FEBRUARY 1981

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Tempo was the first with a synthesized hand held for amateur use, first with a 220 MHz synthesized hand held, first with a 5 watt output synthesized hand held...and once again first in the 440 MHz range with the S-4, a fully synthesized hand held radio. Not only does Tempo offer the broadest line of synthesized hand helds, but its standards of reliability are unsurpassed...reliability proven through millions of hours of operation.

No other hand held has been so thoroughly field tested, is so simple to operate or offers so much value. The Tempo S-4 offers the opportunity to get on 440 MHz from where ever you may be. With the addition of a touch tone pad and matching power amplifier its versatility is also unsurpassed.

The S-4...$349.00
With 12 button touch tone pad...$399.00
With 16 button touch tone pad...$419.00
S-40 matching 40 watt output
13.8 VDC power amplifier...$149.00

**Tempo S-1**
The first and most thoroughly field tested hand held synthesized radio available today. Many thousands are now in use and the letters of praise still pour in. The S-1 is the most simple radio to operate and is built to provide years of dependable service. Despite its light weight and small size it is built to withstand rough handling and hard use. Its heavy duty battery pack allows more operating time between charges and its new lower price makes it even more affordable.

S-30...$89.00*  
S-80...$149.00*  
*For use with S-1 and S-5

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With an S-2 in your car or pocket you can use 220 MHz repeaters throughout the U.S. It offers all the advanced engineering, premium quality components and features of the S-1 and S-5. The S-2 offers 1000 channels in an extremely lightweight but rugged case.

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**Tempo S-5**
Offers the same field proven reliability, features and specifications as the S-1 except that the S-5 provides a big 5 watt output (or 1 watt low power operation). They both have external microphone capability and can be operated with matching solid state power amplifiers (30 watt or 80 watt output). Allows your hand held to double as a powerful mobile or base radio.

S-30...$89.00  
S-80...$149.00

**Specifications:**
- Frequency Coverage: 440 to 449.995 MHz
- Channel Spacing: 5 kHz minimum
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- Current Drain: 17 ma-standby 400 ma-transmit (1 amp high power)
- Antenna Impedance: 50 ohms
- Sensitivity: Better than 3 microvolts nominal for 20 db
- Supplied Accessories: Rubber flex antenna 450 ma ni-cad battery pack, charger and earphone
- RF output Power: Nominal 3 watts high or 1 watt low power
- Repeater Offset: ± 5 MHz

**Optional Accessories for all models**
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- 16 button touch tone pad (not installed): $48  
- Tone burst generator: $29.95  
- CTCSS sub-audible tone control: $29.95  
- Leather holster: $20  
- Cigarette lighter plug mobile charging unit: $6

**TEMPO VHF & UHF SOLID STATE POWER AMPLIFIERS**
Boost your signal... give it the range and clarity of a high powered base station. VHF (135 175 MHz)

<table>
<thead>
<tr>
<th>Drive Power</th>
<th>Output</th>
<th>Model No</th>
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</thead>
<tbody>
<tr>
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<td>130A02</td>
<td>$209</td>
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<tr>
<td>10W</td>
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<td>30W</td>
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</table>

UHF (400 to 512 MHz) models, lower power and FCC type accepted models also available.

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Prices subject to change without notice.
**Operates from 120 V-ac, 50/60 Hz primary line voltage.**

Amplifier is comprised of two units—rf deck for desk top and separate power supply.

**6.75"H x 8.5"D x 17.1"W (33.26 x 36.2 x 33 cm). Power Supply: 6.75"W x 7.88"H x 11"D (17 x 20 x 28 cm). **

**Weight: MN7—10 lbs (4.5 kg). MN2700—11 lbs (5 kg).**

**Drake L7 Utilizes a pair of Eimac 3-500 Z triodes for rugged use, and lower replacement cost compared to equivalent ceramic types.**

**Accurate built-in rf wattmeter, with forward/reverse readings, is switch selected. Calibrated 300/3000 watt scales. Temperature controlled two speed fan is a high volume low noise type and offers optimum cooling.**

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By-pass switching is included for straight through, low power operation without having to turn off amplifier.

Bandpass tuned input circuitry for low distortion and 50 ohm input impedance. Amplifier is comprised of two units—rf deck for desk top and separate power supply.

Operators from 120/240 V-ac, 50/60 Hz primary line voltage.

**DRAKE L7 SPECIFICATIONS**

- **Frequency Coverage**: 1.8 - 30 MHz
- **Antenna Choice**: Matches antennas fed with coax, balanced line (use optional B-1000 Balun), or random wire.
- **Antenna/Bypass Switching**: Allows matching unit bypass regardless of antenna in use, and selects various antennas.
- **Extra Harmonic Reduction**: Employs “pi-network” low pass filter type circuitry for maximum harmonic rejection.
- **Built-in Metering**: Accurate Rf Wattmeter and VSWR Reading, pushbutton controlled from front panel.
- **Input Impedance**: 50 ohms resistive.
- **Power Capability**: MN7—250 watts average continuous duty (0-300 W scale). MN2700—1000 watts average continuous duty (2000 watts PEP). (0-200 or 0-2000 W scale).
- **Dimensions**: MN7—13.1"W x 4.53"H x 8.5"D excluding knobs and connectors (33.26 x 11.5 x 21.6 cm). MN2700—13.1"W x 4.53"H x 13"D excluding knobs and connectors (33.26 x 11.5 x 33 cm).
- **Weight**: MN7—10 lbs (4.5 kg). MN2700—11 lbs (5 kg).

**Drake MN7 and MN2700 Specifications**

- **Operating Conditions**: 1.8 to 30 MHz. Band Switch marked for 160, 80, 40, 20, 15, and 10 meter amateur bands; however, frequency coverage between amateur bands is possible by using the nearest band positions with a small reduction in matching capability. **Input Impedance**: 50 ohms (resistive). **Load Impedance**: 50 ohm coaxial with VSWR of 5:1 or less at any phase angle (3:1 on 10 meters). 75 ohm coaxial at a lower VSWR can be used.
- **Balanced Feedlines**: With the Drake B-1000 accessory balun, which mounts on rear panel, tunes feed point impedances of 40 to 1000 ohms, or 5:1 VSWR referenced to 200 ohms (3:1 on 10 meters).
- **Dimensions**: MN7—13.1"W x 4.53"H x 8.5"D excluding knobs and connectors (33.26 x 11.5 x 21.6 cm). MN2700—13.1"W x 4.53"H x 13"D excluding knobs and connectors (33.26 x 11.5 x 33 cm).
- **Weight**: MN7—10 lbs (4.5 kg). MN2700—11 lbs (5 kg).

**Specifications, availability, and prices subject to change without notice or obligation.**
In the race of popular demand for quality in fully synthesized, multifeature hand held transceivers, the Santec HT-1200 emerges as the commanding front runner. More than just handy, the Santec stands on a solid platform of big rig features which fully utilize the very latest microprocessor technologies.

When you choose Santec, you opt for 4 modes of automatic scan and search of 10 memories and the whole band. When you choose Santec, you opt for selectable output power of 3.6W or 1.0W, with only a 6mA drain for the optional continuous display of the bright LED readout. When you choose Santec, you opt for variable scan steps in any multiples of 5kHz. And when you choose Santec, you opt for a band range that covers most Army MARS, Navy MARS, and CAP frequencies and the ease of entering all frequencies from the integrated keyboard. Assuredly, when you choose Santec, you opt for the majority leader which hands over features hand over flout.

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February 1981
The urge to compete seems to be a part of human nature. Amateur Radio has its share of competition: DXCC, T-Hunts, Field Day. Competition stimulates people to improve, and that’s healthy.

Another contest, which was popular years ago but which hasn’t received much publicity recently, is the world high-speed CW championship. This is the challenge of challenges for operating skill: to break the record of Ted McElroy, ex-W1JYN, who made the Guinness Book of World Records by copying Morse code at a speed of 75.2 words per minute in a contest at Asheville, North Carolina, on July 2, 1939. Ted’s record still stands. It’s time for someone to try to break it.

Many readers will sniff in disdain at such a contest: “Who needs it?” “What will it prove?” I’m here to tell these people that Morse code is here to stay, like it or not.

Since I became editor of ham radio, I’ve received many letters from readers who scoff at the Morse code requirement in the Amateur license examination. For the most part, their reasons are that Morse isn’t necessary for today’s communications. I won’t argue this point except to say that these people are somewhat misguided and know not whereof they speak. Listen to the parts of the Amateur bands devoted to traffic handling, the extra-class sub-bands, the Novice bands. It’s CW, in whatever form.

A contest to break the world’s record in Morse code reception is challenging, exciting, and in the best tradition of Amateur Radio for those who like to compete. Ted McElroy’s record has been unbroken for 42 years. Who will be the next champ?

We at ham radio are proposing a contest for those who wish to try to break Ted’s record. The contest will be conducted under official rules similar to those in effect during the contest in Asheville, North Carolina, in 1939. Appropriate prizes will be awarded to the winners.

Right now the contest is in the planning stage. The first contest will probably be held at one of the larger ham conventions in the spring of this year. We haven’t yet decided which convention it will be. At any rate, the contest will be held under strictly controlled conditions, in a room devoid of distractions and noise. A contest of this sort must be done by the rules to guarantee fairness to all.

More information on the contest will be upcoming in future issues of both ham radio and HR Report. Look for it and plan to enter. CW is certainly not dead!

Our ex-Horizons readers will find some familiar topics in this issue: an equipment owner’s questionnaire on three popular transceivers, Bill Orr’s column on “Ham Radio Techniques,” and of course Garth Stonehocker’s “DX Forecaster.” Next month we’ll have the results of the Collins KWM2 and KWM2A equipment survey. Also look for the popular Q and A column and an interesting article by W7JWJ on the world’s champion high-speed Morse code operator.

Alf Wilson, W6NIF editor
2A Versatility
10 Options Guaranteed to Make the Extremely Popular 2A and 2AT Even More Popular!
hyperbolic navigation

Dear HR:

Amateur Radio experts often reinvent the wheel in novel ways. A case in point is the article in ham radio, September, 1980, by Henry S. Keen, W5TRS, on "Navigational Aid for Small Boat Operators." The whole idea here is basically a hyperbolic navigation method and is markedly similar to the DECCA system used in Europe for many decades. DECCA operates on harmonic-related frequencies in the 75 kHz to 150 kHz range and uses exact integral divisors or multipliers as the intermediate beat frequency, very similar to Keen's idea of the second harmonic or subharmonic of the beat note. A problem that Keen has not addressed is that of "lane jumping," or resolution. At transmitter frequencies in the 10-meter range, the lane width between adjacent hyperbolas will be 5 meters, which taxes the resolution of the phase detector (and the steering navigator) for keeping track of which hyperbola the navigator is seeking.

At short ranges (a few miles), the use of the 1-watt-limit, 1750-meter experimenter band at 160 to 190 kHz might possibly make Keen's idea practical with lane widths of 1/2 wavelength or 875 meters for one cycle of phase change of the beat note. Thus 875 meters becomes 360 degrees of the phase detector output. Typical phase detectors resolve to 1 per cent or so at audio beat frequencies, so in practice 875-meter resolution of the path over a particular hyperbola might be resolved.

Another system is available from Hastings-Raydist Division of Teledyne Corporation. This has used transmitters in the 500 kHz to 2.5 MHz range, with hyperbolas 100 meters apart and resolution to within 1 meter. Still other worldwide hyperbolic navigation systems like OMEGA (10.2 to 13.6 kHz) and LORAN-C (100 kHz) use time-sequence bursts or pulses to enable a large number of stations to all transmit on the same frequency and very effectively measure phase difference by the time of arrival or sequential memory-aided phase-locked loop methods. The method is high power (1 megawatt) Navy vlf communications transmitters operating in the 14 kHz to 20 kHz range have also been used for worldwide navigation. Here, they are all atomic clock controlled, so all one has to do in principle is to convert the receiver measurement to a common i-f in the audio range at something like 100 Hz.

There are a great many pitfalls in devising new navigation systems that have been thoroughly worked over in the past 50 years. A general reference on the subject is Kayton and Fried Avionics Navigation Systems, John Wiley & Sons, published in 1969. Another reference, particularly on the early history of hyperbolic navigation, is NBS Monograph #129, "The Development of LORAN-C Navigation and Timing," U.S. Government Printing Office, $4.50, published October, 1972. A major problem with any CW-type hyperbolic system is that of proper lane identification; that is, how does the navigator know where to start the phase measurement, which lane or which line of position is he on? The SHORAN system that Keen mentions is not a CW hyperbolic method but rather a direct ranging time of arrival of pulse technique operating in the 200-300 MHz range. CW hyperbolic systems have largely been replaced by direct ranging ideas using coherent phase-locked transponders, but this always makes the system hardware more complex. When engineers think about these methods, what invariably happens is that the actual working hardware becomes much more complex and expensive than the inventor originally intended. Also, it is very hard these days to come up with something new. There are so many people thinking about the same idea at any given time that ten people will come up with the same idea at once, and there is just too much prior art to study.

Ralph W. Burhans
Athens, Ohio

RST
Dear HR:

I would like to make a comment to the "Observations & Comments," ham radio, September, 1980. I wholeheartedly agree with the idea of changing the RST system to something like Q1-Q2-Q3 as reporting signal conditions.

I am not a DXer or contest man, but I have put in some time logging on Field Day. It sure looks ridiculous to see the whole log with just RST 599. The RST system doesn't give a true picture of conditions. I like the Q1-Q2-Q3 because it seems to cover the total spectrum. But as it is done now, the whole contest report could be just all Q3s. Just for the record I think I will start using this system of Q1,2,3 and wait and see how many ask about it. It is worth a try.

George F. Schmidt, WBUCK
St. Louis, Missouri
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AM-414

More Details? CHECK — OFF Page 98

February 1981
PLAIN LANGUAGE AMATEUR RULES docket released in the form of a Notice of Proposed 
Rule Making, PR Docket 80-279, includes both the texts of the present Part 97 rules 
and the proposed rewrite, plus explanations. It was printed in the Federal Register 
of December 19. 

Significant Changes, such as the deletion of all logging requirements and addition 
of a requirement that licensees must keep a copy of the Amateur rules on hand, also 
include a warning that the FCC can inspect a station "at any time during the business 
day or any time your station is transmitting or has just finished transmitting." The 
proposed new rules also clarify rules on interconnects (phone patches), antenna heights, and emergency 
and prohibited communications. They also include much more information on exams, both 
written and code, and propose that applicants with FCC Commercial CW licenses get 
credit for the equivalent Amateur CW exam. The rewrite also endeavors to consolidate and 
reorganize the rules into a more concise and logical arrangement. 

In Addition To Being Printed in December 19's Federal Register, PR Docket 80-279 is 
also available in limited quantities from the FCC Office of Consumer Assistance, Room 
258-150, 1919 M Street, Washington, D.C. 20554. Comments won't be due until June 19, 

ITALIAN EARTHQUAKE AREA COMMUNICATIONS depended very heavily on Amateur Radio until 
television and other services were partially restored in mid December, with Amateur 
Radio still providing a major channel for relief traffic. Initial traffic from the 
disaster area included casualty lists, relayed from VHF links in the area by 1W8JL 
early December. Many stations throughout the U.S. and Canada participated, with KAI8BQ 
and W8FID leading the action on 28802 mornings and 14240 later in the day when con-
ditions permitted. 

Many Needed For Transatlantic Relief communications links should continue for at least 
several more months, because of the extent of the damage (over 26,000 square kilometers 
devastated) and the magnitude of the U.S.-originated relief effort. KAI8BQ (T8CGW) left 
for Italy last month to work on the scene and attempt to convince the Italian govern-
ment to continue its third party OK. 

The UN's Principal Terminal for U.S./Italy traffic, has been shut down several times 
by aftershock damage. KLM donated a replacement beam, which Allitalia shipped to Naples, 
visit station. 

Participants In Relief communications represent all ethnic backgrounds, KAI8BQ noted, 
and the Canadian government, and Amateur operations on this band will 
be illegal until January, 1982.

30-METER BAND OPERATION was begun in early December by VE3OB, using his Canadian 
commercial callsign, VE9LFZ, for preliminary one-way transmissions with partner VE9LIN 
(VE3RFD). They plan to operate during all 1500, 1700, and 1900Z, plus random times eve-
nings starting at 2200Z. CW and (later) ASCII will be the modes, using 10.101 and 
10.169 MHz. 

VE9LFZ was Solid Copy on 10.101 MHz in the Midwest Thanksgiving afternoon, with a 
more than hour-long transmission that peaked as high as 5-6 even though Larry was running 
only 5 watts to an inverted V. These are test transmissions only, authorized by 
the Canadian government, and Amateur operations on this band will be illegal until 

CALIFORNIA BRUSH FIRES, which destroyed about 350 homes and burned hundreds of 
thousands of acres in December, brought out plenty of volunteer Amateur Radio support. 
More than 30,000 acres burned east of El Toro, where more than 50 operators used 
VE6TGR and simplex channels to provide M. Cross, paramedics, and fire headquarters 
with needed radio services. A link with the National Traffic System was also set up 
providing health-and-welfare communications for the fire fighters, who came in from a 
seven-state area. 

K6TEH, Or So Amateurs served in San Bernardino/Riverside areas, where, along 
with many CBers, they provided communications for the Lake Arrowhead Evacuation Center. 
Another Fire In The Big Basin Redwood State Park destroyed 350 acres of young red-
woods there. Sixty-five-year-old K6TEH set up his portable 34-94 repeater there at 
the request of the Division of Forestry. A dozen others also took part. 

PHASE III OF FCC'S CALLSIGN assignment system went into effect December 15, and with 
it all license classes except Novice became eligible to request callsign changes. Any 
Amateur who now holds a callsign not appropriate for his license class (1X3 for General/ 
Technician, 2X2 for Advanced, 1x2/2x1 for Extra) may request a change to a callsign of 
the proper format; though without any choice as to the specific callsign he will receive. 
FCC's New Form 610 (August, 1980 edition) is required by Phase II. So all previous 
editions are now obsolete and may not be used. As before, licensees still have the op-
tion of retaining their old callsigns when upgrading or changing call areas. A new callsign 
will not be assigned unless it's specifically requested by the licensee's having 
checked a box in the box in Form 610. 

Though Both The 4th and 6th call areas are running low on 2x1 callsigns for Extras, the 
Commission does not expect to be ready to go back to 1x2s until 1983 at the earliest.
MFJ Super Keyboard

For $279.95 you get: CW, Baudot, ASCII, buffer, programmable and automatic messages. Morse code practice, full featured keyer, human engineering.

Sending CW has always been a task, especially when you get a little tired. Electronic keyers help, but it's still too much work.

Now MFJ has a Super Keyboard that makes sending perfect CW effortless. It also sends Baudot RTTY and ASCII.

"Big deal" you say. "What's so special about that? There are lots of keyboards." Yes, but this one is different.

HUMAN ENGINEERED

A lot of thought has gone into human engineering the MFJ-494 Super Keyboard.

For example, you press only a one or two key sequence to execute any command.

All controls and keys are positioned logically and labeled clearly for instant recognition.

Pots are used for speed, volume, tone, and weight because they are more human oriented than keystroke sequences and they remember your settings.

A meter gives continuous readout of buffer memory and speed. Two characters before full, the meter lights up red and the sidetone changes pitch.

PROGRAMMABLE, AUTOMATIC MESSAGES

Four automatic messages and two programmable message memories (A and B) are provided. Messages A and B can be a total of 30 characters. B starts where A ends.

When recalled, each message takes only one character of the buffer. They may be chained and/or repeated via the buffer.

"Well," you say, "that sure is not much memory." But it's more than it seems because of the built-in automatic messages.

The buffer, programmable and automatic messages, backspace delete and PTT control (keys your rig) are included.

The ASCII mode includes all the features of baudot. Transmission speed is 110 baud. Both upper and lower case are generated.

MORSE CODE PRACTICE

There are two Morse code practice modes. Mode 1: random length groups of random characters. Mode 2: pseudo random 5 character groups in 6 separate repeatable lists. With answer lists.

Insert space between characters and groups to form high speed characters at slower speed for easy character recognition.

Select alphabetic or alphanumeric punctuation. Pause function lets you stop and then resume.

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Tune switch with LED keys transmitter for tuning. Tune key provides continuous dots to save finals. Built-in sidetone and speaker. PTT (push-to-talk) output keys transmitter for Baudot and ASCII modes.

Reliable solid state keying for CW: grid block, cathode, solid state transmitters (-300 V, 10 ma. Max, +300 V, 100 ma. Max). TTL and open collector outputs for RTTY and ASCII.

Fully shielded. RF proof. All aluminum cabinet. Black bottom, eggshell white top. Top x 7½" (Front) x 3½" (back).

9-12 VDC or 110 VAC with optional adapter.

OPTIONS

MFJ-53 AFSK Plug-in Module. 170 and 850 Hz shift. Output plugs into mic or phone patch jack for FSK with SSB rigs and AFSK with FM or AM rigs. $39.95 (+$3).

MFJ-54 LOOP KEYING Plug-in Module. 300 V, 60 ma. Loop keying circuit drives your RTTY printer. Opto-isolated. TTL input for your computer to drive your printer. $29.95 (+$3).

BENCHER IAMBIC PADDOLE. $42.95 (+$4).

110 VAC ADAPTER. $7.95 (+$3).

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DIPOLES

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for preamplifiers and converters

A recent article by W6NBI describes an easily duplicated temperature-limited diode noise generator and power supply. This generator provides both a reproducible source of noise and, by measuring the diode plate current, an easy method to measure the noise power output of the source. As will be discussed, verification of a receiver’s noise figure by the use of this generator is straightforward, using either the $y$-factor or twice-power methods.

Optimization of the noise figure of a receiver is quite tedious because each time a parameter is varied, two measurements (insertion of a pad and some calculations) are required. Also, since the two measurements are taken at different times, any gain drift in the system will introduce error into the measurement. If you are willing to restrict the noise source to a temperature-limited diode, it’s possible to build a very accurate automatic noise-filter meter that avoids some of the compromises multisource meters must make to accommodate different sources.

**derivation of the noise-figure concept**

Noise factor ($F$) of a receiver is defined as

$$ F = \frac{S/N_J(\text{Ideal Receiver})}{S/N_A(\text{Actual Receiver})} = \frac{N_A}{N_I} $$

(1)

and in logarithmic terms

$$ \text{Noise Figure (NF)} = 10 \log F $$

(2)

It’s important to keep the log $NF$ terms and the numerical ratio $F$ terms separate in your mind; if you mix them up you’ll make errors when calculating correction factors.

If we call $N_I$ the noise output power from the receiver when its input is terminated in a 50-ohm resistor at a temperature of 290 K (62 F), then

$$ N_I = N_{RA} + N_TG $$

(3)

where $N_{RA}$ = receiver added noise power

$N_T$ = termination resistor noise power

$G$ = receiver gain

If we then apply an excess noise to the receiver input we can define:

$$ N_2 = N_{RA} + N_TG + (EN)G $$

(4)

where $EN$ = excess noise power.

Noise power ($N$) = $kTB$

and

$k$ = Boltzmann’s constant $1.374 \times 10^{-23}$ Joules/°K

$T$ = absolute temperature °K ($°C + 273°$)

$B$ = bandwidth

then

$$ N_T = kT_0B $$

(5)

where $T_0 = 290 K (62 F)$ (by IEEE Convention)

$EN = kTB$

(6)

where $T$ = effective temperature of the excess noise source in °K.

The definition of the noise factor of a receiver (eq. 1) is

$$ F = \frac{N_A}{N_I} = \frac{N_I}{kT_0BG} $$

(7)

By Edward T. Gisske, K9IMM, 7256 Mineral Point Road, Verona, Wisconsin 53593
The amount of noise added by the receiver is
\[
N_2 = \frac{kT_oBG + (F-1) (kT_oBG) + kTBG}{kT_oBG + (F-1) (kT_oBG)}
\]
\[
N_2 = \frac{F T_o + T - T_o}{F T_o}
\]
Rearranging
\[
F = \left(\frac{T - T_o}{T_o}\right) \left(\frac{1}{N_2} - 1\right)
\]
or, in dB
\[
NF = 10 \log \left(\frac{T - T_o}{T_o}\right) - 10 \log \left(\frac{N_2}{N_1}\right)
\]
The first term is equal to the excess noise ratio (ENR) of the source expressed in dB
\[
NF = ENR(dB) - 10 \log \left(\frac{N_2}{N_1}\right)
\]
The term \(N_2/N_1\) is referred to as the y-factor and is used by automatic noise-figure meters such as the HP-340 series to measure noise figure in the following manner:

With reference to fig. 1, note that the source is gated on and \(N_2\) is measured; then the source is gated off and \(N_1\) is measured. This sequence is repeated at about a 500-Hz repetition rate. The ENR of the source is known, and \(N_2\) is used to set the gain of the i-f amplifier so that \(N_2\) is a fixed output regardless of the receiver gain. Then, by measuring \(N_1\), the ratio \(N_2/N_1\) is known. The meter is calibrated to solve the equation:
\[
NF = ENR - 10 \log \left(\frac{N_2}{N_1}\right)
\]
This ratiometric measurement factors receiver gain out of the measurement, so it's possible to tune for minimum noise figure without recalibration. Note that the i-f amplifier agc loop must be very tight, as the measurement depends on maintaining a constant reference (\(N_2\)) level. The i-f amplifier and detection circuitry must also be linear over a range of agc levels to get a valid \(N_1\) measurement.

Another noise-figure measuring method, usually used for manual measurements, is called the twice-power method. This method forces \(N_2 = 2N_1\) by adjustment of the source ENR.
\[
NF = ENR(dB) - 10 \log \left(\frac{N_2}{N_1}\right)
\]
\[
N_2 = 2N_1
\]
\[
NF = ENR - 10 \log (2) - 10 \log (1)
\]

**Fig. 2** shows a block diagram of the measurement. In practice, the measurement is performed as follows: with the noise source off and the pad out of the circuit; the power meter reading is noted. The source is then activated and the 3-dB pad inserted into the circuit. The source ENR is adjusted to produce exactly the same reading as before. When this condition is satisfied, the ENR of the source is equivalent to the receiver noise figure. The ENR of the source is usually adjusted by padding the source with a precision variable attenuator.

The attenuator setting is subtracted from the known ENR of the source to compute the receiver noise figure. This works for temperature-limited diode, argon discharge, or semiconductor diode sources. With the temperature-limited diode, an additional method of adjusting source ENR is to adjust the diode plate current (by varying the filament current) and thus vary the effective source temperature. Coincidentally, in a 50-ohm system, the noise factor \(F \equiv \text{diode plate current} \text{ and noise factor} \) \(NF \equiv 10 \log (I(mA))\). (See reference 1 for a derivation of this relationship.) The advantage of the twice-power method over the y-factor method is that the power-measuring circuit is always operated at the same signal level; therefore linearity of the amplifiers and detection circuitry is assured.

---

*The transition from eq. 6 to eq. 7 may not be obvious to some readers, in view of the appearance of the term \((F-1)\). The equation for \(N_2/N_1\) is correct, however, as the following shows:

By definition, the noise temperature, \(T\), of the input terminating resistor is related to the equivalent noise factor, \(F\), contributed by the terminating resistor by the relationship
\[
T = T_o(F-1)
\]
rearranging
\[
\frac{T}{T_o} = (F-1)
\]
therefore
\[
(F-1) (kT_oBG) = \frac{T}{T_o} (kT_oBG) = kTBG
\]
Note that if \(T = T_o(F-1) = 1\), \((F-1)\) accounts for the noise power at the amplifier output due to the input terminating resistor operating at some temperature \(T^*\). When \(T \approx T_o\), then a correction for overall noise figure is made. Editor.
fig. 2. Block diagram of the twice-power method of manual noise-figure measurement. This method forces $N_2 = 2N_1$, by adjustment of the source excess noise ratio (ENR).

tector in the circuit has no effect on the accuracy of the measurement.

an automated twice-power measurement system

Commercial automatic-noise-figure (ANF) meters use the y-factor method because they’re designed to work with a combination of sources, argon discharge, semiconductor or temperature-limited diode, necessary to cover a wide range of frequencies up to the GHz region. Frequencies of major interest to Amateurs are in the 10-600 MHz region. This allows the use of the temperature-limited diode as the only necessary source and greatly simplifies the measurement problem.

With reference to the block diagram of fig. 3 and the timing chart in fig. 4, note that the noise source is gated both in the filament circuit and in the plate circuit. The plate gate turns the source on or off, and the filament gate adjusts the ENR by pulse-width modulating the filament current. Because of its long thermal time constant, the filament is not used for noise source on-off gating.

The receiver under test can be any combination of amplifiers and/or mixers with an output frequency of 28 MHz and an output impedance of 50 ohms.

The ANF-meter input is through an electronically switched 50-ohm 3 dB attenuator. This pad is switched into the circuit when the source is on, and out of the circuit when it is off. A train of noise pulses from the attenuator is fed to the i-f amplifier, which amplifies the noise pulses to a usable level. The input level of this meter should be $7 \mu V (-90 \text{ dBm})$ or greater for proper operation.

The i-f strip output is detected with a half-wave hot carrier diode detector and fed through an amplifier to the two sample-and-hold (S&H) amplifiers. The S&H amplifiers are circuits that will follow the input voltage when in sample mode and hold the final voltage of the sample period in hold mode until updated with a new sample pulse. S&H 1 samples the last half of the attenuator out-source off period. Sampling is done in the last half of the period to allow attenuator and source switching transients to die out. S&H 2 samples the last half of the source on-attenuator in period. The outputs of these two S&H amplifiers are presented to the comparator. If the comparator decides S&H 1 output is higher than S&H 2, it turns on the source filament. If S&H 2 output is higher than S&H 1, it turns off the filament. This sample-and-compare cycle is repeated at a 170-Hz rate.

At this update rate, the filament thermal inertia will average the on and off pulses to give a filament temperature corresponding to exactly 3 dB ENR. The S&H 1 output is fed back to the agc input of the i-f strip to reduce the i-f gain for converters or amplifiers with very high gain or poor noise figure. This is a rather loose agc loop but, for this application, where the sample-and-hold amplifiers are compared only to see which one is higher, it’s only necessary to keep the i-f output within the common-mode range of the comparator and the linear range of the sample-and-hold amplifiers. The agc loop time constants and loop gain are somewhat critical because this is a sampled-data servo loop. Such loops, unless properly compensated, will tend to be unstable. Linearity of the system is unimportant, as the i-f amplifier, the detector and the S&H preamplifier are all working at the same level of noise when the system is in balance.

The source plate current is detected as a voltage across the 100-ohm resistor in the source plate supply return. As this current is being pulsed by the gating circuitry, S&H 3 is needed to sample during the source on period and hold during the source off period. S&H 3 output, which is proportional to the source plate current, is supplied to the log amplifier, which converts noise factor to noise figure and allows the meter to have a linear scale. The log amplifier output feeds a “perfect” rectifier, which ensures that only positive voltage reaches the meter. The summing junction of this op amp makes a handy place to supply a calibrated offset voltage to add or subtract a correction factor for the source ENR vs. frequency error and for loss pads.

manual noise figure measurement circuit

This meter can also be used for manual twice-power-method noise figure measurements when it is difficult to get a 28-MHz output from the receiver under test. In this mode the source is turned on all the time, and a comparator monitors a voltage corresponding to desired plate current (set by a front-panel pot) and the voltage across the meter. When the meter voltage is higher than the set-point voltage, the filament is turned off and vice-versa. When the source is adjusted to give exactly 3-dB ENR, the
noise figure can be read directly from the meter. The i-f loop is disabled during operation in manual mode.

**circuit details**

Fig. 5 shows the noise-figure meter schematic. The noise source can be either an HP-343A or the homebrew 5722 source described by W6NBI. I prefer the 5722 source because the price for the tube is $9.00 compared to the $90.00 that HP charges for their noise diode. The homebrew source, if carefully constructed, should be as good as the HP source. The meter power supply is a fairly conventional ±15V regulated supply. The 10-µF bypass capacitors for U13 and U14 should be mounted immediately at the device terminals or oscillation is a likely result.

The source has a grounded plate, so the 200-volt plate supply has its positive end grounded through the gate transistor, Q1, and the current measuring 100-ohm resistor. Q1 and Q4 form a quasi-Darlington switch designed to minimize base current injection into the current-measuring circuit. The negative end of the plate supply is fed up the filament line to the source. Q2 gates the filament current, and the 6.2-volt zener diode ensures that the maximum filament voltage is 4.9 volts. Q2 is driven by opto-isolators, as it is floating 200 volts below ground.

The receiver noise output is applied to the electronically switched 3-dB pad at the input to the i-f strip. When the voltage at point D is +15 volts, CR5 is turned on and CR4 and CR6 are back biased. This removes the pad from the circuit. When point D is grounded, the pad is switched into the circuit by CR4 and CR6, while CR5 is back biased. This pad should be symmetrically constructed using minimum lead lengths. The ultimate accuracy provided by the ANF meter depends on the accuracy of this pad. One-quarter-watt carbon film resistors and small disc ceramic capacitors should be used for best results. The output of the pad is connected to the next stage through a highpass filter to reduce the effect of switching transients on the next stage. Q4 is a broadband amplifier designed for 50-ohm input and output.
fig. 5. Schematic of the automatic twice-power NF meter.
impedance and has 10 dB gain. A diplexer interstage network tuned to 28 MHz feeds another 11-dB broadband amplifier. The broadband negative feedback amplifiers are used to ensure unconditional stability and proper wideband termination for the pad.

U15, an MC 1590G, provides the bulk of the gain (60 dB) as well as a 60-dB agc range. Both input and output of this amplifier are tuned to 28 MHz; since it packs a lot of gain into a small package, shielding is necessary for stability. A hot-carrier diode coupled to the MC 1590 tank is the detector, and the 360-pF capacitor provides light filtering of the detected noise level. Averaging of the noise level is done by the memory capacitors in the sample-and-hold amplifiers. The detector output is coupled to U4A, which has a dc gain of 31 and provides some additional filtering.

N1 and N2 pulses are separated by the sample-and-hold amplifiers U5 and U6. Q3 buffers the output of U5. The 6.2 V zener diode and forward-biased silicon diode level-shift the agc for the MC 1590. The agc level starts at 6.8 volts and goes up with increasing signal level.

U7B compares N1 and N2 levels and decides whether or not to turn on the filament in the source. U7A is another comparator that decides if there is sufficient noise signal for an accurate measurement. If the N1 pulse level is too low, the front panel "low gain" LED is lit, and the cathode of the LED in U8 is elevated to +15 volts. This action disables the filament circuit, keeping the terminating resistor cool and saving the noise tube.

U1, U2, and U3 compose the timing circuit for generating the gate signals. U1, an NE555V, functions as an astable multivibrator at 340 Hz. U2, a flip flop, divides U1's output by 2 and by combining U2 and U1 outputs in U3, the nonoverlapping quadrature sampling pulses are synthesized. In the manual mode, U2's reset input is held high. This action enables the source continuously and U9, the meter circuit sample-and-hold amplifier, operates at a 340 Hz rate. In the automatic mode U9 samples during the last half of the source-on period and supplies a smoothed voltage proportional to plate current to the log amplifier, U12. The signal at the output of U12 corresponds to noise factor x 0.1, which the log amplifier converts to noise figure. This chip is quite expensive (about $35) and can be eliminated if the meter is recalibrated. The meter will now read noise factor and should have 3 mA and 30 mA full-scale positions. If you decide not to use the log amplifier, pull U12 and disable U10B by removing its external components. Connect points Y together and do not install the compensation pot, R1, or its switch.

U10B, a perfect rectifier, blocks negative voltages from pinning the meter down-scale. U12 output is negative for source plate currents of less than 1 mA and -15 V for zero plate current. U10A is the comparator for the manual mode. It decides if the source current, as represented by a voltage across the meter circuit, is higher or lower than the desired current, set by the front panel manual-current control. The 4.7 megohm resistor between the output of U10A and its noninverting input supplies a minor amount of hysteresis, and the 4.7 megohm resistor between the inverting input of U10A and +15 V swamps out any offset in U10A and ensures that the plate current of the source can be zeroed with the manual current control.
construction

The i-f strip is built into an enclosure made of double-sided PC board. All voltages are brought into the strip through feedthrough capacitors. Button ceramic capacitors are used for bypass purposes, and ceramic standoffs are used for unbypassed tie points. Even though the i-f strip operates at 28 MHz, the $F_T$ of Q4 and Q5 is 1.4 GHz, and the MC 1590 operates up to 300 MHz; therefore vhf construction techniques must be used to ensure stability. A shield should be mounted across pins 8 and 4 on the MC 1590 to isolate the input and the output of this stage.

The logic and analog circuits are all on the PC board. Sockets should be used for the integrated circuits as some must be pulled during calibration. All resistors are 1/4 watt 10 per cent tolerance, and all capacitors are disc ceramics unless otherwise noted. The power supply and switching transistors are mounted onto the chassis. Q2 should be bolted to the chassis for a heat sink. This transistor and the rest of the filament power circuit should be treated with caution, as it is at −200 volts.

Don’t use a 2-pin connector for the source and rely on the connector shell for a ground; otherwise you may get a 200-volt surprise when you plug in the source with the power on. Use a 3-pin plug with the ground routed through a pin. U13 and U14 should be heat-sinked, and attention should be paid to the wiring of these ICs. Even though they are complementary ICs, the pinouts are different. The meter has a 1-mA 1000-ohm movement and is calibrated for 0-3 and 0-15 dB noise figure by erasing the original scale with an electric eraser and recalibrating with transfer letters. The compensation pot is a 10-turn linear digital readout pot with 10 volts applied across it. Either +10 or −10 volts can be used to give −10 dB to +10 dB compensation. This adjustment is used to null out the excess ENR of the source with increasing frequency and to compensate for loss pads between the source and the receiver.

checkout and alignment

First unplug all the ICs and confirm that the power supply voltages are correct. If they are, plug in U1, U2 and U3 and see if you get quadrature pulses out of U3A and U3B. Connect a 28-MHz signal generator to the input jack and an oscilloscope to point C. Increase the signal generator output until you see a train of pulses at point C. Peak the U15 input and output circuits. Reduce the signal level to some convenient value and verify that the levels of the pulse train are 3 dB apart. This must be done with a calibrated attenuator of known accuracy. Connect an rf pad (10 dB for example) between the signal generator and the input of the ANF meter. This standardizes the signal-generator output impedance to 50 ohms. Unplug U2 and connect point D to +15 V. Connect a DC voltmeter (preferably a digital voltmeter) to the i-f output jack and note the reading on the voltmeter. Then connect point D to ground and plug a 3-dB pad between the 10-dB pad and the ANF meter. The volt-
meter level should remain the same. Disconnect the
ground on point D and plug in U2. Plug in U4 and U5,
and check to see if the pulse train is amplified by a
factor of about 30 in U4A. Increase the signal level
and see if the pulse train level at the i-f output jack
stabilizes. This verifies that the agc loop is operation-
al. Plug in U6 and U7. With the signal generator set
for 7 µV and the pads removed, adjust R4 until the
low gain LED just goes out. Turn the signal down and
the LED should come on. Plug in U12 and temporarily
solder a 10 k resistor between pins 2 and 7 of this IC.
Ground pin 5 of U9 (make sure U9 is out of the soc-
et), and adjust R3 for zero volts at U12 pin 7. Unsol-
der the 10 k resistor and unground U9 pin 5.

Connect an accurate source of 0.1 volt to U9 pin 5
(make sure U9 is still out of its socket) and adjust R2
for zero volts at pin 10 U12. Now turn up the source
to +10 volts and adjust R5 for exactly -2.0 volts at
pin 10 U12. Plug in U10, turn the compensation pot
to zero, and adjust the voltage source to +0.2 volts
at U9 pin 5. With the meter switch in the 3-dB posi-
tion, adjust R7 for full scale. Change the meter
switch to 15 dB, increase the source voltage to
+3.16 volts, and adjust R6 for full scale.

Disconnect the voltage source and plug in the re-
mainder of the ICs. Turn the AUTO STBY MAN switch
to manual and plug in the noise source. The manual
current control should vary the plate current (as ex-
pressed in NF) from zero up to 12 or 14 dB before sat-
urating. Flip the switch to automatic and verify that
the filament remains dark.

Connect the output of an amplifier to the input
d and apply power to the amplifier. The filament
should light and the low-gain LED should extinguish.
The meter should swing to saturation (12-14 dB).
Now connect the source to the amplifier. Assuming
the noise figure of the amplifier is in the range of the

instrument, the meter should now indicate its noise
figure.

operation

The reader is referred to the article by W6NBI on
automatic noise-figure measurements for back-
ground on proper use of ANF meters. A few com-
ments pertaining to this particular meter are in order.
Fifty-ohm output impedance of the receiver under
test is required for accurate operation of the input
pad in the meter. Amplifiers and converters seldom
have 50-ohm output impedance, so a 3-db or greater
pad should be inserted between the receiver under
test and the meter input. This pad won’t cure the
mismatch, but it will swamp out its effects on the
measurement.

The receiver under test must be stable, since the
meter is unable to tell the difference between noise
and oscillation. In the same vein, if you are in a high
rf-level area, the receiver should be well shielded. I
live within three miles of four TV stations, four com-
mercial fm stations, and a multitude of commercial
and Amateur repeaters and paging services; conse-
quently I find it difficult to get proper measurements
on unshielded converters or preamps.

An i-f output jack is mounted on the front panel for
connection to a scope to verify proper operation of
the comparison circuitry. Fig. 6 shows what the
scope picture should look like. The important thing is
that the N1 and N2 sample periods should be at the
same level. The large negative pulse at the beginning
of the source off period is caused by the source not
turning off immediately. This is because of the finite
discharge time of the bypass capacitors in the fila-
ment circuit of the source. A 5-way binding post
mounted on the front panel is used as a handy source

Chassis layout.
PC-board layout, foil side.

PC-board layout, component side.
of +15 volts to supply converters and amplifiers. When working with preamps with a sub-3-dB noise-figure, be aware that the input impedance for best noise figure is seldom 50 ohms. This presents a mismatch to the source and indicates an erroneous noise figure, which is usually too high. A 3-dB pad between the source and the receiver input will swamp most of the error. The 3-dB-pad effect can be nulled out by the compensation pot, so the meter will read noise figure directly. I use the technique in fig. 7 to measure converters or preamps. The first 3-dB pad terminates the source, and the 20-dB-gain amplifier after the preamp under test reduces the effect of mixer loss on noise figure to a negligible level. The mixer is a broadband, double-balanced mixer (ANZAC MD-108) packaged in a small box with BNC connectors for the ports. The 3-dB pad after the mixer terminates the switched pad in the meter. The signal generator supplies local-oscillator power at f ± 28 MHz. If the amplifier has a reasonable noise figure (≤4 dB), and the preamp has a reasonable gain (≤15 dB), then the compensation for a 2-meter preamplifier would be figured as follows: At 144 MHz, ENR error is +0.45 dB. A 3 dB pad is used so that compensation is 0.45 dB − 3 dB = −2.55 dB.

Set the compensation pot to −256 and read the system noise figure directly from the meter.

The method for determining preamplifier noise figure from system noise is:

\[
NF = 10 \log \left[ \frac{F_2 - 1}{G_1} \right] - \left( \frac{F_3 - 1}{G_2} \right) - \ldots
\]

\[
NF = \text{preamp noise figure (dB)}
\]

\[
F_s = \text{system noise factor}
\]

\[
G_1 = \text{preamp numerical gain}
\]

\[
G_2 = \text{second stage numerical gain}
\]

\[
F_2 = \text{second stage noise factor}
\]

\[
F_3 = \text{third stage noise factor}
\]

Note that this formula uses noise factors and numerical gains, not noise figures and decibel gains.

If the source terminating resistor temperature is other than 290 K (62 °F), a correction must be made for this error. 290 K (62 °F) is below room temperature, and the resistor is very close to a hot tube, so this correction is usually necessary. Unfortunately this is a non-constant error, so the compensation pot cannot be used. The best technique is to factor the other errors into the compensation pot correction and then use that figure to work up the temperature correction from fig. 8. The ENR correction for frequency for the HP 343A source and the W6NBI 5722-type source is given in fig. 9. This error should be nulled out as a + compensation with the compensation pot. Be aware that the source accuracy is the limiting factor for the measurement accuracy. I suggested that the hot-cold resistor noise figure measurement system be used to verify the excess-noise ratio output of the source at various frequencies. If this is done, this meter should be as accurate as the commercial models.

Noise figures, like antenna gains, are numbers that are often claimed but seldom measured. My involvement in this project has been well worth the effort, especially when I see the long faces (mine included) on the owners of "hot" preamps when the meter reads otherwise.

I'd like to acknowledge the assistance of W9XM and WA9ACI in reviewing this paper and for many spirited discussions on the philosophy of noise-figure measurement.

References

2. “Noise Figure Primer,” Hewlett Packard Application Note 57, January, 1965.

Bibliography

1. Fisk, James R., WIDTY, “Receiver Noise Figure, Sensitivity and Dynamic Range — What the numbers mean,” ham radio, October, 1976, page 8.
4. Operating and Service Manual, Model 3408 Automatic Noise Figure Meter, Hewlett-Packard Company, Palo Alto, California.
Amateur Radio equipment survey

Detailed reports from owners of several models of popular Amateur Radio gear were featured in various issues of *Ham Radio Horizons*. These reports were received with much favor by readers who were contemplating the purchase of equipment, either new or used.

This month we continue our owners’ equipment survey by selecting for review three radios that have enjoyed much popularity in the Amateur community. The radios have been in use long enough so that a fairly broad sample of opinion and experience can now be collected. They are the Icom 701, Drake TR-7, and Kenwood TS-520 series — all high-frequency transceivers.

The items in the owners’ report form have been chosen to extract the most information of use to the prospective buyer in making his choice. The results of the survey will show what owners really think about their equipment — what was best liked, what was disliked, what types of problems were encountered and how they were resolved, and in general what owners felt about performance, maintainability, and reliability.

Reading the results of the survey will surely help you decide how to spend your money for that new rig. You can profit from the experience of Amateurs who have learned by doing — putting the equipment to work under actual operating conditions. Such information can be much more meaningful than a laboratory report made from tests under controlled conditions.

The report sheets can be even more useful if comments are added, in addition to answers being checked off where called for. Feel free to let us know your opinions. The more information we can gather, the better we’ll be able to serve prospective buyers.

Next month we’ll be publishing the first part of our two-part rundown on Collins gear, in which we’ll present the data we’ve collected from users’ comments on the KWM-2 and KWM-2A transceivers. In the April issue, we’ll appraise the 32S-series transmitters and the 75S-series receivers. As in the past, the readers of *Ham Radio* have made some perceptive and revealing comments on the equipment they own and use. If Collins equipment interests you, be on the lookout for these two articles.
Owner's Report on Amateur Radio Equipment

(Please report only from your own experience. Type or print clearly.)

1. Make and Model (please circle the exact unit you are reporting on).
   - ICOM 701
   - Drake TR7
   - Kenwood 520
     - 520 S
     - 520 SE

2. What year did you buy it? __________ New? __________ Used? __________

3. Where did you buy it? Dealer__________ Mail Order__________ Individual__________ Flea Market__________
   - 800 Number__________ Other__________

4. Would you buy from the same source again? __________

5. Amount of use: Daily__________ Often__________ Occasional__________ Seldom__________

6. Is this your primary__________ or backup__________ rig?

7. What modes have you used? CW__________ SSB__________ RTTY__________ SSTV__________ AM__________ Other__________

8. What is the rig's best feature?

9. Worst feature?

10. Have you had any problems? __________ Explain __________

11. Have you had the rig serviced? __________ Where? Manufacturer__________ Dealer__________ Other__________

12. Was the service satisfactory? Yes__________ No__________

13. What accessories have you purchased for this rig?

14. Have you been able to obtain all the accessories and parts you need? __________

15. Have you been satisfied with these accessories? Yes__________ No__________

16. If not, why?

February 1981
17. Additional features you would like to see built into a rig of this type

18. Give the equipment a score from 1 to 10 (with 1 being poorest, 4 to 6 average, and 10 perfect).

   Ease of operation ____________________________
   Reliability ____________________________
   Durability (in continuous use) ____________________________
   Instruction Book ____________________________
   Factory/Dealer Service ____________________________
   Quality of Workmanship ____________________________

   Performance ____________________________
   Maintenance ____________________________
   Parts Availability ____________________________
   Accessories (ease of connection) ____________________________
   Price ____________________________
   Flexibility ____________________________

19. How long have you been licensed? ________ Your Age ________ License Class ________________
   Principal activities: Contest ________ DX ________ Rag Chewing ________
   Traffic Handling ________ Experimenter ________

20. What antenna do you use most? Beam ________ Wire ________ Vertical ________ Other ________

21. What rig would you like to see reported on in the future? ____________________________

22. Would you buy this same rig again? ____________________________

23. (Optional: fill in the following only if you wish.)

   Submitted by: Name ____________________________ Call ____________________________
   Address ____________________________
   City ____________________________ State ________ Zip ____________________________

   (Signature)

(Your signature authorizes *Ham Radio* to quote portions of your comments in our report.) May we use your name and/or call?

Yes ________ No ________

Note: If you own more than one of the rigs indicated, please use a separate form for a report on each rig.

Completed survey forms must be returned no later than March 31, 1981, to be included in our report.

Mail To: *Ham Radio* Owner's Report No. 4, Greenville, NH 03048

24 February 1981
80-meter receiver for the experimenter

Basic building blocks for those who like to build their own gear

This simple receiver covers the 80-meter band. Other bands can be received by adding converters. This article has been submitted with the idea of giving other experimenters some ideas about receiver construction. A simple low-frequency i-f filter is also included. It provides a bandwidth of about 1200 Hz — great for CW if the band isn’t too crowded. The nice thing about the filter is that it’s inexpensive: two crystals at $2.00 each plus a few other parts (also inexpensive).

description

My receiver was built on a 5 x 9 inch (12.7 x 23 cm) chassis with a panel measuring 9 x 5 inches (23 x 12.7 cm). I found room for a power supply and small speaker. The dial was Japanese. With a switch on the back of the chassis I can change to battery operation instead of the ac supply, thus making a nice portable receiver that will fit into a travel bag.

antenna input circuit

No rf stage was used in this receiver design because I anticipated that converters would be used for higher-frequency bands. An rf stage isn’t needed on 80 meters — this saves some space. The antenna is fed directly into an attenuator, which I found necessary to prevent receiver overload. The attenuator was made from a dual 10k-section pot (see fig.1).

The antenna coils are double tuned with separate 100-pF capacitors for simplicity rather than a split stator capacitor. This eliminates the tracking problem and hard-to-find parts.

The antenna coils are wound on red Amidon cores. I used T-80-2, 1 inch (25.4 mm) in diameter, because they were available. The 88-2 will also be correct — anything to resonate at 80 meters. It takes about forty-five turns of no. 26 (0.51-mm) wire using a 100-pF variable for tuning. I used a 50-pF and padded it for resonance at mid-capacitor position. Resonance can be checked using a grid-dip oscillator with a loop around its coil and one around the toroid.

mixer

A 40673 dual-gate MOSFET was used for the mixer. The resistor in gate 1 isn’t critical and can be anything from 6.8k to 100k; however, the lower values are better, as overloading is possible with higher values.

I lucked out for a coil in the drain circuit: a small, potted, ceramic toroid about 1 inch (25.4 mm) square. I found it in a bag of coils sold by Radio Shack. It’s not listed in their catalog, so it is worth looking for in the store. Otherwise, a J.W. Miller variable slug coil 4515, a 350 μH to 475 μH inductance

By Ed Marriner, W6XM, 528 Colima Street, La Jolla, California 92037
fig. 1. Schematic of the 80-meter receiver. Easy to build and easy to get working, it's a good project for those who like to experiment.
with a 220-pF capacitor should work. Another solution is to use half of an old 455 kHz i-f transformer.

**Crystal filter**

The filter was made with two crystals, one of 455 kHz and one of 453.5 kHz. This is great for CW with a bandwidth of about 1200 Hz. However, a little wider spacing could be in order for SSB. The reason for these particular crystals is they are inexpensive: $2.00 each from the source indicated. The J.W. Miller Company offers an input and output transformer (1725 and 1726) to match crystals for the filter. Note that the capacitors in the output of the 1725 transformer are inside the can. You don’t need to add them; just ground pin 1.

**I-f stage**

Two i-f stages were used, although it might be possible to get by with only one as the gain of this receiver is pretty high. I used two stages and reduced the gain with the i-f gain control.

**Product detector and audio**

Rather than using a passive detector with diodes I used a 40673, which has some gain, to drive the first audio stage: a 2N2222. The product detector needs about 1.5 volts RMS injection voltage. I’ve had pretty good luck with this audio circuit, which delivers about 2 watts into a big speaker. Other lower-powered chips are available, but I used this circuit, which is in most of the commercial sets in use at the moment.

**BFO**

A crystal-controlled BFO could be used, but I've had difficulty making crystals oscillate at this frequency so I used the variable BFO. It’s also very useful for zeroing in SSB signals and changing CW pitch. It’s very stable, with no pulling.

**VFO**

The VFO tunes 3955-4205 kHz to cover the 80-meter band. It will take a little playing around to get it right. It’s nice if you can borrow a counter or have a receiver that will cover this range. I used a National XR-50 5/8-inch (15.9 mm) diameter slug-tuned form for the coil. I had some silver wire that was nylon covered. It was no. 24 (0.511-mm) diameter. Using this wire, the VFO was very stable, but locating such wire is difficult. (This wire was found at a flea market; enameled wire is the next best choice.)

The variable capacitors available will determine your bandspread: capacitors of 0-50 or 0-100 pF will cover the range, or you can use a switch and two silver mica padding capacitors, which is what I did to cover the 80-meter band in two steps.

The capacitors I used from gate to ground and the coil coupling capacitor also have an effect on the tuning. The coupling capacitor has an effect on the oscillation and its value sometimes must be reduced. However, with the values shown, the VFO worked well and produced 1.5 volts rms — enough for mixer injection. While many circuits don’t show buffers, I’ve found that signals don’t pull the oscillator if a buffer is used. Thus, the set is more stable.

**Construction**

Because of the difficulty in obtaining parts these days, it’s impossible to specify an exact component (see table 1). I search the surplus ads, flea markets, and surplus stores. One of the best sources is the flea markets that radio clubs sponsor. There I’ve found all my parts.

This set was made from copper board and black drafting tape and dots, then etching. The board was mounted onto the chassis using spacers. I cut my panels with a hacksaw, with the aluminum held between two pieces of angle iron secured in a vice. After drilling, I dipped the panel in lye water. Or I let the panel set in Lime Away, a grocery store product, overnight.

Sometimes I spray the panel with black crackle paint and bake it in the oven at 175F for 15 minutes. The finished products look good. The boards can be dipped into a tinning solution to make them commercial-looking.

Holes for parts are drilled with a number 60 drill. There are a lot of little things you can do to make your homebrew projects look nice if you so desire. Many hams just want them to work, but I like to have them look nice, too.

<table>
<thead>
<tr>
<th>Table 1. Suggested sources for parts.</th>
</tr>
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<tbody>
<tr>
<td><strong>J.W. Miller Co.</strong></td>
</tr>
<tr>
<td>19070 Reyes Avenue</td>
</tr>
<tr>
<td>Compton, California 90221</td>
</tr>
<tr>
<td>Low Frequency Crystals ($2.00 each):</td>
</tr>
<tr>
<td>John L. Winton</td>
</tr>
<tr>
<td>8062 San Mateo Cr.</td>
</tr>
<tr>
<td>Buena Park, California 90621</td>
</tr>
<tr>
<td>Radio Shack Stores</td>
</tr>
<tr>
<td>Integrated Circuits Unlimited</td>
</tr>
<tr>
<td>7888 Clairemont Mesa Boulevard</td>
</tr>
<tr>
<td>San Diego, California 92111</td>
</tr>
<tr>
<td>Semiconductor Supermart</td>
</tr>
<tr>
<td>P. O. Box 3047</td>
</tr>
<tr>
<td>Scottsdale, Arizona 85257</td>
</tr>
</tbody>
</table>

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February 1981
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February 1981
solid-state power for 1296 MHz

Here's a Class C amplifier that delivers 2 watts of output power.

In the past few years quite a few construction articles describing preamplifiers, converters, filters, and test equipment for the 1296-MHz band have been published. However, there has been a conspicuous lack of articles about transmitters for this band. This is a serious omission, because, for reasonable communications range, a transmitter power of at least a watt or two is needed — far more than the milliwatts produced by most converters.

background

Most of the 1296-MHz transmitters described in the last decade have used surplus microwave tubes as the active components in the final stages. These planar triode tubes, commonly known as "lighthouse" tubes because of their distinctive shape, have been available on the surplus market for many years. And, although amplifiers built around this type of tube are capable of delivering tens or even hundreds of watts output, they suffer from at least two drawbacks that have limited their popularity.

First, the tubes are normally operated in a cavity or coaxial type of structure. Fabrication of these types of matching networks is not particularly difficult, but some machine shop work is generally required. Second, these tubes, usually of the type 2C39 family, are becoming somewhat scarce on the surplus market, as the original users of the tubes have largely switched to diode and transistor devices for medium-power amplification at the lower microwave frequencies.

At the present time, bipolar transistors are commercially available that are capable of at least 40 watts of continuous output at one GHz and 20 watts at 2 GHz, approximately the same power level to be expected from a single 2C39 tube.

Few Amateurs have built transistor power amplifiers for the 25-cm ham band, however. This is mainly because microwave transistors have a reputation for being expensive, tricky, and easily destroyed. But with recent improvements in technology, rf transistors have become not only better but also more rugged, while the cost per unit has dropped because of the tremendous increase in the volume of production. As a result, transistor amplifiers capable of producing several watts output power are now easily within the technical and financial reach of Amateurs.

This article describes a two-stage amplifier chain that will deliver over 2 watts output. The total gain of the two units together is at least 30 dB, which means that a few milliwatts of drive power from a low-level converter or exciter will produce full output. The amplifiers are sufficiently broadband to cover the entire 1250-1300 MHz range, so that once tuned up they need not be retuned for operating frequency changes.

Construction of these amplifiers is straightforward and only hand-tool work is required. They are built using a mixture of microstrip line and lumped component techniques on copper-clad boards. Each stage is built as a module with 50-ohm input and output to simplify testing and to increase flexibility.

The first stage produces at least 100 milliwatts of linear output power. The gain at this power level is approximately 17 dB. The next stage provides a minimum of 2 watts output. It is operated Class C and has a gain of 13-14 dB. When the two are cascaded together as shown in fig. 1, a 2-milliwatt drive signal will produce over 2 watts output. Alternatively, the first stage may be used alone as lower-power transmitter to produce up to 150 milliwatts of saturated power.

By Jerry Hinshaw, N6JH, 4558 Margery Drive, Fremont, California 94538
100-mW stage

The first stage of the chain is a linear, Class A amplifier. As such, it's designed using the small-signal, grounded-emitter, s-parameter information provided by the manufacturer.

The transistor used in this stage is a Hewlett-Packard 2N6679, also known as the HXTR 2101. There are several reasons for selecting this transistor in preference over another, even though at approximately $22 it isn't the most inexpensive device available. This microwave transistor is designed to produce moderately high linear output power and is therefore fully characterized for this type of operation. Second, it has a higher matched gain than most less-expensive transistors. This means that one less gain stage is needed to amplify a signal up to the 100 mW level required to drive the output stage. This reduction in system complexity more than offsets the higher initial cost of this one stage.

The design of this amplifier follows the approach described in detail by Shuch. Each input and output matching networks consists of a series quarter-wave transmission line transformer that matches the real part of the transistor input or output impedance. Shunt capacitance is used to compensate for the reactive portion of the output impedance. The input impedance of this transistor is by coincidence nearly a pure resistance at this frequency, so that satisfactory matching is achieved without a shunt capacitor at the transistor base. A schematic diagram of this amplifier is shown in fig. 2.

The design is accomplished using s-parameter data for 1275 MHz, data which were obtained by interpolating the 1.0- and 1.5-GHZ data provided by the manufacturer. Although such a design is, strictly speaking, valid for only this one frequency, in practice the s-parameters do not vary rapidly for small changes in frequency, so the usable range is a band several per cent wide centered at 1275 MHz.

The input impedance of this transistor at 1275 MHz is found to be approximately 5.3 ohms. As it is very nearly a pure resistance, it can be matched with only a quarter wavelength transformer whose characteristic impedance is 17 ohms. This 17-ohm transformer is realized on 1/32 inch (0.8 mm) glass-epoxy board by a microstrip line approximately 0.225 inch (5.7 mm) wide and 1.14 inches (29.0 mm) long.

At the transistor collector the impedance is approximately 50.6 ohms in series with 110.9 ohms of capacitive reactance. The real part of this impedance presents a good match to the 50-ohm load as it is, without further matching. The reactive part of the impedance is tuned with a capacitor located a quarter wavelength from the transistor. This capacitor must have a reactance of 22.5 ohms, corresponding to 5.7 picofarads at 1275 MHz. The quarter wavelength line itself is 0.056 inch (1.4 mm) wide and 1.15 inches (29.2 mm) long on this 1/32-inch (0.8-mm) printed circuit board material.

Dc power is provided by the constant-current bias network shown in the schematic. In an earlier version of this amplifier a simpler, passive bias scheme was used, but it proved to be a false economy because bias instabilities destroyed the HXTR 2101 transistor. The present circuit automatically compensates for the current gain variations from one transistor to another and for variations that result from temperature changes. Thus it provides for stable, Class A operation. Collector current is held at 25 milliamperes while the collector-to-emitter voltage (Vce) of the rf transistor is stabilized at approximately 15 volts.

construction

The amplifier is built on a piece of double-clad Fiberglass epoxy PC board material 1/32 inch (0.8 mm) thick. One side of the board is left fully clad with copper to serve as a ground plane for the microstrip
lines. The other side is etched to form the matching and bias circuit mounting areas. A full-scale illustration of this side of the board is shown in fig. 3.

Feedthrough eyelets are mounted in the board at the positions marked on fig. 4 with an X. These eyelets are used to help ensure that the two emitter leads of the transistor are connected to ground by low impedance paths and at the ground ends of the taping and bypass capacitors. Solder the eyelets to the copper ground plane on the bottom of the board.

Where component leads will protrude through the board, the ground plane must be cleared away to
prevent shorts. This can be done with a small drill. Clear away enough copper from around the hole to ensure that the component doesn’t touch anything but Fiberglass.

Once the fabrication of the board is done, the components are installed as shown in fig. 4. The 2N6679 and the chip capacitors are mounted on the top of the board, while the bias circuit components are installed on the ground-plane side. Be careful when soldering the transistor that solder does not flow underneath the package and short out any of the leads. The transistor package is very small, and the leads come quite close together on the bottom side, so that it’s easy for even a tiny amount of solder to wick along one lead and short to another. Also, note that the variable capacitor in the output circuit must be mounted right at the output end of the quarter-wave line for maximum performance.

The two emitter leads on the 2N6679 are bent at right angles to the transistor package so that they will fit through the two eyelets to the ground plane side of the board to be soldered. It’s important that the emitter leads be connected to the ground plane by low impedance paths if the amplifier is to perform properly. To get a low impedance path, the transistor package should be mounted flush with the PC board so that the emitter leads are as close as possible to the feedthrough eyelets.

The input and output connections are made with small-diameter 50-ohm coaxial cable such as RG-179 or similar. The coax-cable shield is twisted into a pigtail and run through the hole in the PC board near the end of the microstrip matching lines. Then the shield is soldered to the ground plane of the circuit board. On the etched side of the board, the center conductor is soldered to the end of the microstrip transformer. The distance between the end of the coaxial shield and the center conductor soldered connection should be as short as reasonably possible. A length of 0.2 inch (5.1 mm) works well. A jumper wire is run between the two points marked with an A in fig. 4.

The completed board is installed in a small sheet-metal chassis box by means of four standoffs. The two coaxial cables are run to connectors mounted in the box wall and a feedthrough capacitor is used to bring in dc power for the amplifier.

tuning

Connect the amplifier to a 28-volt power supply and check to see that the supply current is approximately 30 milliamperes. As a further check of the bias, measure the voltage at the 2N6679 collector. It should be about 15 volts above ground.

If you’re hesitant about trying out an untested bias circuit with your somewhat expensive rf transistor, you can first test the circuit by soldering a small-signal NPN transistor in place of the 2N6679. The amplifier won’t work at 1250 MHz, of course, but the small-signal transistor will duplicate the dc operation of the rf transistor. If the bias circuit properly regulates the collector voltage and current of this “fuse,” then it is safe to go ahead and install the 2N6679.

Tuning the amplifier requires a signal source of about 1 milliwatt and a power meter or signal detector of some sort. Apply dc power and the rf drive signal, then tune the output matching capacitor until maximum output is seen. If the amplifier is tuned up at 1275 MHz, it will cover the range 1250-1300 MHz with less than a dB of gain “droop” at the band edges. Once the output capacitor is peaked, no other adjustments are necessary.

2-watt stage

The final stage of this chain is a Class C common-base amplifier capable of 2.5 watts output power. The transistor used in this stage is the Motorola MRF2001, the lowest-power member of a family of 2-GHz, common-base power transistors. The 2000 series transistors have been available from several manufacturers for a number of years and have come to be an unofficial standard type of microwave transistor. They have been used in many military and industrial designs, but their high cost has kept them out of the range of most Amateur experimentation. However, in late 1978, Motorola announced a low-cost version of this 2000 series designed to penetrate the commercial marketplace.

These transistors are rated for 2-GHz operation, and this means that their performance in the 1250-1300 MHz range can be fairly impressive. It’s generally difficult to achieve high gain and high power output simultaneously, but when the device is operated well below its design frequency these two goals can be more easily met. Thus, the MRF2001, rated at 1 watt minimum output with 9 dB gain at 2 GHz, when operated at 1.3 GHz, easily produces 2 watts with an associated gain of 13-14 dB. The cost of these transistors is about $19 each.

design

Since this stage is to be operated as a large-signal, Class C amplifier, the s-parameter design approach used to design linear Class A amplifiers is not appropriate. Instead, matching networks must be designed to present to the transistor the impedances that produce the best input match while simultaneously giving the highest output power.

This approach is different in several ways from that used for small-signal linear amplifiers. In the case of a low-level amplifier, the matching networks are...
chosen to maximize gain, and perhaps to minimize the input and output VSWR. By contrast, in a large-
signal amplifier, only the input circuit is designed to
provide a low VSWR to maximize the driver power
transferred into the amplifier. This part of the design
is not wholly unlike that of the small-signal amplifier.

At the output of the Class-C stage, however, the
intent is to provide that matching network which
maximizes the output power. This requirement usu-
ally means that output VSWR and overall power gain
are compromised somewhat in the interest of in-
creasing output power and efficiency. A detailed dis-
cussion of this design approach and of the tradeoffs
involved is provided by Pitzalis.6

To permit such a design the manufacturer pub-
lishes typical impedance data for their rf power tran-
sistors. The input impedance they specify gives a
good match and hence a good power transfer into
the transistor. The output impedance they list is that
into which the transistor delivers maximum power at
a given drive level.

As with the 100-milliwatt stage, the fractional
bandwidth required for the amplifier to cover this
ham band is small enough so that the design can be
at a single frequency. This approach is much simpler
than would be a broadband optimization.

The data sheet for the MRF2001 lists the eq-
ivalent series input impedance at 1250 MHz as

\[ Z_{\text{in}} = 7.6 + j10.3 \text{ ohms} \]

The best input match will be obtained with a network
that presents the complex conjugate of this impe-
dance to the transistor. Thus, we want to design a
network that will transform the real 50-ohm input
feedline impedance to

\[ Z_{\text{in}}^* = 7.6 - j10.3 \text{ ohms} \]

where the asterisk indicates the complex conjugate.

This series input impedance is equivalent to the parallel
impedance

\[ Z_{\text{in}}^* = 21.6 \frac{\text{ohms}}{1 + j15.9 \text{ ohms}} \]

a resistance of 21.6 ohms in parallel with a capacitive
reactance of 15.9 ohms.

At 1250 MHz, a capacitor with this reactance has the value of

\[ C = \frac{1}{2\pi f X_c} = 8.0 \text{ pF} \]

If this capacitor is shunted to ground very close to
the transistor emitter, the result will be a driving
impedance at the emitter of 21.6 ohms, a pure resis-
tance without a reactive component.

To transform this pure resistance to the 50-ohm in-
put impedance, we can use a quarter-wave micro-
strip transformer whose characteristic impedance is

\[ Z_{\text{input line}} = \sqrt{(50)(21.6)} = 33 \text{ ohms} \]

This input circuit is shown in the schematic, fig. 5.

The required output series impedance is given by the
data sheet as

\[ Z_{\text{out}} = 9.6 + j23.1 \text{ ohms} \]

The real part of this series equivalent impedance can
be matched with a quarter-wave transformer whose
characteristic impedance, as before, is given by

\[ Z_{\text{output line}} = \sqrt{(9.6)(50)} = 22 \text{ ohms} \]

The imaginary term can be dealt with by either a
series inductive reactance at the transistor collector
or by a shunt capacitive reactance at the transformer
output. Since it is easier to obtain good, high-Q, vari-
able capacitors than inductors at high frequency, it's
better to choose the latter. The reactance required is
equal to

\[ X_c = \frac{Z_{\text{in}}^2}{X_c} = \frac{(22)^2}{23.1} = 20.8 \text{ ohms} \]

This corresponds to a capacitor of

\[ C = 6.1 \text{ pF} \]

A 1-8 pF trimmer capacitor will provide some adjust-
ment range. The completed output circuit is shown
in fig. 5.

The matching circuits are built on 1/32-inch (0.8-
mm) Fiberglass epoxy board material of the type
known as G-10. The 33-ohm input line is 0.110 inch
(2.8 mm) wide and 1.14 inches (29.0 mm) long. Since
the transistor emitter tab is wider than this matching
line, and since a shunt capacitor from the emitter to
ground is needed, a portion of the required capaci-
tance is distributed in a short open-ended stub. This
stub provides about 2.7 pF of the required 8 pF and it
is wide enough so that the emitter lead can be sol-
dered over its entire width.

The 22-ohm output transformer is realized with a
line 0.190 inch (4.8 mm) wide and 1.11 inches (28.2
mm) long. The output must have a dc blocking ca-
pacitor; this should be a microwave chip-type capac-
itor. A chip capacitor with a 50-mil (1.3-mm) package
width will fit the 0.056-inch (1.4-mm) 50-ohm output
line with minimum discontinuities. The variable tun-
ing capacitor must be mounted right at the end of the
22-ohm transformer.

Bias voltages are applied to the transistor through
two high-impedance quarter-wave lines bypassed to
ground at the end away from the matching net-
works. Since the input is grounded, no dc blocking
 capacitor is required. At the output, the supply end
of the bias line is bypassed to ground with a chip ca-
Capacitor in parallel with a higher capacitance ceramic capacitor. The chip capacitor provides effective decoupling at microwave frequencies, while the larger capacitor maintains a low-impedance path to ground down to low frequency.

**construction**

The construction of this 2-watt stage is complicated somewhat by the fact that both thermal and rf factors must be considered. Good rf circuit techniques are needed so that the potential performance of the amplifier can be achieved, while at the same time the transistor must have a good path for heat transfer, or the heat generated might destroy the transistor or shorten its life. For this reason, the transistor package is designed so it can be mounted to a heat sink. If this is properly done, the transistor junction temperature can be kept low enough so that no damage or degradation will occur.

**thermal considerations**

Heat is a major enemy of power transistors. The temperature of the transistor die or chip inside the package is the critical factor. For a silicon transistor, the maximum allowable junction temperature is usually specified as 392 F (200 C). However, it is very desirable to operate it at a lower temperature than this, since, as a rule of thumb, the transistor lifetime doubles for every 18 F temperature reduction. If the junction temperature is kept below 302 F (150 C), the average time to failure for a gold-metalized transistor, such as the MRF2001, is measured in decades. Since in Amateur applications a transmitter is used only intermittently, a transistor transmitter operated below this temperature should easily outlive its creator.

The data sheet for the MRF2001 states that the thermal resistance, measured from the transistor junction to the mounting flange of the package, is 45 F per watt of dissipation. If the amplifier has an efficiency* of 50 per cent, then, when it is producing 2.5 watts of rf output, it will also be generating 2.5 watts of heat. This waste heat must be carried away from the die. In this instance the transistor junction will be approximately 2.5 x 45 F = 112.5 F hotter than the case of the package. If the case itself is held at a temperature of 122 F (50 C), for example, the junction temperature will be a fully acceptable 243.5 F (117.5 C).

To keep the transistor's case below this target temperature of 122 F (50 C), it must be coupled to a cool heat sink with a connection of low thermal resistance. At this power level, if the transistor flange is bolted to a small finned aluminum heat sink the transistor case temperature will remain well below 122 F (50 C) when the heat sink is located in a normal room temperature environment.

**assembly**

Because of the flange mounting transistor, the matching circuit is mounted on two separate circuit boards, one for the input and one for the output. The board material is 1/32 inch (0.8 mm) thick G-10 Fiberglass epoxy double clad with copper. Full-scale illustrations of the boards are shown together in fig. 6. The other side of the board is left unetched to serve as a groundplane for the microstrip lines. After etching, the boards are separated along the marked edges. Components are mounted on the boards as indicated in fig. 7.

The transistor is bolted directly to a small aluminum heatsink, which is approximately 1.2 by 4 inches (3 by 10 cm) in size. The heat sink is located on the outside of the chassis box with the transistor mounted on it and projecting through the wall of the box in a hole cut with a 1-inch (2.5-cm) chassis punch.

The boards for the input and output circuits are inside the chassis box and are attached to the heat sink with machine screws that run through the box wall. The distance from the bottom of the transistor case up to the bottom of its stripline leads is 0.12 inch (3.0 mm). This distance is taken up by the box wall, which is about 0.05 inch (1.2 mm) thick, by the circuit board thickness of 0.031 inch (0.8 mm), and by a spacer, which is a small piece of the same type of circuit board. Thus the total height is about 0.11 inch (2.8 mm), so that the circuit board traces fit snugly.

---

*Efficiency of rf power semiconductors has been defined in many ways. Here it is taken to be the ratio of the rf output power to the dc collector input power x 100 per cent.
beneath the transistor leads, ready for soldering. A cross-sectional view of this construction method is shown in fig. 8. Device outlines are shown in fig. 9.

**tuning**

One of the more challenging problems facing anyone who tries to tune Amateur microwave equipment is to devise test and tune-up procedures that are effective but don't require the use of elaborate test gear, not available to most hams. For instance, if you have access to a microwave rf sweeping signal generator, a spectrum analyzer and a calibrated power meter, you'll not have any difficulty in tuning this amplifier chain for peak performance. Unfortunately, few of the ham shacks I've visited have been quite so well equipped.

When I first tuned up these two units, I made use of a spectrum analyzer and power meter to tune and
to verify that each stage was operating correctly and had clean, spurious-free outputs. Then I detuned them and retuned each at a single frequency using only the power meter, to show maximum signal.

This simplified method worked surprisingly well. Each amplifier had a single peak in output power, a fact that makes tuning with no spectral display easy and not misleading. When the amplifiers are peaked in this way, their bandwidths are wide enough to cover the band and nearly as flat in amplitude response as when they had been tuned with a swept signal source.

To tune up the 2-watt stage using the “no-equipment” approach, you need a signal source that will give a 100-milliwatt output at 1275 MHz, or else at the operating frequency if you prefer to optimize performance there. The first stage driven with a 2-milliwatt signal will serve as a driver, of course. To indicate power, a receiver with a signal-level meter, an rf power meter, an rf millivoltmeter, or a crystal detector may be used.

The output from the final stage should not be fed directly into most types of signal indicators, though, because the power level expected would probably damage them. The signal must be reduced to a level that the power meter can safely handle.

One way to do this is to use a directional coupler as shown in fig. 10. The amplifier signal is sent through the directional coupler, and a low-level sample of the signal appears at the coupled port.

Alternatively, the output signal can be attenuated with a resistive network as in fig. 11. A suitable attenuator pad can be built to do this. It is a pi-section attenuator with a loss of 20 dB, so that the output of the Class C final stage is reduced in passing through it to a level of about 20 milliwatts. If this is still too much power for your detector, two attenuators can be placed in series.

The attenuator pad can be built using 1/2-watt, 5 per cent carbon composition resistors by following the schematic shown in fig. 12. The 1/2-watt resistors are used because, although 2-watt-rated resistors would be better able to stand the heat generated by the amplifier output, their physical size leads to excessive reactance at high frequency.

I realize that any microwave engineer would cringe
at the thought of using such a pi-attenuator at 1300 MHz. However, even though this attenuator is a bit crude, if it's built on a small piece of copper-clad board with the shortest possible lead lengths, it can give an acceptably low VSWR.

This attenuator won't stand 2 watts of rf input for long, so tune rapidly and give the resistors a chance to cool down often. Remember that once heated above a certain point, the resistors will not return to the same resistance they had when new. This will change network attenuation and could lead to errors in tuning.

Once you have the setup together, the hardest part of the task of tuning is done. All that remains is to apply the drive signal and peak the two variable capacitors for maximum power output. It's best to go back and forth between the two capacitors a few times; their adjustments do interact a bit.

Fig. 13 shows the final result of this method of tuning. It shows the output of the cascaded system when the input signal is held at a constant 2 milliwatts and swept in frequency from 1250 to 1300 MHz. The output is greater than 2 watts across the band and is nearly 3 watts at the center point. The final amplifier stage draws about 165 milliamps at 28 volts when producing 2.3 watts output. This indicates that it's operating at approximately 50 per cent efficiency. No attempt was made to tune for better efficiency, although this can often be done.

conclusions

The amplifiers described here are stable, fairly inexpensive, and simple to reproduce. Second stage output power is sufficient to provide solid horizon coverage for voice communication when used with only a moderate gain antenna. The flexibility of the modular construction means the amplifiers can be adapted to a range of uses.

The final stage was biased as a Class C amplifier for use in an fm system. In SSB or ATV service, however, a more linear amplifier is needed. It is likely, as the manufacturer suggests, that the transistor could be operated in Class B, although I have not tried this.
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- Sensitivity: Less than 10 nV to 150 MHz
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- Resolution: 0.1 Hz (10 MHz range)
- 1.0 Hz (60 MHz range)
- 10.0 Hz (600 MHz range)
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February 1981

More Details? CHECK - OFF Page 98
Diana to EME in 20 years

Sharp-eared newcomers to the Amateur bands may occasionally hear operators talking about EME schedules. A recent issue of *QST* magazine listed the scores earned by stations engaging in an EME contest. How did it all get started?

For years man has dreamed of reaching the moon. Jules Verne wrote about it. In 1930, a well-known inventor and science writer told how it would be possible to use the moon as a reflector to bounce very short radio waves around the earth (fig. 1). But nobody had attempted the task; it was an idle dream. No one was even sure that radio waves would penetrate the ionosphere and reach the moon. Perhaps one day this fanciful idea would take root.

While others dreamed, John DeWitt, Jr., W4ERI, decided to act. A Radio Amateur and avid astronomer, John had combined his hobbies while still in high school, and while a young student in Nashville, Tennessee, he had constructed vhf receiving equipment sensitive enough so that he could hear radio noise from the Milky Way — noise which Karl Jansky had discovered a few years earlier.

Finally, in 1940, young DeWitt assembled an 80-watt transmitter, a high-gain antenna, and a sensitive receiver and attempted to send a signal from his transmitter to the moon and back. The experiment was a failure and John set about to determine the cause of his problems. He finally understood that more power, bigger and better antennas and a more sensitive receiver were the keys to success.

The onset of World War II brought all of W4ERI’s plans to a stop. Amateur Radio was closed down for the duration. But, as John assumed military service, the idea remained planted in the back of his memory. By then a recognized authority in broadcasting, John rose rapidly in the expanding field of military communications, and by 1944 had risen to the rank of lieutenant colonel and was in charge of the Army’s Evans Signal Laboratory at Belmar, New Jersey.

The highly classified work of the laboratory drew to a close in August, 1945, with the abrupt end of the war. DeWitt’s important jobs quickly evaporated, but he did not have sufficient discharge points to return to civilian life. He fretted under the boredom and inaction.
While John bided his time, the Pentagon had a vital question at hand, brought about by the V-2 rocket attacks on London during the war. Was there a way an enemy could direct a rocket attack on the United States using radio-controlled work and that reflected signals could be detected from the moon — but nobody was sure it could be done.

No matter. DeWitt forged ahead, and by January, 1946, he was ready for on-the-air tests. Preliminary tests in December had been inconclusive but he felt that his team was on the verge of success.

The elaborate 432-MHz moonbounce antenna array of ZE5JJ in Rhodesia boasts 128 elements and can track the moon automatically. Peter has since constructed a parabolic reflector using aluminum angle stock and wire screening. It has been very successful.

On the morning of January 10, 1946, DeWitt and his staff fired up the “moonbounce” transmitter. The cumbersome antenna was aimed at the moon, and one-second pulses were sent out every four seconds. Finally, after an agonizing wait, they heard the first echo return on a loudspeaker and saw the returned signal on an oscilloscope connected to the receiver. For the first time, man had touched the moon with an electronic signal and the moon had answered back.

Project Diana was a success and fired the imagination of the public in a manner which may seem surprising in today’s more technically sophisticated atmosphere. Soon the U.S. Navy had a microwave moonbounce link from Annapolis to Pearl Harbor and, very shortly, Amateur moonbounce (EME) circuits would come into being.

amateur moonbounce experiments

It was not until July, 1960, that the first two-way Amateur moon-bounce contact was recorded.1 It happened on the 1296-MHz Amateur band between W6HB (The Eimac Radio Club) and W1BU (The Rhodedendron Swamp VHF Society). Hank Brown, W6HB, and Sam Harris, W1BU, and their crews worked for weeks getting the equipment ready to go, and finally made contact. Moonbounce communications, using Amateur power levels, was proven possible and it

![Fig. 2. The Earth-Moon-Earth radio circuit. This illustration shows the great obstacles which would seem to make detection of moon-reflected signals highly improbable. The path to the moon and back is about half a million miles and the moon reflects only about 7 per cent of the radio energy striking it. The reflected energy is diffused all over the heavens and only a small portion of the energy which left the radio transmitter is reflected back to earth. Finally, the largest vhf receiving antenna is only a fraction of the earth’s pickup area facing the moon. In spite of these staggering difficulties, the earth-moon-earth radio circuit can be made to work with equipment well within the capabilities of many vhf-minded radio Amateurs (drawing courtesy of Radio Publications, Inc.).](image-url)
now remained only to see if other enterprising Amateurs would follow the lead established by these two radio clubs.

Interest grew slowly (possibly because the experiments had been done in a little-used and relatively unknown ham band), and it was not until 1964 that Amateur interest in EME communications was awakened with a jolt when Bill Conkel, W6DNG, ran 2-meter schedules via the moon with Lenna Suomienen, OH1NL, of Finland. Here was real moonbounce with everyday Amateur vhf equipment.

Since those early years, EME interest has grown until today hundreds of Radio Amateurs maintain schedules and experimental contacts via the moon on 144, 220, and 432-MHz. At last, EME has come of age.

the EME path

What kind of equipment and antennas does it take to establish a moonbounce station? Who can be worked? Does all the work have to be done at night?

The moon is about 2160 miles in diameter and orbits the earth at a distance that varies from 221,463 to 252,710 miles. An orbit takes about twenty-eight days and is somewhat eccentric, so that the moon travels across a different segment of sky each night of the lunar month. And, although the moon looks quite large when it is full, it subtends an arc of only about 0.5 degree when seen from the earth (fig. 2). Even the highest gain Amateur vhf antenna has a beam width much greater than this, consequently only a small portion of the signal aimed at the moon actually strikes it; the rest passes out into limitless space. Furthermore, an estimated 93 per cent of the signal that does strike the moon is absorbed. Also, as our astronauts verified, the moon surface is exceedingly rough; thus the 7 per cent of the reflected energy is diffused all over space.

Viewed from the moon, the earth subtends an arc of about 2 degrees, and the vhf signal that returns to earth is spread over half the earth's surface, or an area of about 98,470,000 square miles. Clearly, only a small fraction of the transmitted energy ever reaches the eager ears of the moonbounce listener.

The various factors point to the use of the 144 MHz and 430 MHz Amateur bands for EME operation: good equipment is available, antenna size is not too great, and there's enough international activity on these bands to make the investment in time and effort worthwhile. On 2 meters, the

<table>
<thead>
<tr>
<th>EME path loss</th>
<th>distance (km)</th>
<th>50 MHz (dB)</th>
<th>144 MHz (dB)</th>
<th>432 MHz (dB)</th>
<th>1296 MHz (dB)</th>
<th>2400 MHz (dB)</th>
</tr>
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<tbody>
<tr>
<td>Perigee</td>
<td>221,463</td>
<td>177.89</td>
<td>187.06</td>
<td>196.62</td>
<td>206.17</td>
<td>211.43</td>
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<td></td>
<td>(356,334)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apogee</td>
<td>252,710</td>
<td>179.03</td>
<td>186.21</td>
<td>197.76</td>
<td>207.21</td>
<td>212.56</td>
</tr>
<tr>
<td></td>
<td>(406,610)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

fig. 3. Free-space path loss for earth-moon-earth circuit at perigee (221,463 miles) and apogee (252,710 miles). The nominal 1.14 decibel difference in signal loss between moon perigee and apogee becomes 2.28 decibels for the round trip to the moon and back.

the EME path loss

Because radio signals travelling through space are attenuated at the square of the ratio of the frequency, the path loss to the moon and back is 8.3 times (9 dB) greater on 144 MHz than on 50 MHz. A similar increase in loss occurs between 144 MHz and the 420-MHz band, and between the 420 and the 1250-MHz band (fig. 3). In addition, transmitter efficiency and receiver noise-figure both tend to become worse with increasing frequency. Thus, there are compelling reasons to use as low an operating frequency as possible for EME work.

On the other hand, the power gain of a beam antenna of a given size increases by the same ratio that the path loss increases and, because the antenna gain is realized in both transmission and reception, there is a net circuit signal gain with increase in frequency, even after deducting the increased circuit losses.

The various factors point to the use of the 144 MHz and 430 MHz Amateur bands for EME operation: good equipment is available, antenna size is not too great, and there's enough international activity on these bands to make the investment in time and effort worthwhile. On 2 meters, the
portion of the band between 144.00 and 144.10 MHz is an international segment, and it is in this region that a great deal of serious moonbounce activity takes place.

**how much power?**
**how big an antenna?**

Fig. 4 provides a guideline to successful moonbounce communications. The scale at the right-hand side of the nomograph labeled Total Antenna Gain shows, for example, that if two stations having a combined antenna gain of about 43 dB and are satisfied with an average signal-to-noise ratio of zero dB, they can achieve two-way communications.

This graph is based upon a transmitter power output of 590 watts, a zero-dB noise figure, and a receiver bandwidth of 100 Hz. I’m sure that no moonbounce station fits these esoteric requirements, but hundreds of them come close, and some may surpass these figures. This is how it is done in the real world.

The Total Antenna Gain scale tells us that if one EME station is equipped with a 26-dB-gain antenna, the station at the other end of the circuit will need only 17 dB antenna gain, all other things being equal. The greater the antenna gain at one end, the smaller the array needs to be at the other end. On 2 meters, there are many stations equipped with high-gain antennas for meteor scatter and other forms of long-distance communication. Long Yagi beam antennas are available from several manufacturers, and many will provide a power gain of 17 dB. Two of them properly arranged can provide about 20 dB power gain. Again, all else being equal, a station equipped with a 20-dB antenna array can theoretically contact another station which has an antenna array with a power gain of 23 dB. And, if contacts are made on a rising or setting moon, the stations can take advantage of ground reflection of the signals to pick up an additional few dB of signal strength.

Moonbounce for everyone. That is just about possible using the new antenna recently assembled by Cushcraft's Chief Engineer, David Olean, K1WHS. Dave’s antenna (below) makes it possible for him to contact stations with single Boomers and only modest power. Recently, he contacted Dave Redman, G41DR, who was using a single Cushcraft 32-19 Boomer and approximately 200 watts at his antenna. Many other hams with single Yagis from Europe and the U.S. have had their first moonbounce contacts this year with K1WHS.

Dave Olean's new antenna consists of 24 Cushcraft Jr. Boomers model 214B. These Boomers are only 15 feet (4.6 m) long. The total antenna gain is about 26 dBi including feedline losses. This is more than sufficient to cover the 450,000 miles (725,000 km) round trip to and from the moon.
fig. 5. Moon position from center of U.S may be determined with this chart. The altitude of the moon above the horizon and its azimuth change minute by minute every day, but they repeat each lunar month. The “Nautical Almanac,” or similar manuals, predict the moon position far in advance. This graph is plotted for a position of 40° North, with the observer facing south. At time T the moon is due south of the observer. At T-1 (one hour before T), the moon is at point A. Given the date, the declination, and the local time that the moon appears due south, the azimuth and elevation may be found. Curves for other values of declination can be interpolated and drawn in between these three curves. (Reference: Lund, “How High the Moon”, QST July, 1965).

Today, stations using relatively modest antennas and everyday equipment are enjoying EME contacts on 2 meters. Many vhfers who have good antennas and high power are inadvertently bouncing their signals off the moon without even knowing it.

I recently spoke on the telephone with Dave Olean, K1WHS, who is a prominent 2-meter operator and well-known moon-bounce enthusiast. Dave has an elaborate antenna system, and tells me that he can aim his array at the moon and tune around 144.1 MHz during periods of high activity and hear Amateurs working each other. Their antennas are positioned so that the moon sweeps through the beam and their signals are reflected back to earth to the waiting ears of K1WHS. Dave guesses that there are probably over a thousand vhf stations in the United States who can work moonbounce but don’t know they have the capability.

I asked Dave what it took to become an EME experimenter. He told me that if a station had a good 2-meter transceiver (such as the TS-700 Kenwood, or equivalent) a low-noise preamplifier, and a good, high-gain Yagi on a 15-foot boom, he would hear moonbounce signals, provided he aimed the antenna at the moon. Hearing signals is the first step to working stations.

the nitty-gritty

The nice thing about moonbounce is that you can let the other fellow do most of the work. The more antenna gain and power the other fellow has, the less you need. And there are enough serious-minded EME experimenters on the air today that a beginner can get in the game and talk to the big guns without having to make a large expenditure of time, money, or effort.

Of course, for the serious experimenter, there's a lot more to it than just hearing signals. Most moon-bouncers have antennas that can track the moon — sometimes automatically. Computer-oriented Amateurs have complete tracking programs worked out showing the position of the moon a year in advance, and have antenna controls that permit automatic moon tracking. But you don’t need all of this to get started. Many Amateurs have fixed antennas placed in such a position that the moon will sweep through the beam during the time the moon is mutually visible to operators at both ends of the chosen path. A typical moon-position chart, such as shown in fig. 5 is useful in positioning the antenna.

Other factors enter the picture, as the moonbouncer soon discovers. Because the moon moves toward or away from the earth at speeds up to 980 miles per hour, Doppler shift changes the frequency of the moon-reflected signal. At 144 MHz, the Doppler shift can be as large as 427 Hz. When the moon is rising, the received frequency goes up; when the moon is setting the frequency goes down. Frequency shift is minimum when the moon is perpendicular to the observer.

what does the signal sound like?

It takes a radio signal slightly over 2 seconds to make the trip to the moon and back, so the return echos of your transmission can be easily received. The best way of testing an EME cir-
The portable moonbounce station of K6YNB/CL7 (now N6NB) puts Alaska on the map. Note that the 2-meter array (left) is composed of sixteen 3-element quads.

Moonbounce array for 2 meters at WA1FFO is composed of four Yagis, each having 12 elements. All of these big antennas make it easier for you to work moonbounce because the other station does most of the work!

The radio telescope at Stanford University in California is occasionally used for moonbounce experiments in Amateur bands. You can really hear this 200-foot-diameter giant when it is on the air! The whole antenna and control building rotates on a circular metal track. Dominating the skyline above Palo Alto, California, the dish can be seen for miles.

circuit, in fact, is to listen to the return echoes of your own transmitter. It is quite an eerie feeling to send CW signals and hear them bounce back at you a short time later. Voice signals returning from the moon have a hollow quality about them that is instantly recognizable to a moonbounce enthusiast.

 Plenty of stations are active today. A good guess is that there are over 350 moonbounce stations active, in all continents, on the 2-meter and 432-MHz bands. Many of them maintain schedules with each other, but on an active weekend plenty of moonbouncers call CQ to raise another moon-bounce enthusiast. During an EME contest, or other weekend of high vhf activity, there is actually QRM among the many moonbounce signals.

The second article in this series will carry more specific information about moonbounce equipment and activity for the 2-meter enthusiast. Suffice to say that if you have a high-gain Yagi antenna, a low-noise receiver, and sufficient know-how to aim your antenna to the moon, you could be hearing moonbounce signals before the next issue of this magazine reaches you.

If you want additional information about moonbounce, write to me and ask for the booklet "Almost Everything You Want To Know About Moonbounce." It is a reprint of important magazine articles on the subject. Send 30 cents in stamps to cover mailing to: William Orr, c/o EIMAC, 301 Industrial Way, San Carlos, California 94070.

references
1. The full story of John DeWitt is told in the May, 1946, issue of QST magazine, and also in the May, 1980, issue of IEEE Spectrum. The story of the first two-way Radio Amateur contact via the moon is told in the September, 1960, issue of QST.
2. Moonbounce contacts have been made on all Amateur bands between 50 and 2400 MHz. In addition, experimenters at Stanford University in California made moonbounce experiments in the 10-meter band using an array of log periodic antennas 1200 feet long and 75 feet wide.

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barefoot operation). The six monitors monitored are: 1) overdrive; 2)
improper control switch setting; 3) heat sink temp.; 4) SWR; 5) overvoltages/off-
current; 6) rf output balance. Two meters monitor collector current, voltage,
and forward/reverse power. And a highly efficient automatic line voltage correction
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enclosure.
Super Styling. Designed to match OMNI, the HERCULES has the same
height as OMNI, plus matching bias and matching colors. The front panel is
simplicity in itself with two push-button switches (power and mode) plus two
knobs (meter and bandswitch), and a "black-out" meter panel (when unit is
off, meters are unreadable). Amplifier size is 5½"h x 16½"w x 15½"d.
Model 444, HERCULES amplifier & power supply... $1575.

Experience SUPER RIG at your TEN-TEC dealer, or write for full details.
High-quality speakers make a big difference. Speaker is a Radio Shack Minimus 7 (40 watts peak). Included are mounting brackets that could be used for under-dash mounting. A typical enclosure is shown at left.

better audio for mobile operation

Some suggestions for improved operating in your car

The concepts described in an earlier ham radio article resulted in many letters to me. The same ideas in that article apply to mobile operation, only more so. When working mobile, you have outside road noise to contend with as well as ignition and other noises. Mobile rigs are now physically smaller; therefore the speakers are smaller, and so it goes. Regardless of speaker size, the audio systems in most of the mobile rigs are deficient.

When the audio gain control is turned up to overcome the various noises, the signal is distorted and most aren't loud enough, even if they aren't distorted. A few sets with small speakers in a small box have produced audio like you've never heard; so it is possible to get good audio from a small box.

loudspeakers

One approach to the mobile audio problem is to use a large speaker and mount it in the car headrest as shown. Lower volume levels are then needed, and this system works well. Use the largest speaker possible with a tweeter.

Another approach is to use a separate, low-level input, 12-volt audio amplifier connected to the top of the volume control as described in reference 1, with a built-in frequency equalizer to emphasize highs. You can also use an audio booster in conjunction with stereo fm cassette radios. The output of the ham rig can be connected in parallel with one channel or, preferably, switched with a dpdt switch. You then get the needed power gain and frequency-response control. Use high-quality, large speakers with mid and high-range tweeters. My booster has a control to fade in two speakers in the front of the car. These speakers can be mounted under the seat, in the door, or in the ceiling headliner. The main stereo speakers are at the car rear, but the headrest speakers are much closer to your ear. You now will have a wide range of combinations, which produce beautiful and understandable audio with no distortion and shaped to your ears' deficiencies by the equalizer.

A suggested hookup is shown in fig. 1. I also use stereo earphones, parallel connected when used with the ham set. The new Sennheiser Model 420 is ideal, as it has an open earpiece and therefore doesn't block out road noises. These units are lightweight and can be used for long periods of time. They can, of course, be used with the stereo fm radio.

tone control

A welcome addition to any rig is a tone control that emphasizes the highs rather than attenuating them. The average person's ears are being bombarded with

By Ken Glanzer, K7GCO, 202 South 124 Street, Seattle, Washington 96168
fig. 1. Basic setup for a near-ideal audio system in your car. Scheme features undistorted audio and plenty of volume for mobile operation.

high levels of noise; the loss of high-frequency response is occurring at an earlier age.

I frequently remove the capacitors between the base and collector in the final transistor audio stage, or any other component that cuts the highs. Or, I may alter the values of some components. Many

have said, “I can understand what they say on your radio.” Many Amateurs are not deaf from the standpoint of level, but are “tone deaf.” They can’t hear the high frequencies. Sometimes, a small tweeter can be installed near one ear with good results.

reference


ham radio
TR-7800

"Easy selection"... 15 memories/offset recall, scan, priority, DTMF (Touch-Tone®)

Frequency selection with the TR-7800 2-meter FM mobile transceiver is easier than ever. The rig incorporates new memory developments for repeater shift, priority, and scan, and includes a built-in autopatch Touch-Tone® encoder.

TR-7800 FEATURES:
- 15 multifunction memory channels, selected with a rotary switch. M1-M13 memorize frequency and offset (±600 kHz or simplex), M14... memorize transmit and receive frequencies independently for nonstandard offset. M0... priority channel, with simplex, ±600 kHz, or nonstandard offset.
- Internal backup for all memories, by installing four AA NiCd batteries (not Kenwood-supplied) in battery holder.
- Priority channel (memory "0") and priority alert.
- Covers 143.900-148.995 MHz, in 5-kHz or 10-kHz steps.
- Built-in autopatch DTMF (Touch-Tone®) encoder.
- Front-panel keyboard for selecting frequency, transmit offset, and autopatch encoder tones, programming memories, and controlling scan.
- Automatic scan of entire band (5-kHz or 10-kHz steps) and memories.
- Manual scan of band and memories, with UP/DOWN microphones (standard).
- Repeater REVERSE switch.
- Selectable power output: 25 W (HI)/5 W (LOW).
- LED S/RF bar meter.
- TONE switch to activate subaudible tone module (not Kenwood-supplied).

OPTIONAL ACCESSORIES:
- KPS-7 fixed-station power supply.

TR-8400

"Go synthesized on 440 MHz FM"... 5 memories, memory/band scan

The TR-8400 synthesized 70-cm UHF FM mobile transceiver covers 440-450 MHz in 25-kHz steps and includes five memories, automatic memory and band scan, UP/DOWN manual scan, and two VFOs.

TR-8400 FEATURES:
- Synthesized coverage of 440-450 MHz in 25-kHz steps.
- Five memories and memory backup terminal on rear panel.
- Two VFOs.
- Offset switch for ±5 MHz transmit offset and simplex operation. Fifth memory allows any other offset by memorizing receive and transmit frequencies independently.
- Automatic scan of memories and of 440-450 MHz band (in 25-kHz steps). Locks on busy channel and resumes when signal disappears. HOLD or mic PTT button cancels scan.
- Up/down manual band scan in 25-kHz steps with UP/DOWN microphones supplied with TR-8400.
- Only 5-3/4 inches wide, 2 inches high, and 7-5/8 inches deep. Weighs only 3.75 pounds.
- TONE switch to activate subaudible tone device (not Kenwood-supplied). DTMF (Touch-Tone®) terminal on rear panel.
- Four-digit frequency display and S/RF bar meter. Other LEDs indicate BUSY, ON AIR, and REPEATER operation.

OPTIONAL ACCESSORIES:
- KPS-7 fixed-station power supply.
- SP-40 compact mobile speaker.

Subject to FCC Approval
TR-9000

"New 2-meter direction"...compact rig with FM/SSB/CW, scan, five memories

The TR-9000 combines the convenience of FM with long distance SSB and CW. It is extremely compact...perfect for mobile operation. Matching accessories are available for optimum fixed-station operation.

TR-9000 FEATURES:
- FM, USB, LSB, and CW
- Only 6-11/16 inches wide, 2-21/32 inches high, 9-7/32 inches deep.
- Two digital VFOs, with selectable tuning steps of 100 Hz, 5 kHz, and 10 kHz.
- Digital frequency display. Five, four, or three digits, depending on selected tuning step.
- Covers 143.900-148.999 MHz.
- Band scan...automatic busy stop and free scan.
- SSB/CW search of selectable 9.9-kHz bandwidth segments.
- Five memories...four for simplex or ±600 kHz repeater offsets and the fifth for a non-standard offset (memorizes transmit and receive frequency independently).
- UP/DOWN microphone (standard) for manual band scan.
- Noise blanker for SSB and CW.
- RIT (receiver incremental tuning) for SSB and CW.
- RF gain control.
- CW sidetone.
- Selectable RF power outputs...10 W (Hi)/1 W (Lo).
- Mobile mounting bracket with quick-release levers.
- LED indicators...ON AIR, BUSY, and VFO.

TR-2400

"Hand-shack"...synthesized, big LCD, scan, 10 memories, DTMF (Touch-Tone®)

The TR-2400 has the most convenient operating features desired in a 2-meter FM handheld transceiver.

TR-2400 FEATURES:
- Large LCD digital readout. Readable in direct sunlight (virtually no current drain) and in the dark (lamp switch). Shows receive and transmit frequencies and memory channel. "Arrow" indicators show "ON AIR," "MR" (memory recall), "BATT" (battery status), and "LAMP" switch on.
- Keyboard selection of 144.000-147.995 MHz in 5-kHz increments. No "5-UP" switch needed.
- UP/DOWN manual scan in 5-kHz steps from 143.900 to 148.995 MHz.
- 10 memories. Retained with battery backup. "MO" memory may be used to shift transmitter to any frequency for nonstandard-split repeaters.
- Built-in autopatch DTMF (Touch-Tone®) encoder, using all 16 keyboard buttons.
- Automatic memory scan.
- Repeater or simplex operation. Transmit frequency shifts ±600 kHz or to "MO" memory frequency.
- Reverse switch. Transposes receive and transmit frequencies.
- Subtone switch (tone encoder not Kenwood-supplied).
- Two lock switches to prevent accidental frequency change and accidental transmission.

OPTIONAL ACCESSORIES:
- PS-20 fixed-station power supply.
- SP-120 fixed-station external speaker.
- BO-9 System Base...with power switch, SEND/RECEIVE switch (for CW), memory-backup power supply, and headphone jack.
- External PTT microphone and earphone connectors.
- Rubberized antenna with BNC connector, NiCd battery pack, AC charger, PTT and microphone connectors.
- Extended operating time with LCD and overall low-current circuit design. Only draws about 25 mA squelched receive and 500 mA transmit (at 1.5 W RF output).
- High-impact case and zinc die-cast frame.
- Compact and lightweight. Only 2-13/16 inches wide, 7.9/16 inches high, and 1-7/8 inches deep. Weighs only 1.62 pounds (including antenna, battery, and hand strap).

OPTIONAL ACCESSORIES:
- ST-1 Base Stand (provides 1.5-hour-quick, trickle, and floating charges, 4-pin microphone connector, and SO-239 antenna connector).
- BC-5 DC quick charger.
- LH-1 leather case.
- BH-1 belt hook.
- PB-24 extra NiCd battery pack.
- NEW SMC-24 speaker/mic.
A combination lock using CMOS devices

The solution was a nonvolatile control. The problem was a secure, remote controlled electronic combination lock for the local repeater; one which would not forget if it was turned on or turned off if the power should fail momentarily, or if the supply line should suddenly become filled with electronic noise. With thoughts of security, simplicity, and ultra-low power drain in mind, the circuit shown here was devised.

features

The control, designed to operate in conjunction with standard TTL tone decoders, uses a sequence of three digits to effect the turn-on function and a different three digit sequence for turn-off. The digits must be applied precisely in the selected sequence to achieve the desired function. The turn-on process automatically prepares the control to accept the turn-off sequence and, similarly, the turn-off process prepares the control to accept the turn-on sequence. To safeguard against the possibility of electronically picking the combination lock, provisions were made to accept digits unused in either control sequence as reset inputs. The entire control uses four ICs, four transistors, and ten diodes.

circuit

Referring to fig. 1, the combination-lock function is accomplished by a series of D flip-flops. U1A, U1B, and U2A comprise the turn-on function, and U2B, U3A, and U3B comprise the turn-off function. Activation of either function is accomplished by clocking the flip-flop string in sequence. Beginning with U1A (or U2B), each flip-flop enables the succeeding one in the string by taking its D input to a high logic level. In this manner, U2A cannot be clocked until U1B has been clocked, which in turn cannot be clocked until U1A has been clocked. After completion of the turn-on sequence, in the proper order, the falling edge of U2A’s Q output clocks the

By Steve Cerwin, WA5FRF, 3911 Pipers Court, San Antonio, Texas 78251
latch comprised by gates U4C and U4D to its ON state. This negative-going pulse also is inverted and coupled to the reset inputs of flip-flops U2B, U3A, and U3B, which prepares them for the turn-off sequence.

In the ON state, U4C output saturates the triple-darlington Q1, Q2, and Q3 through a 1 megohm resistor. The open collector output of Q1 may be used to control an external relay. The base lead of Q3 has been brought out on the printed-circuit board for the possibility of using an external master override for either the ON or OFF function.

The unused digit inputs are connected in OR fashion to Q4 through diodes CR1 through CR8. If any one of these inputs is selected, Q4 will saturate, taking one input of gates U4A and U4B to a logic zero level. This will reset both flip-flop strings to their zero state, thereby effecting the anti-picking feature by neutralizing any accidental progress made by non-authorized attempts to operate the control. Assuming different digits are selected for each sequence input, the odds against someone happening upon the proper combination for either control operation by chance are $16 \times 15 \times 14$ or 3,360 to 1 for a sixteen-button pad. The odds may be increased simply by adding additional data latches to the string.

Nonvolatility was achieved by designing the circuit for ultra-low power drain. All the ICs are CMOS, and the total supply current for all four chips is less than 1 microamp. The power hog in the unit is the base current required to saturate the triple-darlington. This current, 2.9 microamps, is essentially the total supply current drain when the control is on. With only the onboard 100 $\mu$F capacitor across the supply, the con-

---

**fig. 1. Schematic of the nonvolatile control for repeater security. The odds against someone finding the proper combination for control operation by chance are 3,360 to 1 for a 16-button pad. System uses CMOS devices with a total supply current drain of about 3 microamps.**
Wire Wrapping Kit

Model WK-6 is a unique new Wire Wrapping Kit that contains a complete range of tools and parts for prototype and hobby applications, all conveniently packaged in a handy, durable plastic carrying case.

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HAL-300A 7-Digit Counter (similar to 600A) with Frequency Range of 0.300 MHz.

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Tell 'em you saw it in HAM RADIO
fig. 2. Single-sided PC board layout for the repeater control.

trol will be nonvolatile for several minutes after power failure. This time may be extended to hours if a larger capacitor is supplied externally, or it may be extended indefinitely if an external battery pack is supplied. The control supply bus is isolated from the supply line by diode CR10. CR10, a 3-amp power rectifier, was chosen to withstand the charge-up current of the large supply bypass capacitor and also provides reverse supply protection. Supply voltage must be 5 volts if the unit is to be compatible with TTL tone decoders.

A single-sided printed circuit board layout for the control is shown in fig. 2. Component placement and a photograph of a completed board are in figs. 3 and 4 respectively. To maintain the ultra-low-power drain characteristics, the assembled board must be kept reasonably clean.

ham radio
transmission-line circuit design

Using distributed resonant circuits for VHF/UHF transmission lines

Part 2 of this article, which appeared in the January, 1981, issue of *ham radio*, dealt with the geometry of the first four of twelve common transmission line configurations. In this, part 3 of the article, another set of four transmission line configurations will be examined: circular wire between planes, parallel wires over a plane, circular wire in an open trough, and parallel wires between planes/rectangular box.

Part 4 of this series will deal with the remaining four configurations. Part 5, the last in the series, will provide a summary of what has been discussed and show a design example for a 2-meter amplifier.

**circular wire between planes**

The formulation for the characteristic impedance of this line is similar to that for a single wire over a parallel plane (reference 4):

\[ Z_0 = \frac{1.38}{\sqrt{\varepsilon_r}} \log_{10} \frac{4h}{\pi d} : d/h < 0.75 \quad (25) \]

where 
- \( Z_0 \) = line impedance (ohms)
- \( \varepsilon_r \) = dielectric constant
- \( h \) = distance between planes
- \( d \) = wire diameter centered between planes

Fig. 12 shows \( Z_0 \) versus \( h/d \) for a reasonable range.

By H.M. Meyer, Jr., W6GGV, 29330 Whitley Collins Drive, Rancho Palos Verdes, California 90274

[Graph showing \( Z_0 \) versus \( h/d \) for a wire centered between parallel planes.]

56 february 1981
Table 20. HP-67/97 program for calculating $Z_0$ and $h/d$ for a wire centered between parallel planes.

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Table 21. Register contents for HP-67/97 program for calculating $Z_0$ and $h/d$ for a wire centered between parallel planes.

- STO 0: $\epsilon_r$
- STO 1: $\sqrt{\epsilon_r}$
- STO 2: $h/d$
- STO 3: INTERIM
- STO 4: $Z_0$

Table 22. HP-67/97 program control for calculating $Z_0$ and $h/d$ for a wire centered between parallel planes.

- Enter $\epsilon_r$, press A
- Enter $h$, press ENTER
- Enter $d$, press B
- Calculates $h/d$, press C
- Calculates $Z_0$, press D

Note: If no value for $r$, is entered, program assumes $\epsilon_r$ = 1 = air.

Parallel wires over a plane

The common application of this line is for push-pull tank circuits with lines spaced much more closely to the ground plane than to the cover. The formulation (reference 4) is:

$$Z_0 = \frac{69}{\sqrt{\epsilon_r}} \log_{10} \left( \frac{4h}{d} \right) \left[ 1 + \left( \frac{2h}{D} \right)^2 \right]^{1/2}$$

(26)

where $Z_0$ = line impedance (ohms)
$\epsilon_r$ = dielectric constant
$h$ = centerline height of wires over plane
$d$ = wire diameter
$D$ = center-to-center spacing between wires

For analysis this equation may be reformulated to

$$Z_0 = \frac{69}{\sqrt{\epsilon_r}} \log_{10} \left( \frac{4h}{d} \right) + \log_{10} \left( 1 + \left( \frac{2h}{D} \right)^2 \right)^{1/2}$$

(27)

which permits solution if $h/d$ and $Z_0$ are known, or if $h/D$ and $Z_0$ are known.

When solving for $h/D$ when $Z_0$ and $h/d$ are known, eq. 27 may be rearranged for easy solution on the HP-67/97 to

$$\log_{10} \left( 1 + \left( \frac{2h}{D} \right)^2 \right)^{1/2} = \left( \frac{Z_0 \sqrt{\epsilon_r}}{69} \right) - \log_{10} \left( \frac{4h}{d} \right)$$

(28)

Eq. 28 is transposed when solving for $h/d$ with $Z_0$ and $h/D$ known.

Fig. 13 is a plot of $Z_0$ versus $h/d$ for various values of $h/D$. Table 23 provides an HP-67/97 program for calculating various combinations of knowns and unknowns. Table 24 identifies the storage registers; table 25 shows how the program is controlled.
table 23. HP-67/97 program for calculating $Z_0$, $h/d$, and $h/D$ for two parallel wires over a plane.

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<td>ST01</td>
<td>35 01</td>
</tr>
<tr>
<td>024</td>
<td>4</td>
<td>04</td>
<td>052</td>
<td>6</td>
<td>06</td>
<td>080</td>
<td>X = @?</td>
<td>16-43</td>
<td>108</td>
<td>RTN</td>
<td>24</td>
</tr>
<tr>
<td>025</td>
<td>x</td>
<td>-35</td>
<td>053</td>
<td>9</td>
<td>09</td>
<td>081</td>
<td>GSB7</td>
<td>23 07</td>
<td>109</td>
<td>*LBL7</td>
<td>21 07</td>
</tr>
<tr>
<td>026</td>
<td>x</td>
<td>-35</td>
<td>054</td>
<td>+</td>
<td>-24</td>
<td>082</td>
<td>RCL6</td>
<td>36 06</td>
<td>110</td>
<td>1</td>
<td>01</td>
</tr>
<tr>
<td>027</td>
<td>LOG</td>
<td>16 32</td>
<td>055</td>
<td>RCL5</td>
<td>36 05</td>
<td>083</td>
<td>x</td>
<td>-35</td>
<td>111</td>
<td>ST01</td>
<td>35 01</td>
</tr>
<tr>
<td>028</td>
<td>6</td>
<td>06</td>
<td>056</td>
<td>+</td>
<td>-55</td>
<td>084</td>
<td>6</td>
<td>06</td>
<td>112</td>
<td>RTN</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>113</td>
<td>R/S</td>
<td>51</td>
</tr>
</tbody>
</table>

---

Table 24. Register contents for HP-87/97 program for calculating $Z_0$, $h/d$, and $h/D$ for two parallel wires over a plane.

<table>
<thead>
<tr>
<th>STO 0</th>
<th>$\epsilon_r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>STO 1</td>
<td>$\sqrt{\epsilon_r}$</td>
</tr>
<tr>
<td>STO 2</td>
<td>$\sqrt{\epsilon_r}$</td>
</tr>
<tr>
<td>STO 3</td>
<td>$d/h$</td>
</tr>
<tr>
<td>STO 4</td>
<td>$h/d$</td>
</tr>
<tr>
<td>STO 5</td>
<td>$Z_0$</td>
</tr>
<tr>
<td>STO 6</td>
<td>$Z_0$</td>
</tr>
</tbody>
</table>

Table 25. HP-67/97 program control for calculating $Z_0$, $h/d$, and $h/D$ for two parallel wires over a plane.

- Calculates $\sqrt{\epsilon_r}$ press A
- Enters $\epsilon_r$ press ENTER
- Calculates $Z_0$ press ENTER
- Enters $d$ press ENTER
- Calculates $h/D$ press ENTER
- Enters $Z_0$ press ENTER
- Calculates $h/d$ press ENTER
- Enters $h/D$ press ENTER
- Calculates $Z_0$ press ENTER
- Enters $h/d$ press ENTER
- Calculates $Z_0$ press ENTER

Note: If no value for $\epsilon_r$ is entered, program assumes $\epsilon_r = 1 = \text{air}$. 

---

February 1981
A common application of this configuration is in rf amplifiers, mixers, and local oscillator or multiplier filter elements at 100 MHz and above. The generalized formulation (reference 4) for a circular wire in an open trough is given by:

$$Z_0 = \frac{138}{\sqrt{\varepsilon_r}} \log_{10} \left[ \frac{4w \tanh \frac{\pi h}{w}}{\pi d} \right]$$  \hspace{1cm} (29)$$

for $d < < h, w$

where $Z_0 = $ line impedance (ohms)

$\varepsilon_r = $ dielectric constant

$d = $ wire diameter

$h = $ centerline height of wire over plane

$w = $ width of trough with wire positioned in center

The formulation can be simplified considerably if one assumes a square open trough where $w$ (trough width) equals $2h$ (two times the centerline height of the wire over the bottom plane). The resulting formula for a square open trough is:

$$Z_0 = \frac{138}{\sqrt{\varepsilon_r}} \log_{10} \left[ \frac{8h \tanh \frac{\pi h}{2}}{\pi d} \right]$$  \hspace{1cm} (30)$$

and $$\tanh \frac{\pi}{2} = 1.0$$  \hspace{1cm} (31)$$

then $$Z_0 = \frac{138}{\sqrt{\varepsilon_r}} \log_{10} \left[ \frac{2.5463 h}{d} \right]$$  \hspace{1cm} (32)$$

Fig. 14 shows $h/d$ versus $Z_0$ for eq. 32. Table 26 is the HP-67/97 program for calculating $Z_0$ and $h/d$. Table 27 shows the registers used. Table 28 shows how the program is controlled.

Table 29 is the HP-67/97 program for calculating $Z_0$, $h/w$, and $w/d$ given any two of the unknowns for any rectangular configuration, which is the general solution of eq. 29. Table 30 indicates the storage registers used in the program, and table 31 shows how the program is controlled. Fig. 15 is a plot of $Z_0$ versus $w/d$ for various values of $h/w$ from eq. 29. Note that eq. 29 is solved directly for $Z_0$ in table 29.

If $Z_0$ and $w/d$ are given, $h/w$ is solved by using eqs. 33, 34, and 35. A similar variant is used if $h/w$ is known and $w/d$ must be calculated.

$$Z_0 \frac{\sqrt{\varepsilon_r}}{138} = \left( \log_{10} \frac{4w}{d} \right) + \left( \log_{10} \tanh \frac{\pi h}{w} \right),$$  \hspace{1cm} (33)$$

recognizing that $$\tanh x = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$  \hspace{1cm} (34)$$

and $$\tanh^{-1} x = \frac{1}{2} \ln \left[ \frac{1+x}{1-x} \right]$$  \hspace{1cm} (35)$$

Table 26. HP-67/97 program for calculating $Z_0$ and $h/d$ for a circular wire in a square trough.

<table>
<thead>
<tr>
<th>Step</th>
<th>HP-97 Key</th>
<th>HP-97 Code</th>
<th>Step</th>
<th>HP-97 Key</th>
<th>HP-97 Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>&quot;LBLA&quot;</td>
<td>21 11</td>
<td>018</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>002</td>
<td>STO0</td>
<td>35 00</td>
<td>019</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>003</td>
<td>\sqrt{X}</td>
<td>54</td>
<td>020</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>004</td>
<td>STO1</td>
<td>35 01</td>
<td>021</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>005</td>
<td>RTN</td>
<td>24</td>
<td>022</td>
<td></td>
<td>35 04</td>
</tr>
<tr>
<td>006</td>
<td>&quot;LBLB&quot;</td>
<td>21 12</td>
<td>023</td>
<td></td>
<td>21 02</td>
</tr>
<tr>
<td>007</td>
<td>+</td>
<td>-24</td>
<td>024</td>
<td></td>
<td>RCL1</td>
</tr>
<tr>
<td>008</td>
<td>STO2</td>
<td>35 02</td>
<td>025</td>
<td>X = 0?</td>
<td>16 43</td>
</tr>
<tr>
<td>009</td>
<td>&quot;LBL1&quot;</td>
<td>21 01</td>
<td>026</td>
<td></td>
<td>GS09</td>
</tr>
<tr>
<td>010</td>
<td>2</td>
<td>027</td>
<td>027</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>011</td>
<td>.</td>
<td>-62</td>
<td>028</td>
<td></td>
<td>ST03</td>
</tr>
<tr>
<td>012</td>
<td>5</td>
<td>05</td>
<td>029</td>
<td></td>
<td>R/S</td>
</tr>
<tr>
<td>013</td>
<td>4</td>
<td>04</td>
<td>030</td>
<td>&quot;LBLC&quot;</td>
<td></td>
</tr>
<tr>
<td>014</td>
<td>6</td>
<td>06</td>
<td>031</td>
<td></td>
<td>ST03</td>
</tr>
<tr>
<td>015</td>
<td>5</td>
<td>05</td>
<td>032</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>016</td>
<td>x</td>
<td>-35</td>
<td>033</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>017</td>
<td>LOG</td>
<td>16 32</td>
<td>034</td>
<td></td>
<td>8</td>
</tr>
</tbody>
</table>

Table 27 shows the registers used. Table 28 shows how the program is controlled. Fig. 15 is a plot of $Z_0$ versus $w/d$ for various values of $h/w$ from eq. 29.
table 26. HP-67/97 program for calculating $Z_0$ and $h/d$ for a circular wire in a square trough (continued).

<table>
<thead>
<tr>
<th>step</th>
<th>HP-97 key</th>
<th>HP-97 code</th>
<th>step</th>
<th>HP-97 key</th>
<th>HP-97 code</th>
</tr>
</thead>
<tbody>
<tr>
<td>005</td>
<td>+</td>
<td>24</td>
<td>051</td>
<td>R/S</td>
<td>51</td>
</tr>
<tr>
<td>006</td>
<td>STO4</td>
<td>35 04</td>
<td>052</td>
<td>*LBLD</td>
<td>21 14</td>
</tr>
<tr>
<td>007</td>
<td>*LBL3</td>
<td>21 03</td>
<td>053</td>
<td>STO2</td>
<td>35 02</td>
</tr>
<tr>
<td>008</td>
<td>RCL1</td>
<td>36 01</td>
<td>054</td>
<td>GTO1</td>
<td>22 01</td>
</tr>
<tr>
<td>009</td>
<td>X = 0?</td>
<td>16 43</td>
<td>055</td>
<td>*LBL9</td>
<td>21 09</td>
</tr>
<tr>
<td>010</td>
<td>GS88</td>
<td>23 08</td>
<td>056</td>
<td>1</td>
<td>01</td>
</tr>
<tr>
<td>011</td>
<td>X</td>
<td>-35</td>
<td>057</td>
<td>STO1</td>
<td>35 01</td>
</tr>
<tr>
<td>012</td>
<td>10^X</td>
<td>16 33</td>
<td>058</td>
<td>RCL4</td>
<td>36 04</td>
</tr>
<tr>
<td>013</td>
<td>2</td>
<td>02</td>
<td>059</td>
<td>GTO2</td>
<td>22 02</td>
</tr>
<tr>
<td>014</td>
<td>.</td>
<td>-62</td>
<td>060</td>
<td>*LBL8</td>
<td>21 08</td>
</tr>
<tr>
<td>015</td>
<td>5</td>
<td>05</td>
<td>061</td>
<td>1</td>
<td>01</td>
</tr>
<tr>
<td>016</td>
<td>4</td>
<td>04</td>
<td>062</td>
<td>STO1</td>
<td>35 01</td>
</tr>
<tr>
<td>017</td>
<td>6</td>
<td>06</td>
<td>063</td>
<td>RCL4</td>
<td>36 04</td>
</tr>
<tr>
<td>018</td>
<td>5</td>
<td>05</td>
<td>064</td>
<td>GTO3</td>
<td>22 03</td>
</tr>
<tr>
<td>019</td>
<td>+</td>
<td>-24</td>
<td>065</td>
<td>R/S</td>
<td>51</td>
</tr>
<tr>
<td>020</td>
<td>STO2</td>
<td>35 02</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

table 27. Register contents for HP-67/97 program for calculating $Z_0$ and $h/d$ for a circular wire in a square trough.

- STO0: $\varepsilon_r$
- STO1: $\sqrt{\varepsilon_r}$
- STO2: $h/d$
- STO3: $Z_0$
- STO4: INTERIM

fig. 14. $Z_0$ and $h/d$ for a circular wire in a square open trough.

table 28. HP-67/97 program control for calculating $Z_0$ and $h/d$ for a circular wire in a square trough.

- enter $\varepsilon_r$ press A
- calculates $Z_0$
- enter $h$
- enter $d$
- enters $h/d$ press B
- calculates $h/d$
- enter $Z_0$ press C
- assumes $\varepsilon_r = 1 = \text{air}$
- enters $h/d$ press D

Note: If no value for $\varepsilon_r$ is entered, program

table 30. Register contents for HP-67/97 program for calculating $Z_0$, $h/w$, and $w/d$ for a circular wire in a rectangular trough.

- STO0: $\varepsilon_r$
- STO1: $\sqrt{\varepsilon_r}$
- STO2: $h/w$
- STO3: $w/d$
- STO4: $\frac{\pi h}{w} = z$
- STO5: $e^{\pi - e^{-\pi}}$
- STO6: $e^{\pi + e^{-\pi}}$
- STO7: $\tanh \frac{\pi h}{w}$
- STO8: INTERIM
- STO9: $Z_0$
- STO10: INTERIM
- STO11: INTERIM
- STO12: INTERIM

Note: If no value for $\varepsilon_r$ is entered, program

table 31. HP-67/97 program control for calculating $Z_0$, $h/w$, and $w/d$ for a circular wire in a rectangular trough.

- enter $\varepsilon_r$ press A
- calculates $Z_0$
- enter $h$
- enter $d$
- enter $w$
- press ENTER
- press B
- calculates $h/w$
- enter $Z_0$ press ENTER
- enter $w/d$ press C
- assumes $\varepsilon_r = 1 = \text{air}$
- calculates $w/d$
- enter $Z_0$ press ENTER
- enter $h/w$ press D

Note: If no value for $\varepsilon_r$ is entered, program

fig. 15. $Z_0$ versus $w/d$ for various values of $h/w$ of a circular wire in an open rectangular trough.
parallel wires
between planes/
rectangular box

This configuration is often used for high-powered, push-pull amplifiers. Even though the formulation in eq. 36 does not consider the effects of side walls (only top and bottom planes), good results can be obtained if the lines are centered between the side walls and the distance from either wire to the side wall is at least greater than $h/2$, as shown in the sketch. A more exact formulation for balanced two-wire lines in a rectangular enclosure is given in reference 4 and discussed later in this section; however, it requires a rather tedious series of calculations.

The following formulation, also from reference 4, is based upon this relationship:

$$Z_0 = \frac{276}{\sqrt{\varepsilon_r}} \log_{10} \left[ \left( \frac{4h}{\pi d} \right) \left( \tanh \frac{\pi D}{2h} \right) \right]$$  (36)
For those who wish the exact relationship, it is given below from reference 4; the geometry is in fig. 16.

\[
Z_0 = \frac{276}{\sqrt{\varepsilon_r}} \left[ \log_{10} \left( \frac{4h}{\pi d} \right) \left( \tanh \frac{\pi D}{2h} \right) \right] - \sum_{m=1}^{\infty} \log_{10} \left( \frac{1 + \tan^2 \theta_m}{1 - \tan^2 \theta_m} \right)
\]

where \( Z_0 \) = line impedance (ohms)
\( \varepsilon_r \) = dielectric constant
\( h \) = spacing between planes with the lines centered
\( D \) = centerline distance between the lines
\( d \) = diameter of the lines (lines are assumed to be of equal diameter)

\[
U_m = \frac{\sinh \left( \frac{\pi D}{2h} \right)}{\cosh \left( \frac{m \pi w}{2h} \right)}
\]

\[
V_m = \frac{\sinh \left( \frac{\pi D}{2h} \right)}{\sin \left( \frac{m \pi w}{2h} \right)}
\]

**Table 32. HP-67/97 program for calculating \( Z_0 \), h/d, and D/h for two parallel wires between planes/rectangular box.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>*LBLA</td>
<td>21 11</td>
<td>002</td>
<td>STO8</td>
<td>35 00</td>
<td>003</td>
<td>√X</td>
<td>35 01</td>
<td>004</td>
<td>STO1</td>
<td>24</td>
</tr>
<tr>
<td>006</td>
<td>*LBLB</td>
<td>21 12</td>
<td>007</td>
<td>R</td>
<td>35 02</td>
<td>008</td>
<td>+</td>
<td>35 06</td>
<td>009</td>
<td>*STO2</td>
<td>35 07</td>
</tr>
<tr>
<td>013</td>
<td>*LBL1</td>
<td>20 01</td>
<td>014</td>
<td>4</td>
<td>35 01</td>
<td>015</td>
<td>x</td>
<td>36 01</td>
<td>016</td>
<td>P</td>
<td>35 04</td>
</tr>
<tr>
<td>018</td>
<td>LOG</td>
<td>36 01</td>
<td>019</td>
<td>STO6</td>
<td>35 06</td>
<td>020</td>
<td>RCL2</td>
<td>36 02</td>
<td>021</td>
<td>P</td>
<td>36 02</td>
</tr>
<tr>
<td>023</td>
<td>2</td>
<td>35 01</td>
<td>024</td>
<td>+</td>
<td>36 02</td>
<td>025</td>
<td>GSB9</td>
<td>23 00</td>
<td>026</td>
<td>LOG</td>
<td>16 01</td>
</tr>
<tr>
<td>028</td>
<td>RCL6</td>
<td>36 06</td>
<td>029</td>
<td>2</td>
<td>02 02</td>
<td>030</td>
<td>7</td>
<td>07 07</td>
<td>031</td>
<td>6</td>
<td>06 06</td>
</tr>
<tr>
<td>032</td>
<td>x</td>
<td>35 07</td>
<td>033</td>
<td>STO6</td>
<td>35 06</td>
<td>034</td>
<td>RCL1</td>
<td>36 01</td>
<td>035</td>
<td>X = 0?</td>
<td>16 43</td>
</tr>
<tr>
<td>037</td>
<td>+</td>
<td>24 01</td>
<td>038</td>
<td>STO4</td>
<td>35 04</td>
<td>039</td>
<td>R/S</td>
<td>51 51</td>
<td>040</td>
<td>R/S</td>
<td>35 51</td>
</tr>
</tbody>
</table>

\[ U_m = \frac{\sinh \left( \frac{\pi D}{2h} \right)}{\cosh \left( \frac{m \pi w}{2h} \right)} \]

\[ V_m = \frac{\sin \left( \frac{m \pi w}{2h} \right)}{\sin \left( \frac{\pi D}{2h} \right)} \]

\[ \text{fig. 16.} \]
Note that the open-sided equation (eq. 36) represents the maximum value of \( Z_0 \) that can be achieved with no side enclosure. The sum of the series in eq. 37 reduces this value of \( Z_0 \) by the closing-in effect of the sides. As a consequence, if eq. 37 and the charts and programs provided here are used, a conservative design will result, permitting the addition of more capacitance than the values calculated, as described in a previous section.

Fig. 17 shows the value of \( h/d \) plotted versus \( D/h \) for various values of \( Z_0 \). Table 32 is the HP-67/97 program for calculating \( Z_0, D/h, \) or \( h/d \) depending on which variables are given. Table 33 shows the registers used in the program, and table 34 describes how the program is controlled.

A more simplified formulation for eq. 36 is used in the program to permit calculation of the desired unknowns:

\[
\frac{Z_0 \sqrt{\varepsilon_r}}{276} = \left(\log_{10} \frac{4h}{\pi d}\right) + \log_{10} \left(\tanh \frac{\pi D}{2h}\right)
\]  

(40)

table 33. Register contents for HP-67/97 program for calculating \( Z_0, h/d, \) and \( D/h \) for two parallel wires between planes/rectangular box.

<table>
<thead>
<tr>
<th>Register</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>STO 0</td>
<td>( \varepsilon_r )</td>
</tr>
<tr>
<td>STO 1</td>
<td>( \sqrt{\varepsilon_r} )</td>
</tr>
<tr>
<td>STO 2</td>
<td>( D/h )</td>
</tr>
<tr>
<td>STO 3</td>
<td>( h/d )</td>
</tr>
<tr>
<td>STO 4</td>
<td>( Z_0 )</td>
</tr>
<tr>
<td>STO 5</td>
<td>( x ) for ( \tanh x )</td>
</tr>
<tr>
<td>STO 6</td>
<td>INTERIM</td>
</tr>
<tr>
<td>STO 7</td>
<td>( \tan^{-1}x )</td>
</tr>
<tr>
<td>STO 8</td>
<td>INTERIM</td>
</tr>
</tbody>
</table>

Table 34. HP-67/97 program control for calculating \( Z_0, h/d, \) and \( D/h \) for two parallel wires between planes/rectangular box.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>press A</td>
<td>Calculates ( \varepsilon_r )</td>
</tr>
<tr>
<td>enter ( \varepsilon_r )</td>
<td>press A</td>
</tr>
<tr>
<td>press ENTER</td>
<td>Calculates ( Z_0 )</td>
</tr>
<tr>
<td>enter ( Z_0 )</td>
<td>press ENTER</td>
</tr>
<tr>
<td>enter ( h/d )</td>
<td>press C</td>
</tr>
<tr>
<td>Note: If no value for ( \varepsilon_r ) is entered, program assumes ( \varepsilon_r = 1 = \text{air} )</td>
<td></td>
</tr>
</tbody>
</table>

In the next part of this article, part 4, the geometry and resonant-circuit design of the following configurations will be discussed: circular wire in a square shield, stripline over a plane, stripline centered between parallel planes, and helical resonators.

references


bibliography


ham radio
NEW ASTRO 103
WITH NEW WARC BANDS

SPECIFICATIONS

Notch Filter: 
1 watt and adjustable
-60dB attenuation from 30 to 50 kHz

Selectivity: (normal)
- 0.1 kHz at 30 kHz
- 0.1 kHz at 100 kHz
- 0.1 kHz at 1000 kHz
- 0.1 kHz at 10 kHz

RF Output Power:
- 100 watts all bands all modes
- Limited by NEC to 100 watts PEP or CW

Sensitivity:
- 0.5 mV for 10 dB

Third Order Intercept:
- Better than 30 dBm

Image Rejection:
- Better than 25 dB

Modes:
- USB, LSB, CW

A real alternative...
The Avanti On Glass Mobile Antenna.

Mounts on glass — no holes!
• Receives and transmits through glass.
• Superior performance 1/2 wave design.
• Superior radiation full Omni-Directional.

Mounting on glass is easy and effective
using the new Duo-Bond method which
combines quick "drive away" with rugged
durability. No holes to drill, no magnet to
scratch paint, no clamps. Takes only minutes
to install, without tools. No ground plane
required. Static and noise cut by up to 30%.
Electrical connection are inside and out of
sight to prevent crimping or corroding
cable.

Models available for 30-50 MHz, 144-174 MHz,
220-225 MHz and 410-512 MHz

Tell 'em you saw it in HAM RADIO!
**More Details? CHECK — OFF Page 98**
computer control for the KLM antenna rotor

The most obvious approach to microprocessor control of antenna rotors does indeed work! In fig. 1 two CMOS quad-clocked D latches, U1, are connected in parallel to the first four least-significant digits of an input/output port of a computer. The computer enables first one, then the other latch, leaving behind an 8-bit word.

This byte, a number between 0-255, is converted through the classic “R-2R” network to a voltage between 0-5 volts. This voltage is compared with the voltage returning from the wiper of the potentiometer in the rotor housing.

The comparators turn on solid-state switches, which are connected across the clockwise and counterclockwise front-panel switches on the rotor control box.

Thus the antenna will rotate in the direction that minimizes the difference between the two voltages.

The two 820k resistors provide a deadband so that when the proper heading is reached, the rotor will stop — not hunt.

Because the quad comparator, U2, loses all resemblance to a comparator as the inputs approach the upper rail, adjust the 15-turn pot, R, for a comparator input voltage of about 3.5 volts at full rotation. This voltage corresponds to a byte of 180. Then merely have the computer poke down to the latches a number between 0-180, which is one-half the required azimuth heading (or twice the required elevation).

The terminal numbers indicated in fig. 1 are for the KLM KR-400 and KR-500 rotors. Terminal 8 must be wired to the common connection of the two front-panel direction controls. Solid-state switches can be homebuilt with an opto-triac driver and triac, as in fig. 2.

This interface is very precise — four-degree resolution or better at most headings. The circuit will readjust for sudden wind gusts, voltage variations, etc., without complex software. The computer needs only to enter direction data every minute, say, using only a few machine cycles then go on to other work.

I conclude with a report of negative results: my first attempt at such an interface was with the new low-cost RCA CA3162E, two 4-bit magnitude comparators and four latches. The plan was to convert the rotor heading to digital information, then compare. Aside from problems with the multiplexer timing of the 3162, this was a wasteful approach. At least ten comparators were at work instead of two!

C.R. Mac Cluer, W8MQW

---

fig. 1, left: Interface circuit for microprocessor control of the KLM KR-400 and KR-500 antenna rotors.

fig. 2, below: Schematic of the solid-state switches, consisting of optically coupled triac driver and 6-ampere triac with heatsink.
**varactor tuning tips**

In tuning power varactor doublers, triplers, etc., there is often a sharp or sudden discontinuity in the tuning of one or more of the tuned circuits; a condition known as hysteresis.

While hysteresis is caused by some non-linearities in the diode function, it seems that it may also be a result of the circuit "Q" aggravating diode non-linearities. I figured that it might be possible to lessen the effect by a reduction in circuit "Q." Accordingly, I reduced the bias resistor in my 144-MHz tripler from 92 kilohms to about 12 kilohms. I was pleased to note that circuit performance was actually improved — tuneup was easier, and there was no appreciable loss of power output.

Richard N. Coan, N3GN

---

**woodpecker noise blanker for the Drake TR-7 transceiver**

If you have been reading the articles about the "Woodpecker Noise Blanker" and wished your TR-7 could do the same to the "Russian Woodpecker," it can — with just two component changes. The Drake noise blanker for the TR-7 is functionally the same block diagram; the problem is that the one-shot and integrator time constants aren't set up for the Woodpecker.

I increased C831 from 0.001 μF to 0.01 μF and the one-shot capacitor from 0.01 μF to 0.1 μF. The results were fair to good. A 10-20 dB over S9 Woodpecker signal would be cut back to S5-6 with no real distortion to SSB, CW, or RTTY. I called Drake about the idea, but they have also made a change which will be in new NB7s to be sold soon. Their results were about the same as regards attenuation of the Woodpecker signal. Drake sent me a copy of their changes and I'll compare it with what I've done.

The noise blanker works best on strong Woodpecker signals (over S7). I have received three Woodpeckers each with its own signature. All have the same rate of 100 millisecond (probably due to a division of the 50-Hz power line) but differ in pulse width and rise time.

The changes are simple and not critical. The only problem is that in my service manual, the pictorial didn't show the position of C840. Fig. 3 shows the area of the schematic where the changes are made, and Fig. 4 shows the pictorial of the components to be changed.

I would like to thank W11HN for allowing me to use his noise blanker to test this idea.

**reference**


John Bird, K1KSY
1900 MHz to 2500 MHz DOWN CONVERTER
This receiver is tunable over a range of 1900 to 2500 mc and is intended for amateur radio use. The local oscillator is voltage controlled (i.e.) making the IF range approximately 54 to 88 mc (Channels 2 to 7).
PC BOARD WITH DATA .................................................. $19.99
PC BOARD WITH CHIP CAPACITORS 13 ............................ $44.99
PC BOARD WITH ALL PARTS FOR ASSEMBLY .................. $69.99
PC BOARD WITH ALL PARTS FOR ASSEMBLY PLUS 2N6680 .......................... $69.99
PC BOARD ASSEMBLED AND TESTED ............................ $69.99
PC BOARD WITH ALL PARTS FOR ASSEMBLY, POWER SUPPLY AND ANTENNA .......................... $159.99
POWER SUPPLY ASSEMBLED AND TESTED ................. $49.99
YAGI ANTENNA 4’ LONG APPROX. 20 TO 23 dB GAIN .... $59.99
YAGI ANTENNA 4’ WITH TYPE (N, BNC, SMA Connector) .... $64.99
2300 MHz DOWN CONVERTER
Includes converter mounted in antenna, power supply, plus 90 DAY WARRANTY ........................................... $259.99
OPTION #1 MRF902 in front end. (7 dB noise figure) ......... $209.99
OPTION #2 2N6680 in front end. (5 dB noise figure) .......... $359.99
2300 MHz DOWN CONVERTER ONLY
$149.99
7 dB Noise Figure 23 dB gain in box with N conn. Input F conn. Output .................................................. $189.99
5 dB Noise Figure 23 dB gain in box with SMA conn. Input F conn. Output .................................................. $189.99
DATA IS INCLUDED WITH KITS OR MAY BE PURCHASED SEPARATELY .................................................. $15.00
Shipping and Handling Cost:
Receiver Kits add $1.50, Power Supply add $2.00, Antenna add $5.00, Option 1/2 add $3.00, For complete system add $7.50.

* INTRODUCING THE HOWARD/COLEMAN TVRO CIRCUIT BOARDS *
(Satellite Receiver Boards)

DUAL CONVERSION BOARD ........................................ $25.00
This board provides conversion from the 3.7-4.2 band first to 900 MHz where gain and bandpass filtering are provided and, second, to 70 MHz. The board contains both local oscillators, one fixed and the other variable, and the second mixer. Construction is greatly simplified by the use of Hybrid IC amplifiers for the gain stages. Bare boards cost $25 and it is estimated that parts for construction will cost $270. (Note: The two Avantek VTO’s account for $225 of this cost.)

47 pF CHIP CAPACITORS ........................................ $6.00
For use with dual conversion board. Consists of 6 - 47 pF.

70 MHz IF BOARD .................................................. $25.00
This circuit provides about 45 dB gain with 50 ohm input and output impedance. It is designed to drive the HOWARD/COLEMAN TVRO Demodulator. The on-board band pass filter can be tuned for bandwidths between 20 and 35 Mrz with a passband ripple of less than 1/2 dB. Hybrid ICs are used for the gain stages. Bare boards cost $25. It is estimated that parts for construction will cost less than $40.

.01 pF CHIP CAPACITORS ........................................ $7.00
For use with 70 MHz IF Board. Consists of 7 - .01 pF.

DEMODULATOR BOARD ........................................ 40.00
This circuit takes the 70 MHz center frequency satellite TV signals in the 10 to 200 millivolt range, detects them using a phase locked loop, de-emphasizes and filters the result and amplifies the result to produce standard NTSC video. Other outputs include the audio subcarrier, a DC voltage proportional to the strength of the 70 MHz signal, and AFC voltage centered at about 2 volts DC. The bare boards cost $40 and total parts cost less than $30.

SINGLE AUDIO .................................................. $15.00
This circuit recovers the audio signals from the 6.8 MHz frequency. The Miller 9051 coils are tuned to pass the 6.8 MHz subcarrier and the Miller 9052 coil tunes for recovery of the audio.

DUAL AUDIO .................................................. $25.00
Duplicate of the single audio but also covers the 6.2 range.

DC CONTROL .................................................. $15.00
This circuit controls the VTO’s, AFC and the S Meter.

TERMS:
WE REGRET WE NO LONGER ACCEPT BANK CARDS.
PLEASE SEND POSTAL MONEY ORDER, CERTIFIED CHECK, CASHIER’S CHECK OR MONEY ORDER.
PRICES SUBJECT TO CHANGE WITHOUT NOTICE. WE CHARGE 15% FOR RESTOCKING ON ANY ORDER.
ALL CHECKS AND MONEY ORDERS IN US FUNDS ONLY.
ALL ORDERS SENT FIRST CLASS OR UPS.
ALL PARTS PRIME AND GUARANTEED.
WE WILL ACCEPT COD ORDERS FOR $25.00 OR OVER, ADD $2.50 FOR COD CHARGE.
PLEASE INCLUDE $2.50 MINIMUM FOR SHIPPING OR CALL FOR CHARGES.
WE ALSO ARE LOOKING FOR NEW AND USED TUBES, TEST EQUIPMENT, COMPONENTS, ETC.
WE ALSO SWAP OR TRADE.

(602) 242-8916
2111 W. Camelback
Phoenix, Arizona 85015

NEW — TOLL-FREE NO. 800-528-0180 — please, orders only!
FAIRCHILD VHF AND UHF PRESCALER CHIPS

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TRW BROADBAND AMPLIFIER MODEL CA651B

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<td>1 GHz to 1.5 GHz</td>
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CARBIDE—CIRCUIT BOARD DRILL BITS FOR PC BOARDS

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CRYSTAL FILTERS: TYCO 001-19880 same as 2194F

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MURATA CERAMIC FILTERS

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TEST EQUIPMENT—HEWLETT PACKARD—TEKTRONIX—ETC.

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<td>500D 10 to 420 mc 1 mc to 35 V into 50 ohms Signal Generator</td>
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<td>614A 900 to 2100 mc Signal Generator</td>
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<td>623N 3.8 to 7.2 GHz Signal Generator</td>
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<td>622C 225 to 400 mc AM/FM Signal Generator</td>
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Singer: MFSVR-4 Universal Spectrum Analyzer with a kHz to 27.5 mc Plug In 12000

Kaelin: X9630-100 TWT Amplifier 8 to 12.4 Gc 100 watts 40 dB gain 92000

Polaron: 2038/2436/1102A Constructed Display with an SSB Analysis Module and a 10 to 40 mc Single Tone Synthesizer 150000

HAMLIN SOLID STATE RELAYS

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ATLAS CRYSTAL FILTERS FOR ATLAS HAM GEAR

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<td>5.595-2.7L5B</td>
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<tr>
<td>9.0US5B/CW</td>
<td>50000</td>
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NEW — TOLL-FREE NO. 800-528-0180 — please, orders only!
MRF454 $21.83
NPN SILICON RF POWER TRANSISTORS

- Designed for power amplifier applications in industrial, commercial and amateur radio equipment to 30 MHz.
- Specified 12.5 Volt, 30 MHz Characteristics -
  Output Power = 80 Watts
  Minimum Gain = 12 dB
  Efficiency = 50%

MRF472 $2.50
NPN SILICON RF POWER TRANSISTOR

- Specified 12.5 V, 27 MHz Characteristics -
  Power Output = 4.0 Watts
  Power Gain = 10 dB
  Minimum Efficiency = 65% Typical

MRF475

- Designed primarily for use in single sideband linear amplifier output applications in citizen's band and other communications equipment operating to 30 MHz.
- Characterized for Single Sideband and Large-Signal Amplifier Applications Utilizing Low-Modulation.
- Specified 13.6 V, 30 MHz Characteristics -
  Output Power = 12 W (PEP)
  Minimum Efficiency = 40% (SSB)
  Output Power = 4.0 W (CW)
  Minimum Efficiency = 50% (CW)
  Minimum Power Gain = 10 dB (PEP & CW)
- Common Collector Characterization

Tektronix Test Equipment

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MRF458 $20.68
NPN SILICON RF POWER TRANSISTOR

- Specified 12.5 Volt, 30 MHz Characteristics -
  Output Power = 80 Watts
  Minimum Gain = 12 dB
  Efficiency = 50%
- Capable of Withstanding 30:1 Load VSWR @ Rated Power and VCC

MHW710 - 2 $46.45
440 to 470 MHz
UHF POWER AMPLIFIER MODULE

- Designed for 12.5 volt UHF power amplifier applications in industrial and commercial FM equipment operating from 400 to 512 MHz.
- Specified 12.5 Volt, UHF Characteristics -
  Output Power = 13 Watts
  Minimum Gain = 19.4 dB
  Harmonics = 40 dB
- 50 Ohm Input/Output Impedance
- Guaranteed Stability and Ruggedness
- Gain Control Pin for Manual or Automatic Output Level Control
- Thin Film Hybrid Construction Gives Consistent Performance and Reliability

Scopes with Plug-ins

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<td>565A</td>
<td>DC to 30MHz Scope with a 20 MHz Dual Trace DC to 37MHz Sampling Plug In and a 377A Sweep Plug In, Rack Mount</td>
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<td>565C</td>
<td>DC to 30MHz Dual Beam Scope with a 2863 Diff. and a 2864 Diff. Plug-In</td>
<td>$900.00</td>
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Tubes

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<td>565C</td>
<td>DC to 30MHz Dual Beam Scope with a 2863 Diff. and a 2864 Diff. Plug-In</td>
<td>$900.00</td>
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<tr>
<td>565D</td>
<td>DC to 30MHz Scope with a 02 Dual Trace High Gain Plug In</td>
<td>$650.00</td>
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NEW — TOLL-FREE NO. 800-528-0180 — please, orders only!
### General Microwave

**Hewlett Packard**

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**RCA**

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**Motorola**

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### Microelectronics

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**Microlab/FXR**

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<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waveguide</td>
<td>75.00</td>
</tr>
</tbody>
</table>

**Narda**

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directional Coupler 2 to 4GHz 10dB Type SMA</td>
<td>25.00</td>
</tr>
</tbody>
</table>

**Computer IC. Specials**

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcomputer</td>
<td>13.80</td>
</tr>
</tbody>
</table>

### Carrier and 800 MHz

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Attenuator 6 to 12GHz</td>
<td>250.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>809A Carriage with a 444A Slotted Line Tuned Detector Probe</td>
<td>175.00</td>
</tr>
</tbody>
</table>

### Merriman

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Attenuator 100 to 200MHz</td>
<td>100.00</td>
</tr>
</tbody>
</table>

### Microelectronics

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Attenuator 0 to 100GHz</td>
<td>125.00</td>
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</table>

### Narda

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
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<tbody>
<tr>
<td>Directional Coupler 2 to 4GHz 10dB Type SMA</td>
<td>25.00</td>
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</table>

### Narda

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Attenuator 100 to 200MHz</td>
<td>100.00</td>
</tr>
</tbody>
</table>

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---

**More Details? CHECK — OFF Page 98**

---

**February 1981**
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- 2 meter drive: 10 W nom.
- Other drive levels available on special order.

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  - Z: 2 Meters
  - 220 MHz
- **Rx Freq.**
  - 146.5
  - 223.5
- **Tx Freq.**
  - 146.5
  - 223.5

**SIMPLEX II (Nat'l SSB Call Freq.)**

- **Rx Freq.**
  - 144.1
  - 220.1
- **Tx Freq.**
  - 144.1
  - 220.1

**REPEATER MODE (2 Meter—600 KHz Offset Required)**

- **Rx Freq.**
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  - 224.94
- **Tx Freq.**
  - 147.34
  - 223.34

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4CX300A
4CX350A

4CX1000
4CX1500
4CX3000
4CX5000

4CX10,000
4CX1500
4CX3000
4CX5000

5CX1500
4-125A
4-400
304TL

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FOR SALE: Icon 5610 with matching supply, manuals and cartons, 3 months old, $685.00 plus shipping. Jim, W1YXW (617) 922-3650.


WANTED: Schematic, power supply, Topaz Hustler C10 XDG-AC, Jack Graham, 5438 Castlecreek, Houston, TX 77053.

ATLAS DD6-C and 350XL Digital Dial/Frequency Counters. $175.00 plus $3.00 UPS. AFCL Stop VFO drift. See June 79 HFL. $95.00 plus $3.00 UPS. Micral Devices, P.O. Box 343, Vista, CA 92083.

AJAX 147 Foot Broadcasting tower complete with guys $2,200.00. Will ship. Heath station SB303 $400.00. HW101 $550.00. Ps303 $100.00. MFJ 520BX processor $50.00. VEGTA, (300) 373-1998.

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HALLICRAFTERS SX-42 receiver 500KC - 110MC $75.00, DuMounth 5890 frequency, deviation meter and signal generator 25-470 KHz $55.00, KX3KT, 2255 Alexander, Los Osos, CA 93402.

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Coming Events

COLORADO: The Grand Mesa Repeater Society’s second annual Western Slope Swapfest on March 7th at the Lincoln Park Barn, 12th and Gunsmoke, Grand Junction, Colorado. 10:00 AM through 4:00 PM. Free admission. Commercial exhibits, flea market, entertainment and prizes. More info: SASE to Larry Brooks, WBEVC, 3183 Bunting Ave., Grand Junction, Colorado 81501. (303) 434-5603.

FLORIDA: The Treasure Coast Hamfest on February 21 and 22 at the Vero Beach Community Center. Admission: $3.00 per family in advance and $4.00 at the door. Talk-in on 146.175 MHz. More info: SASE to Larry Brooks, WBEVC, 3183 Bunting Ave., Grand Junction, Colorado 81501. (303) 434-5603.
OPERATING EVENTS

FEBRUARY 14 and 15 starts off the phone portion of the YL-OM contest. The CW segment will be on February 26 through March 1. Both contests start and end at 1800 UTC. They are to be treated separately and separate logs are to be kept. OM's call "GO YL" and YL's call "GO OM." All logs must show ARRL section or country to qualify and must be signed by the operator. No logs will be returned. Logs must show claimed score and be sent to YLRL Vice President, Kay Eyman, W5GDF, RR #2, Garnett, KS 66032 no later than April 6. Duplicates penalized by the removal of three contacts.

July 25 thru August 7, 1981

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OCTOBER 23, 1980 - OCTOBER 23, 1981: The New Bern Amateur Radio Club is sponsoring "The Swiss Bear Award." This award is given for working three different amateur stations in the New Bern area within the above time period. Extracts from logs for QSO's, along with a SASE or two IRC's for DX stations, should be sent to: New Bern Amateur Radio Club, Inc., P.O. Box 2453, New Bern, NC 28560. Certificate depicting "The Swiss Bear" will be awarded stating that the station has met the requirements for this award.

FEBRUARY 22nd - 28th: The Simon Langton Grammar Schools in Canterbury, England, will be celebrating the 100th anniversary of the founding of the school in 1881. A special events station, active on all HF bands under the call GB4SFL, will be used. It is hoped that many past pupils of the school will be contacted; especially licensed Amateurs now residing in the United States. Anyone interested in making a sked should contact: G4BBW, 40 Virginia Rd., Tankerton, Whitstable, Kent or G3LCK, Simon Langton Grammar School for Boys, Nackersting Rd., Canterbury, Kent, England.

MARCH 14th: The Edison Radio Amateur's Association is celebrating its 40th anniversary by hosting a QSO party. The ERAA group will operate from a commemorative station at "Station A" in Greenfield Village, Dearborn, Michigan. This was Thomas Edison's first power generating station. Contact ERAA and exchange signal reports. QSL with business size SASE and receive a handsome two color certificate to: Detroit Edison Radio Amateur's Association, 2000 Second Ave., Detroit, Michigan 48226.

MARCH 14th: The Playground Amateur Radio Club (PARC) of Fort Walton Beach, Florida, will operate a special event station at the 1981 Boy Scouts of America – Choctawhatchee District Scout Exhibition. PARC members will operate ARS WB4SFU (Scouts For Unity) from 0000 to 2400 hrs UTC, 14 March, 1981 on 14.290 MHz, 21.370 MHz, and 28.600 MHz SSB. A special commemorative QSL card will be sent to those who QSL with a SASE. The QSL manager is PARC, c/o Joe Giangrosso, WDAZG, P.O. Box 3075, Fort Walton Beach, FL 32548.

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More Details? CHECK—OFF Page 98

february 1981
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RM-40S Super resonator, 40 meters, KW, reg. $24.95... 22.46
RM-20 Resonator, 20 meters, 400 watt, reg. $14.95... 13.46
RM-20S Super resonator, 20 meters, KW, reg. $21.95... 19.76
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The computerized TV, stereo, and test equipment you build are not hobby kits or preassembled commercial units with retrofitted lessons. They are designed by NRI engineers and instructors to give you valuable experience as you build them, reinforce theory with practical demonstrations, and end up as fully operable, high-performance units you’ll be proud to have. And only NRI gives you “power-on” training...you introduce and correct problems in live circuits as you learn.

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More Details? CHECK — OFF Page 98

February 1981 / 83
ANTENNAS

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lncludlng 8 BY 8 VERTICAL POL.
144.148 MHz 28
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84 / February 1981

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More Details? CHECK — OFF Page 98

Hatry Electronics
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203-527-1881

Code reading makes ham radio more fun!

Field Day 2

A code reader can add to the fun of ham radio by allowing you to copy many signals that are too complex or too fast to decode by ear. You can get in on such things as news-wire service transmissions, weather information and financial reports that are sent by radioteletype (RTTY), ASCII computer language or Morse code.

Some code readers only copy one or two types of signals, but the Kantronics Field Day 2™ allows you to copy RTTY at 60, 67, 75 and 100 WPM Baud, ASCII at 110 and 300 (if sent as it is typed) WPM Baud and Morse at 3 to 80 WPM.

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Call or visit your Authorized Kantronics Dealer for a demonstration!
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<tr>
<th>State</th>
<th>Company Name</th>
<th>Address</th>
<th>Phone Numbers</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Arizona</td>
<td>Power Communications Corp.</td>
<td>1640 W. Camelback Road, Phoenix, AZ 85015</td>
<td>602-242-6030 or 242-8890</td>
<td>Arizona's #1 &quot;Ham&quot; Store. Canwood, Yaesu, Icom and more.</td>
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<td>213-834-5868</td>
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<td>714-463-1886 San Diego The Home of the One Year Warranty — Parts at Cost — Full Service.</td>
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<td>Quemult Electronics</td>
<td>1000 S. Bascom Avenue, San Jose, CA 95128</td>
<td>408-998-5900</td>
<td>Serving the world's Radio Amateurs since 1933.</td>
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<td>California</td>
<td>Shaver Radio, Inc.</td>
<td>1375 S. Bascom Avenue, San Jose, CA 95128</td>
<td>408-998-1103 Azden, Icom, Kenwood, Tempo, Ten-Tec, Yaesu and many more.</td>
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<td>Connecticut</td>
<td>HATRY Electronics</td>
<td>500 Ledyard St. (South), Hartford, CT 06114</td>
<td>203-527-1881 Connecticut's Oldest Ham Radio Dealer</td>
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<td>813-461-HAMS West Coast's only full service Amateur Radio Store.</td>
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<td>305-573-8363 The place for great dependable names in Ham Radio.</td>
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<td>1415 N. Eagle St, Naperville, IL 60540</td>
<td>312-420-6229 &quot;Amateur Excellence&quot;</td>
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<td>312-363-5181 Outside Illinois — 800-821-5802 Hours: 9:30-5:30 Mon, Tu, Wed &amp; Fri.; 9:30-6:00 Thru, 9:00-3:00 Sat.</td>
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<td>Indiana</td>
<td>Evans Radio, Inc.</td>
<td>Box 893, Rt. 3A Bow Jct, Concord, NH 03301</td>
<td>603-224-9961 Icom, DenTron &amp; Yaesu dealer. We service what we sell.</td>
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COILS FOR HOME BUILT

Coil Spec.

Sardine Sender 80 Meter ORP Rig
GST Oct 78, p. 15

ORP Transmatch 25 Watt Max
ARRL Handbook p. 350

Tune Tin 2-WAS 40 Meter Transmitter
GST May 76, p. 21

Mini Mor's Dream Receiver — GST Sep 76, p. 21
20 Meter Direct Conversion Receiver

GST Apr 78, p. 12
Amplifier for HW-8 ORP Transceiver

GST Apr 79, p. 18
Harmonic Filter (for above) per band

Low Frequency Transmitter — SS Sep 79, p. 23

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Many other interesting coil kits in our new list 5C. You must send a stamped envelope to receive our coil kit list.

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<tr>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>8K x 8 Eprom</td>
<td>$5.00</td>
</tr>
<tr>
<td>6/2516 2K x 8 5V single supply</td>
<td>$9.99</td>
</tr>
<tr>
<td>4/914 1K x 4 Static</td>
<td>$5.00</td>
</tr>
<tr>
<td>7 4K x 1 Dynamic Ram</td>
<td>$2.99</td>
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<tr>
<td>2/114 16K x 1 Dynamic Ram</td>
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<td>2-6 32K Eprom</td>
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1900 MHz to 2500 MHz DOWNCONVERTERS
Intended for amateur radio use.
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3 switch with end plates
$8.99 New $6.95 Used

More Details? CHECK-OFF Page 98
predictions

We are still in the good old winter DX months with February; expect, however, a couple of periods of short-lived geomagnetic disturbances from solar flares about February 19-21 and February 27-March 4. Another longer-lasting period of disturbance may be expected near February 2-6. The best DX periods are probably about February 7-10 and 22-27.

a look at February

February is the month when changes in the ionosphere portend leaving the winter DX conditions of November, December, and January behind. Longer days are beginning to be seen as earlier sunrises and later sunsets in the northern hemisphere. The 10, 15, and 20 meter bands can be expected to open sooner in the morning and stay open longer into the evening. On the 40, 80, and 160 meter bands, which depend on darkness for their openings, the DX hours can be expected to begin to shrink. The DXer’s evening schedule has to wait for sunset. The earlier sunrise decreases the S-meter readings of the long-skip DX, and exchanges it for short skip to the locals. Still, there are many hours in which to take advantage of the superb winter DX.

February is often the month with the highest mean solar radio flux values of the year. This is a long-lasting, averaging effect of the earth’s being closer to the sun this time of year, and the winter months of November, December, and January being geomagnetically the quietest of the year. The combined result is that the ionosphere usually supports the highest daytime high-frequency and vhf DX paths of the year for many of the years of any particular eleven-year solar cycle.

The moon is at periapsis on February 9. An annular eclipse of the sun takes place for our down-under and South-Pacific friends. The annular path (maximum duration is 1 minute 11 seconds) goes from the Island of Tasmania south of Australia at sunrise (1928 UT), then south of New Zealand, and across the South Pacific almost to Peru at sunset (0049 UT). The eclipse will be seen across the east side of Australia, across Antarctica (McMurdo from 2110 to 2220 UT), and from Chile, Argentina, Peru and Central America at its end. All this goes on from February 4 (1928 UT) to 5 (0049 UT).

band-by-band summary

Six meters will open occasionally toward Europe, that is, to the east, before noon, toward the south during noontime to afternoon, and toward the west and northwest in the late afternoon into early evening. The best openings are most likely trans-equatorial during high solar radio flux.

Ten and Fifteen meters will exhibit the same pattern as 6 meters but will be open a longer part of the day. This is particularly true this month since it is nearing springtime with its noticeably longer days and its probably higher maximum usable frequencies from higher solar flux. Short skip (500 to 1500 miles) is part of the fun on these bands, like the lower frequency bands. The short-skip opening pattern, although closer to mid-day, is the same follow-the-sun sequence as mentioned for 6 meters.

Twenty meters is a great band for everyone’s pleasure, limited only by QRM. It should be open nearly every day and late into each evening to almost every part of the world. Best DX conditions can be expected just after sunrise and just before sunset for long skip. Short skip will be essentially as given for 10 and 15 meters, except for longer openings during midday.

Forty meters begins its transition into a night band. Short skip during the daytime in winter, however, gives some interesting opportunities for working your close neighbors for the WAS certificate. Then, at evening time, as the long skip (1000 to 2500 miles) develops, reach out for the far states and the WAC certificate. This band is very active to most areas of the world. In late afternoon the band will open to Europe, then swing around to South Africa and Central and South America, and then swing still farther into the Pacific by dawn.

Eighty and One-Sixty meters DX conditions will be very good this month. Soon the atmospheric noise of the spring storms will give days of short skip QRM and local QRM. On toward summer the static will become so bad that DX will have to be forgotten until fall. Take advantage of what’s left of this year’s quiet winter season. The directional pattern for these bands is similar to that of 40 meters. The low take-off angle of vertical antennas is very useful for DX here. Horizontal antennas are mainly short skip, high take-off-angle radiators because of being so close to the ground. Look for particularly interesting DX as these bands come in (open) near sunset and go out at sunrise.

ham radio
short circuits
regulated power supply
The following corrections should be made to the schematic on page 58 of the September, 1980, issue of *ham radio*: M2 is 0-10 amps dc; C1 is 100 μF; C2 is a 0.01-μF/100-volt disc ceramic; the capacitor at pin 9 of U1 is 500 pF/100V paper/Mylar.

quads and quagis
In W2PV’s quads and quagis article, which appeared in the September, 1980, issue of *ham radio*, fig. 2 on page 38 should be turned 90 degrees to correspond with the caption. On page 45, in the last line of item two in the summary, the ratio should be expressed as width to height (W/H).

measuring inductance
and capacitance
The Ham Notetook item on this subject by W2CHO that appeared on page 68 of the July issue should have included this equation:

\[ LC = \frac{1000}{(2\pi)^2} \left( \frac{1}{f_2} - \frac{1}{f_0} \right) \]

digital logic probe
In fig. 5 of N6UE’s digital logic probe article (August 1980), pin 1 of U1 (not pin 16) goes to VDD. In fig. 6 there should be traces from the emitter of Q1 to ground, from Vcc to the collector of Q2, and from the collector of Q1 to pin 2 of Q2.

CW regenerator
The values of two capacitors are incorrect as printed in W3BYM’s article (October, 1980, *ham radio*). C3 should have a value of 2.2 μF, C4 a value of 1.0 μF.

super quad
The boom pictured in fig. 4 of W3NZ’s article (November, 1980, *ham radio*) should be solid PVC, not PVC tubing.
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- Low impedance, low distortion, adjustable sinewave output, 5v peak-to-peak.
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- Off position for no tone output.
- Reverse polarity protection built-in.

**Group A**

<table>
<thead>
<tr>
<th>Tone</th>
<th>Group</th>
<th>Tone</th>
<th>Group</th>
<th>Tone</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>67.0 XZ</td>
<td>91.5 ZZ</td>
<td>118.8 2B</td>
<td>156.7 5A</td>
<td>156.7 5A</td>
<td></td>
</tr>
<tr>
<td>71.9 XA</td>
<td>94.8 ZA</td>
<td>123.0 3Z</td>
<td>162.2 5B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>74.4 WA</td>
<td>97.4 ZB</td>
<td>127.3 3A</td>
<td>167.9 6Z</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77.0 XB</td>
<td>100.0 1Z</td>
<td>131.8 3B</td>
<td>173.8 6A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79.7 SP</td>
<td>103.5 1A</td>
<td>136.5 4Z</td>
<td>179 9 6B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82.5 YZ</td>
<td>107.2 1B</td>
<td>141.3 4A</td>
<td>186.2 7Z</td>
<td></td>
<td></td>
</tr>
<tr>
<td>85.4 YA</td>
<td>110.9 2Z</td>
<td>146.2 4B</td>
<td>192.8 7A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>88.5 YB</td>
<td>114.8 2A</td>
<td>151.4 5Z</td>
<td>203.5 M1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Frequency accuracy, ± .1 Hz maximum - 40°C to + 85°C
- Frequencies to 250 Hz available on special order
- Continuous tone

**Group B**

<table>
<thead>
<tr>
<th>TEST-TONES:</th>
<th>TOUCH-TONES:</th>
<th>BURST TONES:</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>697 1209</td>
<td>1600 1850 2150 2400</td>
</tr>
<tr>
<td>1000</td>
<td>770 1336</td>
<td>1650 1900 2200 2450</td>
</tr>
<tr>
<td>1500</td>
<td>852 1477</td>
<td>1700 1950 2250 2500</td>
</tr>
<tr>
<td>2175</td>
<td>941 1633</td>
<td>1750 2000 2300 2550</td>
</tr>
<tr>
<td>2805</td>
<td></td>
<td>1800 2100 2350</td>
</tr>
</tbody>
</table>

- Frequency accuracy, ± 1 Hz maximum - 40°C to + 85°C
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