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The code-free license . . . the end of Amateur Radio?

On July 1 the FCC commissioners directed their staff to prepare a Notice of Proposed Rule-Making for a code-free Amateur Radio license. As reported earlier in “Presstop,” the suggested alternatives include deleting the CW requirement for the Technician license and developing a new Digital license, such as the license now in effect in Canada.

Any proposal for a code-free Amateur license always seems to stir strong emotions in the bosoms of U.S. Amateurs. The concept was firmly rejected just a few years ago when Amateur restructuring (Docket 20282) was under consideration. In response to this new proposal, which seems to have strong, important support from within the FCC, the League has already indicated in the July 9 “Directors’ Letter” that it will be taking a firm stand in opposition to any license without a code requirement, based on the ARRL Board action taken at the 1982 Annual Meeting.

Let’s back off a bit and review where Amateur Radio is today and how it got there. When Amateur Radio began, code was a necessity since, with spark gaps and crystal detectors, that was the state of the communications art. Even the development of the vacuum tube and radiotelephony didn’t significantly alter the value of CW for communication since it was so much more efficient in spectrum and power than a-m telephony. But this is 1982, not 1922, and the technology of wireless and Amateur Radio has made incredible advances in those 60 years.

Most Amateur high-frequency voice operation today uses SSB, a spectrum-conserving, power-efficient mode of communications. Non-voice operation, on the other hand, employs radio-teletype, fast/slow scan ATV and facsimile. In addition, the growing popularity of computers is starting to have an impact on Amateur Radio in the newer forms of communications, such as packet radio and spread-spectrum. In light of these developments, is CW still needed for every Amateur Radio license?

Japan has a code-free Amateur license, and as a result it has the largest and fastest growing Amateur population in the world. Japan’s Amateur marketplace has become the healthiest in the world, capable of supporting more companies who produce more new Amateur Radio products than the rest of the world combined. But that’s not why we at ham radio are advocating that we all take an open-minded look at a no-code Amateur license.

The decision to publish this editorial was very difficult. One might easily say that of course we would want a no-code license since the growth in licensed Amateurs would be good for our business. Actually, we did some real soul-searching to absolutely ensure that our decision came truly from our hearts as the best route for Amateur Radio, and was absolutely not made for business considerations. We sincerely believe some form of code-free Amateur license will best serve the long-term interests of all Amateurs and of the Amateur Radio service.

Projections have been made of the great numbers of new licensees that will appear as soon as the no-code policy is adopted. We think this is overstated. Under one proposal currently offered by the FCC, the license candidate is still going to have to pass at least the equivalent of the Technician/General class written exam. For most people this is probably an even greater hurdle than five words per minute of Morse code. This is especially true in light of the new examination proposals discussed in our July editorial. It now appears these will become real possibilities and could largely eliminate the quick and easy type of answer-memorizing license study.

The greatest threat to Amateur Radio in the United States today is not a code-free Amateur license. It is restrictive legislation like that of Burbank, Illinois, discussed in last month’s editorial. It is the encroachment of other services like cable TV, whose continued use of 144 and 220 MHz channels must eventually lead to a confrontation whose outcome is far from clear. It’s even the shifting pattern of housing, with economic considerations putting more and more Amateurs into condominiums and other multiple-family dwellings where the opportunity to put up an antenna or even operate a transmitter is severely restricted.

The FCC has indicated its interest in granting Amateur Radio the strongest voice in licensing procedures and regulations that we’ve ever had. This spring saw a significant change in the upper-echelon leadership at the ARRL. Perhaps the time has come to discard the “what’s good enough for grandpappy is good enough for you” mentality that’s long saddled any discussion of a no-code license, and consider just how such a license could be incorporated into our Amateur structure without cheapening what we’ve got.

A growing Amateur Radio is a strong Amateur Radio, and if CW is indeed scaring off today’s computer-oriented young people, it’s time we did something to bring them back. Remember, a code-free license, whether it’s entry level or only for very limited privileges, would not mean that CW itself — or the requirement that CW be mastered in order to achieve greater operating privileges — need ever change!

Joe Schroeder, W9JUV
associate editor
Skip Tenney, W1NLB
publisher and editor-in-chief

W9JUV and ham radio Publisher W1NLB are both Extra Class licensees, and both spend almost all their low-band operating hours on CW. For the past several years W9JUV’s principle contest activity has been in the various DX contests, using an HW-8 barefoot.
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<tr>
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<td>TR-5 9-band transceiver</td>
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<td>MN-2700 1kW, ant. tuner</td>
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<td>MW-7 200W, ant. tuner</td>
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<td>AK-75 Multiband antenna</td>
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<td>Service manuals for TR-5, TR-7A &amp; R-7A</td>
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<td>1982 World Radio/TV Handbook</td>
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<td>Satellite TV Products:</td>
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September 1982
and research people. I am continually amazed by his ability to refresh and renew, with a dash of humor and wit, my understanding of topics I had long lost a grasp of, or failed to follow, since the pre-transistor days when I first became an Amateur.

Thanks for his imaginative time-flight into Amateur Radio, circa 2015, A.D. (ham radio, May, 1982). I didn’t know whether to laugh or cry; I did both!

Best wishes to W6SAI and ham radio, always. I hope Bill Orr will be writing for you right through 2015!

Marty Wincott, K2BRY
Harrison, New York

inductance meter

Dear HR:

I constructed Ed Marriner’s (W6XM’s) inductance meter (ham radio, April, 1982) using parts that I had on hand. Here are two changes I made that others who build this unit might be interested in.

I used a PNP transistor in the tuned stage so that the tuning capacitors would be at ground and it wouldn’t be necessary to insulate it from the chassis. The emitter was returned to +12 volts through 390 ohms and the collector through the tuned circuit to ground. The bias resistors were also reversed.

I needed more sensitivity with my transistors for the metering circuit to work, so I added a 27k resistor from +12 to the base of the metering circuit transistor.

Norman R. Fisher, WB2LAO
Tuckerton, New Jersey

for the blind ham

Dear HR:

The Smith-Kettlewell Technical File is a technical journal aimed specifically at the blind and visually impaired Amateur, hobbyist, student, and professional. It’s available quarterly at low cost in Braille, large print, and in Talking Book form.

The purpose of the Smith-Kettlewell Technical File is to provide access to state of the art devices, circuits, and techniques for the visually handicapped. It typically includes articles on soldering and construction techniques, IC pin diagrams and application notes, the design of practical aids and the adaptation of test equipment, and bibliographies of technical materials.

The first issue is free. Contact William A. Gerrey, editor, Smith-Kettlewell Institute of Visual Sciences, 2232 Webster Street, San Francisco, California 94115; telephone 415-561-1619.

Bill Gerrey
Editor, S-K Technical File

Also of interest to the blind Amateur may be the Braille DX Service. Contact them at 8347 West 6th Avenue, Lakewood, Colorado 80215. Editor
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More Details? CHECK — OFF Page 94
A CODE-FREE U.S. AMATEUR LICENSE NOW SEEMS ALMOST CERTAIN, with the FCC staff instructed by the Commissioners July 1 to prepare a Notice of Proposed Rule Making for release later this year. Several alternatives will probably be offered in the NPRM, but the one that seems to have the strongest Commission support is to simply drop the CW requirement from the Technician Class and make it the "Code-Free" license. 

Though A Codeless License Is Drawing Increasing support from the Amateur community, the ARRL has already stated its complete opposition to eliminating the CW requirement. 

ARRL WILL SUPPORT THE BURBANK (ILLINOIS) LAWSUIT, discussed in last month's "Observations and Opinion." In a special July 9 meeting, the Executive Committee authorized the expenditure of up to $7500 of League funds to fight the anti-tower and RFI legislation.

The Suit Should Be Filed during August in the U.S. District Court for the Northern District of Illinois, and will seek injunctive relief against enforcement of the ordinance and a declaratory judgment that it is unconstitutional. Constitutional challenges will include the violation of the Amateur and CB operators' right to communicate, intrusion into areas reserved for the Federal government, and violation of due process and equal protection under the law, since it applies only to Amateur and CB antennas.

Despite The ARRL Contribution And Substantial Donations from area clubs and individual amateurs, additional funding will almost surely be required before this battle is resolved. Contributions to the Burbank Tower Fund can go to Fund Chairman WA9EKA.

420-435 MHZ SHARED USED BY COMMERCIAL RADIOLOCATION WAS AUTHORIZED by the FCC July 22. Meeting on General Docket 80-135, the Commissioners authorized Del Norte Communications to operate spread-spectrum radio-location throughout the continental U.S. and Alaska, on a non-interference basis. Amateur objections to the original proposal, the FCC limited Del Norte to spread-spectrum for all its inland operations, and its transmitters must identify periodically by sending "DN" in Morse Code in such a way that it can be copied on a conventional receiver.

Permitting Del Norte On 420-435 MHz Is Not All Bad; Land Mobile has had designs on that part of the spectrum for some time, and the Commission decision to put radio-location there on a shared basis should protect it from complete loss to Amateurs, as in Canada.

Further Power Limits On 420-450 MHz Amateur Operations near certain military installations have been announced by the FCC in an unrelated action. Effective August 16, 1982, Amateurs within a 100-mile radius of Otis AFB, Massachusetts, Elmendorf AFB, Alaska, and Grand Forks AFB, North Dakota, are limited to 50 watts ERP. The same power limit applies to Amateurs within a 150-mile radius of Beale AFB, California.

A NEW LEAGUE NEWSLETTER WAS JUST ONE of several significant developments to come out of the ARRL July Board meeting in Cedar Rapids. The new publication, which will replace the present "Directors' Letter," will be a bi-weekly that will not only be distributed free to League officials and appointees, but will also be available on a subscription basis to members. Unlike other Amateur Radio newsletters, the ARRL offering will be primarily oriented toward League matters and concerns rather than toward Amateur Radio in general. The initial issue should be published before the end of the year.

New Ad Hoc Committees Were Also Established by the Board to deal with Washington representation, strengthening the CRRL, the Intruder Watch program, and future Amateur volunteer monitoring and exam programs.

An Informal, Off-The-Record meeting with Personal Radio Bureau Chief Jim McKinney was another highlight of the Board's weekend. Although reports of the session are not available, it's certain that the no-code license and similar topics got a thorough going over.

SIX MONTHS IN PRISON PLUS FIVE YEARS PROBATION with 1500 hours of community service was the sentence meted out June 28 to Richard Burton, ex-WR6JAC, by U.S. District Court Judge Manual Real. Burton was convicted June 8 of continuing to operate his Amateur station despite having lost his license a year ago for jamming and indecent language violations. Judge Real had ordered Burton to start serving his sentence immediately, but another judge has since permitted his release on bond pending possible appeal.

NEW METHODS OF SPECIFYING AMATEUR POWER LIMITS are to be proposed in a Notice of Proposed Rule Making that should be released in August. The NPRM, believed to be about ready for presentation to the Commissioners at presstime, will recommend changing the traditional power input limits to power output limitations.

What Output Level Will Actually Be Recommended is still to be decided.

NEW THIRD-PARTY TRAFFIC AGREEMENTS ARE NOW IN EFFECT between the U.S. and Australia, Antigua, and St. Lucia. In addition, the FCC has announced that a reciprocal licensing agreement has been signed with Belize.

THE UOSAT AMATEUR SCIENTIFIC SATELLITE IS STILL LOCKED UP by the inadvertent simultaneous activation of both beacons. New efforts to overcome the resulting receiver desensitizing and command it back into proper operation are under way in California, where SSB diode 4' foot parabola has been brought out of retirement. Its 430MHz gain is 42 dBi, yielding an incredible 12 megawatt ERP when driven with 750 watts of rf!
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**ATR-6800 vs ACT-1**

The most often asked question we hear is "What's the difference between the ATR & the ACT-1?" The ACT-1 is a dedicated system for RTTY/CW/SSTV. It provides all the features and functions you need for a multi-mode station. Along with this superior "ON-THE-AIR" performance, the ATR-6800 extends your operation into the realm of automatic station control and computer programming. Plug-in applications modules expand the ATR's memory to add new HAM oriented programs which are enabled by simple keyboard commands. By adding the BASIC option package, you'll have programmed full community mailbox, contest dupe sheet, personal station log, message editor, BASIC computer language and 16k of battery-backed (non-volatile) memory. We also provide a subroutine list so that you can write programs to directly control the ATR-6800 in easy to use BASIC language. The ATR-6800 then is the expandable, "do everything" system where your imagination is the only limit! The ACT-1 is designed for the HAM who needs the essentials of a complete video system for digital communications.

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folded umbrella
top loaded
vertical antenna

Design data for
operation on 160 meters
— adaptable to any band

Interest in the 160-meter band has traditionally been limited to a persevering few who delight in the technical challenge of working DX on this “top band” — almost to the exclusion of operation on the other bands. The antenna requirements and the lack of suitable equipment have, to some extent, restricted operations on this band. For example, until recently, few transceivers tuned to the 160-meter band, and most antenna tuners would not tune to this band. Today, however, nearly every manufacturer of Amateur Radio equipment has one or more transceivers that tune to 160.

Popular antennas for the 160-meter band are various versions of wire radiators. For example, the series of articles by Bob Eldridge describes a double-size G5RV antenna and the G8ON antenna, which is an up-over-down-and-back version of the former. This latter description gives some insight into the problem. Most wire antennas are also too close to the ground to provide good low-angle radiation, and the construction of an efficient vertical antenna for DX is considered by most to be out of reach. A quarter-wave tower antenna would be 125 feet (38 meters) high at 1.815 MHz, which is higher than most Amateurs care to go, and a 5/8-wavelength antenna (an ideal DX antenna) would be 309 feet (94 meters) high.

Practical considerations with regard to height and size usually mean that some form of capacitive top loading must be used to limit the height of the

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antenna. The *ARRL Antenna Handbook* illustrates several methods to realize practical 160-meter antennas; grounded towers supporting plumber's-delight (grounded) beam antennas can be shunt fed for 160-meter operations as described by True. In fact this is probably the easiest way to achieve satisfactory operation on this band. Various methods of constructing and feeding 160-meter antennas have been described by Booth.

One of those briefly discussed in the *Antenna Handbook* was the umbrella top-loaded vertical radiator. The umbrella antenna is more economical than the T- or L-type radiators because, for the same performance, it uses only one mast. The other types require two. A further simplification is obtained by folding the vertical element to raise its impedance to that required by the feedline which, if the antenna is resonant, can be connected directly to the transmission line without the need of a matching circuit.

While such an antenna is used for fixed point-to-point communications and for broadcasting (Nolan), it is virtually unknown to Radio Amateurs. Furthermore, published information on the umbrella antenna does not give curves that are useful for design. This article explains how to design an umbrella antenna, and it will be shown that a mast height of about 1/10 wavelength (54 feet, or 16.5 meters at 1.815 kHz) can be designed for a radiation efficiency of 70 percent or better, and bandwidth of 200 kHz or less.

### the umbrella antenna

The umbrella top-loaded antenna is illustrated in fig. 1A. The top loading consists of a number of wires strung obliquely to ground from the top of the radiator, and insulated from the ground. The important parameters for such an antenna are the height, $h$, of the radiator, the horizontal distance, $d$, from the base of the radiator to the extremities of the guys supporting the umbrella wires, and the vertical distance, $s$, from the top of the tower to the height at which the umbrella wires are broken by an insulator. This antenna was first used by Smith and Johnson in 1947. It was investigated experimentally by Belrose, et al; and by Gangi, et al. These authors, along with Smeby, examined the antenna theoretically. Smith and Graf have experimentally investigated umbrella antennas using multiwire rib construction, which is particularly applicable for very short antennas at VLF.

The sketches in figs. 1A, B, and C show by the direction of the arrows the phasing of the currents on the umbrella top-loaded vertical, the T-, and the L-type antennas thus illustrating the difference be-
between these types of radiators. In the case of the T- and L-type radiator, the currents on the flat top and the vertical part of the radiator do not interfere, since these currents are orthogonal to each other in space. Recall that only the currents on the vertical part of the radiator contribute appreciably to the radiation. The currents on the flap top and the image of the flat top in the ground plane are in phase opposition and essentially cancel insofar as radiation is concerned, whereas the currents on the vertical part of the radiator and its image are in phase. However, the current on the umbrella wires have a vertical component that is oppositely directed to the current on the tower; therefore, the radiation from the top part of the tower over the distance $s$ and that from the umbrella wires partially cancel.

If there are many umbrella wires, the current on the top part of the tower over the distance $s$ is essentially "screened." Thus, as the length of the umbrella wires is increased, the radiation resistance first increases due to the increased current area on the tower, then it decreases. The maximum in radiation resistance occurs for $s/h = 0.43$ for umbrella antennas operated on frequencies equal to or less than the fundamental frequency of the antenna. For resonant antennas $s/h_0$ can be adjusted such that the tower height, $h = h_0/\lambda_0$, is resonant at the operating wavelength, $\lambda_0$.

While these considerations seem to be fairly straightforward, and, although many measurements have been made on short umbrella antennas, insufficient attention was paid to operation at frequencies near the fundamental frequency of the antenna, which is the desirable situation at low and medium frequencies. The author and a colleague in 1970 therefore decided to make an extensive study of the umbrella antenna by modeling, supplemented by measuring the field radiated from full-size low-frequency antennas. The curves presented here, which have not so far been published, summarize the observational data in a very compact way, make clear the performance of the umbrella antenna, and simplify its design.

**Experimental Setup**

The umbrella antenna was modeled as follows. The tower was 1/4-inch (0.6 mm) square aluminum rod 30 inches (76 cm) long. The umbrella wires were No. 24 (0.5 mm) wire. Dimension $d/h$ was fixed and equal to 1.4 (42 inches, or 107 cm for the model). It is clear that $d$ should be as large as possible for maximum top loading, since as $d$ becomes large, the umbrella antenna becomes more like a disk top-loaded radiator. The dimension $d/h = 1.4$ is considered to be a practical design.

The fundamental frequency (for quarter-wave resonance) of the tower alone was measured to be 90.6 MHz. That is, the physical length of the monopole was 82.8 degrees. Laport gives $H(\lambda/4) = 84$ degrees for a vertical antenna where $h/2a = 107$ ($a$ is the effective radius of the tower).

The model antenna (fig. 2) was mounted at the center of a 20-foot (6-meter) diameter hexagonal shaped ground plane, which was elevated so that the impedance measuring equipment, a Hewlett Packard vector impedance meter, model 4815A, could be connected directly to the antenna base from beneath the ground plane. A Hewlett Packard frequency counter, model 5247M, was used so that the frequency could be measured accurately.

Several umbrella antenna configurations were constructed full size and the radiation resistance at low frequency was deduced from field strength measurements. A Stoddard model NM-12AT field-strength meter was used. Field strength measurements were made at eight sites in the distance range 3-22 km so that ground loss and site errors could be accounted for. From these measured field strengths
the radiation resistance, $R_r$, was determined. Using the appropriate radiation resistance together with the measured model antenna resistance, $R_m$, the ground loss resistance, $R_g$, could be estimated. Recall that $R_g = R_r + R_m$. For the model at the frequencies of the measurement, $R_g$ was about 3/4 ohms.

**Experimental results**

Antenna impedances for the model were measured over a range of frequencies up to and above the fundamental frequency of the antenna (2-100 MHz) for a) no top loading, b) various amounts of top loading, $s/h = 0.43$, 0.57 and 0.71; and c) numbers of umbrella wires, $n = 8$, 16, and 24, both skirted and not skirted. Graphs summarizing the results of the measurements are given in figs. 3 through 6.

The curves in fig. 3 give the size of the umbrella hat, as measured by the parameter $s/h_o$, necessary to resonate the antenna of height $h_o$. That is, $h_o$ is the height of antenna, which together with umbrella top-loading $s/h_o$, resonates at $\lambda_o$. Naturally as the height of the radiator increases, less and less top loading is required for resonance, until $h_o/\tau_o = 0.23$ is reached when the antenna is quarter-wave resonant with no top loading ($s/h_o = 0$). The effect of skirting the umbrella wires can also be seen in this figure, which is equivalent to increasing the number of umbrella wires. According to these data, 8, 16, and 24 wires skirted are approximately equivalent to 21, 33, and 40 umbrella wires without a skirt.

The curves in fig. 4 show how the radiation resistance, $R_r$, with top loading adjusted for resonance, increases with decrease in top loading and increase in $h$; that is, decreases in $s/h_o$. As expected, when the top loading decreases to zero or $s/h_o = 0$, $R_r$ is the radiation resistance of a quarter-wave monopole, or 35.5 ohms according to our measurements.

If the realizable antenna height is shorter than that can be resonated with optimum top loading; that is, $s/h_o = 0.43$ (for the case where eight umbrella wires are used), the antenna will be capacitively reactive. The curves in fig. 5 show how the antenna reactance $-jX_a$ increases as the frequency decreases below the resonant frequency, $f_o$. Since frequency and height scale directly, this graph can also be used to estimate the reactance for an antenna of height $h$ less than $h_o$ for which the antenna is resonant. The graph also gives the reactance for a tower antenna with no top loading ($h/2a = 107$).

The radiation resistance for antenna shorter than that for resonance is calculated according to

$$R_r = R_r(h_o) \left( \frac{h}{h_o} \right)^2$$

(1)

where $h$ is the height of the umbrella antenna and $h_o$ is the height required for resonance.

The curves in fig. 6 show how the antenna Q-factor increases with increase in top loading; that is, with increase in $s/h_o$. The curves apply to resonant antenna conditions. The antenna Q-factor can be estimated for full-scale antennas where the ground loss resistance is more than 3/4 ohm from the ratio

$$Q_a = Q_{model} \left( \frac{R_{a \, model}}{R_{a \, full \, scale}} \right)$$

(2)
I. ANTENNA FACTOR

Fig. 6. Antenna Q factor, as deduced from the bandwidth of the antenna, versus \( \frac{s}{h} \), as a function of number of umbrella wires (for resonant antennas).

**design examples**

**Resonant antenna.** The following considers the design, step-by-step, for a 160-meter antenna

\[
\begin{align*}
  f_o &= 1.815 \text{ MHz} \\
  \lambda_o &= \frac{984}{1.815} = 542.1 \text{ feet (163 meters)}
\end{align*}
\]

For \( \frac{s}{h} = 0.43 \), from fig. 3, for an antenna employing eight radials

\[
\frac{h_o}{\lambda_o} = 0.1
\]

or

\[
\frac{h_o}{\lambda_o} = 0.1 (542.1) = 54 \text{ feet (16.5 meters)}
\]

Suppose we choose a tower having a nominal height of 56 feet (17 meters), comprising seven sections 8 feet (2.4 meters) long. If the tower sections overlap by 4.25 inches (11 cm) the actual height is approximately 54 feet (16.5 meters). Since

\[
\frac{d}{h} = 1.4
\]

\[
d = 75.6 \text{ feet (23 meters)}
\]

According to fig. 4, the radiation resistance, \( R_r \), is 6.75 ohms. If ground loss resistance \( R_g \) is 5 ohms, the radiation efficiency \( \eta \) is

\[
\eta = \frac{R_r(100)}{R_r + R_g + R_c}
\]

\[
= \frac{6.75(100)}{6.75 + 5 + 0} = 57 \text{ percent}
\]

Note that \( R_c \), the coil tuning loss, is zero since the antenna is resonant.

The antenna Q factor is given in fig. 6. \( Q_{\text{model}} = 20 \), and using eq. 2

\[
Q_a = \frac{20(7.5)}{11.75} = 12.8
\]

and the antenna bandwidth is

\[
BW = \frac{2f_o}{Q} = \frac{(2)(1815)}{12.8} = 283 \text{ kHz}
\]

The factor of 2 accounts for the fact that the antenna bandwidth is doubled when driven by a transmitter that is matched to the load.

**Folded umbrella antenna.** A further simplification can be obtained by folding the vertical element to raise its impedance to the value required by the feeder. The latter may then be connected directly to the antenna without the need for a matching unit. The mast is grounded at the base (see sketch in fig. 1D), and a cage of wires surrounds the tower, connected to the top and insulated at the bottom. The feeder is connected directly to the bottom of this cage of wires supporting the mast and a skirt wire joins their ends.

Four or more wires in the cage will be needed. The antenna must first be made self-resonant; that is, the capacitance of the umbrella top must tune with the inductance of the mast and the cage of wires in parallel. This will require slightly more top loading than discussed above. The input impedance (base of mast insulated), which was estimated above to be about 11.75 ohms, will then be raised by about a factor of four to 47 ohms.

**Antenna shorter than resonance.** To illustrate use of the curves, suppose we design an antenna of height \( h \) that is shorter than that required for resonance \( h_o \). If the height of the tower is, say, 30 feet (9 meters), then

\[
\frac{h}{\lambda_o} = \frac{30}{542.1} = 0.055
\]

(in metric terms, \( \frac{h}{\lambda_o} = \frac{9}{165} = 0.05 \))

For eight umbrella wires, and \( \frac{s}{h} = 0.43 \), see above, \( \frac{h_o}{\lambda_o} = 0.1 \). Therefore, \( \frac{h}{h_o} = \frac{0.055}{0.1} = 0.55 \)

and, according to fig. 5,

\[
X_a = -j215 \text{ ohms}
\]

The radiation resistance is

\[
R_r = \frac{R_r(h_o)}{\left(\frac{h}{h_o}\right)^2} = 6.75(0.55)^2 = 2 \text{ ohms}
\]

*We could decide to use longer umbrella wires; that is, \( \frac{h}{h_o} > 0.43 \) or use more of them.
For a tuning coil $Q$ factor of 300,$$ R_c = \frac{215}{300} = 0.72 \text{ ohm} $$
and the radiation efficiency is
$$ \eta = \frac{\frac{2(100)}{2 + 3 + 0.72}}{\frac{2}{3} + 0.72} = 35 \text{ percent} $$
The antenna $Q$ factor is
$$ Q = \frac{X_a}{R_a} = \frac{215}{5.72} = 37 $$
and the antenna bandwidth is
$$ BW = \frac{f_o}{Q} = \frac{2(1815)}{37} = 96 \text{ kHz} $$

ground-screen requirements

As with all short antennas, a radial wire ground screen must be used to realize high radiation efficiency. For a ground loss resistance of 5 ohms, we estimate, (fig. 7) that a ground system of at least ten radial wires would be needed, and these wires should be one-quarter to one-half wavelength long (typically broadcasters employ radial wires 0.412 wavelength long). Note the rather unusual scale in fig. 7; this is because $R_g \propto \frac{1}{n}$, where $n =$ number of radials, and $R_g$ has been plotted versus $\frac{1}{n}$. In fact $R_g$ is inversely proportional to the total length of wire employed in the radial ground screen. The more wire that is buried, the lower the ground loss resistance, but there is little point to increasing the number of radial wires to more than 120 or their length to greater than one-half wavelength.

concluding remarks

Design data have been presented for umbrella-type top-loaded vertical antennas for operation on 160 meters. The various curves are plotted as ratios of the height of the antenna to the wavelength and therefore can be used to design such antennas for any frequency. The 54-foot (16.5-meter) high umbrella antenna at 1.815 MHz would be 26 feet (8 meters) high at 3.8 MHz, 14 feet (4.3 meters) high at 7.2 MHz, and 7 feet (2 meters) high at 14.2 MHz. In addition I have shown how to feed a grounded tower vertical radiator — a method that does not seem to have been used by Radio Amateurs. Shunt-fed or gamma-matched grounded towers have been used, but difficulty has been experienced in exciting a "fat" tower employing a "thin" gamma-match element. Besides, the folded unipole type of feed increases the bandwidth over the conventional base-fed radiator; whereas gamma matching introduces additional reactances (the inductance of the gamma section and the capacitances of the tuning and matching elements), which reduce the bandwidth of the radiator.

The radiation from the antenna system, of course, requires a return current flow in the tower. Therefore the tower sections must be carefully bonded by jumper straps if the tower is painted, and a good connection to the ground system must be made at the base of the tower. Adequate insulation must be used, especially at the ends of the active guys.

acknowledgments

Thanks are due to Mr. John A. Orosz, formerly of CRC, who meticulously made the model measurements for this study.

references

efficiency of short antennas

Some unsettling facts about power radiated from short antennas

Because of space limitations, many of us often must use antennas that are shorter than free-space resonant size. This happens, naturally, most often on the lower frequencies, and it's almost a universal practice in high-frequency mobile installations. How efficient are these antennas? That depends on many things, but there are ways to measure the efficiency of your antenna. In this article, we will examine the resistance method of determining antenna efficiency. You might be surprised at the results of such a test on your antenna system.

antenna or antenna system?

We can speak of the efficiency of the antenna itself, or we can speak of the efficiency of the entire antenna system. The latter includes not only the actual radiator, but also the feed line, the transmatch (if any), and the transmitter tank circuit components. In either case, efficiency refers to that percentage of the applied power that is actually radiated into space.

For our purposes, when speaking of efficiency, we will be talking about the efficiency of the antenna only. Losses may occur in the antenna conductors, splices in the conductors, loading coils, or the surrounding earth and terrain in general. The object, of course, is to minimize such losses.

radiation resistance

Once an antenna radiates energy, that energy is gone forever: it never comes back. When a resistor dissipates energy, that is also gone forever; in fact, to a transmitting system, radiation is just the same as dissipation. Radiation of energy by an antenna appears to occur across certain values of resistance.

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Replacing an antenna with the correct value of resistor allows the transmitting system to perform normally, and in precisely the same way it would with the antenna. The value of this resistance depends on certain characteristics of the antenna, but it is primarily a function of the physical size of the antenna. This property is called the radiation resistance.

For vertical antennas, the radiation resistance is a direct function of the height in wavelengths. Fig. 1 illustrates this function. For a center-fed antenna in free space, the radiation resistance versus length is shown in Fig. 2. A dipole (center-fed) antenna acts like two vertical antennas operating in series; note that a dipole whose overall length is x wavelength has twice the radiation resistance of a vertical whose height is x/2 wavelength.

**reactance**

An antenna is resonant if and only if there is no reactance at the operating frequency. Although resonance is a desirable condition from the standpoint of impedance matching, it is not necessary. Many antennas are not resonant yet still function well. The antenna system, however, should always be resonant at the operating frequency in order for the transmitter to deliver the maximum energy into it.

When a vertical antenna is physically shorter than 1/4 wavelength in free space, or a dipole is shorter than 1/2 wavelength, it is necessary to put loading coils in series with the radiator in order to obtain resonance. The shorter the antenna is at a given frequency, the larger the inductor must be. It is possible, theoretically, to make an antenna resonant no matter how short it is.

When a vertical antenna is physically longer than 1/4 wavelength, or a dipole is longer than 1/2 wavelength, it is necessary to use series capacitors to get resonance. This can be done up to any length.

In both of the above-mentioned cases, the coils and capacitors serve to get rid of the reactance in the antenna system. A short antenna is capacitively reactive and needs an inductor to cancel the reactance; a long antenna is inductively reactive and requires a capacitor to cancel the reactance. Short antennas are far more common than long ones, and thus inductive loading is seen much more often than capacitive loading.

Unfortunately, coils always have a certain amount of loss resistance. When we use an inductor in a short antenna to get rid of the reactance, we are left with a pure resistance. But this resistance is not just radiation resistance; some of it is loss caused by the coil. And of course, all the other loss resistances, such as conductor and earth losses, are still in the cir-

**fig. 1.** Radiation resistance of a vertical antenna in terms of its height in wavelengths. This graph is valid only for antennas without parasitic or phased elements.

**fig. 2.** Radiation resistance of a center-fed dipole antenna in terms of its overall length in wavelengths. This graph is valid only for antennas without parasitic or phased elements.

*That is, for a given inductor position in the radiating element. For a given antenna length and frequency, the amount of inductance required gets larger as the coil is moved toward the end of the radiator.
cuit. The pure resistance consists of two components, then: the radiation resistance, denoted by \( R_R \), and the loss resistance, denoted by \( R_L \).

**Loss resistance**

The total resistance of the antenna is

\[
R_T = R_R + R_L
\]

because \( R_R \) and \( R_L \) are effectively in series. The value of \( R_R \) is a function of the physical length of the antenna, and thus a constant for a given antenna. Loss resistance, \( R_L \), is a variable; it can be minimized by using a radial or ground screen system, large-diameter conductors, low-loss coils, and the like. Of course, the objective is to minimize \( R_L \).

At resonance, the impedance of the antenna is purely resistive, and has a value of \( R_T \). If the line has a characteristic impedance of \( Z_0 \), then

\[
\text{SWR} = Z_0/R_T \text{ if } Z_0 \geq R_T, \text{ and}
\]

\[
\text{SWR} = R_T/Z_0 \text{ if } Z_0 \leq R_T
\]

Oddly enough, it is often true that the higher the efficiency of the antenna, the higher the SWR. Quite often, a low SWR with a short antenna is an indicator of terrible efficiency! Thus, we can get a very close approximation of the efficiency of an antenna by simply measuring its resistance at resonance. To do this, you need an impedance bridge.* Obtaining \( R_T \) in this way, and knowing \( R_R \) from fig. 1 or fig. 2, the efficiency of the antenna is approximately

\[
\text{efficiency (percent)} = 100 \frac{R_R}{R_T}
\]

Only the energy delivered to \( R_R \), the radiation resistance, is radiated; that delivered to \( R_L \) is lost. The loss resistance is concentrated mainly in the loading coil and the earth near the antenna. Sometimes we cannot install a ground radial system — for example, in a mobile installation. We can make the coil only so big before it gets excessively bulky. Thus, the efficiency of a short antenna is limited by practical considerations.

**No impedance bridge?**

You most probably have an SWR meter, but chances are you do not have an impedance bridge. You can still measure the efficiency of a short antenna, in most cases, using only an SWR indicator, because it is much more likely that \( R_T \leq Z_0 \), when the antenna is short, than vice-versa. (There is a limit to how lossy even the worst installation can be!) Thus

\[
\text{SWR} = Z_0/R_T; \quad R_T = Z_0/\text{SWR}
\]

Determining \( R_R \) from fig. 1 or fig. 2, we can calculate the efficiency as before.

For longer antennas (verticals over 1/4 wavelength high or dipoles longer than 1/2 wavelength), it is quite possible that \( R_T \) will be larger than the line \( Z_0 \). Unfortunately, using just an SWR meter, we have no way of knowing whether \( R_T \) is larger or smaller than \( Z_0 \), except by using intuition. So it is definitely best to use an impedance bridge, if possible, for measuring efficiency. The impedance bridge or SWR meter should, of course, be placed at the point where the line feeds the antenna. Placing the instrument at any other point will cause false readings.*

**Practical examples**

Suppose we have a 40-meter vertical, ground-mounted, and 14 feet (4.3 meters) high with a loading coil at the center, as shown in fig. 3. We have managed to install several radials, and measure the SWR at the feed point as 1.0 at resonance. (Resonance is indicated by the frequency where the SWR is minimum, for all practical purposes.)

At 7 MHz, a free-space wavelength is given by

\[
\text{length (feet)} = \frac{984}{7} = 140.6, \text{ or}
\]

\[
\text{length (meters)} = \frac{300}{7} = 43
\]

and thus 14 feet (4.3 meters) represents about 0.1 wavelength. From fig. 1, the value of the radiation resistance, \( R_R \), is approximately 4 ohms.

Since the SWR is 1.0, the value of \( R_T \) must be equal to the line impedance, which is 50 ohms. Consequently,

\[
\text{efficiency (percent)} = 100 \times \frac{4}{50} = 8
\]

That’s correct. Eight percent!

If the antenna were one-hundred percent efficient, \( R_T \) would be equal to \( R_R \), which is 4 ohms. Then the SWR would be 50/4, or 12.5!

To illustrate another example, suppose we have a 75-meter mobile antenna that displays an SWR of 2 at resonance, using no matching transformers of any kind. If this antenna is 8 feet (2.4 meters) high at 3.875 MHz, it is a paltry 0.03 wavelength high. In fig. 1.

*An impedance bridge is a more sophisticated device than the common SWR bridge. An impedance bridge shows the values of reactance and radiation resistance in an antenna system.

*If an SWR meter is used, the SWR seems to get smaller (closer to 1) as the instrument is moved away from the antenna. If an impedance bridge is used, reactance will be introduced when the instrument is not at the feed point, unless the match happens to be perfect \( R_T = Z_0 \).
that is just about off the chart; $R_L$ is roughly 1 ohm.

Since the SWR is 2, we may assume that $R_T = 50/2 = 25$. So

$$\text{efficiency (percent)} = 100 \times \frac{1}{25} = 4$$

It is possible (though not likely) that $R_T$ is twice $Z_0$, or 100 ohms; then

$$\text{efficiency (percent)} = 100 \times \frac{1}{100} = 1$$

We would need an impedance bridge to be certain.

**Conclusion**

These results may, in fact should be, unsettling. Short antennas generally are not efficient ones. This is especially true for vertical antennas over less-than-resonance. This, however, can be alleviated by using matching networks. If the feed line is short, the matching network can be placed at the transmitter for convenience, since the SWR loss will be rather small in a short run of cable. If the feed line is long or the SWR is extremely high, you would do better to put the matching device at the antenna feed point. Broadbanded matching transformers are available for this purpose.

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More Details? CHECK — OFF Page 94
Digital techniques: inside a phase-frequency detector

Widespread use of phase-lock techniques for Amateur frequency control has increased digital circuitry in receivers and transmitters. The heart of a phase-locked loop (PLL) is the phase detector and this article examines one specific device: The Motorola MC4044 phase-frequency detector.

Each PLL should have a phase detector with linear phase response greater than ±180 degrees and, for lock-in purposes, hold at maximum or minimum output until the controlled frequency comes within phase of the reference. The phase-frequency detector digital section of the MC4044 in fig. 1 does this well. The gate arrangement allows it to be duplicated by three conventional gate packages.1 The circuit can be duplicated in any digital family.

The MC4044 has TTL input/output and includes a “charge pump,” or time-to-capacitor-charge converter. Digital output is a pulse width proportional to phase so a summing integrator can substitute for the charge pump. Either is part of the loop filter block in fig. 2A. Transfer characteristics of both phase detector and loop filter are shown in fig. 2B. Emphasis will be on the digital portion.

inputs, outputs and the stable state

Gate identification is arbitrarily alphabetical since only NAND gates are involved. Reference frequency is designated R and VCO or divided VCO input is S for signal. Phase detection takes place only on negative-going transitions of R and S.

Phase-proportional output is the low state time of gate B (LAG) or gate D (LEAD). Lead and lag is defined as S phase relative to reference R. Gate arrangement symmetry requires the output designations positioned relative to the particular inputs.

Gate states are stable when both inputs are high, or Logic 1, and gates A, C, F, and H are low, or Logic 0. This can be seen in the time-start of timing diagram in fig. 3. Outputs (gates B and D) will remain high; no phase has been detected at time-start.

By Leonard H. Anderson, 10048 Lanark Street, Sun Valley, California 91352
If the stable condition seems confusing, work it out on scratch paper using the "NAND Rule" given in previous articles of this series: Any low input will make the output high; all inputs must be high to make the output low.*

fig. 1. NAND gate array of the Motorola MC4344/MC4044 phase-frequency detector, digital section only. See text and timing diagrams for gate identification.

A rather complex flip-flop

The amount of gate feedback requires "walking through" the circuit in time, always remembering that every gate takes a finite amount of time to change state (propagation delay). Fig. 3 is used for starters with an assumed signal lag. It should be noted that all timing diagrams have exaggerated gate delays for illustration only.

Reference R goes low. Gate A output goes high from the NAND Rule. Gate B goes low since all its inputs are now high and this reinforces holding A low. Gate E doesn't change since it was already held high by F.

Signal S now drops low, C goes high, then D goes low, all similar to R, A, and B. The difference is that all inputs of gate J are now high; E and G were stable.

fig. 3. Timing diagram of phase-frequency detector with signal lagging reference. Gate propagation delays are exaggerated. Arrows indicate gate state changes affecting other gates.

fig. 2. General block diagram of a phase-locked loop (A). Transfer characteristic of a phase-frequency detector is shown in (B).
high, A went high from R, then C went high. Gate J goes low and forces a sequence: Both B and D are made high (D remains low only for the gate delay of J), F and H are forced high.

Gate E must go low since inputs from A and F are both high. Gate G also goes low from C and H. Gate J is reset low from E and G even though A and C are still high. J has remained low for only three gate delays.

Set-reset flip-flops E and F, G and H are required for the intermediate time-state until either R or S return high. When R goes high, A goes low to hold B high. B was forced high due to the input from gate E being low. E will now go high but doesn’t change B; the A change occurred first. Gate F returns to its stable low state since all inputs are high.

Returning S high will change, in order: C, G, and H in the same manner as A, E, and F. An important note is that all gate propagation delays are approximately the same so that the time-state changes occur in proper sequence.

LAG output is low only for the time difference (phase) of R and S negative transitions. It is low for one extra gate delay but a summing integrator will cancel this via the LEAD short low state. Any lag will have the same short low state of LEAD plus the extra gate delay time of LAG.

**short input times and maximum speed**

The timing diagram of fig. 4 has a lagging signal input but both inputs are short and do not overlap.

---

Gates A and B behave as in fig. 3. The difference occurs in the duration of intermediate flip-flop gates E and F.

When gate B is made high by a low J, A goes low since R was high before the negative edge of S. Gate F was forced high by a low J but E would go low due to A still being high. Gate A then drops low to force E high again. E is low for only one gate delay. Gate F resets since J has returned high by way of E and G going low.

The stable state is restored as in fig. 3 when the positive-going edge of S occurs. The LAG output still represents the time difference between negative-going transitions of R and S.

The minimum low-state time of R or S is approximately 7 gate delays including the reset time on the positive edge of S. Maximum operating speed is inversely proportional to about 9 gate delays — about 6 MHz at 18 nanoseconds per gate.

**letting the signal run faster**

Fig. 5 shows an S input leading R, then increasing in frequency. There is a momentary low state of LEAD (gate D) followed by a one-gate delay of LAG (gate B). Thereafter, LEAD will remain low until the next negative-going edge of R. Transfer characteristics of fig. 2B will be satisfied if both detector outputs are averaged.

In-phase maximum output extends very near to ±360 degrees. The phase-frequency detector would make an excellent, wide-range phase meter when preceded by input comparators and followed by an integrator and analog voltmeter.

---

30 September 1982
question sure to be asked

Fig. 6 shows timing at an absolutely in-phase time situation. No race condition exists and both outputs will go low for only one gate delay; summed outputs are zero. Any nonzero output is due to propagation delay differences between gates B and D, a nanosecond or two.

This timing diagram illustrates the symmetry of the gate arrangement. Inputs and outputs may be interchanged without affecting operation.

The stable state may not exist on power-up. I checked all 2048 combinations on nine gates and two inputs on an Apple II program for automatic settling. Forty combinations do not settle immediately but all will settle on the first arrival of a reference or signal input.

creating an analog output

A Motorola chip can use the on-board charge pump. The reader is referred to Motorola literature for connections and values.3

Greater flexibility is possible with separate op-amp integrators and filters. A summing integrator is given in fig. 7. Open-collector gates are assumed for B and D. The difference in collector return and integrator input resistor value ratios minimize op-amp offset bias; ratios are not absolute.

This integrator is an active lowpass filter with 6 dB per octave (20 dB/decade) high frequency response. The −3 dB frequency \( F_c \) is found by:

\[
F_c = \frac{1}{2\pi R_2 C}
\]

Dc voltage gain is simply \( R_2/R_1 \). Low-frequency gain must recognize that Logic 0 is not zero volts; TTL swings +0.3 to supply voltage with open-collector outputs.

Assuming all resistors are 10 k and \( C \) is 0.33 \( \mu \)F, dc gain is unity and the −3 dB corner frequency is 48.2 Hz. Voltage gain is −26 dB at 1 kHz.

Many variations are possible in the PLL’s analog portion. Texts in the bibliography are suggested for the serious experimenter.

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If your autopatch has developed some obnoxious habits, such as interrupting your 2-meter conversations with random dial tones or rudely ending your autopatch calls, then this decoder circuit is for you. The phase-lock-loop system used on many autopatch decoders works well for strong signals or signals that are precisely tuned to frequency. When a weak signal or one that is slightly off frequency is encountered, however, the phase-lock-loop decoder tends to false, which results in noise being received as a tone, and tones being rejected as a noise. One cure for a mischievous tone decoder is to require a long delay in activating or dropping the autopatch. A better cure is this state-of-the-art system that uses two new integrated circuits from Mitel.

The system is built around the Mitel 8860 and 8865 DTMF decoder and filter ICs. These chips, introduced in August, 1980, feature high-quality detection, excellent voice and noise rejection, crystal controlled accuracy, and rapid detection time. They are low-power CMOS chips, requiring only about 30 mW apiece. The system will provide a 30 dB dynamic range; in other words, the range of audio levels that it will accept is -30 dB to 0 dB. This wide tolerance of tones means that the user’s Touchtone pad audio level is not extremely critical, the way it is with some phase-lock-loop decoding systems. The maximum tone frequency deviation is ±2.5 percent, compared with the general standard in the telephone industry of ±1.5 percent.

This circuit will provide either binary or digit-by-digit output. The binary lines are tri-state, which means that the decoder can be connected directly into the data bus of your computer-controlled repeater. The sixteen-line digit-by-digit output can connect to a repeater control that requires a line for each tone decoded. Although many repeaters use only the twelve standard Touchtone pairs, the Mitel chip is able to decode all sixteen pairs.

a case history

The decoder system shown in the schematic has been installed and tested on K9ORU/R, located in Belvidere, Illinois. The repeater formerly used a phase-lock-loop tone decoder, which falsed frequently. Several types of filters and AGC amplifiers were used in trying to correct this problem, but none of them met with much success. Setting a long delay on the auto-patch code ended the falsing, but required users to hold their Touchtone pad buttons down for several seconds to access the auto-patch. Because the long delay wasted air time, and because that decoder had numerous other minor problems, the group looked for an entirely new decoder system. Their research pointed to the Mitel dual-tone multi-frequency (DTMF) chips as the ideal solution, and the circuit described in the schematic was designed around those chips.

The new decoder system cost the K9ORU members about $65.00 to build and install, using primarily new parts. The Mitel chips themselves cost almost $50.00, and $15.00 was spent on other parts, including an aluminum box to house the circuit.

Since this decoder was installed, in early 1981, there has been no falsing of the repeater. The need for a long delay before accessing the autopatch was eliminated, as were all of the minor problems that had afflicted the system. Because the new decoder doesn’t need such critical settings of tone frequency, every member’s phone pad is able to activate the au-

By E.M. Dean, WD9EIA, and P.K. Dean, WB8HGZ, 415 Superior Avenue, Machesney Park, Illinois 61111
topatch. All phone calls into the repeater for control purposes have worked, from every phone that's been tried. And the microprocessor-controlled automatic dialers used by some of the repeater members can no longer out-dial the decoder.

circuit description

This circuit uses a total of six integrated circuits: one MT8865 DTMF filter; one MT8860 DTMF decoder; one 74154 four-to-sixteen line decoder, and three 7404 inverters, two of which are optional. (Omit the optional 7404s and the sixteen-line output will be normally high, active low.)

Our circuit was constructed on a 2½ × 5 inch perf-board and housed in an aluminum utility box. We connected it to our existing repeater control through ribbon cable and dip-headers.

Referring to fig. 1, audio from the receiver is brought into the 8865 filter pin 4 through an 0.015-mF capacitor. This chip is a six-pole bandpass filter that rejects noise, voice, and dial tones, and separates the high and low tone groups. Frequency reference is provided by an internal oscillator in the 8865 that is controlled by an inexpensive 3.5-MHz TV colorburst crystal. This oscillator also provides frequency reference for the 8860 decoder. The high group tones are brought out on pin 10 and the low group tones are brought out on pin 1. They are fed into the 8860 decoder on pins 4 and 13 respectively.

The 8860 performs the actual decoding of the DTMF pairs. Pin 15 of the 8860 provides a logic high whenever a valid tone pair is being received. This output is buffered by a 7404 inverter. It is used to strobe the sixteen-line decoder and to illuminate the

fig. 1. Schematic for the DTMF decoder.
valid tone LED. This LED is placed on the board and is used for diagnostic purposes. The strobe is necessary because the binary lines are latched, and the desired output should present a 1 while the tone is being received. Pin 9 is the output control line. When pulled low, the outputs are put in their high-impedance state. This feature may be used if you are connecting the decoder directly to a computer, but in this instance, we simply tie the line to a logic high through a 1K resistor. Pins 5, 6, 7, and 8 are the binary output lines, which are connected to the binary input line of the 74154. This IC simply decodes the binary number from the 8860 to a single line output of each Touchtone pair.

When the 74154 is enabled by a valid tone signal, it presents a logic low at the output corresponding to the specific tone pair decoded. This low is then inverted by a section of a 7404 to provide an active high signal.

Shown in the schematic are inverters for the twelve standard Touchtone pairs. The four remaining sections of the 7404 used in the valid tone signal circuit may be connected to the 74154 to provide Touchtone pairs A, B, C, and D if desired. The inverters may be left off if an active low is desired.

The entire circuit is powered by a single 5-volt supply.

testing

Apply 5 volts to the unit and connect the audio input to a source of Touchtone signals, either your receiver or a telephone or Touchtone pad. Depress a button on the Touchtone pad. The valid tone LED should light up and the corresponding output should switch to a logic high (approximately 5 volts). Release the button and the light should go out and the output should go to 0 volts. Repeat the procedure for the remaining Touchtone pairs. If you have difficulty, the high and low tone outputs can be monitored at pins 10 and 1 of the DTMF filter using a pair of high-impedance headphones connected through a 0.1-mF capacitor.

final comments

This circuit can easily be built into a new control right on board, or it can be wired into an existing control as we did. If the unit will be located more than 6 inches away from the power supply, the supply leads should be bypassed with a small capacitor to prevent rf pickup. If the output leads will be more than 6 inches long, they too should be bypassed.

Once you put this control into operation, you can expect many years of trouble-free operation. And your autopatch won’t hang up on you ever again.

ham radio
A full-size Quad that's lightweight and inexpensive

Shortly after my first antenna article was published, I received my degree in geological sciences and took a job that meant moving to Brazil, where I held the call PP6ZAA. As soon as I received my license I got on the air using a borrowed FT-101 and dipole antennas. The responses I could generate with my unusual prefix were many, but I got into a couple of contests and did miserably. My 100 watts and dipoles were just no competition for those hams using gain antennas.

I decided a change in antennas was necessary, and, having been a quad fan ever since my Novice days, I knew what my choice would be. Because my job requires a lot of moving around, I had to have a quad that was light in weight, and easily assembled and disassembled.

I like the delta-loop-type quad mainly because it mounts in such a way that the entire antenna is above the supporting structure. On the other hand, the traditional square or diamond quad has easy-to-feed wire elements and is not "top-heavy." Both of these two quads, however, are wind-catching rotator damagers.

What I have designed is an antenna that combines the favorable qualities of these two quads. The antenna has two wire loops in the inverted-delta configuration, and it is fed at the bottom of the driven element in the classic wire-quad fashion (break the loop and connect the coax). See fig. 1. There are four main spreaders but no boom, and there is an additional bottom spreader which has no major support function. The bottom spreader can be made of very lightweight material because its only functions are to keep the bottoms of the loops in proper position with respect to the rest of the antenna and to support the coax to the driven element.

The four main spreaders are attached to a main spreader hub by means of U bolts. The main hub is bolted to a bracket which, in turn, is U bolted to the mast. The antenna is designed to have 0.2λ spacing between the elements. The bottom spreader is, thus, 0.2λ long.

The reflector loop is connected, on top, to the tips of the two rear main spreaders and to the tip of the rear of the bottom spreader. The loop wire will form an equilateral triangle.

By Paul J. Kiesel, K7CW, 25180 E. Hickory Lane, Broken Arrow, Oklahoma 74012
Table 1. Formulas used to obtain proper dimensions of the antenna as labeled in Fig. 1.

<table>
<thead>
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<th>Formulas</th>
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<td>( X = \frac{1000}{9.84F} )</td>
<td>( F ) = design frequency of antenna (3X = total distance around reflector loop).</td>
</tr>
<tr>
<td>( A = \frac{1005}{9.84F} )</td>
<td>3A = total distance around driven element loop.</td>
</tr>
<tr>
<td>( H = \frac{X}{2} )</td>
<td>( X ) = distance from main hub to top of antenna (the imaginary plane which contains the tips of all four spreaders).</td>
</tr>
<tr>
<td>( D = 0.2\lambda )</td>
<td>( \lambda ) = wavelength at design frequency.</td>
</tr>
<tr>
<td>( E = \sqrt{\frac{X^2}{4} - H^2} )</td>
<td>( E ) = distance from bottom spreader to main hub.</td>
</tr>
<tr>
<td>( C = \sqrt{2H^2 + \left(\frac{D}{2}\right)^2} )</td>
<td>( C ) = distance from hub to where loop is attached to main spreader.</td>
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The driven element loop does not form an exact equilateral triangle because of the fact that it is also connected to the bottom spreader (which is horizontal with respect to the ground) and is smaller in size than the reflector. So a little shifting of position of the loop on the spreaders is called for (otherwise the bottom spreader can be tilted to conform, but this will disrupt the visual symmetry of the quad).

A list of formulas for obtaining proper dimensions of the antenna is given in Table 1. If you follow the table, you will be able to construct the antenna for any frequency. In order to save you time, however, I have done the necessary calculations for frequencies in all the Amateur bands, 80 through 6 meters. These dimensions are found in Table 2.

The main spreader hub was designed to be simple. It consists of two parts, the hub itself, and a bracket which is used to mount the hub to the mast. See Fig. 2. The hub is fashioned from an 18 x 10 inch (45.72 x 25.4 cm) piece of 3/16-inch (4.76-mm) aluminum sheet. Steel may be used, but I discourage its use because it defeats the purpose of trying to build a lightweight antenna. Before the pieces are bent to form the indicated angles, holes for the mounting bolts and U bolts should be drilled. Locations of the bolt holes for mounting the bracket to the hub are marked. However, each builder must determine for himself the exact locations of the U bolt holes to fit his particular needs with respect to diameter of spreaders and mast (that is, U bolt sizes). Center lines have been drawn on Figs. 3 and 4 to show approximate loca-
tions of the U bolts. It is important to note that the axes of the spreaders must lie on the lines indicated in fig. 4.

An interesting sidelight appeared to me as I designed the antenna. The fact that I assigned (arbitrarily) the distance from the hub to the top of the antenna to be equal to the loop circumference divided by six, (or \( H = \frac{x}{2} \)), resulted in an arrangement that would readily allow the addition of other loops for different bands, with proper spacing, simply by the addition of another bottom spreader per band. See fig. 5 and 6. One need only use the formulas in table 1 to determine the proper lengths and locations of the loops within the main structure.

Undoubtedly, it's already occurred to many readers that the antenna could be turned upside down to obtain better weight distribution of the antenna on the tower. See fig. 7. A description of this principle is made by Myers.\(^2\) At first, it never occurred to me to do this because I'd wanted to get the whole antenna above the tower. However, it seems to me that one could build, say, a 40-meter version of my antenna, invert it on the tower and have a lightweight, low-torque, inexpensive beam with reasonable gain for 7 MHz. The builder might have to beef up the hub somewhat.

The kind of hub I have already described would work well. In this case it could be made of steel. The only modification needed would be to include a hole a bit larger than the mast diameter in the sheet metal before it is bent. Then, rather than having the hub sit on top of the mast, the mast would pass through the hub to be bolted to the bracket above the hub. Now, obviously, 99.99 percent of us won't be able to con-

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**fig. 4. Reduced template, main spreader hub.**

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**table 2. K7CW quad dimensions.**

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<tr>
<th>Frequency (MHz)</th>
<th>X</th>
<th>Y</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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**Note:**

- X = length of reflector loop side
- Y = distance around reflector loop
- A = length of driven element loop side
- B = total distance around driven element loop
- C = distance from hub to top of antenna
- D = bottom spreader length
- E = element spacing
- F = distance from bottom spreader to main hub
- C = distance from hub to where loop is attached to main spreader, that is, spreader length

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38 IN September 1982
struct an 80-meter version, but go-getters who have lots of room can — and I challenge them to try it. The mechanical problems involved in building a full-size rotatable 80-meter beam are numerous, but I personally helped put a full-size two-element 80-meter beam on top of a 170-foot (51.8-meter) tower, so I know it can be done.

I used bamboo for the spreaders on the first version of the antenna because fiberglass is hard to get in Brazil. Bamboo works well. However, fiberglass would appear to be the best choice for spreader material.

I won’t go into a lecture on how well my quad works. Everyone knows how good quads are. Let me tell you, though, about the advantages of having an antenna with no boom. Since there is no boom, there is a marked reduction in rotational torque applied to the rotator (caused by wind loading or sudden starts and stops). There can be no appreciable amount of damage to the rotator due to torque because everything on the antenna is flexible. There are, in fact, a lot of advantages to the antenna. Let’s go over them.

1. Low torque applied to the rotator — there is no boom.
3. Only four main spreaders instead of eight.
4. Wire elements mean the antenna is easy to feed.
5. Antenna completely above top of tower.
6. Lower cost because of fewer parts.
7. Lower weight because of very little metal.
8. Antenna symmetrical and well-balanced.
9. Antenna easy to fabricate and mount.
10. Easy addition of loops for other bands with simple addition of lower spreader for each new band.
11. Possibility to invert antenna to obtain gravity/balance advantage on tower.

I am very interested in hearing from those who have any comments, suggestions for improvement or questions regarding this antenna.

references
It’s the old story: RFI (radio frequency interference) is no problem if you don’t have it, but it’s hell if you do. This point was emphasized to me a few weeks ago when I became the proud owner of a new microwave oven. I was eager to buy it because of its advantages in quick-cooking — and the oven came highly recommended. No doubt about it: it was a well-made unit and we had a lot of fun doing some experimental cooking with it.

The only problem was that when the oven was running it obliterated the kitchen radio with a raspy sound like that of a chain-saw cutting through a hard oak knot, and it produced a broad, wiggly band across TV channels 2, 4, and 5. I could also hear the same raspy noises on the 160- and 80-meter ham bands.

Now how could a microwave oven operating around 2 GHz cause such RFI on radio and television? The racket sounded so much like an SCR, or light dimmer, that I concluded that it might be the oven’s power supply rather than its magnetron that was causing the interference (see fig. 1). I removed one end of the cabinet to expose the control circuits and power supply — and my guess was right. A simple half-wave rectifier system was used.

Holding a small transistor radio near the supply confirmed the source of interference. As far as could be determined, there were no shunt capacitors across the high-voltage rectifier to suppress diode noise or switching transients. And, obviously, no rf filtering in the power leads.

I decided to call the factory about the problem, as I didn’t relish the idea of digging into the oven to install haphazard filtering. A phone call to the manufacturer in Iowa brought cold comfort. When I mentioned television interference from the oven, the serviceman immediately asked me if I lived near a Radio Amateur! (That really frosted me!) Finally, after admitting that the company knew nothing about the problem, the voice on the phone told me to call the local service depot in San Francisco.

I telephoned the local outfit and finally got through to a gentleman who would level with me (but only after I told him I was in the electronics business and knew what I was talking about).

He readily admitted the problem and said that the ovens manufactured for export outside the United States have an RFI filter in them, but those intended for use in the U.S. do not. (This clearly points up why this country requires FCC jurisdiction over RFI emissions from home entertainment equipment and appliances.)

The upshot was that the manufac-
turer would not give me a filter for their noisy product, but they would sell me one for $24 plus a dollar shipping. I bowed to this suggestion and mailed off a check. The filter soon arrived in the mail, and I must admit that it was a neat little package, made in Germany. It incorporated both a semiconductor device that protected the oven from line transients and a filter.

No information was included regarding mounting the filter, so I merely drilled a hole in the rear of the cabinet for the filter’s single mounting bolt and sandpapered the paint away from the area where the filter would rest. The filter was equipped with residential-type snap-on terminals, and a quick trip to the hardware store turned up matching snap-on lugs. The power cable was snapped on one set of filter terminals and short leads were made up, going from the output terminals of the filter to the terminal board that originally held the power cable.

Once the cabinet had been reassembled, it was immediately apparent that the filter was doing its job. The TVI had disappeared, the racket was gone from the kitchen radio — and also from my receiver in the ham shack!

For those who have RFI from a microwave oven, you can get a filter for it. I’ll be interested to hear from readers who have experienced this form of RFI, and I’d like to hear from owners of other brands too. Do other manufacturers incorporate RFI filtering in their products? Is Amana the only manufacturer that evades this problem? Or are they all in the same league? I’d like to know.

**Lightning protection**

Summer is the time for thunderstorms. A cloud-to-ground discharge can have a potential of 300 million volts at hundreds of thousands of amperes. The damaging effect of a stroke results from the power developed by the passage of a large current through a resistance (a human body, for instance). A lightning arrester provides a controlled path to ground for the lightning energy, shorting it to ground before it can damage the equipment being protected.

A secondary effect of a lightning strike is the tremendous electrostatic field set up in the vicinity of the bolt — up to 5 kV/cm. When the strike reaches earth a great potential is set up between the strike point and “neutral” earth, and earth currents flow outward from the strike point to re-establish equilibrium. These currents can flow along the outside of a coaxial line located in the vicinity of a strike (see fig. 2). This potential can be induced into the inner conductor despite the presence of a lightning arrester in the line, or it can elevate the chassis of the radio equipment to thousands of volts above ground — even though the equipment is normally at ground potential.

One simple way to prevent the coaxial line from rising above ground potential is to pass it through a very simple waveguide-beyond-cutoff filter made of a ten-foot-long piece of electrical (EMT) tubing. The coaxial line is passed through the tubing, and line and tubing are then securely grounded at the station end of the
line (as shown in the illustration). The opposite end of the tubing is not grounded. The ground potential passing along the outer conductor of the line will be shunted back to earth at the grounded end of the filter, thus protecting the equipment, which is grounded to earth at the same ground point. When this approach is used in conjunction with a conventional lightning arrester, maximum protection is afforded the equipment in the ham-shack during a thunderstorm.

**simple antenna for 7/14/28 MHz**

A recent issue of *CQ-ham radio* (Japan) described an interesting tri-band antenna used by JK1AYE. It is an updated version of the old off-center-fed antenna that used a 300-ohm ribbon line for the feed system (fig. 3). In this simple design, a 4-to-1 balun and coaxial line replace the ribbon line. JK1AYE adjusts the lengths of the flat top sections a bit at a time until he achieves lowest SWR in the middle of each band. He claims an SWR value of 1.6-to-1 at resonance on 14 MHz, less than 1.3-to-1 on 7 MHz, and less than 1.2-to-1 at resonance on 28 MHz. Because of the unbalanced antenna there is bound to be some minor radiation from the transmission line, and it is recommended that the line drop down to ground level directly below the antenna so that distortion of the antenna pattern is held to a minimum.

**W1PLH revisited**

In my March, 1982, column I described some interesting antenna designs used by Charlie, W1PLH. Here are the results of more of his antenna experiments.

The W1PLH-W1BCN compact 15-meter ground plane antenna. Shown in fig. 4 is Charlie’s answer to the problem of where to run radials for a ground plane antenna. Simply curl one radial into a circle. The W1PLH-W1BCN antenna is mounted with the feed point about thirteen feet above ground level. Results seem to be equal to those of a full-size radial system. The whip can be adjusted in length to zero-in the resonant frequency at the middle of the 15-meter band (about 21.2 MHz). Bandwidth is quite broad, showing SWR readings of less than 1.8-to-1 at the band edges and near unity at the middle of the band.

The W1PLH 75-80 meter dipole. In my March column I showed a drawing of the W1PLH 80-meter antenna. Charlie has modified this a bit and now gets very low SWR readings across the entire 80-meter band (fig. 5). If you have enough trees or supports to hold this antenna about twenty-five to thirty feet in the air, it should prove to be a good, all-round radiator for the complete band —
both phone and CW sections! SWR is about 2.4 to 1 at the band edges and near unity at 3.75 MHz. The array is tuned by adjusting the seventeen-foot end sections.

The W1PLH 10-meter compact dipole. Want a small, unobtrusive antenna for 10-meter operation? Charlie has constructed this small antenna that's only 7-1/2 feet long (fig. 6). It's a dipole folded back upon itself and fed via a quarter-wave matching transformer. The pattern is bidirectional and the bandwidth between the 20 to 1 SWR points is about 900 kHz. At the resonant frequency (28.5 MHz), the measured SWR is about 1.2 to 1 or less.

The main, central portion of the antenna is composed of two pieces of 3/4-inch-diameter aluminum tubing, each piece 44 inches long. The center junction is made up of a short plug of Lucite, Plexiglas or phenolic material. At the ends of this short dipole, 36-inch-long outriggers are attached by means of triangular aluminum plates. The outriggers are made of 3/8-inch-diameter aluminum tubing. The ends of these rods are flattened and drilled for small bolts, and the outer wires (insulated at the center) are attached to these points. The insulators in the wire are made of 3-inch-long sections of plastic rod.

Although drawn in the vertical plane for clarity, the assembly is supported in the horizontal plane with all sections parallel to the ground. And, as with any other antenna, the higher this little dipole is placed the better it will work.

**A personal note**

At long last, the twenty-second edition of the Radio Handbook has come on the market. It is now sold by all the leading electronic distributors and can also be obtained at the Ham Radio Bookstore. This 1200-page, hardbound handbook covers HF and VHF communications from A to Z, and from 160 meters to the new 920-MHz ham band. As the editor, I take pride in this new edition! I know you will enjoy it and find it useful!
### MICROPROCESSOR COMPONENTS

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### INDUSTRIAL SUPPORT DEVICES

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### ROMS

- **NOR READ ONLY MEMORIES**
- **NAND READ ONLY MEMORIES**

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### IC SOCKETS

#### LOW PROFILE (TIN) SOCKETS

- **8 pin**
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- **18 pin**

#### WIRE WRAP (GOLD) SOCKETS

- **LEVEL #1**
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by Jim Rafferty, N6RJ

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More Details? CHECK—OFF Page 94

September 1982
**TS-930S FEATURES:**

- 160-10 Meters, with 150 kHz-30 MHz general coverage receiver. Covers all Amateur frequencies, plus WARC, on SSB, CW, FSK, and AM. Incorporates general coverage receiver.
- Excellent receiver dynamic range. Typical two-tone dynamic range, 100 dB (20 meters 500 Hz CW bandwidth).
- All solid-state 28 volt operated final amplifier. Lowest IM distortion. Power input 250 W on SSB/CW/FSK. 80 W on AM.
- SWR/P Power meter.
- Available with AT-930 automatic antenna tuner built-in, or as an option. Covers Amateur bands 80-10 meters, including WARC bands.
- CW full break-in, CMOS logic IC, plus reed relay. Switchable to semi break-in.
- Dual digital VFO’s, 10-Hz steps, includes band information.
- Eight memory channels. Stores frequency and band data. Internal battery memory back-up, est. 1 yr. life. (Battery not Kenwood supplied.)
- Dual mode noise blanker (“pulse” or “woodpecker”). NB-1, with threshold control, for “pulse” noise. NB-2 for “woodpecker.”
- SSB IF slope tuning, allows independent adjustment of the low and/or high frequency slopes of the IF passband.
- CW VBT and pitch control. Variable bandwidth tuning tunes out interfering signals. CW pitch control shifts IF passband and beat frequency. “Narrow-Wide” filter switch.
- IF notch filter 100 kHz, deep, sharp, better than -40 dB.
- Tuneable, peak-type audio filter for CW.
- AC power supply built-in. 120, 220, or 240 VAC, switch selected. (Operates on AC only.)
- Fluorescent tube digital display. with analog type sub-scale, in 20-kHz steps.
- RF speech processor provides higher average “talk-power.”
- One year limited warranty.
- Other features: SSB monitor circuit, 3-step RF attenuator, VOX, and 100-kHz marker.

**Optional Accessories:**

- AT-930 Automatic antenna tuner.
- SP-930 External speaker with selectable audio filters.
- YG-455C-1 (500 Hz) or YG-455CN-1 (250 Hz) plug-in CW filters for 455 kHz IF.
- YK-88C-1 (500 Hz) CW plug-in filter for 8.83 MHz IF.
- YK-88A-1 (6 kHz) AM plug-in filter for 8.83 MHz IF.
- MC-60 (SB) Deluxe desk microphone, with UP/DOWN switches.

---

**TR-7730**

Dyna-“mite”... miniaturized, 5 memories, memory/band scan.

The TR-7730 is an incredibly compact, reasonably priced, 25 watt, 2 meter FM mobile transceiver, with five memories, memory scan, automatic band scan, plus other convenient operating features. It is available with a 16-key autopatch UP/DOWN microphone, (MC-46), or with a basic UP/DOWN microphone.

**TR-7730 FEATURES:**

- 25 watts RF output power, with HI/LOW power switch.
- Five memories. Simplex or repeater operation, with transmit offset switch. The 5th memory stores receive and transmit frequencies independently, for non-standard splits. Memory back-up terminal on rear panel.
- Memory scan, plus automatic band scan. Locks on busy channel, resumes when signals disappear, or when scan switch is pressed. Scan HOLD or PTT switch on microphone cancels scan.
- UP/DOWN manual scan on microphone, either version.
- Four digit LED frequency meter.
- S/RF bar meter. LED indicators for BUSY, ON-AIR, REPEATER operation.
- Tone switch for internal tone encoder (not Kenwood supplied). Offset switch ±600 kHz, or simplex. Fifth memory for non-standard offset.

**Optional Accessories:**

- MC-46 16-key autopatch UP/DOWN microphone.
- SP-40 Compact mobile speaker.
- KPS-7 Fixed station power supply.

---

**TR-8400**

Synthesized 70-cm FM mobile rig

- Covers 440-450 MHz, in 25-kHz steps, with two VFOs.
- Transmit offset switch for ±5 MHz. Non-standard offset uses fifth memory.
- HI/LOW power switch selects 10 or 1 watt RF output.
- Similar to TR-7730 in other features, including five memories, memory scan, automatic band scan, UP/DOWN manual scan, four digit display, S/RF bar meter, LED indicators, tone switch, and same optional accessories.
- Basic UP/DOWN microphone supplied with unit.
**TS-830S**

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

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

**TS-830S Features:**
- LSB, USB, and CW on 160-10 meters, including the new 10, 18, and 24-MHz bands.
- Receives WWV on 10 MHz.
- Wide receiver dynamic range. Junction FETs in the balanced mixer, MOSFET RF amplifier at low level, and dual resonator for each band.
- Variable bandwidth tuning (VBT). Varies IF filter passband width.
- Notch filter high-Q active circuit in 455-kHz second IF.
- IF shift (passband tuning).
- Noise-blanker threshold level control.
- Built-in digital display, (fluorescent tube), with analog dial.
- 6146B final with RF negative feedback. Runs 220 W PEP (SSB/180 W DC) input on all bands.
- Built-in RF speech processor.
- Narrow/width filter selection on CW.
- SSB monitor circuit.
- RIT and XIT (transmitter incremental tuning).

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

**TS-130SE**

"Small talk"...IF shift, Processor, N/W switch, affordable.

A compact, all-solid state IF SSB/CW transceiver for mobile or fixed base station, covering 3.5 to 29.7 MHz.

**TS-130SE Features:**
- 80-10 meters including the new 10, 18, and 24 MHz bands.
- Receives WWV on 10 MHz.
- TS-130SE runs 200 W PEP/160 W DC input on 80-15 meters, 160 W PEP/140 W DC on 12 and 10 meters. TS-130V version at 25 W PEP/20 W DC, all bands, also available.
- Digital display, built-in.
- IF shift circuit.
- Speech Processor, built-in.
- Narrow/width filter selection on CW and SSB with optional filters.
- Automatic SSB mode selection (SSB on 40 meters and below, USB on 30 meters and up). SSB reverse switch provided.
- RF attenuator, built-in.
- Effective noise blanker.
- Final amplifier protection circuit assures maximum reliability. Output power is reduced if abnormal operating conditions occur. For very severe operations, optional cooling fan, FA-4, is available.
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- Other features: VOX, CW semi-break-in with sidetone, one fixed channel, and 25 kHz marker.

**Optional Accessories:**
- PS-30 matching power supply (TS-130SE).
- KPS-21 power supply (TS-130SE).
- PS-20 power supply (TS-130V).
- PS-20 power supply (TS-130V).
- SP-120 external speaker.
- VFO-120 remote VFO.
- FA-4 fan unit (TS-130SE).
- YK-88C (500 Hz) and YK-88CN (270 Hz) CW filters.
- YK-88SN (1.8 kHz) narrow SSB filter.
- AT-130 antenna tuner.
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More Details? CHECK — OFF Page 94

September 1982 p. 53
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Tell 'em you saw it in HAM RADIO!
I have two questions that I’ve often wondered about and would appreciate your looking at.

I’ve often noticed that transmitter power is rated in terms of peak envelope power (PEP). How can I use this figure to estimate the approximate output power of the rig?

Also, I have an older transceiver that displays a mild hum on the received signals, just enough to cover very weak stations. How can this hum be eliminated, and what causes the power supply to jump somewhat when it is first turned on? — Christopher B. Hays, WB0LPV.

As for power output, the Amateur service is the only one in which power limitations are expressed in terms of final-stage input power. In all other services, the output power is used. With certain exceptions, the Amateur limit is 1000 watts to the plate circuit of the final amplifier; while FCC 97.67 doesn’t say so, this means the product of the dc plate voltage and the current. This is known as the average power.

When we modulate the transmitter we get an envelope containing the modulation that has peaks and valleys — but there is no simple relationship between the peak and the average level of the human voice. So we “assume” that the PEP is twice the average power. Hence, the limit of 2 kw PEP, or 1 kw CW or average.

Now, the output power is a question of the efficiency of the transmitter’s output stage. Assume 55 percent efficiency. If the transmitter is rated at 180 watts input CW, its output is 100 watts CW. If it is rated 360 watts PEP input, it will yield 200 watts PEP output — which is still 100 watts CW! Your primary interest is output power. Since PEP is a function of the individual voice, there is no standard of comparison other than average power output.

As for your “older” transceiver, I have to make some assumptions. My first assumption is that it is a tube-type. If the hum is 60 Hz, it can be heater-to-cathode leakage, remedied by tube replacement. If it is 120-Hz hum, it probably means your filter electrolytic capacitors need replacement — they have a finite life. Also, the cathode bypass capacitors in the audio stages of the receiver section should be checked.

That “jump” you refer to is usually a “grunt” from the power transformer that results from high inrush current. Assuming solid-state rectifiers, when the radio has been off, the filter capacitors look like a short-circuit until they charge. Also, some power transformers are designed so that they are operated at high flux density and with low primary-winding resistance, thus causing a “grunt” that depends on when in the 60-Hz supply cycle they are turned on.

I have a question about the efficiency improvement of a beam antenna. Would it be possible to have a gain in dBS if the beam could be rotated not only in the horizontal but also in the vertical plane, say in line with the radiation angle? Since the latter could be found only by experimenting for the best gain, rotation should also be a possibility. I wonder if any tests have been done in this respect. — Hans W. Schaedel, VE3BWE.

Thirty years ago, there was a ham in Chicago who used two rotators on his 10-meter beam, one for horizontal azimuth and the other for vertical radiation angle. I remember that when we could no longer hear other stations (this was at distances of 15 miles), he would still be very strong because he “tilted” his boom for maximum received signal. The only formal reference I could find was in regard to NBS studies of ionosphere opacity at 50 MHz, but there were no definitive conclusions that are applicable here.

The propagation experts claim that after one skip off the ionosphere the transmitted wave changes polarization, becoming more vertical or circular than it was at the transmitting antenna (which was horizontally polarized). This idea of adjusting vertical radiation lobe angle from ground is
intriguing, but I think you will agree it becomes somewhat impractical with large Yagis; the mechanical problems are difficult to solve.

I might suggest you try a combination: a vertical with a good radial system, a Yagi on a tower than can be raised and lowered, and a horizontal long wire close to ground. By switching among these antennas you might be surprised by the difference in received signals. And you may be surprised to find that the "reciprocity theorem" (that transmitting and receiving capability should be the same) doesn’t always hold true! A combination of antennas with different vertical radiation angles can accommodate many point-to-point communications situations. And then there are the slopers and drooping inverted-Vs — if you have enough real estate, you can have a ball.

Why is it when I use my rig on SSB that the current meter shows only about half the tune-up (plate) current and the wattmeter shows only about half the (output) power? — Mike Bruce, KA4BCM.

The answer is found in the characteristics of human speech and the mechanical (ballistic) characteristics of meters. When you tune up on CW, you are injecting a fixed-level audio signal into the low-level audio circuits, or the balanced modulator is set so an actual carrier is transmitted, depending on the type of transceiver/transmitter.

Now, when you speak into the microphone, you no longer have a fixed-level signal. The ratio of peak-to-average in the human voice is about three to one or more; speech is not sinusoidal. When using meters (plate current, power, VU, etc.), the ability of the meter to follow these instantaneous changes comes into play — the meter needle moves slowly at first, might overshoot, miss a short burst of energy entirely, and slowly settle back. The type of meter you should use to monitor your modulation level is called an oscilloscope — it is not affected by these ballistic problems to any significant degree. Then you can set your mike control to produce maximum peak output power without flat-topping or distorting. Incidentally, an interesting question arises: How do manufacturers arrive at the ALC maximum line on their meters? I’ll wager it’s done with a constant-amplitude audio signal at one frequency. So again, use a scope!

What can you tell me about the "gray line," and how can I use it for DX? — Donald G. Ramras, KD6GR.

This topic involves the subjects of short-wave radio propagation and astronomy. Simply, the "gray line" is the "twilight zone," that is, the portion of the earth that delineates daytime from nighttime. This line (really a band) usually occurs ± 30 minutes on either side of local sunrise and local sunset, so we have about two hours of gray line per day. It has been found that hf propagation along this line is extremely efficient. The popular reason given is that the D layer of the ionosphere is minimal or nonexistent then and the signals are not absorbed as they would be during the day.

Astronomy? The position of this path varies with the earth’s inclination to the sun. The position of the path can be predicted with the use of a globe, and a piece of cardboard cut in it, and a table of inclination angles from the North/South Poles for different dates. A commercial version of this globe specifically designed for the purpose of gray-line prediction is available in Europe.

Insofar as short- or long-path Great Circle propagation is concerned, a signal bounced off the ionosphere will take the path that has the least absorption. Again, this is related to D-layer absorption, affected by the sun striking the ionosphere. The frequency optimum de travail (optimum working frequency) for a given path (point-to-point) is determined by the maximum usable frequency, MUF, the highest frequency that can be used for transmission using reflection off the regular ionospheric layers. The MUF is affected by sunspot activity.

For those interested in pursuing this fascinating subject, the suggested bibliography is: The Short-wave Propagation Handbook by Jacobs and Cohen, from Cowan Publishing; 80-Meter DXing by DeVoldere, from Communications Technology, Inc., Greenville, NH; “The Gray Line Method of DXing,” by Hoppe, Dalton, Capossela, CQ, September, 1975; and The ARRL Antenna Book, Chapter 1, from the American Radio Relay League.

I need a clear, concise definition of an rf ground. I have read that they can be important, especially with QRP operation. — Elliott Gee, KA4POF.

An rf ground is one that makes a low-impedance connection with earth for frequencies in the radio spectrum. Now, for 60 Hz, it is not much of a problem to contact “earth.” A fair sized conductor is connected to a single rod. To improve contact with earth, multiple rods (or radials) should be used, usually the more the better. When operating at rf, however, a problem arises — this single wire has inductance as well as resistance.

For instance, a ten-foot length of #10 AWG solid copper wire has a resistance of about 0.01 ohm and an inductance of 4.13 μH (assuming it’s straight and that most of the current is flowing on its surface — skin effect). At 21 MHz our ground wire looks like 0.01 + j 552 ohms — not very effective! Also, consider that as rf travels along a wire there are standing-waves of voltage (and current) produced. The impedance at any point is the voltage divided by the current. Therefore, the solution is to use several ground wires of different lengths, avoiding lengths that are multiples of quarter-wavelengths in our bands. Then, if one length shows a high impedance at the operating frequency, it is probable that one or more of the other wires will be at low impedance to ground.

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Starting from one common point in our shack (the "equipment ground" point), run these different lengths to our ground rods or radial system. Connect each piece of equipment with its own lead (try and keep them the same length to minimize potential differences) to this equipment ground. Use insulated wire so it doesn't rub against any metallic object and create noise. Make solid connections and inspect them periodically. Do not use water pipe or electrical wiring grounds. Use at least #10 AWG wire and keep the run as short as practical, usually out the window along the outside of the building to earth. If all else fails, consider using a counterpoise underneath your antenna. Good luck!

I would like information on the new WARC bands, phone and CW portions — Brian Grant, VE4AL.

WARC-79 produced three new bands for Amateur use: 10, 18, and 24 MHz. The frequencies from 10.1 to 10.15 MHz, the first to be used, will be on a shared basis with fixed services, and the earliest date of use was to have been January 1, 1982. The other two bands, 18 and 24 MHz, will be exclusive — after the fixed service stations now using these frequencies are reassigned. That will probably be after mid-1989!

The 50 kHz of the 10-MHz band we have will be shared on a secondary basis; that is, they can cause interference to us, but we can't cause interference to them. There is some move toward CW-only use of the 30-meter band, but even this is not universally accepted.

Your British cousin went on the air on January 1, along with some other countries. Here in the States, the FCC is still contemplating the situation, listening to objections from current users of these frequencies and waiting for Senate ratification of the WARC-1979 treaty. It will probably be a while before U.S. hams use this band. Canada has use of this band now.

ham radio
The ninth article in this series on upgrading your license presents in reasonably simple terms what is in actuality quite a complete group of theories. The first article (September, 1981) discussed direct current circuits. This was followed by some alternating current theory, active devices Amateurs use, simple power supplies, and practical amplifier circuits. The last two articles discussed the fundamentals of CW transmitters and receivers.

This month we will investigate the radiation of radio frequency energy, or waves, from wires, some basic antennas, wave motion through space, transmission lines, and the SWR meter. You should understand that, without a properly operating antenna, even maximum power input to a transmitter may not produce satisfactory communications.

**electromagnetic radiation**

When an antenna wire is fed rf ac energy, electrons are forced to oscillate back and forth along the wire. This produces an alternating electromagnetic field around the wire, and an alternating electrostatic field from one end to the other end of the antenna. We will consider only the electromagnetic part, but remember that it could not exist without the electrostatic field being there also.

The fundamental center-fed dipole-type antenna is shown in fig. 1. It consists of a half-wavelength (λ/2) horizontal wire, fed in the middle by a two-wire transmission line (feeder, or feed line). The bottom of the feed line is coupled to a transmitter (if you want to transmit energy) or to a receiver (if you want to receive energy picked up by the antenna).

The antenna wire can be cut to the basic $\lambda/2$ length from a formula based on the velocity of radio wave travel in meters per second (the velocity is roughly 300,000,000 m/s). For a frequency of 7 MHz, or 7,000,000 cycles per second (Hz), the full wavelength can be determined by dividing the velocity by the frequency. So, a 7-MHz signal has a wavelength of

$$\lambda = \frac{300,000,000}{7,000,000} = 42.857 \text{ meters}$$

If 7-MHz ac has a wavelength of 42.857 meters, its

By Robert L. Shrader, W6BNB, 11911 Barnett Valley Road, Sebastopol, California 95472
north magnetic field being radiated from the antenna would travel 42.857 meters outward in the air before the next north magnetic field would be produced around the wire. During this period, the field around the wire would decrease to zero, become a south-polarity field, reach maximum, decrease to zero, and expand out to maximum north again. The magnetic fields build out and back because an alternating electron current is being driven back and forth in the wire by the transmitter. Although 42.857 meters is the full wavelength of a 7-MHz ac wave, the wire can be cut to a half-wavelength ($\lambda/2$) and still allow the electrons to oscillate back and forth in it with minimal opposition.

We might expect that a 7-MHz, $\lambda/2$ antenna would be 42.857/2, or 21.4 meters long. But that's too easy. A properly operating $\lambda/2$ antenna will be only about 95 percent of our computed length, because of "end effects." You can use one of the following formulas, which include the 5 percent end effect correction, when computing the correct length of a $\lambda/2$ antenna:

\[
\text{In meters, } \lambda/2 = \frac{142.5}{f_{\text{MHz}}} \\
\text{In feet, } \lambda/2 = \frac{468}{f_{\text{MHz}}}
\]

According to your own calculations, to what length should you cut a 7-MHz $\lambda/2$ antenna wire? How about 20.357 meters, or 66.857 feet? Do you agree?

An interesting point regarding an antenna is its impedance. If you were to measure the impedance of a $\lambda/2$ antenna end to end it would be something like 2500 ohms, depending on wire size, height, and so forth. If you cut a $\lambda/2$ antenna in the middle, this opening should exhibit an impedance of about 72 ohms to any feedline coupled to it, again depending on conductor size and height. We will say that a $\lambda/2$ antenna has a center impedance of about 72 ohms. If we connect a pair of wires of just the right diameter and spacing they can also be made to have a characteristic impedance of 72 ohms. If such a parallel-wire transmission line is fed 7-MHz rf ac, it will transfer all of its energy to the 72-ohm opening at the antenna center and all of this energy will be radiated into space by the antenna. Actually, a $\lambda/2$ antenna exhibits a 72-ohm impedance when at any quarter-wavelength ($\lambda/4$) multiple above the ground. If it's only an eighth-wavelength ($\lambda/8$) above ground, the center impedance drops to about 35 ohms. At 3/8-wavelength (3$\lambda/8$) above ground, it shows about 98 ohms. At 5$\lambda/8$ above ground, it shows about 58 ohms, and so on. Above two wavelengths in height, the center impedance will be constant at 72 ohms.

Of course, if you change the frequency of the rf ac you are feeding to the transmission line from 7 to 7.1 MHz, the antenna will no longer be in resonance with the ac. The 66.86-foot antenna will now be a little too long (for 7.1 MHz it should be 65.9 feet). Electrons oscillating at 7.1 MHz will not have enough time to reach the end of the antenna before the ac cycle alternates and they must start back again. As a result maximum current never is produced in the antenna and some of the energy which the antenna is unable to accept is reflected back down the transmission line. The reflected energy develops high and low voltage points (loops and nodes) on the transmission line which can make the line act as an antenna and radiate rf waves. When the antenna is taking all of the energy and none is reflected back down the line, the voltage across the line at all points is equal and the line is said to be "flat."

When the antenna is not the proper length for the frequency of the ac being fed to it, then the impedance exhibited at the center will no longer be a resistive 72 ohms, and will no longer be a match for a 72-ohm line feeding it. An impedance mismatch always results in less than maximum power transfer, as discussed previously.

In the case of an antenna being too long for the ac frequency being fed to it, the antenna looks inductive (appears to have $X_L$) to the feeder. The inductive reactance can be cancelled by opening both wires of such a dipole (two $\lambda/4$s makes a $\lambda/2$) and adding the correct value of capacitance ($X_C$) to bring the antenna back into resonance. The antenna will now be resonant to the exciting ac and no standing waves (high and low voltage and current points) will be developed on the feed line.
An antenna that is too short for the ac frequency will appear capacitively reactive to the driving source (feed line). Both sides of the antenna can be opened and loading coils with the correct value of inductive reactance can be added to bring it to resonance and make it accept maximum power from the feeder. However, when an antenna is loaded to make it resonant, its center impedance may decrease somewhat.

**basic vertical antennas**

The basic horizontal antenna is the dipole discussed above. If such an antenna is rotated 90° so that the wire is oriented vertically (assuming the lower end does not touch the ground), it can be called a vertical λ/2 dipole. Maximum radiation of energy from any λ/2 antenna is always at right angles to the wire (E and W and skyward for a horizontal antenna laid out N and S). There is essentially no radiation off the ends. The radiation lobes of such an antenna are shown dashed in fig. 1. When the dipole is vertical it radiates nothing upward, but radiates equally well in all horizontal directions from the wire. It is said to have omnidirectional, or all-directional, lobes, whereas the horizontal dipole has bidirectional, or two-directional, lobes (disregarding the upward radiation component).

If a second λ/2 wire is attached to one side of the horizontal dipole we would have a full-wave antenna, fed at the center of one of its λ/2 sections. We could keep adding λ/2 sections to one side of the antenna, and the feedpoint could remain where it is. An unlimited number of such λ/2 sections could be added and it would still be resonant. Whereas a λ/2 antenna has maximum radiation lobes at right angles to the wire, a 1λ antenna has two lobes, each about 50° from the wire. A 3 λ/2 antenna has one lobe at right angles to the wire and two at about 40° from the wire. A 2λ antenna has four lobes, a 3λ has six lobes, and so forth. Every time a λ/2 is added a new lobe is formed. As the antenna is lengthened the lobes of greatest length (those which contain the most energy) fall closer and closer to the wire. A 4λ or longer "long-wire" antenna becomes most directional in line with the antenna wire, rather than at right angles to it as in a λ/2 dipole.

It is also possible to use just half of a vertical dipole and use a "ground" connection to make the earth operate as the unlimited number of λ/2 sections for the other part of a long-wire antenna. In such a case a λ/4 vertical antenna is developed, fig. 2. The earth connection, called a ground, may be a series of four to perhaps twenty λ/4 wire radials extending out from under the vertical section, as shown. An electrical ground rod might be used but only if it makes a very good electrical connection to an area of exceptional electrical conduction (salt marsh, for example).

If the ground system radials are buried under the ground they may be made less than a λ/4. If the ground is kept wet the radials may not need to be more than λ/10 long, nor number more than four or six.

The impedance of a vertical antenna, if the antenna wire is opened at the point where the ground radials converge, will be about half that of a horizontal dipole, or about 36 ohms. Feed lines are manufactured in 50-53 ohm and 73-75 ohm values. To match a 36-ohm feed point, two equal-length 75-ohm lines can be paralleled, or a 50-ohm line can be used and the mismatch tolerated (this produces an SWR of 50/36, or 1:1.39, discussed later).

A λ/4 vertical working against ground has an omnidirectional radiation pattern, but because of the reflection of the radiated wave from the nearby ground the horizontal part of the lobe will be somewhat shorter (shown dashed) than that of a vertical λ/2 well above ground. We can say the vertical λ/2 has more horizontal gain than the vertical λ/4 antenna. The better the ground under any antenna, particularly a λ/4, the better it will reflect waves from or to the antenna and the more gain the antenna will have.

The polarization of a radio wave is the direction taken by the electrostatic field of the antenna. Thus, a horizontal antenna transmits horizontally polarized waves, and a vertical antenna radiates vertically polarized waves.

**solar and ionospheric effects**

The earth is surrounded by a band of air, thickest near the earth's surface and thinning as altitude increases up to about 600 miles (1000 km). Ultraviolet energy radiated from the sun can cause ionization (breaking up of atoms and molecules of air in the higher altitudes into positive and negative particles). These ionized particles tend to form into reasonably well-defined bands above the earth's surface, and are referred to as the D, E, and F (F1 and F2) layers. Radio waves travel at higher velocity in the areas of lowest density. The top part of a wavefront starting...
out at 45° above the horizon, for example, will begin to accelerate more than the part of the wave that started at 44°. This results in the top of the wavefront speeding up, causing the wavefront to bend back down toward the earth, Fig. 3. Can you see that the same wavefront traveling at different angles from ground might return to earth at different places?

The part of a radio wave that travels directly over the surface of the earth will induce currents into buildings, trees, and the earth itself. It will lose energy and become weaker as it travels. Such a ground wave may produce readable signals for only a few miles if its frequency is in the high-frequency range. Low and medium frequency (VLF, LF, MF) radio waves may produce usable signals for hundreds to thousands of miles. Anyone in the area between the ground wave and the point where the closest reflected (or refracted) wave returns to earth is said to be in the skip zone. In the skip zone you will not be able to hear signals from the transmitter at all. As the day progresses, however, the ionospheric layers change density and the skip zone may close up — or it may lengthen. In general, the higher the frequency, up to about 30 MHz, the longer the paths that will be usable but the longer the skip zones may be. Above 30 MHz, radio waves may bend so little under normal conditions that they pierce the ionosphere instead of being refracted by it, as indicated by the nearly vertical ray shown in Fig. 3.

It is quite common for one point on earth to be simultaneously receiving the same signal refracted from two different layers or from two different parts of the same layer. Since the path lengths of two such waves are different, the two signals may be in phase and augment each other at a receiver at one moment, or they may be out of phase and cancel each other the next. To the listener the signals are fading in strength. Because of changing solar activity, the ionospheric layers are continually varying in density. As a result, all signals out of strong ground-wave range will continually be fading to a greater or lesser extent. Even ground-wave signals with a path of over a couple of miles will fade to some extent, because of reflections from the ionosphere, from aircraft, or other variables. However, the true ground wave does not change in strength at all, day or night.

It is almost unbelievable how much difference there can be in the strength of two radio signals from the same station if only a couple of hundred hertz apart in frequency. An amplitude modulated (a-m) voice signal consists of a carrier frequency with sidebands out 3 kHz on both sides. If the carrier frequency fades out but the sidebands do not, the signal is still loud, but very badly distorted. As you listen to such signals, first the low frequency sidebands of the voice may fade out, and then the higher frequencies may fade. This is called selective fading and is one reason why single-sideband (SSB) emissions are so much more satisfactory than a-m. SSB signals have no carrier to fade and cause distortion.

During sunlight hours the layers are most dense. At night, the D layer thins and the two distinct F₁ and F₂ components thin out and rise to form a single F layer.

It is difficult to generalize on the daily variations of radio wave paths for the many different frequencies of our high-frequency bands. We might state that the low frequencies (1.8-2 MHz) are at their best at night for long-distance communications. The higher frequencies (28-30 MHz) tend to be better in the daytime for DX. Sometimes, when the solar activity is great, the layers are so dense that they attenuate radio signals of all frequencies outside of the ground wave range. In general, communications at 50 MHz and higher are made by line-of-sight (direct wave) only. If you can see the other station you can work it. However, VHF and UHF signals do bend down over hills, particularly if the hills present a sharp demarcation to the wavefront. As a result it is not unusual to be able to work such stations that are a little past line-of-sight. The higher your antenna the farther to both the visual and radio horizons. The approximate VHF and UHF radio horizon can be computed to be:

\[ D = \sqrt{2h} \]

where \( D \) = distance in miles to the radio horizon
\( h \) = height of the antenna in feet

The formula allows for the fact that VHF and UHF radio waves traveling over reasonably flat terrain extend somewhat past the visual horizon.

It is possible to transmit radio waves upward and receive reflections back on earth a split second later. If the frequency of these ionosphere "sounding" emissions are checked, it will be found that at any particular time of day, above a certain frequency no return will be produced. From this the maximum usable frequency (MUF) can be determined. MUF charts are made up to indicate what frequencies might be best to use at specific times of day, for several days or weeks in advance. Such charts are particularly helpful when you're looking for DX contacts.

The D layer is present only when the sun is nearly directly overhead. If dense, it can absorb lower high-frequency-band radio waves. The E layer, about 75 miles up, is most effective at refracting signals during early morning and afternoon. Some solar flare-ups can develop a sporadic E layer, which can produce some interesting short-skip communications up to 1000 miles or more on the 28 and 50 MHz bands.
Most long distance high-frequency communications make use of refraction from the F layer(s).

Every eleven years the number of sun spots increases producing active DX radio communications. But at any time, if there is a spot on the sun with particularly high activity, its radio effect on earth may be felt again in twenty-seven days, which is the rotational period of the sun on its axis.

When there is a sudden ionospheric disturbance (SID) caused by solar flare-ups, many particles enter the ionosphere. All radio communications can be shut down for hours or days because of the absorption of the energy of radio waves by the highly ionized layers.

Solar particles may stream into the earth's magnetic field and produce visible ionization above the magnetic pole. This illumination is called the aurora, and, in the Northern Hemisphere, is visible roughly north of latitude 45. It is possible to bounce Amateur Radio signals off the auroral sheets and communicate for several thousand miles if both stations point their antennas at the ionized areas. CW is the best means of communications, because of the rapid flutter of such reflected signals.

The troposphere is the band of air from ground level up to about ten miles altitude. The air in the troposphere can form in warmer and cooler layers. Warm air is less dense than cool air, so when VHF or UHF radio waves are radiated into a strata of warm air between two cooler layers, they bend and travel along such a duct for hundreds of miles before the layer decays and they escape, possibly returning to earth. Ducting is most often experienced over large flat areas, such as oceans or deserts.

The variations normally present in air masses slightly above ground level are usable for what is termed scatter transmissions. High-power VHF or UHF radio waves are beamed at the horizon. Normal disturbances in the air 10 to 50 miles out can scatter the radio wavefronts. Some of the waves may be scattered in a downward direction toward earth and may be picked up as a usable signal several hundred miles away. Metallic wires and objects on top of hills can also produce a scatter effect bouncing signals down into a valley on the far side of a hill as seen from the transmitting station.

coupling the PA to an antenna

There are a variety of methods that can be used to carry radio frequency energy to an antenna from a transmitter. Remember that the far end of any antenna is its high impedance or high voltage point. Exactly $\lambda/4$ from the high impedance point will be the lowest impedance point. The high impedance point of a $\lambda/2$ antenna (or $1\lambda$, $1.5\lambda$, $2\lambda$, etc.) can be directly attached to the high impedance end of the power amplifier (PA) tuned LC circuit, fig. 4a. In this way the impedances of antenna and PA tuned circuit are reasonably well matched and the antenna accepts rf power.

A $\lambda/4$ antenna has a high impedance at its far end, but $\lambda/4$ away there is a low impedance ($\pm 40$ ohms) point. This end of the antenna wire can be looped and grounded, with the loop coupled to the PA tuned circuit as shown in fig. 4b. Since the loop adds inductance to the $\lambda/4$ wire a capacitor should be added to resonate the antenna. If the capacitor is variable it will allow resonating the antenna to any frequency in the band. Such an antenna may be $\lambda/4$, $3\lambda/4$, $5\lambda/4$, and so forth, in length. The third method, fig. 4c, is the pi-network described in previous articles. Bringing part of the antenna into the ham shack like this tends to induce rf ac into everything metallic in the shack. (You may be able to draw rf ac arcs off thumbtacks in the wall with a lead pencil!) Such energy is not being usefully radiated and can cause all kinds of difficulties in transmitters, receivers, and other electronic equipment. It is much better to install the antenna somewhere else and run a nonradiating feed line from transmitter (and receiver) to the antenna.

transmission lines

An important point to remember about transmission lines is that they should be matched with an impedance equal to their own characteristic impedance. The characteristic impedance that two parallel wires will have can be computed from the formula:

$$Z_0 = 276 \log \frac{d}{\gamma}$$

where $Z_0 =$ characteristic impedance in ohms

$\gamma =$ center-to-center distance of separation of conductors in inches (or cm)
fig. 4. Shunt-fed VT power amplifier with (A) direct coupled λ/2 antenna; (B) link coupled λ/4 antenna; and (C) pi-network coupling system.

\[ r = \text{radius of the conductors, in inches (or } \text{cm}) \]

If two wires of 0.04-inch radius are six inches apart, the \( Z_e \) will be 276 \( \log(6/0.04) \), or 276 \( \log(150) \), or 276(2.176), or 600 ohms. Such a feed line would not match a λ/2 or λ/4 antenna having 72 or 36 ohm feedpoint impedances. However, if a λ/2 antenna has high impedances at the end and low at the middle, there must be two points equal in distance from the center where the impedance between the points is 600 ohms, fig. 5. This feeder-to-antenna coupling method is called a delta match system. If the λ/2 is exactly the correct length, the 600-ohm feeder energy will be accepted by the antenna and will be radiated. If the matching points are not properly selected, or if the antenna is not exactly λ/2 long, not all of the energy will be accepted and some will be reflected back down the transmission line, setting up points of high voltage (loops) and low voltage (nodes). The ratio of loop to node voltages is known as the standing wave ratio (SWR). If SWR is measured at high and low voltage points it may be called VSWR. (If measurements are made at current loops and nodes the SWR will be the same.) The SWR ratio tells us how well the antenna matches the feed line at the feedpoint. The greater the mismatch the higher the SWR. A perfect match would produce a 1-to-1 (1:1) SWR. A 1:2, or even a 1:3 SWR delivers a reasonably high percentage of the PA output power to the antenna. If you have SWR values above 1:3 you should probably improve your antenna system dimensions.

Although open-wire lines discussed above make excellent low-loss transmission lines, it is usually simpler to use coaxial ("coax") types of transmission line. A coaxial line has a center copper conductor surrounded by a solid but flexible plastic (polyethylene) insulating material. This in turn is covered by a metallic wire braid, which is then protected by a black rubbery outer insulating coating. The inner conductor and the braid (sometimes a solid metal tubing) form the two conductors of the transmission line. Whereas the open-wire lines are balanced types (neither wire is grounded), coaxial lines attach the braid conductor to ground, which makes them unbalanced.

A 72-ohm coaxial line coupled to the center opening of a λ/2 antenna which exhibits a 72-ohm impedance should theoretically transfer all of the rf ac energy from feeder to antenna — but it does not. The capacitance between outer braid to the two sides of the dipole antenna is not the same as the capacitance from the center conductor to the two antenna ends. This means the antenna and feeder are not balanced, so there will be some reflected power and standing waves developed both inside the coax and also along the outside braid. The standing waves on the outer surface of the braid cause the coaxial line to act as a vertical antenna and radiate energy. (The duty of any transmission line is to carry energy without radiating any of it.) A little vertically polarized radiated energy is not all that bad in transmitting, but for receiving, vertically polarized antennas usually tend to pick up more noise than horizontal antennas.

To properly couple an unbalanced coaxial line to the center of a balanced antenna, a balun should be used. This is a balanced-to-unbalanced rf transformer of some kind. It might be a 1:1 ratio toroidal (doughnut-shaped) transformer for the antenna-feeder difficulty above. If the coaxial line has a 50-
ohm impedance and it is to match a 72-ohm dipole, the balun should have a 72:50, or a 1:1.44 impedance ratio. Its turns ratio should be the square root of the impedance ratio, or \( \sqrt{1.44} \), or 1:1.2 in this case.

A quarter-wavelength-long transmission line can also act as an impedance changing transformer. For example, to match a 600-ohm balanced open-wire feeder to a 72-ohm dipole a \( \lambda/4 \) of transmission line between feeder and antenna can be used, fig. 6. The proper impedance for this impedance-matching transformer can be determined from:

\[
Z_o = \sqrt{Z_1/Z_2}
\]

where
\[
Z_o = \lambda/4 \text{ transformer impedance in ohms}
\]
\[
Z_1 = \text{ antenna feed point impedance in ohms}
\]
\[
Z_2 = \text{ feeder impedance in ohms}
\]

In the problem above, the impedance transformer should be constructed as a \( \lambda/4 \) open-wire line where \( Z_o = \sqrt{72(600)} \), or 208 ohms.

Resonant transmission lines (feeders cut to \( \lambda/4 \), \( \lambda/2 \), and so forth) can be used to match impedances also. Every \( \lambda/4 \) along a resonant feeder (or resonant antenna) the impedance changes from a high value to a low value. If a \( \lambda/4 \) wave open-wire line (any \( Z_0 \) value) is coupled to the center of a dipole (a low \( Z \) point), at the other end of the \( \lambda/4 \) line a high impedance will appear. This end of such a balanced resonant line can be connected across the ends of a high impedance tuned LC circuit if it is grounded at the center. If the open-wire line is a \( \lambda/2 \) long, the low impedance at the antenna will be changed to a high impedance at the center of the line, but back to a low impedance at the transmitter end. A low impedance link coil of a few turns can be used to inductively couple from the PA LC circuit.

When a \( \lambda/2 \) horizontal dipole has one wire of an open-wire line attached to the end of the dipole, this is called a Zepp (from Zeppelin) antenna, fig. 7. To make the open end of the open-wire line match the high impedance at the end of a dipole, the feed line must be resonant. If the line is \( \lambda/4 \) long it will reverse the high \( Z \) at the end of the dipole to a low \( Z \), which can be link coupled to a PA tuned LC circuit. If the feed line is \( \lambda/2 \) long it will repeat the high \( Z \) of the end of the dipole and will have to be coupled across the high \( Z \) of the PA tuned LC circuit. Since one of the feed lines of a Zepp antenna terminates in the air, the system is not well balanced. This can be corrected by adding a second horizontal \( \lambda/2 \) wire (shown dashed) to the unterminated feed line, making a double-Zepp \( \lambda/2 \) in phase) antenna out of it.

For resonant open-wire lines the length in feet can be computed essentially as with antennas, but using \( \text{Length} = 483/f_{\text{MHz}} \) for a \( \lambda/2 \). When coaxial lines are used, a velocity factor, caused by the slowing of wave travel through the solid plastic insulation between center conductor and braid, must be figured in. A polyethylene insulated coaxial cable will need to be only about 66 percent as long as an open-wire feeder. The length in feet for a resonant \( \lambda/2 \) coax cable can be computed by the formula, \( \text{Length} = 319/f_{\text{MHz}} \). Here are some velocity factors used to convert electrical to physical lengths of different types of transmission line:

<table>
<thead>
<tr>
<th>dielectric material used</th>
<th>velocity factor</th>
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<tbody>
<tr>
<td>air-insulated open-wire line</td>
<td>0.975</td>
</tr>
<tr>
<td>air-insulated coaxial cable</td>
<td>0.850</td>
</tr>
<tr>
<td>polyethylene parallel line (twin lead)</td>
<td>0.820</td>
</tr>
<tr>
<td>polyethylene coaxial cable</td>
<td>0.660</td>
</tr>
</tbody>
</table>

The efficiency of an antenna system is essentially...
that of the feeder system. There is usually little resistance in an antenna wire to lose power due to $P = I^2R$. Open-wire lines, unless many wavelengths long, may also have very little ohmic resistance and losses. Solid dielectric coaxial cables, however, do have losses. For example, at a certain frequency, a 100-foot-long piece of coax may have a loss of 3 dB. This is a loss of just half power. If 100-watts is fed into the coaxial cable, at the antenna end the power delivered and radiated (assuming a 1:1 SWR) will be only 50 watts. In this case the effective radiated power (ERP) is only 50 watts. Suppose an antenna system has a 2 dB loss in the coupling circuit, a 3 dB loss in the transmission line, and a 1 dB loss in the resistance of the antenna, the total loss would be 6 dB. If 3 dB represents a loss of one half power, then another 3 dB (total of 6 dB) represents a further one half loss, or a total loss to one quarter of the starting power. With 100 watts of rf ac from the PA tuned circuit, the ERP would be only 25 watts. It pays to have a well-designed antenna system!

an SWR meter

We have mentioned that mismatching the feed line to the antenna feed point, as well as unbalanced feeder-antenna conditions, can produce a reflected signal back down the feeder that produces standing waves on the feed line. (Standing waves are desirable on resonant antennas, of course. The maximum voltage or current peaks developed on an antenna occurs when the feed line matches the antenna feed point.) But how can we determine the SWR on a transmission line? Is it possible to go along the feed line and measure the voltages present at different points? Perhaps, but this is quite difficult even with open wire lines. What we can do is to use a reflectometer, a meter that compares the energy moving up the feed line with that reflected back down the line. The ratio of the result of these two factors expressed in voltage or current will be the SWR.

If a wire is held a short distance from one feeder wire it will have voltage induced in it from the current flowing in the feeder. The reflectometer, or SWR meter, shown in fig. 8, is constructed to present a 50-ohm impedance to the rf ac from the 50-ohm coaxial cables coupled to it so that the meter itself will not reflect any standing waves back to the transmitter. Energy passing from the transmitter to the antenna through the middle conductor of the three wires induces a voltage into the top wire. This voltage affects the meter marked W/A (watts, mA). Any energy being reflected from the antenna feed point will induce a voltage into the lower meter wire and show up on the meter marked SWR. The two potentiometers (''pots'') are ganged together. To obtain an SWR reading, first tune the transmitter (and antenna tuner, if any follows the SWR meter). Adjust the ganged pots so that the W/A meter reads exactly full scale. The reading of the SWR meter will be the standing-wave ratio on the transmission line. Now, retune any antenna tuner following the SWR meter to produce the lowest possible SWR.

This same SWR meter can be used for power indications. First, the antenna is tuned to minimum SWR. Then the ganged pots are set to the predetermined position for the band being used. What the W/A meter now reads is supposed to be the power being transmitted down the feed system. If the SWR is high the power indications may read considerably higher than is possible with the power input computed from PA power supply current and voltage ($P = EI$). If you read a power value much over 60 percent of the dc power supply input power to the PA you should regard the power readings with a jaundiced eye.

FCC test topics

The following Novice class FCC test topics are discussed in this article, but should be understood by Technician/General, Advanced, and Extra class license applicants also:

- frequency and wavelength
- ground wave
- sky wave "skip"
- parallel conductor feed lines
- coaxial cable feed lines
- quarter-wave vertical (dimensions)
- half-wave dipole (dimensions)
- possible causes of unacceptable SWR readings
- acceptable SWR readings
- ground system

The following Technician/General class FCC test topics are discussed in this article, but should be un-
understood by Advanced and Extra class license applicants also:
- vertical and horizontal polarization
- antenna orientation
- feed point impedance; half-wave dipoles, quarter-wave verticals
- line-of-sight communications
- ionospheric layers, D, E, F1, F2
- absorption of radio waves
- sunspot cycle
- regular daily variations
- sudden ionospheric disturbances
- ducting, tropospheric bending
- scatter transmissions
- maximum usable frequency
- balanced, unbalanced feed lines
- characteristic impedance of antennas
- antenna-feed line mismatch
- standing-wave ratio, significance of
- physical dimensions of antennas
- use of a reflectometer (VSWR meter)
- sidebands
- single sideband emission
- radiation patterns, directivity, major lobes
- attenuation in antennas

For additional information on these subjects you can refer to *Electronic Communication*, or to *Amateur Radio Theory and Practice*, by Robert L. Shrader, W6BNB, McGraw-Hill Book Company, available through Ham Radio's Bookstore, Greenville, New Hampshire 03048.
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More Details? CHECK — OFF Page 94
A major expense in a satellite ground receiving system is the high-gain antenna. Most Amateur satellite trackers will want to build their own antenna to reduce this expense. Thus, we present a homebrew 68-inch (173-cm) parabolic antenna designed for receiving the 1691 MHz Geostationary Operational Environmental Satellite (GOES) weather facsimile (WEFAX) signal. The reflector of our antenna is identical in size and shape to a surplus reflector we obtained from a 12-GHz radar system. Using the same feed components and receiver with each reflector, we were able to test the gain of the homemade versus the commercial reflector. We found the homemade antenna's gain was within 1 dB of that of the commercial antenna. This difference is most likely due to variations of \( \frac{1}{10} \) wavelength (approximately 2 cm) in the reflector's surface. We did not go to great lengths to perfect these surface irregularities, so most antennas built with this design should perform as well or better than our version. Fig. 1 gives dimensions of the antenna.

The absolute gain of the antenna has not been tested. However, by comparing our receiving sys-

By Philip A. Johnson and Noel J. Petit, WB0VGI, University of Minnesota, Minneapolis, Minnesota 55455
tem's overall performance (that is, signal to noise) with a GOES-WEFAX link calculation\(^2\) it appears that the gain of our two antennas is within 2 dB of the theoretical gain. This indicates that for our parabolic dish at this frequency, our dipole feedpoint design\(^3\) is good.

**construction details**

The reflector was designed to be simple and inexpensive without sacrificing performance. This was accomplished by using a single machined part for a base, 1/2-inch aluminum tube for ribs, and 4 x 4 hardware cloth for the reflector surface. The dipole feed (fig. 2), which is more difficult to construct, is made from 3/8-inch brass rod and 9/16-inch O.D. (0.065-inch wall thickness) brass tube. An alternative tubing that may be easier to obtain is 1/2-inch O.D. with 0.032-inch wall thickness. The advantage of this size feed line is that it is very easy to connect to a UG-58/U connector (type N).

The base of the antenna is machined from 3/4-inch aluminum stock as shown in fig. 3. After the base has been machined, building the reflector is straightforward. Insert two aluminum tubes in opposing holes and pull the ends together until they can be held securely with a 68-inch (173-cm) length of wire. A 16d nail inserted into the hole at the end of each rib will hold the wire in place. Once the tube is held in place, a check with a template (details in fig. 4) must be made to determine if the tube is curved in the shape of a parabola. Ours was not. Tension at the end of a tube will produce a true parabola only for shallower parabolas. For this deep parabola, judicious bends must be made in the tubes until a parabolic shape is obtained. After each pair of ribs is bent, set them aside until all are bent.

When all tubes are bent insert them into the base and string a 1/8-inch (3-mm) cable through the hole at the outer end of the ribs. Correct tension will be applied to the ribs if the wire measures 17.8 feet, or 5.4 meters, which is the 68-inch (173-cm) diameter circle. Fine adjustment of the cable length, and thus tension on the ribs, may be obtained by inserting a turnbuckle in the cable.

The screen is cut from 36-inch (91-cm) wide 4 x 4 hardware cloth as shown in fig. 5. The 36-inch (91-cm) width screen is the exact size needed so that the folded edges of wire will be on the outer rim, preventing many puncture wounds from sharp wires. Tie the screen to the ribs with short pieces of iron wire.

With the reflector finished, mount the feed by removing the UG-58/U and its collar, inserting the brass tube into the hole in the baseplate, and reattaching the UG-58/U (type N) connector and collar. It may be necessary to guide the center conduc-

---

**fig. 1.** Overall dimensions of the antenna designed for receiving weather facsimile (WEFAX) signals on 1.691 GHz.

**fig. 2.** Details of the rear connector and dipole feed of the antenna.

**fig. 3.** Details of the central hub of the reflector. Material is 1-inch aluminum stock.
fig. 4. Details of the template used to form the reflector. Template is cut from card stock and taped to a 9/16-inch pipe to check dimensions and contour of the reflector.

fig. 5. Pattern for cutting the hardware cloth used to form the reflector. Material is cut along the solid lines to form pie-shaped pieces.

fig. 6. Comparison of deep and shallow reflectors. The aperture angle for an antenna of any given diameter depends on the focal-length-to-diameter ratio, \( f/D \). The aperture angle, \( \theta_A \), in terms of \( f/D \) is

\[
\theta_A = 2 \tan^{-1} \left( \frac{1}{2a - \frac{1}{16a}} \right)
\]

where \( a = f/D \)

It is possible to determine the focal length of an existing reflector from the formula \( f = D^2/16d \), where \( d \) is the depth of the dish. (See fig. 6.)

You may wish to construct a parabolic reflector of a different size and shape than the one presented here. One problem is determining the length of the tubing necessary for constructing a particular parabolic reflector. A formula giving the arc length is

\[
s = \sqrt{4x^2 + y^2} + \frac{y^2}{2x} \ln \left( 2x + \sqrt{4x^2 + y^2} \right) - \frac{y}{y}\sqrt{2y^2 + y^2}
\]

where \( x = d, y = D/2 \)

For a parabola with a \( f/D \) ratio of 0.25, this reduces to

\[
s = \sqrt{2y^2} + y \ln \left( y + \sqrt{2y^2} \right)
\]

where \( y = D/2 \)
Photo of the feedpoint. The antenna may be redesigned for 1296 MHz or 2304 MHz by modifying the dimensions given for the 1691-MHz antenna. The 9/16-inch pipe is slotted on both sides of the dipole, although only one slot can be seen.

The choice of an antenna with a dipole feed has two general advantages: short focal length and rear feed arrangement. A short focal length makes it unnecessary to support a feed distant from the reflector. The rigid coax is both a support for the dipole and a low-loss waveguide that terminates at a convenient position at the rear of the antenna. The disadvantages are difficulty in constructing the dipole and the severity of bends in the reflector ribs.

Horn-feed antennas have nearly opposite advantages and disadvantages. Advantages are that there will be few or no adjusting bends necessary on the ribs with the shallower dish, and a horn feed is very easy to construct. The great disadvantage is in the difficulty in supporting and adjusting the feed for focus and polarization. Also, a length of hardline coax must be used to minimize loss if the preamp is not mounted out on the horn. Excellent directions are available§ for construction of horn feeds.

**references**

4. Northern Microwave, 306 9th St. S.E., Minneapolis, Minnesota 55414.
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**WEST COAST BULLETIN**

1. **AMTSAT East Coast Net:** 1900 GMT (0300 UTC) Wednesdays
2. **AMTSAT West Coast Net:** 1900 GMT (0300 UTC) Wednesdays

**HAM CALANDAR**

**SUNDAY**

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**TUESDAY**

| AMTSAT East Coast Net: 1900 GMT (0300 UTC) Wednesdays (Saturdays) |
| AMTSAT West Coast Net: 1900 GMT (0300 UTC) Wednesdays (Saturdays) |

**WEDNESDAY**

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**THURSDAY**

| 3RD ANNUAL GRANT COUNTY ARC HAMFEST |
| 4TH ANNUAL CINCINNATI HAMFEST |

**FRIDAY**

| SUPTON COUNTY ARC 5TH ANNUAL HAMFEST |
| 3RD ANNUAL BURTONS HAMFEST |

**SATURDAY**

| 5TH ANNUAL LAMBERT HAMFEST |
| 4TH ANNUAL CLEVELAND HAMFEST ASSOCIATION 5TH ANNUAL HAMFEST |

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**MALL OF SCIENCE ARRC**

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2. **AMTSAT West Coast Net:** 1900 GMT (0300 UTC) Wednesdays (Saturdays)

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Military technical manuals, catalog $1.00. Colonel Russell, 9140 Walthamton, Louisville, KY 40222.

DRAKE SATELLITE RECEIVER with modulator installed only $969. Satellite and Microwave TV catalog $1.00. TEM Microwave, 22516 97th Ave. No., Concarbon, MN 55374. (612) 498-8014.


WANTED: Hammarlund HQ145, Call Arnie (212) 925-6046.


WANTED: Surplus 1.3 KW HF transmitter type FRT-15, Collins 5DM or equivalent, or higher power up to 20kW SSB not necessary, P.J. Finnin, 2 Lake Ave. Ext., Danbury, CT 06810. W5LUD.

RTTY-EXCLUSIVELY for the Amateur Teleprinter. One year! $7.00. Beginners RTTY Handbook $8.00 includes journal index. PO Box RY, Cardiff, CA 92007.

WANT complete set back issues Ham Radio 1960 to 1982. Also books on antennas. W5OMJ, Walter Volk mann, 4739 Denton Dr., Dallas, Texas 75219.

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HAVING GONE FROM CB to Amateur Radio three years ago, have a good general coverage receiver, would like a low priced used general coverage transmitter or transceiver, also 6 meter and 2 meter transceivers, tubes for anything, KAREPP, RR 1, Box 138A, Zim, MN 55799. (218) 744-3719.

OVERPRINTED: 1981 Fox Tango Club Newsletters. Sixty leaflet pages packed with modifications and information on Yaesu rigs. Only $8 while they last! Also a few 1980 sets at $5 (oversea add $3 each, airmail). N4ML, Box 15944, W. Palm Beach, FL 33406.

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MASSACHUSETTS: ELECTRONICA — Boston’s first public electronics show, Columbus Day weekend, Fri., October 8 through Monday, October 11, Hynes Auditorium. Personal electronics and home entertainment products, computers, games, home radio, TV, stereo, cameras, projection TV, security systems, video and stereo systems. Come see and buy the latest in electronics.

MICHIGAN: The Adrian Amateur Radio Club’s tenth annual Hamfest, Sunday, September 26, Lenawee County Fairground, Adrian. For tickets, tables, info: Adrian ARC, PO Box 26, Adrian, MI 49221.

MICHIGAN: The L’Anse Creuse Amateur Radio Club’s 10th annual Swap and Shop, Sunday, September 19, 9 AM to 3 PM, L’Anse Creuse High School, Mt. Clemens. Admission: $1.00 advance, $2.00 door. Prizes include $250.00 first prize, $100.00 second and $50.00 third. Talk in on 147.609 and 146.52. For information SASE to Maurice Schietecatte, NBC 2503 Touraine Ct., Mt. Clemens, MI 48044.

NEW HAMPSHIRE: The 6th annual Connecticut Valley FM Association’s Hamfest/Flea Market, Sunday, September 26, 9 AM to 3 PM, King Ridge Ski Area, New London. Adults $2.00, Children under 12 free. Flea market setup $5.00. Food concession by King Ridge. For information: KA18WE.

NEW YORK: RAGS. The Radio Amateur of Greater Syracuse, annual Hamfest, Saturday, October 2, 9 AM to 6 PM, Art and State Home Center, New York State Fairgrounds, Syracuse. Door prizes, tech talks, DXpeditions programs, contests, entertainment. Large indoor flea market. Admission: $3.00. Flea market space $6.00. Outdoor flea market space available also. Talk in on 9030 and 3191.

NEW YORK - LONG ISLAND: Suffolk County Radio Club’s 5th annual Flea Market, Sunday, September 12, Old Fellow Hall, Bayville, Port Jefferson Station. Rain date September 19. Door prizes, raffles, refreshments. Buyers $1.50 each. YLs, XYLs and harmonics, no charge. Sellers $3.50 each includes car and driver. Talk in on 145.215/144.61 repeater. For information: Floyd, W2LJS, (516) 233-8700 after 6 PM evenings.

NEW YORK: The Yankees Electronics Fair and Giant Flea Market, Sunday, October 3, 9 AM to 5 PM, rain or shine, Yankees Municipal Parking Garage, Corner of Nepperhan Avenue and New Main Street. All-day demonstrations — computers, satellite TV, lasers, Hi-Fi/Audio. Hourly prizes, giant auction, 50-50 drawings, instant bingo, free coffee all day. Admission: $2.00. Children under 12 free. Sellers $6.00. 50% of parking space, bring your own table. For information: Yankees ARC, 53 Hayward Street, Yonkers, NY 10704.

NORTH CAROLINA: The Western North Carolina Amateur Radio Society’s seventh annual Autumnfest, October 9, Asheville Civic Center. Admission $3.00 advance, $4.00 door. Flea market tables $5.00 at door. Camping facilities available. Talk in on 3191, 1876 and 52. For information: WCARS, PO Box 1448, Asheville, NC 28802.

OHIO: The Findlay Radio Club Hamfest is celebrating its 40th anniversary on September 12, 1982, Hancock Recreational Center Arena, N. Main St., 750, exit 161. Open 6:30 AM to 5:00 PM. Largest Hamfest in Northwest Ohio, second in state. Tickets $2.00 advance, $3.00 at entrance. Exhibit tables are $5.00 per table. Flea market truck sales $2.00 per space. Open Saturday for setups and evening entertaining. Talk in on 147.75/195/145.25/52. For reservations and tickets SASE to Findlay Radio Club Hamfest, PO Box 587, Findlay, Ohio 45840.

OHIO: The original forty-fifth annual Cincinnati Hamfest, Sunday, September 19, Stricker’s Grove, State route 126, Venice (Ross). Exhibits, prizes, refreshments, flea market, talks, entertainment and a thrilling air show by the Hawks. For information request your copy of the Club magazine, “The Mike and Key” Hamfest Edition. WBAL, WABST, KBCX.

OHIO: The Cleveland Hamfest Association’s 8th annual Hamfest, Sunday, September 26, Cuyahoga County Fairgrounds, Berea, 0890 to 1700 hours. Advance tickets $2.50 prior to August 31, $3.00 at door. Exhibits, forums, ladies’ programs, outdoor flea market. Three main prizes and mobile check in prizes. Talk in on 146.52 with W9OVJ. For information: Cleveland Hamfest Association, PO Box 27211, Cleveland, OH 44127.

OREGON: The 36th annual Walla Walla Hamfest, Saturday and Sunday, September 25 and 26, Milton-Freewater, Oregon. Community Building. Free registration. Saturday opens 9 AM. Sunday 8:00 AM. Swap and shop, contests, prizes. Ladies bingo. Camping at Fort Walla Walla
OPERATING EVENTS

"Things to do..."

SEPTEMBER 8: The 20th anniversary of "Howdy Days", starts Wednesday, September 8, 1800 UTC to Friday, September 10, 1800 UTC. All licensed women operators worldwide are invited to participate. Say hello to old friends. Meet new ones. Extend an invitation to non-members to join YRL Call "CQ YL". All bands and modes of emission may be used. No cross band operation. Send logs by October 11, 1982, to: Sandi Heyn, W5WZN, 962 Chynowth St., Costa Mesa, CA 92626.

September 11: KN5S will operate from 1300-2200Z to commemorate the 4th annual Burnsville Fire Muster. Frequencies: 7.250, 14.340, 21.400 ± 5 kHz phone; 7.125 CW in AM, 14.567, 20 locally FM. For a special certificate send large SASE to: KN5S, ARS, PO Box 23349, Richfield, MN 55423-0349.


OCTOBER 9: The Coosa Valley AR will operate from Rome, GA, from 1200Z. October 9 to 2200Z. October 17 to commemorate Heritage Days. 25 kHz lower side of General Class phone band 80 - 10 meters. For a special certificate SASE to: CVARC, Box 183, Rome, GA 30161.

OCTOBER 12: The Colquit County Ham Radio Society will operate a club station, WB4KOW, from the site of the fifth annual Sunbelt Agricultural Exposition, October 12, 13 and 14. 0900Z to 1700Z each day, Operations in the General portion of the HF bands. Club members will be listening for visiting Hams on local repeater 146.1979. For a special QSL SASE to: Colquit County Ham Radio Society, PO Box 813, Moultrie, GA 31788.
inductive reactance controls fan speed

Living in Florida as I do, I find that temperatures in the shack can rise quickly in summer, particularly when I'm running a linear. Some kind of cooling is desirable. Using a large window fan to cool the shack, I found, had two drawbacks. First off, it was a single-speed type, and just a bit too fast — always blowing papers all over the place. And secondly, as it got older, it developed an annoying rattle at its normal speed.

When I experimentally slowed down the speed of the fan with my Variac, I got both less air blowing around, and the rattle completely disappeared. Not wanting to tie up my very useful Variac for this purpose, I thought up other ways of reducing the fan voltage and speed.

A voltage-dropping resistance would do the job, but resistance dissipates both heat and uses expensive energy. Why not use a reactance to cut down the voltage? I tried first an inductive reactance and then a capacitive reactance. Although both kinds worked, I decided on an inductive reactance to slow the fan down. I found that using the secondary winding of an old filament transformer provided enough reactance to slow the fan to the speed I desired.

William Vissers, K4KI

novel two-tone signal generator

For experimentation and tuning up, a two-tone generator is surely a desirable piece of equipment to have. But being lazy by nature and not too good at building test equipment, I wanted to come up with a simple substitute method.

Like many other Amateurs, I like music and have a Hammond organ. A check with my scope showed that the upper and lower manuals both readily provide a very good sine wave if only one organ stop per manual is pulled out. It was simple to use a couple of variable resistance potentiometers to mix the two tones to the proper level for the audio signal to my transceiver. The tone voltages from the organ can be picked off directly from the output speakers, or at some lower level by tapping into the organ circuitry.

I will admit that this is probably the largest two-tone generator in existence, but it does a very satisfactory job. And for Amateurs who do not have their own organs, I found that it is very easy to put the two tones on a small cassette recorder tape. Several Amateurs have come over and done this using their own tapes, which they now use instead of building a tone generator of their own. So you save money and time by using something you already have, instead of building a piece of test equipment that you will use only a very small percentage of your operating time.

William Vissers, K4KI

decreasing dust buildup

In line with extending the life of my Yaesu FT-101-8 transceiver, I have found that dust pulled into the unit by the cooling fan becomes a real problem over an extended period of time. And as I do spend a great deal more time listening than transmitting, I rigged up a simple switching circuit that cuts off the cooling fan when the transceiver amplifier filaments are turned off. There is no noticeable rise in temperature when operating like this. You keep your equipment a lot cleaner this way. And, naturally, a dust cover is a must for all equipment when the station is shut down. Clean equipment will break down a lot less often than equipment coated inside with dust, which, by absorbing moisture, can cause severe corrosion and expensive breakdowns.

William Vissers, K4KI

cheap dots

I use black dots when making up printed circuit boards, and they are very expensive: $4.00 per one hundred dots. The reason is that they are precision drafting aids. Recently I found in a stationery store that you can buy black dots that work just as well, manufactured by the Avery Company or Dennison. Ask the stationer to show you his catalog and you might also see tapes that you can use with the dots. I find that it is cheaper to use shelf paper and cut it out with a razor. It makes a sharp image when etched and the acid does not sneak under it, the way it will with black masking tape.

Ed Marriner, W6XM
How often has your HT signal become heavily distorted, or even entirely unreadable, because of dead batteries? With an accurate voltage monitor to flag you before your Ni-Cds die, you can avoid such incidents. And you also gain the peace of mind of knowing that your weak or distorted signal is, in fact, due to your batteries — and not some other cause. The monitor described here is easy to build and adjusts to any battery voltage. It draws about 0.25 mA and consists of only four parts.

The heart of the circuit is a precision voltage-monitor chip produced by Intersil, the ICL8211CPA. This eight-pin miniDIP contains a temperature-compensated voltage reference and other circuitry to make up the basics of a voltage monitor. Because of its CMOS design, the chip is eminently suitable for an rf environment, and it draws only 22 microamperes. Adding a pot, resistor, and LED completes the monitor circuit.

By Alan Lefkow, K2MWU, 17 Jacobs Road, Thiells, New York 10984

Fig. 1 is a schematic of the monitor. A ten-turn pot, R1, divides down the battery voltage to match the built-in reference voltage of IC1 (1.15 volts). When the voltage at pin 3 falls below 1.15 volts, pin 4 of IC1 supplies a constant current of 7 mA, enough to drive a small LED directly. A 2.0-megohm resistor, R2, is used to provide a small amount of hysteresis, an option provided for by IC1. Without hysteresis, the LED could flicker on and off when the monitored voltage varies around the set point, as might be the case on voice peaks during receive. About 0.2 volt of hysteresis is added with R2. Thus, if the monitor were set to trip at a voltage of 10.0 volts, it would turn off when the voltage rose above 10.2 volts.
For absolute compactness, the parts are wired together using the pins and leads of the parts themselves, as shown in Fig. 2. In the author’s HT, a Wilson Mk II, the ground wire supports the whole circuit. The LED can be placed anywhere convenient and connected to the circuit with thin wires. The monitoring point (which is also the B+ supply for the circuit) is best picked up just after the HT’s ON/OFF switch.

Determining the desired trip point is not difficult. Generally, Ni-Cd batteries are close to the end of their discharge capacity when the voltage per cell falls below 1.2 volts. At 1.1 volts per cell there’s about 5 percent capacity left, and at 1.0 volt per cell, the battery can be considered discharged. A convenient trip point, therefore, is 1.1 volts per cell.

Recharging at that point on a regular basis will not cause memory to set in, and allows for a few more minutes of use before the battery voltage really starts to plummet. Hence, if your battery pack has, say, nine cells, the trip point for the monitor would be 9.9 volts. (You can figure out the number of cells your pack contains by dividing its nominal output voltage by 1.2.) Your rig may run on less than 1.1 volts per cell, but to do so entails the risk of reversing voltage on one of the cells, which can kill a battery pack.

The trip point is easily set using an adjustable power supply and DVM. Adjust the pot until the LED turns on at the desired battery voltage, using the power supply as an adjustable source for the HT. The circuit is accurate enough to make use of the greater resolution and accuracy of a DVM. In the author’s rig, the monitor was originally set to trip at 9.9 volts. A recent test showed the trip point still at 9.9 volts, three years later!

Reference

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SAY YOU SAW IT IN ham radio!

September 1982
last minute forecast

Another equinox season is here with its special propagation features. Features to note are these:

- Trans-equatorial one-long-hop openings on the higher frequency bands during geomagnetic disturbances;
- Trans-polar openings (gray-line DX) near twilight on the lower frequency bands during quiet geomagnetic periods between disturbances;
- High ionospheric electron densities giving high maximum usable frequencies (MUFs) favoring long-skip DX on the high bands;
- Some sporadic E layer openings, mainly near twilight for the lower bands;
- Geomagnetic disturbances increase, moving the ionosphere around, creating DX openings in unusual locations and providing an auroral curtain to reflect east/west paths by VHF-auroral scatter.

More detail on equinocial propagation can be found in the March, May, and September columns of ham radio beginning in 1981.

The forecast for September emphasizes that the upper frequency bands (10, 15, and 20 meters) will be excellent for DX during the middle of the month. These ham bands will probably begin to feel the solar flux effects of the eleven-year sunspot cycle, decreasing to an expected 100 or so (150 solar flux units). The beginning and ending weeks will be the worst, these time periods being closest to the 27-day solar cycle minimums. The lower frequency bands (40 through 160 meters) should be very good throughout the month. Overall, average thunderstorm QRN should decrease in the Northern Hemisphere, except for localized QRN, which builds up a day before and a day after a thunderstorm's passing, and while the storm is within sight of your QTH.

The full moon will occur on September 3rd; the moon perigee will occur on the 13th. The autumnal equinox will be on the 23rd at 0846 UT. No significant meteor showers are expected, so activity may be quite mediocre for the meteor-burst DX work.

Last month I presented a formula for determining northern latitude radio quality. It may also be used as a base-line quality number from which you can make your own calibrations to fit your operations. A typical base-line calibration for north Atlantic paths is shown in table 1.

<table>
<thead>
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<th>Band</th>
<th>Quality</th>
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<tr>
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<td>10</td>
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</table>

Radio propagation quality (QRO) seems to be made up of signal strength (QRA) and its variability (QSB) factors. The formula uses the radio flux and $\sin^2X$ values for the signal strength factor. The variability factor is tied into the geomagnetic A value. A fairly reasonable estimate can be calculated using these assumptions. Give it a try at your station if you've a programmable calculator or computer available.

**band-by-band summary**

Ten and fifteen meters will be loaded with good DX signals from morning until the early evening hours on many days. Periods of geomagnetic disturbance will limit the number of signals heard, but listen carefully — they can be from very unusual places. Fifteen meters should be open later in the day, after 10 meters, so, hit 10 first and finish off with 15.

Twenty meters will be the main daytime DX band, as it is almost always open to some part of the world. It opens in the east as the sun rises and extends into the late evening hours in the west. Geomagnetic disturbances do not affect this band as much as the higher ones, but look for unusual trans-equatorial DX locations that will come through once in a while. One-hop trans-equatorial DX of 5,000-7,000 miles (8,000-11,200 km) may be possible in the late evening hours during some of these unusual conditions.

Forty and eighty meters will have good short skip during daylight hours and turn to DX after dark. The bands will open in the east soon after sun-down, swing toward the south to Latin America about midnight, and end in the Pacific areas during the hour or so before dawn. Some nights these bands will be as good as can be expected during the winter DX season, coming up from November-February. The coastal regions usually have the edge for working the rare DX on these bands.

One-sixty meters will be quieter (QRN) now. This band should have renewed DX possibilities with LORAN phased out and privileges restored.

---

Forecaster
Garth Stonehocker, K0RYW

---

82 September 1982
*Look at next higher band for possible openings.*
NEW products

TR-2500

Trio-Kenwood Communications announces the new TR-2500, a compact 2-meter fm handheld transceiver. The TR-2500 weighs approximately 1.2 pounds yet includes such features as LCD digital frequency display, ten-channel memory with memory scan, built-in five year lithium memory back-up, manual scan, programmable automatic band scan, built-in tunable subtone encoder, built-in sixteen key auto-patch encoder, and 2.5 watts rf output with HI/LO power output switch.

Complete with rubberized antenna with BNC connector, 400-mAH heavy-duty NiCd battery pack, and ac charger, the TR-2500 has a factory suggested retail price of only $329.95.

For additional information, contact Trio-Kenwood Communications, P.O. Box 7065, Compton, California 90224.

micro-based repeater controller

The RC-850 Repeater Controller is a microcomputer based control system remotely configurable by the owner, with TouchTone™ commands. No hardware or software changes are required.

Remote configurability enables repeaters to be customized without trips to the site, and eliminates dependence on the manufacturer to make changes over the life of the repeater. Configuration parameters are stored in a non-volatile memory which requires no batteries for data retention.

The RC-850 controller’s autopath is based on a store and forward technique — the controller dials numbers into the phone, using TouchTone or dial pulse. Phone number readback helps prevent wrong numbers and allows the control operator to monitor autopath activity. The user-loadable autodialer speeds dialing of home phone numbers. The emergency autodialer reads back a configurable message for each location, to verify selection of the correct emergency autodial location.

Voice-response telemetry provides remote monitoring capability. A natural sounding speech synthesizer, analog measurement capability, plus configurable meter faces permit readback of user’s S-meter, frequency error, or deviation readings, plus power, temperature, and other parameters using external transducers. Users can receive diagnostic information about their signals, and you can remotely monitor your equipment and your site.

The synthesized remote base capability permits linking to other machines and simplex channels, to extend coverage area or pick up additional operators during emergencies and public service activities. The low power consumption, single supply operation simplifies power backup, and maximizes endurance when commercial power is lost.

Audio processing, including an analog delay line, mutes squelch tails on received signals. TouchTone is also muted — not even a blip of tones gets through. No more annoying double squelch tails and screeching tones.

For more information, contact Advanced Computer Controls, 10816 Northridge Square, Cupertino, California 95014; telephone 408-253-8085.

base station antenna

The Ringo Ranger II has 5.5 dB gain with an additional 5/8 wave section and decoupling radials for a low angle of radiation. Ringo Ranger II antennas are broadband and easily field tuned for quick installation. They are made from the highest quality aluminum, with stainless steel hardware. They cover frequency ranges from 146-512 MHz.

84 September 1982
For more information, contact Cushcraft Corporation, P.O. Box 4680, Manchester, New Hampshire 03108; telephone 800-258-3860.

3-band package for vacationing hams

Dentron Radio Co. has introduced a 3-band 25-watt CW transceiver and accessory package designed to help the Novice learn CW operation or to allow the experienced ham to keep in touch when he's away from a traditional power supply. It will run off any 12 Vdc battery. The transceiver covers 80, 40, and 15 meters and will receive SSB as well as CW. The complete package includes a code key, 3-band dipole antenna, head set, log book, an ARRL license manual, and a complete radio and code course on cassette tape. Optional accessories include a 120 Vac power supply with built-in speaker and antenna tuner.

For more information, contact Dentron Radio Co., Inc., 1605 Commerce Drive, Stow, Ohio 44224; telephone 216-688-4973.

morse code and teletype reception

Commsoft’s Cipher89 is a receive-only program for Morse code and radioteletype transmissions. The program features Baudot and ASCII operation up to 1200 baud and Morse code operation from 4 to 99 WPM.

Lunar’s GaAS FET Preamps on your repeater makes your customers’ handheld as powerful as though they were using a 40 watt amp and 30 pound battery.

Typical circuit improvements reported by our customers using Lunar’s GaAS FET Preamps indicate a 6 to 9 dB improvement. In other words, by installing a 7 ounce Lunar GaAS FET Preamp at your repeater, your customers’ signal from a 5 watt handheld is equivalent to his using a 40 watt amp and 30 pound battery.

Users state that areas which were formerly considered fringe reception areas are now rock solid. Increase your competitive position by installing a Lunar GaAS FET Preamp in your repeater now.

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If you attended the ARRL Hudson Division Convention in '76 or '78, then you know what a great time we’ll be having on the weekend of October 30-31, 1982, at the same fantastic location in Great Gorge, New Jersey. If you missed either of these years, ask someone who was there. You’ll hear about all the super activities, seminars, forums, fleamarket and exhibits covering everything from 160 meters to microwave; all modes, all facets of our great hobby...plus, new for '82, even more on computers and TVRO earth stations! As in the past, we also have a full women's program for non-ham XYCs, and the Great Gorge resort has everything in sports and leisure activities you could ever want.

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<td></td>
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<td>@ $24.00</td>
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</tr>
</tbody>
</table>

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Cipher89 is heavily graphics oriented with many on-screen menus to help the listener identify the format and natures of received messages. Histogram and map modes can be used to correlate data against previous intercepts and to identify the use of encryption.

The program comes with an instruction manual containing chapters covering many aspects of shortwave listening. An audio cassette tape, containing recordings of many types of signals the shortwave listener will encounter, is included.

Cipher89 requires a Heath H-8/ H-19 or H-89 computer with 32K of RAM and one disk drive. The program runs under the Heath Disk Operating System (HDOS). In addition, a hardware interface, such as the Comsoft Codem, is required to connect the shortwave receiver to the computer.

The price of the package is $99.95. A combination package, which includes the program plus a Codem, interconnect cable and power supply is available for $249.95. For more information, contact Comsoft, Inc., 665 Maybell Avenue, Palo Alto, California 94306; telephone 415-493-2184.

**multi-site repeater voting system**

Heil Sound has developed a repeater voting system, the VT-3, designed to work with three remote receivers using a UHF radio link between receiver and transmitter sites. The equipment is designed around a delay board that measures the strength of incoming receiver signals. Activation of the link transmitter depends on the strength of the signal. The stronger the signal, the faster the link equipment is turned on. The first link signal heard enables the transmitter latch board, locking out other receivers. Audio from the receiving link is fed through an active audio equalizer so that audio loss is regained.

Only an external timer from the transmitted latch board and the ID system is needed to use the system. Each receiver delay board and transmitter latch board have dc switching to operate all keying lines.

The complete kit, all boards and components for three receivers and one transmitter site, is available for $82 plus $3 shipping and handling. For more information, contact Heil, Ltd., Heil Drive, Marissa, Illinois 62257.

**terrestrial frequency analyzer**

The Model 4043 Terrestrial Tracer is a tunable, calibrated wavemeter for diagnostic evaluation of TVRO system terrestrial interference in the 3.7-4.2 GHz band. The tunable notches (approximately 20 dB deep) can be adjusted to obtain best system performance while viewing a transponder which displays symptoms of interference. When best performance is obtained, the calibrated indicators can be used to determine the terrestrial carrier frequency. Then, a permanent microwave notch filter can be fabricated to remove the offender.

The 4043 is installed in the signal
path between the LNA and the down-converter. The unit passes dc for supplying power to the LNA. The 4043 costs $790.00.

For more information, contact Emily Bostick, Microwave Filter Co., Inc., 6743 Kinne Street, East Syracuse, New York 13057; telephone (in U.S.) 1-800-448-1666.

digital multimeter

Beckman Instruments, Inc., has expanded its line of digital multimeters. The attention-getting DMM is called the Tech™ 320B digital multimeter and has both audible and visual indication of continuity. When it’s not possible to see the large LCD, the meter will alert the user when continuity is detected by emitting a single, loud beep. Continuity is also visually displayed (in less than 1/10 of a second) by the appearance of an ohm sign in the upper left corner of the LCD.

Like other Beckman portable DMMs, the Tech 320B features an easy-to-use single center selector switch, 0.1 percent basic Vdc accuracy, 10-ampere ac/dc current ranges, 2,000-hour battery life from a standard 9-volt battery, semiconductor test function, and overload protection on all ranges.

The Tech 320B has twenty-nine ranges and is protected against overload. Voltage ranges are protected to 1,500 volts dc or 1,000 volts RMS ac.

versatile transceiver

The Ic-740 transceiver has front panel or top controls allowing convenient access to all operating functions. Adjustable receiver parameters are: rf preamp, rf gain, noise blanker (width and level) i-f shift, passband tuning, crystal filter in/out, notch filter, AGC (time constant and on/off), squelch, tone, and audio gain. Transmitter controls are mic gain, VOX, compressor and power (10-100 watts). The IC-740 includes capability of operating in the increasingly popular fm mode.

The IC-740 features dual VFOs with three tuning rates, split operation and memory. Analog control of frequency with the incremental tuning works on TX and RX. You are able to meter receive signal strength, transmit relative rf output, compressor level, ALC and collector current plus a built-in SWR meter.

A large selection of options are available. All items are compatible with the IC-740, including the popular AT-500/100 automatic antenna tuner, as well as the IC-2KL solid-state linear.

For more information, contact ICOM America, Inc., 2112 116th Avenue, N.E., Bellevue, Washington 98004; telephone 206-454-8155.
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repeater power amps

A new line of continuous-duty power amplifiers for repeater service has been introduced by Micro Control Specialties. Three different models in the new PA-75 series serve the popular repeater frequencies of 144-148, 220-250, and 420-450 MHz.

Each model in the new PA-75 series provides 75 watts output with 10 to 15 watts of drive from a repeater or base station. The PA-75 also includes a three-section harmonic filter, ac power supply, front panel fuse access, and metering in a handsome rack mount package.

Dependable continuous-duty operation is obtained by using a generous heat sink plus a quiet axial fan arranged to cool both amplifier and power supply components. In addition, efficient 28-volt transistors are used for high reliability and long life.

For further information write to Micro Control Specialties, 23 Elm Park, Groveland, Massachusetts 01834; telephone 617-372-3442.

UHF Amateur antenna

Hustler, Incorporated has announced a mobile trunk lip-mount co-linear antenna for 438-450 MHz Amateur service. Model BBLT-440 has a unique 5/8-wave design that develops a 5 dB gain, compared to a quarter wave stub, and features a 10 MHz bandwidth with under 2:1 VSWR.

handheld 4½-digit multimeter

Fluke's 8060A is a handheld, microcomputer-based 4½-digit multimeter that includes true RMS measurements for ac signals to 100 kHz, frequency measurements to 200 kHz, resistance measurements to 300 megohms, and can store any measurement as an offset value. Voltage measurements can be directly displayed in dBm referenced to 600 ohms, or in relative dB. Continuity testing (with selectable visual/audible indication), conductance, and constant current source diode testing are
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The SWD-1 Video Converter utilizes cable TV systems to remove the KHz signal from a distorted video (channel 3 in/out) and also passes thru the normal undistorted/detected audio signal. Receiver switch selects operating mode to remove KHz distortion from the video or pass all other channels normally. Simple to assemble—less than 30 minutes Pre-Printed Channel 3 Impedance 75 ohms, 117VAC
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Antenna input 75 ohms
Channels 14-83 Output Channel 3

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4 RF-35 SW Resistor Kit, 1/4 W, 5% Carbon Film, 12 pieces $4.95
5 PF-11W Power Transformer, PHI-117VC, SEC-24VC 250mA $4.95
6 PP-5W Panel Mount Potentiometers and Knobs, 1-KRT $5.95
7 LS-34W IEC jacks, 3 sets 4-4-4 Res, Regulators 3-3-3 $29.95
8 CE-9SW Electrolytic Capacitor Kit, 9 pieces $9.95
9 CE-33SW Ceramic Disk Capacitor Kit, 50-27 $33.75
10 CT-SW Variable Ceramic Trimmer Capacitor Kit $4.95
11 14 SW Coil Kit, 100 ohms, 2-2 pieces (power inductors) and 2 T37-12 Ferrite Toroids 2.27 w $5.95
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Daiwa announces a compact audio speech processor that rivals the performance of the rf types at an economical price. The RF-670 will give your signal the boost it needs to cut through QRM. The unique photo-coupler design delivers a high level of processing with a minimum of distortion.

Traditional audio processor design is handicapped by the circuitry time constants that limit the ability of the processor to respond to rapid variations in the level of the input audio signal. The result is distortion and poorer performance. The RF-670’s photocoupler/variable gain amplifier design permits a very rapid response to input levels, and the result is clean output and excellent performance. The RF-670 features velcro pads for easy mobile or base mounting.

For more information, contact MCM Communications, 858 E. Congress Park Dr., Centerville, Ohio 45459; telephone 513-434-0031.

1:1 balun antenna

Hustler, Inc., offers a 1:1 balun hf Amateur antenna. The balun, model BLN, features a low-loss air core design that eliminates saturation at high power levels while maintaining a uniform power balance in the system. It is rated at 1 kW, and has a bandwidth of 7 to 35 MHz. The stainless steel hardware and flying leads are supplied for connection to the driven element of beams, quads, or dipoles. Coax termination is to an SO-239 connector.

For additional information, contact Hustler, Inc., Sales Department, 3275 North B Avenue, Kissimmee, Florida 32741.

base station antenna

Sinclair Radio Laboratories have introduced a new VHF/UHF combination base station antenna for mobile communications systems. Called the
310/210, the antenna uses one SRL-210 and one SRL-310 exposed dipole. The 310/210 offers exceptional bandwidth and efficient coverage for both the 138-174 MHz and 406-512 MHz frequency ranges.

This extremely rugged antenna has been designed with the needs of the service shop in mind. The two dipoles are mounted on a 10-foot mast of 1½-inch ISP-schedule aluminum pipe. The 310 dipole is secured to the mast while the 210 dipole is left unassembled for shipping. The antenna can be easily transported and quickly assembled for an on-site test or demonstration.

Both dipoles are spaced one-half wavelength from the mast. This provides a nominal gain of 2 to 2.5 dB in an essentially omnidirectional pattern. VSWR across the full bandwidth is 1.5:1 or better. The 210 dipole can handle 200 watts; the 310 is rated at 75 watts. With half-inch radial ice, the rated wind velocity is 85 MPH. Both dipoles are at dc ground potential for maximum lightning protection.

For further information, contact Sinclair Radio Laboratories, Inc., 14614 Grover Street, Suite 210, Omaha, Nebraska 68144; telephone 800-228-2763.

**shock mount antenna**

Antenna Specialists Co. introduces a new line of professional mobile communications antennas designed around a new concept in shock mounting, called Dura-Flex. In place of the conventional steel shock spring, the antenna is equipped with a tapered, cylindrical shock mount of molded neoprene which performs the basic shock-absorbing function while solving two special problems experienced in several mobile environments.

A/S engineers discovered the high noise levels were being generated in spring-equipped antennas by interaction of metal spring coils, which normally carry a small amount of rf. This problem is especially noticeable with slightly corroded springs. The solution was to use neoprene along with a material capable of withstanding pounding, flexing, and extremes of temperature. The whip and base mount are mechanically interconnected by means of solid brass threaded connectors totally sealed changes instantly. A second light bar displays power. It follows with the speed of light so you can see all the SSB peaks.

The frequency range of the M-827 SWR meter is 1-30 MHz. The SWR scale is 1 to 10 with a logarithmic response that gives much improved resolution where you need it.

The M-827 SWR meter sells for $97.50. For further information, write to Palomar Engineers, 1924-F W. Mission Road, Escondido, California 92025.

**automatic SWR meter**

Palomar Engineers introduces the M-827 SWR meter which computes SWR automatically and displays it on a light bar. The SWR reading is always correct regardless of power level, and the light bar follows the speed of light so you can see all the SSB peaks.

The frequency range of the M-827 SWR meter is 1-30 MHz. The SWR scale is 1 to 10 with a logarithmic response that gives much improved resolution where you need it.

The M-827 SWR meter sells for $97.50. For further information, write to Palomar Engineers, 1924-F W. Mission Road, Escondido, California 92025.
within the shock mount. The connecting braid is totally isolated from the mount through an interior cavity and thus not subject to any strain from deflection. The mount is completely waterproof and may easily be removed.

Dura-Flex-equipped antennas are available in standard roof, trunk lid, cow, and magnetic mounting configurations at high band and UHF frequencies. The ASP-1450 series, with 3 dB gain, is designed for 138-174 MHz. Three UHF series are offered: Model ASP-1790 (3 dB gain) for 445-512 MHz; Model ASP-1650 (a 5 dB-gain collinear) for 406-512 MHz; and ASP-1750 series (a deluxe 5 dB-gain collinear with low loss Pro-Flex cable). A 3 dB motocycle model, ASP-1791, and a no-ground-plane model, ASP-1751, both for UHF, also are available.

For complete technical details and specifications, write to Marketing Department, The Antenna Specialists Co., 12435 Euclid Avenue, Cleveland, Ohio 44106.

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Prices of the Model 9370, which is equipped with a 700 degree heater, and Model 9380, which comes with an 800 degree heater, are $27.97.

For further information, contact Ungar, Division of Eldon Industries, Inc., 100 West Manville Street, Compton, California 90220; telephone 213-774-5950.

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Collins KWM2 300.00

KLM BT344A 489.00
BG341 Nonmil copperbraid coax 70C/ft.

AMPHENOL PL259 Silverplate 1.00
SPRAGUE 1000PF/30KV Doorknob C10 16.00
125PF/500V Fedar thru 1.95
CDE 001/2KV Cap 1.95
TCA 25A/1000 PIV Epoxy diode 19C ea.

Belden 9258 RRGB 19C/ft
8214 RG8 Foam 366/ft
8267 RG213 43C/ft
9405 Heavy Rotorcable 45C/ft

LARGE BOOKSTORE

Mosley .................................................. 20% Off List

ALL ITEMS GUARANTEED

PLEASE SAY YOU SAW IT IN THIS

MAGAZINE AD.

MASTERCARD VISA

All prices fob Houston except where indicated. Prices subject to change without notice, all items guaranteed. Some items subject prior to sale. Texas residents add tax. Please add sufficient postage, balance collect.
... for literature, in a hurry — we'll rush your name to the companies whose names you print below.
It's simple to do. Simply select the advertiser's number and name from the Advertisers' Checkoff list found on the same page as the Advertisers' Index. Just print the number and the company's name and drop in the mail.

<table>
<thead>
<tr>
<th>NUMBER</th>
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Please select month _______ July _______ Aug. _______ Sept.  Limit 14 inquiries please.

NAME ____________________________________________
ADDRESS _________________________________________
CITY ____________________________ STATE ______ ZIP _______
ATTN: Reader Service Dept.
The Great Boxboro Convention Returns!!

Remember the fantastic Boxboro hamfest back in 1980? Well here we go again with improvements galore to make the show even better! Located “in the country” on Route 495 at Route 111 the New England ARRL Convention for 1982 features free shuttle bus service to and from a giant free parking area — no more parking worries!!

Prizes Awarded Both Days of Show

Through the generous cooperation of the manufacturers and dealers lucky conventioners will be taking home transceivers. handi-talkies. amplifiers. HF and VHF antennas. rotors. CW & RTTY decoders. and even a Tektronix scope! The list is endless as the affair is non-profit and all surplus funds so directly into prizes.

See Every Possible Make of Ham Gear

Exhibits will be open Saturday 9 to 5. Sunday 10 to 5. Manufacturers and distributors are turning out in force! Virtually everybody will be at Boxboro from all parts of the country bringing with them the latest equipment in HF and VHF plus exotic antennas. test equipment. RTTY. CW plus color and B&W SSTV.

Big Events All Weekend

Two meter fox hunts. YL programs. seminars on all aspects of ham radio including microprocessors. RTTY. color SSTV. DX. a Wouff Hong ceremony. Saturday night banquet. show and dance plus prizes awarded all weekend.

There will be a home brew equipment exhibit and contest. CW and QSL contests. Booths will include AMSAT and MARS. CAP. and the QSL bureau.

Early Bird Tickets Available by Mail Only!

Registration is $4 early bird, $5 at the door. Combination banquet. dance and show tickets are $13.50 each including tax and gratuity. Order tickets from Arthur Tomkinson. W1HT. 9 Oliver Terrace. Revere. Massachusetts 02151. Include SASE! Make checks payable to FEMARA. The Sheraton Boxboro may be sold out by the time you read this but their address is Boxboro, Massachusetts 01719. You must mention “radio show” to get the convention discount!
Stuck with a problem?

Our TE-12P Encoder might be just the solution to pull you out of a sticky situation. Need a different CTCSS tone for each channel in a multi-channel Public Safety System? How about customer access to multiple repeater sites on the same channel? Or use it to generate any of the twelve tones for EMS use. Also, it can be used to access Amateur repeaters or just as a piece of versatile test equipment. Any of the CTCSS tones may be accessed with the TE-12PA, any of the audible frequencies with the TE-12PB. Just set a dip switch, no test equipment is required. As usual, we’re a stickler for 1 day delivery with a full 1 year warranty.

- Output level flat to within 1.5db over entire range selected.
- Immune to RF.
- Powered by 6-30vdc, unregulated at 8 ma.
- Low impedance, low distortion, adjustable sinewave output, 5v peak-to-peak.
- Instant start-up.

**TE-12PA**

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<thead>
<tr>
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<th>04</th>
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<td>74.4 WA</td>
<td>77.5 XA</td>
<td>79.7 SP</td>
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- Frequency accuracy, ±0.1 Hz maximum -40°C to +85°C
- Frequencies to 250 Hz available on special order.
- Continuous tone

**TE-12PB**

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- Frequency accuracy, ±1 Hz maximum - 40°C to +85°C
- Tone length approximately 300 ms. May be lengthened, shortened or eliminated by changing value of resistor

$89.95

**COMMUNICATIONS SPECIALISTS**

426 West Taft Avenue, Orange, California 92667
(800) 854-0547/California: (714) 998-3021
FT-230R: QUITE A SIGHT! (AND EASY TO SEE, TOO!!)

Sporting an all-new Liquid Crystal Display, the FT-230R is Yaesu's high-performance answer to your call for a very affordable 2 meter mobile rig with an easy-to-read frequency display! The FT-230R combines microprocessor convenience, a sensitive receiver, a powerful yet clean transmitter strip, and the new dimension of LCD frequency readout. See your Authorized Yaesu Dealer today — and go home with your new FT-230R!

- LCD five-digit frequency readout with night light for high visibility day or night.
- Two VFOs for quick QSY across the band.
- Ten memory slots for storage and recall of favorite channels.
- Selectable synthesizer steps (5 kHz or 10 kHz) in dial or scanning mode.
- Priority channel for checking a favorite frequency for activity while monitoring another.
- Unique VFO/Memory Split mode for covering unusual repeater splits.
- Up/Down band scan plus memory scan for busy or clear channel. Scanning microphone included in purchase price.

- Full 25 watts of RF power output from extremely compact package.
- Built-in automatic or manual tone burst.
- Optional synthesized CTCSS Encode and Decode boards available.
- Lithium memory backup battery with estimated lifetime of five years.
- Optional YM-49 Speaker/Microphone and YM-50 DTMF Encoding Microphone provide maximum operating versatility.

And don’t forget! Yaesu has a complete line of VHF and UHF handheld and battery portable transceivers using LCD display!!!

Price and Specifications Subject To Change Without Notice or Obligation

FT-208R - 2 Meters
FM Handheld
2 Meters

FT-708R - 70 cm
FM Handheld

FT-290R - 2 Meters
SSB/CW/FM Portable

FT-690R - 6 Meters
USB/CW/AM/FM Portable

Yaesu
The radio.
Outstanding features providing maximum ease of operation include a large, easy-to-read (direct sunlight or dark) LCD display, 21 multi-function memories, automatic offset, programmable priority channel, memory and band scans, built-in lithium battery memory back-up, built-in 16-key autopatch, and a choice of a hefty 45 watts output (TR-7950), or 25 watts output (TR-7930).

TR-7950 FEATURES:
- NEW, large, easy-to-read LCD digital display
- Easy to read in direct sunlight or dark (back lighted). Displays transmit/receive frequencies, memory channel, repeater offset, (+, -), sub-tone number (F-O, 1, 2, 3), tone, scan, and memory scan lock-out. Includes LED S/RF bar meter, and LED indicators for REVERSE, CENTER TUNING, PRIORITY, and ON AIR.
- 21 NEW, multi-function memory channels
- Stores frequency, repeater offset, and optional sub-tone channels. Memories 1 through 15 for simplex or +600 kHz offset. Memory pairs 16/17, and 18/19 are paired for non-standard repeater offset. Memories “A” and “B” set upper and lower scan limits, or for simplex or +600 kHz offset. In MEMORY mode, a circle of light appears around the memory selector knob. When the memory selector knob is rotated in either direction to channel 1, an audible “beep” will sound.
- Choice of 45 or 25 watts output
- The TR-7950 provides a hefty 45 watts output, while the TR-7930 features a more modest 25 watts. A H/Low power switch allows power reduction to approx. 5 watts.
- Long-life lithium battery memory back-up
- Built in lithium battery has an estimated 5 year life.
- Automatic offset
- The microprocessor is pre-programmed for simplex or ±600 kHz offset, in accordance with the 2 meter band plan. “OS” key allows manual change in offset.
- Programmable priority alert
- The PRIORITY channel may be programmed in any of the 21 memories. With ALERT switch “ON”, a dual “beep” sounds when a signal is present on the PRIORITY channel. An O/P switch allows an easy move to the PRIORITY channel.
- Programmable memory scan lock-out
- "LO" key for programming scan to skip selected memory channels, without erasing the memory.
- Programmable band-scan width
- The lower limit may be programmed into memory “A” and the upper limit into memory “B”.
- Center stop during band-scan
- with indicator
- Stops in center of channel during band-scan, with center tuning indicator.
- Scan control using up/down microphone
- Momentarily pressing UP or DOWN button on microphone tunes one step in the selected direction, on memory or on 5-kHz step tuning. Holding the button for about 2 seconds starts UP or DOWN automatic scan action. Scan starts also possible using “SC” key on keyboard. Scan may be cancelled by momentarily pressing the PTT switch, or by pressing both UP/DOWN buttons simultaneously.
- Programmable sub-tone channels
- Optional TU-79 3 frequency sub-tone unit provides keyboard selectable sub-tone channels, which may be stored in memory.
- Built-in 16-key autopatch, with monitor
- The keyboard functions as a 16-key autopatch during transmit. DTMF tones appear in the speaker output when a key is pressed during transmit.
- Front panel keyboard control
- Used for selecting frequency, offset, programming memories, controlling scan, and autopatch encode. Keyboard lighting is provided.
- Extended frequency coverage
- Covers 142.000-148.995 MHz, in 5-kHz steps.
- Repeater reverse switch
- Locking-type switch, with indicator.
- “Beep” amplified through speaker
- Compact, lightweight design
- Easy-to-install adjustable-angle mobile mounting bracket

Optional accessories:
- TU-79 3 frequency tone unit.
- KPS-12 fixed-station power supply for TR-7950.
- KPS-7 fixed-station power supply for TR-7930.
- SP-40 compact mobile speaker.

More information on the TR-7950 and TR-7930 is available from all authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.

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