weather VSWR, while widening the gain bandwidth. The initial project was so successful that an extended boomlength version was also perfected.

An initial look at the 424B shows that it uses one close-spaced director of 0.135 wavelength spacing, a second director spaced at 0.368 wavelength, and the rest of the directors spaced at 0.375 wavelength. The first ten directors have a length taper. The final ten are all the same length. Long Yagis (over 5 wavelengths), which use constant director spacings, generally have radiation patterns with very high sidelobe levels and overly narrow main lobes. In addition, such director arrangements create Yagis with narrow gain bandwidths and a very sharp gain dropoff on the high frequency side of the gain peak. Design improvements are even more beneficial when the Yagi is used in an array. Reference 2 illustrates this relationship. Mutual impedance effects, which tend to lower the gain peak frequency of an array versus the individual Yagis, also magnify these shortcomings in an array.

One little-known aspect of the NBS study was that the researchers tried designs up to 7 wavelengths long. These longer Yagis were not included in the formal NBS report (NBS Technical Note No. 488), however — probably because of their poor performance. NBS researchers faced the limitations of constant spacing Yagis over 30 years ago; unfortunately, the NBS study wasn’t extended to include variable spacing Yagis.

The development of these new Yagis began on a backyard antenna range. The first step was the addition of another close-spaced director, which improved the pattern but gave no significant gain increase. Application of directors with a constant taper gave further pattern improvements but still no meaningful gain increase. The time and effort required to build and measure the different antenna designs gave me some insight as to why Cushcraft ended their development of the 424B at the point they did: the task of optimizing the directors’ lengths while simultaneously keeping the Yagi’s gain peak near 432 MHz and maintaining a reasonable driven element match appeared to be overwhelming.

computer analysis helped

The WB3BGU series of articles on the computer analysis of Yagis3 ended with a description of the computer program, which ham radio made available to readers for an SASE. Initially, I set up the program in FORTRAN (in which the original was written) on a computer at work; I then translated it to BASIC, which could be run on a home computer. The translation to BASIC gave me the opportunity to correct some bugs in the program and add graphics routines.

I spent the next three months analyzing every Yagi design for which I could get dimensions, paying special attention to designs with reliable pattern and gain data. Such an examination of the program was deemed necessary in order to ensure that any design created with the program would offer realistic results.

Computer analysis of various designs confirmed the desirability of both additional close-spaced directors and an element taper to improve the pattern of the Yagi. Antenna modeling indicated that continuously increasing spacing, as used by DL6WU, was not necessary to create a high performance Yagi. In fact, it appeared that several less complicated spacing patterns could be used as long as all element lengths were optimized for that chosen spacing. An important step in the design of the improved Yagi, it was intended to retain as many of the original 424B element spacings as possible in order to simplify construction.

There are distinct advantages of the DL6WU design approach. The foremost is the ability to add or subtract directors without having the gain peak frequency shift appreciably. A number of designs were examined for frequency shift as elements were added. It was found that the center frequency of all Yagi designs oscillates up and down as elements are added. Even the DL6WU design shows this tendency, though the effect was the least of all designs examined. The wide gain bandwidth of the DL6WU design also minimized any frequency shift effects.

The 24- and 32-element designs presented here all have similar dimensions. Note that the directors of the 24-element Yagi are shorter than the 32-element version. Both Yagis have been adjusted to have a gain peak that’s very close to the same frequency (436 MHz), even though the elements lengths are different for the two Yagis. One should be forewarned that if construction of a Yagi from this design with a different number of elements is attempted, its gain peak may be several MHz away from that of the 24- or 32-element antennas.

variable element lengths and spacings

The Yagi designs presented in this article use both varying element spacings and lengths. This was consistently found to give not only the highest gain, but the cleanest patterns and widest gain bandwidths. DL6WU pointed out the theoretical reasons for this condition.4 Long Yagi designs which use either con-
FEATURES INCLUDE:

- SWITCH SELECTABLE — ELEVATION FROM 0° - 90° AND 0° - 180°
- ELEVATION SCALING X1 OR X2
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- BAUD RATE (300 - 2400)
- 100 PAGE DETAILED MANUAL
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CALL YOUR DEALER TO ORDER ONE NOW!

CJ2M

ELECTRICAL:
BANDWIDTH: 144-148 MHz
GAIN: 8.9 dBd
VSWR: 1.5:1
F/B: 20 dB
BEAMWIDTH: 50°
FEED IMP: 50 ohm
BALUN: 3.1 coax

MECHANICAL:
ELEMENT LENGTH: 13½" max.
BOOM LENGTH: 28" max.
TURN RADIUS: 2 sq. ft.
WEIGHT: 2½ lbs.
MOUNT: Rear

CJ220

ELECTRICAL:
BANDWIDTH: 220-224 MHz
GAIN: 8.9 dBd
VSWR: 1.5:1
FEED IMP: 50 ohms

MECHANICAL:
HEIGHT: 54" max.
WEIGHT: 2 lbs.
MOUNT: 1½" o.d.

CJ440

ELECTRICAL:
BANDWIDTH: 420-470 MHz
GAIN: 8.9 dBd
VSWR: 1.5:1
FEED IMP: 50 ohms

MECHANICAL:
HEIGHT: 19½" max.
WEIGHT: 1 lb.
MOUNT: 1½" o.d.
stant element spacings or element lengths give poorer performance and should no longer be worthy of consideration for use by VHF/UHF weak signal operators.

The formal design of the 432-MHz super Yagis started with a selection of varying director spacings. These were chosen to fit best within the existing element holes to minimize the necessity of drilling new holes in the boom. I tried adapting the DL6WU spacing pattern to the 424B; except for the final director, spacing became 10.25 inches (260 mm) or 0.375 wavelengths, since that was the ultimate spacing of the 424B. The DL6WU design used a final spacing of 11 inches (280 mm) or 0.400 wavelengths. Electrically, this approach appeared to work very well. Mechanically, however, this was not an acceptable solution because eight or nine new holes would have to be drilled into the boom — not in keeping with the relatively simple modification I was hoping to develop.

Next, five different new spacing patterns were examined on the computer. It was apparent that a good progressive spacing pattern didn’t fit easily within the existing holes. The solution was to move the position of the driven element. Once this was done, an acceptable spacing arrangement was adapted to the 424B. The extra effort in devising this new director arrangement paid off by making a new design that requires only three new element holes to be drilled in the boom.

Though not yet the ultimate answer, this extensive computer analysis (and in general, use of the computer in antenna design) helps to dispel several long-standing myths Amateurs have maintained about Yagi design. The first myth is the notion that a design has to be tuned for maximum gain or best radiation pattern. It was found that for designs with proper variable spacing arrangements, the best gain and best pattern solutions were convergent. While a design could be adjusted to maximize any particular aspect of the radiation pattern (lowest first sidelobes, highest f/b), the best overall pattern quality occurred concurrently with the highest forward gain solution. The only way to further improve the pattern was to move the operation point of the Yagi lower on its frequency response curve — i.e., slightly shorten all of the directors. I found that first sidelobe strengths were usually close to -18 dB in the E plane and -16 dB in the H plane when a Yagi with a good spacing pattern was optimized. Students of physics will recognize the significance of -18 dB because it’s the expected strength of the first sidelobes from a fully illuminated circular aperture.

Another common myth holds that when a Yagi is tuned for maximum gain, its bandwidth will be very narrow. This condition was found to be true for constant spacing and constant length designs, but it was also true for those constant designs even when they were not gain optimized. For designs with variable spacings and lengths, the gain bandwidth of such designs was remarkably wide. Even more significant was the fact that the gain bandwidth was best when the elements were optimized for maximum forward gain. As an indication of this wide gain bandwidth the 24-element modified Yagi has a -1.0 dB gain bandwidth of 25 MHz! (Gain bandwidth should not be confused with VSWR-bandwidth. VSWR bandwidth is merely an indication of feed impedance versus frequency and is not normally an indication of forward gain.)

single reflector used over trigon

At this point I decided to drop the tri-reflector arrangement in favor of a single reflector. There have been some exaggerated claims made for various multiple reflector arrangements. Previous experimental work indicated that any of the various multiple reflector arrangements gave about 0.2 dB additional gain over a single reflector, once they were optimized for the individual Yagi design to which they were added. Subsequent computer analysis has indicated that the amount of additional gain obtainable in these multiple reflector arrangements decreases in direct proportion to how well the directors are optimized. That is to say, an antenna that doesn’t have its directors fully optimized for maximum forward gain could very well see 0.5 dB additional gain with the addition of a tri-reflector or screen reflector. Conversely, a Yagi with its directors optimized for maximum gain may be fortunate to see a 0.1-dB gain improvement from such a multiple reflector arrangement.

There also seems to be a common misconception that multiple reflector arrangements improve the f/b ratio. Except for screen or grid reflectors such as those used by DL9KR, this has not been observed to be the case. Dual or tri-reflectors show some tendency to increase the bandwidth over which a particular f/b will be maintained, but don’t show any consistent tendency to always increase the f/b. Many of these multiple reflector arrangements can be tuned to decrease the strength of the rear lobe right at 180 degrees. Since the overall gain of the Yagi doesn’t significantly increase with these multiple reflector arrangements, the strength of other minor lobes increases. It should also be noted that the actual f/b at the 180-degree point of the pattern is not a good indicator of the performance of a Yagi. Many Yagis, including the stock 424B and F9FT-21 element Yagi have nulls at the 180-degree point which give an artificial sense of a high f/b. In order for a Yagi to have an excellent G/T (Gain-to-Noise Temperature ratio), it must have all lobes in the rear hemisphere of the Yagi, in all planes, down a significant amount (over 25 dB). Lobes on either side of 180 degrees are actually conical in shape when the antenna pattern is viewed in three dimensions. There-
fore, they intercept a large amount of radiated energy and can be a troublesome source of noise reception. The modified Yagis have measured f/b ratios of close to 25 dB. In addition, the lobe at 180 degrees is strongest in the rear hemisphere of the pattern and almost all other rear lobes are down 30 dB or more.

If a high or broadband f/b ratio is desired, a non-tuned grid or screen reflector arrangement will be most effective. If one is concerned mainly with forward gain and pattern at a particular frequency, none of the multiple reflector arrangements is as effective in terms of windload versus additional gain when compared to simply lengthening the boom and adding more directors.

The quad-type feed and reflector were also examined. Many of the performance claims for the quad feed were not substantiated by computer analysis. It was found that on short Yagis (under 1.5 wavelengths) every other element had to be checked to see if its length should also be changed, the number of calculations required to optimize each of the elements might require sitting at the computer for half a year. To free me from that chore, I designed an algorithm to optimize the element lengths automatically. This algorithm could also be utilized to optimize element spacings. It could be extended to optimize both spacings and lengths as well; however, with the level of computer power available to most Amateurs, such an optimization of a 32-element Yagi might take considerably longer than we're willing to wait. Therefore, the design must start with some geometry constants determined by the designer’s knowledge of antenna designs.

It was found that the Yagi analysis program lacked sufficient accuracy to completely self-optimize a long Yagi. Specifically, the program showed a tendency to make the elements at either end of the antenna longer than desired. In addition, the program would make the elements in the center of the Yagi considerably shorter than would be believable. At the same time, gain figures would become higher than expected. Moreover, the free-running gain optimization would result in an antenna with a low f/b ratio (less than 15 dB). Therefore, it was necessary to go into the design process manually from time to time and correct element lengths that appeared to be out of line. These adjustments were based on real-world experience with designs which were known to work. Final manual element adjustments were made to perform pattern cleanup on the Yagi.

With a good mathematical model in place, the next step was to build and test a real antenna. This is the point where theory meets reality; if an antenna is optimized with even a slightly erroneous model, those errors will surely be designed into the resultant Yagi. A further complication was the use of elements mounted through the boom but insulated. At that time, no reliable element length correction information existed for that method of mounting elements. An additional uncertainty was the fact that very few existing 432-MHz Yagis peaked very close to 432 MHz on the computer. First attempts to build real 24- and 32-element Yagis resulted in antennas which peaked in gain around 444 MHz.

This occurred for several reasons. First, the design was intentionally peaked high in frequency because the Yagis were designed to be used in arrays of up to 16 elements. In addition, at the onset of antenna construction, I expected a much smaller boom correction for insulated through-the-boom elements than the actual correction factor turned out to be. Another set of elements were made 1/16-inch (1.6 mm) longer. This lowered the gain peak to 442 MHz. An additional set of elements were made for the 32-element Yagi again 1/16-inch (1.6 mm) longer. The gain peak moved

**design knowledge reduces computer time**

The computer hardware available to me over a year ago required about 2-1/2 minutes to calculate the gain and pattern of the 24-element Yagi and close to 4 minutes to calculate the 32-element version. Considering that every time an element length was changed, every other element had to be checked to see if its length should also be changed, the number of calculations required to optimize each of the elements might require sitting at the computer for half a year. To free me from that chore, I designed an algorithm to optimize the element lengths automatically. This algorithm could also be utilized to optimize element spacings. It could be extended to optimize both spacings and lengths as well; however, with the level of computer power available to most Amateurs, such an optimization of a 32-element Yagi might take considerably longer than we're willing to wait. Therefore, the design must start with some geometry constants determined by the designer's knowledge of antenna designs.

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another 2 MHz lower to 440 MHz. Both the real antenna and additional computer modeling showed that a 432-MHz Yagi with 3/16-inch (4.8 mm) diameter elements shifted in frequency approximately 1 MHz for each 1/32 inch (0.8 mm) added or subtracted from the elements. Since 1/32 inch is also very close to 1 mm, this becomes a handy rule of thumb for shifting the center frequency of a 432-MHz Yagi for those working in either English or metric units.

**boom correction**

During this phase of antenna development I examined the boom correction. Three different insulators — the original 424B type (Heyco nylon inserts), the Delrin™ RIW Products type, and the KLM polyethylene type — were tried; all three gave similar, but not identical, results. The amount of capacitance between the element and boom appeared to be the major variable in boom correction. In modeling the effect of the insulated elements mounted through theboom, one can think of the element as an inductor. The boom is looked at as additional inductors in parallel with the center portion of the element. For insulated elements these inductances are capacitively coupled, reducing the amount of parallel inductance. This lowers the amount of boom effect over elements mounted through the boom and not insulated.

**Figure 1** describes the boom correction model. An additional complication in the model is an apparent shielding effect that the boom has on the portion of the element which is inside the boom. This increases the boom correction over the amount implied by the simple capacitive/inductive reactance model. The correction I normally use for this type of element mounting is 25 percent of the boom diameter. The effect appears to change slightly with boom diameter. For example, a 0.75-inch (19 mm) boom shows closer to 20 percent correction, while a 1-1/2 inch (38 mm) boom requires nearly 30 percent correction. This non-constant effect was also charted by DL6WU for uninsulated elements mounted through the boom.9 The -0.5 dB gain bandwidth of a well-designed Yagi is close to 3 percent, or nearly 14 MHz at 432 MHz. Because of this, one doesn’t have to be all that fussy in the exact determination of the boom correction.

**square cut end lengthens element**

Another impediment to having the computer model come out right the first time is what I call the element end effect. This is an apparent effect where a rod element with square cut ends will appear electrically longer than its physical length. I believe the sharp corners at the end of the element cause a field strength concentration; a more even current and field distribution would be obtained by using elements with spherical ends.

This effect is probably negligible below 50 MHz. At 432 MHz, where a 3/16-inch (5 mm) diameter is a measurable portion of a wavelength, the effect can no longer be ignored. I believe this element end effect is the main reason Amateurs had so much trouble scaling Yagis to 432 and 1296 MHz for many years; it’s also further substantiated by persistent stories that the NBS Yagis wouldn’t work above 1000 MHz. Most likely the element length graphs provided by NBS did not have this factor taken into account for frequencies significantly different than the 400-MHz test frequency used by the NBS.
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My work leads me to believe that at 432 MHz, a 3/16-inch (4.8 mm) diameter element with square cut ends acts as if it were close to 0.15 inch (3.8 mm) — electrically longer than its physical length. Using the previously outlined nominal 1-MHz frequency shift per 1/32 inch (0.8 mm) of element length change rule of thumb, this element end effect accounts for close to a 5-MHz lowering in center frequency at 432 MHz. To minimize this effect and to help lower the field concentration at the element ends, I use about a 1/32-inch (0.8 mm) chamfer on the element ends. This appears to reduce the frequency shift to less than 2 MHz. This rounding of the element ends also appears to help wet weather performance.

After being sidetracked by the element end effect investigation, it was decided that an additional 1/8 inch (3.2 mm) would be added to the length of all the elements. This would move the gain peak down to 436 MHz. This tuning makes the gain at 432 MHz approximately 0.1 dB lower than the maximum at 436 MHz — the most desired frequency to which the antenna would be tuned — because the pattern at 432 MHz is somewhat cleaner and mutual impedance effects from the other Yagis in arrays would not be detrimental. These mutual impedance effects tend to lower the center frequency of an array of Yagis relative to the free-space center frequency of a single Yagi.

An array of four medium-sized Yagis (RIW-19s) had both a measured and calculated frequency shift of about 600 kHz. Based on this, an array of 16 Yagis could have a frequency drop of nearly 2 MHz. If these mutual impedance effects cause the array to move over the high frequency gain dropoff point, the array will never perform as well as expected. In fact, it is for this reason that some Yagis can never obtain the theoretical 3-dB stacking gain. In addition, the radiation pattern of most Yagis deteriorates rapidly above the gain peak. It is for these reasons that Amateurs were not very successful in getting EME arrays made from some of the early Amateur Yagi designs to work properly.

Computer-generated patterns for the 24-element, 17-foot, 3-inch (5.2 m) and the 32-element, 24-foot (7.3 m) Yagis are given in figs. 2 and 3. Actual E plane pattern measurements for both Yagis are shown in figs. 4 and 5. A comparison with the patterns of the stock 424B (figs. 6 and 7) demonstrates the attention paid to improving the radiation patterns. When comparing the patterns, keep in mind that the revised Yagis use a single reflector instead of the tri-reflector on the
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original antenna. The calculated gain-versus-frequency plots (fig. 8) provide more interesting data. The maximum gain point of the modified Yagis has been moved 4 MHz higher, to 436 MHz. In addition, the high-side gain cliff, the point at which the gain of the Yagi rapidly drops off, is moved almost 8 MHz higher in frequency. A smooth gain-versus-frequency curve is an indication that the directors are operating in a synergistic mode and hence at or near their maximum possible performance.

Between the 24- and 32-element versions of the Yagis, eight different test Yagis were built before the published dimensions were selected. There’s still room for a little improvement in the 32-element Yagi; this will be covered in more detail later.

It’s obvious that with the accuracy of antenna analysis programs available to most Amateurs, an important post-computer optimization process is required. One shouldn’t put too much confidence in any analysis program until the results have been confirmed with real antennas. With the help of the more sophisticated method of moments analysis programs, I now need only one or two tries building a real antenna to get it right. Getting to this point required two years of learning both the limitations of the programs I use and more about the design of Yagis.

**design procedure**

The design cycle is still an iterative process. It first uses a rough optimization using WB3BGU’s computer program. Next, the results of the YAGI program are confirmed by a more sophisticated but vastly slower method of moments program. If the design is believable, a test Yagi is made and measured at this point. From that data, further computer tuning is done and other test antennas are made. Figure 9 shows the flow chart for the computer-aided Yagi design process.

The calculated patterns were done on an enhanced version of MININEC. This program’s results appear to have gain figures and calculated patterns that more closely represent the real world than those generated by the YAGI program. It should be noted that the calculated gain figures are slightly optimistic because they do not account for balun and element resistive losses, mechanical tolerances, or unwanted radiation from the feed. Likewise, the calculated patterns are also optimistic for the same reasons. One may expect that the real Yagi’s sidelobes will be 1 to 2 dB poorer than calculated, with the main lobe slightly narrower than
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**fig. 7. Measured E plane pattern for unmodified 424B Yagi.**

Calculated and gain typically 0.1 dB lower than calculated.

Careful comparative gain measurements between these Yagis and both the RIW-19 Yagi (14.9 dBd) and the KLM 432-30-LBX Yagi (17.3 dBd) indicate that the 32-element version 2 Yagi has 17.7 dBd forward gain and the 24-element model has about 16.4 dBd gain, or 0.5 dB over the original 424B. Computer analysis by both the WB3BGU program and the more sophisticated method of moments programs agrees with these gain comparisons. As a reference, a 31-element, 24-foot (7.3 m) DL6WU design Yagi measures 17.5 dBd and has a slightly poorer pattern. The optimized 31-element DL6WU design for which I calculated the revised element lengths has a slightly better pattern than the 32-element version 2 Yagi, but lower gain at 17.6 dBd. The improved 32-element design (version 3) theoretically has as good an overall pattern as the optimized DL6WU design, but with almost 0.2 dB higher forward gain. Accuracy of these gain figures should be within 0.2 dB.

I believe that the maximum theoretical gain that can be obtained with a 17-foot (5.2 m) 432-MHz Yagi is 16.6 dBd and that the maximum for a 24-foot (7.3 m)
Yagi is 18.0 dBi. Thus, these Yagis are near the theoretical maximum possible gain, given their boom-lengths. Further performance increases would require radical changes in element spacings, and therefore defeat the objective of devising an improved antenna that was easy to build from an existing commercial model. These theoretical gain improvements are also very small (approximately 0.2 dB). Keep in mind that a measured gain of 18.0 dBi for a 24-foot (7.3 m) 432-MHz Yagi may never be obtained because of resistive losses, construction tolerances, unwanted feed radiation, and feed imbalance. Although the original design objective was to create an easy-to-copy modification of a commercial Yagi, the above performance comparison indicates that the design is worthy enough to be considered for construction from scratch. This is verified by the fact that the 32-element, 24-foot (7.3 m) design has never been beaten at an antenna gain contest by a similar size Yagi. The only Yagi ever to exceed its gain at an antenna contest was almost 29 feet (8.8 meters) long, which is 5 feet (1.5 meters) longer in boomlength.

Table 1. Dimensions for a 24-element Yagi, version 3.

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<th>Spacing</th>
<th>Length</th>
<th>Boom (inches)</th>
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</tr>
</tbody>
</table>

Fig. 8. Calculated gain versus frequency is higher than actual gain, since 100 percent power transfer is assumed at all frequencies — i.e., feed impedance changes are ignored.
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fig. 9. Computer-aided Yagi design cycle.

construction

The actual construction of either of these Yagis starts with the drilling of three new element holes in the boom. The driven element is mounted in a new hole 2.625 inches (66.7 mm) behind the original driv-
en element hole. The old DE location now becomes director 1 and the original director 1 is now director 2. A second new hole is drilled for director 3. The original director 2 hole is no longer used and a final new element hole is added between the original director 2 and 3 holes where a new director 4 now goes. This provides a new antenna with 24 elements — the same number as the original 424B.

The improved Yagis use a single reflector instead of the 424B’s tri-reflector. Thus two additional closely spaced directors are added in the new design. A new hole for the N connector bracket is drilled 2.625 inches (66.7 mm) behind the original. The hole for the balun clamp is moved 3.125 inches (79 mm) further back to accommodate the shortened baluns used on the modified Yagis. Figure 10 shows the new hole drilling pattern for the rear boom section. This revised element spacing is common to both the 24-element and 32-element versions.

Constructing a 24-element Yagi from an unassembled 424B requires only 27 inches (0.69 m) of 3/16-inch aluminum rod and 2 inches (5 cm) of No. 12 copper wire. Modifying an assembled 424B requires the same parts plus a number of element retainers to replace those which will be destroyed in disassembly. One should note that most of the directors could be filed down while in place on the boom, provided that one was careful in checking dimensions during the filing process. It’s easier, however, if the element lengths are checked carefully when they’re removed from the Yagi. Cutting tolerance should be kept within ± 1/32 inch (0.8 mm). For reassembly of an existing 424B, suitable stainless steel element retainers (No. 6100-18) made by Industrial Retaining Ring Company of Irvington, New Jersey, can be ordered from most local industrial hardware distributors. Suitable retainers can also be ordered from Cushcraft.

Table 1 is a list of the dimensions for the new element lengths of the 24-element Yagi. There are few common dimensions with the original 424B. No attempt was made to save existing element lengths.

The listed dimensions are for version 3 of the 24-element Yagi; they supersede any information I distributed before August, 1986. The version 3 Yagi incorporates additional element adjustments which were modeled on MININEC and confirmed on a test antenna. The latest version features improvements in both gain and pattern. Be sure to put a slight chamfer on the end of the elements — otherwise the antenna will tune lower in frequency and the driven element match may not be acceptable.

The driven element is described in fig. 11. Note that the rectangular black spacer insulators used between the driven element and T match bars are no longer used. The No. 16 wire used to connect the T match to the N connector is replaced by a No. 12 wire. This was done both to improve the VSWR bandwidth and reduce unwanted radiation from the jumper wire. Measurement of a stock 424B gave a VSWR of 1:15:1 when dry and over 10:1 when doused with water from a garden hose. The revised match arrangement on the modified Yagi has a VSWR less than 1:12:1 when dry and about 2:0:1 (measured at the feed) when drenched with water.

When radiation patterns were first made on the modified Yagis, an imbalance in the sidelobes was noted. A similar pattern distortion was also measured on a stock 424B. Several more measurements were made to determine whether the pattern distortions were occurring in the measurement method or were actually in the Yagis. To confirm that the imbalance was really in the antenna, the test 424B was flipped over. The pattern imbalance changed sides when the Yagi was turned over. This indicated that the pattern distortion was in the antenna and not attributable to range reflections.

After checking a number of possible causes for the imbalance, it was determined that the balun on the 424B was 1.00 inch (25.4 mm) too long. A length error of exactly 1.00 inch (25.4 mm) leads me to believe that the error in balun length was due to a simple number translation mistake when the 424B’s designer calculated the balun length, and that it wasn’t made that length intentionally. The main objective of a half-wavelength balun is to provide a 180-degree phase shift to feed the other half of the drive element. The actual length of the balun should be 180 electrical degrees, including the ends of the balun that protrude from the shield. One should not change the length of the balun to obtain a good match; this will cause pattern distortion. The shorter balun also appears to help the wet weather VSWR. If you don’t shorten the balun, the driven element dimensions will be different for a proper match.

**designing (and mounting) a longer Yagi**

The success of the 24-element, 17-foot (5.2 m) Yagi inspired a longer version. The design objective of the long Yagi was simply to outperform any available commercial or homemade Yagi. The appearance of the 22-foot (6.7 m) KLM 432-30-LBX, based upon the DL6WU design (with 17.3 dBd gain), plus the increasing use of homemade DL6WU Yagis up to 24 feet (7.3 meters) long, added to the challenge. A secondary design objective of the longer version was to make it from readily available parts.

A 24-foot (7.3 m) length was selected because I believed it to be a practical size limit, so the Yagi would be reasonably easy to handle. While longer Yagis may appear practical on paper, the construction of an EME array, which requires elevation movement, places...
### Table 2. Dimensions for a 32-element Yagi, version 2.

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### Table 3. Dimensions for a 32-element Yagi, version 3 (not tested).

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fig. 10. New spacing pattern for 24, 32, and 38-element Yagi.
additional demands on the supporting tower. Typical EME arrays are mounted about 20 feet (6.1 meters) above the ground; an array of 16 of the 24-foot (7.3 meters) long Yagis has only 4 feet (1.2 meters) of ground clearance when tilted back. Longer Yagis will need a higher tower and hence one that is considerably stronger than the commonly used Rohn 45. If an array of such long Yagis is intended to be mounted atop a tall guyed tower, for use on tropo, for example, the design becomes more difficult. An array made from even longer Yagis would have to be mounted a large distance above the top guy wires in order to allow elevation movement. In the case of an array made from 24-foot (7.3 meters) Yagis, the height above the guys is 14 feet (4.3 meters). An array made from eight of the Yagis stacked two wide and four high has a total windswept area of over 40 square feet when phasing lines, preamplifier enclosure, and all other required accessories are included. Such an array presents a loading force that is at the limit of what a Rohn 55 can handle. When one considers that an array of eight 29-foot (8.8-meter) Yagis has a wind area approaching 50 square feet and would have to be mounted over 16 feet (4.9 meters) above the guys, one can see how quickly the tower loading can get out of hand.

The 24-foot (7.3-meter) length worked out well because it could be obtained by purchasing an additional center boom section for the 424B from Cushcraft. The availability of the additional boom section, in pre-drilled form, sealed the design length. To complete the boom only a simple, short, 1-1/4 inch (38 mm) OD, 0.058-inch (1.5 mm) wall, 6061-T6 aluminum tube splice was required.

Those who build the Yagi may note that it could have been made with an additional director (10.25 inches/260 mm longer). I decided to keep the anten-
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Element lengths for the 32-element version 2 Yagi are given in table 2. These are the latest tested dimensions and are representative of the version that’s been brought to several antenna contests and also used in NCTI’s EME array. The director lengths, which don’t get progressively shorter, may not seem logical, but I found that this length arrangement was necessary to keep an acceptable pattern, given the closer-than-desired director spacing used in the 424B boom sections.

Since the version 2, 32-element Yagi was perfected, access to more sophisticated computer programs has allowed an improved director string to be calculated. The new director arrangement uses an element length scheme similar to the version 3, 24-element Yagi. That is to say, all directors are shorter than the preceding one. This new director string theoretically has 0.1 dB more gain than the version 2 arrangement. The pattern is also slightly cleaner, in theory. Dimensions for the new arrangement called version 3 are given in table 3. These dimensions haven’t been confirmed by the construction and measurement of test antennas. Experience with the version 3, 24-element Yagi makes me confident that the revised 32-element design will perform as predicted. One can never be completely certain that it will perform as expected until a real antenna is built and measured. The design data for all of these Yagis is presented here because publishing my work up to this point was long overdue. One

na at 32 elements and overlap the rear and center boom sections for additional strength. The selected length and mast mounting position creates a balanced antenna when a feedline is attached. Having a balanced antenna is an important consideration, especially when it will be used in large arrays. The center boom piece is detailed in fig. 12.

The longer, 24-foot (7.3-meter) length made the original Cushcraft 424B boom support inadequate. A solution was again found in Cushcraft parts. A new boom support was made from preformed boom support pieces for the 220B antenna. This required only the fabrication of two simple straight splice sections of 3/4-inch (19-mm) OD, 0.058-inch (1.5-mm) wall aluminum tube. The new boom support center pieces are described in fig. 13.

Alternately, one can make one’s own boom supports. Another possibility would be to lengthen the original 424B supports by using 0.625-inch OD, 0.058-inch wall aluminum tubing. Since the parts for the new boom support were purchased, Cushcraft changed the design of its boom supports. Suitable boom supports can now also be made from the supports used on either the latest A32-19 or 4218-XL 144-MHz Yagis. A rigid boom support is preferable to a simple support wire; it adds lateral strength to the boom, minimizing oscillation in the wind.

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Element lengths for the 32-element version 2 Yagi are given in table 2. These are the latest tested dimensions and are representative of the version that’s been brought to several antenna contests and also used in NCTI’s EME array. The director lengths, which don’t get progressively shorter, may not seem logical, but I found that this length arrangement was necessary to keep an acceptable pattern, given the closer-than-desired director spacing used in the 424B boom sections.

Since the version 2, 32-element Yagi was perfected, access to more sophisticated computer programs has allowed an improved director string to be calculated. The new director arrangement uses an element length scheme similar to the version 3, 24-element Yagi. That is to say, all directors are shorter than the preceding one. This new director string theoretically has 0.1 dB more gain than the version 2 arrangement. The pattern is also slightly cleaner, in theory. Dimensions for the new arrangement called version 3 are given in table 3. These dimensions haven’t been confirmed by the construction and measurement of test antennas. Experience with the version 3, 24-element Yagi makes me confident that the revised 32-element design will perform as predicted. One can never be completely certain that it will perform as expected until a real antenna is built and measured. The design data for all of these Yagis is presented here because publishing my work up to this point was long overdue. One
could become consumed in a lifetime project to continually improve upon the last design. If such a cycle were to continue forever — without publishing any of the earlier work — there would be no benefit to the Amateur community. However, be forewarned that if you decide to build a Yagi using the table 3 dimensions, you'll be entering uncharted territory. Calculated E and H plane patterns for the version 3 Yagi are given in fig. 14.

The maximum performance objective for the 24-foot (7.3-meter) Yagi also required a new driven element construction. I felt that the 424B-based driven element had excessive, unwanted radiation from the
wire between the N connector and T match bars. To remedy this situation, a driven element patterned after that used on the RIW Products 19-element 432-MHz Yagi was made, moving the N connector closer to the boom. This has been done both by cutting down the Cushcraft-supplied connector brackets and also by making copies of the brackets employed on RIW Products’ Yagis. The new T match uses No. 12 copper wires, as does the RIW Yagi. A UT-141 balun was used, replacing the Cushcraft RG-303 balun. The Yagi with the new T match appears to have close to 0.1 dB more gain than one with the modified Cushcraft match. Either match can be used on either version of the antenna. The builder will have to decide if the less than 0.1 dB gain increase is worth the added effort. Those perfectionists in the audience may note that the UT-141 balun accounts for about 0.05-dB loss. A larger size copper hardline such as UT-225 or a sleeve balun could be fabricated if one finds that loss upsetting. Construction details of the new T match for the 32-element Yagi can be found in fig. 15 (see Photo A). The boom layout for the 32-element Yagi is shown in fig. 16 and Photo B.

There are sure to be some operators who won’t be satisfied with a 24-foot Yagi. For those adventurous souls, element lengths for a 38-element, 29-foot version (see fig. 17) are given in table 4. The expected gain of this 38-element model is 18.5 dBi. If you attempt to build the 38-element version, please keep in mind that because I haven’t built or tested this version, I won’t be able to give advice on the construction of a driven element for it or assist in debugging it. As with the improved 32-element Yagi listed in table 3, there is a possibility that the calculated dimensions won’t work as expected. Other length versions are also possible.

Any of the presented designs can be used in the OSCAR, ATV, and fm portions of the band. For use in the satellite portion of the band, a 1/16-inch shortening of the elements is desirable, but not really necessary. For use on ATV, shorten all elements by 1/4 inch (6.4 mm). The Yagi will still be usable at 432 MHz, but will have about 0.2 dB lower forward gain. To use the Yagi in the fm portion of the band, shorten all elements by 7/16 inch. If the Yagis are to be mounted vertically polarized, they should be used in pairs with a boom support placed in the middle of the pair of Yagis (fig. 18). The driven element T match will have to be readjusted for best VSWR if the elements are shortened.

stacking considerations

Optimum stacking distances for the best array gain versus array temperature have been worked out for the antennas. The 24-element, 17-foot (5.3-meter) Yagi should be spaced 70 inches (1.78 meters) in the E plane (horizontal) and 66 inches (1.68 meters) in the H plane (vertical). The 32-element, 24-foot (7.3-meter) version 2 antenna works best with 81-inch (2.06-meter)
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E plane and 75-inch (1.91-meter) H plane spacing. These relatively wide spacings also confirm both the high gain and pattern cleanliness of the new Yagis. Calculated optimum spacings for the 32-element version 3 Yagis are 82-inch (2.08-meter) E plane by 77-inch (1.95-meter) H plane. For the 38-element Yagi, the calculated stacking distances are 88-inch (2.25-meter) E plane by 83-inch (2.11-meter) H plane. At these spacings, both E and H plane stacking gains will be close to 2.9 dB (negating phasing line losses and mechanical errors.)

**when modification is worthwhile**

Before you decide to tear down and modify your existing 424B’s, you should carefully consider the results. A casual tropo operator using a single Yagi may be hard pressed to tell any forward gain difference between the stock and modified 24-element Yagi. The only noticeable differences will be in the pattern (signals off the main lobe will be weaker) and the better wet weather performance. Certainly most Amateurs aren’t capable of detecting 0.5-dB gain variations. For an EME operator using eight or 16 Yagis, changing to even the modified 24-element version will result in significant improvement. On EME receive, it’s expected that an eight-Yagi array will have about a 3-dB

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**Table 4. Dimensions for a 38-element Yagi (not tested).**

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**fig. 18. Recommended method of mounting a pair of vertically polarized Yagis.**
fig. 19. H Plane pattern of a pair of unmodified 4248s spaced 52 inches apart (H plane. The total array gain is 18.50 dBd.

signal-to-noise improvement with the modified 24-element Yagis. This improvement is attributable to the following: +0.5 dB individual Yagi gain advantage; +1.0 dB higher array gain from wider optimum G/T spacings; +0.5 to 1.5 dB S/N due to lower array temperature from the cleaner array pattern.

On transmit, the gain advantage will be 1.5 dB because only the higher Yagi gain and wider spacings in the array contribute to the improvement. The signal-to-noise improvement is highly dependent upon the total receive system noise temperature. This is a combination of both the system noise figure and total phasing line loss. The actual S/N improvement could be from 0.5 dB to over 1.5 dB, depending upon the loss in the phasing lines and how low a noise figure the preamp has.

importance of clean patterns

In order to understand why a clean pattern on the individual Yagis is important, a computed H plane array pattern for two stock 4248's spaced at 52 inches is given in fig. 19. For comparison, the pattern for two of the modified 24-element Yagis, spaced 66 inches in the H plane, is given in fig. 20. Note that even at the significantly wider spacing, the array pattern of
fig. 20. H plane pattern of a pair of modified 24-element Yagis spaced 66 inches apart (H plane). The total array gain is 19.4 dBd.

the modified Yagis is significantly cleaner than the original. At 432 MHz there is approximately a 15-dB difference between cold sky noise and Earth noise. Total Earth noise pickup will be a sum total of all side-lobes pointing into the Earth. This large difference in noise is why clean patterns are so important on 432-MHz EME arrays.

Although not an even comparison, it’s informative to relate the experience of NC11 (ex-WA1RWU.) Frank had an array of 16 stock 4248’s for 432-MHz EME. The array was rebuilt using 16 of the extended modified Yagis (32-element, 24-foot version). The results of the array rebuild are nothing short of spectacular. The receive improvement is far greater than the 1.8 dB extra gain the 24-foot (7.3-meter) Yagi has over the stock 17-foot (5.2-meter) antenna. Receive signals appear to be 5 to 6 dB above the old array, and echos are nearly 10 dB better. SSB speaker quality echos are frequently obtained with 100 watts output in the shack (approximately 80 watts at the array). Stations running four medium-sized Yagis such as the RIW-19s or F9FT-21s and 500 watts are readily workable.

A more even comparison is given by WA3FFC. Scott used an array of four stock 424B’s on EME. Upon switching to the modified 24-element, same boomlength Yagis, his Sun noise increased by 1.5 dB. Cold sky areas became much easier to find. Copy of his own echos was never obtained with the stock Yagis. With the modified 24-element versions, his echos are now regularly copied. Random EME QSOs are now possible with the modified array.

To further expound on how the state of four Yagi 432-MHz EME has evolved, consider the results of a recent portable EME expedition to Vermont by NC11. Frank took four of the 32-element Yagis to Vermont in the middle of June. Because of higher ionospheric absorption, greater Faraday shifts, increased tropo scattering, and longer daylight hours, the summer months are usually the poorest for 432-MHz EME. In spite of these obstacles, NC11 worked 22 stations on a single weekend. More impressive is that all QSOs were random — no prearranged schedules were used!

**conclusion**

With Yagi analysis software, the computer has succeeded in moving Amateurs from the dark ages of Yagi design to the point at which a well-performing Yagi can be readily made from materials at hand. The successful use of any antenna analysis program requires that the antenna designer have a thorough understanding of its capabilities and limitations.

In this project, the total design time — from the first correct running of the analysis program to completion of the initial Yagis — was over 10 months of continuous work. This time included physical tuning of the Yagis. Further improvements made to create the version 3, 24-element Yagi and version 2, 32-element Yagis were done during a year's intermittent work on the antennas. While this amount of design time may represent a high initial investment for a manufacturer of Yagi antennas, the design knowledge gained would most likely allow a similarly complex Yagi to be perfected in about one month. Continued enhancements of antenna design programs and more good Yagi designs will allow still further improvements in the quality of tomorrow’s Yagis.

**references**

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MODEL RS-50A
19" X 5¼ RACK MOUNT POWER SUPPLIES

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build a 1-1000 MHz amplifier using MAR-4 MMICs

Simple device, many applications

During the last few years the availability of surplus test equipment has made fairly sophisticated rf measurements possible for hams on small budgets. Many own rf signal generators with accurate output attenuators that provide precise signal levels. Using the new microwave IC amplifiers, it’s easy to build a broadband utility amplifier to serve as a handy test aid for signal generators.

Broadband amplifiers are widely used — and sold in many different models — to increase the accuracy and range of rf measurements. Typical uses include the following:
- Boosting signal generator output for aligning a “numb” receiver or a badly misaligned bandpass filter.
- Increasing isolation between signal generators in multi-generator setups (as in two-tone third-order intermodulation tests).
- Regaining lost power (when attenuators are used at the test interface to ensure a proper 50-ohm impedance match).
- Increasing measurement range (to determine insertion loss of filters).

Parts information and construction details are given for making a broadband utility amplifier that covers hf through UHF with 13 dB gain and +10 dBm output. Most parts are readily available, and construction takes only a few hours.

**design considerations**

The amplifier IC was selected on the basis of gain and output power required. I needed at least +10 dBm output because this is the maximum power indicated by my thermistor-mount power meter. Because the signal generator output sometimes drops to 0 dBm, 10-dB gain was required. Designed around the Mini-Circuits Lab MAR-4, the amplifier and power supply are shown in fig. 1.

Specifications of the MAR-4s are shown in table 1. Since the amplifiers have 50-ohm input/output impedances and are guaranteed to be stable regardless of load, the only design effort is selecting a power supply dropping resistor. I decided to sacrifice gain for simplicity and not use a series rf choke, making the resistance as large as possible. The power supply current is a substantial 50 mA, so power dissipation is a consideration. The 180-ohm resistance was selected as a maximum convenient value within the restric-

Photo A. Self contained MMIC amplifier and power supply, with mini-box cover removed.

By Cliff Klinert, WB6BIH, 1126 Division Street, National City, California 92050

July 1987
Table 1. Specifications of Mini-Circuits Labs MAR-4 MMICs.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>dc to 1000 MHz</td>
</tr>
<tr>
<td>Gain</td>
<td>7 dB (minimum)</td>
</tr>
<tr>
<td>Flatness</td>
<td>±0.5 dB</td>
</tr>
<tr>
<td>Output (+1 dB compression)</td>
<td>+11 dBm</td>
</tr>
<tr>
<td>Input (no damage)</td>
<td>+15 dBm (maximum)</td>
</tr>
<tr>
<td>Noise figure</td>
<td>7 dB typical</td>
</tr>
<tr>
<td>VSWR (in)</td>
<td>1.9:1</td>
</tr>
<tr>
<td>VSWR (out)</td>
<td>2.0:1</td>
</tr>
<tr>
<td>DC power</td>
<td>5 volts at 50 mA</td>
</tr>
<tr>
<td>Price</td>
<td>$1.90 (minimum quantity)</td>
</tr>
</tbody>
</table>

building the amplifier

The main objective of this project was to use fast, easy construction techniques with readily available parts. The components were soldered together on an unetched printed circuit board, with component leads cut as short as possible. Small 0.01-μF disc ceramic capacitors were used for coupling. Photo A shows the amplifier mounted in a small chassis box, which is mounted on a larger box housing a power supply.

Fig. 1. Complete broadband amplifier including power supply. The 0.01 and 0.1-μF capacitors are disc ceramic and the resistors 1/2-watt carbon composition.

A circuit board is used as a ground plane and is fastened with small brackets. This type of construction avoids etched stripline circuit boards and chip components typical of microwave construction. Photo B is an underside view of the power supply components and wiring. The large cylindrical item in the middle is the 3300-μF capacitor. Be careful when soldering the MMIC leads; they break easily.

Because this amplifier is a test accessory, it will be handled frequently, and you may find that screws and other parts loosen easily. Make sure that the connectors used for J1 and J2 are fastened securely; adding a drop of paint or glue to the mounting hardware will help prevent loosening. The feedthrough capacitor shown in fig. 1 was a junkbox item which conveniently

Table 1. Specifications of Mini-Circuits Labs MAR-4 MMICs.

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>278-105</td>
<td>BNC connector</td>
</tr>
<tr>
<td>276-1772</td>
<td>7815 regulator</td>
</tr>
<tr>
<td>270-238</td>
<td>chassis box (5-1/4 x 3 x 2-1/8 inches)</td>
</tr>
<tr>
<td>270-235</td>
<td>chassis box (2-3/4 x 2-1/8 x 1-5/8 inches)</td>
</tr>
<tr>
<td>273-1366</td>
<td>transformer 24 VAC 450 mA</td>
</tr>
<tr>
<td>276-1103</td>
<td>diodes</td>
</tr>
</tbody>
</table>

My surplus thermistor-mount power meter goes down to almost −30 dBm. Notice the use of the word “almost” here; it indicates the difficulty in making measurements below −30 dBm because of thermal drift. Increasing the top end from 0 dBm to +10 dBm by adding this amplifier provides a 10-dB increase in total range, which represents significant improvement.

Photo B. Bottom view of the power supply components and wiring. The large tubular item in the middle is the 3300-μF capacitor.

Photo A. Top view of the amplifier mounted in a small chassis box.
Both models include time proven computer designed features with T match driven elements for lowest SWR over the entire two meter band. The strong construction is heavy wall tubing, solid aluminum rod elements plus all stainless steel hardware, and precision machine formed components. You will also like the quick easy assembly of these antennas.

Make Boomer your choice today for more 2 meter enjoyment.

**SPECIFICATIONS**

**124WB 215WB**

<table>
<thead>
<tr>
<th>Frequency MHz</th>
<th>144-148</th>
<th>144-148</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>F/B Ratio dB</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Boom length ft</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Beam width Deg.</td>
<td>$2 \times 30$</td>
<td>$2 \times 17$</td>
</tr>
<tr>
<td>E Plane</td>
<td>$2 \times 42$</td>
<td>$2 \times 18$</td>
</tr>
<tr>
<td>H Plane</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

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**K.V.G. CRYSTAL PRODUCTS**

**9 MHz CRYSTAL FILTERS**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Application</th>
<th>Bandwidth</th>
<th>Poles</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF-9A</td>
<td>SSB</td>
<td>2.4 kHz</td>
<td>5</td>
<td>$61.00</td>
</tr>
<tr>
<td>XF-9B</td>
<td>SSB</td>
<td>2.4 kHz</td>
<td>8</td>
<td>$83.00</td>
</tr>
<tr>
<td>XF-9D-01</td>
<td>SSB</td>
<td>2.4 kHz</td>
<td>10</td>
<td>$110.00</td>
</tr>
<tr>
<td>XF-9B-02</td>
<td>USB</td>
<td>2.4 kHz</td>
<td>10</td>
<td>$110.00</td>
</tr>
<tr>
<td>XF-9B-10</td>
<td>USB</td>
<td>2.4 kHz</td>
<td>10</td>
<td>$110.00</td>
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<tr>
<td>XF-9C</td>
<td>AM</td>
<td>3.75 kHz</td>
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<tr>
<td>XF-9D</td>
<td>AM</td>
<td>5.0 kHz</td>
<td>8</td>
<td>$89.00</td>
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<tr>
<td>XF-9E</td>
<td>FM</td>
<td>12.0 kHz</td>
<td>8</td>
<td>$89.00</td>
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<td>XF-9M</td>
<td>CW</td>
<td>500 kHz</td>
<td>4</td>
<td>$42.00</td>
</tr>
<tr>
<td>XF-9NB</td>
<td>CW</td>
<td>500 kHz</td>
<td>4</td>
<td>$42.00</td>
</tr>
<tr>
<td>XF-9P</td>
<td>IF rose</td>
<td>450 Hz</td>
<td>2</td>
<td>$127.00</td>
</tr>
<tr>
<td>XF-9T</td>
<td>IF rose</td>
<td>500 Hz</td>
<td>2</td>
<td>$21.00</td>
</tr>
</tbody>
</table>

**10.7 MHz CRYSTAL FILTERS**

**MICROWAVE MODULES EQUIPMENTS**

Use your existing HF or 2M rig on other VHF or UHF bands.

**RECEIVE CONVERTERS**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Frequency</th>
<th>Bands</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMK 1691-137</td>
<td>270.00</td>
<td>2M, 70cm</td>
<td>$60.00</td>
</tr>
<tr>
<td>MMK 1268-144G</td>
<td>190.00</td>
<td>2M, 70cm</td>
<td>$370.00</td>
</tr>
<tr>
<td>MMK 1268-144</td>
<td>290.00</td>
<td>2M, 70cm</td>
<td>$370.00</td>
</tr>
<tr>
<td>MMK 436 ATV</td>
<td>90.00</td>
<td>2M, 70cm</td>
<td>$280.00</td>
</tr>
<tr>
<td>MMK 436-265</td>
<td>70.00</td>
<td>2M, 70cm</td>
<td>$300.00</td>
</tr>
<tr>
<td>MMK 436-265(P)</td>
<td>70.00</td>
<td>2M, 70cm</td>
<td>$300.00</td>
</tr>
<tr>
<td>MMK 144-142(F)</td>
<td>144.00</td>
<td>2M, 70cm</td>
<td>$200.00</td>
</tr>
<tr>
<td>MMK 144-142</td>
<td>200.00</td>
<td>2M, 70cm</td>
<td>$200.00</td>
</tr>
<tr>
<td>MMK 144-140-200</td>
<td>200.00</td>
<td>2M, 70cm</td>
<td>$200.00</td>
</tr>
<tr>
<td>MMK 144-110-250</td>
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<td>2M, 70cm</td>
<td>$200.00</td>
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<td>MMK 144-140-250</td>
<td>250.00</td>
<td>2M, 70cm</td>
<td>$200.00</td>
</tr>
<tr>
<td>MMK 144-209-300</td>
<td>300.00</td>
<td>2M, 70cm</td>
<td>$200.00</td>
</tr>
</tbody>
</table>

**LINEAR POWER AMPLIFIERS**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Frequency</th>
<th>Power</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>MML 144-30-LS</td>
<td>15.00</td>
<td>1200 W</td>
<td>$49.99</td>
</tr>
<tr>
<td>MML 144-100-LS</td>
<td>150.00</td>
<td>600 W</td>
<td>$49.99</td>
</tr>
<tr>
<td>MML 144-100</td>
<td>300.00</td>
<td>500 W</td>
<td>$49.99</td>
</tr>
<tr>
<td>MML 144-100-2</td>
<td>500.00</td>
<td>300 W</td>
<td>$49.99</td>
</tr>
</tbody>
</table>

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**Table 2. Measured test results.**

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Amplifier input power (dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+1.0</td>
</tr>
<tr>
<td>3</td>
<td>-2.0</td>
</tr>
<tr>
<td>5</td>
<td>-2.6</td>
</tr>
<tr>
<td>10</td>
<td>-3.0</td>
</tr>
<tr>
<td>25</td>
<td>-3.0</td>
</tr>
<tr>
<td>50</td>
<td>-3.0</td>
</tr>
<tr>
<td>75</td>
<td>-3.0</td>
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<tr>
<td>100</td>
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<tr>
<td>150</td>
<td>-2.9</td>
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<tr>
<td>200</td>
<td>-3.0</td>
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<tr>
<td>300</td>
<td>-2.8</td>
</tr>
<tr>
<td>400</td>
<td>-2.0</td>
</tr>
<tr>
<td>450</td>
<td>-1.8</td>
</tr>
</tbody>
</table>

**measured results**

The amplifier was connected between a signal generator and thermistor power meter using short RG-58 BNC cables to test gain and frequency response. The data shown in table 2 was measured with the amplifier output power set to +10 dBm at each frequency.

The low frequency gain starts to roll off at 1 MHz because of the three 0.01-µF coupling capacitors. The small reduction in gain at 450 MHz may have been caused by the type of construction used and losses in the cables. I was delighted to find the amplifier stable and free from oscillation, with nearly constant gain over the frequency range of interest.

**references**

2. RF/IIF Signal Processing Guide 1986-87, free catalog available from Mini-Circuits, P.O. Box 166, Brooklyn, New York 11235.

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operating a VHF/UHF/microwave station

Just as in hf operation, good operating practices make VHF, UHF, and microwave operation a pleasure not only for you but for other Amateurs as well. These practices enhance your chances of experiencing some of the more exotic propagation modes and operating techniques. Since some Amateurs may be hesitant about entering the VHF territory, I’ll devote this month’s column to those practices, in hope that the information presented will ease their transition to the world above 10 meters and help increase the enjoyment for those already operating there.

frequency plans

Each Amateur band above 50 MHz covers a wider frequency spectrum than all the present hf bands combined! Furthermore, on VHF and above there are more types of transmission emissions than you’ll find on the typical hf bands: CW, SSB, packet, a-m, RTTY, and slow-scan ATV. While the FCC has placed limits on types of emissions within each of these bands, the only real restrictions above 50 MHz are between 50.0 and 50.1 and 144.0 to 144.1 MHz, which are allocated exclusively for CW operation. Reference 1 lists all the Amateur frequency allocations above 50 MHz; reference 2 shows the microwave/millimeter-wave bands after the FCC update of March 1, 1986. Reference 3 lists the modes permitted on all Amateur bands.

After World War II, North American VHFers established gentlemen’s agreements or frequency (usage) plans. This worked fine while the VHF bands weren’t too populated, but started to break down in the 1970s as activity increased and the number of different emissions and repeaters in operation increased. Let’s face it; weak-signal operation using CW or SSB is virtually impossible alongside an fm repeater radiating reasonable ERP (effective radiated power) from a mountaintop location!

In 1978, therefore, North American “band plans” were drawn up by the ARRL VHF/UHF Advisory Committee (VUAC) in accordance with the wishes of many users from various interest groups. I was the chairman of that committee when these plans were formulated. It wasn’t an easy job to satisfy everyone. All inputs had to be integrated so that the overall band plan would be fair and equitable for the majority rather than the minority. At the same time, band plans had to allow some room for specialized communications such as EME and OSCAR. Finally, they had to have some flexibility for future operating trends. Believe me, there were some tense moments.

The first band plans that emerged were for the 2-meter, 135-cm (220-225 MHz), 70-cm (420-450 MHz), and 23-cm (then 1215-1300, now 1240-1300 MHz) bands. Still more or less as originally formulated, these band plans also established the primary “calling frequencies” (to be discussed shortly) that are now in use. Several years later band plans were formulated for the 6-meter and 33-cm (902-928 MHz) bands. These band plans are fairly comprehensive and also list recommended fm repeater pairs.

Most important for weak-signal work is the recommended calling frequency on each band. When the Amateur population density is low, there’s a need for a specific frequency to monitor for unexpected openings or to serve as a place for meeting new friends or greeting new arrivals on the band. Tuning or scanning the whole band isn’t only time consuming; it can often result in missing stations who call a quick CQ, hear no takers, and move on.

Furthermore, with the lower power and narrower antenna beamwidth that are typical of the VHF and above frequencies, it’s sometimes difficult to hear someone, even on the calling frequency. The modern antennas are sporting pretty clean radiation patterns, so don’t forget to change your antenna beam heading occasionally. I’m sure that those who use the present calling frequencies will agree that this is a much more productive approach to locating other stations and band openings than the methods used in “the good old days.”
Table 1. Recommended North American calling frequencies.

<table>
<thead>
<tr>
<th>Band</th>
<th>Calling Frequency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 m</td>
<td>50.110</td>
<td>DX</td>
</tr>
<tr>
<td></td>
<td>50.200</td>
<td>National</td>
</tr>
<tr>
<td>2 m</td>
<td>144.100</td>
<td>CW</td>
</tr>
<tr>
<td></td>
<td>144.200</td>
<td>SSB</td>
</tr>
<tr>
<td>135 cm</td>
<td>220.100</td>
<td></td>
</tr>
<tr>
<td>70 cm</td>
<td>432.100</td>
<td></td>
</tr>
<tr>
<td>33 cm</td>
<td>903.100</td>
<td></td>
</tr>
<tr>
<td>23 cm</td>
<td>1296.100</td>
<td></td>
</tr>
<tr>
<td>13 cm</td>
<td>2304.100</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 shows the recommended calling frequencies where applicable. A few suggestions are in order. Once contact is established on the calling frequency, it’s common courtesy to QSY up or down at least 10 kHz in order not to QRM the calling frequency and to make it available for others to use. Always remember that many people may be monitoring or want to use the calling frequency whether the band is open or not, so don’t tie it up needlessly!

However, if no one transmits, how do you know the band is open? Never use the calling frequency as a tune-up frequency. Find another frequency where you won’t cause interference or blow the head off somebody who’s monitoring the calling frequency. However, put out a call or CQ occasionally. You may be pleasantly surprised by a response.

**HF versus VHF Dxing**

If there’s one major difference between operating on the hf and VHF bands, it’s most easily summed up in the term “DX.” Generally speaking, the communication distances on the VHF bands aren’t those that many of us work on hf. As a result, VHFers have a different notion as to what constitutes DX. Working Europe, Africa, or Asia on 20 meters may be routine for an hf DXer; but for a VHFer, working over 250 miles on 2 meters may involve a greater degree of difficulty.

Consequently, VHF and UHFers need a different yardstick by which their accomplishments can be measured. For many years, while DXers on hf were busy contacting new DXCC countries, VHF and UHFers in North America were chasing new ARRL sections, states, or counties. Probably the most popular award was the WAS (Worked All States). However, without EME, a WAS award is virtually impossible on 2 meters and above. What do you do when you’ve worked all states that are available using all the normal propagation modes?

European VHFers have an advantage over North Americans: in Europe, an area slightly smaller than the size of the continental United States, there are more DXCC countries than there are states in the United States. However, Europeans still weren’t satisfied and in the early 1960s devised a system called “QTH Locator” or “locator” for short.

Europe was essentially subdivided into latitude/longitude blocks, each 2 degrees in longitude by 1 degree in latitude. At mid-latitudes this locator system yielded a square measuring about 70 by 60 miles. Each square was given a two-letter designation between AA and ZZ. For more accuracy, each square was further subdivided to pinpoint the location down to a few miles. A typical European locator, then, had five characters such as FR30c for SK6AB or TH69c for UW6MA. Unfortunately, the European locator system couldn’t be used elsewhere without ambiguities or duplication. Hence, when out-of-continent DX modes such as EME became popular, a different locator scheme was needed.

The search for a worldwide locator system was long and arduous. Several systems were proposed. The ARRL finally adopted the “Maidenhead” locator system, a scheme named after the town in England where a committee finally agreed upon a worldwide system without ambiguities.

This locator system divides the Earth into 324 different “fields,” each 20 degrees in longitude by 10 degrees in latitude. The system reference begins at the South Pole on the 180th parallel. Each field is given a two-letter designation between AA and RR. Each field is further subdivided into 100 different sections, numbered 00 thru 99, usually referred to in North American as “grid squares.”

Figure 1 shows the ARRL grid square map covering the continental United States and lower Canada. If you live in this region and know your latitude and longitude (a must for all VHFers) you can quickly determine your four-character grid square using the map in fig. 1. Maps similar to this one are now widely available from various VHF equipment suppliers. If you don’t know your grid square, just ask local VHFers. They’ll be glad to assist.

However, note that a four-character locator has an accuracy of only approximately 50 to 75 miles. If greater accuracy — such as that offered by the European five-character scheme — is necessary, more information is required. In the Maidenhead system, two additional characters are used. Information on how to determine your six-character grid square may be found in tables listed in reference 5.

For example, my home is located at North latitude 42 degrees, 34 minutes, 58 seconds, and West longitude 71 degrees, 22 minutes, 35 seconds. Therefore the six-character grid square is FN42HN. When even greater accuracy is needed — on the microwave frequencies, for example — an eight-character system can be used by adding two more characters to pinpoint the exact location.
This ARRL Grid Locator map is based on the worldwide "Maidenhead" system. The first two characters (letters) constitute the 20" X 10" field. This is followed by two numbers designating the 2" X 10" square. To indicate location more precisely, 5th and 6th characters (letters) are used to indicate the 5' X 2.5' sub-square. More information on grid locations and the ARRL VHF/UHF Century Club Awards (based on contacting 100 grid squares) can be obtained from the Headquarters of the American Radio Relay League, 225 Main Street, Newington, CT 06111, U.S.A.

This ARRL Grid Locator map is based on the worldwide "Maidenhead" system. The first two characters (letters) constitute the 20" X 10" field. This is followed by two numbers designating the 2" X 10" square. To indicate location more precisely, 5th and 6th characters (letters) are used to indicate the 5' X 2.5' sub-square. More information on grid locations and the ARRL VHF/UHF Century Club Awards (based on contacting 100 grid squares) can be obtained from the Headquarters of the American Radio Relay League, 225 Main Street, Newington, CT 06111, U.S.A.

fig. 1. This is a copy of the official ARRL VUCC grid locator map for North America. An 18 x 12-inch copy is available from the ARRL for $1.00.
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NEMAL LINE - 50 OHM

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CONNECTORS—MADE IN U.S.A.

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ROTOR CABLE—6 COND.

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</tr>
<tr>
<td>1136</td>
<td>5/8&quot; Tinned Copper</td>
<td>40</td>
</tr>
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</table>

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Many home computer programs are now available for determining the six-character grid square for any point on Earth if the latitude and longitude are known. Conversely, there are now computer programs that will break out the longitude and latitude from a six-character grid square. Some of the programs will even determine the distance and bearing between two stations if the grid squares are known.

It's now common practice on 6 meters and above to exchange your four-digit locator or grid square when establishing initial contact with a new station. In fact, the use of grid squares has become so widespread in North America that one often has to ask the other station in which state they're located!

**VHF/UHF/microwave awards**

As previously mentioned, the WAS award is still very popular in North America on the VHF frequencies. WAS has been obtained by several hundred Amateurs on 6 meters using ionospheric propagation. WAS has been attained on 2 meters by almost 100 Amateurs, but EME was needed because the distance necessary to work all states exceeds the normal propagation modes even for those located in the central part of the United States. Likewise, about ten WAS awards have been attained on 136 and 70 cm using all available normal propagation modes and EME.

The WAC (Worked All Continents) award is also available on VHF. Many 6-meter WACs have been issued, especially after the F2 propagation peaked a few years ago. WAC has also been accomplished by several dozen stations on 2 meters and 70 cm, but EME was required. Several stations are now waiting for the arrival of a South American Amateur on 23-cm EME to complete WAC on that band.

In 1981 the Central States VHF Society started an awards program using squares similar to those used in Europe. This scheme was eventually adopted by the ARRL; on January 1, 1983, they launched a new VHF awards program called the VUCC (VHF/UHF Century Club). Based on the Maidenhead QTH locator system, it's the DXCC of the VHF world.

Each VHF band through 47 GHz now has its own separate VUCC award. Only confirmed contacts made on or after January 1, 1983 qualify. The minimum number of confirmed grid squares varies for each band, with the minimum established according to the degree of difficulty involved. Six and 2 meters require at least 100 grids, while 135 and 70 cm each require 50 grids. Stickers are available for specific levels above the minimum requirements.

**Table 2** has been prepared to show the minimum number of grid squares required on each of the designated bands as well as the endorsement sticker requirements. Unlike the DXCC, for which several of us have already confirmed all 317 presently designated countries, the VUCC Award has 32,400 grid squares available for each of the bands shown in table 2. That should keep most VHFers busy for the foreseeable future!

Think of the excitement you could have with a North or South Pole expedition, where you could put out 18 different squares just by moving your station a few feet for each square. Better yet, sit right over the Pole and put out all 18 polar squares simultaneously! What say, KC4AAA?

For those interested in the worldwide grid squares, Folke Rosvall, SM5AGM, has published a World Atlas showing all 32,400 grids superimposed on maps of the world along with principal cities and geographic boundaries. I find this atlas indispensible for serious grid square work.

**DX records**

Ironically, the most prestigious accomplishments on VHF have no awards! The ultimate claim is to be one of the few who can document the best DX on a particular VHF frequency band. For many years this was done on a worldwide basis and hence the chance to claim a record was slim unless you lived near one of the systematic locations favored by one of the exotic propagation modes.

Therefore, in the July, 1985 column I introduced a North American-only DX record list. This gave North American Amateurs a means of comparing their accomplishments more equitably with their peers. Furthermore, I added a twist by listing the records according to the suspected mode of propagation. This not only created many more mountains to climb, but also distributed the records according to the most favorable propagation in different regions of North America. Judging from all the calls and letters, this listing has generated substantial enthusiasm for new record challenges.

Occasionally I hear second-hand claims that individuals have or know of longer records, but are either unable or unwilling to produce the necessary material to document their case. Claims come cheap, so I disregard...
<table>
<thead>
<tr>
<th>Frequency</th>
<th>Record Holders</th>
<th>Date</th>
<th>Mode</th>
<th>Miles (km)</th>
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<tr>
<td>50 MHz</td>
<td>Note 3</td>
<td></td>
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<tr>
<td>144 MHz</td>
<td>Aurora</td>
<td>KA1ZE (FN31TU)-WB0DRL (EM18CT)</td>
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<td>Ducting</td>
<td>KH6GRU (BL01XH)-WA6JRA (DM13BT)</td>
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<td>cw</td>
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<td>EME</td>
<td>VETUT (FN63XV)-VK5MC (GF02EJ)</td>
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<td>Sporadic E</td>
<td>W4EQR (EM601M)-W7HAH (DN28NB)</td>
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<td>FAI</td>
<td>W5HUQ/4 (EM900C)-W5UN (DM82WA)</td>
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<td>MS</td>
<td>K5JR (EM35WA)-KP4EKG (FK68VG)</td>
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<td>KP4EOR (FK78AJ)-LU5DJZ (GM04RO)</td>
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<td>Tropo</td>
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<td>903 MHz</td>
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<td>K6MEP (DM041O)-WA6EJO (DM04KT)</td>
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<td>Laser</td>
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</table>

**Notes:**
1. The records are listed alphabetically by mode. Ducting is suspected when the path is mostly over water. No efforts are made to separate out ducting on overland paths, so they're grouped under tropo.
2. The information within the brackets is the grid square locator.
3. Six-meter records were omitted since the primary mode is often hard to distinguish. Also, long-path QSOs exceeding 12,433 miles (20,004 km) were reported during solar cycles 19 and 21.
them unless the proof can be obtained. All record claims must be two-way contacts on recognized Amateur bands using legal power.

Since the last North American claimed records list was published in January, 1987, there have been many changes; the pace quickens to increase records even if only by a few more miles. Table 3 shows the latest VHF and above record claims. I've also added a further refinement by listing crease records even if only by a few changes; the pace quickens to include the details on the QSL. Always include the following minimum information on your QSL cards: your call sign, the other station's call, your QTH and grid square, the date and time of your QSO, plus your frequency and emission type. The following additional information is also recommended: the propagation mode, a signal report (try to note this in your log even though it may not be used at the time — during contests, for example); your six-character grid square or exact latitude and longitude, a description of your equipment, some comment on the weather, and any other pertinent information. The latter information could immensely assist others who are trying to evaluate propagation or station performance.

Always use UTC time and date. There's a special problem on 6 meters in North America, since over half the sporadic E openings occur in the early evenings between 2200 and 0300 UTC, during which the date changes! There's nothing more frustrating than trying to verify a QSO in your log when there are 50 to 100 QSOs (or more during contests), all on the same date, and you get a QSL from another time zone. UTC is universal. If UTC is a problem to figure, buy an inexpensive clock just for logging and set it on UTC, as given by radio station WWV. Note the UTC date; it's just as important as the UTC time!

Finally, be careful when dating QSLs so there's no ambiguity about the month and day. Many years ago dates were customarily given as month-day-year (for example, 6/12/87); slowly the trend has changed to day-month-year (that is, 16/6/87). Now there seems to be a feeling internationally that this is confusing.

The newest date system suggested by the IARU (and by many governments) is to indicate dates by stating the most important parameter, namely the year, first. The month and day follow (for example, 87/6/16). I now use this format in my log and had my latest QSLs printed this way. There's no longer any confusion about which part of the date is being numbered, especially when exchanging QSLs internationally. Don't you agree?

I often receive QSLs sent as postcards. Quite frankly, most of these arrive looking as if they'd been through a meat grinder and are often illegible, with postage stamps obscuring important information — such as the date! I strongly recommend that you show a little pride and always send QSLs in a protective envelope even though the cost will be higher.

Please answer all QSLs received on the VHF bands. What may seem like an easy contact to you may have been like climbing a mountain for the other person. QSL as soon as possible after a contact; the longer you wait, the less chance of a return. We live in a mobile society. People move, lose interest, and often postpone answering QSLs, especially if a large batch arrives.

Finally, don't forget the SASE. QSLing is no longer an inexpensive proposition. If you want a reasonable guarantee of a QSL in return, including an SASE is the least you can do. One exception is when both parties want a card and mutually agree ahead of time to dispense with the SASEs.

**what constitutes a QSO?**

Does this sound like a stupid question? I don't think so — not when it's applied to VHF and above. With the arrival of new operating techniques and the use of more exotic propagation mechanisms, many QSOs are no longer straightforward and may require more than a few seconds to complete. It may be more a matter of minutes or even hours.

Let me be more specific. I believe that the minimum requirements for a valid contact are a two-way exchange of both call signs, some type of information, and a confirmation that all this information was received.

The call sign exchange should be obvious. If both call signs aren't heard by both stations, how can you be sure who you're communicating with — especially if signals are weak? I totally deplore the often single-call contest type of contacts, presently so popular on hf and beginning to appear on VHF.

When you call a station for the first time, send his or her call sign followed by your call sign. If several stations call simultaneously (such as in reply to a CQ), there may be confusion. It's often easier and quicker to sign both calls twice, once at the beginning and once at the end of the first information exchange, rather than repeat them in QRM if two stations reply.

The exchange of some specific information may require some amplification. On hf and often on VHF, this is usually a signal report such as RS(T). Nowadays, it's popular on VHF and above to just exchange grid squares. There's nothing wrong with this. On EME and meteor scatter, the exchange is usually a letter or abbreviated report such as "S2" on meteor scatter. Again, there's nothing wrong with this as long as it's mutually understood by the two stations having the contact.

The exchange of information shouldn't be sent until the call signs are

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confirmed. After the information exchange, the most crucial part of the contact takes place; this is the confirmation that all the necessary information has been received. Frequently this is accomplished by an “R” on CW or “roger” on SSB.

Most operators agree that the roger should never be sent until both call signs and all the information exchange is completed. Furthermore, most operators agree that the contact is complete when at least one of the stations hears a roger and then responds with same. Some purists may want to hear rogers both ways, but that can lead into the roger-of-the-roger syndrome.

If there’s any doubt about the confirmation required, try to get a definition of what the other station requires ahead of time. One scheme I use to break the routine is to send 73, but I never send it unless I’m sure that the other station has received my roger. When you hear my 73, you know that I’ve received all the necessary ingredients for a completed QSO.

transmission modes

Nowadays most weak-signal communications use SSB on the VHF/UHF frequencies because it has a much faster information exchange. This is especially true on meteor scatter, where some bursts are measured in seconds. CW is usually reserved for long-haul, weak-signal paths, EME, and aurora, where signals are more difficult to copy, especially when there’s severe distortion or doppler shift.

More specific information is required to operate meteor scatter and EME because they each have a special reporting format. On meteor scatter contacts, stations in North America usually transmit and receive in 15-second increments. Generally speaking, the station furthest west or south transmits the first and third 15 seconds of each minute and the station furthest east or north transmits the second and fourth 15 seconds. More specifics are discussed in reference 8.

EME operation is another matter because it differs on each band. Transmission periods are typically 2 or 2-1/2 minutes and special reporting sequences are used. 70-cm reporting and scheduling are discussed in reference 9. Time and space won’t allow a lengthy dissertation at this time, so these matters will have to be covered at a later date.

when and where to operate

So far I’ve discussed band plans, grid squares, awards, QSLing, and what constitutes a two-way contact. By now you’re probably asking, “Where do I go to find all those stations to contact?” One answer is to tune into the various calling frequencies and scan 10 to 25 kHz on either side of them. If nothing is heard, try a CQ on one of the calling frequencies.

If you still don’t hear anyone, don’t be alarmed. Your rig is probably working, but there just isn’t any activity at the time. “So when is the activity?” you ask. The answer is sometimes a function of your location. You may have to be patient at first or ask a local Amateur when it all takes place.

Activity nights. Sometimes activity can be sparse, especially on the higher VHF and UHF bands. Many of the “dyed-in-the-wool” VHF/UHFers operate on more than one band. You can’t be everywhere all the time — thus the concept of “activity nights.”

Basically the scheme goes like this. Each night of the week is designated for a different major VHF/UHF band. This way you can pool your resources and cover all bands equally. This concentration has been proven to be very effective and easy to remember. Sunday night is 6-meter night, Monday is 2-meter night, and so forth; table 4 shows the whole scheme. Local areas choose the time, but it’s typically between 8 and 10 PM local time.

Contests usually provide plenty of VHF/UHF activity. The major North American contests are listed at the end of this column. Again, the operation can get out of sync; that important multiplier may be on a particular band when you’re busy elsewhere. Therefore, activity hours are recommended during contests. Here in the Northeast, 7 AM and 7 PM are 2-meter hours, 8 AM and 8 PM are 135-cm hours, and so forth.

<table>
<thead>
<tr>
<th>Band</th>
<th>Activity Night</th>
<th>Activity hours during contests</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 meters</td>
<td>Sunday</td>
<td>6 AM/PM</td>
</tr>
<tr>
<td>2 meters</td>
<td>Monday</td>
<td>7 AM/PM and 1 PM</td>
</tr>
<tr>
<td>135 cm</td>
<td>Tuesday</td>
<td>8 AM/PM and 2 PM</td>
</tr>
<tr>
<td>70 cm</td>
<td>Wednesday</td>
<td>9 AM/PM and 3 PM</td>
</tr>
<tr>
<td>23 cm</td>
<td>Thursday</td>
<td>10 AM/PM and 4 PM</td>
</tr>
<tr>
<td>33 cm</td>
<td>Friday</td>
<td>11 AM/PM and 5 PM</td>
</tr>
</tbody>
</table>

Many special-interest VHF/UHF nets convene on hf so that wider area coverage can be conducted. The Central States VHF Society has a net on 3818 kHz on Sunday evening. I believe it’s at 10 PM Central Time. Members and nonmembers can often be found on this frequency in the evenings, especially during meteor showers. The 70-cm EME net meets on 14.345 MHz every Saturday and Sunday at 1600 UTC, followed by the 2-meter EME net at approximately 1700 UTC.

VHF/UHF and microwave conferences, many held annually, are usually listed at the end of each month’s column (if I get the informa-
conveniences

All your operation can go for naught if some conveniences aren’t provided. Try to make your operating position as comfortable as possible. Have a separate light over the operating position so that your log book can easily be seen. It will not only be less tiring, but safer if you have to make any gear changes.

Have keyers and microphones readily accessible on the operating table. If any antennas have to be switched, provide a switch, preferably with easy access from the operating position. Don’t take any shortcuts on an antenna relay. A poor isolation or unreliable relay can cause instantaneous equipment burnout.

Finally, if possible, have a secondary frequency standard.11 Not only will it tell you what frequency you’re on, but it will provide a weak signal source to indicate whether your gear is grossly inoperative.

summary

This month’s column, devoted to operating a VHF/UHF/microwave station, was further dedicated to newcomers to ease and speed their transition to the VHF and above frequencies. Various tips for improving your chances of success were also offered.

Remember to let me know about any VHF/UHF/microwave clubs, societies, newsletters, and conferences. I’ll be glad to share the information I receive in a future column.

new records

Reference 7 indicated that the best reported DX on 48 GHz in North America was a puny 0.3 miles. That’s all history now, as you’ll note in table 3. That record was broken on March 7, 1987 when WB7JNU, W7TYR, and W7ADV in Portland, Oregon (CN85PL), had a two-way SSB contact on 47.040 GHz with WA3RMX and K7RUN in Beaver, Oregon (CN850L), over a distance of 5.42 miles!

Not only is this a new North American record, but it probably represents the highest frequency at which narrowband SSB communications has ever taken place. The power was only 44 microwatts into a 9.5-inch diameter dish on one end of the path! The power on the other end of the path was 3.5 milliwatts (QRO!) into a 28.5-inch dish.

Judging from the signal strength and low power, this same group has improved on the highest frequency at which narrowband SSB communications has ever taken place. The power was only 44 microwatts into a 9.5-inch diameter dish on one end of the path! The power on the other end of the path was 3.5 milliwatts (QRO!) into a 28.5-inch dish.

Congratulations all around and good luck on your next record attempt.

Table 5. Several major North American newsletters that are not directly associated with a club or organization.

| VHF/UHF and Above Information Exchange | Rusty Landes, KAOHPK, P.O. Box 270, West Terre Haute, Indiana 47885. Issued monthly. One-year subscription: $15.00. |
| KCOV’s UHF-Plus Update | 3090 Point Pleasant Road, Hebron, Kentucky 41048. Issued monthly. One-year subscription: $5.00. |
| 220 Notes | c/o Walt Attus, WD9GCR, 215 Villa Road, Streamwood, Illinois 60103. Issued quarterly. One-year subscription: $5.00. |
| 2-Meter EME Bulletin | c/o Gene Shea, KB7Q, 417 Staudaher Street, Bozeman, Montana 59715. Issued monthly. One-year subscription: $15.00. |

references


**ham radio**

important news about MININEC 3

In W1JR's column in the May, 1987 issue (see page 101), it was erroneously stated that copies of MININEC 3 could be obtained from the United States Naval Ocean Systems Center (NAVOCEANSYSCEN).

According to NAVOCEANSYSCEN, engineering software such as MININEC is developed by NAVOCEANSYSCEN for use by the United States Navy and other Department of Defense (DOD) agencies. NAVOCEANSYSCEN software is made available to the DOD and DOD contractors upon written request as part of the technology transfer goals of NAVOCEANSYSCEN.

The documentation for MININEC 3, NOSC Technical Document No. 938, is available to the general public at a nominal fee from the National Technical Information Service (NTIS). Copies of MININEC 3 on diskette will be available from the Federal Software Exchange Center, a service of NTIS. To request copies, please contact NTIS at 5200 Port Royal Road, Springfield, Virginia 22161 (703 487-4650).

Please note that foreign requests must be handled through appropriate diplomatic channels. — Ed.
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Yaesu’s FT-726R is a very popular and well-made radio, offering a lot of flexibility in one small package. But some owners feel that for the 726R to really “come alive” on 2 meters, it’s necessary to add an external GaAsFET preamp.

After owning a 726R for several days, I too felt that performance on the 6- and 2-meter bands could be improved. My observations lead me to believe that any shortcomings were not the result of insufficient front-end gain or a high noise figure, but were due instead to an apparent lack of i-f gain in the VHF modules. While the receiver’s MDS seemed to be a cut above most other stock transceivers, signals that are too weak to activate the AGC threshold level require the operator to continually ride the a-f gain control for adequate recovered audio. The actual spread between the receiver MDS point and start of AGC action is considerable, resulting in an appreciable weak-signal “dead-zone.”

It’s interesting to note that the UHF 430- and 440-MHz modules don’t suffer from this problem. This is because of the additional overall gain produced by the 70-MHz i-f stages unique to these modules. While switching bands, note how the receiver background noise increases when the UHF module is activated.

does a preamp really help?

I live in Connecticut’s “Kilowatt Valley.” During contests a multitude of high-power VHF stations surround my QTH and put the best of receivers to the test. The Yaesu 726R uses a single-ended dual-gate FET mixer preceded by a dual-gate FET high-gain amplifier — hardly a “crunch-proof” combination! Whatever benefits offered by a 20-dB GaAsFET preamp would be significantly outweighed by greatly diminished receiver dynamic range.

where gain will do some good

Two cascaded monolithic i-f “roofing” — or IMD — filters follow the first mixer, providing the first real degree of receiver selectivity. These filters protect the subsequent stages from strong signals falling outside the filter passband. While the filter bandwidth isn’t adequate for closely spaced SSB/CW signals, the real limiting factor with the 726R lies in its VCO phase noise-produced reciprocal mixing products.

A common-gate JFET stage provides all of the i-f gain in both the 6- and 2-meter modules. Adding another 10 to 15 dB of i-f gain will solve most of the receiver sensitivity problems.

the circuit

Figures 1 and 2, respectively, show the original and modified circuits. An additional FET stage was added to produce the needed gain. While there were many ways to do this, my method involves only minimal disruption of the existing circuitry; the radio may be returned to its original condition without difficulty. The component values are critical. I deliberately used interstage mismatching and resistive loading to assure predictable gain and a stable circuit.

The added components are mounted “cordwood” fashion on the rf unit pc boards for the 2- and 6-meter modules. The modification is neither lengthy nor involved, but some manual dexterity and soldering skills are needed. Don’t perform these modifications if you’re not comfortable tearing into your radio. Since the rf boards for both VHF modules are nearly identical, and many of the Yaesu part numbers are the same, I’ll give the 6-meter information in parentheses only when the part numbers differ.

Only six parts are needed per module; total cost should be about $10 for both modules. Use 1/8-watt resistors if available, and use the smallest size capacitors you can find. Extremely short, direct connections must be used for stability — there’s a fair amount of in-line gain at 10.7 MHz with the additional i-f stage. I suggest pre-tinning the component leads before mounting. Be sure to use a grounded iron.

step-by-step procedure

Carefully remove the modules from the radio. Re-

By Peter J. Bertini, K1ZJH, 20 Patsun Road, Somers, Connecticut 06071

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gate lead and ground; use the coil shield for TO9 (TO8 in the 6-meter) as the ground point. Using short leads, tack-solder the 24-pF capacitor between the gate lead of the 2N5486 at the 1.8-k resistor junction and to the junction of the Q03 drain lead and the 6.8-μH choke. This completes the modification to the radio.

Check your work again for errors, making sure that none of the JFET leads have twisted and shorted together.

---

**fig. 1. Original circuit.**

---

**fig. 2. Modified circuit.**

---

**fig. 3. Preshape leads as shown.**

---

move the top cover shield for the rf board, which is held in place with four screws. Carefully lift the board upwards and locate the drain lead for Q03, the 2SK125 i-f amp. Unsoldier this lead carefully and lift it from the pc run. Re-dress the lead as shown in fig. 3A. Because there's a small possibility that the lead may break off at the device case, you may wish to have a few RCA SK replacements on hand.

Preshape the 6.8-μH choke leads as shown in fig. 3B. Locate the resistor lead on the 10-ohm resistor (R19) nearest capacitor C34 (C32 for 6 meters) and carefully tin the lead. Slide the L-shaped hook lead of the 6.8-μH choke under the resistor lead and solder. Carefully shape and tack-solder the free drain lead from Q03 to the free choke lead — another lead will be added here later.

Preshape the 2N5486 leads as shown in fig. 3C. Arrange the source and gate leads so they face towards the J02 pin connections and insert the drain lead into the hole previously used by Q03's drain lead. Solder the lead to the PCB run and trim. Check your work carefully. If everything appears to be correct, reinstall the rf board for the 6-meter module only.

A 120-ohm resistor and 0.01 μF capacitor are installed between the 2N5486 source lead and ground. On the 2-meter module there are holes for an unused i-f transformer that will provide a good short ground path to the pc ground foil. For the 6-meter module the coil shield for i-f transformer TO8 is used; be careful not to overheat the coil assembly. The 2-meter rf board may be reinstalled at this point.

Next, a 1.8-k resistor is installed between the 2N5486

---

**alignment**

Connect the module to the radio and let it sit atop the other modules so that the i-f transformers can be aligned. Inject a signal into the receiver that's strong enough to produce S-meter deflection; keep the level under S9 so that small signal variations will be more readily apparent. Carefully repeak coils TO8 and TO9 (coils TO7, TO8, and TO9 for the 6-meter module) for maximum meter deflection; repeat the procedure until no further improvement is noted. There should be no signs of regeneration or oscillation. When alignment is completed, remove power from the radio and reinstall the rf cover shield and the module in the radio.

**increased performance**

With no antennas connected, the receiver background noise is at the same level regardless of the band selected. Signals are about 10 to 15 dB stronger than before the modification. Weak signals that were difficult to copy are now easy to copy without an external preamp.

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that golden day

Some readers may remember my April column, wherein I mentioned the “black hole” in Amateur Radio, an area of western China between India and the USSR. Known as Xinjiang Province — and void of Radio Amateur activity — it measures some 600 miles in diameter.

But now BYOAA was rumored to be active in Ulumqui! One afternoon around 0100Z, I was tuning around 14,127 kHz when I heard a weak, watery signal working a UA9 station. Could this be . . . ? I closed my eyes — all good DXers know you can hear a weak signal better with your eyes closed — YES! The signal signed BYOAA. This was my chance. No one else was calling . . . the frequency was clear. To avoid alerting the competition, I gave a quick one-by-two: BYOAA DE W6SAI W6SAI K.

The room filled with a golden light. I heard the BY come back to me, but my mind slipped back to the early days of DX when I was a high school lad. The goal of active DXers then was to achieve the near-impossible: WAC (Worked All Continents) on phone! It wasn’t hard from the west coast, because a few Asians were on phone, but their signals never seemed to filter through to the New York area. True, a few DX giants such as W2AZ, W2HUQ, W2IXY, and W4DLH had done the impossible, but never a greenhorn kid running 120 watts into a dipole.

And then on that long-ago golden day, when the big DXers must have been asleep, I worked VU2CQ in Bombay, India on phone. It was truly a shattering experience and one not repeated until I had the thrill of working a station in the elusive “black hole” — Xinjiang province, formerly known as Chinese Turkestan!

Other DXers share the same exciting experience. The 1986 Top Band Annual News Digest edited by Ivan Payne, VE3INQ, is a revelation. Armed with a good antenna, sufficient power, stamina, and an urge to excel, a group of 160-meter DXers are turning the top band into a replica of 20 meters! According to Ivan’s DX log, W8LLR has 203 countries on 160, followed by N4PN and VE1ZZ with 184 and 189, respectively. And G3SZA and PA0HIP both have 39 zones on 160 meters! Now that’s real DX!

a wideband 80-meter antenna

The wideband 80-meter antenna is still an elusive concept. The best way of doing the job is to make a “fat” dipole. Some of these designs have been shown in earlier columns. I recently received a note from Frank Geisler, W7IS, who had built various “fat” cage antennas for 80-meter operation. They seemed to work after a fashion, but they were large and unwieldy. They were easy to tangle up during erection and had heavy wind loading.

Searching for a better solution, Frank came up with the antenna shown in fig. 1. Very simple, it consists of five dipoles connected in parallel. The complete antenna is only 114 feet long. The short dipoles have a 2-foot separation so that overall spread of the wires is 10 feet. This interesting antenna is easy to get up in the air because only one wire is erected at a time. The top wire is pulled up first, then the other wires are added, one at a time, from top to bottom. Frank used No. 18 wire and cut all the dipoles to the same length. The operating bandwidth is sufficient to cover the range of 3.5 to 4.0 MHz with an SWR of less than 2:1.

No spreaders are necessary in this simple antenna. The wires have never tangled — not even in 60-mph winds. The wires attach separately to the center mast and are connected together with a short length of wire. A 1:1 balun is used to match a coax line.

Next, Frank wants to try reducing the number of wires to three, separated by 4 feet. It will be interesting to see if he can maintain operating bandwidth with fewer wires.

a 160-meter discone antenna

W7IS is a stalwart experimenter. He had always wanted to try a discone antenna for 160 meters to achieve vertical polarization with good operating bandwidth (see fig. 2). The top disc was assembled from wire and was 90 feet in diameter! The disc was pre-assembled on the ground and hauled
into position at the 80-foot level. He used nylon ropes to steady the assembly. The ropes ran to seven nearby trees. Pulleys and weights on each of the ropes allowed the top disc to flex in the wind.

The center support tree was 80 feet high and the discone wires were 130 feet long. The cone wires dropped down to the 10-foot level and then were run along the ground at this level for 45 feet. The natural resonance of the antenna turned out to be 2.1 MHz, so an antenna tuner was used to reach 1.8 MHz.

The last step was to ground the end of each discone wire with an 8-foot rod. All ground rods were tied together. This lowered the resonant frequency of the antenna to 1.8 MHz and dropped the SWR to less than 3:1 over the range of 1.8 to 7 MHz.

Frank states this was a major construction project that required large amounts of No. 12 wire. The antenna has been up for three years and is still in use. He says the antenna is good for DX and illustrates how much better vertical, rather than horizontal, polarization is on 160 meters.

For a simple 160-meter DX antenna, Frank says it's very hard to beat a simple dipole about 80 feet high. The discone is a better antenna, but it's difficult to construct, takes up a lot of wire, and requires plenty of real estate!

the 160-meter beam at PY1RO

The robust signal of Rolf, PY1RO, is well known to all 160-meter DX operators. He's tried various antennas and says that the array shown in fig. 3 is one of the best. Suspended from a 230-foot tower, the array consists of six half-wave (quad style) loops, equally spaced around the tower. They use two half-loops as a director, two more

---

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half-loops as reflectors, and the remaining loops as a "fat" radiator. The loops are electrically switched in six different directions. Polarization is vertical and a front-to-back ratio of better than 10 dB is noted. Front-to-side ratio is about 15 dB.

The switch box is located at the 16-foot level. Because each of the loops is self-resonant at 1925 kHz, they act as "natural" directors at the low frequency end of the band. The relays add sufficient length to the loops to make them resonant at 1740 kHz to act as reflectors.

Rolf notes that the high tower is a natural attraction for lightning. During a recent storm, he had two direct hits on the tower in the space of two hours. The installation is protected by a lightning arrestor (charge dissipator, or lightning rod) at the top and by six grounds at the bottom. Unfortunately, the coax from tower to station was left uncovered.

fig. 3. "Rotary" beam for 160 meters at PY1RO (courtesy VE3INQ).
 hused during the storm. His station suffered extensive damage, including charred connectors, outlets, and wires all the way back to the circuit breaker box! Now, all wires to the tower are disconnected during a storm!

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Interested in an ultra-compact VHF fm receiver? Motorola has just announced the MC3362 bipolar analog IC, which comprises a single-chip receiver from antenna input to audio amplifier output. Useful from 50 to 150 MHz, the device provides excellent sensitivity and good image rejection in narrowband voice and data link applications.

The MC3362 was featured at the recent RF Expo East as a single-chip receiver operating in the 2-meter band (144.585 MHz) and drew crowds of interested Amateurs and engineers! For more information on this formidable device, contact Motorola, Inc., Bipolar Analog IC Division, Tempe, Arizona 85200.

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A new supply of the popular "144 MHz EME Directory" has been printed. This lists many of the moonbounce stations and operators, giving the name, call, address, phone number (where applicable), and equipment. To obtain your copy, send five first-class stamps (or five IRCs) to me at EIMAC, 301 Industrial Way, San Carlos, California 94070.

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battery problems: part 1

As its title states, this column covers the practical aspects of Amateur Radio. Yet because much of my electronic servicing career has involved working with non-Amateur applications, it would seem to make sense to share some of the results of that experience with you here, since the principles addressed apply to Amateur Radio as well.

As I’ve mentioned before, I spent several years working in biomedical electronics at a large university medical center, where batteries were used for many different reasons. Some equipment was battery-powered for reasons of portability. A defibrillator, for example, might be needed anytime, anywhere... heart attacks don’t always happen when patients are conveniently near electrical outlets or fixed-location machines. Although most of our defibrillators were ac- or dual-powered, we also had a number of purely battery-powered models.

We had battery-powered monitors used to keep track of ECG and blood pressure as patients were transferred between units — for example, from the Emergency Room to the Intensive Care Unit. Small VHF/UHF fm ECG telemetry transmitters kept track of ambulatory patients, and still other devices relied on battery power for reasons of patient safety. A cardiac output computer, for example, makes measurements based on a thermistor inserted into the heart. Because even minute amounts of ac “leakage” current could be fatal, batteries were used to completely isolate the instrument from the ac power line. During those years I learned a few valuable lessons on the use of batteries in electronics equipment.

First, though, a note on terminology. In rigorous usage, a “cell” is the most basic element, and has the minimum voltage for that sort of device. We gain additional voltage by connecting the cells in series and extra current by connecting them in parallel. To be strict, we would refer to the single entities as “cells” and multiple-cell entities as “batteries.” But in common usage — where it’s usually acceptable to be less rigorous — all cells and batteries are called “batteries.” We’ll follow that practice here.

Portable medical electronics equipment is powered with NiCds. These batteries have a nominal terminal voltage, at full charge, of 1.2 volts, except immediately prior to turn-on after a fresh charge, at which time the open-terminal voltage is 1.4 volts. Sometime after turn-on, however, the open-terminal voltage drops to the nominal value of 1.2 volts for the duration of operation. As the stored energy is used up, however, the terminal voltage drops lower.

NiCds will normally sustain 1000 charge-discharge cycles before becoming unusable. Manufacturers typically rate a battery unusable when the capacity of the battery drops below 80 percent of its original specified value.

The capacity of a battery is measured in ampere-hours — that is, the product of the current load (in amperes) and the time required to reach the officially designated discharge state. The NiCd is capable of delivering some tremendous currents: for example, the D cell (4 A-H) and F cell (7 A-H) can deliver short duration currents of 50 amperes or more. (This is why they’re used in defibrillators, and why portable Amateur Radio transmitters can use them.)

Because they deliver huge currents, NiCds should be fused in order to protect printed wiring tracks, wires, and other conductors. I’ve seen copper foil pc tracks and an on/off switch smoked by a shorted capacitor across the dc line from a NiCd battery.

The amount of time that a battery will sustain its charge is a function of the discharge time, which in turn is determined by the amount of current drawn.

Figure 1 shows two different discharge scenarios: one for a current of 1/10 the A-H rate, and one for a current equal to the A-H rate. In fig. 1A, the battery will be fully discharged in 10 hours, while in fig. 1B discharge will occur in 1 hour. This particular chart is derived from the data published for a D cell rated at 4 A-H.

The standard cell ratings for NiCds are as follows:

<table>
<thead>
<tr>
<th>Battery Size</th>
<th>A-H Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>0.4/0.5/0.7</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
</tr>
<tr>
<td>F</td>
<td>7</td>
</tr>
</tbody>
</table>

As you can see, the AA cells are available in three ratings from 400 to 700 mA-H, depending upon the manufacturer and style.

You’ll find plenty of variation from this chart, especially among consumer product quality (rather than professional quality) NiCd batteries. I’ve seen
C cells rated at both 1 and 1.2 A-H, and D cells rated at 2 A-H. I suspect that these are lesser cells dressed in C and D packages; one manufacturer's representative admitted to me that his consumer D cells were actually C cells inside of D packages!

This chicanery, of little consequence to most consumer electronics users, results in a lower cost product. But if you use these batteries in communications equipment, make sure that you get the correct A-H rating. It's been my experience that Gould brand cells are fully rated; others may require caution.

Some distributors play the rating game by quoting different discharge rates. One standard method of measuring A-H capacity is the amount of current required to discharge a cell to 1.0 volts in 1 hour. Some makers, however, define A-H capacity in terms of the 10-hour discharge rate normalized to ampere-hours. In analyzing figs. 1A and 1B, you can see how this might result in a warm, fuzzy — but false — feeling of capacity.

The charging protocol for NiCds depends some what on the application and manufacturer. In general, though, the charge current must be at least A-H/20, and in many commercial consumer battery chargers it's often A-H/15. For most applications where you can control the charge rate, it's safe to use a charge rate of A-H/10. That is, charge the battery at a current not greater than 1/10 the ampere-hour rating. In addition, the battery must be charged to 140 percent of capacity, so a charge time of 14 hours is mandated. The general rule is: charge at 1/10 ampere-hour rating for 14 hours.

Some chargers are designed to fast-charge the battery in as little as 1 hour; most, however, demand 3 to 4 hours. Fast-charging should not be done unless the battery manufacturer recommends it. Even then, I'm a little cautious about fast-charging, having once seen a D cell explode during too-fast charging. NiCds can be dangerous, so follow the maker's recommendations carefully.

NiCds have finite shelf lives as well. Some users find that a battery charged, then stored, is unusable when it's eventually turned on. My old Wilson walkie-talkie suffered that fate several times. Figure 2 shows a storage discharge curve for a typical NiCd. As you can see, the battery or cell will be of questionable utility after only a few weeks' storage. The cure for this problem is a trickle charge during long-term storage at a rate between A-H/30 and A-H/50. Some commercial battery chargers have a switch that allows either A-H/10 regular charge rate or a A-H/30 trickle charge.

Another problem with NiCds is operating temperature and its effects on available capacity. As shown in fig. 3, the available current capacity is a function of temperature. As the temperature increases above room temperature (72 F, 25 C), the available capacity diminishes. I'd like to see some data on NiCd performance at cold temperatures.

**NiCd “memory”**

You'll hear a running debate about whether or not NiCds have or do not have a memory problem. In this context, memory means that a battery won't allow deep discharge after repeated shallow discharges. For example, if a battery is repeatedly discharged in some particular application to only 80 percent of capacity, after a while it will "remember" the 80-per-cent level as the fully discharged point. The battery will then exhibit the fully discharged potential when the charge level is only 80 percent of fully charged. This makes the battery appear to have suffered premature failure. A NiCd battery with memory problems can sometimes be rehabilitated by repeatedly fully charging it, and then immediately deep-discharging it. Eventually the memory phenomenon should work itself out.

The best cure for the memory phenomenon is to avoid it. I have a friend who lives in constant pain, and as a result uses an electronic pulse generator called a "Transcutaneous Electronic Nerve Stimulator" (TENS) to keep the pain at a manageable low level. This physician-prescribed device runs on small NiCd batteries. When my friend complained that the $90 battery pack lasted only a few weeks, I questioned him further and found that he routinely placed the TENS in the charger every night, even though he didn't use it all the time. The TENS battery was obviously being routinely shallow-cycled, and consequently had developed a memory. I advised my friend to keep two battery packs available: one in an insulated bag in his briefcase, for use when the other one goes dead, and the other in the TENS itself. When the TENS battery is low, my friend simply swaps battery packs.
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He used one battery pack for two years, and had been averaging at least a year on each — instead of six weeks.

When equipment is subject to routine maintenance, it’s possible to keep the batteries healthy by following a certain routine. In most of the equipment I’ve serviced over the years, the manufacturer recommended that the batteries be periodically discharged and then recharged. The protocol for most is as follows:

- Fully charge the battery or cell.
- Discharge it fully with a resistor that draws a current of A-H/10 for 8 to 9 hours for multi-cell batteries, and 10 hours for single cells.
- Recharge the battery at the A-H/10 rate for 14 to 16 hours.

If the battery is not fully discharged, a phenomenon called “polarity reversal” may occur because not all cells have the same terminal voltage at any given time. It might happen that one cell will become charged backwards by the others in the series chain. For this reason, multi-cell batteries are discharged to only about 10 to 20 percent of capacity.

When a unit uses multiple cells to achieve higher voltage levels — and it’s possible to remove those cells individually — it’s better to discharge and recharge them one by one.

Batteries left in a discharged condition for a lengthy period of time may develop inter-element shorts: little whiskers (called “dendrites”) grow from plate to plate, causing a short circuit. The cell potential drops to zero never happening.

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The Dick Smith Electronics (DSE) Model K-6345 Radio Direction Finder (RDF) unit* has drawn considerable interest among transmitter hunters. The low price of this kit, compared with the cost of other commercial Doppler RDFs, has been its main attraction.

The direction finder consists of two assemblies—a control/display electronics section and the ASU or Antenna Switching Unit. The display has an electronic compass, which is a series of 32 LEDs arranged in a circle whose illumination is a function of the transmitted signal arrival angle. The unit has potential applications from 6 meters to 70 cm for both sport and serious use in volunteer enforcement as well as search and rescue efforts. It's intended to work with any fm receiver in the appropriate frequency range, including handhelds and scanners.

problem areas

After evaluating the DSE unit and comparing it with similar homebrew and commercial Doppler RDFs, I found several shortcomings. Voice or tone modulation on the signal being hunted caused a “spreading” of the direction indication, frequently causing it to light all the LEDs in the circle on modulation peaks; getting a good bearing on a signal with continuous tone modulation was nearly impossible. Noise created by the electronic antenna rotation sometimes obliterated signals that were not full quieting, or spread the indication further. In addition, parasitic reradiation in the antenna system worsened the effects of multipath on the indication.

I found the original design virtually useless for mobile hunting in urban areas because the display dashed around rapidly with no discernible trend. Though the Doppler RDF technique is easier to use in motion than beam/quad/loop schemes — and also averages out multipath indications — this was not the case with the DSE unit because of the problems cited above.

Fortunately, there are several ways to improve the unit and make it a credible performer. Some of them have been mentioned briefly by the manufacturer in an addendum sheet now being supplied with the kit. I developed several others, including the fixes to the active filter stage described here. The modifications, all quite simple and involving little additional cost, are made in two areas, the Antenna Switching Unit (ASU) and the bandpass filter stage.

The instruction manual discusses the theory of how the Doppler effect is used for direction finding, but it gives no advice on how to install and use a Doppler RDF on a vehicle. Some practical hints on that topic are included later in this article.

the antenna unit

Electronic rotation of the antenna assembly is achieved by sequentially switching each of the four whip antennas to the receiver by the ASU. Only one antenna is connected to the receiver at any one time. The other three are disconnected by diodes D201-D204* in the ASU and shorted to ground by diodes D205-D208 at the antenna bases. Because these unused whips are grounded, they affect system performance by adding undesirable harmonic content and amplitude modulation to the induced Doppler signal. The effects of reflections from nearby terrain features are magnified by the reradiation. So even a small amount of multipath results in unreadable displays when the unit is used in motion.

The solution is to have the switched-off whips be electrically floating instead of grounded. Remove and discard the shunt diodes (D205-D208) at the bases of the four whips. Doing this won’t adversely affect the operation of the ASU. There is 26 dB isolation from each switched-off whip base to the receiver using the shunt diode and 23 dB without it. The difference is insignificant.

The switched-off whips will still appear to be grounded if the coax lines to the ASU are an odd multiple of an electrical quarter wavelength. That’s because a nonconducting diode in the ASU is trans-

By Joe Moell, K0OV, P.O. Box 2508, Fullerton, California 92633

*Component designations indicated are as used in K-6345 RDF kit and differ from customary HR nomenclature.
formed to an apparent short at the end of an odd quarter wavelength multiple line. For best results, change these lines to be exact electrical half wavelengths at the frequency of interest.

Be sure to take the velocity factor of the coax into consideration in the computation. For 2 meters, using ordinary polyethylene dielectric RG-58 (with a 66 percent velocity factor), the coax lengths should be 26-1/2 inches (or a multiple of that) from the antenna base to the ASU circuit board. This length includes the connector on the box and the coax from the connector to the board. For foam dielectric cables such as RG-8/X (with a 78 percent velocity factor), the length should be 31-1/2 inches for 2 meters. It’s important that all four lines be of equal electrical length.

A one-piece antenna assembly like the one shown in fig. 1 is easy to mount on the roof of a car with suction cups and nylon straps (not shown). Use an all-metal enclosure, such as an aluminum chassis and cover plate. The plastic ASU box supplied by DSE is acceptable if it’s placed inside a larger metal enclosure like the one shown.

Other ways to configure the antenna system include setting an open wooden frame with individual ground planes in the back of a pickup, mounting a set of four vertical dipoles on a PVC pipe support, or using four individual mag-mount antennas on the vehicle roof. In any of these cases, the ASU board should be placed either inside a metal box or inside a plastic box that has been sprayed with conductive paint for shielding.

The short leads inside the ASU box from the four coax receptacles to the board should be changed to equal lengths of small coax, such as RG-174/U, replacing the bare wire provided. Alternatively, when the entire antenna system is housed in a metal enclosure such as shown in fig. 1, the four connectors can be deleted and the RG-58 lines can go directly from the antenna bases to the ASU board.

A good ground plane for the antenna system is very important. Eight radials are attached to the antenna base chassis with lugs as shown in fig. 1. The radials and the whips should be stiff enough that they don’t flop around when in motion. Bronze welding rod (3/32 inch diameter) is ideal for this purpose; it accepts solder readily and is available inexpensively at welding supply stores.

Switching noise from the BA244 diodes supplied by DSE is objectionable because it can mask weaker signals. You’ll notice an improvement by replacing D101-D104 with PIN types, such as Motorola MPN-3401. An equivalent part is available in the ECG and NTE replacement semiconductor lines as ECG-555.

fig. 1. This antenna system is built in an aluminum chassis and uses bronze welding rod for elements. RCA phono plugs and jacks are used to attach the whips.

what is direction finding?

The classical method of direction finding employs a rotatable antenna and a receiver. Depending upon the antenna pattern and the detection method, the antenna is slowly rotated until either a maximum or minimum signal is detected.

Each antenna and receiver comprises one station. Two or three stations working from different locations are then able to compare bearings and determine an approximate location of the source. This process is known as triangulation.

A second method known as Doppler RDF uses a rapidly rotating antenna that in addition to receiving the main signal, introduces an fm component that is proportional to its speed of rotation. For example, as the antenna approaches the source, the frequency increases. As it rotates away from the source, the frequency decreases slightly. This is similar to the effect noticed as a train, with horn blaring, draws nearer. The tone rises and then diminishes. Note, however, that it’s the phase — not the actual frequency of the tone — that contains information about the direction of arrival of the transmitted signal.

Instead of physically rotating the receiving antenna(s), an electronic switching method can be employed that in effect rotates the pattern and accomplishes the same purpose without moving parts. Practical Doppler RDFs sequentially switch four or more elements to simulate the single rotating antenna. Sometimes this technique is known as “pseudo-doppler.”
and NTE-555. These diodes are in low-inductance packages with tabs instead of wire leads, and should be surface-mounted to the etch side of the ASU board, as shown in fig. 2.

optimizing the filter

The reason for "spreading" of the indication with modulation lies in the filter section. First of all, the $Q$ of the switched capacitor filter section is set to 15 by the resistor values. This is far too low, giving poor voice rejection and a response time that is too rapid. Second, the peak in the filter response doesn't occur at exactly the detected Doppler tone frequency.

In a properly designed switched capacitor bandpass filter, the response peak is at an exact submultiple of the clock frequency. The filter peak should follow the clock input exactly, so that any drift in the antenna rotation frequency is tracked by the filter. Due to a characteristic of the MF5* filter IC, the peak will be offset by 0.615 percent if the two 10-k resistors (R16 and R17) are perfectly matched.

Such a good resistor value match is unlikely with the 5 percent resistors supplied. With unmatched resistors, the offset could be up to 10 percent. In the case of the evaluation unit, it was 7.1 percent. Any offset causes phase changes in the filtered Doppler signal when voice modulation and multipath cause amplitude changes in the input tone level. These phase changes result in erroneous changes in bearing on the RDF display.

Fortunately, it's easy to make significant improvements in the filter section. Figure 3 shows the modifications and fig. 4 indicates parts locations. First, raise the value of R12 from 150k to 2.7 megohms. This gives a filter $Q$ of 270. Next, correct the offset problem by making the resistance at R17 0.615 percent (about 61.5 ohms) greater than R16.

Although it's possible to do this by choosing fixed resistors with a precision ohmmeter, there's an easier way that makes use of the greatly increased $Q$ of the filter. Add a 1000-ohm variable resistor in series with R17. Since its adjustment is a bit touchy, a multiturn miniature trimpot is best. Glue it to the circuit board and wire it in; it will become a permanent part of the unit. Set the pot for zero ohms at first.

The pot is adjusted with the control unit hooked up to a completed antenna unit and VHF-fm receiver. Transmit an unmodulated test signal (from a separate transmitter) and measure the filtered df tone at pin 1 of IC5 (the MF5) with an oscilloscope or ac voltmeter.

If an ac voltmeter is used, put a 0.1 $\mu$F capacitor in series with the meter lead to measure the dc level at pin 1 from obscuring the filtered df tone.

Slowly adjust the pot for maximum amplitude of this df tone. The test signal must be unmodulated and full quieting or it will be difficult to find the peak. The setting of the pot will depend on how well matched R16 and R17 are. If the level goes down instead of up as the pot resistance is increased, then R17 is already more than 62 ohms higher than R16. In that case, swap resistors at R16 and R17, set the pot to zero ohms, and try readjusting again.

It's important to mention that the Doppler tone into the control unit does not vary in frequency. Doppler shift introduces instantaneous change in frequency of the received rf signal, causing a tone to come out of the receiver's discriminator in addition to any other fm modulation on the signal (voice, for example). The phase of this tone is important — not the frequency, which is the same as the antenna rotation frequency. If the tone changes in frequency, it's because the

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*This is a National Semiconductor part number. For more information, see the data sheet for the MF10, which is two identical MF5-type filters in one package.
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Antennas are numbered 1 to 4 in clockwise order as viewed from the top of the antenna system.

You can also use an oscilloscope to observe that the control pulses proceed from antenna to antenna in clockwise order. Look at the waveform at each whip. It's low (-0.6 volts) when the whip is on and nearly +12 volts when the whip is off. Sync the scope on whip No. 1 and observe that No. 2, No. 3, and No. 4 follow in proper sequence.

calibration

The DSE manual suggests an obvious method of calibrating and checking a VHF Doppler: just walk around the vehicle with a transmitting handheld and adjust the calibration control on the front panel for correct bearings. But that method won't give optimum accuracy. It's adequate for only a very rough check. Nearby reflections and the near-field characteristics of the signal cause inconsistent and inaccurate indications.

Repeaters or strong base stations that are a mile or more away give better results. The signal should be strong and the path should be unobstructed. The antenna should be in a relatively clear area. For a mobile system, try a large, empty parking lot. Turn the antenna unit or drive the car around in a circle to verify that the bearing is reasonably consistent. Again, don't expect super accuracy on this check, particularly if the repeater is many miles away.

For mobile use, the best final calibration is done with the vehicle in motion. Drive slowly down a long stretch of straight, vacant road with a friend a quarter mile or so ahead, transmitting. With the other vehicle keeping pace ahead of you, adjust the calibration control until the top LED (zero degrees) is on. Now pass the signal source; after you pass, the bottom LED (180 degrees) should be on. Doing the calibration while in motion helps average out the local reflections which can throw off stationary bearings.

The calibration control on the front panel allows for correcting the display to match the orientation of the antenna unit. It also compensates for differing phase delays of the df tone through different receivers. Unfortunately, the control has less than ±90 degrees of range. The display can be rotated in 90-degree steps for more calibration range by rotating the antenna connectors.

For example, let's say that with the signal straight ahead, the calibration control swings the indication from 190 to 330 degrees, but can't get it to zero degrees where we want it. The indication can be rotated 90 degrees clockwise by connecting antenna No. 4 to the D204 input, antenna No. 1 to the D205 input, and so forth. Now the calibration control covers the range 280 to 60 degrees for a straight-ahead signal, which includes the desired zero degree indication.

fig. 4. Parts layout of the bandpass filter. Early units do not have reference designators silk-screened on the board.
using a Doppler RDF in a vehicle

As with any RDF system, it’s important to get to know the gear well before taking it out for an actual hunt. To become familiar with the unit, try to hunt local known signals for practice. The instantaneously updating display of a Doppler RDF unit is easy to read, but there are some subtleties in its interpretation. Remember that it can indicate only one bearing for each rotation of the antenna. When reflected signals approach the strength of the direct signal, the result in a Doppler RDF is a bearing indication that is incorrect for both the direct and reflected sources.

The best strategy is to keep moving and watch the general trend of the indications. By moving along, the effects of close-in reflections are averaged out. Take the time to learn to read the display and listen to the audio out of the speaker in different types of terrain and with different transmitting sites, power, and antennas.

As you drive around you’ll note that the df tone in the receiver audio changes quality from smooth to “raspy.” Raspiness of the tone generally indicates that multipath is present. Multiple Doppler signals are summing together in a random fashion, giving a high harmonic content to the resulting df tone. At worst the tone seems to jump in pitch by exactly one octave, and may stay high for a block or so. Put your greatest trust in the bearings indicated when the tone isn’t raspy or an octave high.

limitations of Doppler RDF gear

Many newcomers to T-hunting have unreasonably high expectations of the many available Doppler RDFs. They think they’ll be unbeatable in the local T-hunts. They also imagine that several Doppler RDFs linked for triangulation will locate jammers with pinpoint accuracy from dozens of miles away. Experienced hunters know that neither is true.

Tests by manufacturers of highly sophisticated commercial and military Doppler RDF systems such as Watkins Johnson, and by long-term users such as the U.S. Coast Guard Auxiliary, have shown that even the very best four-antenna designs have significant inherent inaccuracies when used for medium-distance bearings at fixed sites. Parasitic effects in the antenna system can cause an error of up to ± 5 degrees around the circle when the unused antennas are properly floated or terminated, and far more if they’re not. The readout steps are 11.25 degrees, limiting resolution. On top of all this, atmospheric effects cause additional error. This error can be 15 degrees or more, varying with time of day. It is greatest if part of the path is over land and part over water.

Ten degrees of error at 10 miles causes the line of bearing to miss the source by 1-3/4 miles. Triangulation from three high fixed sites 20 miles apart with a ± 10 degree error margin will produce an area of uncertainty 13.8 square miles in size. This is where the mobile hunters come in; when it comes to pinpointing the source of malicious QRM and gathering credible evidence, there’s no substitute for a cadre of mobile hunters who’ve practiced their skills and become familiar with their gear.

Mobile hunting with any type of RDF setup can be a difficult task when the hunted operator uses sufficient cunning. Competitive hunters using Doppler RDF sets in southern California generally don’t do better than teams using vehicle-mounted beams or quads. But the Doppler RDF’s ease of use and rapid updating make it a good choice, particularly when you’re hunting alone or hunting a mobile jammer. Having high accuracy is less important in a vehicle because the RDF is being used primarily as a “homing” device.

On the other hand, there are situations when a Doppler RDF isn’t the best choice for the task. If the signal is very weak, the lack of gain and the residual switching noise in the Doppler antenna system will make it hard to get accurate indications. If the hunted signal is horizontally polarized, reflected signals (often vertical) will be emphasized with respect to the direct signal into the vertical whips. Again, it will be much more difficult to get an accurate bearing. In those situations, a high gain beam or quad, properly polarized, is a better choice for getting a high-accuracy bearing on the signal.

conclusion

A properly operating Doppler RDF really shines when used in a vehicle for closing in on a fixed or moving RF source. With the modifications suggested in this article, the Dick Smith K-6345 RDF does a respectable job without the need for major redesign. I’d like to hear from other users who discover further improvements.

acknowledgments

I want to thank fellow T-hunters J. Scott Bovitz, N6MI, and Jorge DiMartino, K16MD, for providing information and equipment that assisted in the evaluation and improvement of this unit. Also thanks to the dozens of transmitter hunters in my area who provide challenging hunts for testing of this and other RDF systems.

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Compiled since 1982, this list uses the Maidenhead Locator system, adopted by IARU Region 2 and the ARRL in 1983. The largest unit in the system is a field. A field measures 20 degrees in longitude by 10 degrees in latitude, and is designated by two letters — for example, RJ. There are 324 fields on the earth's surface; the goal is to work all of them on the same band. This is a very difficult task - much more difficult than working all DXCC countries, partly because 54 of the fields are areas on the oceans and partly because very few stations know their own field designators. (Though it may be a long time before locator information becomes part of each QSO, we should all work towards this goal. By exchanging only six characters, such as JO99DK, we can identify the position of our stations within ±10 km anywhere on earth.)

The middle unit of the locator is called a square. To help Amateurs identify their own and other squares, I've produced a 24-page atlas that shows all 32,400 squares worldwide. The atlas is available from Ham Radio's Bookstore ($4.00 plus $2.00 shipping and handling) or directly from me for six IRCs plus a large SASE (minimum size: 9 x 12 inches). The atlas also contains computer programs for determining both locator data (from longitude and latitude) and distance and direction between two locators.

All readers are invited to take part in this competition. The list covers all bands — from 1.8 MHz to 10 GHz — and includes the top 20 operators on each band. The rules are very simple and are presented at the bottom of each list, which is compiled four times per year.

If you'd like to participate, send your information to me as soon after the following dates as possible: March 31, June 30, September 30, and December 31.

By Folke Rosvall, SM5AGM, Vasterskarsringen 50, S-184 00 Akersberga, Sweden
LOCATOR FIELD LIST

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220 MHZ | 1 | W1JR | FN 10 8700301 | 2 K58MJR | EN 4 8600331 | 3 WJR | FN 10 8700301 | 4 WJR | FN 10 8700301 |

432 MHZ | 1 | K2YUY | FN 31 8600331 | 2 W5SJU | EM 5 8600346 | 3 Y7WUJ | KN 26 8500071 | 4 WJR | FN 26 8700301 | 5 WJR | FN 26 8700301 |

902 MHZ | 1 | W1JR | FN 2 8700301 | 2 WJR | FN 2 8700301 | 3 WJR | FN 2 8700301 | 4 WJR | FN 2 8700301 | 5 WJR | FN 2 8700301 |

1.3 GHZ | 1 | K2YUY | FN 26 8500331 | 2 W5SJU | EM 5 8600346 | 3 WJR | FN 26 8700301 | 4 WJR | FN 26 8700301 | 5 WJR | FN 26 8700301 |

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5.7 GHZ | 1 | SM3HYG | JO 1 8600144 | 2 SM3HYG | JO 1 8600144 | 3 SM3HYG | JO 1 8600144 | 4 WJR | FN 1 8700301 | 5 WJR | FN 1 8700301 |

10 GHZ | 1 | SMOD/LJW | JO 2 8600025 | 2 Y5UW | KN 26 8500205 | 3 SM5HYG | JO 1 8600144 | 4 WJR | FN 1 8700301 | 5 WJR | FN 1 8700301 |

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Total output current 500 mA with AC transformer that is included, 1 amp with optional high current transformer or external DC supply. This unit has our popular five (5) year warranty.

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THE APS-1 MAY BE POWERED BY THE POWER ADAPTOR INCLUDED OR MAY ALTERNATELY BE POWERED FROM A VEHICLE OR OTHER 13-17 VDC SOURCE.

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- **Power Requirement (AC)**: 117V ± 10% AC 50/60 Hz 15 Watt
- **Power Requirement (DC)**: 11-16 VDC 500 mA
- **Outputs**: Two 12 VDC unregulated, switched (antenna relay supply). One 6-13 VDC variable regulated auxiliary supply.

TOTAL OUTPUT CURRENT 500 mA WITH AC TRANSFORMER THAT IS INCLUDED, 1 AMP WITH OPTIONAL HIGH CURRENT TRANSFORMER OR EXTERNAL DC SUPPLY. THIS UNIT HAS OUR POPULAR FIVE (5) YEAR WARRANTY.

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- **Oscar 10 Demodulator**...
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3. - 1-100 turns counter...
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DX FORECASTER
Garth Stonehocker, KØRYW

summer thunderstorm noise

At any given moment an estimated 3600 thunderstorms are in progress around the world. They can be classified as air mass, frontal, or orographic, depending on how they are formed.

The main source of summertime QRN is the air mass thunderstorm, which builds up from the sun’s heating the ground and the air above it. Most air mass storms form in afternoons when the humidity is above 50 percent, and last into the night before cooling off enough to dissipate. Air mass thunderstorms linger for several days until rain releases their moisture or they slowly move on. During the evening DXing hours, air mass thunderstorm QRN may limit the usefulness of low-band signals to local ragchewing and rule out, for the most part, weak-signal DX. This QRN, propagated from the equatorial land regions, or closer, increases the overall average noise level on the 80- and 160-meter bands which — except for a small peak at about 10 MHz — decreases as frequency is increased.

The noise can be minimized by careful operating practices. First, try to decrease the receiver bandwidth. You can go narrower until the signal you are demodulating becomes so distorted that readability is affected.

Then, by taking advantage of the directional properties of beam antennas (either parasitic or driven), you can improve overall signal-to-noise ratios by literally steering clear of the major noise source locations. The tropical areas where the noise is mainly generated are concentrated over the land masses. Consulting a world map, look from your QTH toward land mass areas between the equator and the 23rd degree meridian. From the East Coast of the United States, this would be parts of Africa (longitude 10 degrees West); from the southern states, parts of Central America (longitude 75 degrees West); and from the western United States, Southeast Asia (longitude 120 degrees East). If you can avoid pointing your beam at these areas, you can help minimize noise pickup. In fact, if you can get the back of the antenna pointed in that direction, you can use the front-to-back ratio (typically 15 dB) to further decrease noise pickup. This may mean working a DX country over the long path or over the Pole. If the ionosphere will support propagation in that direction and no geomagnetic field disturbance is occurring, you may find that the solution to some of the summer noise problems.

last-minute forecast

The lower frequency bands are expected to be at their best the first two and a half weeks of the month. Solar flux should be low at this time, leading to better signals on east-west paths to Europe and Japan. Geomagnetic disturbances, possible from the 6th to 10th, may reduce MUFs on these paths so that only 80 and 160 meters are available, showing weak signals and OQB. The last two weeks of the month are the higher frequency bands’ time to shine. Solar flux is expected to be highest then; MUFs should also be highest, making long-skip possible at this time. Of course, this is the month when numerous short-skip sporadic E openings are possible, with their subsequent positive effect on the higher bands. Check WWV at 18 minutes after the hour or the Space Environment Services Center (SESC) computer bulletin board (303 497-5000) to verify the solar and geomagnetic data.*

A full moon will occur on the 11th; perigee (closest approach of the moon) is also on the 11th. The Aquarids meteor shower begins on July 18, peaks on the 28th, and lasts until August 7. (All dates are approximate, but close.) The radio-echo rate at maximum is about 34 per hour.

band-by-band summary

Six-meter paths will open for half an hour to a couple of hours on some days around local noon. Sporadic E propagation will make this short-skip path possible out to nearly 1200 miles per hop.

Ten, fifteen, twenty, and thirty meters will support DX propagation to most areas of the world during the daylight hours and into the evening with long-skip out to 2000 miles per hop. Sporadic E short-skip will also be available on many days for several hours around local noon. The direction of propagation will follow the sun across the sky: east in the morning, south at midday, and west in the evening. Long daylight provides many hours of good DXing. Solar flux is low this year, so daytime absorption allows higher signal strengths than usual on these bands during this month.

Thirty, forty, eighty, and one-sixty meters are the nighttime DXer’s bands. On many nights, 30 and 40 meters will be the only usable bands because of thunderstorm QRN. Try the pre-dawn hours for best DX. The direction of propagation follows the darkness path across the sky: to the east in the evening, south around midnight, and toward the west in the pre-dawn hours. Skip distances will decrease to 1000 miles. Sporadic E openings will be observed most frequently around sunrise and sunset. These may be the only signals getting through the noise in the evening. Once again, because of the low solar flux, daytime DX — particularly in the mornings — may be good this month.

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

*Look at next higher band for possible openings.*

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the versatile PAKRATT

Amateur Radio is really dozens of hobbies in one, with communication by radio the common thread. Some of us are dedicated to only one aspect — DXing, for example. Others want to sample many areas. If you’re one of the latter, and have an interest in digital communications, the AEA PK-232 may be for you, particularly if you already have a computer with an RS-232 serial port.

The PK-232 works on Packet, AMTOR, RTTY, and CW on both hf and VHF. By the time you read this, AEA will be shipping an upgrade kit that will let you add software for decoding weather facsimile signals, too.

When RTTY was young, I had a teleprinter that weighed more than I did. With the advent of the microcomputer revolution, RTTY has become much simpler — nowadays it doesn’t take much more than a computer and an appropriate interface. One of the more versatile interface designs is the AEA PK-232 Controller. Weighting in at about 3 pounds, it decodes Packet, CW, RTTY, and AMTOR signals. Connect it to any computer with an RS-232 serial port, and you’re in the digital end of ham radio.

The PK-232’s operating manual covers just about anything you need to know, including the standard advice to “Read the entire manual before you begin.” What ham is ever going to do that? Fortunately, there’s a section titled “Quick Start Installation,” and that’s where I began. The instructions on how to connect the PK-232 to my pc clone and to my radio are clear and easily followed.

The manual also includes a helpful appendix of instructions for connecting the PK-232 to several of the most popular radios. Though this appendix wasn’t referenced in the Quick Start chapter, I found it on my own after I’d hooked up my handheld.

For a computer to act as a terminal, a terminal emulation program is required. I began with a 300 baud Dumb Terminal program. The PK-232 defaults to 1200, but I sent a couple of asterisks and the PK-232 adjusted to 300 baud automatically. (It handles 110 to 9600 baud, with the rate set by command.)

Using the cables supplied, I hooked the Pakratt to my VHF handheld. With just a Rubber Duck for an antenna, I was able to copy one side of a QSO. (“I’ll use the call “W4AAA” as an example.) When the QSO ended, I typed “C W4AAA” and a couple of seconds later my screen showed “**** CONNECTED W4AAA!” That was almost as good as my very first QSO, (a l-o-n-g time ago.) It was brief. I “DISCONNECT-ed” and read more of the manual, discovering that I needed three small flashlight batteries in the unit to make sure it remembered my call and my choice of baud settings as well as other parameters.

Hooked up to an outside whip, I could hear several stations on the handheld, so I tried connecting myself to a digipeater. Any Packet station of course, can act as a digipeater (unless it’s told not to), so I typed in “C VE3ZL VIA W4AAA” and got “**** CONNECTED.” I checked six or seven more stations and found that two or three of them were accessible as digipeaters.

In my ordinary Amateur operating, I do a lot of listening. The same was true when I started using the PK-232. A front panel switch lets you switch between two radios at will (in my case the VHF handheld and my SSB hf rig), so after listening to Packet for awhile on 145.01 MHz, I switched to the hf rig and copied some hf Packet on 20 meters. I was pleasantly surprised to find how easy it was to tune hf signals using the front panel bargraph LED indicator. And the PK-232’s ability to copy weak-signal CW was better than I expected it would be.

Operating the PK-232 is fun, and although it’s easy to go from any one mode to another, I find that most of my operating is on RTTY on 20 or Packet on 2 meters.

If you’re already active on Packet, you may have noticed a message about the PK-232 on some bulletin boards indicating that the wide shift (1000 Hz) used by the PK-232 in RTTY mode isn’t authorized by the FCC. This is not so. Part 97.89 (a)(12) of the latest FCC rules permits 1000 Hz shift — so not to worry!

The PK-232 uses a Z-80 microprocessor, with software in PROM’s. Twenty indicator LED’s on the front panel let you keep tabs on what’s going on.

The PK-232 is priced at $319.95 (Amateur Net). It takes 12 VDC at about 0.7 amp. A power adapter is available for $25.00.

For more details, contact Advanced Electronic Applications, Inc., P.O. Box C-2160, Lynnwood, Washington 98036.

— VE3ZL

Circle #31 on Reader Service Card.

shirt pocket multimeter

Like most Hams, I’m a sucker for neat little gadgets. So when Eaglestone, a division of Siber Hegner of North America, sent me one of their new Ishii Checkman DM-1000 multimeters for review, I jumped at the opportunity.

Over the years I’ve used plenty of different multimeters — from the heaviest analog, drop-em-from-the-Empire State Building and they’ll still work-units to handheld models with digital LCD readouts. What makes the Ishii Checkman unique is that it’s the first one that I’ve seen that will actually fit in my shirt pocket, yet can still be regarded as a commercially reliable instrument.

Weighing in at just 100 grams and measuring only 4 1/2 x 3 x 1 1/2 inches in size, the Checkman is a three-function tester; you can measure dc volts, ac volts, and resistance. The dc volt range is from 200 mV to 500 volts, with an accuracy of ± 2 percent at 200 mV and 1.3 percent at 500 volts. Its ac vol range is 2 to 500 volts at 2.3 percent accuracy, from 40 to 500 Hz. Resistance can be measured from 200 ohms to 20 megohms, with an accuracy of 2 percent at 200 ohms and 10 percent at 20 megohms.

All ranges are automatically set by the meter. Input impedance is 12 megohms at 2 volts and 11 megohms for other ranges. Operating on the principle of dual slope integration, the meter samples the circuit under test twice per second, indicating its readings on a 3.5-digit LCD readout measuring 10 m high.

In tests run using an analog VTVM and another digital multimeter as a control, the Checkman compared favorably. The margin of difference between the three units was insignificant in each test.

This is a neat little meter. It weighs practically nothing and really will fit in your shirt pocket. Technicians will find it easy to carry all day on the job; you’ll no doubt appreciate its small size and portability, too.

Covered by a 30-day, money-back guarantee and a full one-year warranty, the Checkman is available from Eaglestone, 84 Research Drive, Milford, CT 06460.
220-MHz HT
Yaesu U.S.A. has introduced the FT-109R, a 5-watt, 220-MHz handheld transceiver. The FT-109R joins the popular 2-meter FT-209R2 and the 440-MHz FT-709R handhelds.

The FT-109R has a frequency range of 220 to 224.995 MHz in 5- or 10-kHz steps. All features of previous models are incorporated, including the exclusive Yaesu battery saver, ten memories, standard or non-standard offset, as well as memory and priority scanning. The unit comes equipped with a DTMF tone generator; a front panel multimeter indicating battery condition, transmitter power output, or received signal strength; and a VOX system for hands-free operation. All optional accessories are interchangeable with other units in the FT-109, 209, 709 series, including a VOX headset, speaker/mic, programmable tone squelch, dc car adapter, quick trickle desk charger, and a durable leather case.

For details, contact Yaesu U.S.A. Amateur Products Division, 17210 Edwards Road, Cerri-tos, California 90701

Circle #303 on Reader Service Card.

new compact speaker
MFJ Enterprises, Inc. has announced the release of its MFJ-280, a high quality compact speaker for only $18.95.

This unit is a rugged, compact mobile speaker with a tilt bracket on a magnetic base. It comes with a 3-1/2 mm phone plug on the end of a long cord and works well with all 8- and 4-ohm impedances and can handle up to 3 watts of audio. Its dark gray color harmonizes with nearly all rigs.

This MFJ product comes with MFJ's double guarantee. If ordered from MFJ, it may be returned within 30 days for a full refund, less shipping. MFJ also backs this product with its one-year unconditional warranty.

For more information, contact MFJ Enterprises, Inc. P.O. Box 494, Mississippi State, MS 39762.

Circle #302 on Reader Service Card.

PCPLOT version 3
BV Engineering has just released version 3 of its PCPLOT high-resolution graphics program. PCPLOT not only makes linear and logarithmic plots, but will also plot line graphs with error bars, stock market charts, bar charts, and stacked bar charts. PCPLOT supports two in-
dependent Y-axes which can be scaled to different data sets. Data points can be connected with dotted, dashed, or solid lines. Open plots, grid lines, or tick marks may be specified. You can mix line graphs, bar charts, stacked bar charts, stock market charts, and error bars on a single graph. X and Y data may be separately scaled. Legends can be specified on an individual data file basis. Alphanumeric labels can be placed anywhere on the plotting surface. AUTO features enable PCPLOT to take instructions from a file instead of the keyboard.

PCPLOT is compiled in machine code to run quickly. A complete semi-log graph of two data files, each containing 200 data points, takes only 1 minute on a stock IBM PC.

File Version 3 sells for $95.00 and runs on the PCDOS and MSDOS operating systems.

For information, contact BV Engineering, 2200 Business Way, Suite 207, Riverside, California 92501.

Circle Z306 on Reader Service Card.

new QTH for Kenwood

Because of Kenwood's growth over the last several years, it has become necessary to move into a new, larger facility. The building spans over ten acres in Carson, California and employs 200 in the warehouse and offices.

This move represents the final phase of Kenwood's consolidation process, in which Kenwood Electronics and Trio-Kenwood Communications will be joined by a new division, the Test Equipment Group. Collectively, the communications and test instruments sections will create a new group within the Kenwood Corporation, called the Communications and Test Equipment Group.

The new facility is located at 2201 East Dominguez Street, Carson, California 90810.

ultralinear amplifier

WI-COMM Electronics' "Superlarm" series now includes the WLA06M Wideband Ultralinear Amplifier, a broadband, feed-forward amplifier covering the frequency range from 0.4 to 80 MHz. This unit employs a field-proven, feed-forward linearization technique to achieve distortion performance equivalent to a 100 watt linear power amplifier. The 3rd order and 2nd order intercept points are typically 62 dBm and 86 dBm, respectively. A linear output power of 1 watt can be delivered into a 50-ohm load with 20 dB of gain. Noise figure is 6 dB and VSWR is better than 1.5:1. Standard powering is 251 ± 1 VDC, 600 MA.

The amplifiers are housed in a die-cast blue aluminum case with BNC female connectors. The unit is particularly suitable for signal distribution networks, receiver multiconfiguration and intermodulation testing.

For more information, contact WI-COMM Electronics Inc., P.O. Box 5174, Massena, New York 13662.

Circle Z304 on Reader Service Card.

cable and connector guide

Nemal Electronics International has released its new 1987 Cable and Connector Selection Guide. The 36-page guide includes more than 100 new cable and connector products covering a wide array of RF coaxial, microwave, broadcast, communications, and data applications. Extensive cross-references and illustrations simplify selection of the appropriate cable, connector and tooling for any application. The guide also includes information on the design and production of Nemal's line of Cable Assemblies.

For a copy of the guide, contact Nemal Electronics Inc., 12240 N.E. 14th Avenue, North Miami, Florida 33161.

Circle Z307 on Reader Service Card.

repeater controller

The new S-COM "5K" repeater controller is a low-cost, compact addition to S-COM's line of repeater controllers. The state-of-the-art CMOS microprocessor design supports both a repeater and a control receiver, and requires only 60 mA at 12 Vdc. Applications include control of main site repeaters, remote receiver links, portable repeaters, and emergency repeaters.

Operating parameters such as ID call signs, courtesy message, timeout timer, pre- and post-timeout messages, CW pitch, and CW speed, are remotely programmable via DTMF commands, eliminating trips to the repeater site for programming changes. Data is retained in non-volatile memory. Three logic inputs and three logic outputs are provided for site control and monitoring purposes.

Among other features are CW shaping, a watchdog monitor, flexible repeater interfacing, a CW clock and calendar, DTMF muting, security passwords, a "polite" identifier, transient protection, power MOSFET outputs, and high-quality G10FR glass epoxy PC board. The board measures 5 1/2 by 6 inches, with the tallest component only 1/2 inch above the board.

Options include full IC socketing, a 3 3/4 x 19-inch rack mount cabinet, a wall-mount power supply, and an audio delay module. The assembled and tested board, with all connectors and manual, is priced at $179.

For information, contact S-COM Industries, P.O. Box 8921, Fort Collins, Colorado 80525.

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MICROCOMPUTER CONTROL: Gives you the most advanced operating features available.
UP TO 11 NONSTANDARD SLOTS: COMPARE this with other units!
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Full details on each zipper kit and case, plus all the attached kits and cases, may be obtained by contacting Hand Tool Industries, Inc., Department ZC, 1933 Lake Street, Kent, Ohio 44240.

Circle #314 on Reader Service Card.

automatic modulation meter

CT Systems' new fully automatic Modulation Meter, Model 4101, was designed to simplify am and fm modulation testing. Already in use in both field environments and manufacturing facilities, its simple pushbutton switches allow for front-panel selection of function, meter range, filter and de-emphasis.

Automatic measurements can be made from 1.5 MHz to 2.0 GHz of fm deviation to 100 kHz and a-m modulation to 10 percent. Input levels from 3 mv to 1 v, selectable de-emphasis of 50, 75, or 750 microseconds. Both i-f and a-f outputs are standard.

Priced at $1395, the 4101 Modulation Meter has a large easy-to-read meter, three selectable filters and is available with a rechargeable battery option. For information, contact CT Systems, Inc., 5245 Hornet Avenue, Beech Grove, Indiana 46107-0470.

Circle #312 on Reader Service Card.

hf base station transceiver

Incorporating advanced new features, the ICOM IC-761 measures approximately 17 x 6 x 15 inches, and is conservatively rated at 100 watts output on CW, SSB, FSK, and SSTV. The transmitter's 28-volt power amplifier uses two husky 2SC2904's operating in push-pull. An internal whisper-quiet cooling fan and large heat sink are included for continuous 100 percent duty cycle operation.

The IC-761 also includes a built-in switching-type ac power supply plus a built-in automatic antenna tuner. The tuner is capable of matching a wide range of impedances from 16 to 150 ohms.

The IC-761's receiver continuously tunes from 100 kHz through 30 MHz, with sensitivity exceeding 0.15 microwatts. The receiver is a triple-conversion, superheterodyne, featuring a low noise, direct feed mixer circuit. Its dynamic range is 105 dB, with a selectable AGC action.

Receiver performance is further enhanced with passband tuning, i-f shift, i-f notch, and a dual-width adjustable-level noise blanker. Frequencies may be selected via the main tuning knob or entered from the front keypad or from a computer with the ICOM "CI-V" interface kit. Thirty-two memory channels are available with direct memory channel input to VFO "A" or "B" for semi-duplex or split-band operation.

Special CW features include a built-in electronic keyer and a steep-skirted narrow CW filter. CW and RTTY selectivity is 500 Hz at 6 dB and 1,000 Hz at 60 dB. The audio notch null is greater than 45 dB. Semi and full break-in keying is rated to 60 WPM.

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The size, price and performance of these new instruments make them indispensable for technicians, engineers, schools, Hams, CBers, electronic hobbyists, short wave listeners, law enforcement personnel and many others.

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IBM/APPLE COMPUTER program "Hamlog", 18 modules logs automatic. Last Log was DSS/DXC. No. 20718, 1989, IBM $24.95. KA1A1WH, PO Box 1835, Peabody, MA 01960.

COMING EVENTS: Activities — "Planes to go . . ."

SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: Please indicate in your announcings whether or not your Hamfest location, classes, meetings, etc. are sponsored in any way. Information to the contrary would be greatly appreciated by our brother/sister hams with limited physical ability.

ILLINOIS: June 7. The DuPage Amateur Radio Club is sponsoring a Hamfest at the Wood Dale Community Center, 12007 57th Avenue, 57840. Gates open 8 AM. Free parking. State Highway 65. For reservations, contact Tom Rosser, W4KJP, 001 754-5811. For tickets (SASE to Hamfest Chairman, W2LJ, PO Box 4, Glen Ellyn, IL 60137 or call (630) 965-2572 evenings on weekdays.


VIRGINIA: August 2. The 7th annual Winchester Hamfest, sponsored by the Shenandoah Valley ARC, 1801 Westwood Drive, Winchester, 22601. Gates open 9 AM. Lunch available 10 AM - 1 PM. Talk in on 147.22/50. For information: Tom Cutler, N4VQ, 2615 Westwood Drive, Winchester, 22601.

PENNSYLVANIA: August 2. The 5th GOLDEN Hamfest of the South Hills Brass Benders rid Modulators ARC. South Campus of Community College of Allegheny County, West Mifflin. Information and reservations required by July 15. Advance fee $5 and 147.34 simplex. For more information: Doug Watson, WA3VNP, 185 Oneida St, Bethel Park, PA 15101.

WISCONSIN: July 11. The Eau Claire ARC will host its annual Hamfest. 4-H buildings on Fairfield Street, Eau Claire, 8 AM to 2 PM. Tickets $2/advance, $3 door. Free tables and coffee. Talk in on 147.22/50. For information: Reserve tickets SASE to Gerald KA9O/W, 2940 Saturn Avenue, Eau Claire, WI 54703.

TEXAS: August 7. Austin Summerfest. Sponsored by the Austin ARC, 3721 Congress Ave., Austin, 78705. 1200 North Congress, 76019. Gates open 9 AM. Lunch available 10 AM - 1 PM. Talk in on 147.22/50. For information: Kevin Fey, WA5ZCM, PO Box 3747, Austin, TX 78766.

OKLAHOMA: July 31-August 2. Central Oklahoma Radio Association Hamfest. Moes WTP, 5445 North Lincoln Blvd, Oklahoma City, OK. Hi-tech programs in addition to the usual hamfest activities. Includes classes and seminars as non-technical programs. Saturday and Sunday free fest. Saturday tickets SASE. Sunday tickets $3. Pre-registration fee SASE. Pre-registration due July 22 $76.00. Free fest tickets with SASE or pre-registration. Registration 99.00 door. Talk in on 147.22/50. For information: Brickly, K5HJ, PO Box 223, Edmond, OK 73024.


OREGON: July 25 and 26. The Willamette Valley DX Club of Portland will host the annual Northwest DX Convention, Green- wood Inn, Basaltown. For information write Willamette Valley DX Club, 56731 Columbia River Highway, Ste. 100, Heisson, 97035.

BROOKLYN: July 15. The Beacon ARC of Hamfest. Arlington Senior High School, Poughkeepsie/Lagrange. Tickets $3.00. Talk-in on 147.22/50. Doors open 8 AM. Talk in on 147.27/57 and 147.32. For information: Julius Jones, W2HY, RR2, Vanesia Lane, Steubenville, OH 43952. (740) 988-4933.


MONTANA: July 17-18, The Great Falls Area ARC will sponsor their 1st annual Hamfest at the Holiday Inn, 2004 7th Avenue South. For information contact Tom Bailey, KA9C, 1115 2nd Ave South, Great Falls, MT 59401. (406) 452-9856.
OPERATING EVENTS

"Things to do..."

July 12: Eric NFQO and Allen KASJR will operate NFQO/8 at Mt. Clemens, MI from 1200Z to 2100Z to commemorate the 200th Anniversary of the Northwest Ordinance of 1787. Primary frequencies are 2100Z and 1242Z. Secondary area is 10 meters, 20 meters, 40 meters and 80 meters. Operating in A2E, 2092 Westheimer, Houston, TX 77025.

July 15: The Valley ARC will sponsor a special events station at the Staller Brothers "Happy Birthday USA Celebration" in Canton, VA. A.M. 1000Z to 1200Z. For details, write: The South Milwaukee ARC, POB 102, South Milwaukee, WI 53172-0102.

July 19-18: The bolingbrook Amateur Radio Society in conjunction with the City of Naperville, Illinois, will be operating a Special Event Station, KE6E, to commemorate the Revolutionary War. 1400Z to 2100Z. 14, 330, 7, 256. For certificate send QSL card and No. 9 SASE to: Special Event Chairman, Rich Wayne, KE5OR, POB 496, Naperville, IL 60546-0969.

July 5-7: Aboard USS MISSOURI (BB-63). The Naval Postgraduate School ARC (K6SLY) will operate a special event station during Fleet Week Monterey in conjunction with celebration commemorating the Great White Fleet journey of 1907-09. 1700Z to 0100Z. Lower 90 kHz of 20 and 15 meters and Novice portion of 10. For a commemorative QSL card send your QSL card and SASE to: NM, 96 Guevena Drive, Monterey, CA 93940.

July 25-26: The Eastern Michigan ARC will operate K6EPV to commemorate the 50th Port Huron to Mackinac Island Yacht Race. 1400Z to 0200Z each day. For large certificate SASE with VE exam to: K6EPV, 954 Georgia, Marysville, MI 48040.

July 11-12: The HOLMDel ARC will operate K2OR to commemorate the 25th anniversary of the launching of the TELSTAR communications satellite. 1400Z to 2000Z. July 11 and 1200Z to 0200Z. July 12, 20. 40, 80 General phone bands. Lower 25 kHz of Novice phone band. For certificate send QSL and SASE to: HOLMDel ARC, POB 205, Holmdel, NJ 07733.

July 12: The Buzzard's Roost Repeater Club will operate KGDA from downtown Petersburg, Virginia, to help this community commemorate its centennial. QSL with SASE to: KGDA, Larry Lehman, 706 West Fairview Avenue, Albion, VA 24401.

July 26: East Aurora "Racing Day" special event station W2OCF operated by the Pioneer Radio Operators Society (PROS). From the Village Park, once the trotting horse mecca of the world. 10 AM to 5 PM EDT, 9363, 7220, 14205. For a special QSL SASE to W2OCF 301 Parkside Avenue, East Aurora, NY 14052.
an introduction to digital communications

I'll explore some of the hows and whys of digital communications in this month's column. But first, I'd like to report on a wonderful Elmer whose work was just called to my attention: Glenn Shaw, W6NI, of Rockport, Texas.

It seems that Glenn has made it a personal goal to be the first contact for new Amateurs. He's been at this for 20 years or so, and has made a lot of friends along the way. Just think how much easier your first contact would have been if you'd known that the guy at the other end of the path was patient and understanding — and wasn't going to laugh at your faltering attempts at sending call letters, QTH, signal reports, name, and all that stuff that's so hard to do on your first contact!

Several of Glenn's “firsts” have gone on to earn Extra class licenses. Many keep in touch by letter or by radio. Glenn has even developed a special certificate to grace the wall of their shacks.

Great work, Glenn, and may your tribe increase! (And thanks to KA5BWL for calling Glenn to my attention.)

the digital business

Now, on to this digital business. It will be many, many license-renewal periods before this mode begins to seriously crowd the bands, but it's an important part of the communications world, and it will become even more important and widespread than it is now. So, don't throw away that key or microphone just yet, but make room for a keyboard alongside.

We've come to think of digital as being associated with computers, but that's not all there is to it. Radioteletype (RTTY) has been around — and on the Amateur bands — for ages. Audio-frequency-shift keying (AFSK) was used on the 11-meter band (when it was still an Amateur band) in early days of RTTY, and is still widely used on VHF and UHF. After 1953, when the FCC allowed FSK to be used on the Amateur hf bands, the number of RTTY stations that could be heard “RYing” on the air increased monthly.

That was digital communications, even though most Amateurs didn’t think of it as such. It was — and is — information propagated by means of pulses, and the pulses were derived from mechanical contacts in a mechanism activated by a keyboard or by contacts that “read” the holes in a punched paper tape.

Pulses have two levels, or states, to their waveform: high and low. Several conventions are used to describe these states: for example, on and off, 1 and 0, plus and minus, mark and space, and so forth. It's basically a matter of changing the dc voltage level from one resting value to another, and the change from one to the other is rather abrupt. Individually, these pulses don't do much for us — but groups of them can be put together in a well-defined arrangement, or code, to convey information. American RTTY employs a code called Baudot (which rhymes with “doe”); the British use an almost identical arrangement they call the Murray code. The RTTY system uses five pulses (called “bits”) in various sequences that allow transmission of all the letters of the alphabet, numbers, some special functions such as ringing a bell, sending a carriage return and/or a line feed to the receiving station, and others, for a total of 64 characters.

A more modern type of code is called ASCII (from American Standard Code for Information Interchange, pronounced “askey”). This code has seven pulses, with the option of adding another for error-checking purposes (this eighth bit, or pulse, is called a “parity” bit). This allows a code table that includes all the letters, numbers, functions, and symbols you’ll ever need, and some you probably won’t. A sample of the pulse combinations for the letter Y is shown in fig. 1. ASCII tables abound in computer books, handbooks, and textbooks about data processing, so there’s no need for me to repeat one here. However, when you do look at an ASCII table, note that it reads backwards compared with the drawing in fig. 1. Most tables list the bits in order of significance, with the most-significant bit at the left, as at the beginning of a word. Figure 1 shows the sequence as it would be transmitted, with the least-significant bit (B0) first. If you have trouble with the notion of significance, look at the dollar amount of $10,005; certainly the “1” is much more significant than the “5” — right? The drawing also shows what happens when two bits of the same polarity (1 or 0) occur together. The voltage doesn't return to its other state between pulses, but stays at the 1 or 0 value for a time duration equal to two bit lengths. Figure 1 shows two zeros together and two ones together;
fig. 1. Digital communications take place by means of pulses arranged to represent characters. This is the ASCII code for the letter Y. A start pulse informs the receiver that data bits follow. P is a parity bit, used to check for errors.

fig. 2. Frequency-shift keying of an rf carrier can be done by switching an extra capacitor in and out of an oscillator circuit. In this simplified circuit, a "high" dc level (pulse at its "1" state,) will cause the diode to conduct, placing $C_s$ in the circuit, thus lowering the frequency. See text for another method of generating FSK.

the dotted line merely illustrates that there are two bits there.

the bit connection

All this business about pulses and bits and ones and zeros is fine, but how do you apply them to a transceiver? Can you just hook the output of a keyboard to the microphone jack and start cranking out digital stuff? Well, no — not unless you have a very unusual transceiver. You’d get an awful lot of clicks from the fast transitions from 0 to 1 and back (plus an equal number of irate phone calls from your neighboring hams whose QSOs you were messing up).

Two basic methods of transmitting digital information are in use on the Amateur bands today: frequency-shift keying (FSK) and audio-frequency-shift keying (AFSK).

FSK, as used on the hf bands, can be generated by either of two methods. One way is to change the frequency of an oscillator in response to a pulse, with a circuit such as the one shown in fig. 2. In this simplified diagram, a diode is in series with an extra capacitor across an oscillator coil. When the dc level at the anode end of the diode is at 1, the diode conducts, and the capacitor is "in," causing the frequency to be at its lowest value. When the pulse falls below the diode’s conduction level (the pulse is at its "0" state), the capacitor is "out," and the oscillator frequency is higher. The difference between the two frequencies is called "shift," and is usually 170 Hz in most applications. With proper design and careful attention to temperature compensation and mechanical stability, this is a very satisfactory system. For years direct FSK was the only system on the hf bands.

The increased availability of SSB equipment, and the frequency stability of these rigs, has brought forth another method of creating FSK for the digital modes. When you apply a pure sine wave to an SSB modulator, you generate a single-frequency rf carrier (that’s how you tune up your SSB rig, isn’t it?). Now, if you cause the audio frequency (sine wave) to change by the desired shift, the generated" rf carrier frequency is going to change right along with it, with the result that someone listening won’t be able to tell the difference between this method and that described in the preceding paragraph: both produce a shift in the rf carrier frequency in response to the state of the modulating pulse.

The audio frequency can be made to shift by several methods: by using diodes or transistors to switch coil or capacitor values in and out of an oscillator circuit; by switching separate oscillator circuits in and out; or by using a microprocessor to synthesize the audio frequencies needed.

So, it all comes down to this: the “encoding” device — which can be a keyboard, a set of contacts in a mechanical arrangement, or a computer — must be hooked to either an hf transmitter (or transceiver) by means of a diode frequency-shift circuit or to the microphone input of an SSB rig when audio-frequency-shift is used to generate the carrier. For VHF and UHF fm equipment, straight AFSK is used, and audio tones can be applied directly to the microphone input (or sometimes to an auxiliary input circuit that doesn’t need the high gain provided by most microphone circuits).

Most equipment used today includes some form of built-in modulator that translates the strictly dc, on/off pulses into something that a transmitter can work with. You might
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even find it combined with a demodulator and called a *modern* (modulator-demodulator). Whatever it's called, it's connected between the keyboard and the transmitter.

Modern digital equipment available for Amateur use is designed to connect easily to most common transmitters or transceivers, and the manufacturer's instructions make it relatively simple to get a station on the air. However, it's best to read carefully and ask questions to be sure that the pieces can get along with each other (in high-tech language, this is called "compatibility").

**other modes**

Packet Radio — the fastest growing aspect of Amateur Radio today — is a special application of digital codes. There's also a system called AMTOR that really helps overcome errors caused by noise and fading. I'll cover these in one or more future issues. They're both fascinating modes of communication, and once you understand what they can do and why, you'll enjoy untold hours of enjoyable operation. (If you enjoy "alphabet soup" such as RTTY, ASCII, SSB, and others you've seen in this column, wait 'til you get to Packet — with its DCEs, DTEs, layers, protocols, RS-232, CCITs, etc. You'll love it!)

**10-meter prospects**

While we're looking at the digital part of the new privileges, let's not forget the 10-meter band. Although the 10-meter band seems like never-never land at the moment, don't cross it off too quickly. There have been a few openings recently (March and April) where the other side of the world was booming in with "ham-in-the-next-block" signal strength, and some of the signals stayed for hours. As sunspot activity increases gradually over the next three to four years, propagation on 10 meters can only get better. Now's the time to get your new station assembled, tested, fine tuned, and ready for the wall-to-wall DX that 10 meters offers in its better moods. This is a great time to try new skills and modes, when the band is usually dead for DX but provides superb interference-free local communications. So, all you Elmers out there, set up some skeds with your favorite Novices or Techs and help them practice the new techniques; when the world is accessible on 10 meters, they'll be ready to communicate. Meanwhile, if there happens to be a great opening to Europe, Africa, New Zealand, Australia, or the Philippines, they'll be there to enjoy it.

For a more thorough — yet still basic — discussion of digital communications, see *The Digital Novice* by Jim Grubbs, K9EI. Available from Ham Radio's Bookstore, Greenville, NH 03048 for $9.95 plus $3.50 shipping and handling. — Ed.

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<td>Communications Specialists</td>
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<td>S-Com Industries</td>
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<td>Yaesu USA</td>
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Please contact this advertiser directly.

Address_____________________________________________________________________
City __________________________ State ______ Zip ______

*Please contact this advertiser directly.

Please use before August 31, 1987.
Please Order Quickly
So We’ll Have Less to Move

EGE VIRGINIA is moving across town during July.

New address: 14803 Build America Drive, Building B, Woodbridge, Virginia 22191. Same phones.

EGE VIRGINIA
13646 Jefferson Davis Highway
Woodbridge, Virginia 22191
Information: (703) 643-1063
Service Dept: (703) 494-8750
Store Hours: M-Th 10-6
F 10-9
Sat 10-4
Order Hours: M-F 9-7
Sat 10-4

EGE NEW ENGLAND
8 Stiles Road
Salem, New Hampshire 03079
New Hampshire Orders,* Info & Service: (603) 898-3750
Store Hours: M-F 10-4
Sat Noon-H
‘Order a vet1 credit you St
for the call

Terms: No personal checks accepted. Prices do not include shipping. UPS $2.75 per package. Prices are subject to change without notice or obligation. Products are not sold for evaluation. Authorized returns are subject to a 15% restocking and handling fee and credit will be issued for use on your next purchase. EGE supports the manufacturers’ warranties. To get a copy of a warranty prior to purchase, call customer service at 703-643-1063 and it will be furnished at no cost.

Spring
Buyer’s Guide
Catalog Available
—Send $1.

Antennas
Amateur HF Bands
Cushcraft, Butterfield, KLM, Mosley, Hy-Gain, Mini-Products, B&W, Van Gordon, Hustler, Larsen, Antenna Specialists, Centurion, Smiley

Antennas in Stock
for Mobiles, Base Stations, and Handhelds

Everything from mini rubber duckies to huge monobanders

ASK FOR PACKAGE DEALS ON ANTENNAS AND ACCESSORIES

Also...
Antennas for Scanners, CBs, Marine, Commercial, and Short Wave Listening

For Orders & Quotes Call Toll Free: 800-336-4799
In New England (except NH): 800-237-0047
In Virginia: 800-572-4201

More Details? CHECK-OFF Page 98

July 1987
Dynamite Discovery

Communications Specialists' latest excavation brings to light yet another dynamite discovery—our new dip switch programmable SD-1000. No need to tunnel your way through Two-Tone Sequential decoding anymore. We've mined this amazing unit! Now, for the first time, you can stock one unit that will decode all calls in a 1000-call paging system with ±.2Hz crystal accuracy. The EEPROM onboard memory can even be programmed for custom tones, and every unit includes group call. Universal switched outputs control your call light, squelch gate and horn. The SD-1000 can also generate CTCSS and decode Two-Tone Sequential. Its miniature size of 2.0" x 1.25" x .4" is no minor fact either, as its a flawless companion for our PE-1000 Paging Encoder. We ensure one-day delivery and one-year standard warranty. Tap the rich vein of Communications Specialists and unearth the SD-1000 or other fine gems.

$59.95 each

COMMUNICATIONS SPECIALISTS, INC.
426 West Tatt Avenue • Orange, CA 92665-4296
Local (714) 998-3021 • FAX (714) 974-3420
Entire U.S.A. 1-800-854-0547
One of the most complex operating controls of our high-performance mobiles.

You don't have to sacrifice performance to gain simplicity in your mobile operation.

Yaesu’s 2-meter FT-211RH and 440-MHz FT-711RH give you all the performance you look for in a sophisticated, microprocessor-controlled mobile.

With controls that couldn’t be more straightforward and easy to learn, which means no operating complexities to interfere with your driving.

In fact, if you own our handheld FT-23R, you’ve already learned how to use our FT-211RH and FT-711RH. Because all three radios are based on the very same technology.

To begin with, you get an autodialer mic with 10 lithium backed memories, each capable of storing any key sequence up to 22 digits long.

Plus you get: 45 watts output (35 watts on 440 MHz). LCD readout. 10 memories that store frequency, offset and PL tone. (7 memories can store odd splits.) Scan all memories or selected memories at 2 frequencies per second. Band scan at 10 frequencies per second. Tx offset storage. Priority channel scan.

Tuning via tuning knob, or up/down buttons. PL tone board (optional). PL display.


What’s more, each radio is perfect for overhead mounting. Just remove a few screws and flip the control panel 180°.

Discover the 2-meter FT-211RH and 440-MHz FT-711RH at your nearest Yaesu dealer today. If you can turn a knob and push a button, you’ll have high-performance mobile operation mastered.
Three Choices for 2m!

TM-2570A/2550A/2530A

Feature-packed 2m FM transceivers

The all-new “25-Series” gives you three RF power choices for 2m FM operation: 70 W, 45 W, and 25 W. Here’s what you get:

- Telephone number memory and autodialer (up to 15 seven-digit phone numbers). A Kenwood exclusive!
- High performance GaAs FET front end receiver
- 23 channel memory stores offset, frequency, and subtone. Two pairs may be used for odd split operation
- 16-key DTMF pad with audible monitor
- Extended frequency coverage for MARS and CAP (142-149 MHz; 141-151 MHz modifiable)
- Center-stop tuning—a Kenwood exclusive!

- New 5-way adjustable mounting system
- Automatic repeater offset selection—another Kenwood exclusive!
- Direct keyboard frequency entry
- Front panel programmable 38-tone CTCSS encoder includes 97.4 Hz (optional)
 - Big multi-color LCD and back-lit controls for excellent visibility
 - The TM-3530A is a 25 watt version covering 220-225 MHz. The first full featured 220 MHz rig!

DCL Introducing...
Digital Channel Link
Compatible with Kenwood’s DCS (Digital Code Squelch), the DCL system enables your rig to automatically QSY to an open channel. Now you can automatically switch over to a simplex channel after repeater contact! Here’s how it works:

The DCL system searches for an open channel, remembers it, returns to the original frequency and transmits control information to another DCL-equipped station that switches both radios to the open channel. Microprocessor control assures fast and reliable operation. The whole process happens in an instant!

Optional Accessories
- TU-7 38-tone CTCSS encoder
- MU-1 DCLR modem unit
- VS-4 voice synthesizer
- PG-2N extra DC cable
- PG-3B DC line noise filter
- MI-10 extra mobile bracket
- CD-10 call sign display
- PS-430 DC power supply for TM-2550A/2530A/3530A
- PS-50 DC power supply for TM-2570A
- MC-60A/MC-80/MC-85 desk mics.
- MC-48B extra DTMF mic. with UP/DWN switch
- MC-43S UP/DWN mic.
- MC-55 (8-pin) mobile mic. with time-out timer
- SP-40 compact mobile speaker
- SP-47B mobile speaker
- SW-200A/SW-200B SWR/power meters
- SW-100A/SW-100B compact SWR/power meters
- SWT-1 2m antenna tuner

Actual size front panel

KENWOOD U.S.A. CORPORATION
2201 E. Dominguez St., Long Beach, CA 90810
P.O. Box 22745, Long Beach, CA 90801-5745