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ham radio magazine

packet radio PSK modem for JAS-1

focus on communications technology

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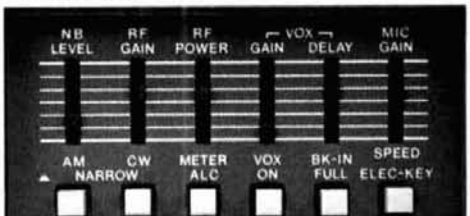

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- **EB-2** external C manganese/alkaline battery case
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- **BH-3** belt hook
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contents

REFLECTIONS

looking ahead to the year 2000: 13 more exciting years for Amateur Radio

In last December's "Reflections" we reviewed the past 13 exciting years of Amateur Radio as reported in *HR Report* and *Presstop*. It's hard to appreciate the extent to which Amateur Radio can change in such a short period until you see it summarized on one crowded page. But as the old saw has it, "You ain't seen nothing yet!"

The art and practice of radio communications has been in a state of flux since even before Hertz, Fessenden, Marconi, and a cast of dozens more started seriously experimenting with "the ether" toward the end of the last century. That's certainly not going to change as this century draws to a close. Look for smaller, smarter, more sophisticated, more efficient versions of the kinds of hardware (not to mention embedded software) we're enjoying today — that's inevitable. And, of course, there'll be comparable new technologies. Just as we've seen a tremendous increase of interest in and use of AMTOR, packet radio and, to a degree, spread spectrum (which, by the way, we in Motorola's Military Engineering Division were examining as an option for "secure battlefield communications" a quarter of a century ago), the next 13 years are sure to see the incorporation of both yet — unthought — of new techniques and revolutionary new applications for well-established techniques. For example, one need go no further than AMSAT's exciting Phase 4, which calls for a geostationary satellite (or satellites) uplinked through "gateway" stations all over the globe. Eventually, a handheld-equipped Amateur operating from almost anywhere will be able to call — selectively — any similarly equipped Amateur virtually anywhere else in the world at any hour of the day or night!

However, it's not in the hardware end of Amateur Radio that the most revolutionary things are likely to happen, but in the perception and application of the Amateur Service itself. Like it or not — and this is a trend that's already upsetting a number of thoughtful, dedicated, active, Amateurs — much of what Amateur Radio is today is going to change drastically or even disappear by the year 2000. Examples of some of these possible new directions may be found in the FCC's *Working Paper 20: Alternatives For Improved Personal Communication*, which was released last September. Authored by Jim McNally, WB3APV, of the FCC's Office of Plans and Policy, this provocative study begins with the assumption that there is a need for some form of readily available "personal communication." Furthermore, it asserts that this need is not being met by any current radio service — namely cellular radio or other common carriers, Amateur Radio, 27 MHz CB, or GMRS (for which McNally also holds a license).

This need, greatly stimulated by the CB explosion of the 1970s, isn't going to go away. If anything, it's going to grow, and services that are unwilling or unable to adjust themselves to accomodate at least some of that need are going to lose — both frequencies and support — to those that do.

What this means to Amateur Radio is that we're going to have to learn to take advantage of this evolution rather than fight it. McNally suggests, for instance, allowing an Amateur's family members limited access to some VHF or UHF frequencies, using the Amateur's callsign. At the same time, there'd also be a correlated relaxation in the limits of "permitted communications." Maybe — at last — we'll even be able to use the autopatch to order a pizza or warn the boss we'll be late for work because of a traffic jam!

Of course, the concept of the Amateur as an experimenter and/or professional communicator isn't going to go away. If anything, it's likely to expand as a more broadly conceived Amateur Radio Service attracts a more diverse group of users who can bring new skills and applications to what is, even today, too widely perceived as a narrow, elitist hobby. Though the popular image of an Amateur cloistered in his basement workshop, punching holes for a new rig in a bread pan chassis, will fade before a growth pattern dominated by entry-level "Communicators" talking through UHF handhelds, there'll still be plenty of room for EME or meteor scatter experimenters, hf traffic handling and DXing, and the kind of all-encompassing technological sophistication that created OSCAR 10 and conceived Phase 4.

Though all this may seem to be radical "pie-in-the-sky" fantasizing to some Amateurs, consider the following: greatly enhanced Novice and Tech privileges are in process at the FCC and may well have been adopted by the time this issue leaves the press. Furthermore, though code-free Amateur license proposals have been knocked flat a couple of times, the concept of further relaxing entry-level Amateur code requirements isn't "out." The Amateur community has demonstrated to the FCC that it is fully capable of running that most vital function of the Amateur licensing program, Amateur examinations. As a result, the Commission is now seriously considering delegating responsibility for issuing Amateur callsigns to the private sector. The long-term implications of this seem obvious — ever-increasing responsibility for self-maintenance and operation, by the Amateur service.

The logical result of all this could very well be — even before the year 2000 — a larger and broader-based, self-administered Amateur Radio Service. Are we ready for such radical change? I hope so!

The next 13 years promise to be most interesting ones for Amateur Radio. Unfortunately, based on the current age profile and the actuarial tables, a shocking proportion of us won't be around long enough to see the new century in and, consequently, all these exciting new developments in Amateur radio, come to pass. I hope I am, and I hope you will be as well.

Joe Schroeder, W9JUV
Associate Editor

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comments

welcome KB2BRL

Dear HR:

My name is Colleen Brady, KB2BRL. I am only 10 years old!

I first got started in learning to be a Ham this past summer. My Dad is an Amateur and I thought that it would be great to get a license too. I wanted to get my license before, but I still needed some more math in school. I have been working on code for a couple of years, but really did serious studying this past summer.

When I started to learn the theory I was surprised that we were covering some of the same things in school. My fifth-grade class was studying powers of 10, and I found out I had a use for them. Now I can note my frequency or even understand what a milliamp is by using 10 to the −3. I told my teacher, and I had the chance to explain how this math can really be useful, and that I was studying to get my license. Another area that I can use both at school and at home is geography. Now not only can I learn maps and countries in school, but I can use them at home too. On only my third contact I had a QSO with HK3IKP in Bogota, Columbia. The other kids in class have studied SA and Columbia, but I have had the chance to *talk* with Columbia! I am doing a Science report on sun spots, because we have studied these in school. My report will be a bit different than the others, since mine will talk about sun spots and propagation with radio waves. I guess there are some things in school that you can use.

In my first month as an Amateur I have had the opportunity to talk with 22 states and two countries. It seems that every time I get on there is a new place to look up on the map. Now I look forward to receiving QSL cards in the mail from these contacts. When learning the Morse Code I found it to be difficult at first. Now, even though it is still difficult at times, it is a lot of fun, and I look forward to making yet another QSO using this form of communications.

I feel I'm a lot luckier than other kids who may want to become a Ham. My Dad, WB2WPM, already has all the equipment. We operate a Kenwood TS-440S, a Cushcraft A-3 Triband, and dipoles for 40 and 80 meters. There's a lot of other equipment too, but until I upgrade I won't be able to use it. I am looking forward to finding an upgrade class this fall so I can get my General class license.

In the picture enclosed you can see my good friend "Lasagna," our 6-month-old Cocker Spaniel. Besides my Dad, my Mom has her Novice license too, KA2TDG. My 8-year-old sister has an interest in being a Ham too. In a year or so I will be able to start to teach her the things she will need to know, so she can have a license too.

Colleen M. Brady, KB2BRL
East Aurora, New York 14052

wanted: M800 RTTY program

Dear HR:

Does anyone have an M800 RTTY program for the TRS80 Model 3 that they're willing to share?

Bernard Gayrard, F6HGB
"Lou Bouis" Laa-Mondrans
64300 Orthez, France

HORANT for CP/M

Dear HR:

Regarding the HORANT program in the October, 1986, DX Forecaster (page 92), I'm sure that you've received many comments on the footnote giving a substitute for ARC SIN (ASN). I use a CP/M version of MBASIC; substituting

*ASIN(Y) = ATN(Y/SQR(1 − Y*Y))*

works fine. Looks like a useful program. Thanks.

Jack G. Hines, K4GIO
Vienna, Virginia 22180

New MFJ-1274 lets you work VHF and HF packet with built-in tuning indicator for $169.95 . . .

. . . you get MFJ's latest clone of TAPR's TNC-2, TAPR's VHF/HF modem and built-in tuning indicator that features 20 LEDs for easy precise tuning

MFJ-1274
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MFJ-1270
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Now you can join the exciting world of packet radio on both VHF and HF bands with a precision tuning indicator . . . for an incredible $169.95!

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Unlike machine specific TNCs you never have to worry about your MFJ-1274 or MFJ-1270 becoming obsolete because you change computers or because packet radio standards change. You can use any computer with an RS-232 serial port with an apropriate terminal program. If packet radio standards change, software updates will be made available as TAPR releases them.

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You can also use the MFJ-1274 or MFJ-1270 as an excellent but inexpensive digipeater to link other packet stations.

Both feature AX.25 Level 2 Version 2 software, hardware HDLC for full duplex, true Data Carrier Detect for HF, multiple connects, 256K EPROM, 16K RAM (expandable to 32K with optional EPROM), simple operation, socketed ICs plus much more.

You get an easy-to-read manual, a cable to connect your transceiver (you have to add a connector for your particular radio), a connector for the TTL serial port and a power supply for 110 VAC operation (you can use 12 VDC for portable, remote or mobile operation).

Help make history! Join the packet radio revolution now and help spread this exciting network throughout the world. Order the top quality and affordable MFJ-1274 or MFJ-1270 today.

MFJ-1273, $49.95

Now you can tune in HF, OSCAR and other non-FM packet stations fast! This MFJ clone of the TAPR tuning indicator makes tuning natural and easy - - it shows you which direction to tune. All you have to do is to center a single LED and you're precisely tuned in to within 10 Hz. 20 LEDs give high resolution and wide frequency coverage.

The MFJ-1273 tuning indicator plugs into the MFJ-1270 and all TNC-1s, TNC-2s and clones that have the TAPR tuning indicator connector.

✓ 248

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Access the world's first flying mailbox with your TNC

a packet radio PSK modem for JAS-1/FO-12

JAS-1, or "Fuji," the first totally Japanese Amateur Radio satellite, was launched flawlessly on August 12th, 1986, from Tanegashima Space Center, located on an island off the southern tip of Japan. It carries two transponders: a traditional one for voice and CW, and a second that functions as the first spaceborne store-and-forward packet radio mailbox. In orbit a thousand miles above the earth, it's inclined at 50 degrees to the equator, with a period of 120 minutes, offering users an aggregate 2 hours of communication per day.

Suppose you want to send a message to someone halfway around the world. You simply send a message to the mailbox, and in less than an hour it's available for retrieval by your addressee.

equipment

What do you need to use the mailbox? In **fig. 1** you'll see that four components are required — a pair of radios, a modem, an AX.25 protocol Terminal Node Controller (TNC) and a terminal. Regular OSCAR users with packet radio stations will have everything shown except the box labeled "modem." Terrestrial packeteers will certainly have the 2-meter equipment and may well have 70-cm SSB receive capability, together with a steerable Yagi. Elevation rotation is highly desirable, but by no means essential; much of any 20-minute satellite pass is low enough to be within the vertical beamwidth of even modest antennas.

Few stations, however, will have the special FO-12 modem. The built-in Bell 202 1200 Baud AFSK modem (modulator/demodulator) found in standard TNCs *cannot* be used with JAS-1/FO-12. You'll have to dis-

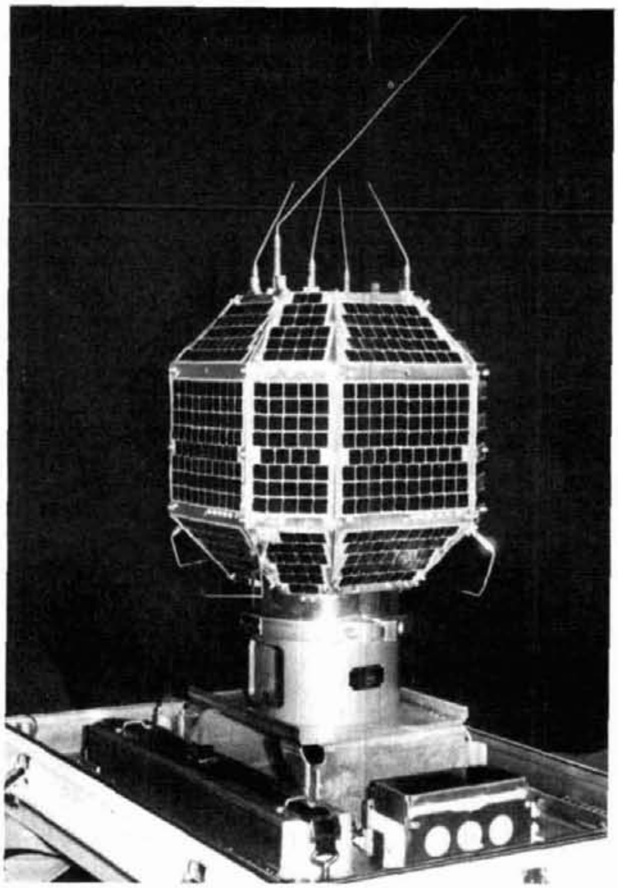


Photo A. Launched in August, 1986, JAS-1 ("Fuji") carries an AX.25 packet radio mailbox. (Photo courtesy JARL)

By James Miller, G3RUH, 3 Benny's Way, Coton, Cambridge, CB3 7PS, England

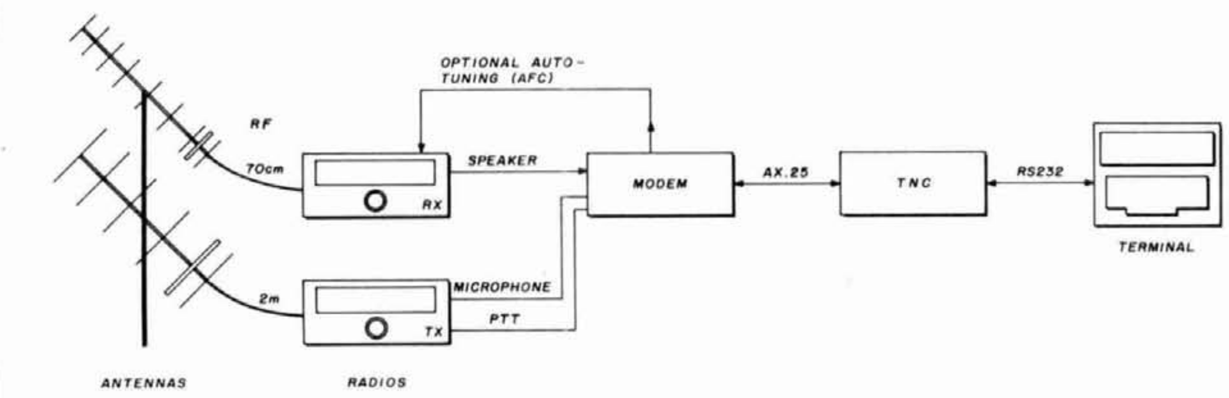


fig. 1. Basic packet station requires addition of special modem for direct JAS-1 operation.

connect the internal modem and substitute an external modulator/PSK demodulator such as the one described in this article. This isn't particularly difficult. Just build the circuit, link it to your TNC with only four or five wires, adjust the audio connections, and the global mailbox is yours to enjoy!

Note: this modem is suitable for your TNC only if your TNC's internal modem can be bypassed. Both the TAPR-1 and TAPR-2 designs allow this (as evidenced by the HD-4040, AEA's PKT-1 and PK-80, PacComm's TNC-200, GLB's TNC2A, and the MFJ 1270, for example).

If your TNC isn't based on the TAPR design, you may nevertheless be able to intercept the RXdata, TXdata and TXclock from their internal modem by cutting tracks. If this appears to be impossible, your best option may be to build a TAPR TNC-2 kit and integrate it with this JAS-1/FO-12 modem, thereby creating a satellite-dedicated TNC.

link format

For reference, here's a brief technical summary of the JAS-1/FO-12 link format. I'll explain unfamiliar terms as we go along:

You receive on 435.910 MHz, SSB/CW mode, in a 2.4 kHz bandwidth. The doppler shift will be up to ±8 kHz, and there is a rate of change up to 40 Hz per second on the highest elevation passes. You transmit on 145.850, 145.870, 145.890, or 145.910- MHz fm; doppler shift correction is unnecessary. An uplink effective radiated power of 100 watts (for example, 10 watts to a 10-element Yagi) is quite sufficient.

The uplink modulation is fm; the downlink is Phase Shift Keying (PSK). Data rates are 1200 bits per second, normal packet NRZI, except that the uplink is exclusive/ored (EXORed) with its own 1200-Hz clock.

modem description

This modem has been designed with as much flexibility as possible so you can tailor it for your particular application. As illustrated in **fig. 2**, it consists of an *uplink modulator*, a *downlink demodulator*, an automatic UP/DOWN *tuner* to track changing doppler shift on receive, and *power supplies*. **Table 1** lists the modem's specs.

Photo B. G3RUH packet radio/satellite station. System components are linked as shown in fig. 1.

The uplink modulator (U1 and U6) takes the signals TXdata (transmitted data) and TXclock from the host TNC and combines them into the TXaudio (transmit audio) signal for the 2-meter fm transmitter. As shown in **fig. 2**, signals flow from right to left. U1 pins 3 and 11 are used as non-inverting buffers. Diodes D1 and D2 prevent U1 from overloading the TNC when the modem is switched off. Note that the modulator ICs use a 5-volt, rather than a 12-volt, supply.

From a TNC-1, TXclock is at 32 times the bit rate. For a TNC-2, it's 16 times, so link LKC selects the correct division ratio from divider U6. The 1200-Hz clock produced at test point TP4 is kept in phase with the data stream by resetting divider U6 on every data transition. This is done from U1 pin 10 and R6-C1, which generate short 16-μsecond pulses. Clock and data are EXORed (this is called "Manchester Coding") in U1

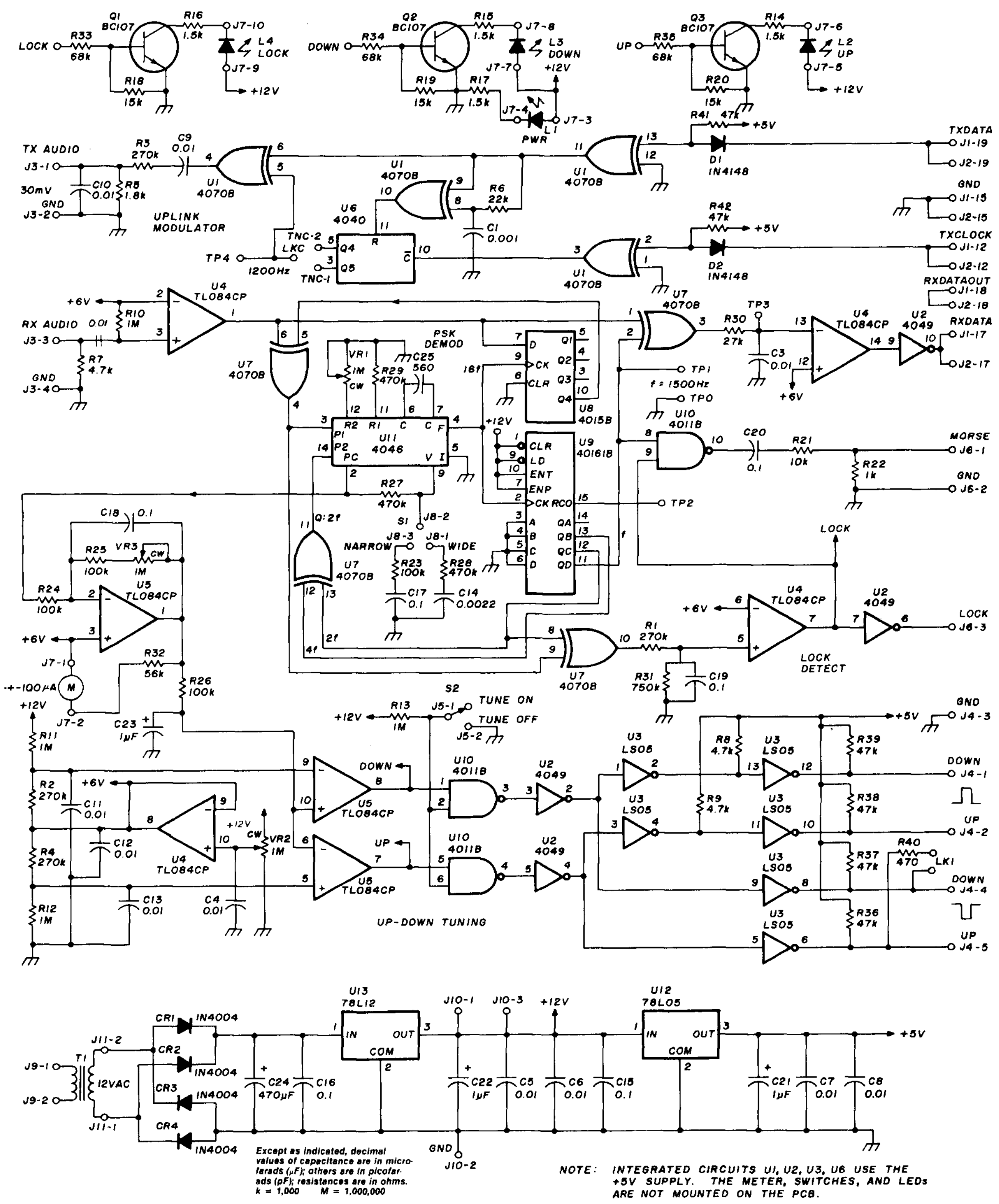


fig. 2. PSK packet radio modem schematic. Modem consists of uplink modulator, downlink demodulator, automatic UP/DOWN tuner, and power supplies.

pins 5 and 6, and the 5-volt peak-to-peak signal at U1 pin 4 is then filtered down to about 30 mV. You can reduce the output voltage if necessary by increasing R3. Superimposing a 1200-Hz clock on the data in this way simplifies the satellite's own electronics considerably.

Note: you may recognize Manchester coding as just PSK in disguise! You can, therefore, use this modem for experimental PSK communication. This subject will be addressed under the heading, "use for terrestrial PSK packet" below.

Considerable effort has gone into the development of the *downlink demodulator* in order to meet the goals of elegance, robustness, simplicity, ease of alignment and testing, minimum number of discrete components, and proper matching to the FO-12 signal characteristics. While it owes its origin to my earlier OSCAR-10 demodulator,[1] it was, in fact, not actually selected until a number of other candidates — both simpler and more complex — had been evaluated.

In contrast to conventional local packet radio, which uses two tones (AFSK) to signal binary 0 or 1, FO-12 uses PSK modulation. The carrier signal PHASE is changed 180 degrees (inverted) when a change in binary level is signaled. You can think of this as using a phase of +90 degrees for "0" and −90 degrees for "1," or vice versa. Either is acceptable because the TNC is interested only in changes.

To demodulate phase-shifted signals you need a phase reference and a phase detector. ICs U7, U8, U9 and U11 recover this reference "carrier" (available at TP1) from the signal. EXOR gate U7 pins 1 and 2 form the phase detector, the output of which is filtered (TP3), limited, level shifted and output to the TNC as RXdata.

A simple phase-locked loop (PLL) can't be used to recover the carrier from a PSK signal because with random data there's no discrete frequency available for a loop to lock onto. Most PSK demodulators have to rely on some non-linear multiplicative processing instead. The recovery circuit used here is a digital "squaring loop."

U4 pins 2, 3, and 1 are a limiter, which simply makes all subsequent signal processing digital. The limited signal is multiplied by itself delayed by 1/4 cycle. The delay is provided by 4-bit shift register (U8), which samples the signal at its pin 7 and is clocked at 16 times the carrier frequency. The multiplication happens in EXOR gate U7 pins 5 and 6. This creates (at U7 pin 4) one cycle of twice the carrier frequency for every zero crossing of the signal. Mathematically we can say the signal is:

$$\cos\left(\omega t \pm \frac{\pi}{2}\right),$$

with the + or − corresponding to data 0 or 1. So the effect of this multiplication is (ignoring amplitude):

$$\cos\left(\omega t \pm \frac{\pi}{2}\right) \times \sin\left(\omega t \pm \frac{\pi}{2}\right) =$$

$$\sin(2\omega t \pm \pi) = \sin 2\omega t$$

or

$$signal \times delayed = constant\ phase\ at\ 2\,\omega$$

The phase-locked loop U11 runs at 16 times carrier frequency. With associated divide-by-16 U9, it locks onto U7 pin 4's double frequency signal, providing a smooth recovered carrier at U9 pin 11. Wide and narrow loop bandwidths can be selected with switch S1 to facilitate initial signal acquisition (use optional).

Recovered carrier, which will be around 1500 Hz, is applied to phase detector U7 pin 2, together with the received signal at pin 1. If they are (for example) in phase, U7 pin 3 will go low, with residual noise being smoothed away by R30-C3. The following op-amp, is used as a comparator/limiter, which then drives 12 volts to the TTL level converter, U2. Signal RXdata then goes off to the TNC.

Two additional circuits complete the demodulator. It's valuable to have a "LOCK" indication. A simple EXOR gate, U7 pins 8 and 9, provides this by multiplying the PLL stimulating doubled-carrier frequency signal by the recovered *2f* signal from divider U9 pin 12. When locked, U7 pin 10 goes high. U4 pins 5 and 6 form a threshold detector, which then drives LED L4 via Q1.

When not in mailbox mode, the satellite sends telemetry in Morse code on 435.795 MHz. Spare gate U10 pins 8 and 9 have simply been wired to provide a regenerated Morse output for (optional) computer use.

With the exception of output buffer U2, the demodulator operates from 12 volts.

This PSK demodulator is completely aperiodic. Its operating frequency is set by VR1, and could in principle operate at the i-f. As shown it tunes from approximately 700 Hz to 70 kHz. The tracking bandwidth is set by R29, and is nominally ±250 Hz. Designed loop bandwidths are 20 Hz and 100 Hz, with a damping factor of 0.7. Data rates faster than 1200 Baud are accommodated by reducing R30 accordingly.

auto-tuning

The received signal frequency changes considerably as a result of doppler shift; a total swing of 16 kHz is typical, with rates of change peaking at 40 Hz per second. Tuning a receiver by hand, maybe even adjusting rotators at the same time, *and* operating a data terminal keyboard clearly poses some logistic problems!

A solution is provided in the auto-tune circuits, which work by activating the UP/DOWN signals of your receiver. They are designed to suit all known ICOM, Kenwood, and Yaesu standards. All differ,

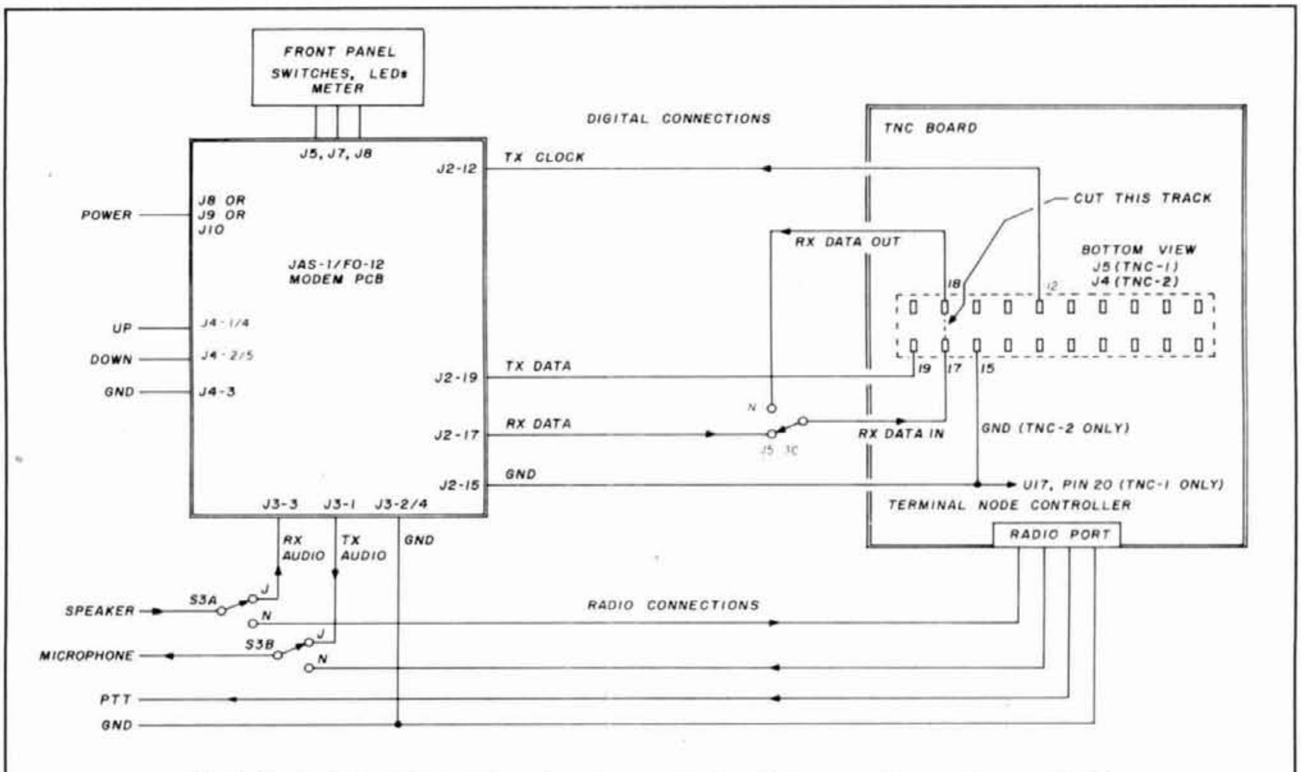


fig. 3. Typical JAS-1 installation, showing connections between radio, modem, and TNC.

Table 1. JAS-1 FO-12 Modem PCB specifications.

Modem:

Downlink: input 50mV to 5-volt rms RX audio. PSK demodulator to TTL digital, 1200 bps.

Uplink: 1200 bps Manchester encoding modualtor to Mic level (about 30 mV p-p) TX audio. RX carrier LOCK LED indication Selectable loop bandwidth. Morse code regenerator.

Connects to AX.25 TNC MODEM DISCONNECT jack. Suitable for TAPR TNC-1 or TNC-2, (and any other, provided the internal modem can be bypassed). TNC digital connections needed include TXdata, RXdata(in), RXdata(out), TXclock, GND.

Digital AFC: tracks changing doppler shift via the UP/DOWN signal lines of your RX rig. Designed for all known ICOM, Kenwood, and YAESU standards. Adjustable for 10-100 Hz per step. Positive pulses, negative pulses, and ICOM bi-level. Tracking ON/OFF switch. Manual tuning indication by LEDs and center-zero meter.

Set-up: three preset pots — for PLL frequency, local 6-volt supply, and UP/DOWN tuning gain.

Power: ac line, built-in PSU; 12-volt ac input; or 12-14 volts dc, a 40 mA.

PCB: 160 by 100 mm (single eurocard) double-sided, plated-through, labeled with instructions. Standard CMOS and LSTTL used. No hard-to-get parts.

even between models from the same manufacturer.

The VCO tuning voltage (about 20 mV/Hz) from U11 pin 2 is amplified by U5 pins 2 and 3, which have gain adjustable from x1 to x10 by VR3. This op-amp also drives a center-zero tuning meter. After filtering by R26-C23, the voltage (which increases for falling frequency) is offered to two comparators, with upper and lower thresholds set by resistor chain R11-R2-R4-R12, 1.28 volts above and below the 6-volt reference. When exactly on tune, outputs U5 pins 7 and 8 are low. If off tune, then the appropriate comparator output goes high.

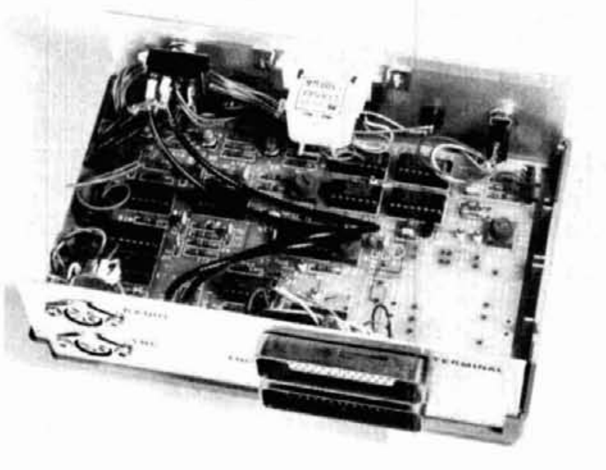


Photo C. Interior and backplane view of modem, showing connectors to radio, TNC, and terminal.

U10 pins 1, 2, 5, and 6, if enabled by Tune ON switch S2, pass the signal via 12 volts to the 5-volt level shifter U2 to the open collector hex inverter U3,

Table 2. Parts list.

C1	0.001μF, 10 percent
C2-13	0.01μF, 10 percent
C14	0.0022μF, 10 percent
C15-20	0.1μF, 10 percent
C21-23	1μF 16-volt tantalum
C24	470μF 25-volt
C25	560 pF, 5 percent
CR1-4	1N4004, etc.
D1-2	1N4148, etc.
DS1-4	LED 10mA
J1	Standard 20-pin IDC Male PCB header, straight (vertical) or right angle. Straight: RS 471-058, 3M 3428-6202JL or 3592-6002JL, Ansley 612-2024 or 609-2027. Right-angle: RS 471-137, 3M 3428-5202JL or 3592-5002JL, Ansley 612-2004 or 609-2007, and many others — e.g. Fujuitsu, Berg, ITT Canon, BICC Vero, etc.
J2-J11	Terminals (about 30) for external connections. Can also use 0.1-inch pitch (center-to-center hole pattern) SIL connectors, (1x2 pin, 5x3pin, 1x4pin, 2x5pin, 1x10pin).
M1	±100 μA meter, RS 259-549, Farnell 143-510
Q1-3	BC107, 2N3904, etc. (NPN)
R1-R4	270 k
R5	1.8 k
R6	22 k
R7-9	4.7 k
R10-13	1 M
R14-17	1.5 k
R18-20	15 k
R21	10 k (all resistors are 5 percent)
R22	1 k
R23-26	100 k
R27-29	470 k
R30	27 k
R31	750 k
R32	56 k
R33-35	68 k
R36-39, 41,42	47 k
R40	470 ohms
S1-2	SPDT toggle switch
T1	12-volt, 3VA Transformer, RS 207-829, Farnell 141-471
TP0,1,2, 3,4	test points
U1,7	4070 Quad Exor
U2	4049 Hex Inverter Buffer
U3	74LS05 Hex Inverter O.C.
U4-5	TL084 Quad op-amp
U6	4040 12-stage divider
U8	4015 Four-bit shift register
U9	40161 Divide-by-16 (MC14161)
U10	4011 Quad two-input Nand
U11	4046 Phase Locked Loop
U12	78L05 5 volt Regulator
U13	78L12 12-volt Regulator
VR1-3	1M Trimmer, 3/8-inch square, flat mounting: RS 187-321, Dubilier D79-30, A-B E2B, Bourns 3386F, Spectrol 63-M or 63M-T-607

LKC, LKI are made from hookup wire

Modular PSU is 12-volt, 100mA (RS 591-281), Farnell 147-545 and others.

NOTES:

The meter, LEDs, and switches are not mounted on the board.

Power supply components T1, CR1-4, C16, C24, U13 (or modular PSU) are optional.

Use of an IDC connector is not obligatory.

Capacitors: 560-pF, 0.4-inch pitch, ±5 percent polystyrene; 0.001-0.1, 0.2-inch pitch, 10 percent dipped ceramic or polyester, 63 to 100 volts typical. 1μF, 0.2-inch pitch, bead tantalum. 470μF 25-volt electrolytic, 1.2-inch pitch, 1.0 x 0.4 inches.

Resistors: Carbon film, 0.25- or 0.5-watt, 0.4-inch pitch.

which creates two pairs of signals. These are high-going UP/DOWN tune signals at J4-1, J4-2, and low-going signals at J4-4, J4-5. All can sink up to 8 mA.

You have to choose the set that suits your rig by referring to your owner's manual. For example, the Yaesu FT726R needs high-going signals, while the Yaesu FT790R uses low-going. The Kenwood 9500 needs low-going. ICOM has a special bi-level standard for the IC741 and similar rigs, where a 0-volt low signals up, and a 1.3-volt level means down, and neither (about 4.2 volts) means no action. So for ICOM rigs, install link LKI, and use J4-5 . . . unless the microphone is left connected. In this case, the link can be omitted, because an R40 will be connected inside the mic housing.

For many rigs that use low-going pulses, the pull-ups R36-R39 can be omitted. You may also have to experiment with the Scan control settings on the receiver. Some rigs tune in 100-Hz steps, others in steps as small as 10 Hz — hence the reason for including an adjustable gain control (VR3).

power supplies

Flexibility is provided so you can choose your own power supply arrangement: either 12 to 14 volts dc, stabilized at 40 mA, or 12 volts ac (about 0.5 VA), or ac mains (line) or a modular encapsulated PSU.

If you supply 12-volt dc (probably the same as used by the TNC), then fit all components on the circuit diagram to the right of U13 (i.e., C22, C5, U12, etc.). Connect power to J10 pins 1 and 2. Pin 3 is 12 volts, too, so if you use SIL (single in-line) connectors, a reversed plug won't lead to disaster.

If you have a 12-volt ac supply, then connect to J11 and fit all the PSU components shown on the bottom of the circuit diagram. The voltage on C24 should nei-

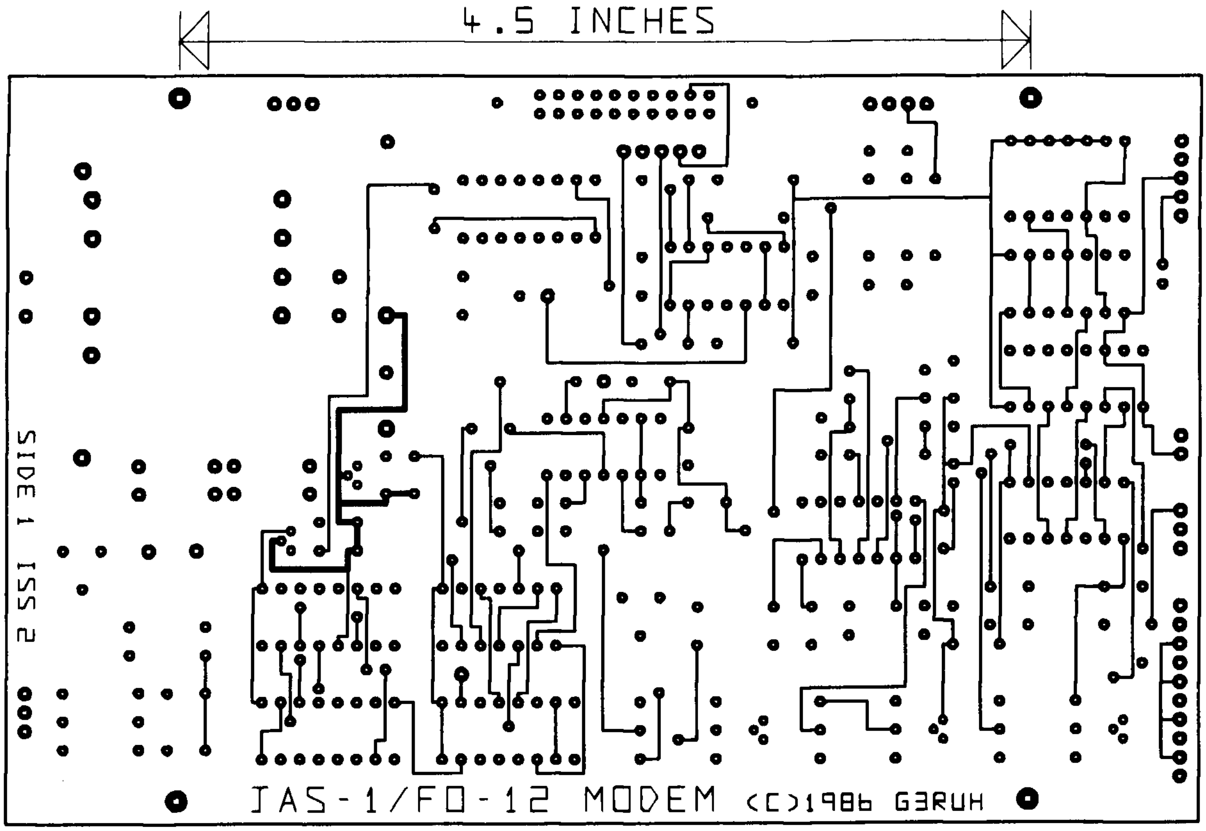


fig. 4A. PSK packet radio modem: top board art (side 1, full-scale).

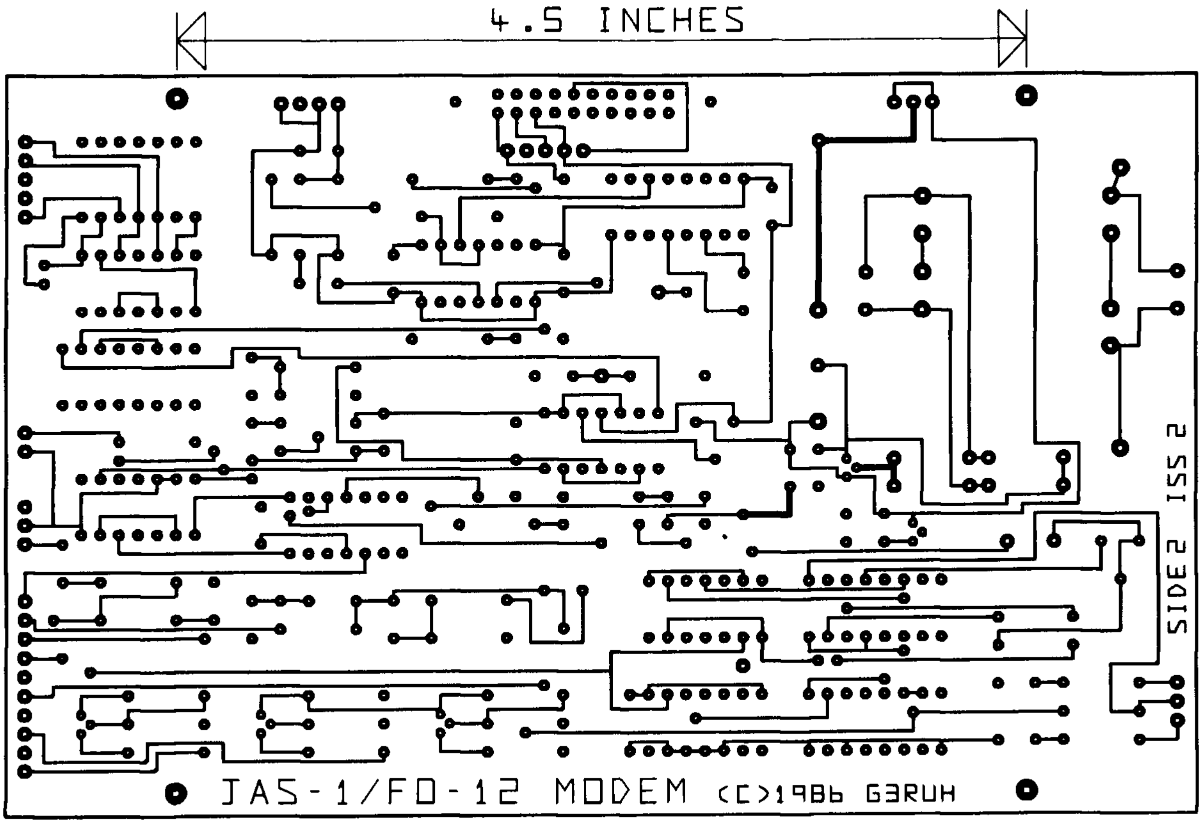


fig. 4B. PSK packet radio modem: bottom board art (side 2, shown full-scale).

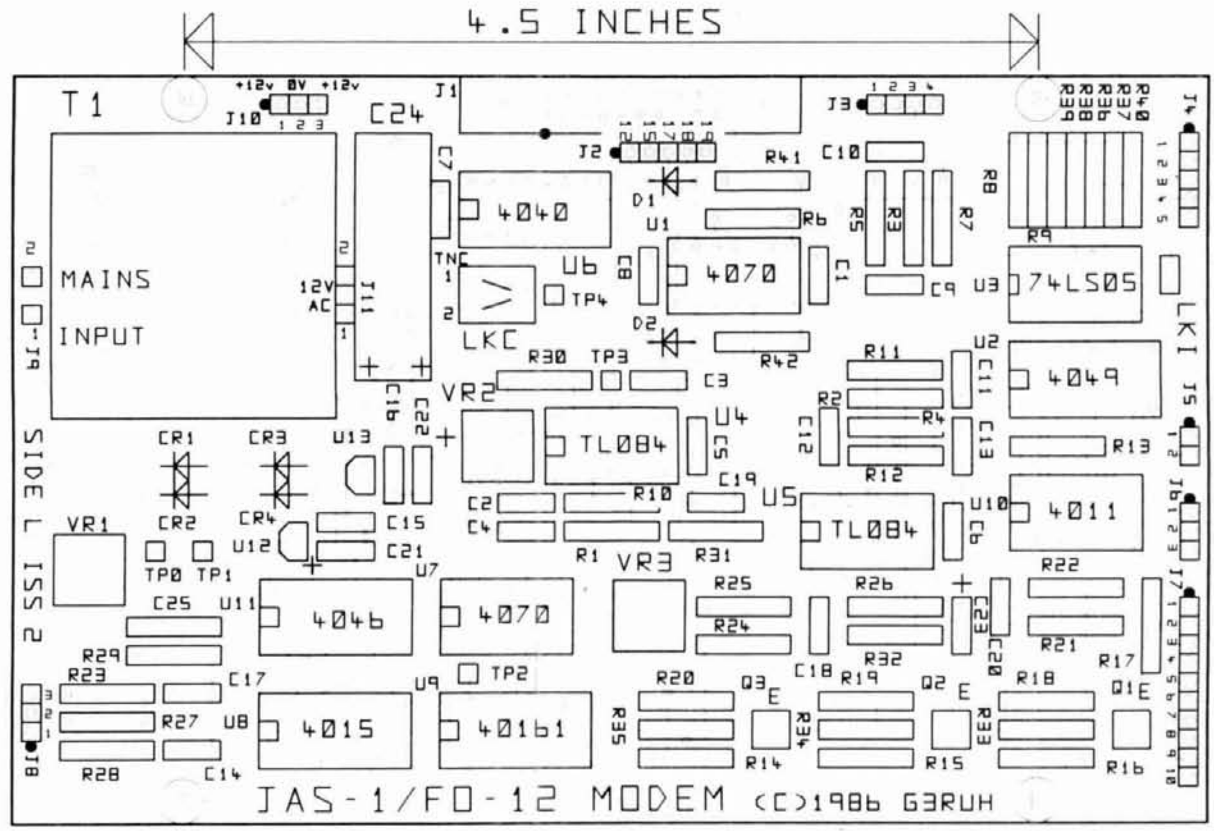


fig. 4C. PSK modem: component layout diagram, shown superimposed on side 1 art. Note components are placed on side 1.

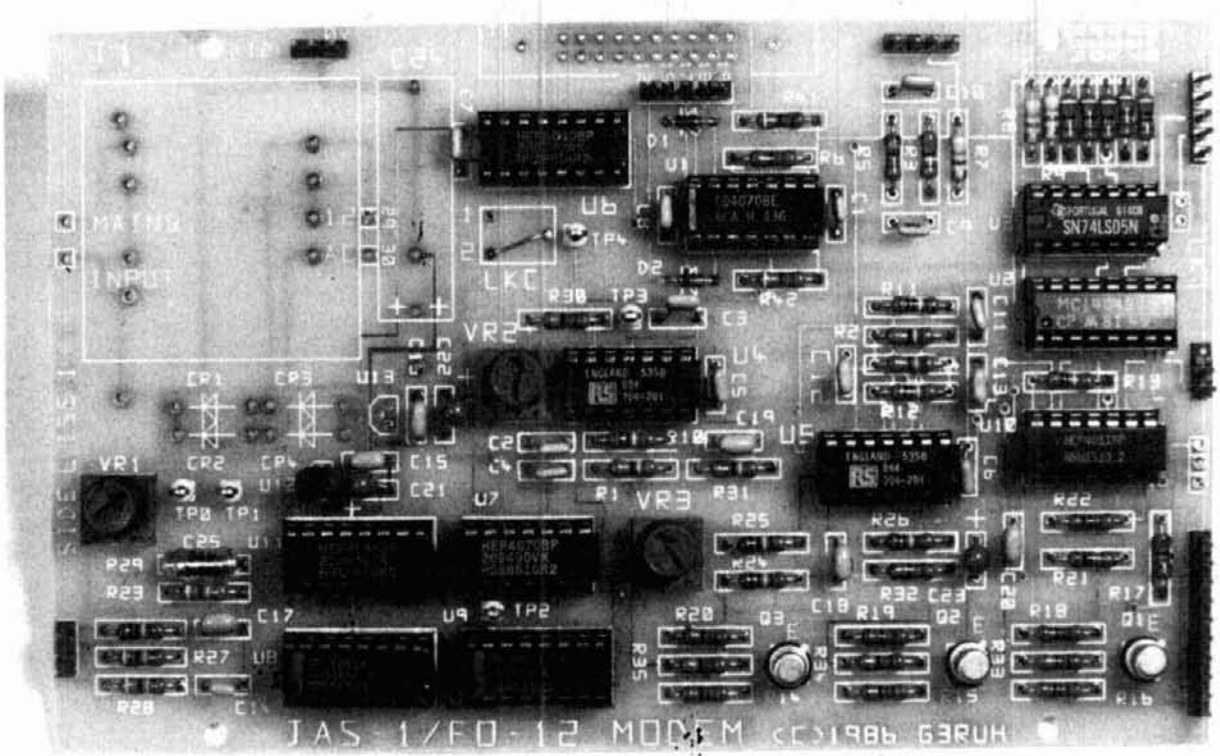


Photo D. Completed circuit board. AC power supply components have been omitted; link LKC is shown for a TAPR TNC-2.

ther drop below 14.9 volts at full load nor exceed 22 volts.

The associated transformer can probably be screwed to the PCB, though you may feel it wiser to place it remotely. The board is drilled for the specified T1, and also for a popular modular PSU (see parts list, **table 2**). Line voltage is applied to J9, at the edge of the board.

If there is 110-volt or 230-volt ac power on this PCB, *you must exercise caution any time the circuit is removed from its enclosure.*

connecting the modem to your system

The modem can be connected to the rest of the system in a number of ways; the minimum requirements are shown in **fig. 3**. First decide whether you're going to use connectors or hand wire it. Select the type of connectors and/or cable you plan to use, and where you're going to locate the PCB. Do you want to dedicate the TNC and modem solely to the satellite application? If so, you could install the PCB permanently within the TNC housing. Do you want to be able to restore instant terrestrial (normal) operation? Then you'll have to use a multi-pole changeover switch (S3) to do this, and put the modem in a properly rf-screened box.

For the radio connections (speaker, mic, and PTT), a socket identical to the one on your TNC can be provided on the modem enclosure, with the signals passing to the changeover switch S3 and then — via a hand-wired connection or another connector plus jumper lead — to the TNC radio port.

connecting to the TNC

The connections necessary for replacing the TNC's standard internal modem with this one are provided on the TNC board at the so-called "Modem disconnect Jack," labeled J5 on the TNC-1 and J4 on the TNC-2. There is no actual connector; the pinout was designed by TAPR to accept a 20-pin IDC plug if required. (See **table 3**.)

Four connections are essential; TXdata, RXdata(in), TXclock, and GND. One PCB track must be cut. A fifth connection — internal modem's RXdata(out) — may also be brought out if you want to be able to restore standard operation with a remote switch. (See **fig. 3**).

Ironically, there's little point in using a 20-conductor ribbon cable if you house the modem in an external enclosure, because screening ribbon is rather messy, and only four or five of the 20 wires are used anyway. However, if your new modem is placed *inside* the TNC enclosure, then it's worthwhile using. For this reason, a 20-conductor IDC facility, J1, has been provided on the PCB. But you'll probably prefer to use J2 instead.

If an external modem is used, select your own method of entry into the TNC enclosure. There are lots of spare pins on the RS232c D-25 wire connector — enough for five digital signals, plus two more for 12-volt power. Choose your pins very carefully, checking that there will be no clash with the regularly used services. I'd suggest pins 12, 15, 17, 18, 19, and 13, 25. Shield all the connections between TNC and the JAS-1/FO-12 modem.

construction

The ready-made PCB for this project is double sided, plated through, and labeled. Full-scale artwork is detailed in **figs. 4A, B,** and **C**. Board and component sources are provided at the end of this article.

The usual caveats apply when assembling the board. Use a fine-tipped iron and fine-gauge resin-core solder. Proceed methodically, checking each soldered joint for integrity immediately after you've done it. Sloppy soldering might send 12 volts back to the 5-volt TNC logic, which will give you no pleasure. I know, I've done it!

Good soldering will flow smoothly through the holes and be visible from both sides. All component leads must be bright and shiny. Any junk box parts — and the PCB as well, if it's been handled too much — will probably need cleaning.

IC sockets are strongly recommended.

If you do manufacture your own non-plated-through PCB, you'll have to drill about 500 holes measuring 0.032 inch (0.8 mm) on the small pads and 0.048 inch (1.2 mm) on the large. Remember to solder every component on both sides, and note that there are 31 through-holes to be wired. Do these first; some will be hidden by components. In addition, if you omit *any* components, you must also install through-wires in their place. Before fitting IC sockets, make sure they're of a type that can be soldered on both sides (many can't) and carefully check for accidental solder bridges between adjacent pins.

Fit components in *ascending* order of height: diodes, resistors, IC sockets, capacitors, trimmers, transistors, and connectors (if you want them). Observe polarity of C21-C24 and all semiconductors. Do not install ICs yet; install them only after PSU testing. Note that the meter, LEDs, and switches are not mounted on the board.

Wire connections to the PCB can simply be soldered into the holes round the board's edge. Note, however, that these holes are spaced 0.1 inch apart to allow for the optional use of SIL plugs and sockets.

For the finishing touch, deflux the board, using a solvent such as 1:1:1 trichlorethylene or alcohol. Besides improving the board's appearance, this will help expose any solder defects. Further excellent advice can be found in reference 2, which also provides useful packet radio information.

SEE AND HEAR THOSE ELUSIVE SCPC SIGNALS WITH AVCOM'S NEW STA-70D TEST ANALYZER!

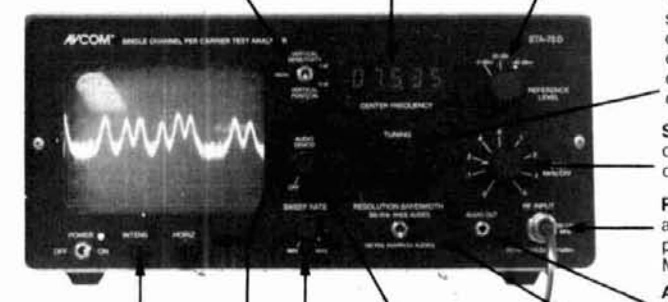
The AVCOM STA-70D IF and FM Test Analyzer was developed to assist in the installation and maintenance of Single Channel Per Carrier (SCPC) satellite reception systems. Designed to be connected to the 70 MHz IF output of a C or Ku Band downconverter the STA-70D displays signal level, interference, and all carriers present. When an antenna is connected to the RF INPUT the FM Broadcast spectrum can be examined. A built in audio demodulator allows the STA-70D to operate as a fixed tune receiver at zero span. This means you not only see the carriers but you can listen to them as well. Price $1960

The STA-70D is adaptable to other than the 50 to 110 MHz frequency band used in SCPC satellite communications. For example the STA-70D can be ordered for use as a spectrum display monitor for special ECM requirements. Possible applications are unlimited call or write AVCOM with your requirements.

VERTICAL SENSITIVITY allows you to change the display between 10 dB/DIV and 2 dB/DIV.

CENTER FREQUENCY is a 5 digit, 7 element LED frequency readout that displays center frequency in MHz.

REFERENCE LEVEL is used to establish the amplitude reference level of the top line of the graticule, either 0, -20, -40 dBm or +49, +29, +9 dBmv.



TUNING allows you to select the center frequency and moves the display "window" up or down the spectrum being displayed.

SPAN controls the width of the spectrum being displayed.

RF INPUT BNC connector accepts signals to be displayed from less than 50 MHz to over 110 MHz.

AUDIO OUT miniature phono jack for low impedance earphones.

RESOLUTION BANDWIDTH Two position switch selects either 100 KHz or 300 KHz resolution bandwidth filters.

INTENSITY controls the brightness of the display.

HORIZ & VERTICAL POSITION these two knobs control the placement of the display on the screen.

SWEEP RATE controls the rate the analyzer sweeps through the frequency band set by span and the rate at which the analyzer sweeps the display.

AUDIO DEMOD turns the audio feature on or off and controls the volume of the internal speaker or the AUDIO OUT miniature phono jack. With the SPAN control set to ZERO (0) the STA-70D will operate as a fixed tune receiver so you can obtain audio identification of the signal displayed.

NEW PSA-35A PORTABLE SPECTRUM ANALYZER

The PSA-35A Portable Spectrum Analyzer accurately measures wide band signals commonly used in the United States and European satellite communications industry. The PSA-35A frequency coverage is from less than 10 to over 1750 MHz, and from 3.7 to 4.2 GHz in 6 bands. The PSA-35A features switch selectable sensitivity of either 2 dB/Div or 10 dB/Div. The portable, battery or line operated, PSA-35A spectrum analyzer is the perfect instrument for the critical dish alignment and tracking requirements necessary for maximum signal reception. Price $1965

AVCOM manufactures many helpful and unique accessories for the PSA-35A, such as the TISH-40 Terrestrial Interference Survey Horn, the WCA-4 Waveguide to Coax Adapter, the SSC-70 Signal Sampler and Calibrator, the QRM-35 Quick Release Rack Mount, AVSAC, and Overlays. Other AVCOM accesories include 2, 4, and 8 way power dividers (with or without DC power block), broad band amplifiers, DC power blocks, line amplifiers, isolated power dividers, and others.

AVCOM manufactures a full line of economical spectrum analyzers, test equipment and accessories for the satellite communication and microwave industries. These include the MSA-65A Spectrum Analyzer, Sweep Generators, Tracking Generators, and others. AVCOM also manufactures SCPC, audio subcarrier, and video satellite receivers for domestic and international reception; including commercial, broadcast, SMATV, institutional, and private use receivers.

NEW!! AVCOM PSA-35A PORTABLE SPECTRUM ANALYZER

10-1750 MHz 3.7-4.2 GHz

INTENSITY controls the brightness of the display.

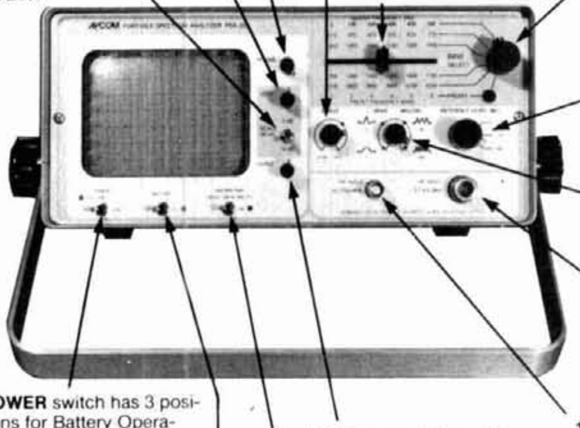
SWEEP controls rate of analyzer frequency sweep and the speed of the trace across the display.

VERT is used to position the display on the screen.

CENTER FREQUENCY control tunes spectrum analyzer through each band and centers signals of interest on the display.

SCALE is used to select amplitude sensitivity of either 10 dB/DIV or 2 dB/DIV.

BAND SELECT controls input frequency range to accommodate IF, BDC, and LNA output frequencies. 12 GHz block downconverter outputs can be examined. One preset band is provided for unusual test situations.



REFERENCE LEVEL controls the sensitivity of the display to allow signals as weak as -85 dBm as well as strong signals to be displayed.

SPAN determines the width of the spectrum being displayed and can be adjusted to display over 500 MHz or less than one transponder in a sweep.

3.7-4.2 GHz RF INPUT is used when observing the output directly from an LNA. Feedline losses can be measured. Can power an LNA with +18 VDC.

POWER switch has 3 positions for Battery Operation, Standby, and AC Line Operation.

BAT CHG switch recharges PSA-35A to at least 80% capacity in about 6 hours.

HORIZ is used to position the display on the screen.

LNA/BDC power for feedline powering of system components via RF input connectors.

10-1750 MHz RF INPUT is used for observing BDC, IF, MATV, and other signals from 10 to over 1750 MHz. Will provide +18 VDC to power system components.

245

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Table 3. TNC connections.

TNC-1	J5 Connections	TNC-2	J4 Connections
12	TX Clock Out	12	TX Clock Out
*	Ground	15	Ground
17	RX Data In	17	RX Data In
18	RX Data Out**	18	RX Data Out**
19	TX Data Out	19	TX Data Out

Cut the track between pins 17 and 18.

*Unfortunately TNC-1 does *not* provide a ground pin on J5. Find a local point, such as the WD-1933 chip (U17) pin 20.
**Optional

final checkout

You will need an oscilloscope, an audio signal source and a multimeter. A frequency counter is desirable, but not essential.

Assuming there are no faults whatsoever, just three preset pots need to be adjusted. However, you should also perform the further tests. The meter, LEDs, and switches must be wired to the PCB. *Do not attach the TNC or radios at this stage.*

First remove all the ICs (U1-U11). Connect the power supply of your choice, verifying that a regulated +12 volts is maintained at J10 pin 1. Verify that +5 volts is found on pin 1 of U2. *Do not proceed if these tests fail.* If they do, you have a power supply problem, which obviously must be fixed first. Check for solder bridges or faulty or misplaced components.

initial alignment

1. Set VR1, VR2 and VR3 to their mid-positions. Set the Loop Bandwidth switch (S1) to NARROW and the Tune switch (S2) to OFF.

2. With power off, insert all ICs. Switch on the power, verifying that both 12-volt and 5-volt supplies are still present. The POWER LED should come on. Ignore all other LEDs.

3. Measure the frequency at TP1, adjusting VR1 until this becomes 1500 Hz; frequency increases clockwise. TP0 is a ground (0 volt) terminal.

4. Adjust VR2 (with VR3 at mid-travel) so that the meter is exactly centered.

5. Set VR3 fully clockwise, re-adjusting VR2 if the meter moves from center. Reset VR3 to mid-position. Neither UP, DOWN nor LOCK LEDs should be lit.

6. Connect a 1500-Hz audio generator at a level of 100 mV to 5 volts rms to the RX audio input, J3-3/4. The LOCK LED *should light. If the frequency is high, the* UP LED will light, with a corresponding movement of the meter. Vary the frequency and check that the DOWN LED lights appropriately.

7. Fine adjustment of the auto-tuning UP/DOWN sensitivity control VR3 is done later.

8. Now for a vital safety check: measure the voltage on every pin of J1, J2, J3, and J4. They should lie between 0 and +5 volts. If for any reason a higher voltage is measured, *find out why — and correct it.* There will almost certainly be a soldering error, component failure, or incorrect component used, which could therefore cause extensive and expensive damage to your TNC or receiver.

demodulator tests

1. Vary the input frequency very slowly, verifying that the PLL stays in lock over a ±250 Hz range approximately. *Though the LOCK LED may go out at tuning* extremes, the UP/DOWN LEDs will be properly lit, and the meter will indicate one extreme or the other.

2. With the audio generator still connected, and with the LOCK LED lit, verify that the demodulator output signal RXdata *is either high* (+5 volts) *or low* (0 volts). Repeat several times by disconnecting the audio, and checking again.

3. Now input receiver noise instead of pure audio. The RXdata signal should jump about at random. The LOCK LED *will go out, and the* UP/DOWN LEDs *and* tuning meter *may flicker.*

4. Final demodulator testing requires a Phase Shift Keyed (PSK) signal. We do this when the modulator has been tested (see "audio loopback," below).

modulator tests

1. The signals TXdata, TXclock and ground must now be connected to the TNC. Switch on the TNC. PCB link LKC should also be connected.

2. *Measure the frequency at* TP4, *which should be a* 1200-Hz square wave. If it isn't, check to make sure you've connected link LKC correctly.

3. Examine TXdata; you should find regular data bits present — "Idling."

4. Now examine the 1200-Hz clock (TP4) and TXdata together. Verify that data transitions are seen only when the 1200-Hz clock makes a negative transition.

5. Examine the modulator output TXaudio at J3-1,2, which will have an amplitude of about 30 mV peak-to-peak. It should have a 1200-Hz clock-like appearance. Each change in TXdata will cause this clock to invert, giving rise to characteristic gaps in the trace.

audio loopback

1. *The TNC should now be connected to a terminal.* Temporarily link TXaudio to RXaudio (J3-1 to J3-3). Re-adjust VR1 very slightly counterclockwise towards 1200 Hz at TP1 until the LOCK LED comes on, and fine tune exactly.

2. *You should now find that you can* CONNECT *to*

your own callsign, and thereby talk to yourself at the terminal. Take this opportunity to study some of the waveforms — for example, the important U7 pins 6, 5, 4, 1, 2, 3, and TP3. Use TP2 as a 1200-Hz negative-going scope trigger; all signals will be synchronized to this. Observe the effect of mis-tuning by varying VR1 slightly.

3. Don't forget to return VR1 to 1500 Hz at TP1 when this test is over.

UP/DOWN tuning

1. If your receiver tunes in 100-Hz steps, you will need to set the loop bandwidth switch (S1) to WIDE. For radios with 10- or 20-Hz steps, use the NARROW position.

2. First verify that the four up-down signals work correctly. Connect a 1500-Hz audio signal to the RXaudio input; set Tune switch (S2) to OFF. Vary the frequency up and down so that the LEDs flash. Verify that there is no change on the UP/DOWN lines on J4. (J4-1, J4-2 will be low; J4-4, J4-5 will be high).

3. Throw the Tune switch to the ON position and see that the four UP/DOWN lines change in the expected manner when the frequency is varied (see circuit diagram). For example, if the UP LED comes on, J4-2 will go high and J4-5 will go low. The others will remain unchanged. Naturally, pull-ups R36-R39 must be installed to measure this. Wire link LKI may need to be connected for ICOM rigs.

4. Place the Tune switch in the OFF position and adjust the frequency to 1500 Hz. Now connect the appropriate UP/DOWN line(s) to the receiver. Turn the switch ON, vary the audio input frequency, and check that an up or a down change in displayed frequency results. Many rigs give a beep when this happens.

5. Set the switch to OFF. Connect receiver audio to the demodulator input (J3-3) as before. Tune in a steady radio carrier exactly, as indicated on the tune meter and LEDs. Set the switch ON. Carefully change the receiver frequency. If the auto-tune system is working satisfactorily, the receiver will automatically retune to the original frequency.

6. Slowly adjust the sensitivity control, VR3, clockwise. Eventually the tuning system will burst into rapid oscillation, hunting rapidly up-down-up-down . . . . Reduce the gain counterclockwise until this stops and back off a little more.

7. You will find that it pays to experiment with performance. You may also have to change the Scan control settings of your receiver. If you have an rf signal generator, a spare transmitter, or a helpful friend on the air, you can quickly optimize performance. Otherwise you must wait for a real satellite signal with changing doppler shift, such as JAS-1/FO-12 in Morse code or digital mode, or UOSAT (145.825 or 435.025 MHz, with your receiver set to CW mode).

using the satellite mailbox

Set the Tune switch to OFF and the bandwidth to WIDE. Locate the mode JD signal at 435.910 MHz, with ± doppler shift of up to 8 kHz. *Slowly* tune the receiver (in SSB/CW mode, maximum bandwidth) until the LOCK LED lights. Center the tuning, set the bandwidth to NARROW (10- to 20-Hz RX steps only), and set Tune to ON if required.

Choose one of the four uplink frequencies: 145.850, 145.870, 145.890, 145.910 MHz fm. Doppler correction is not needed. The mailbox callsign is 8J1JAS, so establish contact (TNC in COMMAND mode) with: **CONNECT 8J1JAS**. When connected, the satellite responds with the prompt: **JAS>**. You communicate with single-letter commands, which may be followed by additional specifiers — for example:

H	Help (respond with commands' syntax)
F	Files (list titles of ten files)
K	Kill (delete specified file or files)
M	Myfiles (list titles of file or files addressed to current user, presumably you)
R	Read (contents of specified file or files)
W	Write (message to mailbox)

When you are finished, return to TNC COMMAND mode, and DISCONNECT.

The mailbox software can be modified by the JARL command station, but the above description is essentially correct. As you can see, it's just like a terrestrial mailbox. LOGIN, and let me know you're winning!

use for terrestrial PSK packet

You can also use this modem to experiment with two-way PSK modulation for terrestrial communications (remember the audio loopback test?) Simply use the transmitter in SSB mode instead of fm. PSK offers at least 10-dB improvement over terrestrial AFSK on fm.

The local audio carrier generated this way is 1200 Hz, which is not at the center of most transmitter SSB passbands. You can change this to another frequency by first breaking link LKC and then injecting the frequency of your choice into the adjacent test point TP4. Use a single-pole, double-throw switch and you can restore normal operation at any time. The frequency needed will lie somewhere in the range 1400-1600 Hz, at a 5-volt TTL level.

follow-up support

You are invited to contact me with any technical queries about this project. You'll get a reply by return mail, provided you supply a self-addressed envelope with 4 IRCs. I can also build and/or test your modem PCB by prior arrangement.

suppliers

For information on the availability of PCBs only, contact AMSAT-UK, London E12 5EQ, England. (Profits will help finance new Amateur satellites.) Bona fide AMSAT groups who wish to order 10 or more PCBs should contact the author directly.

Complete kits including PCBs and components are available from RADIOKIT. (Contact Carl Huether, KM1H, P.O. Box 973, Pelham, New Hampshire 03076).

Readers in the U.K. may order from AMDAT, Crofters, Harry Stoke Road, Stoke Gifford, Bristol, BS126QH, England.

references

1. J.R. Miller, G3RUH, "A PSK Telemetry Demodulator for OSCAR-10," *ham radio*, April, 1985, pages 50-62.
2. *The ARRL Handbook for the Radio Amateur*, ARRL, Newington, Connecticut, 1986, Chapter 24.

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360-degree MINIMUF propagation prediction

Simultaneous view of MUF in all directions — on your C-64

MINIMUF, a method of determining propagation modes and paths by computer, has received wide acceptance and use. Provide the sunspot number or solar flux quantity and the latitude and longitude of the two points between which communication is desired, and a 24 hour prediction of the maximum usable frequency (MUF) is obtained for that path. It's especially helpful for determining the band to use when you're interested in contacting that specific country.

However, what if you're interested in knowing where the band's open to in general? Sure, you could "Listen, listen, listen — as any successful DXer will tell you. But just now you want to get on the air, call "CQDX" and work somebody. Perhaps the whole band is filled with listeners; *somebody* has to break the ice. There's no point in rotating the beam to a nonproductive direction; you have to have some knowledge as to where to point the antenna. Unless you have some other tool at your disposal, all you'll have to go on is your own experience with conditions on that band.

How many of you old-timers remember "Instantaneous Prediction of Radio Transmission Paths," the 1952 *QST* article written by the W6YG boys of Stanford University?[1] It discusses using a rotary beam to generate short transmissions of 50 WPM CW and receiving the back-scatter signals in a radar-like manner, then presenting the results on a PPI (plan position indicator). What they saw, in a 360-degree view, were the areas of the world that were open to propagation, including the first hop as well as second and third hop returns. Marvelous! They could actually see the 20-meter band openings in the morning and the different paths available during the day, and watch the band close when nighttime came. That's what we need for casual operation — a method of determining, with confidence, which direction to point our beam. There's only one problem, however; the FCC won't let us do it.

an alternate method

Dreams like that lie dormant in the mind until the state-of-the-art produces a means of accomplishing the same thing by different (and legal) means. If we accept the validity of the MINIMUF program for prediction of propagation paths — and most of us do — why not modify it to predict 360 degrees of propagation for any given hour, rather then just propagation in only one direction for 24 hours?

Suppose we scribe a circle about our QTH along great circle paths, every 10 degrees. Hold the hour constant in the MINIMUF program and have it predict the MUF for every 10 degrees of bearing. If you

0	DEG.	71.7	LAT.	HOME	LONG.+.1
10	DEG.	70.4	LAT.	62.9	LONG
20	DEG.	67	LAT.	49.7	LONG
30	DEG.	62.3	LAT.	41.5	LONG
40	DEG.	56.9	LAT.	37	LONG
50	DEG.	51.2	LAT.	34.9	LONG
60	DEG.	45.3	LAT.	34.4	LONG
70	DEG.	39.4	LAT.	35.1	LONG
80	DEG.	33.7	LAT.	36.7	LONG
90	DEG.	28.2	LAT.	39	LONG
100	DEG.	22.9	LAT.	41.8	LONG.
110	DEG.	18	LAT.	45.3	LONG.
120	DEG.	13.5	LAT.	49.2	LONG.
130	DEG.	9.5	LAT.	53.6	LONG.
140	DEG.	6.1	LAT.	58.4	LONG.
150	DEG.	3.4	LAT.	63.7	LONG.
160	DEG.	1.4	LAT.	69.2	LONG.
170	DEG.	.1	LAT.	74.9	LONG.
180	DEG.	-.3	LAT.	HOME	LONG.+.1
190	DEG.	.1	LAT.	86.5	LONG.
200	DEG.	1.3	LAT.	92.3	LONG.
210	DEG.	3.4	LAT.	97.8	LONG.
220	DEG.	6.1	LAT.	103	LONG.
230	DEG.	9.5	LAT.	107.9	LONG.
240	DEG.	13.5	LAT.	112.3	LONG.
250	DEG.	18	LAT.	116.2	LONG.
260	DEG.	22.9	LAT.	119.6	LONG.
270	DEG.	28.1	LAT.	122.5	LONG.
280	DEG.	33.7	LAT.	124.8	LONG.
290	DEG.	39.4	LAT.	126.4	LONG.
300	DEG.	45.2	LAT.	127.1	LONG.
310	DEG.	51.1	LAT.	126.6	LONG.
320	DEG.	56.9	LAT.	124.6	LONG.
330	DEG.	62.3	LAT.	120	LONG.
340	DEG.	67	LAT.	111.8	LONG.
350	DEG.	70.4	LAT.	98.7	LONG.

fig. 1. Table of bearing vs. latitude/longitude for the periphery of a 4000 km radius circle around the transmitting site at Cleveland, North Carolina.

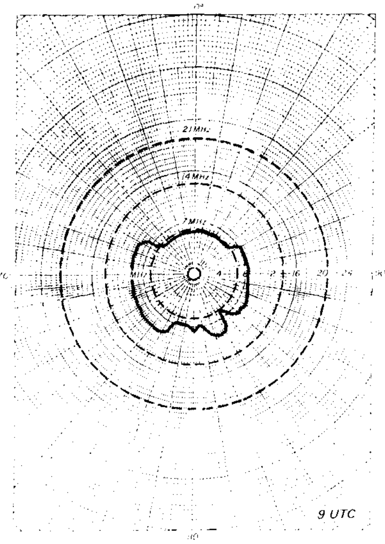
Henry G. Elwell, Jr., N4UH, Route 2, Box 20G, Cleveland, North Carolina 27013

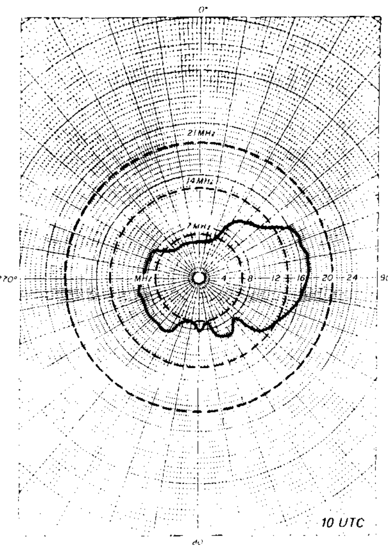
Table 1. Program determines *latitude* and *longitude* of *great circle* locations 4000 km from a specified transmitting site.

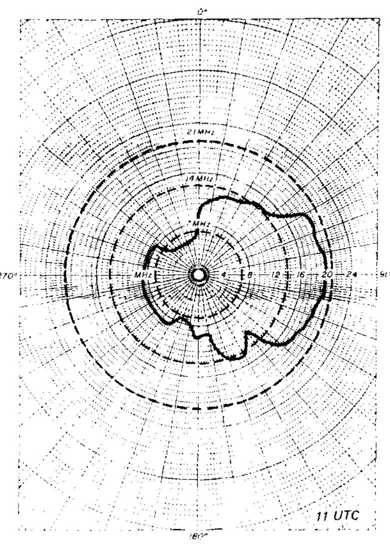
```
1 A$=CHR$(17):REM CURSOR DOWN
2 B$=CHR$(18):REM REVERSE ON
3 C$=CHR$(29):REM CURSOR RIGHT
4 D$=CHR$(147):REM CLEAR/HOME
5 PRINT D$
6 DIMH(40),P(40),T (40)
7 OPEN1,4,6:PRINT#1,CHR$(27)CHR$(69):CLOSE1
8 REM PROGRAM WRITTEN BY HENRY ELWELL N4UH DATED 7 AUGUST 1986
10 PRINTA$A$A$B$"PROGRAM TO DETERMINE THE 4000KM LATITUDE AND LONGITUDE 360 DEGR
EE":
20 PRINTB$" AROUND THE TRANSMITTING SITE TO PROVIDE PROPAGATION PREDICTIONS 360"
:
30 PRINTB$" DEGREES IN AZIMUTH FOR ANY HOUR OF THE DAY. DATA IS GIVEN EVERY ";
40 PRINT"  TEN DEGREES."
45 PRINTA$A$A$A$A$A$C$C$C$C$"PRESS SPACE BAR TO CONTINUE"
46 GETAN$:IFAN$=""THEN46
47 IFAN$=" "THEN GOTO80
50 REM THE FOLLOWING EQUATIONS MUST BE SOLVED FOR INDIVIDUAL LOCATIONS
55 REM FOR DISTANCE LAT.: L2=ARCSIN(SIN(D/60)COS(L1)COS(H)+SIN(L1)COS(D/60))
56 REM L1 IS HOME LAT.:L2 IS DIST. LAT.:D=2160 NAUT. MILES. THE ONLY VARIABLE
57 REM IS H; ALL OTHER ITEMS ARE CONSTANTS ACCORDING TO YOUR LOCATION
58 REM FOR DISTANCE LONG.: SEE LINE 59
59 REM LO2=ARCCOS(COS(D/60)-SIN(L1)SIN(L2) / COS(L1)COS(L2)) + LO1
60 REM WHERE LO2 IS THE DIST. LONG.; LO1 IS THE HOME LONG.; L2 AS COMPUTED ABOVE
70 REM ALL SIN/COS VALUES ARE CHANGED TO RADIANS FOR C-64 COMPUTATIONS.
80 PRINTA$A$:INPUT"WHAT IS YOUR HOME LATITUDE";L1
85 PRINTA$:INPUT"WHAT IS YOUR HOME LONGITUDE";LO1
87 PRINTD$A$A$A$"PLEASE WAIT FOR PRINTOUT"
90 OPEN1,4:
95 PRINT#1,"PRINTOUT OF 4000KM LATITUDE/LONGITUDE FROM 0 TO 350 DEG.; 10 DEG. ST
EPS"
97 PRINT#1:CLOSE1
100 FORH=0TO350STEP10
110 L2=.587785*COS(L1*.01745)*COS(H*.01745)+.809017*SIN(L1*.01745):REM ARCSIN
120 M=L2
130 X=ATN(M/SQR(1-M*M))*57.2957795 :REM LAT. OF DISTANT POINT
140 LETP=INT(X/0.1+.05)*.1:REM PROVIDES LAT. OF DISTANT PT. TO ONE DEC. PT.
170 REM X REPLACES L2 IN FORMULA FOR Y FOR CONVENIENCE IN ASSIGNING VARIABLES.
180 Y=(.809017-(SIN(L1*.01745)*SIN(X*.01745)))/(COS(L1*.01745)*COS(X*.01745))
190 S=(π/2-ATN(Y/SQR(1-Y*Y)))*57.296
195 IFH<180THENS=S-LO
197 IFH>180THENS=S+LO
198 T=INT(S/.1+.05)*.1
199 IFH=0THENOPEN1,4:PRINT#1,CHR$(16)"07"H;CHR$(16)"10"" DEG.";CHR$(16)"20"P;
200 IFH=0THENPRINT#1,CHR$(16)"26"" LAT.";CHR$(16)"40"" HOME LONG.+.1"
201 IFH=0THENCLOSE1:NEXTH
202 IFH=<90THENOPEN1,4:PRINT#1,CHR$(16)"06"H;CHR$(16)"09 DEG.";CHR$(16)"20"P;
203 IFH=<90THENPRINT#1,CHR$(16)"26 LAT.";CHR$(16)"40"ABS(T);
204 IFH=<90THENPRINT#1,CHR$(16)"47"" LONG":CLOSE1:NEXTH
205 IFH=180THENOPEN1,4:PRINT#1,CHR$(16)"05"H;CHR$(16)"08"" DEG.";CHR$(16)"20"P;
206 IFH=180THENPRINT#1,CHR$(16)"26"" LAT.";CHR$(16)"40"" HOME LONG.+.1"
207 IFH=180THENCLOSE1:NEXTH
208 OPEN1,4
210 PRINT#1,CHR$(16)"05"H;CHR$(16)"09"" DEG.";CHR$(16)"20"P;CHR$(16)"27""LAT.";
215 PRINT#1,CHR$(16)"40"ABS(T);CHR$(16)"47"" LONG.":CLOSE1:NEXTH
59999 END
60000 OPEN15,8,15,"S0:LAT/LONG PROP.PR":CLOSE15:SAVE"0:LAT/LONG PROP.PR",8

READY.
```

Table 2. Program provides 360-degree propagation prediction for a given hour of the day.

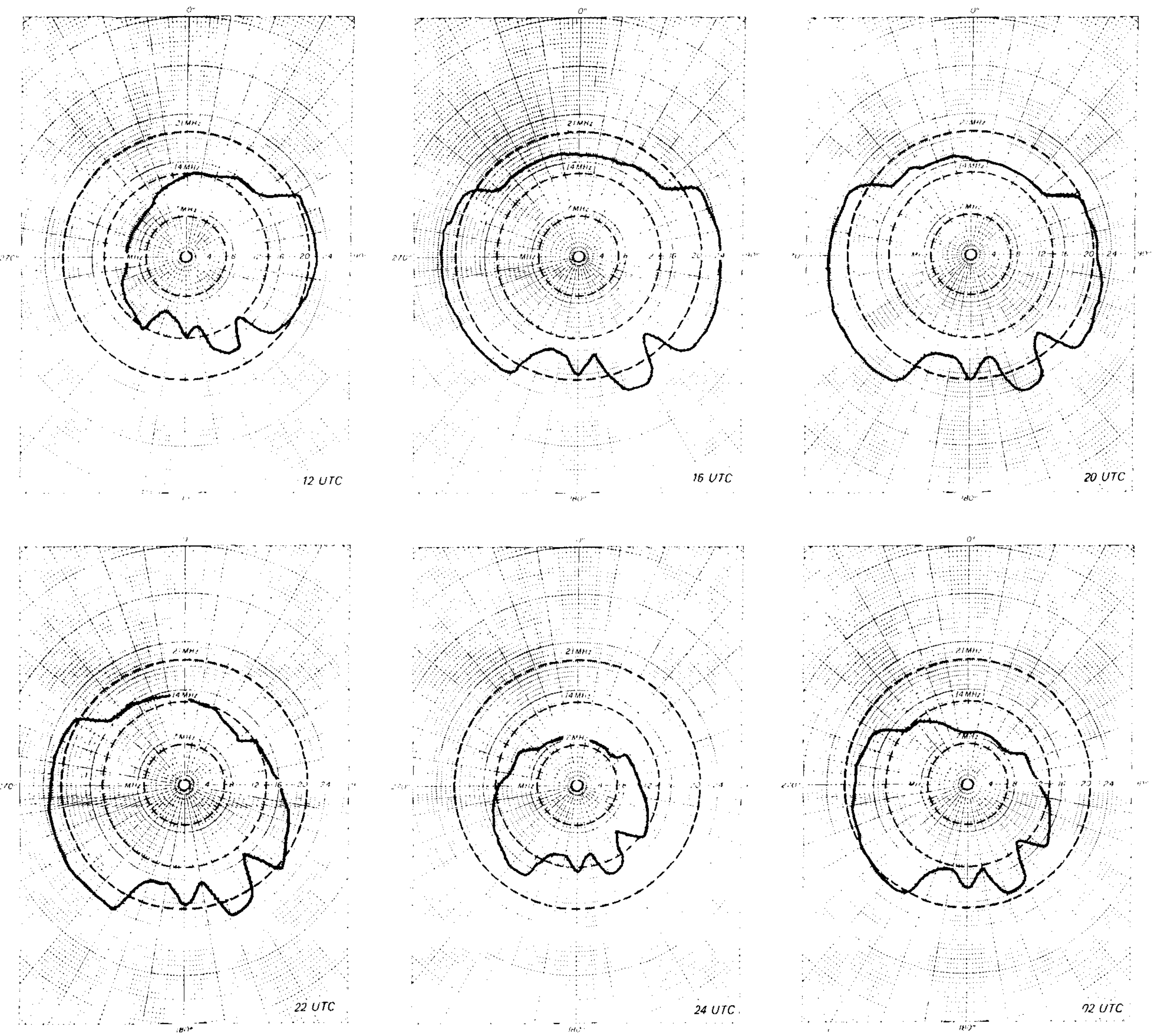
```
READY.
READY.
HOUR OF THE DAY
TABLE 2: PROGRAM TO PROVIDE 360 DEGREE PROPAGATION PREDICTION FOR A GIVEN
2 REM THIS PROGRAM PROVIDES A MINIMUF PROPAGTION PREDICTION FOR 360 DEGREES
3 REM FOR A SPECIFIED TIME FROM 0 TO 24 HOURS GMT
4 REM IT HAS BEEN MODIFIED BY HENRY ELWELL N4UH TO DO THAT FROM AN EARLIER
5 REM PROGRAM BY ALAN MEMLEY. KE6UY
6 REM THE REVISED PROGRAM IS DATED 7 AUGUST 1986
10 PRINT CHR$(147):"LOADING PROGRAM"
11 A$=CHR$(17):REM CURSOR DOWN
12 B$=CHR$(18):REM REVERSE ON
13 C$=CHR$(19):REM HOME
14 D$=CHR$(29):REM CURSOR RIGHT
15 E$=CHR$(145):REM CURSOR UP
16 F$=CHR$(147):REM CLEAR/HOME
17 G$=CHR$(158):REM CONTROL-YELLOW
20 FOR N = 0 TO 96
30 READX:POKE(53000+N),X
40 NEXT N
50 PRINT CHR$(147)
60 DATA 169,127,162,4,160,0,32,186
70 DATA 255,169,0,32,189,255,32,192
80 DATA 255,176,74,169,0,133,253,169
90 DATA 4,133,254,162,127,32,201,255
100 DATA 162,25,169,13,32,210,255,32
110 DATA 225,255,240,49,160,0,177,253
120 DATA 133,252,41,63,6,252,36,252,16
```







figs. 2, 3, 4: MUF propagation predictions from North Carolina at 09, 10, 11, UTC (solar flux = 70).



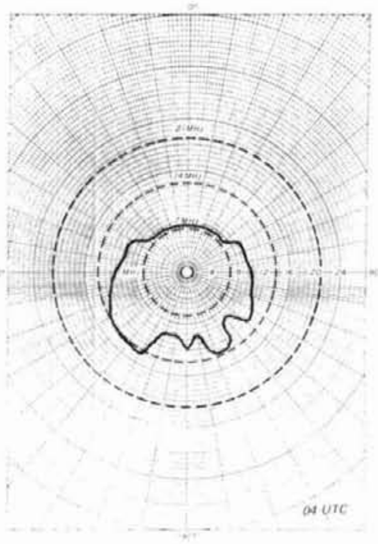
figs. 5-10: MUF predictions from North Carolina at 12, 16, 20, 22, 24, 02 UTC (solar flux = 70).

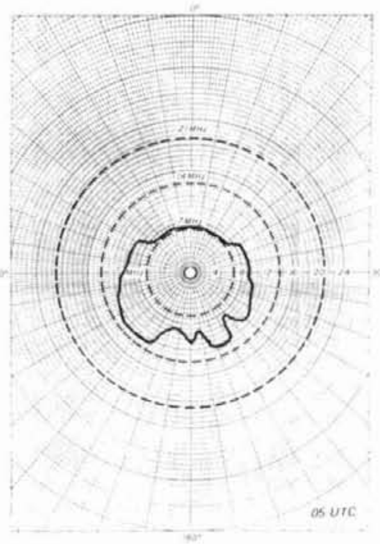
plot the MUF vs. circular degrees on polar coordinate paper, you'll have somthing very similar to the radar plots of W6YG. For any given hour you'll be able to see which bands are open or closed and in what direction you should point your beam.

One of the inevitable questions that follows this suggestion is "What distance from the home QTH should be used as a constant?" Ordinarily, you're not faced with that question in the MINIMUF program because you're concerned only with the latitude and longitude of the sending and receiving locations. True, some of the MUF programs give you the distance just for information; however, now we're going to select some arbitrary constant distance from our QTH and determine the latitude and longitude of those places every ten degrees from 0 to 360 degrees.

The following logic was used to arrive at that arbitrary distance. The W6YG boys got back-scatter from the first hop, the second hop, and even the third hop. We can get theoretical first hop by using the assumptions of the ITS[2] group who use 4000 km as the reference hop length. Four thousand km per hop length requires very low elevation angles of radiation and reception — less than about 3 degrees. Not many of us have antennas that will provide substantial ener-energy at those angles, but let's stretch it. Bob Rose, W6GKU, in his December, 1982, *QST*[3] article says the MINIMUF program is good from 250 miles to 6000 miles, so 4000 km (2500 miles) should be an acceptable number to use. We'll use it for the first hop point.

The data describing the great circle around your QTH with a radius of 4000 km must be tailored specifically to your location. You have to determine the latitude and longitude of the periphery of that circle





figs. 11, 12: MUF predictions from North Carolina at 04 and 05 UTC (solar flux = 70).

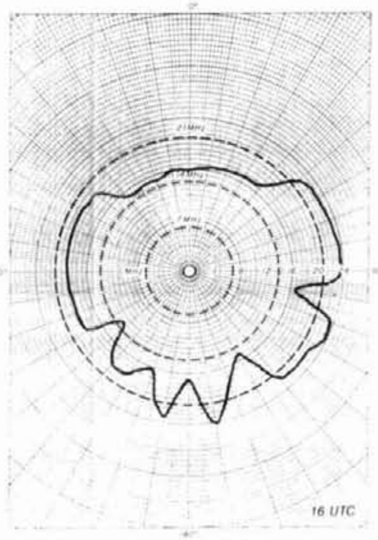


fig. 13. MUF propagation prediction from Los Angeles, California at 1600 UTC at a solar flux of 70.

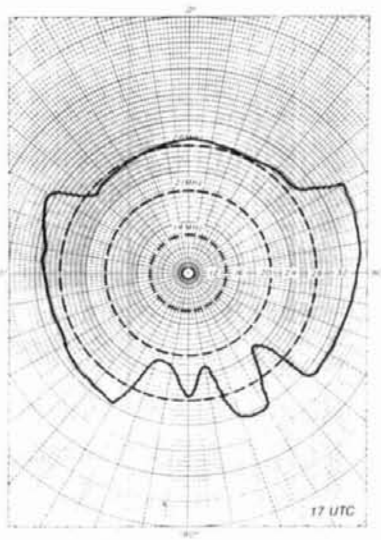


fig. 14. MUF propagation prediction from North Carolina at 1700 UTC at a solar flux of 180.

Table 2, continued.

```
130 DATA 2,9,128,112,2,9,64,32,210,255
140 DATA 200,192,40,208,230,152,24,101
150 DATA 253,133,253,144,2,230,254,202
160 DATA 208,205,169,13,32,210,255,32
170 DATA 204,255,169,127,76,195
180 REM MINIMUF FOR COMMODORE-64/ALAN MEMLEY, KE6UY
200 POKE 53280,14
210 POKE 53281,6
220 PRINT G$
230 PRINT F$
250 DIMM$(37),A$(4),M(12)
260 DATA31,28,31,30,31,30,31,31,30,31,30,31
270 FORX=1TO12:READM(X):NEXT
280 M$="JANFEBMARAPRMAYJUNJULAUGSEPOCTNOVDEC"
290 RO=π/180
300 P1=2*π
310 R1=180/π
320 PO=π/2
330 PRINT F$
340 L1=35.75:W1=80.75 :REM THE USERS HOME LATITUDE AND LONGITUDE MUST GO HERE
345 L1=L1*RO
```

Table 2, continued.

```
350 W1=W1*RO
430 GOTO600
478 REM THE BEARING, LATITUDE & LONGITUDE OF THE USER'S LOCATION MUST REPLACE
479 REM THAT SHOWN, WHICH IS FOR CLEVELAND NC ONLY
480 DATA0,71.7,80.7,10,70.4,62.9,20,67,49.7,30,62.3,41.5,40,56.9,37,50,51.2,34.9
481 DATA60,45.3,34.4,70,39.4,35.1,80,33.7,36.7,90,28.2,39,100,22.9,41.8
482 DATA110,18,45.3,120,13.5,49.2,130,9.5,53.6,140,6.1,58.4,150,3.4,63.7
483 DATA160,1.4,69.2,170,.1,74.9,180,-.3,80.7,190,.1,86.5,200,1.3,92.3
484 DATA210,3.4,97.8,220,6.1,103,230,9.5,107.9,240,13.5,112.3,250,18,116.2
485 DATA260,22.9,119.6,271,28.1,122.5,280,33.7,124.8,290,39.4,126.4,300,45.2,127
486 DATA310,51.1,126.6,320,56.9,124.6,330,62.3,120,340,67,111.8,350,70.4,98.7
487 DATA-1,0,0
488 :
500 READH,L2,W2
501 IFH=-1THENRESTORE:GOSUB3050:PRINTB$A$A$"PRESS P-PRINT:Q-QUIT:T-TRY AGAIN"
502 IFH=-1THENGOTO3000
590 GOSUB2640:GOTO865
600 PRINT:INPUT"DATE (DAY,MONTH):";D6,MO
610 IFMO<=12THEN640
620 PRINT "INVALID MONTH, MUST BE IN RANGE 1-12"
630 GOTO600
640 IFM(MO)-D6<0THEN660
650 GOTO680
660 PRINT "INVALID DAY"
670 GOTO600
680 PRINT:INPUT"SOLAR FLUX NUMBER:";SF
681 IFSF<70THENPRINT"DO NOT USE SF < 70":GOTO680
682 PRINT:INPUT"WHAT GMT DESIRED: 0 TO 23 HOURS ONLY ";TG
683 IFTG>23THENPRINT"USE HOURS 0 TO 23 ONLY":GOTO682
685 PRINT:PRINT"TURN UP AUDIO GAIN TO HEAR END OF RUN      SIGNAL"
710 S9=(-0.73+SQR((.73)^2-4*(.0008)*(65-SF)))/(2*.0008)
720 S9=INT(S9)
730 GOTO500
865 IFG=1GOTO910
866 PRINT:PRINTF$A$"HOUR="TG"Z  DAY="D6"  MONTH="MO" SF="SF
870 PRINTTAB(4)"BEARING";TAB(15)"MUF";TAB(21)"BEARING";TAB(33)"MUF"
910 L2=L2*RO
920 W2=W2*RO
940 CO=0:PRINTG$
950 T5=TG
960 CO=CO+1
970 GOSUB1140
980 J9=J9*10
990 J9=INT(J9)
1000 J9=J9/10
1010 IFCO=2THEN1050
1020 PRINT E$
1021 IFH=190THEN ED=20:GOSUB4000:PRINTTAB(22)H;TAB(32)J9:GOTO488
1022 IFH>190THENPRINTE$ TAB(22)H;TAB(32)J9:GOTO488
1030 PRINTE$ TAB(4)H;TAB(13)J9
1040 GOTO488
1050 PRINTE$E$:PRINTTAB(21)B;TAB(27)J9
1060 CO=0
1065 GOTO488
1140 REM MINIMUF 3.5
1150 K7=SIN(L1)*SIN(L2)+COS(L1)*COS(L2)*COS(W2-W1)
1160 IFK7=>-1THEN1190
1170 K7=-1
1180 GOTO1210
1190 IFK7<=1THEN1210
1200 K7=1
1210 G1=-ATN(K7/SQR(-K7*K7+1))+π/2
1220 K6=1.59*G1
1230 IFK6>=1THEN1250
1240 K6=1
1250 K5=1/K6
1260 J9=100
1270 FORK1=1/(2*K6)TO1-1/(2*K6)STEP0.9999-1/K6
1280 IFK5=1THEN1300
1290 K5=0.5
1300 P=SIN(L2)
1310 Q=COS(L2)
1320 A=(SIN(L1)-P*COS(G1))/(Q*SIN(G1))
1330 B=G1*K1
1340 C=P*COS(B)+Q*SIN(B)*A
1350 D=(COS(B)-C*P)/(Q*SQR(1-C^2))
1360 IFD>=-1THEN1390
1370 D=-1
1380 GOTO1410
1390 IFD<=1THEN1410
1400 D=1
1410 D=-ATN(D/SQR(-D*D+1))+π/2
1420 WO=W2+SGN(SIN(W1-W2))*D
1430 IFWO=>0THEN1450
1440 WO=WO+P1
1450 IFWO<P1THEN1470
1460 WO=WO-P1
1470 IFC=>-1THEN1500
1480 C=-1
1490 GOTO1520
1500 IFC<=1THEN1520
1510 C=1
1520 LO=PO-(-ATN(C/SQR(-C*C+1))+π/2)
1530 Y1=0.0172*(10+(MO-1)*30.4+D6)
1540 Y2=0.409*COS(Y1)
1550 K8=3.82*WO+12+0.13*(SIN(Y1)+1.2*SIN(2*Y1))
1560 K8=K8-12*(1+SGN(K8-24))*SGN(ABS(K8-24))
1570 IFCOS(LO+Y2)>-0.26THEN1660
```

every 10 degrees (or every 20 degrees, if you prefer) from 0 to 360 degrees. One way to do this is to solve the great circle equations for distance and bearing.

equations and calculations

Equations 1 and **2** provide a relationship between the distance (D) in nautical miles (2160 nautical miles = 4000 km), the heading (H) in degrees from your QTH (every 10 degrees), and the latitude/longitude of your location, and the first hop location.

$$D = 60 \arccos [\sin L1 \cdot \sin L2 + \cos L1 \cdot \cos L2 \cdot \cos(LO1 - LO2)] \quad (1)$$

$$H = \arccos \{[\sin L2 - \sin L1 \cos (D/60)]/[\sin (D/60) \cos L1]\} \quad (2)$$

where

L1 = latitude (your QTH)
L2 = latitude (each 4000-km hop location)
LO1 = longitude (your QTH)
LO2 = longitude (each 4000-km hop location)

The plan of attack is to solve for *L2* in **eqn. 2** since everything else is known, then solve for *LO2* in **eqn. 1**. Simplify by setting $\sin (D/60) = 0.587785$ and $\cos (D/60) = 0.809017$, substituting these values in **eqn. 2** and rearranging terms:

$$L2 = \arcsin [0.587785 \cos L1 \cos H + 0.809017 \sin L1] \quad (3)$$

After you enter your latitude, which is a constant, *L2* simplies to:

$$L2 = \arcsin [(0.587785)(\text{latitude constant}) \cos H + (0.809017)(\text{different latitude constant})] \quad (4)$$

The arc sin (inverse sine) function is available on most hand calculators. Solve for *L2*, starting with 0 and continue in 10-degree steps to 350 degrees. This provides 36 latitudes around the periphery of the circle. Now all you need are the corresponding longitudes, which you can calculate from **eqn. 1**. The program in **table 1** will do all this for you automatically, but it's good to understand what you're doing. Part of a typical printout is shown in **fig. 1**.

solving for the 4000-km longitudes

By rearranging terms in **eqn. 1**, the last unknown, *LO2* can be determined.

$$LO2 = \arccos \{[\cos(D/60) - (\sin L1)(\sin L2)]/[(\cos L1)(\cos L2)]\} \pm LO1 \quad (5)$$

At this point we now have constants for all bearings of *cos(D/60), sinL1, cosL1,* and *LO1*. *CosL2* can be determined for each azimuth with a hand calculator with sin/cos functions if you don't want to use the program in **table 1**. Note that there is a + or - before the *LO1*. Use the minus sign for all calculations of LO2 from 0 to 180 degrees, and a plus sign for all values from 190 to 350. When you've completed the calculations, you'll have a table of bearing vs. latitude/longitude for the periphery of a 4000-km radius circle around your transmitting site. For the 0- and 180-degree bearings, you mustn't use the same longitude as your transmitting site *even if it's the same as your transmitting site*. If they do correspond, just add 0.1 degree to your own longitude, as shown in **fig. 1**, if only to keep the mathematics under control.

MINIMUF program modifications

The updated MINIMUF program of Alan Memley, KE6UY, was modified to provide a 360-degree propagation prediction in tabular form on the screen or a printer (see **table 2**). It's necessary to provide data statements in the program for latitude and longitude crossings of the 4000-km great circles around the transmitting site, and a means for inputting time of prediction (i.e., the hour you're interested in). The basic information for month, date, solar flux, and computation of the prediction was retained. A printout for the 360-degree prediction is shown in **table 3.**

The data statements are included in **lines 480-486** of the revised program. Each data point has three numbers; bearing, latitude, and longitude. The latitude and longitude are specific to your location, and have to be calculated by hand, or by the program shown in **table 1**. Remember that commas must separate each number, and the word "DATA" must be at the the beginning of each line. If your location has three digits for latitude and/or longitude, it will be necessary to use **lines 488** and **489**. Be sure "DATA-1,0,0" is the last data item, because that ends the use of the data and restores the data pointer to the beginning of the READ information. (Basically, it helps the computer keep its bookkeeping in order.)

examples of 360-degree predictions

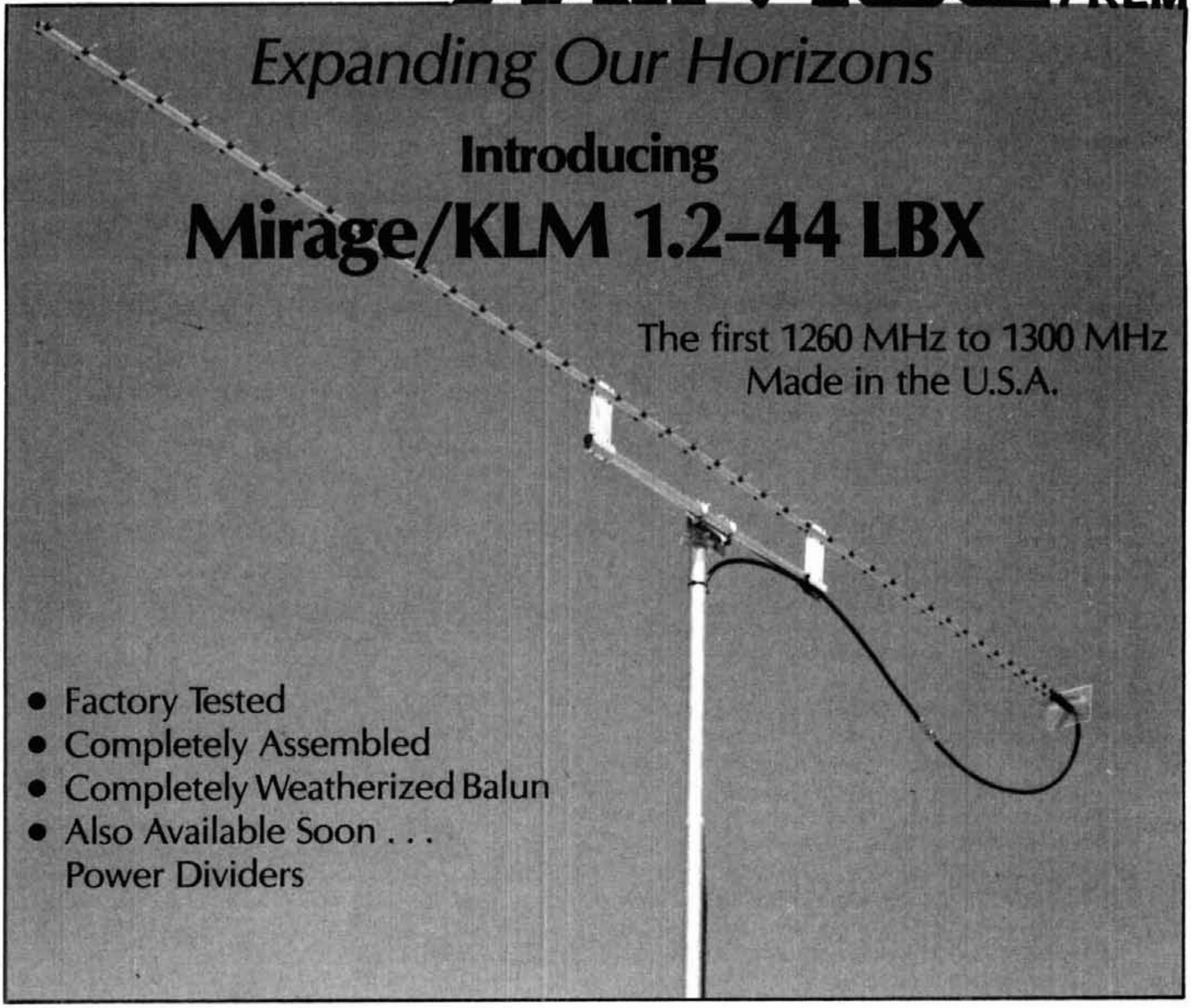
Let's look at several examples and see what the program tells us. We'll consider a day when the solar flux was 70. **Figures 2 through 12** show how propagation varied to different parts of the world from North Carolina from 0900 UTC through 0500 the following morning. At 0900 UTC, the maximum usable frequency (MUF) would be 10.4 MHz with propagation to all parts of the world up through 40 meters except for bearings of 310 through 50 degrees; 20 meters would not yet have opened. By 1000 UTC, 20 meters opens for the middle African countries only. By 1100 UTC, propagation is possible into Europe, all of Africa, and all except the westernmost sections of South America; the MUF into Africa is now 19.9 MHz. By 1200 UTC, the path into northern Europe, Finland (OH) is open on 20 meters and 15 meters is open to Africa, with an MUF of 21.8 MHz for Togo and countries along that bearing of 90 degrees.

Between 1600 and 2300 UTC, world-wide operation

Table 2, continued.

```
1580 K9=0
1590 G0=0
1600 M9=2.5*G1*K5
1610 IFM9<=P0THEN1630
1620 M9=P0
1630 M9=SIN(M9)
1640 M9=1+2.5*M9*SQR(M9)
1650 GOTO1910
1660 K9=(-0.26+SIN(Y2)*SIN(L0))/(COS(Y2)*COS(L0)+1.0E-3)
1670 K9=12-ATN(K9/SQR(ABS(1-K9*K9)))*7.639437
1680 T=K8-K9/2+12*(1-SGN(K8-K9/2))*SGN(ABS(K8-K9/2))
1690 T4=K8+K9/2-12*(1+SGN(K8+K9/2-24))*SGN(ABS(K8+K9/2-24))
1700 C0=ABS(COS(L0+Y2))
1710 T9=9.7*C0^9.6
1720 IFT9>0.1THEN1740
1730 T9=0.1
1740 M9=2.5*G1*K5
1750 IFM9<=P0THEN1770
1760 M9=P0
1770 M9=SIN(M9)
1780 M9=1+2.5*M9*SQR(M9)
1790 IFT4<TTHEN1820
1800 IF(T5-T)*(T4-T5)>0THEN1830
1810 GOTO1960
1820 IF(T5-T4)*(T-T5)>0THEN1960
1830 T6=T5+12*(1+SGN(T-T5))*SGN(ABS(T-T5))
1840 G9=π*(T6-T)/K9
1850 G8=π*T9/K9
1860 U=(T-T6)/T9
1870 G0=C0*(SIN(G9)+G8*(EXP(U)-COS(G9)))/(1+G8*G8)
1880 G7=C0*(G8*(EXP(-K9/T9)+1))*EXP((K9-24)/2)/(1+G8*G8)
1890 IFG0=>G7THEN1910
1900 G0=G7
1910 G2=(1+S9/250)*M9*SQR(6+58*SQR(G0))
1920 G2=G2*(1-0.1*EXP((K9-24)/3))
1930 G2=G2*(1+(1-SGN(L1)*SGN(L2))*0.1)
1940 G2=G2*(1-0.1*(1+SGN(ABS(SIN(L0))-COS(L0))))
1950 GOTO2020
1960 T6=T5+12*(1+SGN(T4-T5))*SGN(ABS(T4-T5))
1970 G8=π*T9/K9
1980 U=(T4-T6)/2
1990 U1=-K9/T9
2000 G0=C0*(G8*(EXP(U1)+1))*EXP(U)/(1+G8*G8)
2010 GOTO1910
2020 IFG2>J9THEN2040
2030 J9=G2
2040 NEXTK1
2050 J9=.93*J9
2060 G=1:RETURN
2640 RA=3956.75
2650 X7=RA*SIN((90-X1)*π/180)*COS(Y1*π/180)
2660 Y7=RA*SIN((90-X1)*π/180)*SIN(Y1*π/180)
2670 Z7=RA*COS((90-X1)*π/180)
2680 DE=((X7^2)+(Y7^2)+(Z7^2))^.5
2690 CA=X7/DE:CB=Y7/DE:CC=Z7/DE
2700 X8=RA*SIN((90-X2)*π/180)*COS(Y2*π/180)
2710 Y8=RA*SIN((90-X2)*π/180)*SIN(Y2*π/180)
2720 Z8=RA*COS((90-X2)*π/180)
2730 DG=((X8^2)+(Y8^2)+(Z8^2))^.5
2740 CD=X8/DG:CE=Y8/DG:CF=Z8/DG
2750 CT=((X7*X8)+(Y7*Y8)+(Z7*Z8))/(DG*DE)
2760 IFCT=0THENCT=.000000000001
2770 DI=((RA^2)+(RA^2)-2*RA*RA*CT)^.5
2780 IFDI>5656.85425THENGOTO2810
2790 SI=(1-(CT^2))^.5
2800 TA=SI/CT:T=ATN(TA)*180/π:GOTO2830
2810 SI=-1*(1-(CT^2))^.5
2820 TA=SI/CT:T=180-ATN(TA)*180/π
2830 DX=69.055*T:DX=INT(DX)
2840 RETURN
3000 GETAN$:IFAN$=""THEN3000
3010 IFAN$="P"GOTO3200
3020 IFAN$="Q"THENPRINTF$A$A$D$D$D$"ENJOY YOUR RADIO!":END
3030 IFAN$="T"THENPRINTF$A$A$A$A$"PLACE CURSOR OVER RUN AND PRESS RETURN"
3031 IFAN$="T"THENGOTO3040
3035 GOTO3000
3040 PRINTE$E$E$E$E$"RUN":END
3050 : REM TONE TO TELL WHEN SCREEN PRINT COMPLETE
3052 FOR AC=54272TO54296:POKEAC,0:NEXT
3054 POKE54296,15
3056 POKE54277,0
3058 POKE 54278,248
3060 POKE54273,35:POKE54272,134
3062 POKE54276,17
3064 FORT=1 TO 1000 :NEXT
3066 POKE54276,16:RETURN
3199 REM SCREEN DUMP
3200 OPEN3,3:OPEN4,4:PRINTC$:FORI=1TO1000:GET#3,A$:PRINT#4,A$;:NEXT:CLOSE3
3210 CLOSE4
3220 END
4000 FORI=1TOED:
4010 PRINTE$;
4015 NEXTI
4020 RETURN
60000 OPEN15,8,15,"S0:360 DEG MUF":CLOSE15:SAVE"0:360 DEG MUF",8

READY.
```

MIRAGE/KLM



SPECIFICATIONS

Electrical

- Band Width .... 1260–1300 MHz
- Gain 18.2
- VSWR .... Better than 1.5 to 1
- Feed Imp. .... 50 Ohms
- Balun .... 4:1 Rigid Coax

Mechanical

- Beam Length .... 12′ 4″
- Element Length .... 4.5″
- Mast .... 2″ O.D.
- Windload .... 1 sq. ft.

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Table 3. 360-degree MINIMUF prediction for Cleveland, North Carolina at a solar flux of 70.

BEARING	MUF	BEARING	MUF
0	16.7	190	15.8
10	16.9	200	15.7
20	17.2	210	22
30	17.5	220	21.9
40	17.9	230	22
50	18.2	240	22
60	23.2	250	22
70	23.6	260	22
80	23.9	271	21.9
90	24.2	280	21.7
100	24.4	290	21.4
110	24.5	300	21.2
120	24.4	310	16.7
130	24.2	320	16.6
140	17	330	16.5
150	23.5	340	16.5
160	23.1	350	16.6
170	16.2		
180	19.2		

is possible in all directions on 20 meters, with the MUF extending as high as 25 MHz on bearings into Pitcairn Island at 230 degrees, although the heavily populated areas of middle Europe had dropped out by 2200 UTC. At 0000 UTC, the next day, the prediction says 20-meter propagation is possible to South America and west up through Hawaii. A possible 15-meter capability is indicated into the southwest.

By 0200 UTC, 4000 km propagation is still possible on 20 meters for South America and the South Pacific. The band is still open at 0400 UTC, with an MUF of 14.5 in the 210-220 degree bearing for some possible Central American stations. Twenty meters is dead at 0500 UTC, with an MUF of 13.3 MHz. To provide a comparison with North Carolina and Los Angeles, California, a prediction was run for 1600 UTC on the same day with a solar flux of 70 for Los Angeles; see **fig. 13**. California is three hours earlier than North Carolina, but it still shows world-wide propagation possibilities on 20 meters, with good openings into Africa and South America on 15 meters.

Just for fun, a prediction for the 21st of June — in a year when the solar flux was 180 — was run (**fig. 14**). As expected, practically the whole world is open on the 10-meter band at 1700 UTC. (I believe the model used for the prediction is quite conservative, since it would appear that the MUF should be higher than 35.9 MHz with such a high solar flux.)

This type of presentation — i.e., 360 degrees — brought out what may be an anomaly in the prediction model. It appears that the 140-degree prediction for North Carolina is always significantly lower than the 130- and 150-degree bearing. Also, the 170- through 200-degree predictions seem to be lower than adjacent bearings. I'd be interested in hearing from any reader who could explain this.

a word of caution

It's important to remember that hops greater than the 4000-km prediction may not be possible because of propagation conditions at the far end. However, this modified program can suggest possible contacts. It's also good to keep in mind that the predicted openings may provide the long path for distant points even when no short path conditions are indicated.

The next step, should anyone want to continue this work, would be to provide the code for a graphic presentation such as the one shown in **figs. 2** through **14**. It should be an easy task to combine the point-to-point prediction with the 360-degree prediction, since the basic MINIMUF program is used by both methods.

references

1. "Instantaneous Prediction of Radio Transmission Paths," *QST*, March, 1952, page 11.
2. Institute for Telecommunication Sciences, *Telecommunications Research and Engineering Report 13*, Ionospheric Predictions, Volume 1.
3. Robert R. Rose, K6GKU, "MINIMUF: A Simplified MUF-Prediction Program for Microcomputers," *QST*, December, 1982, page 30.

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C64/128 routines determine optimum Class B or C operation

linear design by computer

A few years ago *ham radio* published an article of mine on low-cost linear design and construction.[1] Judging from the number of letters and phone calls I've received, the techniques have been widely used. It seems that linear construction is second only to antennas as an Amateur activity.

Recently, while doing some study on a new linear to fit our new regulations, I went through these design steps a number of times. Finally, I decided that this was a lot of unnecessary work, so I took time to reduce the process to a computer routine.

The core of the computer routines are the tables and relations given in the booklet, *RCA Transmitting Tubes, Technical Manual TT-5*. (My copy is dated October, 1962.) As far as I know, the book is out of print, but copies are occasionally found at hamfests. It isn't necessary to have the book to use the program — just refer to the manufacturer's literature for design data on the types of tubes you plan to use.

As written, the program listed in **table 1** is for the Commodore 64/128. However, only routine constructions are used, so only minor changes would be needed to make it run on other computers.

Lines below **500** are introductory. **Line 180** sets up a function for output formatting. The amplifier design goals are established in **lines 500-990**. The last lines allow either acceptance of the "preliminary" design developed at that point or redesign. On the C-64, it isn't necessary to re-enter all values; you need enter only the ones you wish to change. Other computers may require complete re-entry.

The basic design parameter chosen is power output, which seems to be the most common goal. The next two inputs are the number of tubes to use and the operating class. The program assumes that the tubes will be in parallel, as is universal in today's hf designs. The program also assumes that designs will be either Class B, with a 180-degree conduction angle, or Class C at 140 degrees. For convenience, a set of values for 100-degree angle is listed in the REM statement at **line 550**. These may be substituted for the 140-degree ones if desired, or a third mode programmed. Although an increase in output will be obtained, harmonic content will increase, so this step is not recommended.

Lines 530-550 introduce some "K" values, and more are used later. These are the core of the RCA design technique, and are tabulated in the RCA booklet. They are derived from the way parameters of truncated sine waves behave. Clipped sine waves are generated by the non-linear relation between driving grid voltage and resulting plate current pulses. (See any good book on vacuum tube amplifiers if you're interested in details.) For calculation, most of the K-factors are used as tabulated; however, one is calculated from a least-squares relation.

The values of plate and screen voltage and plate dissipation are entered in **lines 570-600**. A *minus* screen voltage is used to indicate a triode. Note that the plate dissipation is specifically a design parameter, but that there is no built-in check for screen or grid dissipation; these are calculated and output later, to check against tube specification values.

It is usually best to operate near the upper limit of

R. P. Haviland, W4MB, 1035 Green Acres Circle N., Daytona Beach, Florida 32019

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Table 1. Linear amplifier design program for the C64.

```
100 PRINT"] **************************************"
110 PRINT" *            VACUUM TUBE               *"
120 PRINT" *  HIGH POWER RF AMPLIFIER DESIGN      *"
130 PRINT" *  REFERENCE RCA TECH MANUAL TT-5      *"
140 PRINT" *   HAM RADIO, PAGE 12, DEC.1982       *"
150 PRINT" *          FEBRUARY 1986               *"
160 PRINT" *        R.P.HAVILAND, W4MB            *"
170 PRINT" **************************************"
180 DEF FNP(X)=INT(X*10+.5)/10
200 PRINT" THIS PROGRAM AIDS DESIGN OF HIGH POWER   RF AMPLIFIERS, CLASS B AND C
"
210 PRINT"   BEST DESIGN REQUIRES INPUT FROM            TUBE DATA CURVES"
220 PRINT"     APPROXIMATIONS ARE SUPPLIED IF           CURVE DATA IS NOT AVAIL
230 PRINT
500 INPUT"ENTER DESIGN POWER OUTPUT,WATTS";PO
510 INPUT" ENTER NUMBER OF TUBES TO USE";NV:PT=PO/NV
520 INPUT"  ENTER MODE, B=CLASS B,C=CLASS C";MO$
530 IF MO$="B" THEN K2=.785:GOTO570:REM 180 DEG.
540 IF MO$="C" THEN K2=.862:GOTO570:REM 140 DEGREE
550 REM FOR 100 DEG CONDUCTION, K2=.927,K3=1.8,K4=2.8,K5=1.45
560 GOTO 520
570 INPUT"   ENTER PLATE VOLTAGE",EB
580 INPUT"ENTER SCREEN VOLTAGE, -1= A TRIODE";SV
600 INPUT"ENTER RATED TUBE DISSIPATION,WATTS";DI:
610 EN=.1*EB:EM=EN:REM TRIAL
620 IP=PT/(K2*(EB-EM))
630 K1=3.14: IF MO$="C" THEN K1=4
640 IM=K1*IP
650 PRINT
700 PRINT"INPUT TUBE DATA-PLATE VOLTAGE AT KNEE OF IP=";INT(1000*IM);"MA. CURVE"
710 PRINT"  OR ENTER ZERO FOR AN APPROXIMATION"
720 INPUT EM: IF EM=0 THEN 740
730 IF ABS(EM-EN) > .01*EM THEN EN=EM:PRINT" ANOTHER TRIAL NEEDED":GOTO620
740 PI=EB*IP*NV
750 PD=(PI-PO)/NV
760 PRINT
800 PRINT"REQUIRED INPUT IS";FNP(PI);"WATTS"
810 PRINT" DISSIPATION PER TUBE IS";FNP(PD);"WATTS
820 PRINT"  WITH PLATE CURRENT =";FNP(1000*IP);"MILLIAMPS"
830 PRINT"   TOTAL CURRENT, AMPS=";FNP(NV*IP)
840 DC=PD/DI
850 PRINT
900 PRINT" DESIGN WILL BE SUITABLE FOR"
910 IF DC<.94 THEN PRINT"   AM VOICE"
920 IF DC<1 THEN PRINT"    FM-TELETYPE"
930 IF DC<1.4 THEN PRINT"   CW"
940 IF MO$="B" AND DC<1.83 THEN PRINT"   PROCESSED SSB"
950 IF MO$="B" AND DC<2.5 THEN PRINT"   NORMAL SSB"
960 IF DC>2.5 THEN PRINT"   LOW DUTY CYCLE OR PULSE ONLY"
970 IF DC>1 THEN PRINT"    USE LOW TUNE-UP POWER"
980 PRINT:INPUT"ENTER A=ACCEPT OR R=REJECT VALUES";T$
990 PRINT:IF T$="R" THEN 500
1000 PRINT"INPUT TUBE DATA, OR 0 IF NOT AVAILABLE"
1010 PRINT"FOR APPROXIMATE DISSAPATIONS AND DRIVE"
1020 INPUT"ENTER GRID VOLTAGE AT I-PLATE MAX";V1:IF V1=0 THEN V1=.1*EB
1030 INPUT"ENTER IG1 (AMPS) AT I-PLATE MAX",J1:IF J1=0 THEN J1=IM
1040 INPUT"ENTER GRID OR SCREEN MU-FACTOR";MU
1050 IF MU=0 THEN PRINT"SET BIAS AND DRIVE BY TEST":GOTO 1260
1060 IF MU=0 THEN PRINT"SET BIAS AND DRIVE BY TEST":GOTO 1260
1070 PRINT
1100 K3=0:K4=1
1110 IF MO$="C" THEN K3=.52:K4=1.52
1120 EX=SV:EY=0
1130 IF SV<0 THEN EX=EB:EY=EM:K4=1
1140 VG=-K3*(V1+EY/MU)-K4*EX/MU
1150 VD=-VG+V1
1160 PRINT"PEAK RF GRID VOLTAGE=";FNP(VD)
1170 PRINT" GRID BIAS VOLTAGE=";FNP(VG)
1180 IF VD=0 THEN 1290
1200 RA=ABS(VG/VD)
1210 K6=11.82-35.59*RA+43.06*RA*RA
1220 IC=J1/K6
1230 PG=ABS(.9*VD*IC)*NV
1240 PRINT"  GRID CURRENT PER TUBE, MA.=";FNP(1000*IC)
1250 PRINT"   TOTAL DRIVE POWER, WATTS=";FNP(PG) PRINT"  PLUS CIRCUIT LOSSES"
1260 PRINT"TYPICAL STAGE POWER GAIN=";
1270 IF SV=-1 THEN PRINT" 10"
1280 IF SV=>0   THEN PRINT" 20"
1290 PRINT
1300 IF SV<0 THEN 1500
1310 INPUT"ENTER IG2 (AMPS) AT IP KNEE";J2:IF J2=0 THEN J2=.1*IM
1320 K5=.25:IF MO$="C" THEN K5=.2
1330 I2=K5*J2
1340 P2=SV*I2:PA=J2*V1*K5/2:IF P2<PA THEN P2=PA
1350 PRINT"SCREEN CURRENT, MA.=",FNP(1000*I2)
1360 PRINT" SCREEN DISSIPATION, WATTS=";FNP(P2)
1370 PRINT
1500 ES=EB-EM
1510 IE=2*K2*EB*IP/ES
1520 K7=2:IF MO$="B" THEN K6=1.57
1530 ZL=ES/K7/IP/NV
1540 PRINT
1600 INPUT"CATHODE DRIVE CONDITIONS, Y/N";T$:PRINT
1610 IFT$="N" THEN 2000
1620 PP=ABS(VD)*IE/2
1630 ZK=VD/(IE+1.5*IC)
```

```
1640 PRINT"TOTAL POWER, EXCITER TO LOAD, WATTS=",FNP(PP*NV)
1650 PRINT"  TOTAL EXCITER POWER, WATTS=",FNP(NV*(PP+PG))
1660 PRINT"     PLUS CIRCUIT LOSS"
1670 PRINT"    TOTAL OUTPUT, WATTS=",INT(PO+PP*NV)
1680 PRINT:PRINT"DRIVE IMPEDANCE=",INT(ZK):PRINT
2000 PRINT"TANK CIRCUIT DESIGN":PRINT
2010 INPUT"ENTER TUBE OUTPUT CAPACITY, PF";CT
2020 INPUT" ENTER C-MIN+C-STRAY, PF";T
2030 CT=CT*NV+T
2040 INPUT"  ENTER MAXIMUM FREQUENCY, MHZ";FH
2050 INPUT"   ENTER LOWEST FREQUENCY, MHZ";FL
2060 PRINT:PRINT"LOAD IMPEDANCE SHOULD BE";INT(ZL);"OHMS"
2200 XH=1E6/(2*π*FH*CT)
2210 QM=ZL/XH
2220 PRINT" TANK Q AT F-MAX="INT(QM+.5)
2230 IF QM>15 THEN PRINT:PRINT" Q IS EXCESSIVE-SEE HAM RADIO REFERENCE"
2240 X1=ZL/12
2250 X2=50/SQR((50/ZL)*145-1)
2260 XL=ZL*(12+50/X2)/145
2270 C1=1E6/(2*π*FL*X1)
2280 C2=1E6/(2*π*FL*X2)
2290 L=XL/(2*π*FL)
2300 PRINT:PRINT" TUNING CAPACITY AT ";FL;"MHZ =";FNP(C1);" PF"
2310 PRINT"  AND 50 OHM LOAD CAPACITANCE, PF=";FNP(C2)
2320 PRINT" MAXIMUM COIL INDUCTANCE,UH=";FNP(L)
2400 INPUT"ENTER COIL DIAMETER, INCHES";CD
2410 INPUT" ENTER COIL LENGTH, INCHES";CL
2420 CN=SQR(L*(18*CD+40*CL))/CD
2430 PRINT"  COIL TURNS=";FNP(CN)
2440 PRINT"    TURNS/INCH=";FNP(CN/CL)
2450 PRINT" TAP COIL FOR HIGHER FREQUENCY BANDS"
2460 INPUT"  ENTER ADDED BAND FREQUENY OR 0";NF:IF NF=0 THEN PRINT:GOTO 2500
2470 TP=CN*FL/NF
2480 PRINT"TAP AT ";FNP(TP);" TURNS APPROX.":IF QM>15 THEN PRINT"BUT SEE HR REFE
RENCE"
2490 GOTO 2460
2500 IF T$<>"Y" THEN 2600
2510 FC=1.5*FH:MP=ZK/50
2520 C3=10↑6/(50*2*π*FC)
2530 C4=C3/MP
2540 LK=(1+MP)* 50 /2/π/FC
2550 PRINT"FOR PI FILTER-GROUNDED GRID INPUT"
2560 PRINT" C-IN=";FNP(C3);" PF"
2570 PRINT" C-CATHODE=";FNP(C4);" PF"
2580 PRINT" SERIES INDUCTANCE=";FNP(LK); "UH"
2600 PRINT:PRINT"ENTER POWER SUPPLY TYPE"
2610 PRINT" 1=FULL WAVE"
2620 PRINT" 2=BRIDGE"
2630 PRINT" 3=FULL WAVE DOUBLER"
2640 INPUT RT
2650 TS=EB/1.3
2660 IF RT=3 THEN TS=EB/2.6
2670 PRINT"TRANSFORMER VOLTAGE=",INT(TS)
2680 IF RT=1 THEN PRINT"EACH SIDE OF CENTER"
2690 FC=30000*NV*IP/EB
2700 IF RT=3 THEN FC=FC*5
2710 PRINT" FILTER CAPACITANCE, MFD =";INT(FC)
3000 PRINT:PRINT"ENTER N=NEW CONDITIONS"
3010 PRINT"       R=REVISE CONDITIONS"
3020 PRINT"       P=REVISE POWER SUPPLY"
3030 PRINT"       Q=QUIT"
3040 INPUT T$
3050 IF T$="N" THEN RUN
3060 IF T$="R" THEN 500
3070 IF T$="P" THEN 2600
3080 STOP

READY.
```


✓ 234

Table 2. Results of a typical run of the program, using approximations (*indicates an input).

```
Example Tube Type- 4-1000A

* Power output- 1600 watts
* One tube
* Class B
* Plate- 3500 volts
* Screen- 0 volts= GG
* Dissipation- 1000 watts
Plate current- 2031 ma peak
Ep min- 0= approximation
Plate input- 2264.7 watts
Dissipation- 664.7 watts
Plate current- 647.1 ma average
Suitable all modes
* Grid, screen current-0= approximation
* MU factor- 7
RF grid voltage- 350
Bias- 0
Grid current- 171.9 ma
Grid drive- 54.1 watts
Stage gain- 20
Screen dissipation- 8.9 watts
Exciterr to load- 177 watts
Total drive- 239.1 watts + losses
Total output- 1777 watts
Z-drive- 274 ohms
* Tube C-out- 7.1 pf
* C-stray- 15 pf
* F max, min- 30, 3.5 mhz
Plate impedance- 2709 ohms
Q max- 12
Max C tune- 201.8 pf
Max C load- 1179 pf
Max L- 11.3 uh
* Coil 4" dia, 5" long
Turns- 13.2
* 14 mhz tap- 3.5 (approx)
Cathode Filter
 C-in 70.7 pf
 C-out 12.9 pf
 L  1.1 uh
* Bridge Rectifier
Transformer- 2692 volts rms
Filter 5 mf
```

plate voltage if maximum output is needed. In the low duty-cycle services, it may be desirable to exceed the usual oscillator-amplifier rating. Up to about 1.5 times the plate modulated amplifier rating seems to work well, with little loss of service life.

Line 700 calls for the plate voltage at estimated maximum plate current, which is the intersection of the load line and the plate current curve for the peak instantaneous grid voltage. Since this is not yet determined, several trials will be necessary to select a reasonable value. Maximum output is usually the design goal in the Amateur Service. For this, use the plate current at the knee of the curve for the maximum grid voltage shown on the tube curves, then follow the instructions. The program allows this important step to be replaced by an approximation, but this is only for the initial design.

After this step, accumulated design values are output for checking. This includes power input, tube dissipation, and current. The type of service the design values are suited to is output; this is based on typical duty factors. Note that these assume good cooling. The design values can be accepted, or new ones calculated.

Program **lines 1000-1680** calculate and output further design data based on curve data. One input is the tube amplification factor, which is the screen factor for tetrodes. Typical values are 4-9 for tetrodes and 20-150 for triodes. Grid and screen dissipation values must be checked against rated values. A small amount of instantaneous overload is allowable for the low duty-cycle services, but there is some risk of shortening tube life if rated values are exceeded. Sometimes it is best to increase plate voltage to reduce drive requirements.

This section also allows estimation of the drive impedance for grounded grid amplifiers. Drive requirements and power fed to the load are calculated.

The section from **lines 2000-2490** relates to the plate tank circuit. A simple tapped coil pi-section tank is assumed. Values are calculated for the lowest frequency. Tap points for higher bands are developed by an approximation. The actual tap points should be determined by a test for maximum output. The reason for this is the difficulty of estimating inductance and stray capacitance of the band switch and leads.

The tank design assumes a *Q* of 10 at the lowest frequency. A flag is printed if the *Q* at the highest band exceeds 15, as a result of high tube plus stray capacitance. (*See reference 1 for a means of avoiding this* by designing the circuit as a L-PI network).

Lines 2500-2580 give design data for a PI network grounded grid excitation input circuit. This assumes cutoff at 1.5 times the highest operating frequency. In principle, this design is not as good as a separate tank circuit for each band ($Q = 2$, approximately), but it is far simpler and has presented no problems in years of use.

Lines 2600-2710 give power supply parameters for three types of rectifiers. (When working with surplus transformers, it may be necessary to base the design on a particular transformer voltage rather than on plate voltage.) Remaining lines relate to re-runs.

Table 2 shows results of a typical run of the program.

references

1. Robert P. Haviland, W4MB, "Low-Cost Linear Design and Construction," *ham radio*, December, 1982, p. 12.

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ham radio TECHNIQUES

Bill Orr W6SAI

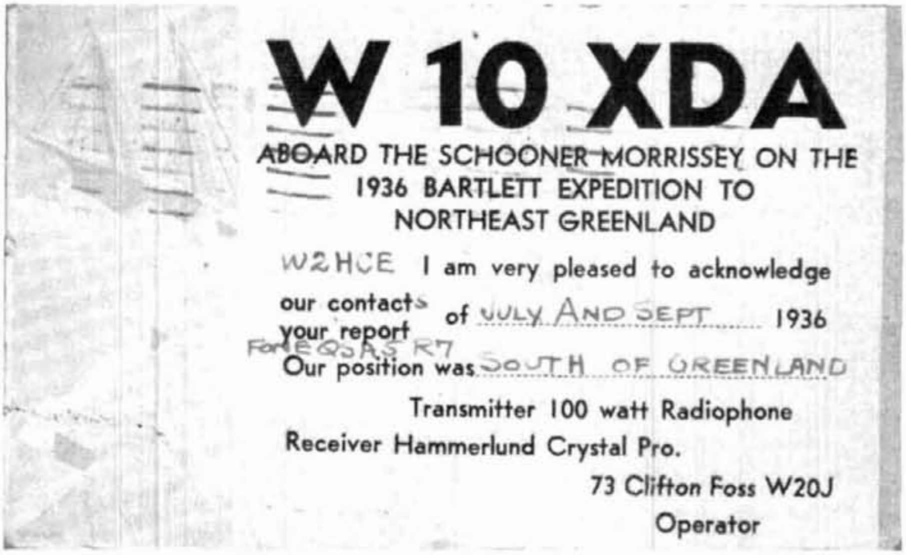
ever work a W10?

Prefix hunters should snap to attention at this one! But the bad news is that W10 prefixes were consigned to the scrap-heap shortly after World War II. The W10 prefix was a catch-all for mobile, experimental stations, and many of the calls were issued to expeditions who wished to keep in touch with home via Amateur Radio.

The most famous of these unusual calls was W10XDA, the ham-band call of the schooner *Effie M. Morrissey*, under Captain Robert Bartlett, a noted Arctic explorer. The *Morrissey* made numerous trips to Northern Greenland from 1936 through 1939, and the call was well-known on the 20-meter phone band.

The adventures of the *Morrissey* and Captain Bob had slipped to the back of my mind until I read an article about New Bedford, Massachusetts in *Yankee*.[1] Almost as an afterthought, the author mentioned the *Ernestina*, an 1894 schooner presently being restored at anchor in New Bedford. The author further stated that this was formerly the famous *Morrissey*, which had not only explored the Arctic, but also served as an immigrant packet in the 1890s.

So Amateurs wishing to review some of their own history might visit this famous schooner, which once bore the proud call sign W10XDA that started a hundred pile-ups on 20 meters, so many decades ago.


W 10 XDA

ABOARD THE SCHOONER MORRISSEY ON THE 1936 BARTLETT EXPEDITION TO NORTHEAST GREENLAND

W2HCE I am very pleased to acknowledge our contacts / your report of JULY AND SEPT 1936

For EQSAS R7

Our position was SOUTH OF GREENLAND

Transmitter 100 watt Radiophone

Receiver Hammerlund Crystal Pro.

73 Clifton Foss W2OJ

Operator

W10 prefix was used by mobile, expedition and experimental stations.

more about the super-cathode driven amplifier

Judging from mail received, there is considerable interest in the cathode driven circuit and the super-cathode driven offspring. Here are some specifics on the 4-400A as used in that circuit (see **fig. 1**).

In conventional grounded grid service, a single 4-400A can run at 1 kW PEP input, requiring about 40 watts PEP drive power. While many Amateurs have operated one or two tubes in this fashion, with both grids grounded, the margin of error for excessive grid dissipation is small. In addition, grid and screen currents are quite high.

When the 4-400A is run in super-cathode driven service, grid and screen dissipation drop, along with the corresponding currents, and grid drive power rises. The circuit for a single 4-400A, in fact, may be adjusted to "soak up" the drive power of most modern hf SSB exciters, which usually run 100 to 130 watts output.

An experimental amplifier was constructed using a single 4-400A; the operating characteristics are summarized in **table 1**. Note the unusually high value of cathode input impedance.

The amount of drive required by the amplifier is determined by placement of the cathode tap. The nearer the tap is to the filament end of the choke, the greater the required drive. When the tap is at the "ground" end of the choke, the tube operates in the conventional grounded grid mode. For the typical 100-watt output exciter, the tap is placed about one-third of the distance down the choke from the tube end.

It is necessary to use a blocking capacitor between the tap point on the choke and the grid in order to prevent the ac filament voltage from reaching the grid. The dc grid return is then completed through a small rf choke.

In any case, total grid current (sum of grid and screen currents) should be limited to about 150 mA.

the tapped filament choke

A handy filament choke can be made by winding two equal lengths of wire on a ferrite rod. One wire is Formvar (or enamel) insulated, the other is

Table 1. Suggested operating parameters for 4-400A in Super cathode driven service.

Plate voltage (key down)	3000 VDC
Plate current (carrier insertion)	333 mA
Power input (peak)	1000 W
Power output (measured)	600 W
Power drive	100-125 W
Plate load impedance	4100 ohms
Cathode input impedance	420 ohms

Drive power depends on tap setting on filament choke.

Note: The above data has been determined experimentally by Bill Orr, W6SAI, and does not represent the opinion of Varian/EIMAC.

bare, tinned. The tinned wire allows the experimenter to tap along the choke; the Formvar insulation on the other wire prevents the solder from flowing onto the adjacent turns and causing a short circuit.

The super-cathode driven amplifier tunes up in the conventional way. Plate voltage is applied and plate circuit resonance is established at a low drive level. Drive power should be checked with an in-line wattmeter in the coax lead to the amplifier. The tap is adjusted on the filament choke for maximum output when the exciter is running at the desired input level.

Warning! Keep your hands out of the amplifier when the high voltage is on. After turning off the power supply, short the B-plus lead to ground in the amplifier with a plastic-handle screwdriver or other insulated tool to make sure the filter capacitors are discharged before you do any work on the amplifier. *High voltage is deadly!*

"stealth" technology —in police radar!

We've all read about the new stealth technology, by which a fighter plane is rendered "invisible" to radar. Well, science has taken another gigantic step. The September issue of *Defense Electronics* tells about an advertisement in a leading auto magazine offering motorists the opportunity to elude police radar for only $17.95. According to the ad, the technique involved is the same as the one used to make U.S. aircraft invisible to enemy radar. A breakthrough in low-cost countermeasures? No. Just an aerosol can of silicone spray unconditionally guaranteed to deflect radar waves!

The editor of *Defense Electronics* tried telephoning the company, but the line was always busy. . . no doubt Washington was calling to learn about the benefits of this momentous idea.

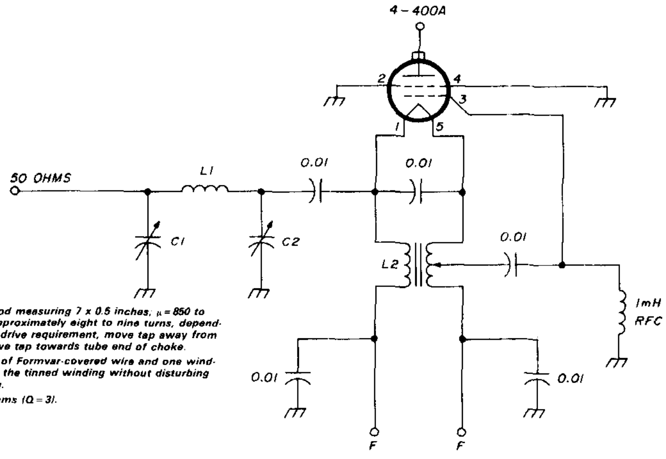
Reminds me of the time I saw a big crowd of curious onlookers outside a shop in the golden days of CB radio. What could be causing the commotion? I stopped and found a fellow selling "SWR grease" from the back of his truck. Smear the grease on your mobile whip antenna, he told the onlookers, and your SWR will instantly drop to 1:1. I should have bought some and tried it on my three-element beam, but I had to finish paying off my purchase of the Brooklyn Bridge first.

how good is a rubber ducky?

The Lee DeForest Club (California) decided to make some meaningful measurements on typical handheld units in the 2-meter band. Willie Sayer, WA6BAN, sent along the results of those tests, along with a description of the setup. The field strength measured at a distance was converted into antenna efficiency, taking into account the power output of the handheld. The winner of the event was KG6NL, who was using an AEA "Hot Rod" antenna, which exhibited an efficiency of about 57 percent. WA6BAN's handheld, with a conventional "Rubber Ducky" produced a reading that indicated efficiency of only 7 percent. Other handhelds with comparable antennas were in the same ballpark.

rf light bulbs — a continuing problem

Light bulbs that actually generate RFI, causing interference to nearby radios, are on the market in quantity.



L2 = 20 bifilar turns No. 14 on ferrite rod measuring 7 x 0.5 inches; μ = 850 to 950 (Amidon). Tap down from tube approximately eight to nine turns, depending upon exciter output. To decrease drive requirement, move tap away from top (tube end). To increase drive, move tap towards tube end of choke.

I wound my choke with one winding of Formvar-covered wire and one winding of tinned wire. It was easy to tap the tinned winding without disturbing the adjacent, Formvar-coated winding.

Tuned input network to match 420 ohms (Q = 3).

f(MHz)	C_1(pF)	C_2(pF)	L_1(μH)
3.5	302	192	6.5
7.0	150	96	3.3
14.0	75	48	1.6
21.0	50	32	1.1
28.0	37	24	0.8

fig. 1. Super-cathode driven 4-400A circuit uses adjustable filament choke tap position to vary input drive level to be used.

Sold under various brand names — GE's "Miser Maxi-light" and North American Philips' "SL-8" are two — they use less wattage to provide light and presumably last longer than conventional bulbs. Their threat to a-m radio (and possibly 160- and 80-meter Amateur operation) is in the way they generate light.

The rf light bulbs have an arc tube containing a metal vapor (mercury, in some cases) under pressure of several atmospheres. Instead of using ordinary line voltage to heat the arc tube, ac is converted to dc through a rectifier and then switched on and off to produce square waves at frequencies of 30 to 60 kHz. The square wave voltage heats the arc tube and the light stays lit. If the arc tubes cools below operating temperature while the lamp is in use, there is a restrike, and rf is generated again. Worst of all, as the lamp ages, restrike occurs more often. The square wave and higher harmonics raise havoc with nearby a-m radios, the interference level from a single bulb is of the same order as that of a light dimmer of the triac variety.

Because the rf bulb may come into widespread use, it is wise to see how the interference problem can be solved before the QRM factor becomes overwhelming.

The National Association of Broadcasters, concerned about the problem, conducted tests on the new bulbs, along with both inexpensive and expensive lamp dimmers. It was found that the more expensive dimmers had rf-suppression built in. Attenuated rf noise caused by their operation was about 8 dB for conducted measurements, and about 30 dB for radiated measurements.

The rf bulbs radiated about the same amount of noise as the inexpensive dimmers. The GE MaxiLight generated noise only during startup and restrike, which resulted in rapid bursts of noise. The Philips bulb, on the other hand, generated continuous noise.

The NAB and the FCC are discussing possible limitations on rf radiation from these devices. So far, nothing has been decided, and the best Amateurs can do is to make sure their receiving antennas are well removed from these rf pests. This is more easily said than done.

old coax never dies

How good is old coax? I had a 50-foot roll of coax in the garage unused since it was bought in 1944. Leaving it in its original coiled state, I shipped the coax back to Ron Stier, W9ICZ, at Belden Cable and asked him to check it, in his spare time, for attenuation. Was it contaminated? Had the rf loss increased over the decades? I pointed out that the cable had been protected from sunlight, but had been exposed to both high and low temperatures over the 42 years that had passed. He tested the cable, and this is what he found:

Frequency (MHz)	W6SAI cable	New, Standard cable
50	1.8 dB	1.6 dB
100	2.5 dB	2.2 dB
200	4.0 dB	3.2 dB
400	6.5 dB	4.7 dB
1000	12.4 dB	8.9 dB

Ron pointed out that up to 200 MHz, any difference in attenuation may be attributed to minor differences in cable manufacture, and cable made to the old JAN specifications did not have design requirements above 400 MHz.

It looks, then, that continuing hamtalk about contaminating and noncontaminating jackets and coax cable life are not necessarily valid, if care is taken in the use and storage of cable. Operating old cable under harsh environmental conditions may be another matter. But coax cable used in a protected environment seems to last forever — at least at frequencies below 200 MHz.

reference

1. "The Dearest Town in All New England," *Yankee*, November, 1986, page 166.

ham radio

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PAKRATT™ Model PK-64

PAKRATT™ Model PK-232

Third, Performance and Features

The real measure of any data controller is what kind of on-air performance it gives. While the PK-64 and PK-232 use different types of modems, both give excellent performance on VHF. The optional HF modem of the PK-64 uses independent four-pole Chebyshev filters for both Mark and Space tones, and A.M. detection. The HF option can be factory or field installed.

The PK-232 uses an eight-pole bandpass filter followed by a limiter discriminator with automatic threshold correction. The internal modem automatically selects the filter parameters, CW Fc = 800 Hz, BW = 200 Hz; HF Fc = 2210 Hz, BW = 450 Hz; VHF Fc = 1700 Hz, BW = 2600 Hz.

The PK-64 uses on screen indicators to show status, mode, and DCD (Data Carrier Detect) while the PK-232 uses front panel indicators. Both units use discriminator style tuning for HF operation. And that's just the tip of the iceberg. Features like multiple connects on packet, hardware HDLC, CW speed tracking, and other standard AEA software features are included in both the PK-64 and PK-232.

Fourth, AEA Quality and Price

Not many manufacturers like to discuss quality and price at the same time. AEA thinks you want high quality and low price in any product you buy, so that's what you get with the Pakratts. Ask any friend who owns AEA gear about our quality. The people who buy our products are our best salespeople. As for price, the PK-64 costs $219.95, or $319.95 with the HF option. The PK-64A, an enhanced software unit with a longer flexible computer cable, costs $269.95 or $369.95 with the HF option. The PK-232 costs $319.95 with the HF modem included. All prices are Amateur Net and available from your favorite amateur radio dealer. For more information contact your local dealer or AEA.

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VHF/UHF WORLD

Joe Reisert W1JR

the ubiquitous diode: part 1

If there's one solid-state component that's taken for granted and seemingly understood by all Amateurs, it's the diode. However, in discussions with fellow Amateurs, it's clear to me that although the basic concept of its operation is understood, its almost unlimited uses are rarely known.

For instance, when you mention diodes, most Amateurs think of power supplies, zeners, "idiot diodes" (if you don't use them, you're an idiot), detectors, and perhaps mixers. But there are many other types of diodes such as varactors, PIN, noise, Gunn, SRD, tunnel, LED, laser, photo, and so forth. These and other diode types are very important to VHF/UHF/microwave Amateurs.

This month's column will be devoted to the electrical and mechanical properties of the different types of VHF/UHF and microwave diodes. Next month's column will discuss specific applications using these diodes.

early solid-state diodes

The dictionary describes a diode as "a two-element electron tube or semiconductor through which current can pass in only one direction." This definition, however, doesn't mention anything about the diode's forward or reverse voltage/current characteristics, or its resistance, current handling capacity, junction capacitance, or applications.

Solid-state diodes were first described in a paper by Braun in 1874. However, they weren't used extensively until the days of the crystal radio sets to detect a-m from broadcast stations. This detection scheme — the process of changing rf to dc — is commonly referred to as rectification. Many years later, diodes were developed as low-voltage rectifiers for power supplies.

point contact diodes

Solid-state diodes are available in two major types, point contact and junction. Point contact diodes, the oldest solid-state type, date back to 1874 as noted above. They were the most common types used in the days of the crystal set.

The point contact diode is aptly named because in the early days it consisted of a piece of galena crystal (lead sulfide) or other suitable semiconductor material and a "cat's whisker" or fine wire that came to a point and contacted the crystal as shown in **fig. 1A**. By properly adjusting the point of contact on the galena crystal, a semiconductor junction is formed.

Low efficiency and the need to constantly readjust the contact on the early point contact diodes led to a change to vacuum tubes in the mid-1920s. However, by the early 1940s, solid-state diode performance was improved by the use of other semiconductor materials with better purity as well as different contact materials.

Some of the improved materials included but were not limited to copper oxide, carborundum, and selenium. Later yet, higher-performance materials such as germanium, silicon, and gallium arsenide became available. Development of materials continues to this day.

The improved point contact diodes performed well for many decades. Probably two of the most famous packaged point contact diodes were the 1N21 and 1N34 types, which are still in widespread use today. However, point contact diodes usually have limited current handling capacity and are difficult to reproduce in large quantities at low cost. They also are very fragile both mechanically and electri-

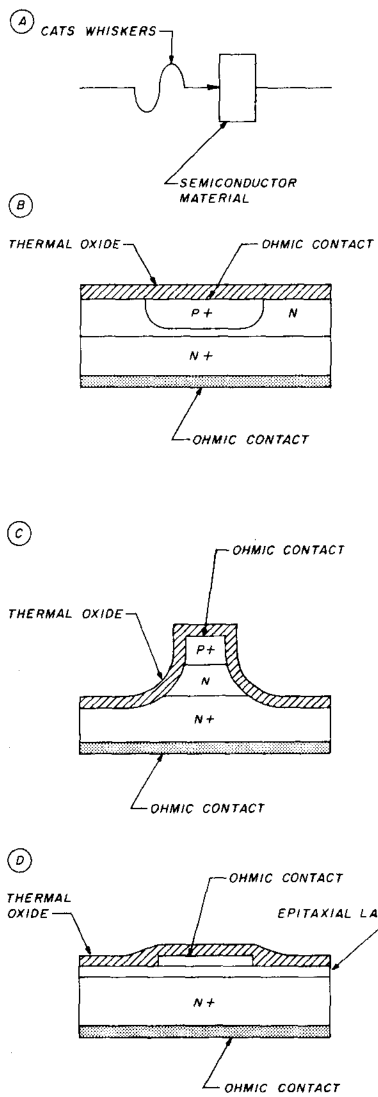

fig. 1. Typical diode construction: (A) point contact: (B) planar junction: (C) mesa junction: (D) hot carrier.

cally because the contact wire and junction are so small.

junction diodes

Fortunately an important technological breakthrough occurred when the Planar™ semiconductor manufacturing process was developed by Fairchild Semiconductor in the late 1950s. This patented process is now widely used to manufacture junction diodes, which offer both economy and repeatable electrical characteristics.

Most junction diodes are available in two geometries, *planar* and *mesa*. The typical planar geometry, shown in **fig. 1B**, resembles a flat plane. Note that the top of the diode is usually covered with a thermal oxide or overlay that adds some additional stray capacitance to the diode. This oxide is a result of passivation, a process meant to help seal the diode against external moisture and impurities.

The mesa geometry (**fig. 1C**), a variation of the planar type, was pioneered by Motorola, ostensibly to lower the capacitance across the junction of the diode. It supposedly takes its name from the geological mesa, a steep-sided hill with a flat top. I've also been told, however, that this geometry was named after the city where it was conceived — Mesa, Arizona — rather than from its apparent shape.

Usually less fragile than point contact types, junction diodes can be designed to have large current handling capacity. Many thousands of these diodes can be easily manufactured simultaneously on a single 2, 3 or 6-inch diameter semiconductor wafer and later divided into individual units.

Schottky diodes

By now you're probably wondering why I haven't mentioned the Schottky barrier or "hot carrier" diode. The reason is that it's a more recent configuration that works on an entirely different principle than the previously mentioned diodes.

The diodes discussed so far operate on the principle of minority carrier current, where the actual junction of the diode is buried within the semiconductor material. The hot carrier diode works on the principle of majority carrier current, where the rectification takes place right at the junction of the two materials.

The hot carrier diode was first theorized in 1938 by W. Schottky,[1] who described an idealized diode that would consist of metal contacts on a semiconductor material. The hot carrier diode as we know it today wasn't produced commercially until the mid-1960s. It uses the planar process but a different metalization scheme (**fig. 1D**).

electrical parameters of solid-state diodes

Let's first review some of the major characteristics of semiconductor diodes and the materials used to produce them. The most important electrical parameters of a semiconductor diode usually are forward voltage drop, reverse breakdown voltage, junction capacitance, and current handling capacity.

The forward voltage characteristic of a diode is a very important parameter. Often referred to as the "barrier" voltage or forward "knee," forward voltage is the minimum voltage required for a specific current to flow in the diode. In point contact diodes, this barrier voltage can approach zero volts. But in junction diodes, the barrier voltage is primarily a function of the solid-state material and the resistance of the metal contacts used to form the diode.

semiconductor materials

The most common semiconductor materials presently used in the manufacturing of junction diodes are germanium, silicon, and gallium arsenide. Germanium has the lowest barrier voltage, typically 0.3 volts at 1 milliampere of forward current at room temperature. However, germanium has poor thermal stability, especially as temperature increases.

Silicon is surely the most common semiconductor diode material in use today. When used in junction diodes it has a medium barrier voltage of about 0.6 volts at 1 milliampere. Silicon is plentiful, inexpensive to produce, easy to use, has good cutoff frequencies (typically greater than 10 GHz), and reasonable thermal stability.

The use of gallium arsenide in diodes is more recent. It is often used in the microwave and millimeter-wave spectrum since it has a much higher mobility and hence a higher cutoff frequency than either germanium or silicon. Its barrier voltage is high, typically around 1.1 volts.

The barrier voltage of a hot carrier diode is influenced by the semiconductor material as well as by the metalization contact materials. By changing the contact metals to the semiconductor material, the barrier voltage can be altered.

Hot carrier diodes usually use either silicon or gallium arsenide for the semiconductor material. Silicon hot carrier diodes have a typical barrier voltage of 0.3 volts, about half that of a typical silicon junction diode. Furthermore, hot carrier diodes can now be made with almost no barrier voltage. These devices are usually used as detectors and are often referred to as "zero-biased Schottkys".

For comparison, the typical low-level forward voltage versus current characteristics of point contact and junction diodes using germanium, silicon, and gallium arsenide are shown on the graph in **fig. 2**. Zero-biased as well as low, medium, and high barrier silicon hot carrier diodes are also shown.

Notice in **fig. 2** that as the current increases, the forward voltage drop across the diode increases. This is true because as current increases, there is an additional voltage drop across the total series resistance, R_T.

This total resistance is the sum of the series resistance, R_S, and the junction resistance, R_J, of a diode. This is shown schematically in **fig. 3** and in **eqn. 1** below.

$$R_T = R_S + R_J \qquad (1)$$

where R_T, R_S, and R_J are in ohms. R_S is primarily a function of the resistance of the connecting wire and the metalization resistance of the semiconductor material. R_J is a function of the forward current in the diode junction and can be approximated by:

$$R_J = \frac{26}{I_T} \qquad (2)$$

where I_T is the total current in the diode in milliamperes.

For instance, if the series resistance, R_S, of a diode is 5 ohms and the forward current is 1.0 milliampere, the total resistance of the diode, R_T, will be approximately 31 ohms. At 10 milliamperes of forward current, the total resistance will drop to about 7.6 ohms.

R_T is very important since the higher the series resistance, the higher the voltage drop across the diode, and the lower the efficiency (especially at small signal levels). High series resistance also means that more power will be dissipated as heat in the diode.

It can be shown that to lower the forward resistance and raise the current handling capacity of a diode, the area of the semiconductor material must be increased. However, this usually increases the junction capacitance and hence decreases the maximum frequency of operation.

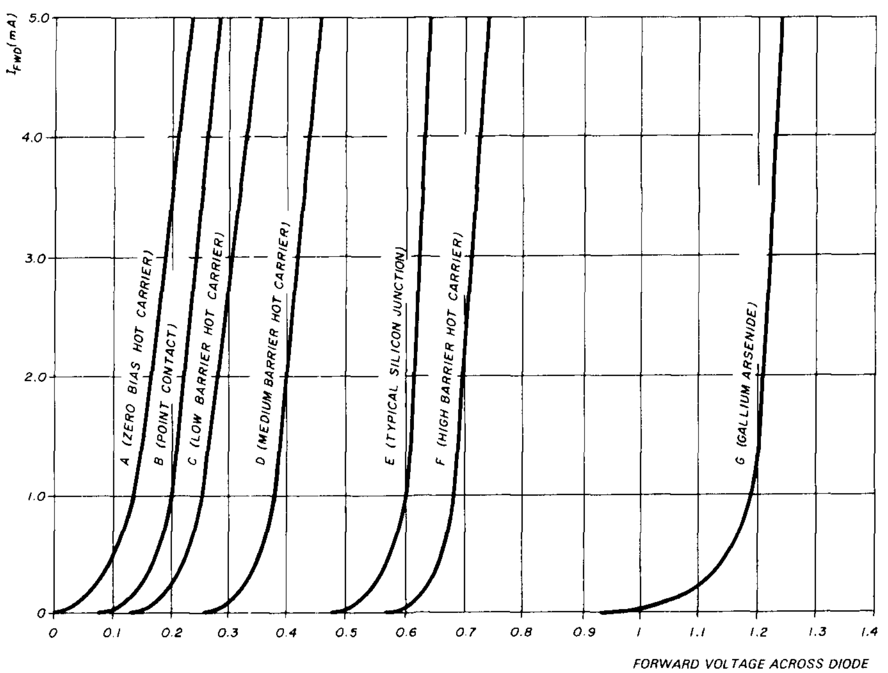

fig. 2. Forward voltage versus current characteristics of typical diodes: (A) zero-biased hot carrier: (B) point contact: (C) low-barrier hot carrier: (D) medium barrier hot carrier (the typical type): (E) silicon junction: (F) high barrier hot carrier: (G) gallium arsenide.

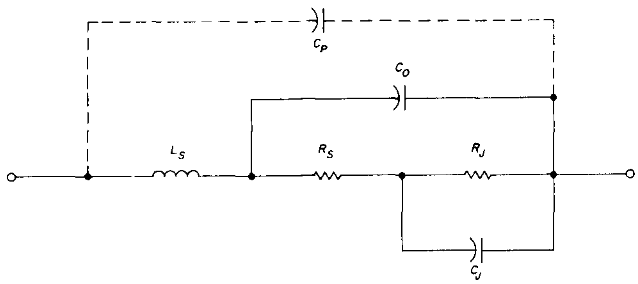

fig. 3. Equivalent circuit for a typical diode. C_j is junction capacitance, C_o is the overlay or passivation capacitance, C_p is package capacitance (if package is used), L_s is series inductance of package, R_j is junction resistance, and R_s is series metalization and bonding resistance.

breakdown voltage

Reverse breakdown voltage is another very important electrical parameter of a semiconductor diode. Typically speaking, at low reverse voltage little (perhaps microamperes) or no reverse current flows through the diode.

Each diode has a specific reverse breakdown voltage at which the junction avalanches and high current flows, limited only by the resistance of the diode itself and any external resistance in series with the power source. If this avalanche current is not sufficiently limited, the diode will be destroyed quickly.

The reverse breakdown voltage of a diode is a function of the material and the metalization. **Figure 4** shows some typical breakdown voltages versus type of diodes. Generally speaking, it is only a few volts on the point contact and zero-biased hot carrier diodes used for low-level signal detection. On the other hand, power supply rectifiers can have high reverse breakdown into the hundreds of volts.

diode capacitance

One of the most important parameters for high frequency operation is the total capacitance across the diode, C_T.

This capacitance is:

$$C_T = C_J + C_O + C_P$$

Referring to the equivalent circuit of a diode in **fig. 3**, C_J is the junction capacitance, C_O is the overlay capacitance (usually kept to a minimum, as described earlier), and C_P is the capacitance due to the package (if any), all in pF.

Package and overlay capacitance are fixed quantities, but junction capacitance decreases to some nominal value when the diode is reverse-biased. For detector and mixer diodes, this capacitance is usually measured at zero volts or at some low reverse voltage — for example, 1 to 4 volts (depending on the reverse breakdown

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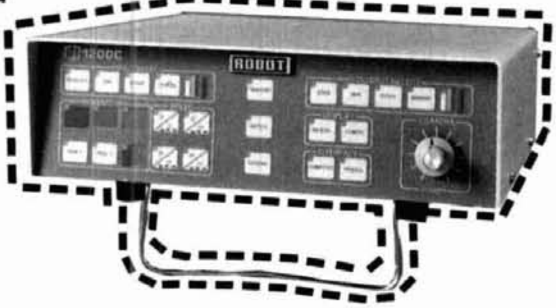

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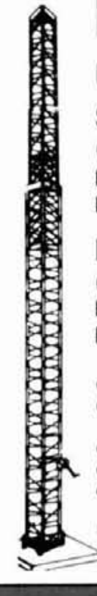

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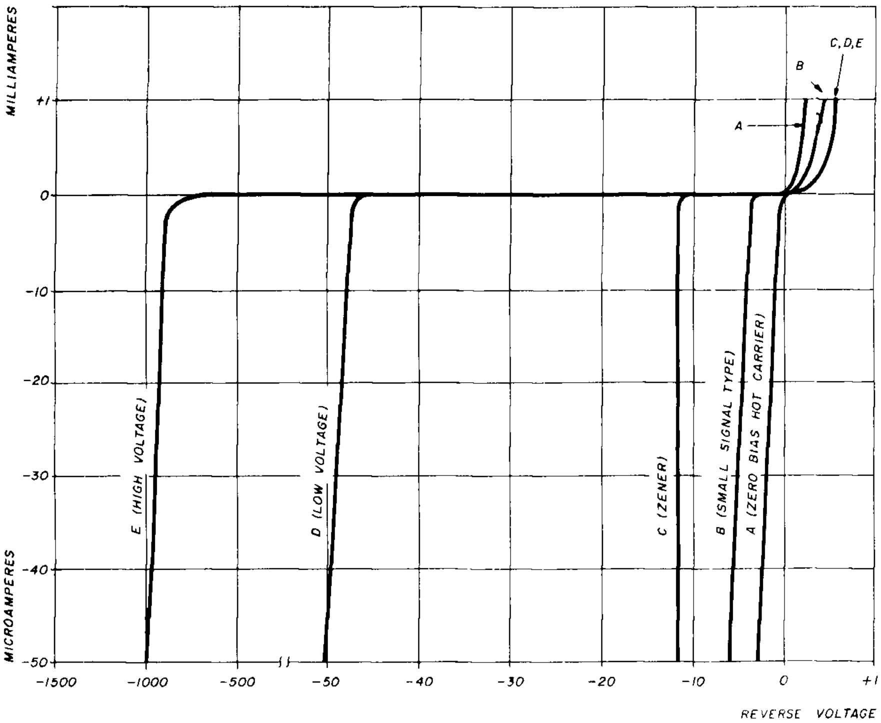

fig. 4. Reverse voltage breakdown characteristics of some typical diodes: (A) zero-biased hot carrier: (B) small signal type: (C) zener: (D) low voltage power supply type: (E) high voltage type.

voltage of the diode). The total capacitance of a typical UHF hot carrier diode versus bias voltage is shown in **fig. 5**.

The effect of the total capacitance on the operation of a diode can be envisioned intuitively. The greater the shunt capacitance, the more likely that the signal entering the diode will bypass the junction resistance, where it can offer the most rectification. Therefore the greater the total capacitance across the diode, the lower the maximum frequency of operation. The maximum frequency of operation versus junction capacitance for a typical hot carrier detector diode can be estimated based on the data shown in **table 1**.

Table 1. Typical maximum recommended junction capacitance versus maximum frequency of operation for hot carrier detector and mixer diodes.

Maximum Frequency in GHz	Maximum C_J in pF
0.1	0.7
0.3	0.6
1.0	0.45
3.0	0.35
10.0	0.22

tuning diodes

Capacitance in the junction of a diode is not always bad. If the semiconductor material is properly doped, a diode can be developed and used as a voltage-variable capacitor or tuning diode, which is often referred to as a "varactor" diode. Varactors are used in modulators, tuned filters, voltage-controlled oscillators, and frequency multipliers.

There are two major types of varactor diodes, abrupt and hyper-abrupt junction. In the abrupt junction type, the capacitance versus reverse voltage follows a logarithmic characteristic as shown in **fig. 5**.

Abrupt junction diodes are most often used where high *Q* and a moderate (i.e., 2:1 or 3:1) capacitance tuning ratio is acceptable. Most abrupt junction diodes are specified at a nominal capacitance with −4.0 volts applied across the junction, a defined tuning ratio, and *Q* at a specified frequency. The *Q* of a diode increases as frequency and the capacitance decreases. It is seldom desirable to operate a varactor diode with low reverse voltages (1.0 volts or less) since the diode may begin to rectify.

Hyper-abrupt junction diodes are most often used where very large (i.e., greater than 3:1) tuning ratios are required. Tuning ratios approaching 10:1 are possible. Hyper-abrupt varactors typically have lower reverse breakdown voltage specifications, are more sensitive to temperature variations, and usually have a lower *Q* than equivalent abrupt junction diodes. Furthermore, they are usually operated over a narrower tuning voltage range. For comparison, a typical hyper-abrupt tuning capacitance versus reverse voltage characteristic is shown in **fig. 5**.

diode packages

In extremely demanding applications, diodes are often used in chip form because this tends to lessen any parasitic elements in the operation of the diode. But this isn't always desirable, especially for Amateurs. Unpackaged diodes are small, fragile, and difficult to handle. Furthermore, they're often not hermetic, even when passivated.

As a result, most Amateurs prefer to use packaged diodes, which are not only easier to handle but also generally easy to remove or change if that becomes necessary. Therefore, it is very important that due consideration be given to the choice of the package.

One of the oldest semiconductor diode packages is the so-called 1N21 style, as mentioned above (**fig. 6A**). Polarity is usually marked on the package. In some versions, the diode package can actually be separated into two pieces and reversed if the opposite polarity is desired. This package is most often used for older and replacement point contact diodes.

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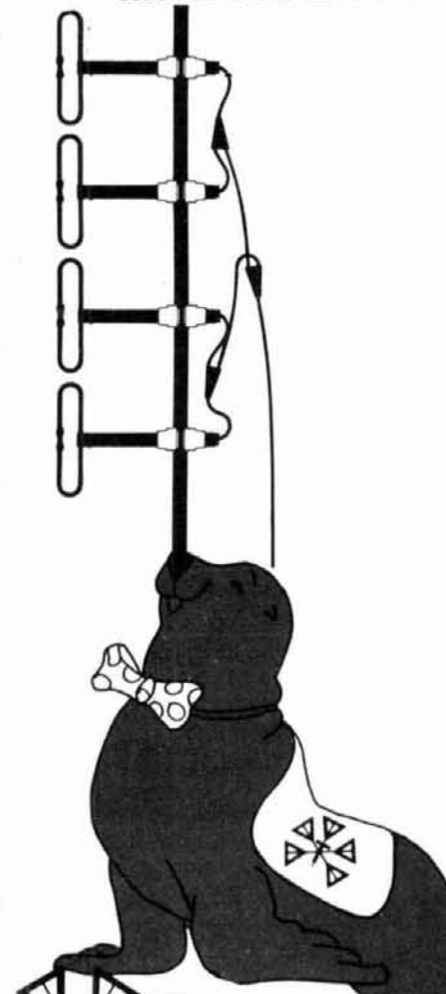

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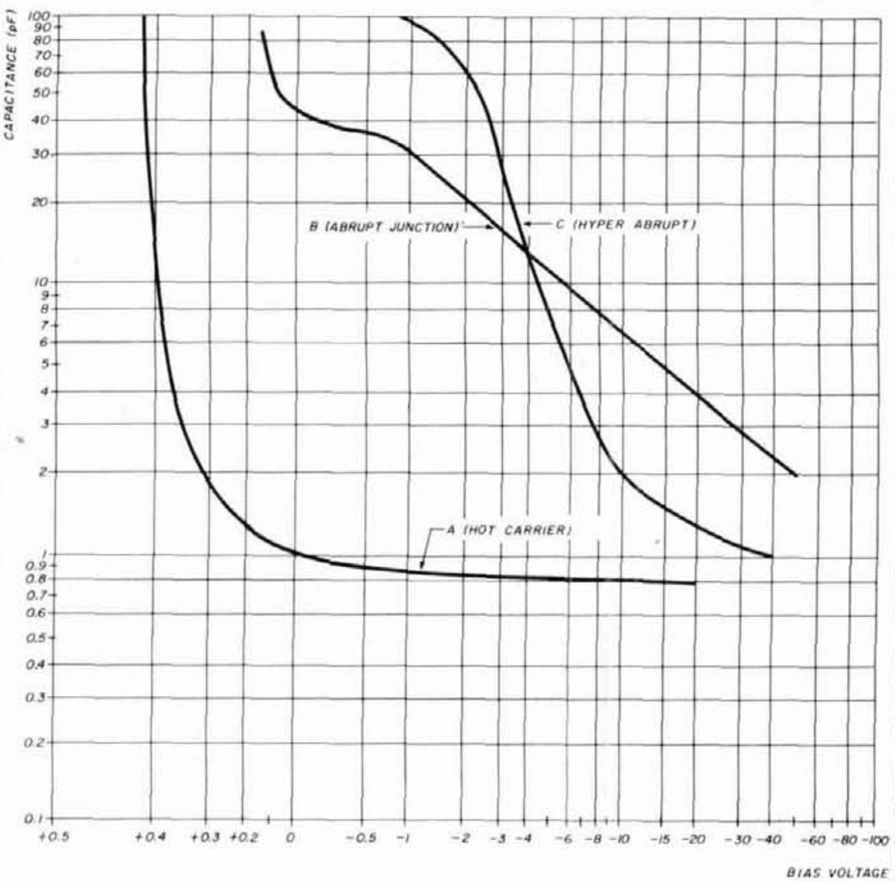

fig. 5. Diode capacitance versus bias voltage: (A) VHF hot carrier detector: (B) abrupt junction: (C) hyper-abrupt junction.

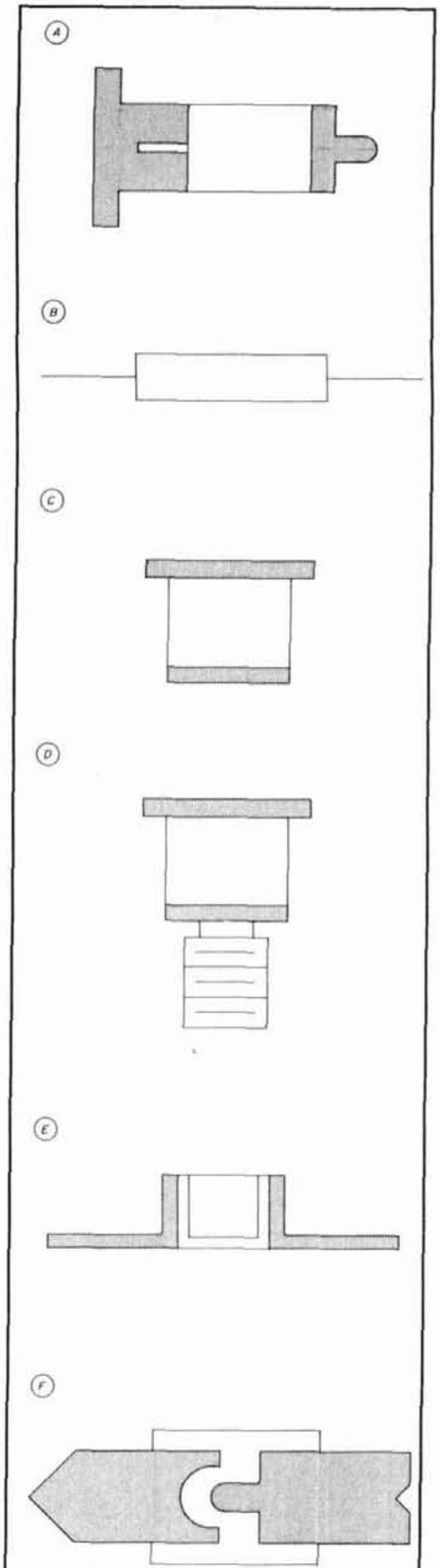

fig. 6. Some typical diode packages: (A) 1N21 type: (B) axial lead glass or plastic type: (C) microwave pill: (D) microwave pill threaded post: (E) stripline: (F) beamlead.

By far one of the most common diode packages used by Amateurs is the glass or plastic axial lead type (**fig. 6B**). The diode substrate is bonded to one lead of the package. The other package lead may be bonded by thermocompression to the other side of the diode lead if high reliability is required. Where economy is important, the second lead is usually attached to the diode with a whisker or pressure-type lead, which is often referred to as a "C" spring. This package usually has low shunt capacitance. However, it also has high (i.e., at least several nanohenries) series inductance shown as L_S in the diode equivalent circuit in **fig. 3**.

Another popular type of package is the microwave pill. Used where dissipation or extremely low inductance contact is required, it is shown in one form in **fig. 6C**. If heat is a real problem, the base of the package may be threaded as shown in **fig. 6D**.

Stripline pill type packages are also used (**fig. 6E**). In special situations, the beamlead diode is popular because it has the diode integrated into the leads as shown in **fig. 6F**. However, this type of diode mounting may also be difficult to handle because it's so small and fragile.

The choice of the proper package for a microwave diode is very important. Hundreds of different diode packages are now in common use. Each one has its advantages and disadvantages. When cost is important, some compromise in performance may be justified. However, in applications where the ultimate in performance is required, the package will be costly and perhaps difficult to use.

summary

In this month's column we discussed the basic electrical and mechanical properties of VHF/UHF and microwave solid-state diodes. Other less well-known properties must be understood before you can choose the appropriate diodes for specific applications; some of these properties *will be discussed next month. Other* types of diodes suitable for specific applications will also be discussed. See you next month!

new dx records

In last month's column we updated all the latest North American DX records.[2] But as the January issue went to press, two more records were broken!

As predicted in that column, the 33-cm (903 MHz) record was further extended. On September 14, 1986, a Georgia VHF/UHF contest group signing WS4F/4, operating from Mount Toxaway, North Carolina (EM85MN), worked W4ODW in Niceville, Florida (EM60SM). This extends the 33-cm tropo DX record to 377 miles (606 kilometers). Congratulations to all involved.

I have also just been informed that the North American 9-cm (3456 MHz) tropo DX record was also broken by a comfortable margin when WB5LUA/5 in Mena, Arkansas, worked WA5TNY/5 in Fairy, Texas. I hope to include all the details on this contact in next month's column. Congratulations to Al and Rick!

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references

1. W. Schottky, "Naturwissenschaften," *Z. Physics,* Volume 26, 1938, page 843.
2. Joe Reisert, W1JR, "VHF/UHF World: Microwave and Millimeter-Wave Update," *ham radio,* January, 1987, page 63.

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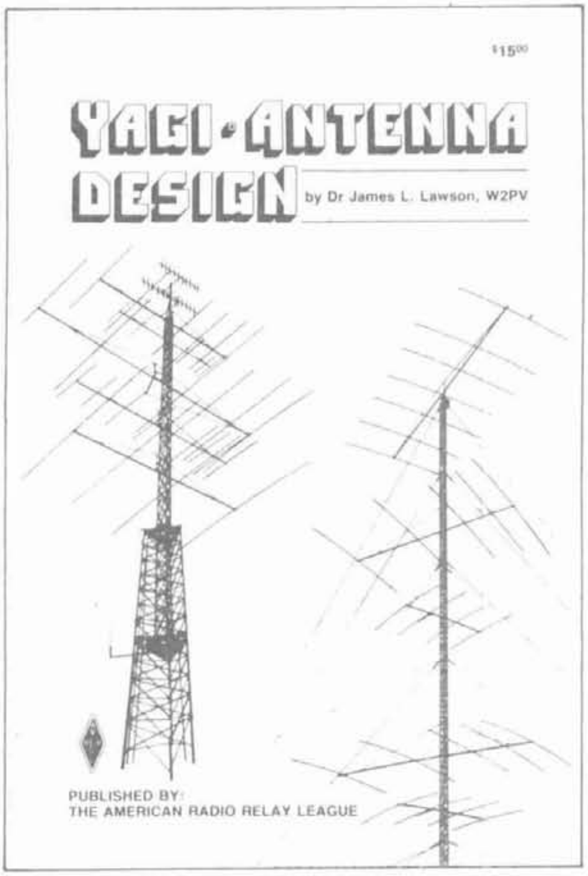

Yagi Antenna Design is based on the series in **Ham Radio Magazine** by the late Dr. James L. Lawson, W2PV. Jim was a highly competitive person and this carried through to his Amateur Radio hobby and work with antennas. Although this book is primarily the work of the author, credit should be given to its editors: Bill Myers, K1GQ; Clarke Greene, K1JX; and Mark Wilson, AA2Z. This ARRL publication stands to be a "classic" that should be added to every radio amateur's technical library. The book is available only in hard cover, and is printed on high quality textbook paper. There are over 210 pages of detailed information on Yagi design. For more detail, refer to the column at right. The retail price is $15.00. Please add $2.50 ($3.50 for UPS) for postage and handling. Also available at your favorite ARRL dealer.

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CONTENTS

PRACTICALLY SPEAKING ... Joe Carr K4IPV

testing components

A basic question often asked is how to test diodes. You can use an ohmmeter to measure the diode's resistance in both directions. If the diode conducts current in only one direction, you'll find — as expected — a large, seemingly infinite resistance when the ohmmeter probes reverse-bias the diode under test. When the probes forward-bias it, you'll find a very low resistance.

For small signal diodes, use the X100 or X1000 scales of a VOM; for power supply rectifiers, use the X1 scale. Note the values obtained in both directions. The positive (the red lead, normally) should show low resistance; the second reading (with leads reversed) should be very much higher than the first.

What does "very much higher" mean? When I first started out as an apprentice technician in 1959, selenium rectifiers showed only a 2:1 ratio between forward and reverse resistances; 500-mA silicon rectifiers (which were all in "top-hat" packages in those days) showed 5:1 or so. Later, the 1N4xxx-series devices showed 10:1 or greater. Similarly, germanium small signal diodes (1N34, 1N60, etc.) showed 5:1 when good, while silicon devices (1N23, 1N914, 1N4148, etc.) showed 10:1. Modern varieties of these same diodes show 100:1, according to ohmmeter tests that I ran for this article. Keep the older values in mind, however, because "antique" diodes tend to show up in bargain packs, in older equipment under repair, and in hamfest "specials".

testing SCRs

Although silicon controlled rectifiers (SCRs) can be tested with an ohmmeter in a similar manner, it's first necessary to determine whether or not the gate of the SCR is capable of controlling the diode. Three questions must be asked. Will the gate turn on the device? Does the SCR act like a regular diode after turn-on? And does it turn off when the current drops below a certain value?

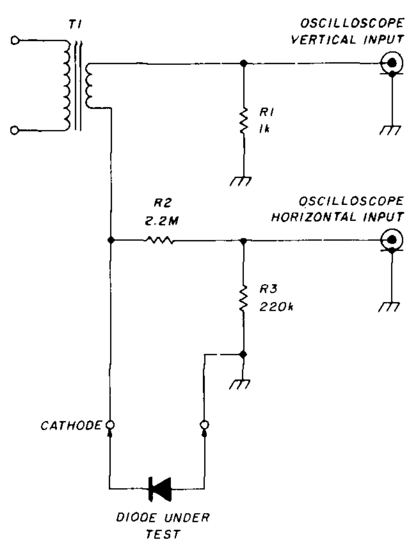

fig. 1. Simple diode curve tracer can be constructed using available oscilloscope and a few additional components.

The gate circuit can be tested by connecting the positive ohmmeter probe to the SCR's anode and then taking a resistor (experiment with the value, which depends upon turn-on current of the SCR) and connecting it between the anode and gate. The resistance of the SCR should be high before the resistor is connected, and low afterwards. After turn-on, remove the resistor. The SCR should still conduct. Disconnect the positive probe and then reconnect it. If the SCR is good, the resistance will again be high. Note: this method works only on low-current SCRs; the ohmmeter current is less than the hold-on current of high-amperage SCR devices.

Because other (parallel) circuit resistances can affect results, testing diodes with an ohmmeter is done out of circuit. When troubleshooting, disconnect one end of the diode before attempting to test. In dc power supplies, there are good reasons to disconnect both ends of the diode under test. Stored charges, even in low-voltage circuits, can destroy the diode — or even the ohmmeter — in the event of a mistake. Considering the voltages present in high-voltage power supplies, it can also be dangerous.

VOM versus DMM

VOMs typically used a 1.5-volt battery in the ohmmeter circuit. Bench model vacuum tube voltmeters (VTVM) also used 1.5-volt batteries (or electronic power supplies in a very few models) for the ohmmeter, even though they were also powered from the 110-volt ac line. Be careful when using ancient VOM/VTVM instruments, by the way; some pre-1955 models used 22.5-volt batteries for the ohmmeter, and these instruments will blow every diode you try to test. Suspect this as the cause if you're using an older instrument, or if every diode you test seems to be shorted (they are!).

Modern digital multimeters typically use low-voltage sources for the ohmmeter function. The voltage levels used won't forward-bias the diode, so the diode will test open. Most instruments of recent design have a "high-power" ohmmeter function specifically for testing diodes. The high-power function will sometimes be marked, but in most instruments it's

designated on the function switch with just a diode symbol. On a few instruments, a Hi/Lo Ohms switch is used for exactly the same purpose.

One reader wrote to ask why different meters give different readings in diode testing. This is because different meters use different voltage sources and have different internal circuit resistances. This same effect is seen when switching scales on the same ohmmeter.

matching diodes

Matched diodes are needed in a variety of circuits — for example, in ratio detectors, in discriminators and other fm demodulators, and in quadrature phase detectors, which are used in instrumentation applications. With modern diodes and most circuits (note the caveats!), diode matching isn't necessary unless you're trying to squeeze every last little drop of performance out of the circuit. Some replacement part manufacturers offer matched pairs of 1N60 diodes for high fidelity fm tuners; in communications applications, diode matching is only rarely important.

If you feel you must match diodes, use an ohmmeter to measure the forward and reverse resistances of several diodes, selecting those with the closest resistance readings.

build a simple diode curve tracer

Figure 1 shows a method by which an oscilloscope can be used to trace the I vs. V curve of a PN junction diode. Transformer T1 is a low-voltage filament transformer. I used a 25.6-VAC, 300-mA model, but anything from 6.3 VAC to 26 VAC can be used. The high resistances, effectively in series with the diode under test, prevent burn-out. **Figure 2** shows several oscilloscope traces under various conditions. **Figure 2A** shows the normal diode trace for a good 1N914; **fig. 2B** shows the trace for an open diode. **Figure 2C** shows a shorted diode, and **fig. 2D**, a very leaky diode (simulated by shunting 2.2 k across the 1N914).

additional notes on transistor substitution

In recent columns (September and October, 1986) we discussed transistor substitution. A reader from California reminded me of something I'd seen in repair shops a decade ago but forgotten. When dealing with older equipment, or with project circuits designed more than 20 years ago, be careful in making substitutions with modern devices. In fact, you can even run into problems with transistors of the same type number, but of modern manufacture. The problem is two-fold.

First, older transistors didn't attain the frequency specs that modern transistors do. Even though recently manufactured units may have the same type number, they'll now have a much higher frequency response. This situation is especially likely when using a substitute from a replacement line, where the original type is no longer available but a "better" substitute is offered. Years ago, circuit designers didn't have to worry as much about layout and stabilization because the transistor was self-limiting. At frequencies where oscillation could occur with a high-frequency device, the gain was too low to support Barkhausen's criteria for oscillation; that isn't the case today. If a high-frequency transistor is substituted for an older device, it might oscillate.

Second, the C-E, C-B and B-E leakage resistances were much worse in older devices, and designers had to compensate for these parallel resistances in the circuits. As a result, a circuit that is properly biased using older devices is not properly biased for the modern replacement. In the late 1960s I worked in a car radio shop after engineering school every day. I once

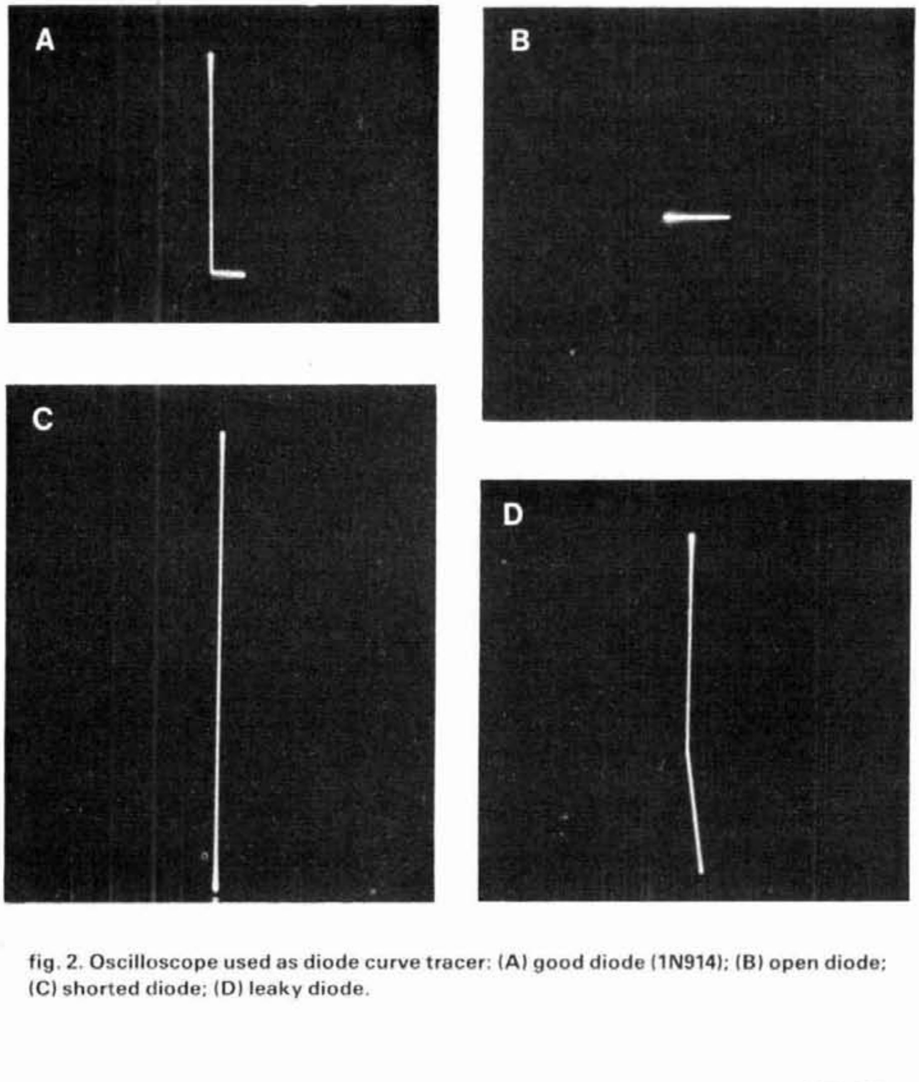

fig. 2. Oscilloscope used as diode curve tracer: (A) good diode (1N914); (B) open diode; (C) shorted diode; (D) leaky diode.

asked a tech rep from one of the major auto radio makers why his company had switched resistor values when the new radio used the same device number in the same circuit. He explained that new production transistors (they were Ge, not Si) were much better in terms of leakage resistance.

Be careful.

NOTE: If you have any tips, techniques, or questions you'd like to see discussed in this column, please contact K4IPV at P.O. Box 1099, Falls Church, Virginia 22041.

ham radio

short circuit

vhf/uhf world

The following text should accompany **fig. 3** of W1JR's December, 1986, column: *The boom is 1-inch square tubing with 0.062-inch wall. One-inch diameter round tubing may be directly substituted, as discussed in the text, though with decreased mechanical strength. The boom should be supported as discussed. All elements are made from 3/16-inch diameter aluminum rod and pass through the boom with insulated shoulder washers and keepers as described. The ends of all elements should be bevelled approximately 1/32 inch. The length of the driven element and/or the spacings and lengths of the T-match are not critical and may have to be modified slightly to obtain a low (1.2:1 maximum) VSWR.*

Figure 3 should include the following note in the second part of the figure: *Note 3: The UG21 connector is attached to the boom with an L-shaped aluminum plate approximately 1.5 by 1/16-inch thick. Drill out two of the UG21 connector holes with a 0.142-inch diameter drill. Prepare a 4:1 (200-50 ohm) λ/2 type balun made from an 11.0-inch piece of 0.141-inch diameter, 50-ohm semirigid coax with 3/8 inch of the outer tubing stripped off each end and 1/4 inch of PTFE removed for connection to the T-match. Bend the coax in a "U" shape and pass the two ends through the two drilled-out holes in the UG21 connector. Solder the coax on both sides where it passes through the connector.*

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mmic multiplier chains for the 902-MHz band

Doublers with gain and simple filters produce reliable results

It's possible to design a simple frequency multiplier chain for UHF and microwave transceiving converters using stable and easily reproduced silicon MMIC (Microwave Monolithic Integrated Circuit) amplifier blocks. In this article, I'll first discuss the use of MMIC amplifiers as multipliers, then describe a specific application — a local oscillator for the 902-MHz band.

MMIC multipliers have gain

The key to the design of this multiplier chain was the realization that silicon MMIC amplifiers not only make good active multiplier stages, but can also provide gain — i.e., the harmonic output power level can be greater than the fundamental input power. MMIC amplifiers offer several advantages over more conventional active multipliers. First, MMIC amplifier "building blocks" are internally matched and unconditionally stable, so there's no need to worry about pulling them into spurious oscillation modes, as can happen when a discrete transistor multiplier is tuned with external networks. MMIC amplifiers are small and inexpensive, too, and consequently attractive for multiple use. Unfortunately, they require a fair amount of dc power to operate.

initial tests

The Avantek MSA 03 MMIC was tested for use as a multiplier. It was biased normally and an input signal at 0 dBm was applied. The second harmonic, viewed on a spectrum analyzer, was typically 10 to 15 dB below the fundamental *output*. Since the gain of the MSA 03 is about 12 to 14 dB, the second harmonic is about equal in power to the drive signal. This suggests that to build an active doubler with this MMIC, all that's required is a filter to reject the fundamental output and enhance the desired second harmonic.

higher order multiplication has disadvantages

Of course it's possible to multiply by a number other than two. Triplers and even quadruplers aren't uncommon in transistor multiplier circuits. However, there are a couple of factors that led me to use only doublers. First, the gain of a multiplier falls off as the multiplication factor is increased. As discussed before, to get unity or greater gain with an MMIC multiplier, a doubler is most effective. Second, the filtering is simplified when doubling, since the *undesired* products are 50 percent away from the desired passband. This ratio decreases for higher order multiplication, to 33 percent in a $\times 3$ multiplier and down to 25 percent for a quadrupler.* As the fractional bandwidth between desired and undesired products narrows, the filter complexity increases to maintain a given amount of rejection. In the interest of keeping the filtering simple and easy to tune, I elected to go to the higher number of stages needed for doublers and pay the price in increased power consumption. This approach worked, since the multiplier chain proved easy to tune and results were repeatable. No undesired spurious oscillations were encountered at any time during the development of these MMIC multiplier stages.

filters *are* needed

Filters are the key elements in the multiplier chain. Each MMIC stage must be followed by a filter to remove the fundamental while at the same time passing the desired second harmonic. Much of the justification for using doublers was to permit the use of simple, easily tuned filters.

At lower frequencies it's easy to build filters using lumped circuit techniques and designs provided in the

*For example, when doubling 100 MHz to 200, the nearest undesired products are the fundamental (X1) at 100 MHz and the third harmonic at 300 MHz. Each is separated by 50 percent from the desired 200-MHz output. Similarly, when tripling 100 to 300, the undesired X2 and X4 products are 100 MHz away, or 33 percent of the 300-MHz center frequency.

By **Jerry Hinshaw, N6JH,** 142 Kensington Place, Frederick, Maryland 21701

literature.[2,3] As one approaches UHF, it becomes more difficult to control the stray capacitances and inductances, and individual components themselves resonate in undesired ways. At this point, it's good to change over to another type of filter, one that's more appropriate to UHF work. It would be nice if such filters were also simple, easy to tune, and fit in well with the other circuitry.

The two higher-frequency bandpass filters were designed using printed inductors (printed coupled microstrip transmission lines). This was done for several reasons. First, at higher UHF frequencies, pure inductances in lumped element filters are smaller and more difficult to make, while the printed coupled lines are easier to construct. In addition, once the coupled lines are designed and printed on the circuit board, they have known, stable characteristics.

These filters are the equivalent of the familiar combline bandpass filters often encountered in microwave work. The difference is that here the usual air-dielectric resonator rods have been replaced by a microstripline version. The two lines, shorted to ground at one end, and capacitively loaded at the far end, are coupled by the electric fields both in the dielectric substrate and in the air above the microstriplines. Here, the substrate is the usual Amateur microwave printed circuit board material, G-10. The coupling between the lines depends mainly upon their width, the spacing between them, and their lengths.*

A number of references contain graphical aids to the design of coupled line pairs, and earlier articles describing the use of similar structures have appeared in the Amateur literature.[4] Several CAD programs including models for coupled lines on microstrip are available; I used such a program to optimize the design of the two filters incorporated in this multiplier. The mechanical details of the filters are given in the PC layout (**fig. 3**).

The characteristics of these filters include good low-frequency response, with no undesired passband below the center frequency. They also offer good high-frequency response up to approximately three times the center frequency. Near the third harmonic, the rods are again quasi-resonant, and there is a second, undesired passband. However, in a multiplier, this band is at approximately the sixth harmonic of the doubler's input signal, and it has generally not caused any problems because the sixth harmonic is quite low in power.

These coupled microstripline filters are also easy to tune to their center frequency because their response is fairly broad. The microstriplines, once printed on the substrate, are, of course, unadjustable, so that only the two trimmer capacitors have to be tuned. Fixing the inductors by printing them on the board has its advantages: fixed-tuned inductors need not be blindly tuned, and it's easier to avoid tuning to the wrong harmonic when the tuning range is restricted.

The other main ingredient in this type of multiplier is the active stages. Here, they are MMIC amplifiers, silicon integrated circuits designed to provide very wideband gain. Packaged in small, transistor-like plastic housings, they contain almost all of the biasing and matching circuitry for a complete rf amplifier. Devices from Avantek have been described in a number of publications recently.[5,6,7] In addition, a new, even lower-cost entry into the MMIC field has been announced by Mini-Circuits Labs.[8] Other manufacturers will undoubtedly announce silicon MMICs of their own soon. Most of these amplifiers are suited for multiplier use if they're driven to near saturation. All are unconditionally stable, which is a great aid to the design of a multiplier gain stage with a reactive filter terminating the output. The multiplier described below uses Avantek amplifier MMICs, but other similar devices could probably work as well.

a local oscillator circuit

A multiplier based on MMIC gain blocks represented an easy and repeatable design approach to 902-MHz band operation. I wanted to build a converter that would translate this band down to the 144-MHz band so that I could use my 2-meter transceiver; doing this would call for a local oscillator operating at approximately 758 MHz. A local oscillator (LO) 144 MHz above the operating frequency would also be possible, but that would invert the sidebands in an SSB system, and otherwise offer no particular advantages.

The choice of exact LO frequency is worth a moment of thought, as many UHF operators have discovered (the hard way) in the past. It's best not to choose an LO frequency that will produce undesired responses at the i-f. Here, we must avoid a local oscillator frequency whose harmonics fall in-band either on the 2-meter i-f or within the 902-MHz band. A second possible problem can occur when there's a strong signal at the i-f from external sources — for example, if the i-f is 144.2 MHz when operating on the suggested calling frequency of 903.1, there will be problems with i-f feedthrough of strong signals on 144.2. These signals leak around the converter and appear on top of the real signals downconverted from the 902-MHz band. It can be difficult to shield the i-f sufficiently to avoid this entirely, so it's prudent to pick a less congested frequency for the i-f. In my area, 144.5 is usually quiet. So, for my example, the LO was designed at 903.1 − 144.5 = 758.6 MHz.

Because I wanted to use only doublers in the multiplier chain, the choice of multiplication factors was restricted to powers of 2, with 4, 8, or 16 the most

*for a given substrate material and thickness.

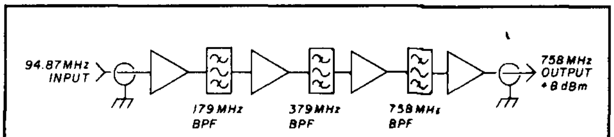

fig. 1. Block diagram of the X8 multiplier.

758.6 MHz, is further amplified after filtering to produce a power level sufficient to drive a standard-level double-balanced mixer.

The first bandpass filter, centered at 189 MHz, consists of two series-resonant sections and a single capacitive shunt element. The series sections use air-wound coils. I've long found inductors of this type

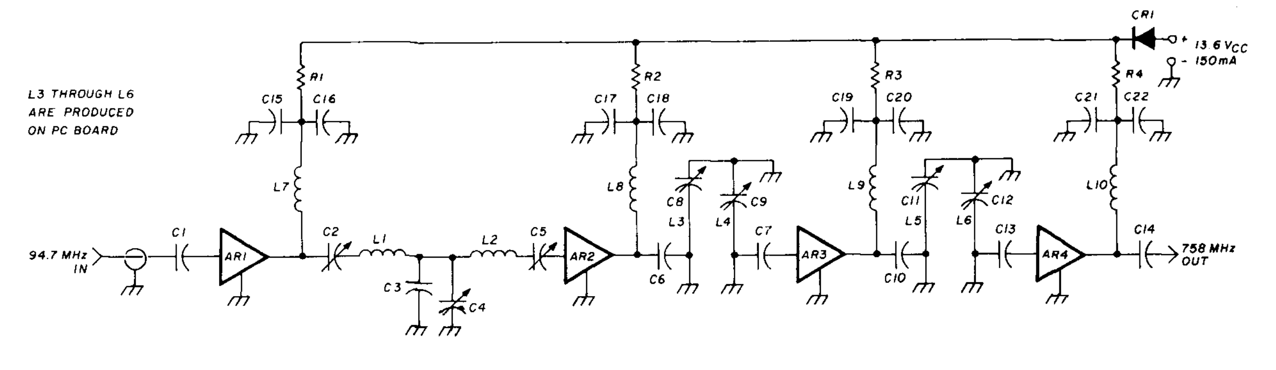

fig. 2. Schematic diagram of the multiplier.

reasonable choices. However, if the total multiplication were only 4, the crystal operating frequency would have to be approximately 188 MHz. Such crystals are available, but they're neither common nor economical. Three doublers in series gives a multiplication of 8 and calls for an input of about 94 MHz, which is a readily available frequency in common series-resonant, fifth overtone crystals. Four doublers would yield a X16 output, with a crystal at 47 MHz, but there appears to be no reason to go beyond an X8 stage. I ordered a crystal for

$$\frac{758.6}{8} = 94.825000 \ MHz$$

The block diagram of this LO chain is shown in **fig. 1**. The crystal oscillator's (approximate) 94-MHz output is buffered and amplified by an MMIC stage, which drives a lumped element bandpass filter centered on 189 MHz. (See schematic of MMIC multiplier chain in **fig. 2**.) This filter presents a good VSWR at its center frequency, but a very poor match at the oscillator's fundamental operating frequency. The fundamental output of the amplifier is reflected back into the MMIC, where it has a second chance to contribute to second harmonic output.*

Though the next two multiplier stages are similar in design, they differ mainly in that their bandpass filters use coupled microstriplines rather than lumped elements. At each stage, there's an MMIC amplifier driving a bandpass filter tuned to the second harmonic of the MMIC's input frequency. The final output, at

*I have no idea if such conversion is significant; however, it would be interesting to experiment.

Parts list for the multiplier.

AR1-4	*Avantek MSA0304 MMIC Amplifier*	
C1,6,7,15, 17,19,21	*0.01μF ceramic disc capacitors*	
C2	*1.7 pF*	*nominal 0.8-8pF*
C5	*1.7 pF*	*trimmer capacitor*
C11	*3.9 pF*	*nominal 0.8-8pF*
C12	*3.9 pF*	*trimmer capacitor*
C3	*10 pF ceramic capacitor*	
C4	*2-8 pF trimmer capacitor*	
C8	*10 pF*	*nominal 4-20 pF*
C9	*10 pF*	*trimmer capacitor*
C10,13,14	*33 pF chip capacitor*	
C16,18,20,22	*0.01 μF (non-critical value)*	
CR1	*Silicon rectifier diode 1N4002 or equivalent*	
L1,L2	*16-1/2 turns No. 24 AWG, 0.3μH. Bare wire wound in threads of nylon 6-32 screw.*	
L7,8,9,10	*10 to 15 turns No. 30 AWG Kynar insulated wire-wrap; Wire close-wound on No. 60 drill.*	
R1-4	*200 ohm, 1/4-watt carbon composition*	

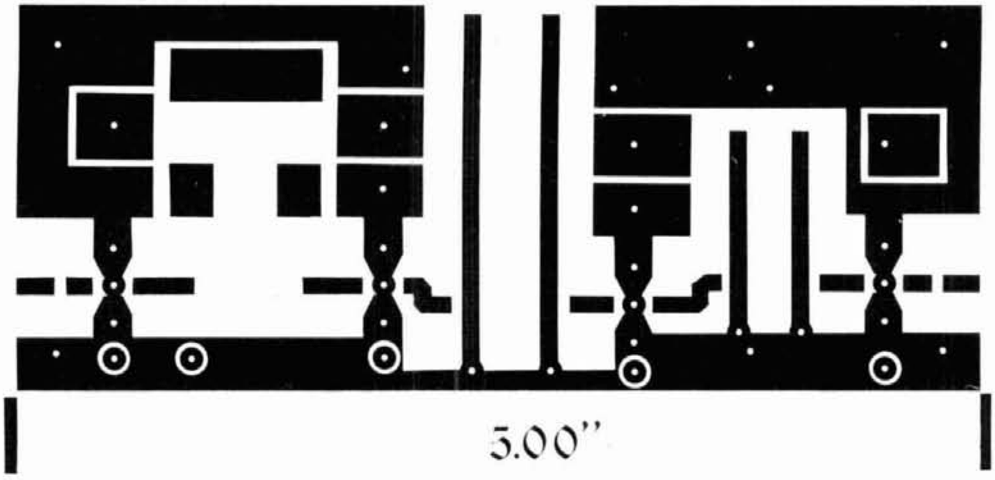

fig. 3. Full size PC negative for the X8 multiplier. The other side of the 0.062" G-10 board is unbroken copper groundplane.

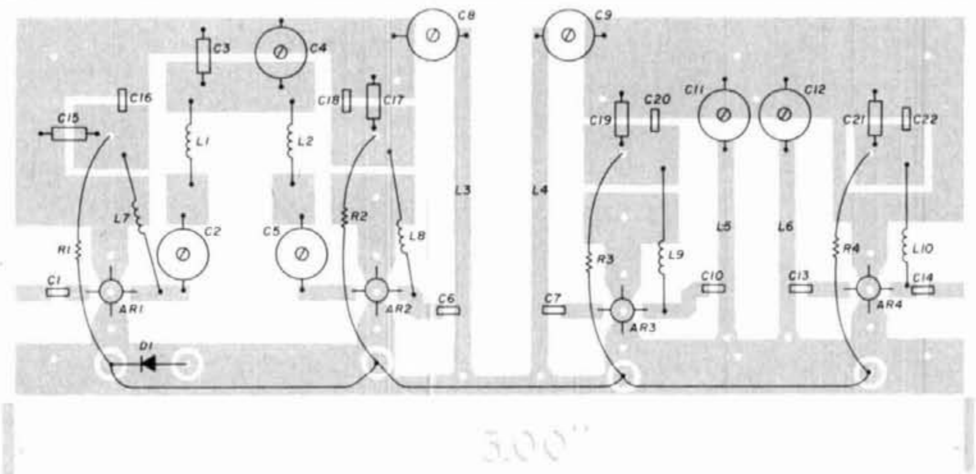

fig. 4. Component locations for the multiplier. Components shown with dashed lines are on the back side of the board. Eyelet locations are shown as an X.

hard to predict, mainly because of the difficulty in winding the coil to the design's dimensions. For this reason, I wound the coils on a form — a nylon screw. The No. 24 wire lies in the threads neatly and evenly, so that the predicted coil spacing is maintained. The nylon apparently doesn't cause an excessive increase in the filter insertion loss, even though nylon is generally a poor rf material. (This simple coil form is available at better hardware stores.) Variable capacitors are used to provide tuning range for the filter. The two capacitors in the series arms of the filter are the main tuning, while the adjustment of the shunt element is not as critical.

The second and third filters, centered at 379 and 758 MHz, were made with printed microstriplines. The key to their performance is in the accurate reproduction in copper of the design dimensions. It isn't necessary, however, to maintain fantastic accuracy; a number of filters have been built with hand-cut lines and work well. Pay attention to the grounding (as always in rf work, poor grounding will rise to cripple otherwise fine circuits). An eyelet at the base of the filter is good insurance, as is wrapping the edge of the top ground traces to the bottom ground with foil and soldering both sides.

The loading capacitors at the ends should be physically small, electrically short, and high Q. That's the ideal. In practice, adequate filtering is achievable with a wide range of capacitors. The best capacitors for the job seem to be the subminiature microwave tubular trimmers, but the circular ceramic types work, too. The main problem with lower-cost ceramic capacitors is really only an irritation; their entire tuning range is compressed into one-half turn of the rotor, so that fine peaking of the filter requires a steady hand and patience.

The only other main concern in the layout is a familiar one in all high-frequency work — the substrate.

The microstriplines require a good ground plane on the far side of the board, a ground plane that should be as unbroken as possible, and well coupled to the ground traces on the top of the board. The thickness of the material is important, too, if the line impedances are to be as designed. Ideally, the dielectric constant of the material should be well controlled, but in practice most Amateur construction is done on G-10 board, which is not intended for microwave work. However, G-10 works well enough for noncritical circuitry. The dielectric constant of G-10 varies with frequency, but is about 4.2 at the high end of the UHF band.[9]

Each MMIC is mounted to the surface of the board with its plastic package recessed in a clearance hole. The amplifiers receive their dc bias via a small decoupling coil, well bypassed to ground at its far end. The MMIC operating voltage is obtained from the 13.6-volt supply and dropping resistor. The resistor is positioned on the bottom side of the circuit board to keep it out of the way. More details of device biasing are given in the references.

construction

The printed circuit board negative shown in **fig. 3** depicts only one side of the board. The other side of the circuit board is unetched copper, which serves as a ground plane for the microstriplines. Component placement is indicated in **fig. 4**. Where component leads pass through the board, small clearance holes should be made to prevent the leads from shorting to ground. Ground plane side artwork isn't needed, since no circuit traces exist on this side, and a few minutes' work with a drill bit will clear the lead holes.

The board doesn't have to be all that precise; the filters are tolerant of inaccurate layout because of their low selectivity. In fact, I've had good results with handcut boards. I make a 1:1 photocopy of the artwork and glue it to the surface of a piece of G-10 board. Then I use a sharp knife and cut through the paper to nick the copper cladding. I then peel the cladding away with the knife and a pair of pliers. The results aren't particularly attractive, but the process is quick and effective.

The crystal oscillator circuit is similar to the one described in Hilliard's article,[10] which was designed to operate around a 2N4124 at 16 percent lower frequency. It's also quite similar to designs described in detail in Frerking.[11] The oscillator uses a fifth overtone crystal, with resonant network in the feedback path to peak the circuit's gain at the desired overtone. Only one minor alteration was needed to get the circuit working: the base of the oscillator transistor requires a good rf ground, and when using only a disc capacitor as a bypass, I had problems with spurious modes and poor starting. I added a small (physically and electrically) chip capacitor to ground and the problems vanished. The final circuit is shown in **fig. 5**.

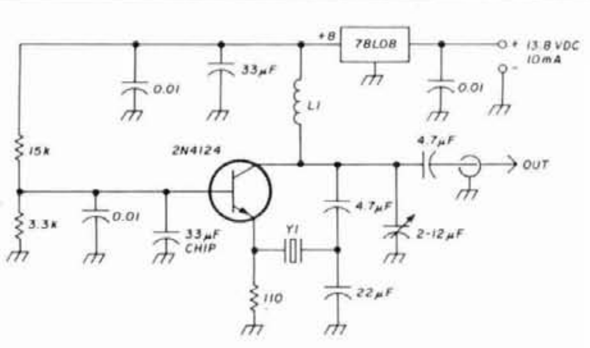

fig. 5. Schematic diagram of the 94 MHz crystal oscillator.

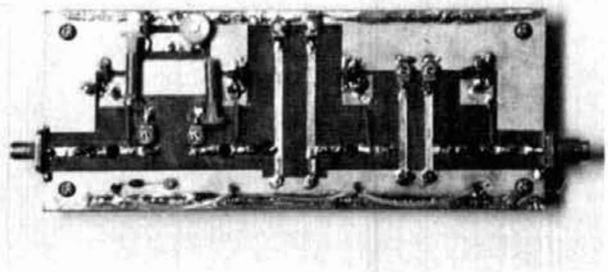

fig. 6. Photograph of the prototype multipler, which was built on hand-cut board.

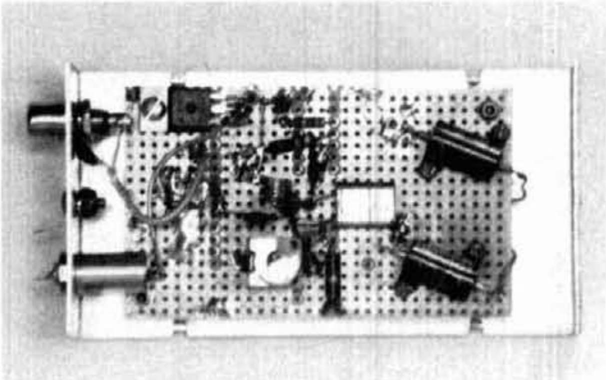

fig. 7. Photograph of the prototype oscillator in its shielded housing.

The oscillator (**fig. 7**) was built on a piece of copper-clad board. I didn't make a circuit board for this circuit because I felt the layout wasn't particularly critical. Where insulated mounting points are needed, a teflon-insulated terminal can be installed on the board, or an isolated island of copper can be cut with a pad cutter. Many of the construction details are visible in **fig. 7**.

This design, like most oscillators, tends to be sensitive to variations in its environment. Stray fields, temperature variations, load variations, power supply changes and even nearby movement can alter the operating frequency. The oscillator's output is multiplied eight times before mixing, so even changes of a few hertz can be noticed at the output of a narrowband converter (consider how a 50- to 100-Hz step can change the pitch of an SSB voice signal). For these reasons, I chose to put the oscillator in its own shielded box, use a voltage regulator, and leave room for a temperature controller.

Shielding helps prevent changes in the local fields of the circuitry and helps lengthen the oscillator's thermal time constant. It's important to note the distinction between temperature compensation, which reduces the total drift of the oscillator, and changing the thermal time constant, which reduces the rate of change of frequency, but not the ultimate magnitude of the change. In an Amateur system, it's usually unimportant if the circuit drifts a bit, as long as the drift rate is quite slow. After all, we don't tend to sit on one frequency for hours (or even for many minutes). So lengthening the thermal time constant is a good strategy for UHF oscillator circuitry, and is easier than temperature compensation or control.

The closed aluminum box, stuffed with fiberglass insulation, helps greatly in slowing the drift rate. The two large resistors visible on the board in the photograph were included for use as heaters if a temperature controller were needed. So far, I haven't seen any need, but if the local oscillator were mounted outside and exposed to wide temperature ranges, temperature control could be added. The space between the two power resistors is sufficient for an LM3911 integrated circuit temperature regulator.

tuning

Start the tuning process by getting the oscillator going. If all is well, the oscillator will start up as the variable capacitor is adjusted. The adjustment range of the capacitor should be broad. Set the capacitor to the middle of the range, making sure that the oscillator will restart when power is interrupted. The oscillator should provide 5 to 10 milliwatts at the output of the attenuator. There is no trimming of the series resonant crystal.

Unfortunately, tuning the multiplier can be more complicated. The tuning range of the three filters is limited, so it should be difficult, *but still possible*, to tune to the wrong harmonic. Start by presetting the variable capacitors to the calculated capacitance. For example, the output filter calculations predict that 3.9 pF wil be needed, so if a 2- to 8-pF trimmer is used, preset it visually to about half-meshed. The calculated values for all of these capacitances are shown on the schematic diagram.

Apply the oscillator output signal to the multiplier, and then apply dc power. See that the MMIC device voltages specified are present, which should verify that the amplifier stages are working. Peak the output for maximum power and measure the output frequency with a counter.

I found that this tuning could be accomplished with just a diode detector to peak the tuning and a counter to verify that the output of the multiplier was at the correct frequency. I then examined the ouput of the chain with a spectrum analyzer, which produced the plot shown in **fig. 8**.

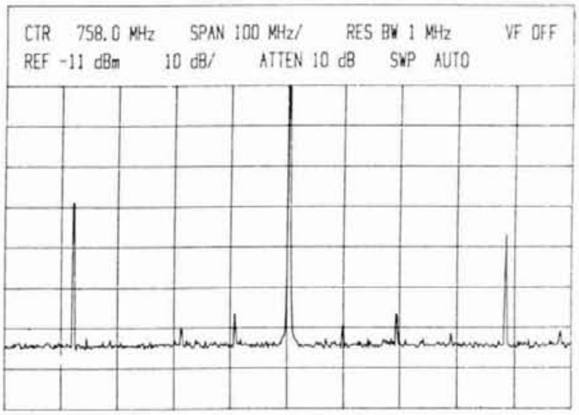

fig. 8. Spectal output plot of the multiplier chain. The desired signal is at +9 dBm. The highest undesired products are at 379 and 1137 MHz, approximately 30 dB down the 758 MHz signal.

If this method of tuning doesn't work, it might be better to tune each stage separately. Tap into the circuit at the output of each filter in turn, and peak it for best output power at its center frequency. This method will take longer, but it's less "blind" than tuning for the final 758-MHz output all at once.

summary

MMIC devices in circuits similar to the one just described can be configured as simple and well-behaved multiplier chains. Silicon MMIC amplifiers now provide good gain to 3 or 4 GHz, so that multipliers using them should be practical to at least such frequencies. The concept outlined here — using doublers followed by simple filtering — provides adequate spectral purity and output power sufficient to drive a mixer directly. The components are inexpensive, and no machine shop work is needed. The only real drawback to this cascaded system is its healthy appetite for dc power due to the MMIC's internal biasing circuitry. The phase noise of the multiplier wasn't measured, but it appears to be quite adequate for Amateur narrowband communications.

parts

I can provide some of the parts for this project, including printed circuit boards; send an SASE to me for a list of what I have available.

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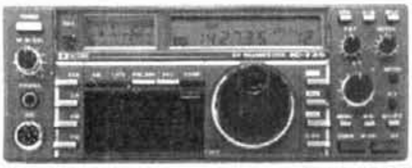

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The circuit described in **fig. 1** allows a car to be driven for about 60 seconds. During that period, the car may be driven to a busy intersection or roadway, where it will stall, never to be started again by the thief. It would be possible to prevent the engine from starting in the first place; however, this could irritate the thief and invite vandalism. It's safer, and usually less costly, to allow the car to be driven briefly, creating a situation in which the thief will be placed in a vulnerable position and possibly caught. At the very least, your car will be abruptly abandoned, minimizing the possibility of vandalism. You may have to pay for towing — and possibly a charge for impoundment — but you'll have your car.

do's and don'ts

The effectiveness of any deterrent device depends partly upon how well its presence can be concealed. Obviously, any would-be thief who wants your car and knows about the device will try to disarm it. Don't tell even your best friend that you've installed a theft deterrent; people talk.

You may want to install a hood lock, which will not only discourage hot-wiring, but will also prevent disarming the deterrent. Some protection is provided by the circuit itself, should the wires be cut; cutting either of the wires marked CA-CB or BA-BB will remove power from the ignition coil. Unfortunately, if the ignition is hot-wired (by placing a jumper from 12 volts to the ignition coil), the jumper simply bypasses the deterrent, removing the theft protection.

Hugh Wells, W6WTU, 1411 18th Street, Manhattan Beach, California 90266

Obviously you've got to be able to disarm the deterrent to drive your car. An automatic circuit built into the deterrent arms the circuit whenever the engine is started. It's up to you to remember to disarm the deterrent before time-out.

It's better to use a pushbutton rather than a toggle switch, installing it where it can be reached comfortably, conveniently, and inconspicuously, even with passengers in the car. It's best to locate it within arm's length, where one hand can reach it without stretching or making any unusual movement. As far as a thief is concerned, it could even be positioned in the middle of the dashboard — after all, who'd suspect that a "secret" switch would be placed where everyone could see it?

oops!

If you forget to press the disarming button after starting the engine, the circuit will time out, leaving you momentarily stranded and embarrassed. If this happens, just turn the ignition switch on and press the button to start the 20-second recovery process.

Twenty seconds feels like an eternity when you're caught in traffic. (If you're uncomfortable, think how a thief would feel . . . .) But the delay is necessary; you want to prevent the thief — had he found the button and pressed it — from associating the action of pushing the button with disarming the deterrent.

What happens when the car goes back to the dealer or into the shop for service? Somebody else, probably a stranger, will be driving it. One solution is to place a clip lead or small alligator clip across the disarm button contacts. Another would be to place a clip lead across Q4. Either action would disable the deterrent so that service people could drive the car without having to know about the device. (Remember to remove the jumper after service to restore protection.) For shorter periods, such as with valet parking and car washes, you can leave the engine running when you get out. If time-out occurs, you can simply remark that your car is temperamental and that you know how to handle it.

circuit description

A small SCR (Q1), used as a remote disarming latching switch, is "fired" when the disarm button is pressed. Once fired, Q1 keeps the circuit from starting the time-out cycle. A 555 (or 556) is used as a timing mechanism for removing power from the ignition system after time-out. A simple RC time constant provides a time-out delay of approximately 1 minute. A specific time-delay value isn't important, but enough time must be allowed for the car to be driven to a vulnerable location. Any additional time could allow the car to be driven too far from the starting point.

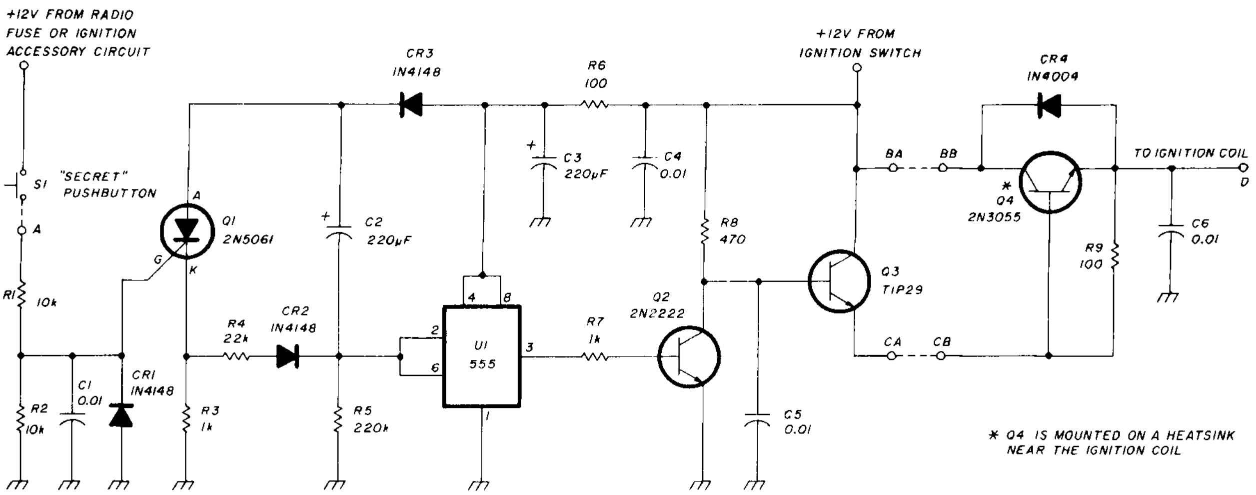

fig. 1. Mobile theft deterrent.

C1,4,5,6	0.01 µF 100-volt disc ceramic
C2,3	220mF 25-volt (RS 272-1017 or RS 272-1029) electolytic
CR1,2,3	1N4148, 1N914, or equivalent signal diode
CR4	1N4004 or equivalent power diode
Q1	2N5061, 2N5062, ECG 5401, or ECG 5402 SCR
Q2	2N2222, 2N4401, ECG 123A, or RS 276-2058 NPN transistor
Q3	TIP 29, TIP 31, ECG 152, or RS 276-2017 NPN power transistor
Q4	2N3055, ECG 181, or RS 276-2041 NPN power transistor
R1,2	10-k, 1/2-watt
R3,7	1-k, 1/2-watt
R4	22-k, 1/2-watt
R5	220-k, 1/2-watt
R6,9	100-ohm, 1/2-watt
R8	470-ohm, 1/2-watt
S1	RS 275-1547 or RS 275-1571 mini SPST momentary pushbutton switch
U1	555 or RS 276-1723 IC timer

The R5 and C2 combination determines the time-out period. Their values have been selected for about the maximum time obtainable when using a low-leakage electrolytic capacitor for C2. Tantalum capacitors are generally not suitable in this application because of their high leakage current.

When power is first applied to the ignition system, pins 2 through 6 of U1 will start out with a logic high of about 11 volts and drift down as capacitor C2 charges through resistor R5. Pin 3 of U1 will remain at a logic low until pins 2 and 6 drop below a threshold voltage value of approximately 4 volts. Then pin 3 will go high, causing the collector of transistor Q2 to go low, turning off the base drive to transistors Q3 and Q4. They, in turn, remove power from the igini-tion system. In the deterrent, U1 operates as an electronic teeter-totter with a resistor and capacitor combination on pins 2 and 6 for timing. The other end of the teeter-totter is pin 3, which provides output drive. When pins 2 and 6 are high (Q1 fired), pin 3 is low, driving the base of Q2 low. Transistor Q2 operates as an inverter, driving high the bases of transistors Q3 and Q4. Transistors Q3 and Q4 are connected as a Darlington for high gain (H_{FE} above 2000). The high gain is required to hold Q4 in saturation when the base drive is at a logic high. Transistor Q4 functions as a pass transistor/switch for controlling ignition current values up to 7 amps. A 7-amp current capability is sufficient for most ignition systems.

Diodes are used in the circuit to perform various functions. CR1 protects the gate of SCR Q1 from negative voltage spikes. CR2 isolates C2, preventing it from becoming charged through resistors R3 and R4. CR2 and CR3 isolate capacitor C2 from circuit power, allowing C2 to retain its charge status regardless of the presence or absence of circuit power. CR4 protects transistors Q3 and Q4 from reverse voltage spikes generated by ignition coil flyback upon power removal. With CR4 in place, the reverse voltage across the transistors will not exceed 1 volt.

construction

The circuit is divided into two assemblies for mounting convenience. All of the electronic circuitry may be placed in a metal box separate from Q4, which is mounted on a heatsink near the ignition coil. Placing the circuit in a grounded metal box ensures rf protection from high voltage ignition pulses and mobile transmitters. Disc ceramic capacitors are used at the input and output of the circuit to prevent rf from disturbing the SCR and 555 logic states. A screw terminal block may be mounted on the side of the box for wiring connections.

Transistor Q4 requires a heatsink to improve its reliability, even though it operates in saturation. At 7 amps of current flow, about 5 watts of power will be dissipated by Q4. That amount of heat requires a heatsink with a surface area of about 5 square inches and a thickness of 1/8 to 1/4 inch. A heatsink with fins, mounted in line with the engine air flow, will provide

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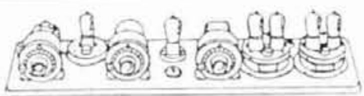

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✓ 190

additional cooling. If desired, the amount of heatsink surface may be reduced for currents around 3 amps. However, a generous amount of heatsink material is cheap insurance for long transistor life.

Transistor Q4 must be insulated with a mica washer from the heatsink if the heatsink is to be grounded. All metal burrs must be removed from heatsink holes. Small burrs around the holes will puncture the mica washer (insulator) and ground the transistor. Apply thermal grease to both sides of the mica washer to provide heat transfer from the transistor to the heatsink. A small amount of nonconductive silicon grease makes a suitable thermal conductor.

deterrent placement

Two types of ignition systems are in common use today. Both can be controlled by the theft deterrent as long as the car battery has its negative terminal grounded (the deterrent would have to be redesigned for a positive ground system). The oldest and most common is the standard ignition system, which consists of an ignition coil and a set of breaker points. The second type is an electronic system consisting of an electronic converter, ignition coil, and a breakerless timing trigger.

It doesn't matter whether the Q4 heatsink assembly is mounted on the engine, firewall, or fender well, but the assembly should be mounted near the ignition coil power wire.

Avoid long extension wires to keep series resistance to a minimum. Finding the correct wire to intercept or cut is usually fairly easy when only one power wire is routed to the ignition system. Some electronic systems have two large wires routed to the system; one of them provides power from the ignition switch, and is the wire that must be intercepted to insert the Q4 assembly. The second wire is used to provide power from the starter solenoid during starting. It will be left alone.

Standard ignition systems use a resistor or resistance wire in series with the ignition switch and ignition coil to reduce power dissipation in the coil. The Q4 assembly is connected in series with that resistor wire at either the coil terminal or at the resistor terminal. If the resistor can't be located, assume that the connecting wire is also the resistor. Note: *do not cut the resistance wire.*

Mount the electronic circuit box in any convenient location where the box will be grounded. Connect a wire from the ignition switch (+12 volts) to the terminal marked BA (Q3 collector). Connect a wire from terminal BA to terminal BB (Q4 collector). Route a wire to the pushbutton from terminal A (resistor R1), and another wire from terminal CA (emitter of Q3) to terminal CB (base of Q4). Connect terminal D (emitter of Q4) to the ignition coil.

✓ 194

for diesels

The theft deterrent may also be used on diesel automobile engines. A warm engine usually starts immediately, providing the thief an opportunity to drive to a street intersection. But cold starts present a challenge, because the "cold" glow plug timing is nearly equal to the deterrent time-out time. A thief might not get the engine started before time-out. In either case, the car won't be driven very far before the engine quits.

To install the deterrent on a diesel engine, locate the electric fuel shut-off valve near the fuel injector pump. There's usually one control wire attached that provides power to operate the valve when the ignition switch is turned on. Connect the Q4 deterrent circuit in series with the control wire. Terminal BA connects to the ignition switch end of the control wire, and terminal D connects to the fuel shut-off valve.

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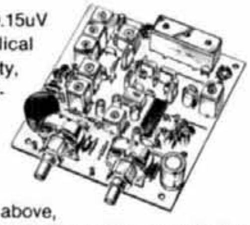

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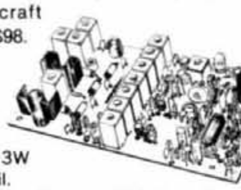

- **TA51 VHF FM EXCITER** for 10M, 6M, 2M, or 220 MHz. 2 Watts continuous, up to 3W intermittent. Kit only $68
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		50-52	28-30
		50-54	144-148
		144-146	28-30
		145-147	28-30
		144-144.4	27-27.4
		146-148	28-30
		220-222	28-30
		220-224	144-148
Kit with Case	$49	222-226	144-148
Less Case	$39	220-224	50-54
Wired	$69	222-224	28-30

UHF MODELS		Antenna Input Range	Receiver Output
		432-434	28-30
Kit with Case	$59	435-437	28-30
Less Case	$49	432-436	144-148
Wired	$75	432-436	50-54
		439.25	61.25
		902-928	422-448

SCANNER CONVERTERS Copy 806 MHz band on any scanner. Wired/tested ONLY $88.

TRANSMIT CONVERTERS

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	Exciter Input Range	Antenna Output
For VHF,	28-30	144-146
Model XV2	28-29	145-146
Kit $79	28-30	50-52
Wired $149	27-27.4	144-144.4
(Specify band)	28-30	220-222*
	50-54	220-224
	144-146	50-52
	144-146	28-30
For UHF,	28-30	432-434
Model XV4	28-30	435-437
Kit $79	61.25	439.25
Wired $139	144-148	432-436*

*Add $20 for 2M input

VHF & UHF LINEAR AMPLIFIERS. Use with above. Power levels from 10 to 45 Watts. Several models, kits from $78.

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MODEL	TUNES RANGE	PRICE
LNG-28	26-30 MHz	$49
LNG-50	46-56 MHz	$49
LNG-144	137-150 MHz	$49
LNG-160	150-172 MHz	$49
LNG-220	210-230 MHz	$49
LNG-432	400-470 MHz	$49
LNG-800	800-960 MHz	$49

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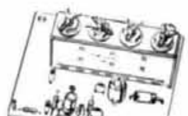
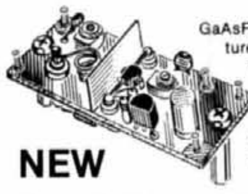


MODEL	TUNING RANGE	PRICE
HRA-144	143-150 MHz	$49
HRA-(*)	150-174 MHz	$49
HRA-220	213-233 MHz	$49
HRA-432	420-450 MHz	$64
HRA-(*)	450-470 MHz	$64

**Specify Center frequency desired*

MINIATURE PREAMPS



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*Specify band

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MODEL	TUNES RANGE	KIT	WIRED
LNS-144	120-175 MHz	$59	$79
LNS-220	200-240 MHz	$59	$79
LNS-432	400-500 MHz	$59	$79

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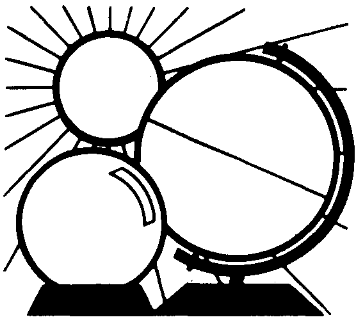

DX FORECASTER

Garth Stonehocker, K0RYW

more DX propagation tips

Last month we discussed weak signal reception in terms of the chart that accompanies this column each month. Numbers shown in the chart represent the highest frequency bands that should be used at specified hours. As a general rule, operate on the highest band available in order to optimize signal strength by minimizing the number of hops through the absorbing D region of the ionosphere.

To fully utilize this optimum propagation mode, the takeoff angle (TOA) of your antenna must be approximately 10 degrees. If the elevation pattern of the antenna doesn't include significant energy at this low angle*, operate on the next lower frequency band but be prepared to pay the price in signal loss, due to the greater number of hops (more hops mean greater loss at the points of reflection/refraction and passage through the D layer). For the shorter paths — for example, Europe to Japan — dropping down to the next lower band raises the TOA required by 12 degrees, but unfortunately means one more hop will be required with an additional loss in signal level of 10 dB. Dropping down two bands nets a TOA 23 degrees higher, one to two more hops, and 24 dB of additional signal loss. Using a lower frequency band on the longer paths accounts for a 4-degree elevation in TOA and a loss of 6 dB for each hop. These longer paths represent five to six maximum-length hops. With this number of long hops and accumulated per-hop absorption, one more hop doesn't make as much difference in the TOA or attenuation, compared to shorter ones.

Knowing your antenna's pattern and using this information, questions of tradeoffs arise. Should I lower frequency to take advantage of my antenna's TOA and lose signal level from more hops, or should I use the antenna on the highest band and be a few dB down from the antenna pattern maximum? If your tradeoff calculations come out about even, consider signal quality parameters (such as stability) rather than available signal strength. Stable signals in frequency, phase, and amplitude over a short time — i.e., seconds or minutes — are needed to "read" the transmitted information.

The length of time needed to decipher the information is a function of the modulation being "read," but in most cases greater stability represents an improvement. This occurs when you operate just below the MUF. As a general rule, for stability, choose a frequency that is just 15 percent below the MUF. If you drop too low in frequency, a form of multipath distortion occurs that sounds like interference. The frequency just below the MUF is the most stable and therefore experiences minimum fading — QSB. Of course, when the geomagnetic field becomes variable, as during a disturbance from a solar wind particle influx, even frequencies near the MUF become more unstable in frequency, phase, and amplitude. After a few years experience or training, DXers can "read" signals having some of these poor characteristics. If you consider these propagation rules and practice learning to "read" the difficult signals, you'll enjoy the experience of rare DX QSOs more often.

last-minute forecast

The higher frequency bands (10-30 meters) are expected to peak the second week of this month. Long-skip openings during periods of higher solar activity and flux should raise the MUFs about 15 to 20 percent over median mid-latitude noontime values. Look for evening transequatorial long-hop openings, especially if the geomagnetic field becomes disturbed as the solar flux drops off toward the end of the week. The lower frequency bands should remain in their winter "finery" during the first and last weeks of the month. Expect geomagnetic (field) disturbances during the middle of the last week.

No significant meteor showers are scheduled to appear in February. A full moon will occur on the 13th, with its perigee on the 25th.

band-to-band summary

Ten and twelve meters, the highest day-only DX bands, are nearest the MUF for southern hemisphere paths. They will be open most days when the solar flux is above 75 during the 7- to 10-hour period centered around local noon. These bands open on paths toward the east and close toward the west. The paths may be as long as 2400 miles in single-hop length, and occasionally twice as long during evening transequatorial openings.

Fifteen and twenty meters, almost always open to the southern part of the world, will be the main daytime DX bands. Twenty should stay open on long southern paths into the night, while 15 will drop out in the afternoon. Total path lengths of from 5000 to 7000 miles are expected on these bands and one-long-hop transequatorial propagation is also possible, favoring evening

*Most don't, unless a rather large ground system is used with verticals or the horizontal array is over a wavelength above the earth

— Ed.

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102	114	126	138	150	162	174	186	198	210	222	234	246	258	270	282	294	306	318	330	342
103	115	127	139	151	163	175	187	199	211	223	235	247	259	271	283	295	307	319	331	343
104	116	128	140	152	164	176	188	200	212	224	236	248	260	272	284	296	308	320	332	344
105	117	129	141	153	165	177	189	201	213	225	237	249	261	273	285	297	309	321	333	345
106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286	298	310	322	334	346
107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311	323	335	347
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
109	121	133	145	157	169	181	193	205	217	229	241	253	265	277	289	301	313	325	337	349
110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314	326	338	350
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315	327	339	
112	124	136	148	160	172	184	196	208	220	232	244	256	268	280	292	304	316	328	340	

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GMT	PST	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)
0000	4:00	30	40	20	10	12	10	10	20
0100	5:00	20	40	20	12	12	10	10	20
0200	6:00	20	40	20	15	12	10	10	20
0300	7:00	30	*40*	20	20	12	12	12	20
0400	8:00	40	*40*	30	20	12	15	15	30
0500	9:00	40	*40*	30	20	15	20*	20	30
0600	10:00	40	*40*	*30*	20	20	20	20	40
0700	11:00	40	*40*	*30*	*20*	20	20	20	40
0800	12:00	40	*40*	*30*	*20*	20	20	20	40
0900	1:00	*40*	*40*	*30*	*30*	*20*	20	20	40
1000	2:00	*40*	*40*	*30*	*30*	*20*	*20*	*20*	40
1100	3:00	*40*	*40*	*30*	*30*	*30*	*30*	*30*	40
1200	4:00	*40*	*40*	*30*	*30*	*30*	*30*	*30*	*40*
1300	5:00	*40*	30	15	20	*30*	*30*	*30*	*40*
1400	6:00	*40*	20	12	12	*30*	*30*	*30*	*40*
1500	7:00	40	20	10	12	20	*20*	20	*40*
1600	8:00	40	20	10	12	15	*30*	20	*40*
1700	9:00	40	20	10	10	15	20	20	*40*
1800	10:00	*40*	20	10	10	12	20	*30**	*40*
1900	11:00	*40*	30	10	10	12	15	20	*40*
2000	12:00	*40*	30	12	10	12	12	20	20
2100	1:00	*40*	40	12	10	12	12	15	20
2200	2:00	*40*	40	15	10	12	10	12	20
2300	3:00	*40*	40	20	10	12	10	12	20

MID USA

MST	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)	CST
5:00	30	40	20	12	12	10	10	30	6:00
6:00	30	40	20	12	12	10	12	30	7:00
7:00	20	40	20	15	12	12	12	30	8:00
8:00	30	*40*	20	20	12	15	15	40	9:00
9:00	40	*40*	*30*	20	15	15	15	40	10:00
10:00	*40*	*40*	*30*	20	20	20	20	40	11:00
11:00	*40*	*40*	*30*	20	20	20	20	40	12:00
12:00	*40*	*40*	*30*	*20*	20	20	20	40	1:00
1:00	*40*	*40*	*30*	*20*	*20*	*20*	*30*	40	2:00
2:00	*40*	*40*	*30*	*30*	*20*	*30*	*30*	40	3:00
3:00	*40*	30	*30*	*30*	*20*	*30*	*30*	*40*	4:00
4:00	*40*	20	15	*30*	*20*	*30*	*30*	*40*	5:00
5:00	30	20	12	20	*30*	*30*	*30*	*40*	6:00
6:00	30	20	10	15	*30*	*30*	*30*	*40*	7:00
7:00	30	20	10	15	20	*30*	20	*40*	8:00
8:00	40	20	10	12	20	20	20	*40*	9:00
9:00	40	20	10	12	15	20	20	*40*	10:00
10:00	40	20	10	12	15	20	20	*40*	11:00
11:00	40	20	10	10	15	20	20	*40*	12:00
12:00	*40*	20	10	10	12	15	20	30	1:00
1:00	*40*	30	10	10	12	12	15	30	2:00
2:00	*40*	30	12	10	12	12	15	20	3:00
3:00	*40*	40	12	10	12	12	12	20	4:00
4:00	*40*	40	15	10	12	10	12	20	5:00

EASTERN USA

EST	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (Caribbean S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)
7:00	*40*	40	20	12	12	12	12	30
8:00	40	40	20	15	12	15	15	30
9:00	40	40	20	20*	15	20	20	40
10:00	40	*40*	*20*	20	20	20	20	40
11:00	40	*40*	*30*	20	20	20	20	40
12:00	40	*40*	*30*	20	20	20	20	40
1:00	*40*	*40*	*30*	*20*	*20*	*30*	*30*	40
2:00	*40*	*40*	*30*	*20*	*20*	*30*	*30*	*40*
3:00	*40*	*40*	*30*	*30*	*20*	*30*	*30*	*40*
4:00	*40*	*40*	*30*	*30*	*30*	*30*	*30*	*40*
5:00	*40*	30	15	*30*	*30*	*30*	*30*	*40*
6:00	30	20	12	20	*30*	*30*	*30*	*40*
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11:00	40	20	10	10	15	30*	20	*40*
12:00	40	20	10	10	12	20	20	*40*
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2:00	40	20	10	10	12	15	20	*40*
3:00	*40*	30	12	10	12	12	15	30
4:00	*40*	40	12	10	12	12	12	20
5:00	*40*	40	15	10	12	10	12	20
6:00	*40*	40	20	10	12	10	12	20

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.

hours during periods of high solar flux and disturbed geomagnetic field conditions.

Thirty and forty meters are both day and night bands. Intermediate distances (up to 1000 miles) in any direction represent daytime DX. Nightime DX on these bands is expected to exceed those distances encountered on 80 meters and, as on 80, will follow the darkness path across the sky. Reduced midday signal strengths and distances may occur on days of high solar flux values or periods of anomalous absorption.

Eighty and one-sixty meters will exhibit short-skip propagation during the daylight hours and lengthen for DX at dusk. These bands follow darkness, opening to the east just before local sunset, swinging more to the south toward midnight, and ending up in the Pacific areas during the hours before dawn. Except for daytime short-skip signal strengths, high solar flux values hardly affect these bands. On some days, however, the condition known as anomalous absorption will diminish day and night signal strengths. The 160-meter band opens later and ends earlier.

ham radio

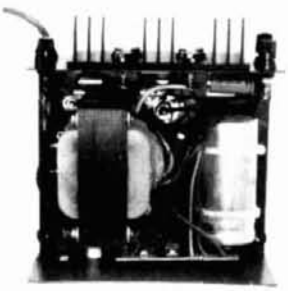
✓ 188

✓ 187

✓ 186

ASTRON CORPORATION
9 Autry
Irvine, CA 92718
(714) 458-7277

Canadian Distributor:
Eastcom Industries, Ltd.
430 Signet Drive
Weston, Ont. Can 49L 2T6
(416) 743-7801



INSIDE VIEW – RS-12A

ASTRON POWER SUPPLIES

• HEAVY DUTY • HIGH QUALITY • RUGGED • RELIABLE •

RS and VS SERIES

SPECIAL FEATURES

- SOLID STATE ELECTRONICALLY REGULATED
- FOLD-BACK CURRENT LIMITING Protects Power Supply from excessive current & continuous shorted output.
- CROWBAR OVER VOLTAGE PROTECTION on all Models except RS-4A.
- MAINTAIN REGULATION & LOW RIPPLE at low line input Voltage.
- HEAVY DUTY HEAT SINK • CHASSIS MOUNT FUSE
- THREE CONDUCTOR POWER CORD
- ONE YEAR WARRANTY • MADE IN U.S.A.

PERFORMANCE SPECIFICATIONS

- INPUT VOLTAGE: 105 - 125 VAC
- OUTPUT VOLTAGE: 13.8 VDC ± 0.05 volts (Internally Adjustable: 11-15 VDC)
- RIPPLE: Less than 5mv peak to peak (full load & low line)

MODEL RS-50A

MODEL RS-50M

MODEL VS-50M

RM-A Series

MODEL RM-35A

19" X 5¼ RACK MOUNT POWER SUPPLIES

Model	Continuous Duty (AMPS)	ICS* (AMPS)	Size (IN) HXWXD	Shipping Wt. (lbs.)
RM-35A	25	35	5¼ × 19 × 12½	38
RM-50A	37	50	5¼ × 19 × 12½	50
• Separate Volt and Amp Meters				
RM-35M	25	35	5¼ × 19 × 12½	38
RM-50M	37	50	5¼ × 19 × 12½	50

RS-A SERIES

MODEL RS-7A

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

RS-M SERIES

MODEL RS-35M

- Switchable volt and Amp meter

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

VS-M SERIES

MODEL VS-20M

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

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

RS-S SERIES

MODEL RS-12S

- Built in speaker

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

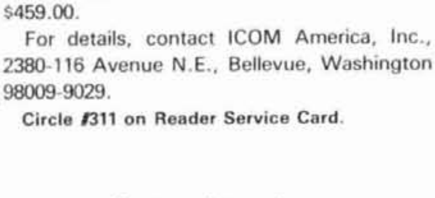
NEW products

ICOM IC-38A 220-MHz mobile

ICOM has announced the IC-38A, a 25-watt, 220-MHz compact mobile that expands ICOM's existing line of IC-28A/H 2-meter and IC-48A 440-MHz mobiles.

The compact unit measures 5.5 x 2.0 x 6.1 inches, transmits from 220 to 225 MHz, and receives from 215 to 230 MHz. It features 21 memory channels, an internal speaker, and a large LCD readout with automatic dimmer circuit to reduce brightness. Scanning is included; you can scan the entire band or just the memory channels from the HM-12 mic. With only 11 front panel controls, the IC38A is easy to operate.

Options include the IC-HM14 DTMF mic; PS-45 13.8-volt, 8-amp power supply, SP-10 external speaker, HM-16 speaker mic and HS-15/HS-15SB flexible boom mic, and PTT switchbox.



The suggested retail price for the IC-38A is $459.00.

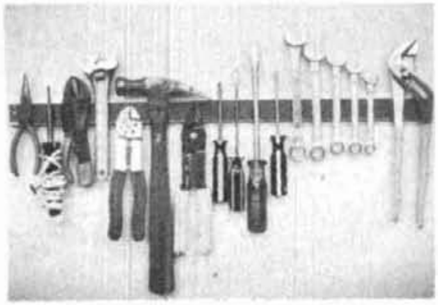
For details, contact ICOM America, Inc., 2380-116 Avenue N.E., Bellevue, Washington 98009-9029.

Circle #311 on Reader Service Card.

magnetic tool racks

Texas Magnetics Corporation — no stranger to Amateur Radio — is celebrating their 10th anniversary. TMC is the largest U.S. supplier of magnetic base assemblies used in the manufacture of mobile antennas. Other "Magna-Grab" products available from TMC include magnetic tool racks, cable and wire routers, fishing tool retrievers, plus permanent magnets and assemblies of all types.

Made of heavy-duty chrome-plated steel, "Magna-Grab" magnetic tool racks come in two sizes: 13 inches (the TMC-100, $12.95 plus $3.50 S&H) and 25 inches (the TMC-200, $18.95 plus $3.50 S&H). No assembly is required; mounting hardware is included.



For information, contact Texas Magnetics Corporation, Special Products Division, Department 100R, 2714 National Circle, Garland, Texas 75041.

Circle #316 on Reader Service Card.

transfer function analysis/synthesis program

BV Engineering has just released XFER, a transfer function analysis and synthesis program that uses short-circuit transfer impedance functions around an operational amplifier to compute circuit element values and circuit configurations which will synthesize a desired transfer function. Conversely, given a circuit configuration and element values, XFER will compute a circuit's transfer function. Multiple stages of short-circuit transfer impedance functions using forward and feedback elements in operational amplifier configurations enable the user to synthesize and analyze most any transfer function having real roots.

Once a circuit or transfer function has been specified, XFER quickly computes the magnitude and phase response, enabling performance of sensitivity and Monte Carlo analysis. Circuit configurations can be viewed on the screen; complete circuit and transfer function editors are built into XFER.

XFER is menu-driven and interactive, with free-format input, and "understands" common engineering abbreviations. Data files generated by XFER are compatible with other BVE software such as SPP, PCPLOT, PDP and TEKCALC. Transfer function files generated by XGER can be used by the SPP program to perform transient and time-domain analysis of user generated waveforms.

XFER is available under the PCDOS and MSDOS operating systems for $72.95 from BV Engineering, 2200 Business Way, Suite 207, Riverside, California 92501.

Circle #312 on Reader Service Card.

AVCOM portable spectrum analyzer

AVCOM's PSA-35A portable spectrum analyzer offers frequency coverages of 10 to 1750 MHz and 3.7 to 4.2 GHz for checking signal strength, inband attenuations, terrestrial interference, filter alignment, faulty connectors, LNA's, feedhorn isolation, and cable loss at all commonly used satellite communication frequencies, including 12 GHz downconverters.

The PSA-35A features a built-in DC block with +18 VDC for powering LNA's and BDC's with the flip of a switch, calibrated signal amplitude display, and rechargeable internal battery with built in charger. Portable and easy to use in field test situations, the PSA-35A is also suited for applications in research and development or classroom use. The PSA-35A is priced at $1965.00.

For information, contact AVCOM of Virginia Incorporated, 500 Southlake Boulevard, Richmond, Virginia 23236.

Circle #309 on Reader Service Card.

tools and test equipment

A new catalog of tools and test equipment is offered free by Jensen Tools, Inc. Illustrated in full color, the 160-page catalog contains information on more than 1000 items.

Two new sections feature supplies and equipment in support of fiber optics and wire/cable systems. An expanded line of circuit board equipment includes breadboard kits, cutter and drill sets, anti-static carrying cases and racks, test cables, insertion/extraction tools, and many other production tools.

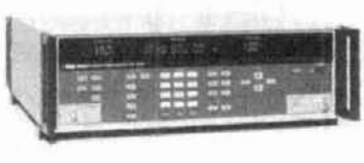
For a free catalog, contact Jensen Tools Inc., 7815 South 46th Street, Phoenix, Arizona 85044.

Circle #314 on Reader Service Card.

new signal generators

John Fluke Manufacturing Company, Inc. has introduced its 6061A Programmable Synthesized Signal Generator, the latest addition to its 6060 signal generator family.

The 6061A's high performance is targeted at rf applications, with increased demands on spectral purity. Residual fm is guaranteed to be less than 6 Hz rms (0.3 to 3 kHz) in the frequency range of 245 to 512 MHz (typically 4 Hz rms), non-harmonic spurious are less than -60 dBc,



NEW products

with -123 dBc typical SSB phase noise at 500 MHz. The 6061A has a frequency range of 0.01 to 1050 MHz with 10 Hz resolution. Amplitude range is from -127 to +13 dBm with 0.1 dB resolution and an absolute accuracy of ±1 dB. Internal and external a-m and fm can be used in combination or separately.

For more information or a demonstration of the Fluke 6061A, write, John Fluke Manufacturing Company, Inc., P.O. Box C9090, Everett, Washington 98206.

Circle #320 on Reader Service Card.

new 2-meter all-mode mobile transceiver

Trio-Kenwood Communications has introduced the TR-751A, an all-new 2-meter, all-mode mobile transceiver. Features include automatic mode selection, many scanning functions, an illuminated LCD display, status lights, and an analog S- and rf meter for easy viewing. The unit puts out 25 watts on high power and 5 watts on adjustable low power.

It covers 142-149 MHz, and can be modified to cover 141-151 MHz (note that a MARS or CAP permit is required to operate on these frequencies). Ten memory channels plus COM channel store frequency, mode, and CTCSS tone offset. Two channels for "odd split" operation are featured, as are all-mode squelch; a noise blanker; RIT; dual, digital VFOs; and semi break-in CW with sidetone. A 16-key DTMF hand microphone and mounting bracket are supplied. Options include a VS-1 voice synthesizer and a front-panel selectable 38-tone CTCSS encoder.

The suggested retail price for the TR-751A is $599.95. Trio-Kenwood Communications, 1111 West Walnut Street, P.O. Box 7065, Compton, California 90224.

ac power line monitor

The Testware LDM-120 is a very low-cost ac power line disturbance monitor designed to measure and store worst-case ac line voltage variations caused by surges and sags. An LED bar graph display covers from 60 to 160 VAC RMS. Priced at less than $100, the unit features a built-in audible alarm, an external alarm output, and selectable time constants.

For details, contact Testware Electronic Test Instruments, 4425 Canoga Avenue, Woodland Hills, California 91364.

Circle #319 on Reader Service Card.

computer rotor control interface

The KR-001 computer rotor control interface from Encomm, Inc., gives satellite enthusiasts automatic control of antenna azimuth and elevation. Used with the Kenpro KR-5400A, which provides the electro-mechanical interface to the rotor motors, the KR-001 provides the hardware interface to the computer, converting analog signals to digital for both the elevation and azimuth channels. It also provides the drive signal for driving the motors in the desired direction.

The unit plugs into the cartridge port of the C-64 and operates with tracking software written by N4HY for AMSAT available only from the AMSAT software exchange. Kenpro and Encomm provide the software needed to point the antenna from data entered into the program in real time; tracking software is *not* available from Encomm or Kenpro. Subroutines of the automatic tracking program which apply to the KR-001/KR5400A combination are supplied with the KR-001 for those who wish to write their own tracking software. The suggested retail price is $149.95.

For information, contact Encomm, Inc., 1506 Capital, Plano, Texas 75074.

Circle #315 on Reader Service Card.

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Daytonian Hilton
Econolodge
Fairborn Motel
Hampton Inn (Englewood)
Holiday Inn Wright State
Holiday Inn Dayton Mall
Holiday Inn Fairborn
Holiday Inn North
Holiday Inn South
Holiday Inn Troy
Knights Inn Franklin
Knights Inn Dayton North
Knights Inn Dayton South
Knights Inn Vandalia
L & K Motel (Brandt Pike)
LaQuinta Inn South
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April 24, 25, 26, 1987

Early Reservation Information

- **Giant 3 day flea market • Exhibits**
- **License exams • Free bus service**
- **CW proficiency test • Door prizes**

Flea market tickets and grand banquet tickets are limited. Place your reservations early, please.

Flea Market Tickets

A maximum of 3 spaces per person (non-transferable). Tickets (for all 3 days) will be sold IN ADVANCE ONLY. No spaces sold at gate. Vendors MUST order registration ticket when ordering flea market spaces.

Special Awards

Nominations are requested for "Radio Amateur of the Year", "Special Achievement" and "Technical Achievement" awards. Contact; Awards chairman, Box 44, Dayton, OH 45401.

License Exams

Novice thru Extra exams scheduled Saturday and Sunday by appointment only. Send current FCC form 610, copy of present license and check for $4.25 (payable to ARRL/VEC) to: Exam Registration, 8836 Windbluff Point, Dayton, OH 45459

Slide Show

35 mm slide/tape presentation about the HAMVENTION is available for loan. Contact Dick Miller, 2853 La Cresta, Beavercreek, OH 45324

1987 Deadlines

Award Nominations: April 4
Lodging: April 4
License Exams: March 28
Advance Registration and banquet:
USA - April 11
Canada - April 4
Flea Market Space:
Orders will not be accepted **before** January 1

Information

General Information: (513) 433-7720
or DARA, Box 44, Dayton, OH 45401
Flea Market Information: (513) 223-0923
Lodging Information: (513) 223-2612
(No Reservations By Phone)

HAMVENTION is sponsored by the Dayton Amateur Radio Association Inc.

Lodging Reservation Form

(Please attach your name, address, and telephone number to this form.)

Dayton Hamvention - April 24, 25, 26 1987
Reservation Deadline - April 4, 1987
MAIL TO - Housing, Dayton Hamvention, 1880 Kettering Tower, Dayton, OH 45423-1880

Arrival Date ____________
( ) Before 6 pm ( ) After 6 pm
Departure Date ____________
Room: ( ) Single
( ) Double (1 bed, 2 persons)
( ) Double Double (2 beds, 2 persons)

Lodging Preference -
See list of Lodging on adjacent page.

1 ____________ 2 ____________

3 ____________ 4 ____________

Deposit required - Room deposit must be paid directly to the hotel or motel by date shown on the confirmation form sent to you. Use canceled check for confirmation.

(PLEASE SEPARATE)

Advance Registration Form

(Please attach your name, address, and telephone number to this form.)

	How Many		
Admission (valid all 3 days)	______	@ $8.00*	$______
Grand Banquet	______	@ $15.00**	$______
Women's Luncheon			
(Saturday)	______	@ $7.25	$______
(Sunday)	______	@ $7.25	$______
Flea Market (Max. 3 spaces) *Admission ticket must be ordered with flea market tickets*	______	@ $23.00	$______
		Total	$______

Make checks payable to - Dayton HAMVENTION.
Mail to - Dayton Hamvention, Box 2205, Dayton, OH 45401

* $10.00 at door ** $17.00 at door, if available

NEW products

changing winds

Though residential-scale wind power is far from being a widely popular energy source, home-generated wind power hasn't disappeared; its following has just gotten smaller. To serve that market, the Thermax Corporation of Burlington, Vermont, manufactures a scaled-down wind generator designed for such modest tasks as charging batteries to supply daily or emergency power to remote cabins, boats, or Amatuer radio equipment.

The Windstream Wind Generator, which stands 20 inches high and weighs only 20 pounds, puts out 12 volts of direct current in an 8-mph wind and has an automatic system that tilts the rotor out of harms's way in strong winds. Priced at $589, the generator won an award from the Department of Energy last year.

For details, contact Thermax, 1 Mill Street, Burlington, Vermont 05401.

Circle #321 on Reader Service Card.

keypad frequency entry

Stone Mountain Engineering has announced the 757 QSYer, a frequency keypad accessory for the Yaesu FT-757GX, which permits the transceiver's operating frequency to be changed to any other frequenccy in the unit's range as often and as rapidly as desired.

The QSYer is a tiny computer terminal that interfaces directly with the 757's accessory jack. It contains its own 8-bit microprocessor, support circuitry, full-size telephone-type keypad, and a

sub-miniature speaker which sounds a different tone for each key as it's pressed. The QSTer's all-metal enclosure measures 3.1 x 3.5 x 2 inches, and is color-matched to the 757's finish. The unit installs in seconds — with only two plugs — into the 757's rear panel jacks.

The QSYer is available for $89.50, plus $2.50 shipping and handling. For further information, or to order, contact Stone Mountain Engineering Co., Box 1573, Stone Mountain, Georgia 30086.

Circle #310 on Reader Service Card.

linear power amplifier

The Commander II is a grounded-grid, class AB2 linear power amplifier that operates on the Amateur band. An Eimac 3CX800A7 external anode triode with forced air cooling and modern stripline circuitry insures efficient and conservative operation. Reduced ratio vernier drives on all tuning controls allow smooth, easy tuneup.

Front panel input tuning control allows a higher circuit *Q* for excellent linearity and a very low input SWR to exciter all across the 2-meter band. A built-in automatic delay circuit insures proper cathode conditioning before rf drive can be applied, greatly extending tube life.

With a frequency range of 144-148 MHz (others available), it can be used on USB, LSB, CW, RTTY, fm, and packet. Priced at $988.00 plus shipping, its power requirements are 117/234VAC, with the latter recommended). Rf Drive power is 15 watts nominal, 25 watts with optional relay; rf output is 600 watts, with 15 watts drive.

For complete details, contact C.C.I.Electronics, 104 West Vine Street, Edgerton, Ohio 43517.

Circle #308 on Reader Service Card.

repeater products demo cassette

Advanced Computer Controls, Inc., is pleased to announce that it has a new audio cassette available which describes and demonstrates its repeater control products. Included in the demonstration are the RC-850 and RC-850 Repeater Controllers, the Digital Voice Recorder, and the ITC-32 Intelligent Touch-Tone Control Board.

The cassette is suitable for individual listening or for club meeting presentation. It lets the listeners hear ACC's repeater control products in operation and how users can benefit from using them on their repeaters. The demonstration cassette is available on request at no charge.

ACC manufactures microcomputer based control systems for Amateur Radio, commercial, and government radio users. For additional information, contact Advanced Computer Controls, Inc., 2356 Walsh Avenue, Santa Clara, California 95051.

Circle #318 on Reader Service Card.

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Specifications Subject to Change.

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NEW products

new Midian catalog

Midian Electronics' new 1987 full-color, 32-page product catalog offers a bright new presentation of its standard tone-signaling products plus an introduction to many new products. Also featured are products from Midian's sister company, Advanced Signaling Technologies, manufacturers of microprocessor-based paging, display, status, and radiotelephone terminals that are system-compatible with Midian's portable and mobile signaling product line. In addition to the listing and description of the product line is a section illustrating the operations of Midian and AST's various departments. Copies are available upon request from Midian Electronics Incorporated, 2302 East 22nd Street, Tucson, Arizona 85713.

Circle #317 on Reader Service Card.

antenna switch

Alpha Delta has announced its new four-position rf switch, the DELTA-4.

Designed to give years of trouble-free use, the DELTA 4 is rated at full Amateur power, 1500 watts. It will ground four antennas not in use or, when an antenna is selected, it will ground the antennas not in use. Lightning surge protection is provided by a field-replaceable ceramic gas tube ARC-PLG cartridge.

The DELTA-4 is designed with both hf and UHF applications in mind. Insertion loss is rated at 0.1 dB at 30 MHz and 0.5 dB at 450 MHz. It's priced at $69.95. For more information, contact Alpha Delta, P.O. Box 571, Centerville, Ohio 45459.

Circle #307 on Reader Service Card.

high-power duplexers

Two new duplexers are available from NCG. The new CF-412 Broad Range Duplexer has a very broad frequency range: 1.3-450 MHz on the low input and 900-1400 MHz on the high frequency side, giving the dual-band operator the same freedom as the VHF/UHF operator enjoys. Maximum power is 70 watts, with isolation more than 39 dB.

The new CF-415 duplexer provides the dual-band operator an extra degree of safety with its high-power capabilities. Most VHF and UHF transceivers develop 45 watts of power; although the old type of duplexers are rated at 50 watts, it has been a common occurrence for them to fail, causing final burnout. The CF-415 safely handles 500 watts on hf, 400 watts on 145 MHz, and 250 watts on 450 MHz. The isolation on both bands is more than 50 dB.

Both the CF-412 and the CF-415 duplexers are available from the manufacturer and through independent dealers. For information, contact NCG Company, 1275 N. Grove Street, Anaheim, California 92806.

Circle #303 on Reader Service Card.

new publication for kit builders

The Heath Company of Benton Harbor, Michigan, has announced the publication of the *Kit Builder's Journal*. Premiering in January, 1987, the bi-monthly *Journal* covers all aspects of building electronic and non-electronic kits — both Heath's and others.

Articles will cover kitbuilding tips, Heathkit news and reviews of products, tips from Heath's technical consultants, and other valuable do-it-yourself information. Subscribers will also be offered special discounts on selected Heath Company products.

For a six-issue subscription, order KBJ-2000-NM and send $9.95 to Heath Company, Box 1288, Benton Harbor, Michigan, 49022.

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continuous coverage receiver

ACE Communications, Inc. has introduced the model AR-2002, a professional grade scanning monitor receiver that covers 25-550 MHz and 800-1300 MHz continuously.

The AR-2002 utilizes latest microprocessor and circuit technology to offer features that include a 20-channel memory scan, priority scan, band search, multi-mode reception, conventional dial tuning, selectable frequency increments, and a bar graph signal strength indicator.

The unit incorporates commercial-type receiver technology such as 750 MHz receiver i-f, a high-level double-balanced mixer, a low-noise wide-band rf amplifier, and a high-stability VCO unit.

The user price for the AR-2002 is $499.00. For further details, contact ACE Communications, Inc., 22511 Aspan Street, Lake Forest (El Toro), California 92630-6321

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basic service kit

Jensen Tools Inc. has developed a new Basic Service Kit for the budget-minded electronic technician. Ideal for field service, in-house maintenance, trade school and personal use, this new addition to Jensen's Telvac economy line contains over 40 hand tools in a solid wood/vinyl case with removable pallets, document pouch, and key-lock latches. Priced at $189, the kit includes standard service tools such as screwdrivers, pliers, nut and hex drivers, punches, wrenches and soldering equipment, as well as a 5-inch hemostat, reverse action tweezer, combination spring tool, wire crimper/stripper, and other specialty items. A choice of test meters is also offered as an optional accessory.

For more information or a free catalog, contact Jensen Tools Inc., 7815 S. 46th Street, Phoenix, Arizona 85044.

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MS-DOS computer users will find this handbook to be an essential addition to their computer library. Includes a full explanation of MS-DOS commands in clear, concise language and examples of command syntax. Hints on command usage and explanations of the hierarchial directory and I/O redirection will enable you to get maximum benefit from your computer investment. For novice and expert users. © 1984 1st Edition 330 pages

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by James Kelly

Here's one of those unheralded gems we stumbled upon recently. This nifty book is jam-packed with ideas and suggestions on how to get more out of your PC-DOS or MS-DOS computer. Not a tutorial; more for the intermediate user who is looking to get more speed and efficiency. Improve your keyboard, enhance your display, organize your files, and manage your printer better than ever before. You'll be amazed at what this book can add to your PC. Also covers Lotus 1-2-3 and Wordstar. © 1985 1st Edition 224 pages

OS-PCS — **Softbound \$16.95**

APPLE II USER'S GUIDE, Apple Plus and II series
by Poole, McNuff and Cook

All time Apple II best seller! Now available in updated third edition. Learn from the experts how to get the most from your Apple home computer and peripherals. You also get a complete explanation on how to use DOS 3.3 and Pro-DOS. Easy-to-use tutorial explanation of BASIC programming will teach you how to use all the sound and graphics capabilities as well as the Apple IIe high resolution graphics. This book is worth it's weight in gold! © 1985 1st Edition 512 pages

OS-UG — **Softbound \$18.95**

We're really proud of the next two books! Doug was Jim Fisk's right hand man during the early seventies. His first computer book, The Introduction to TURBO Pascal, quickly went best seller. The TURBO Library is an invaluable addition to TURBO user's libraries.

INTRODUCTION TO TURBO PASCAL
by Doug Stivison WA1KWJ (ex Ham Radio assistant editor)

Thousands have learned Pascal programming with this popular best seller. As a tutorial this book enhances the unique aspects of Turbo Pascal by concentrating on the extended applications capabilities offered. Includes graphics, look-up tables, word processor to typesetting equipment conversion tables, TTS to ASCII conversion and fast sort/search routines. © 1985 1st Edition 268 pages

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TURBO PASCAL LIBRARY
by Doug Stivison WA1KWJ

Perfect compliment to the Turbo Pascal Introduction book listed above. Stivison shares his extensive collection of proven programs and will save experienced programmers time and illustrate to beginners good programming techniques and Turbo versions of standard algorithims. Includes games, systems utilities, and routines for business and engineering applications. © 1986 1st Edition 350 pages

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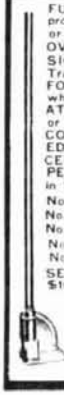

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COMING EVENTS

Activities — "Places to go . . ."

OHIO: February 15. The Mansfield Mid*Winter Hamfest/Computer Show, Richland County Fairgrounds, Mansfield. Doors open to public 7 AM. Tickets $3.00 advance; $4.00 at the door. Tables $5.00 advance; $6.00 at the door. Forums, Flea Market in large heated buildings. For more information, tickets, tables SASE to Dean Wrasse, KB8MG. 1094 Beal Road, Mansfield, Ohio 44905 or phone (419) 589-2415 after 4 PM EST.

OHIO: February 22. The Cuyahoga Falls ARC will sponsor its 33rd annual Auctionfest, Tallmadge High School. Flea Market opens 8 AM. Tables $6.00 advance. Auction begins 11 AM. Admission $4.00 at the door. $3.00 advance. Check in on 147.87/.27 repeater. For more information SASE to Cuyahoga Falls ARC, PO Box 614, Cuyahoga Falls, Ohio 44222.

MICHIGAN: February 22. The 17th annual Livonia ARC's Swap 'n Shop, 8 AM to 4 PM at the Dearborn Civic Center, Dearborn. ARRL/VEC FCC Amateur exams given by the Motor City Radio Club. Plenty of tables, refreshments and free parking. Talk in on 144.75/5.35 and 146.52. For further information SASE to Neil Coffin, WA8GWL, c/o Livonia ARC, PO Box 2111, Livonia, MI 48151.

INDIANA: March 8. The Morgan County Repeater Association's Indiana Hamfest, Indiana State Fairgrounds Pavillion Building, Indianapolis. Admission $5.00 at the door. Open to the public 8 AM. 8' flea market table $8.00.Talk in on 145.25. For table reservations or information SASE before February 25 to Aileen Scales, KC9YA, 3142 Market Place, Bloomington, IN 47401. (812) 339-4446.

OHIO: April 24, 25, 26. DAYTON HAMVENTION.

ILLINOIS: March 15. The Sterling-Rock Falls ARS 27th annual Hamfest, Sterling High school Fieldhouse, 1608 Fourth Avenue. Doors open 7:30 AM. Dealers, large flea market and space for self-contained RV's Concession stand will be available. Tickets $3.00 advance, $4.00 at the door. Commercial tables $5.00 and $3.00. Talk in on 146.25/85, W9MEP. For information, tables or tickets: Sue Peters, PO Box 521, Sterling, IL 61081 or call (815) 625-9262.

MASSACHUSETTS: March 1. Annual MTARA Flea Market, K of C Elder Council 69 Hall, Granby Road, Chicopee. General admission $2.00. Spouse and kids free. Tables $10.00 at door. $8.00 advance. Tailgating $5.00. Vendor setup from 7 to 10 AM. Public admitted 10 AM. Food and refreshments. Walk in Amateur license exams 10:30 AM. Talk in on 146.34-146.94 and 52 simplex. Write MTARA, Box 3494, Springfield, MA 01101 or call Bob, WB1EQS (413) 532-4891 days or Mickey, N1CDR (413) 562-1027 evenings.

FLORIDA: March 21-22. The Playground Amateur Radio Club's 17th annual North Florida Ham/Swapfest, Shrine Fairgrounds, north Ft. Walton Beach. Doors open 8AM both days. FCC exams Saturday only. ARRL, and QCWA meetings. Banquet Saturday night. RV parking. Talk it on 146.19/79 and 52. For more information write PARC, PO Box 873, Ft. Walton Beach, FL 32548.

NEW YORK: February 15. Long Island ARRL Indoor Hamfest, sponsored by LIMARC, Electricians Hall, 41 Pine Lawn Road, Melville, LI. Doors open 9 AM.Admission $4.00 at the door; $3.25 in advance with SASE. Exhibitors admitted 7:30 AM. For more information call Hank (516) 484-4322 evenings.

FLORIDA: March 7. The City of Palms (Fort Myers) annual Hamfest, Moosehall on Parkmeadow Drive. 9 AM to 4 PM Dealers, forums, swap tables, snack bar, luncheon and more. Talk in on 28/88. For information: Harry Arnold, K9ALX, 5414 Brandy Circle SW, Fort Myers, FL 33907 (814) 482-3113.

NEW HAMPSHIRE: March 14. The Interstate Repeater Society of Derry, NH will hold its annual Flea Market, Lions Club Hall, Lions Avenue, Hudson. Doors open 8 AM. Admission $1.00 at the door. Tables $8.00 each. For table reservations (603) 623-0628 or (603) 883-9441. Write I.R.S., PO Box 693, Derry, NH 03038.

NEW YORK: March 1. The Mt. Beacon Amateur Radio Club's first annual Winter Hamfest, State Armory, Newburgh. 8 AM to 3 PM. Doors open for sellers 7 AM. General admission $3.00. Table space $4.00. Reserved tables $5.00. Refreshments available. Talk in on 146.37/.97 and 146.52. For reservations and information: Stan Disbrow, WA2KQY, Mt. beacon ARC, PO Box 841, Wappingers Falls, NY 12590. (914) 876-1659.

MINNESOTA: February 21. The Robbinsdale ARC's 6th annual Midwinter Madness Hobby Electronics Show. New site--Medina Ballroom, Hwy 55, Medino (western suburb of Mineapolis). Admission $3.00 advance; $4.00 at the door. Flea Market and Retail Exhibits open 8 AM. 8' flea market tables $8.00. FCC exams start 9 AM. Talk in on K0LTC Club Repeater and 146.52 simplex. To register SASE with fees to Robbinsdale ARC, PO Box 22613, Robbinsdale, MN 55422 or call Bob (612) 533-7354. FCC Exam registration: Send completed Form 610, photocopies of current license with $4.00 payable to ARRL/VEC to Ron Schulz, NA0U, 6308 Peacedale Avenue, Edina, MN 55424.

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"Things to do . . ."

February 1. 1987 Classic Radio Exchange, 2100 UTC Sunday to 0400 UTC Monday. Exchange name, RST, QTH, receiver and transmitter with other hams interested in restoring, operating and just enjoying older equipment. Send logs, comments, anecdotes, pictures, etc. to Jim Hanlon, W8KGI, 5560 Linworth Road, Columbus, OH 43085. Please include SASE.

February 7. 1987 New Hampshire QSO Party sponsored by the NH Amateur Radio Association. 1900Z February 7 to 0700Z February 8. 1400Z February 8 to 0200Z February 9. Send log and comments to Mount Moriah Repeater Society, c/o Bud Valcourt, N1BYQ, 19 Teague Drive, Salem, NH 03079.

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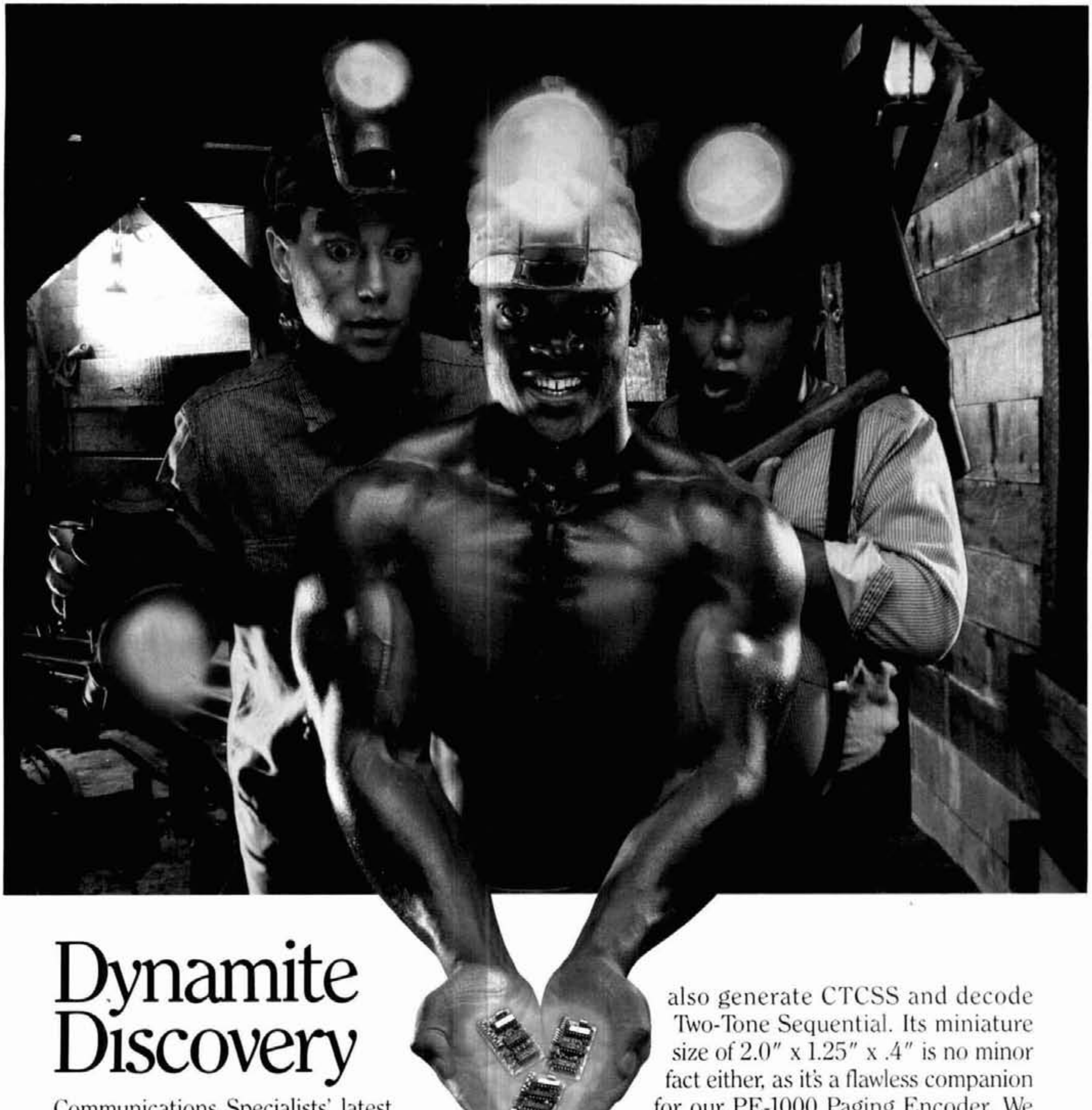

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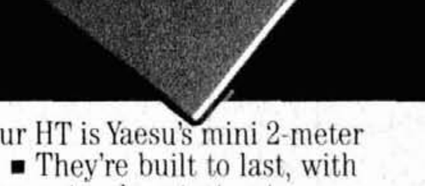
Let's face it. It's easy to bump, drop, or get rain on an HT. ■ But if your HT is Yaesu's mini 2-meter FT-23R or 440-MHz FT-73R, such mishaps are a lot less worrisome. ■ They're built to last, with rugged aluminum-alloy cases that prove themselves reliable in a one-meter drop test onto solid concrete. Plus, their moisture-resistant seals really help keep the rain out.

Built for the realities of operating. Despite their miniature size, both radios have all the operating capabilities of larger microprocessor-controlled HTs. Yet operating them couldn't be easier. Consider: ■ You get a 7.2-volt, 2-watt battery pack. (Optionally, a 12-volt, 5-watt pack, or 7.2-volt miniature 2-watt pack.) 10 memories that store frequency, offset and PL tone. (7 memories can store odd splits.) Memory scan 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. External PL selection. Independent PL memory per channel. PL encode *and* decode. Expanded Rx coverage.* LCD power output and "S"-meter display. Battery saver circuit. Push-button squelch override. Eight-key control pad. Keypad lock. High/low power switch (½ watt on low power.) ■ Options available: Dry cell battery case for 6 AAA-size cells. Dry cell battery case for 6 AA-size cells. DC car adapter/charger. Programmable CTCSS (PL tone) encoder/decoder. DTMF keypad encoder. Mobile hanger bracket. External speaker/microphone. And much more. ■ So get the intelligent mini HT that's built for life's realities. Yaesu's 2-meter FT-23R, or 440-MHz FT-73R.



Radios above shown actual size.

YAESU

Yaesu USA 17210 Edwards Road, Cerritos, CA 90701 (213) 404-2700. **Repair Service:** (213) 404-4884. **Parts:** (213) 404-4847.
Yaesu Cincinnati Service Center 9070 Gold Park Drive, Hamilton, OH 45011. (513) 874-3100.

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KENWOOD

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NEW! Computer Interface!

"DX-cellence!"

TS-940S

The new TS-940S is a serious radio for the serious operator. Superb interference reduction circuits and high dynamic range receiver combine with superior transmitter design to give you no-nonsense, no compromise performance that gets your signals through! The exclusive multi-function LCD sub display graphically illustrates VBT, SSB slope, and other features.

- **100% duty cycle transmitter.** Super efficient cooling system using special air ducting works with the internal heavy-duty power supply to allow continuous transmission at full power output for periods exceeding one hour.
- **High stability, dual digital VFOs.** An optical encoder and the flywheel VFO knob give the TS-940S a positive tuning "feel."
- **Graphic display of operating features.** Exclusive multi-function LCD sub-display panel shows CW VBT, SSB slope tuning, as well as frequency, time, and AT-940 antenna tuner status.
- **Low distortion transmitter.** Kenwood's unique transmitter design delivers top "quality Kenwood" sound.
- **Keyboard entry frequency selection.** Operating frequencies may be directly entered into the TS-940S without using the VFO knob.
- **QRM-fighting features.** Remove "rotten QRM" with the SSB slope tuning, CW VBT, notch filter, AF tune, and CW pitch controls.
- **Built-in FM, plus SSB, CW, AM, FSK.**
- **Semi or full break-in (QSK) CW.**
- **40 memory channels.** Mode and frequency may be stored in 4 groups of 10 channels each.
- **Programmable scanning.**
- **General coverage receiver.** Tunes from 150 kHz to 30 MHz.
- **1 yr. limited warranty.** Another Kenwood First!

Optional accessories:

• AT-940 full range (160-10m) automatic antenna tuner • SP-940 external speaker with audio filtering • YG-455C-1 (500 Hz), YG-455CN-1 (250 Hz), YK-88C-1 (500 Hz) CW filters; YK-88A-1 (6 kHz) AM filter • VS-1 voice synthesizer • SO-1 temperature compensated crystal oscillator • MC-43S UP/DOWN hand mic. • MC-60A, MC-80, MC-85 deluxe base station mics. • PC-1A phone patch • TL-922A linear amplifier • SM-220 station monitor • BS-8 pan display • SW-200A and SW-2000 SWR and power meters.

Interface IF-232C/IF-10B

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

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

KENWOOD

TRIO-KENWOOD COMMUNICATIONS
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Compton, California 90220